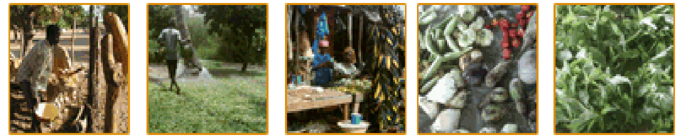

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Groundwater management and climate impacts: Analysis of the Niayes region of Senegal

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Session 6B: Optimizing GW management

12th Annual Meeting of the International Water Resource Economics Consortium (IWREC)
11-13 Sept 2016
The World Bank, Washington DC

Context : Climate Change and irrigated agriculture in Senegal

- Irrigated agriculture
  - Senegal River Valley
  - Northern coastal region called Niayes

- Niayes
  - Main area of horticultural crops' production and supplies 40% of horticultural products' market (Senegal's Direction of Horticulture, 2010)
  - Horticulture, an important source of revenue to producers and contributes to the country's economy (exports, raw material to food processing industry, food security, etc.)
  - Producers use almost exclusively groundwater for irrigation

Context : Climate and irrigation water availability in Coastal North of Senegal Niayes

- Studies show average decrease of GW levels in 1958-1994 period (Aguiar, 2010)
- Aquifer recharge is also low or absent during dry season in the south of the area (Dasylva, 2005)
- Hydrologic studies showed variable recharge depending mostly on precipitation levels (Gaye, 1990; Eil Faid, 1999; Tine, 2004)
- Besides discharge related to climate conditions (precipitations and evaporation), the aquifer is subject to competing use : potable water needs for urban population, rural populations boreholes, horticultural producers

===>*Assess the impact of rainfall variability (normal and dry scenarios) on irrigation water availability and its implications for farmer welfare and policies*

Sample and data

- Area of study:
Niayes (Dakar, Thies, Louga, St-Louis)

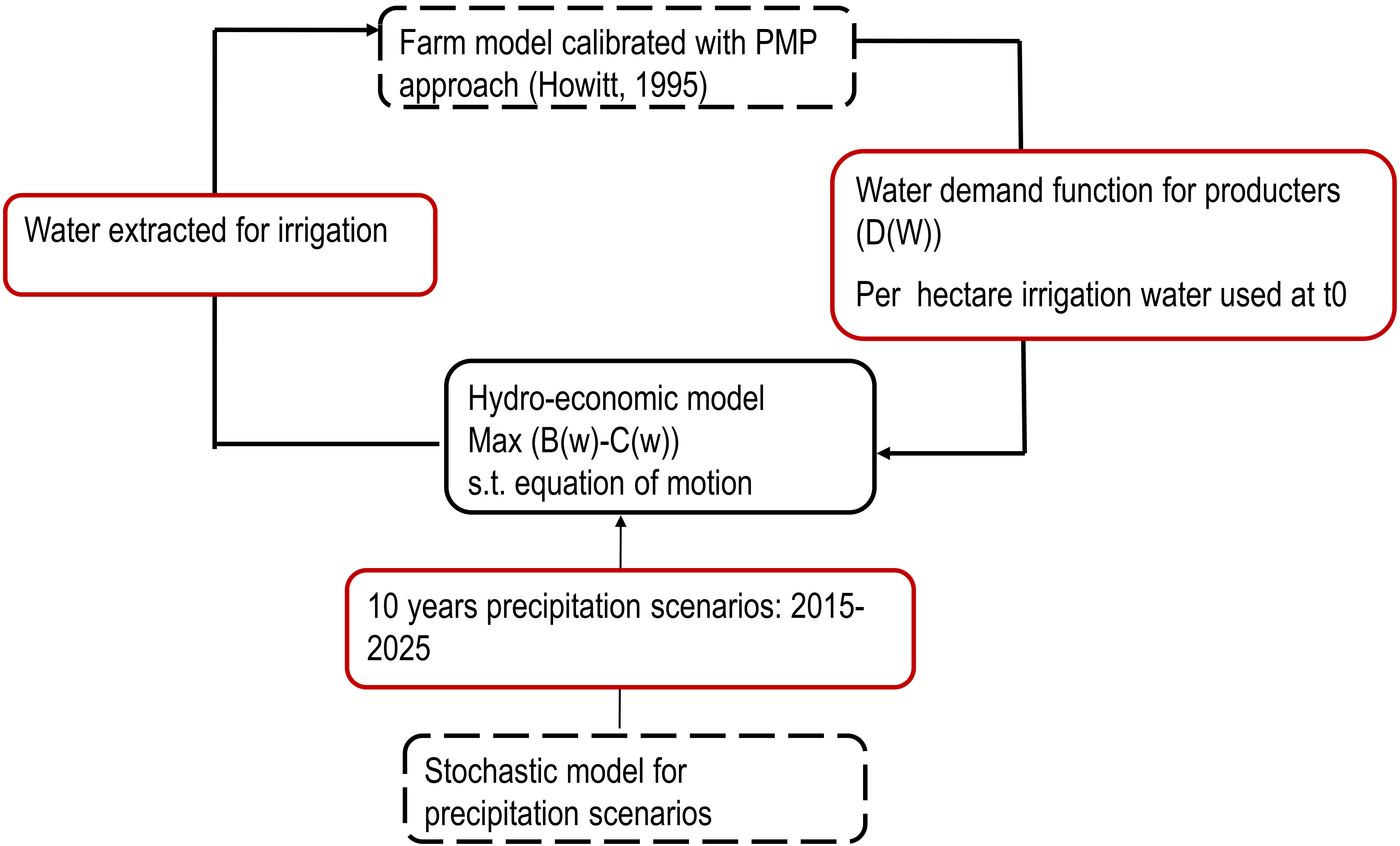
- ISRA-BAME Survey data undertaken in 2014 on agricultural activities of 369 horticultural crop producers

