



HYDRO-ECONOMIC ANALYSIS OF MIDDLE MAGDALENA VALLEY ASSOCIATED TO EXPLORATION AND PRODUCTION OF OIL AND GAS. Case Study: Barrancabermeja - Colombia

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Research Line

WATER AND ENVIRONMENTAL ENGINEERING

50 AÑOS
POSGRADOS
INGENIERÍA CIVIL

PhD Program in Civil Engineering
School of Engineering
Bogotá Campus



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DE COLOMBIA

Outline

1. Background
2. Motivation
 - Supply
 - Demand
 - Hydro-economic models
3. Research Problem
4. Hypothesis
5. Objectives
6. Methodology

1. Background: Application of Hydro-Economic Models



Conflict resolution

- **Water shortages and infrastructure development.**
- **Location:** Turkey, Gediz River Basin.
- **Model:** The multi-objective optimization and heuristic methods with dynamic simulation
- **Source:** Fedra et al. (2007), Cetinkaya et al. (2008)



Water markets and Pricing assignmet

- **Design water pricing policy.**
- **Location:** Rio Grande Basin, New Mexico, USA
- **Model:** hydrological and economical analysis to evaluate water quality constraints
- **Source:** Ward and Pulido-Velázquez (2008, 2009)



Water distribution and use

- **Water Demand.**
- **Location:** Neste Basin, French.
- **Model:** economic optimization.
- **Source:** Reynaud y Leenhardt (2008)



Water supply and expansion of the infrastructure

- **Water preservation and infrastructure expansion.**
- **Location:** Jordan
- **Model:** stochastic programming model
- **Source:** Rosenberg et al. (2008)



Ground and underground wáter use

- **Optimization of ground-water in an integrated system.**
- **Location:** Israel and South of California, USA
- **Model:** economic optimization (demand curves)
- **Source:** Bear et al. (1964), Bear and Levin (1966, 1970), Harou and Lund (2008)

2. Motivation



Water Axis

- ✓ It concentrates 80% of the population
- ✓ 2% of population and generates 8% of the national GDP

Infrastructure Projects

- ✓ Connectivity: Ruta del Sol
- ✓ Navigability
- ✓ Port works
- ✓ Hidrosogamoso
- ✓ Crops: Wax Palm

Oil and Gas

- ✓ Second largest production region in the country (137,000 bpd in 37 fields)
- ✓ More refining capacity (300,000 bpd)

The availability of water resources and variability (**Morón et. al., 2013**)
 Water supply in Colombia (**Rodríguez et. al., 2015**)

