ROLE OF ECONOMIC DIVERSIFICATION IN SUSTAINABLE WATER MANAGEMENT: A SOCIO-HYDROLOGICAL ANALYSIS

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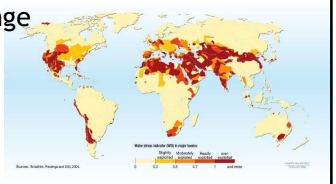
Background

- Water scarcity and food security
  - Suffering **700 million** people in 43 countries.
  - **1.8 billion** people will be living under "absolute" water scarcity (<500 M^3/year) in 2050.
- Growing demand for a finite resource
  - due to increasing population, climate change and unevenly distributed water resources.
- "Tragedy of the commons "
  - is a freely accessible, common pool resource,
  - Individuals seek to optimize its use for different purposes and over exploit.

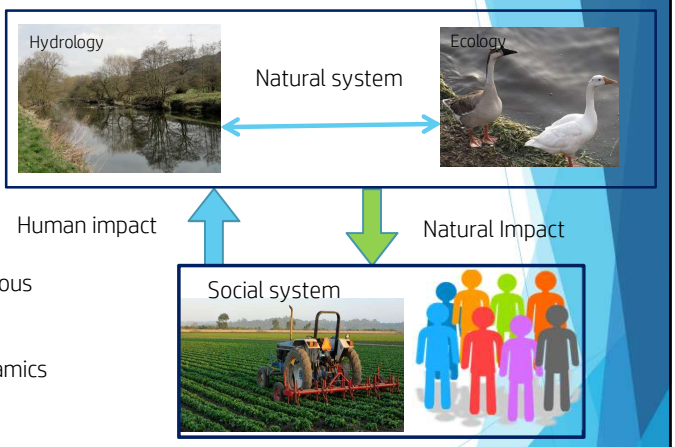


Water stress indicator

(gleick and palaniappan,2010;IPCC,2014;IPCC,2007;van Emerik et.al,2014)

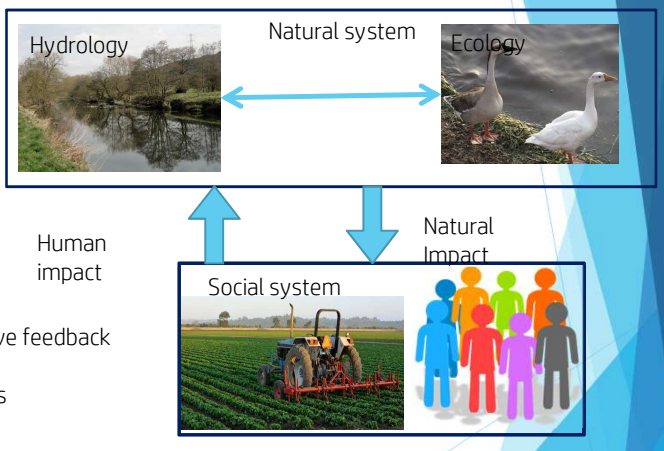
Development of framework for water security

- Several frame works used
  - Hydrology,
  - Eco-hydrology,
  - Intergrated water resource management (IWRM)



- Social system as exogenous driver
- No feedback
- Very simple system dynamics
- Less understanding
  - Fast, slow process
  - Threshold dynamics

New framework : Socio-Hydrology



- Fully coupled
- Complex system
- Positive and negative feedback
- Fast, slow process
- Threshold dynamics

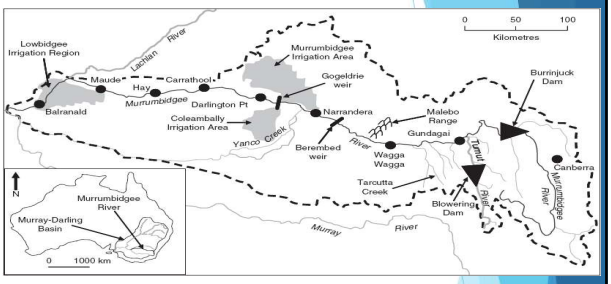
Socio-hydrology: new science of people and water

- Integrates socio-economic, environmental, technological, human behavior and governance systems in holistic manner incorporating feedback loops.
- Socio-hydrology is used to understand the dynamics of coupled human-water system in different perspectives
  - The human flood interaction
  - The feedbacks between the human, engineered and hydrologic water supply system
  - The competition for water between humans and the environment (Liu et al., 2014, van Emmerik et al.,2014)

Case study: Murrumbidgee basin

Murray Darling Basin (MDB) and Murrumbidgee basin

Courtesy : Department of the Environment , Australian Government



Murrumbidgee
- 3rd largest river in MDB
- biggest rice growing area in Australia
- 50% of irrigation water is used to rice production