- Data on crops, inputs, labor quantities and costs and associated revenues

- Hydrologic and climate data from national institutions

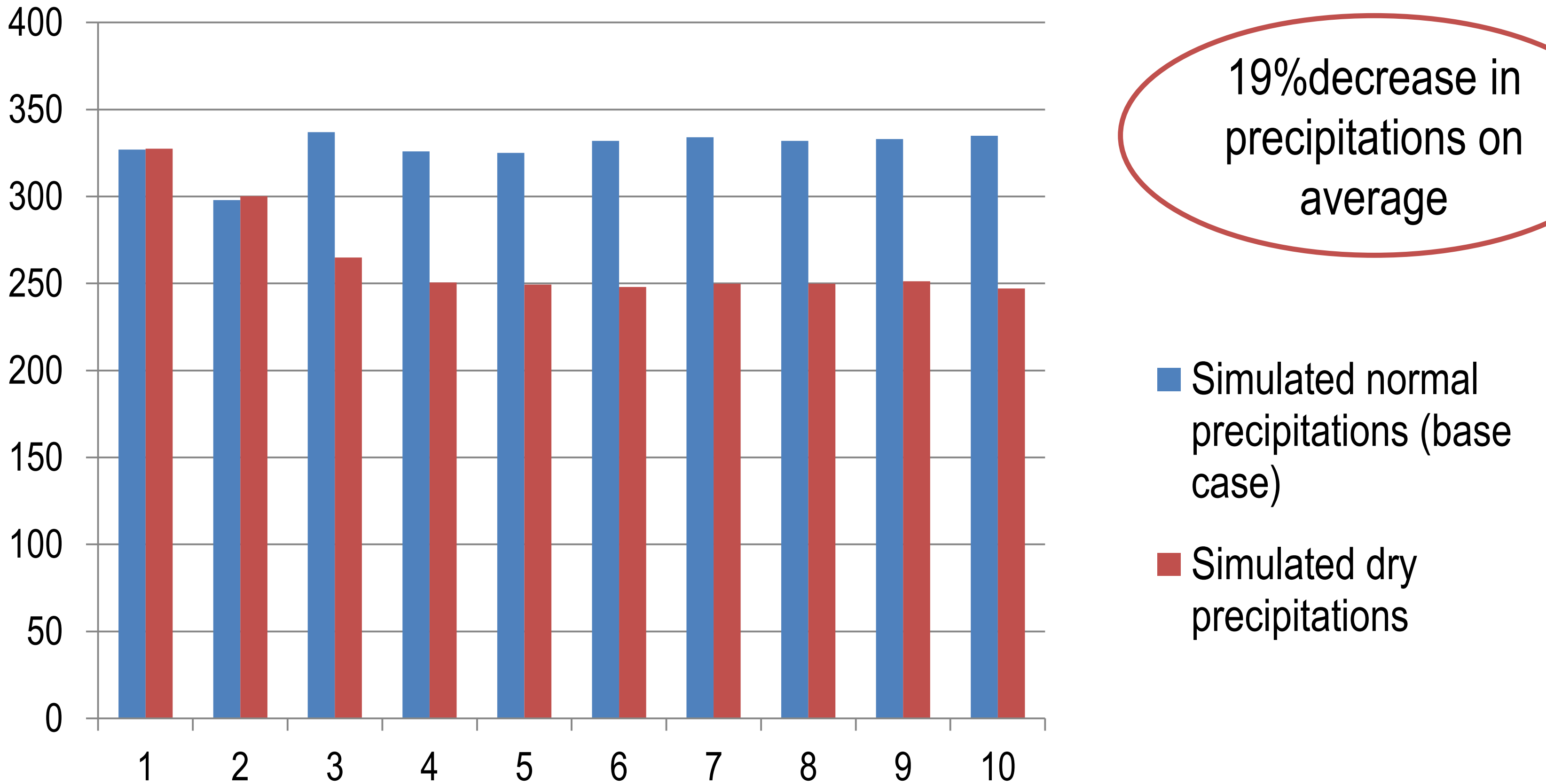
Figure 1: Map Niayes area (adapted from PADEN)