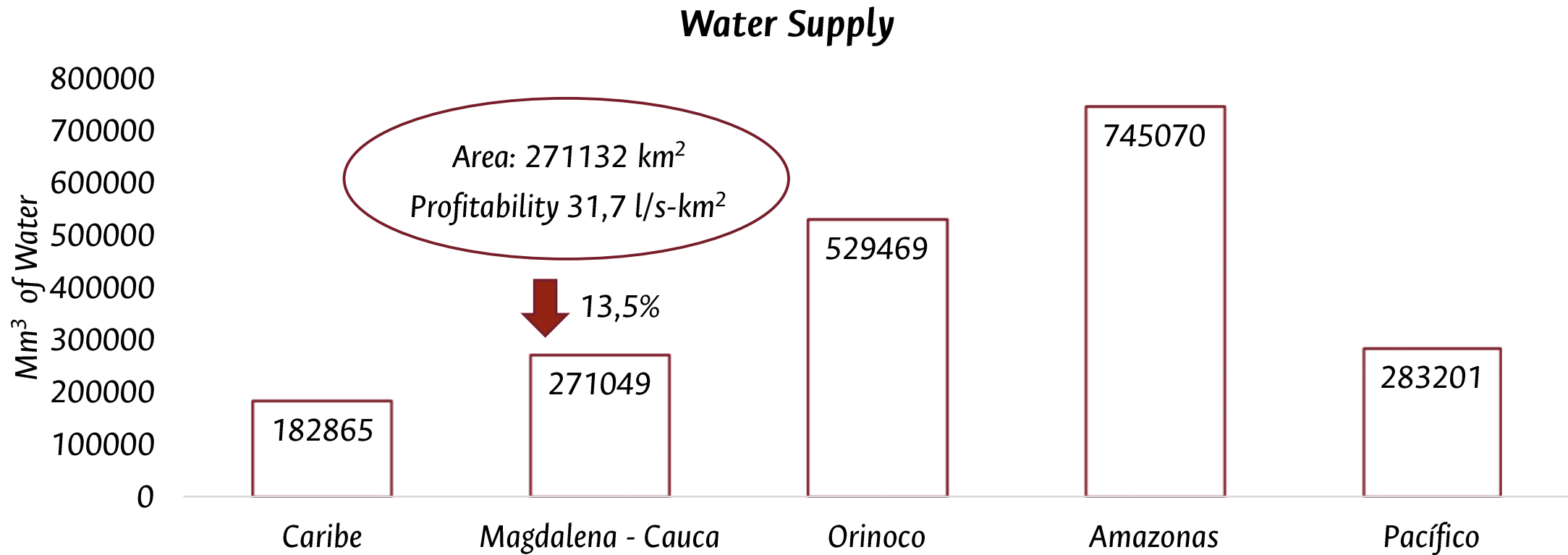


Figure 1. Water supply in Colombia. Source. Ideam. ENA. 2014

- ▶ Average performance of water in Colombia is 56 l/s-km²
- ▶ World average yield: 10 l/s-km²
- ▶ Performance Latin America: 21 l/s-km²