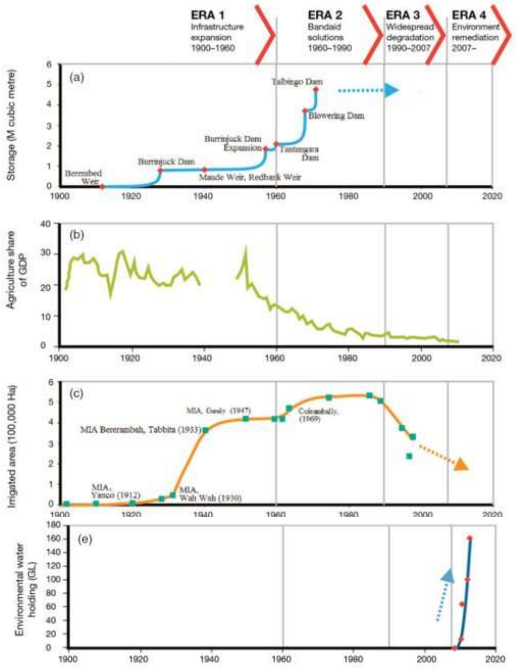
Background

- Problems
  - More water extracted to irrigation
  - Long drought
  - Environment degradation ~1980
  - Loss of wetlands
  - Loss of native species (8 out of 21)

- Created awareness of Environment

- Change in water management policy
  - Environment water
  - Reduction in irrigation water

Gillian, 2005

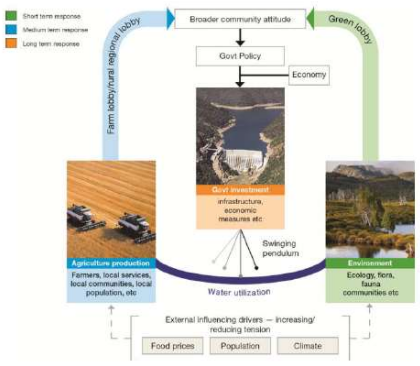


Co-evolution of in Murrumbidgee river

Kandasamy et al, 2014

Changes in water management

- Broader community concern over environmental degradation was raised over subsequent decades and attributed to the pendulum swing of water management.

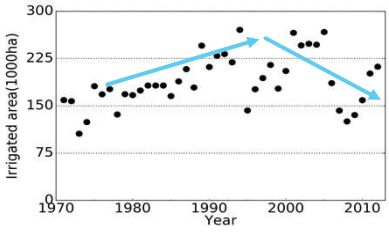


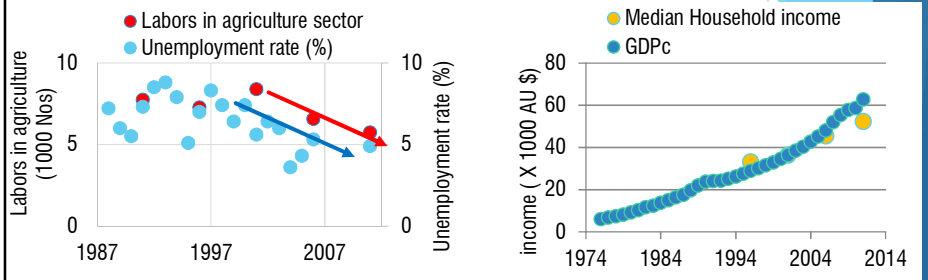
Kandasamy et al, 2014

- Water management changed as society's value and preferences changed.
- What are the factors influence the value system of society?
- How did people adapt to economic stress due changing water management?

Impact of changing water management

- Irrigated land area is dropped





- Labours in agriculture sector is dropped but paradoxically basin unemployment rate dropped
- Median house-hold income increased despite of shrink in agriculture sector.

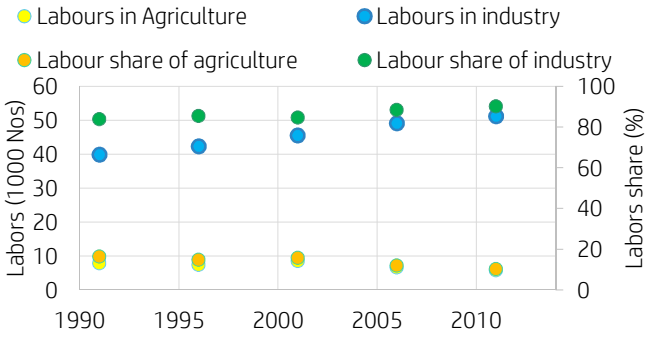
Objective

- To understand the unemployment paradox in context of a basin scale coupled human water system through data analysis and modelling.

Methodology

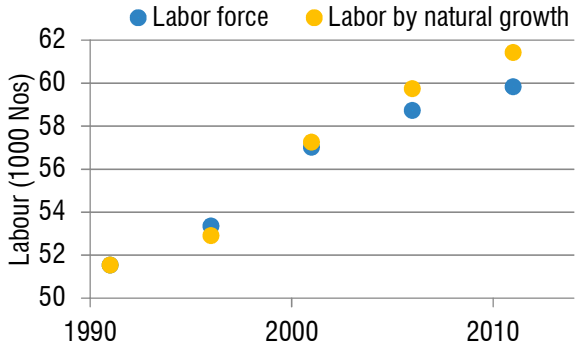
- Relevant census and economic data was analyzed in order to understand how the change in water allocation affected the basin economy.
- Developed a simple dynamical system model of employment in a diversified economy to reinforce the understanding obtained from the data analysis.