Methodology: integrated approach



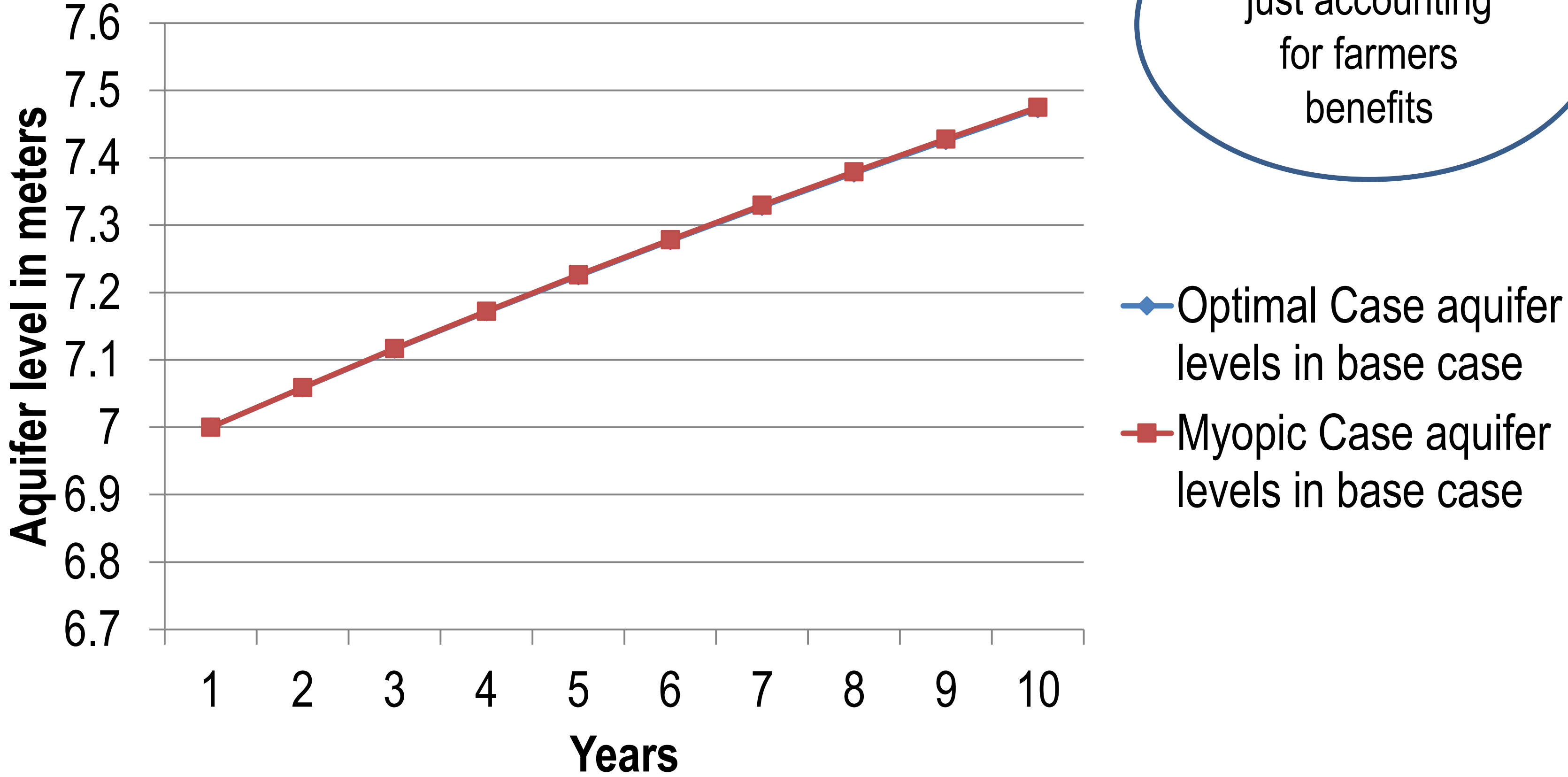
Results: simulated rainfalls

• Use of **Standardized Precipitation Index** (1993 par McKee, Doesken et Kleist) and rainfall