Water Demand Evaluated by: Department and Sector

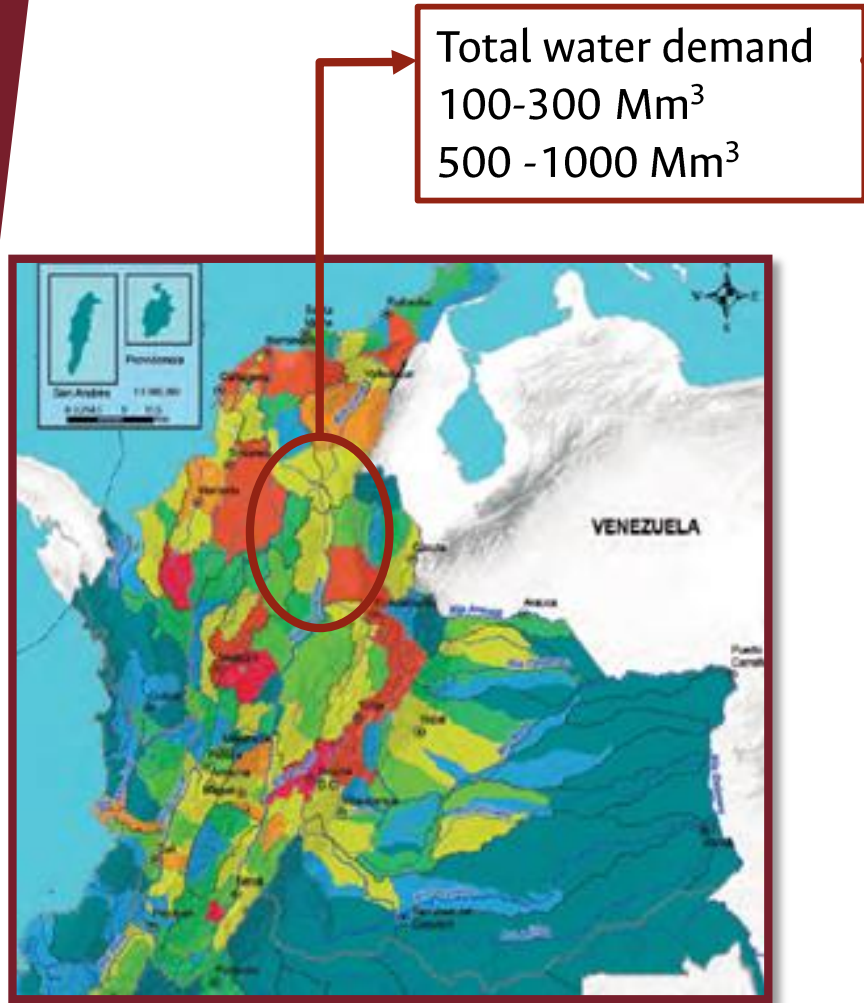