Results: Data analysis



- Employment in Industry sector continue to grow
  - Growth was sufficiently enough to absorb the labours who were from agriculture sector.

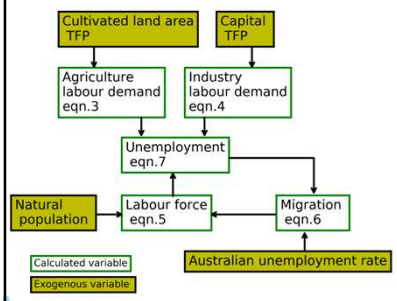
Results: Data analysis



- Before 1995, the labour force was slightly larger than the natural labour force
- After water management changed, Out migration reduced the labour force in the basin.
- Both reduced the basin unemployment rate

Modeling

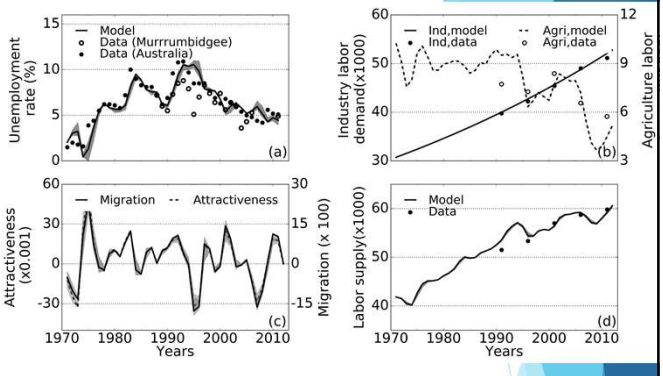
Simple model is used to understand the dynamics.



- ❑Model is driven by cultivated land area and Australian unemployment rate data
- ❑Model coefficients, initial conditions are obtained from data.
- ❑Only one parameter is calibrated using GLUE method creating 100000 samples using Monte-Carlo method.

- $\frac{\dot{D_a}}{D_a} = \frac{\dot{L_a}}{L_a} + \frac{\gamma_i}{\alpha} - \frac{\gamma_w}{\alpha}$ (labour demand in agriculture)
- $\frac{\dot{D_i}}{D_i} = \gamma_c + \frac{\gamma_i}{\theta} - \frac{1}{\theta}\gamma_w$ (labour demand in industry)
- $\frac{\dot{L_s}}{L_s} = (\varsigma - \Omega + \mathrm{Mg})$(Labour supply)
- $\mathrm{M} = \nu\,(\mathrm{Ua} - \mathrm{Ub})$ (Attractiveness)
- $\mathrm{Ub} = \max(0, \frac{\mathrm{L_s} - (D_\mathrm{i} + \mathrm{D_a})}{\mathrm{L_s}} \mathrm{x}100)$ (unemployment rate)

Model result



- ❑ Modelled unemployment rate follows the observed
- ❑ Labour demand in agriculture declines as agriculture sector become constrained
- ❑ Labour demand in industry sector grows due to capital growth
- ❑ Attractiveness generally positive before 1995 (in-mig) then negative (out-mig)
  - ➢ Outside economy was growing with mining boom.
- ❑ Labour supply growth is reduced after changing water management
- ❑ The model captures and explains observed unemployment paradox of falling unemployment during the post-1995 decline in agriculture reasonably well.

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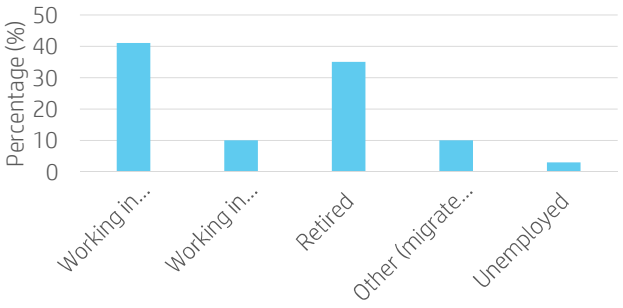
Choices after selling water entitlement to Commonwealth in 2009



Percentage of farmers who were reemployed in the industry sector, continued to work in farms, retired, migrated-out or became unemployed after selling their water entitlement (license) to the government

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Marsden Jacob Associates,2012

Summary

- Diversified economy reduced the impact of changing water management.
  - Soften the impact of water policy interventions in case of reduced water allocation to agriculture
- Society adapted to water management through sectoral transformation and out-migration.
  - Migration is a response of unemployment rate gradient.
- Sustainable development studies should include the understanding of dynamics between sectoral transformation, migration, changing value and preference of society and policy implementation in diverse hydro-climatic, sociological, and economic settings.


Thank you very much
4/1/2020
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