data 1970-2011 to define year types and build probability transition matrix with a first order Markov chain



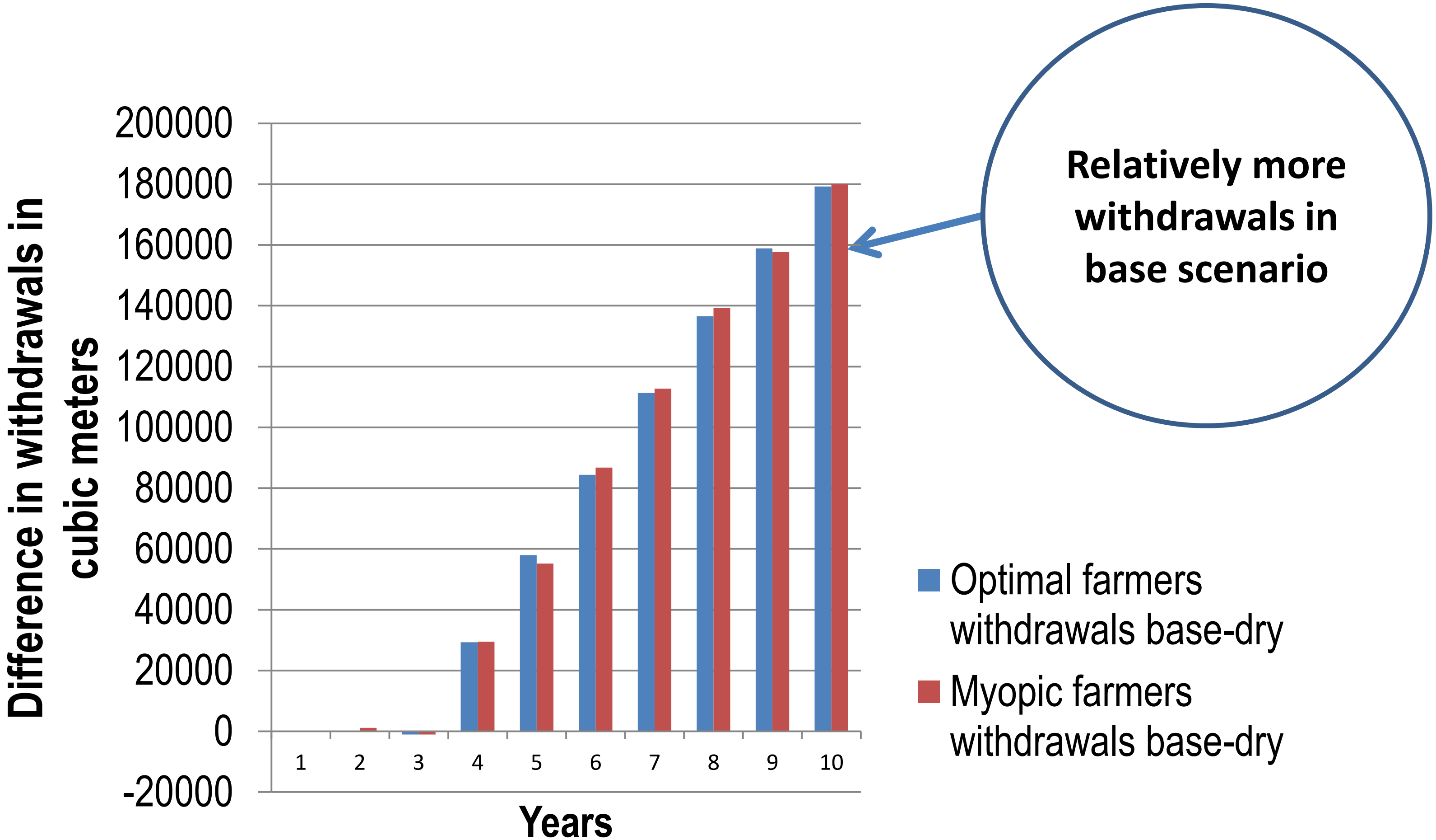
19%decrease in precipitations on average