Figure 2. Water Demand per Department in Colombia.
Source. Ideam. ENA. 2014

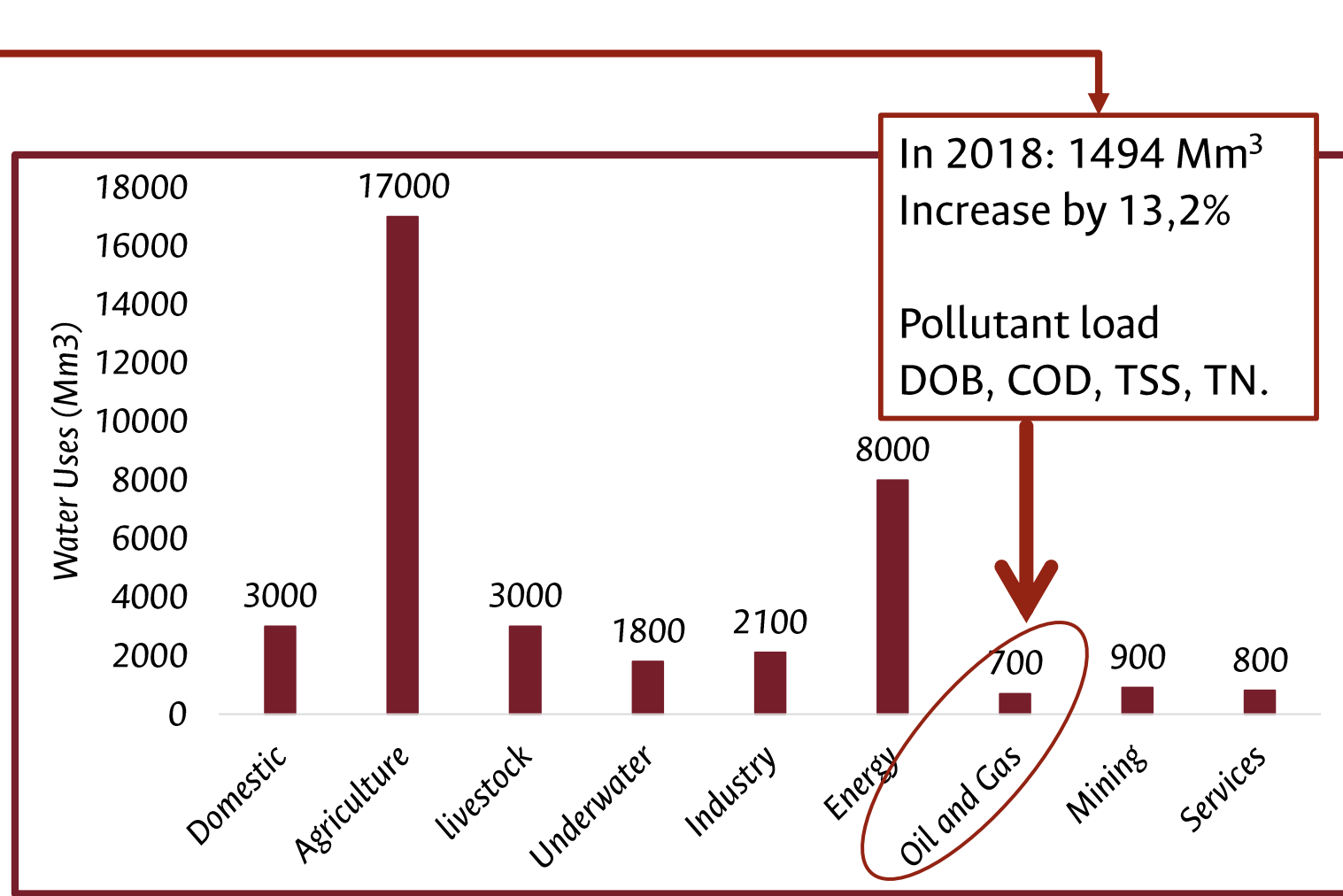
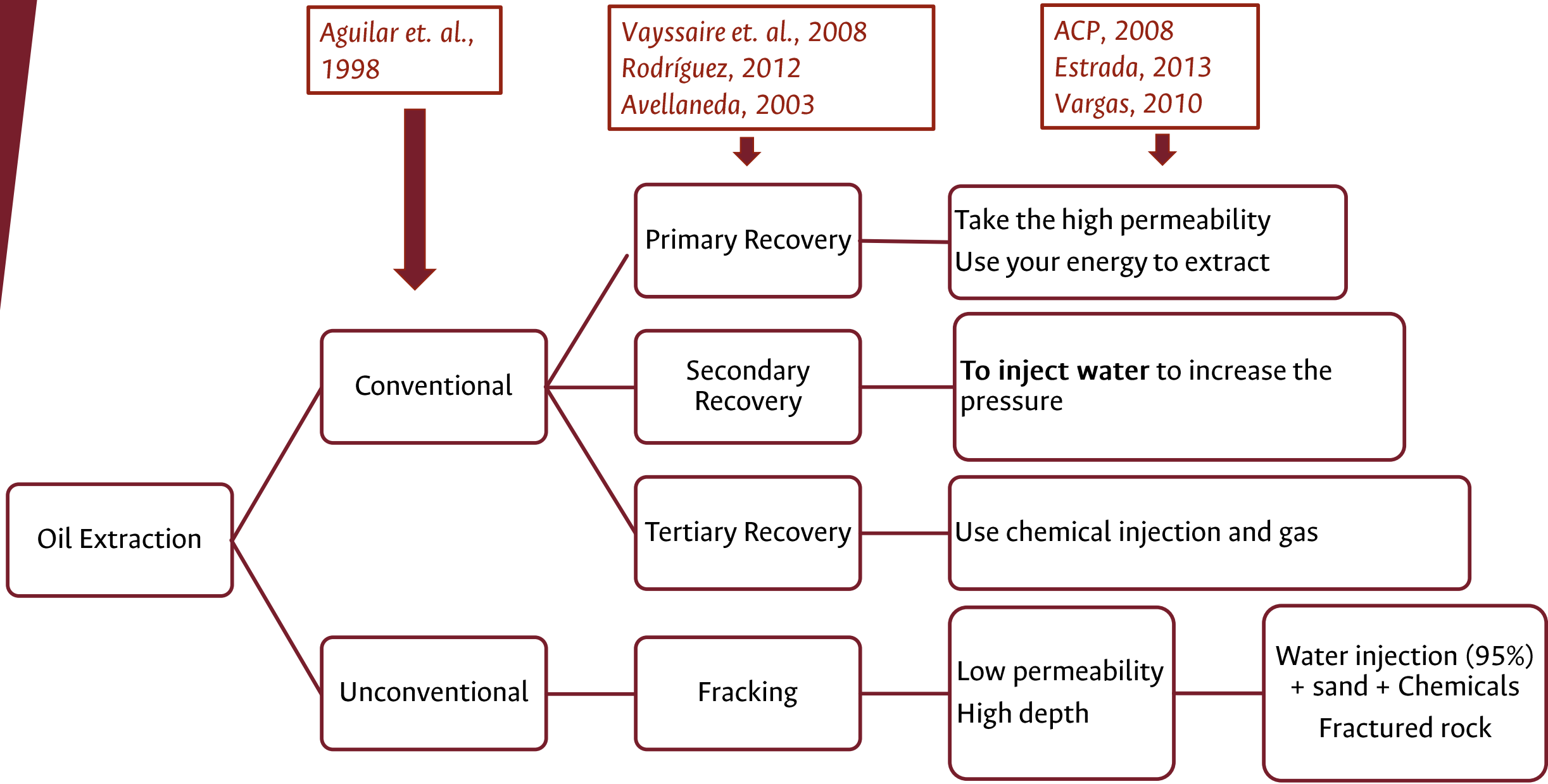
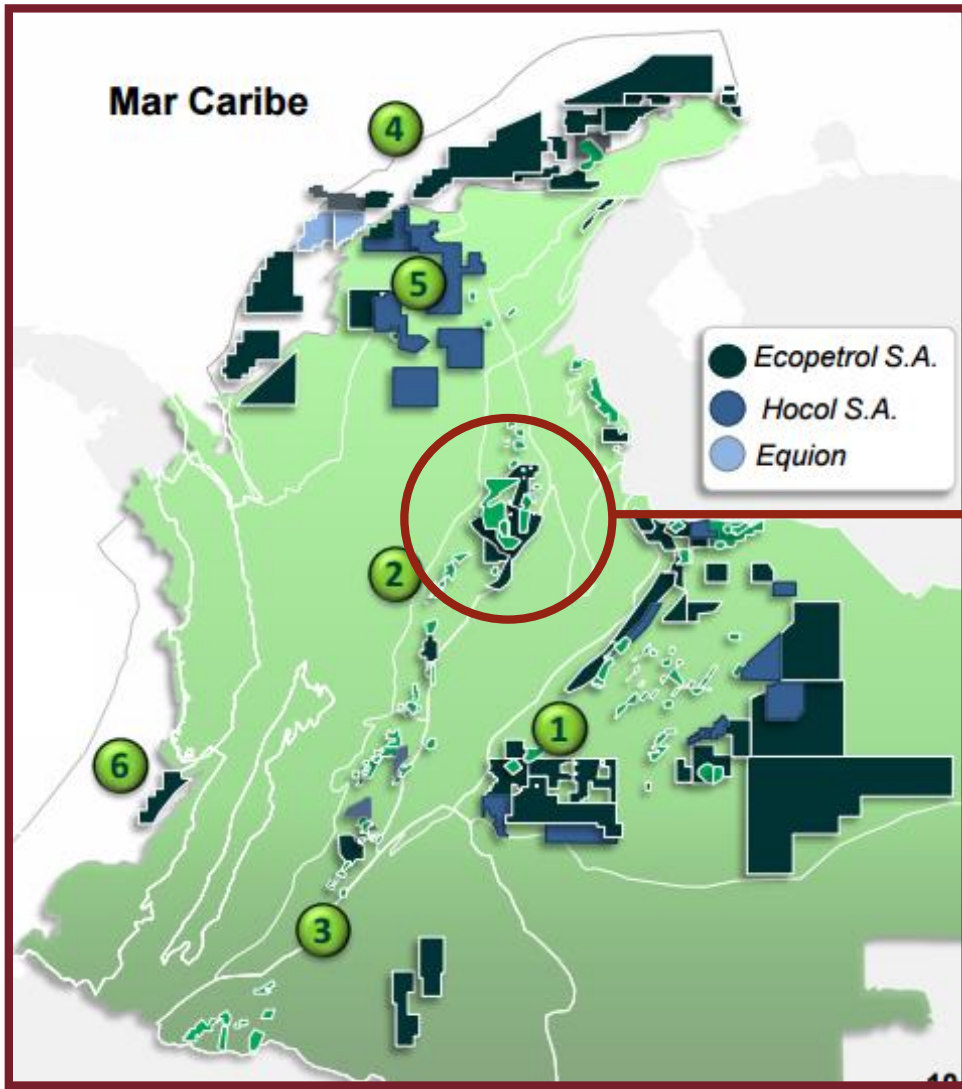