Results: Depleting resource over time

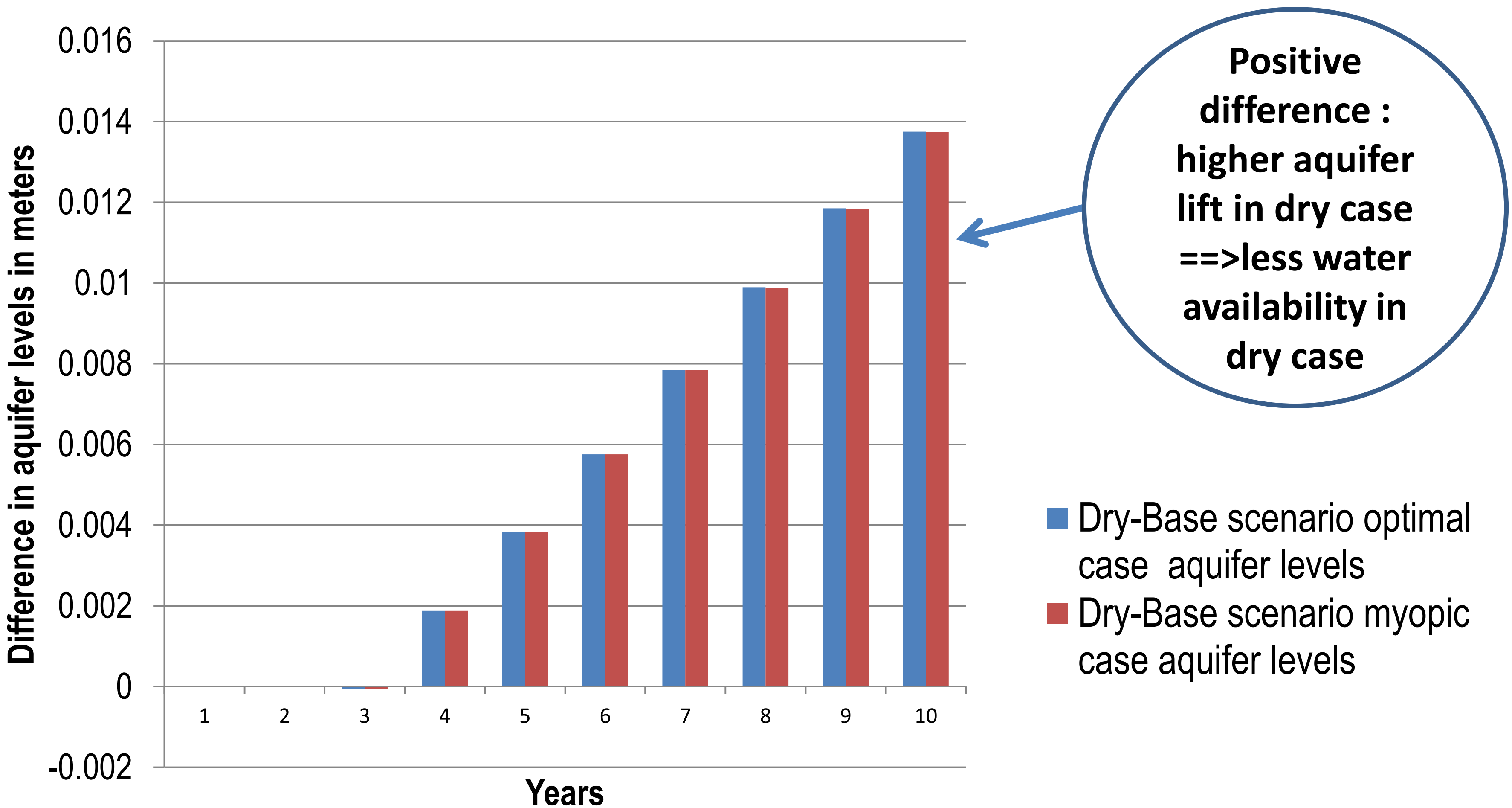


G-S effect when just accounting for farmers benefits

Results : Difference in Ag withdrawals under base and dry scenarios



Results : Difference in aquifer levels under base and dry scenarios



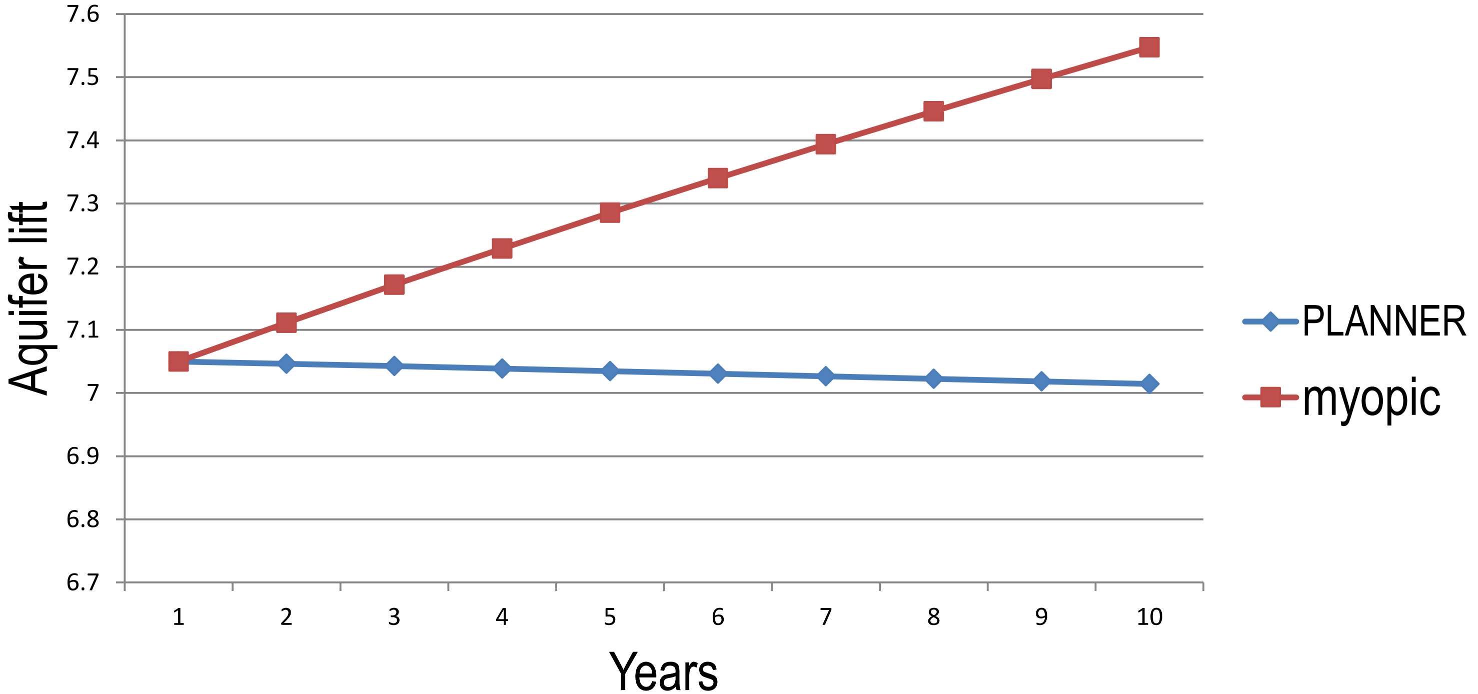
Policy implications: Including additional costs in objective function

- The “Gisser-Sanchez” effect, often mentioned in literature, refers to the relatively small gains to optimal resource management that some models show

- Some authors have shown this could arise from the functional form or from the lack of accounting for the environmental externalities associated with the resource (e.g. ecosystem benefits, etc)

- We carried out an exercise to add a quadratic environmental cost and found that it leads to noticeable differences between myopic and optimal lift

Policy implications: Changing GW lift with environmental cost



- The magnitude of the environmental cost that would lead the social planner to stabilize the aquifer is equivalent to a user cost of between 0.2 and 0.3 fcfa per cubic meters

- On average, **11 million cubic meters** are required annually to stabilize the resource over the next ten years (2015-2025)

Conclusions

- Regardless of the climate scenario GW resources are likely to decline over time under prevailing conditions in the Niayes area
- Results also highlight small differences between myopic and optimal situations when we just account for on-farm net benefits
- To stabilize the resource, policy makers should think of a range of options including :
  - increasing recharge into the aquifer
  - demand side measures (focusing on ag water use)
- Further work is needed to quantify the potential environmental cost (say saline intrusion) of depleting the aquifer
- Extend the hydro-economic model into a four cell aquifer model to account for spatial heterogeneity