Figure 3. Water Demand per Sector in Colombia. Source. Ideam. ENA. 2014



Conventional Production

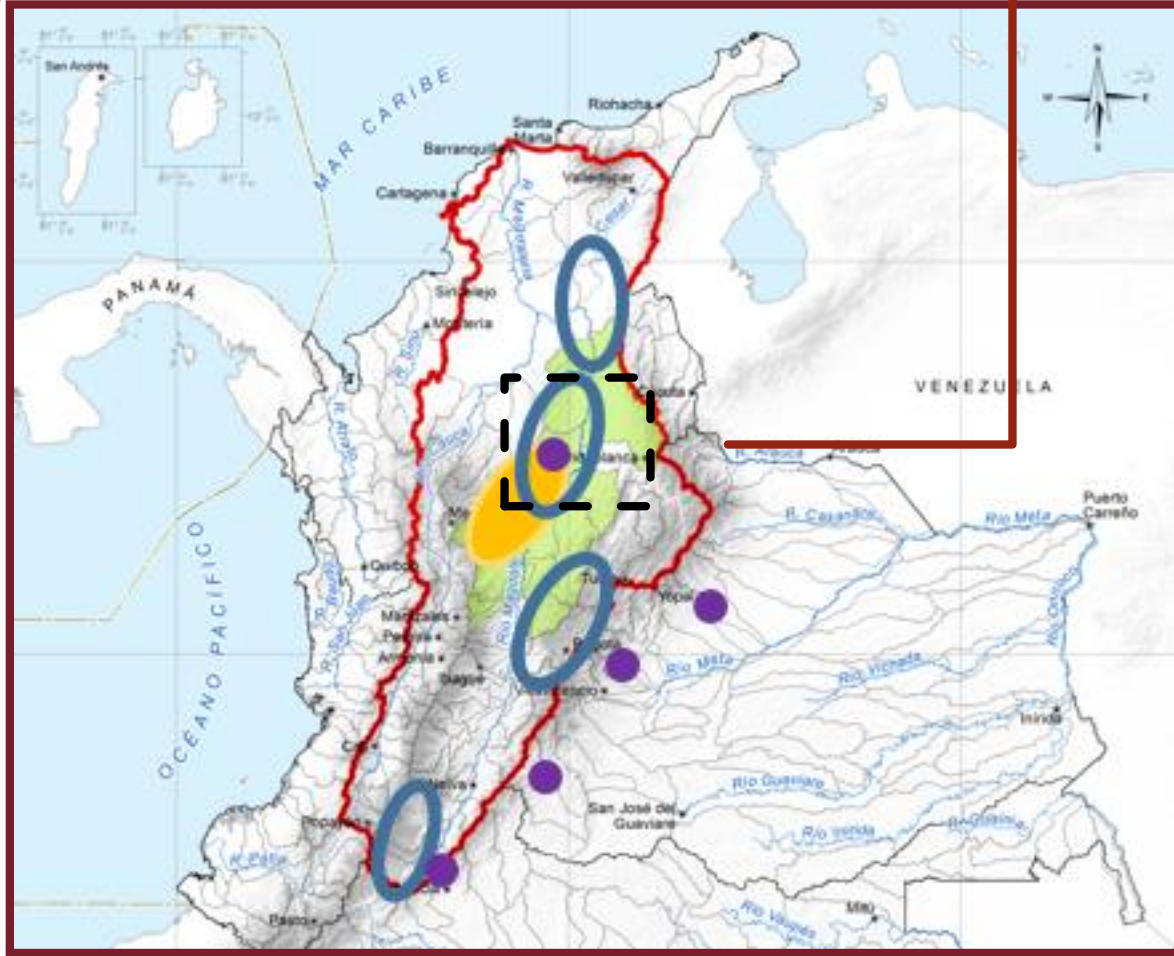


51 Productive Oil Wells

- 1 Plains- Catatumbo
- 2 Middle Magdalena Valley ✓ 15%
- 3 High Magdalena - Putumayo ✓
- 4 Caribbean Offshore
- 5 Lower Magdalena Valley ✓
- 6 Pacific Offshore

In 2012 → 55.6 Mm³ of water were taken out

Unconventional production



- Shale oil and gas
 - Sands Oil
 - Tight sands
- ┌ Ecopetrol's area
└ of Interest

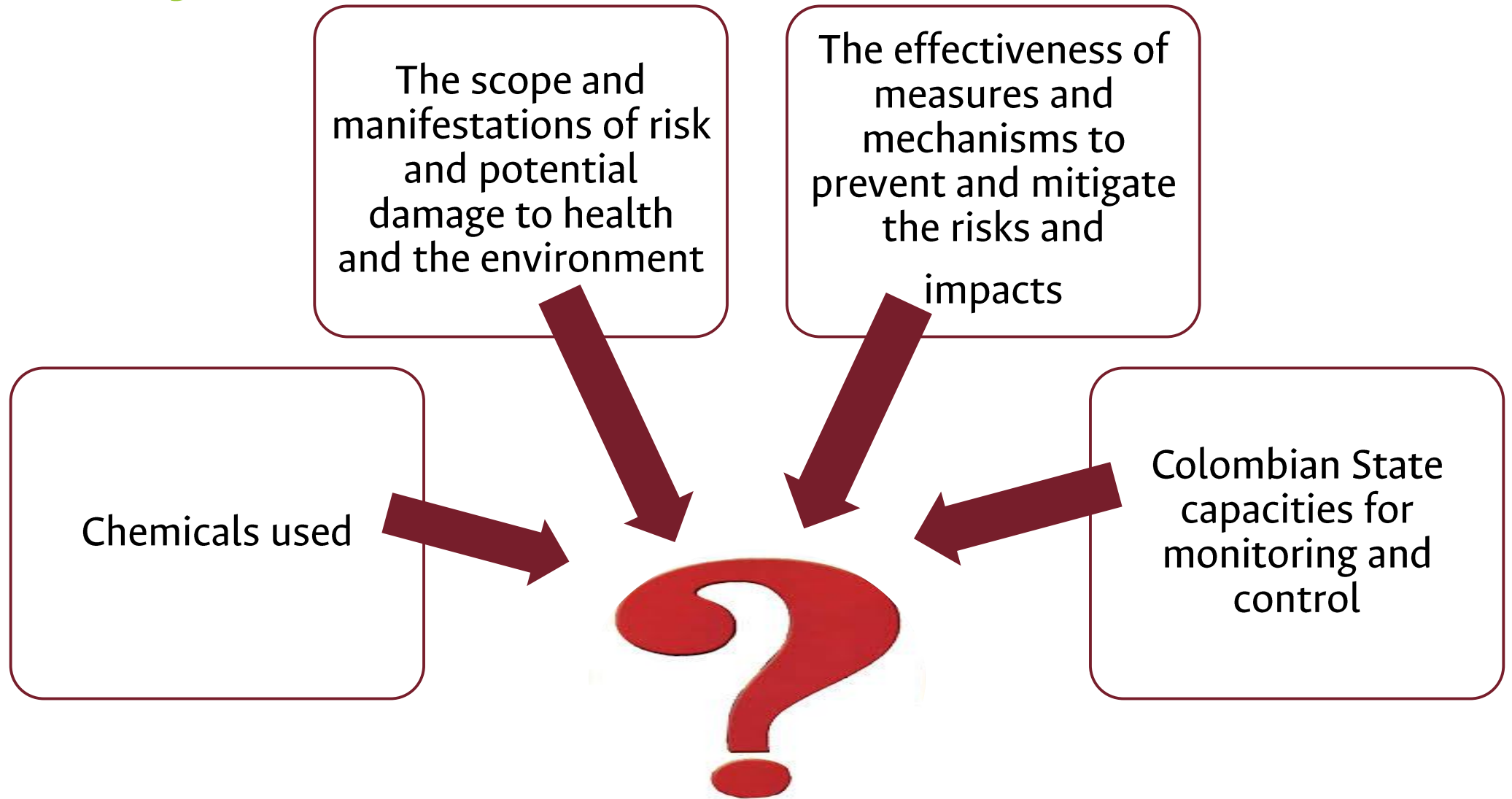
Oil Auction: Round Colombia 2014

Colombia auctioned 19 wells of Unconventional extraction

Ecopetrol's wells: Coyote, Prometheus, Iwana and Moon. Exploratory: Casabe-K

60 millions L/day per well with recoveries of 15% to 70%

Uncertainty



3. Research Problem

IWRM: Water Use

Available Water supply



Variable

Hydrologic Conditions:

- 1. Half Year
- 2. Wet Year
- 3. Dry Year

Water Demand

Sectors:

- Agricultural
- Domestic
- Industrial

Exploration processes and production of Oil and Gas



Volume and Quality

To Optimize IWRM

Restrict the water supply and availability:

Ground
Underground

Volume and Quality



4. Research Questions and Hypothesis

To conceive more efficient management tools in water management should social, environmental and economic approaches be assigned?

Could the economic cost of water be assigned differently to each use?

Is the water use optimized in different sectors if the Organizations make a charge associated with the impacts generated?

Hypothesis: The integrated management approach in determining the cost of water associated with its use is a helpful tool in designing policies for water resource management

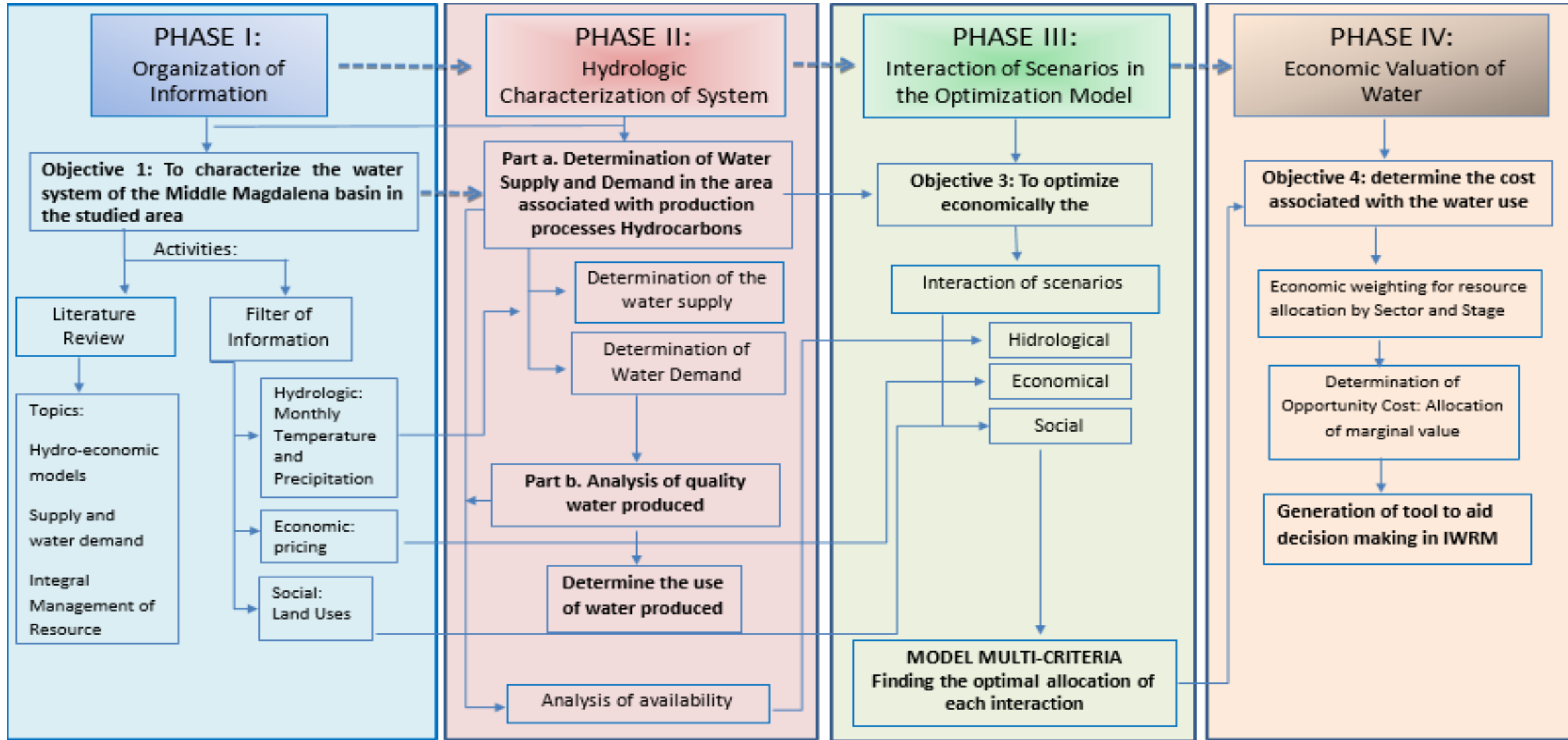
5. Main Goal

To Analyze hydro-economic strategies Water resources management

In processes associated with exploration and production of oil and gas.

To optimize the use of water resources:
Allocation and Prioritization

6. Methodology



DANKSCHEEN
 SPASSIBO SNACHALHUYA NUHUN CHALTU YAQHANYELAY YUSPAGARATAM
 TASHAKKUR ATU WADEEJA HAITEKA HUI
 GRACIAS SUKSAMA EKHMET
 ARIGATO ANHA DHAUYADAD HATUR GUI
 SHUKURIA MERASTANHY ATTO DENKAUJA UNALCHEESH
 MERASTANHY GAEJTHO SIKOMO
 TAVTAPUCH MERASTANHY MERASTANHY
 MEDAWAGSE GOZAIMASHITA AGUYJE
 BAIKA JUSPAXAR FAKAAUE
 KOMAPSUMNIDA LAH
 MAAKE GRAZIE MEHRBANI PALDIES
 BIYAN SHUKRIA
 TINGKI
 YOU
 BOLZIN MERCI
 MINMONCHAR

Bibliography

- ❖ Bear, J., Levin, O., Buras, N., 1964. Optimal utilization of aquifers as elements of water-resources systems. Progress Report No. 1: Basic Concepts and Program of Research, Technion – Israel Institute of Technology, Hydraulic Laboratory, Haifa.
- ❖ Cetinkaya, C.P., Fistikoglu, O., Fedra, K., Harmancioglu, N.B., 2008. Optimization methods applied for sustainable management of water-scarce basins. *Journal of Hydroinformatics* 10, 69–95
- ❖ Fedra, K., Kubat, M., Zuvela-Aloise, M., 2007. Water resources management: economic valuation and participatory multi-criteria optimization. In: Second IASTED International Conference. IASTED, Honolulu, Hawaii, USA.
- ❖ Harou, J.J., Lund, J.R., 2008. Ending groundwater overdraft in hydrologic-economic systems. *Hydrogeology Journal* 16 (6), 1039–1055.
- ❖ Ideam. 2014. *Estudio Nacional del Agua 2014*.
- ❖ Moron, S., Fox, D., Feinberg, J., Jaramillo, C., Bayona, G., Montes, C., & Bloch, J. 2013. Climate change during the early Paleogene in the Bogota Basin (Colombia) inferred from paleosol carbon isotope stratigraphy, major oxides, and environmental magnetism. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 388, 115–127.
- ❖ Ramos Gorostiza, J. L., & Rosado Cubero, A. 2015. Ideas económicas en torno al servicio de abastecimiento urbano de agua en la Gran Bretaña del siglo xix. *Investigaciones de Historia Económica - Economic History Research*, 11(1), 1–9.
- ❖ Reynaud, A., Leenhardt, D., 2008. MoGIRE: a model for integrated water management. In: Proceedings of the iEMSs Fourth Biennial Meeting: International Congress on Environmental Modelling and Software. International Environmental Modelling and Software Society, Barcelona, Catalonia, pp. 576–583.
- ❖ Rodriguez, N., Armenteras, D., & Retana, J. 2015. National ecosystems services priorities for planning carbon and water resource management in Colombia. *Land Use Policy*, 42, 609–618.
- ❖ Rosenberg, D.E., Howitt, R.E., Lund, J.R., 2008. Water management with water conservation, infrastructure expansions, and source variability in Jordan. *Water Resources Research* 44, W11402.
- ❖ Ward, F.A., Pulido-Velázquez, M., 2008. Efficiency, equity, and sustainability in a water quantity-quality optimization model in the Rio Grande basin. *Ecological Economics* 66 (1), 23–37.
- ❖ Ward, F.A., Pulido-Velázquez, M., 2009. Incentive pricing and cost recovery at the basin scale. *Journal of Environmental Management* 90 (1), 293–313.



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