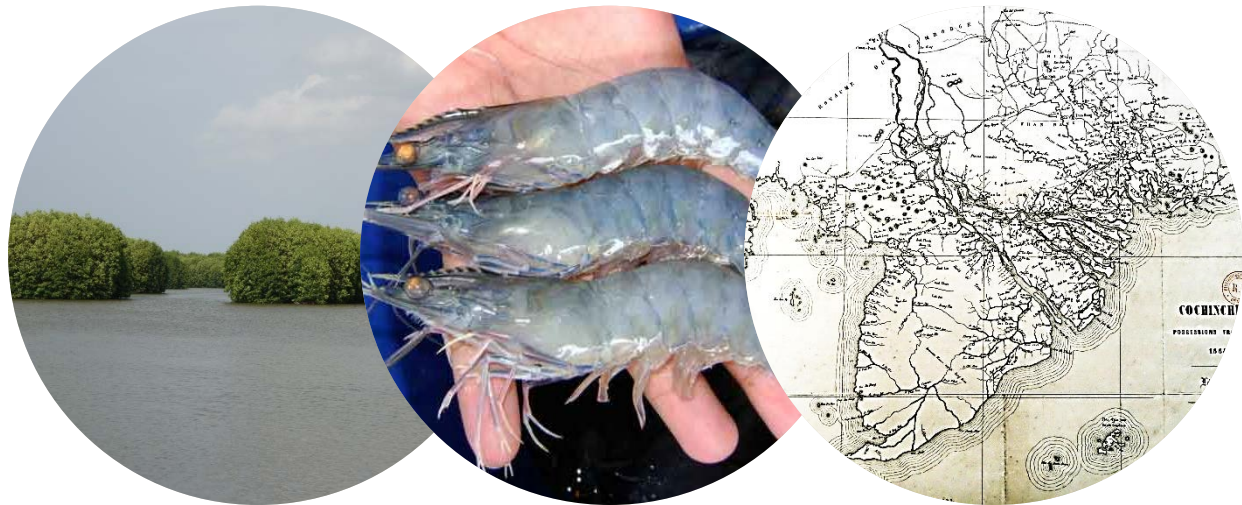# Considering shrimp aquaculture as a Complex Adaptive System : implication(s) for planning a more resilient sector

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Knowledge, Technology and Innovation Group

CAS Symposium 'Strategies for our changing and complex world: concepts, methods and applications'

8th December 2015, Wageningen

The tropical farmed
shrimp you eat

destr
mangrov

Shrimp Aquaculture in the Mekong Delta

- Shrimp sector in the Mekong Delta
  - Fast Grow in 1990-2000
  - Mekong Delta - 500,000ha

- Based on small scale producers
- Coastal zone mono-culture landscape
- Risk of diseases outbreak

Agriculture
Shrimp aquaculture
Mangrove - shrimp
Mangrove

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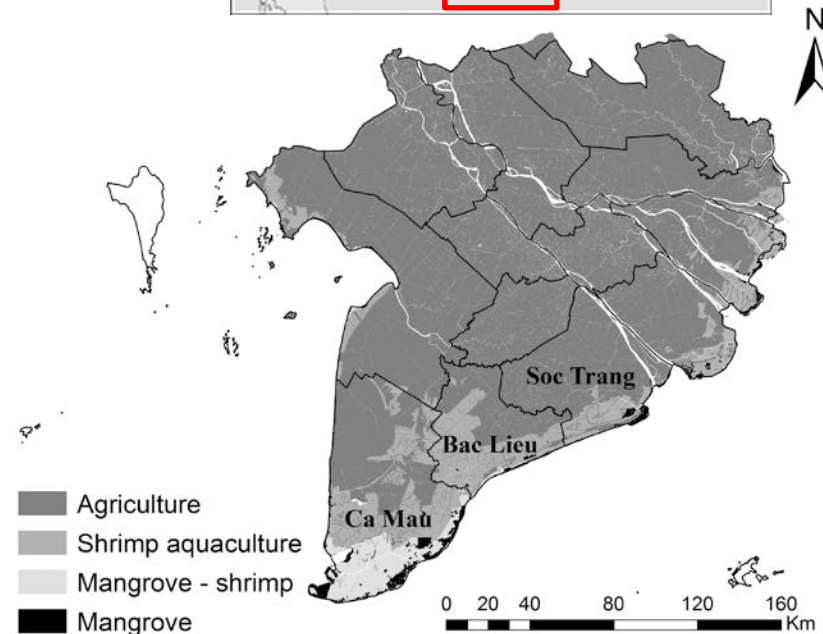
Shrimp Aquaculture in the Mekong Delta

- Need policies that :
  - Support sector's growth
  - Limit environmental & social impact

- Policies are not effective with sometimes undesirable effects:
  - No response, i.e. no intensification or not in the right area
  - Limited conversion to Organic shrimp farming
  - Deforestation and over-exploitation of natural resources

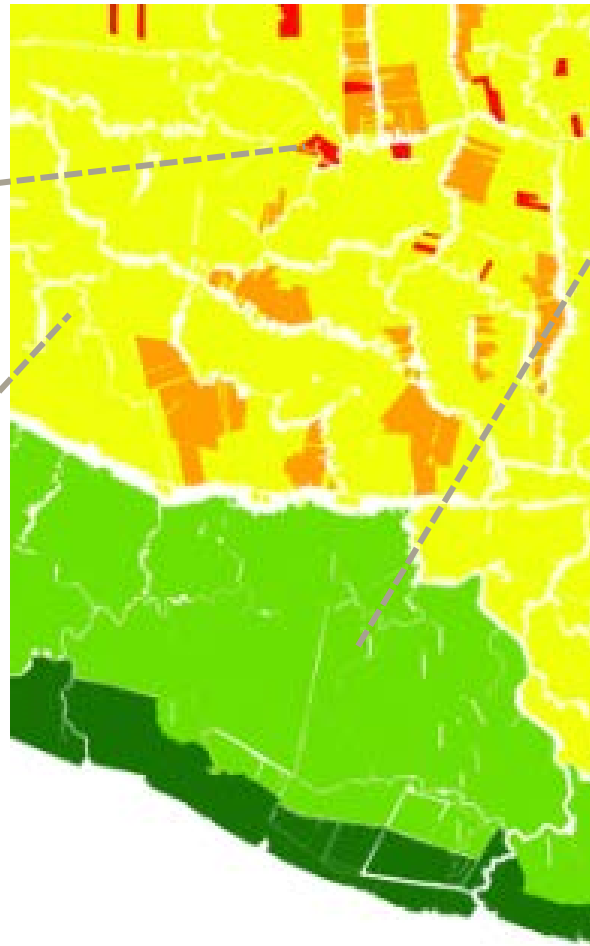Aquaculture production of *P. monodon* and *L. vannamei* 1990-2013
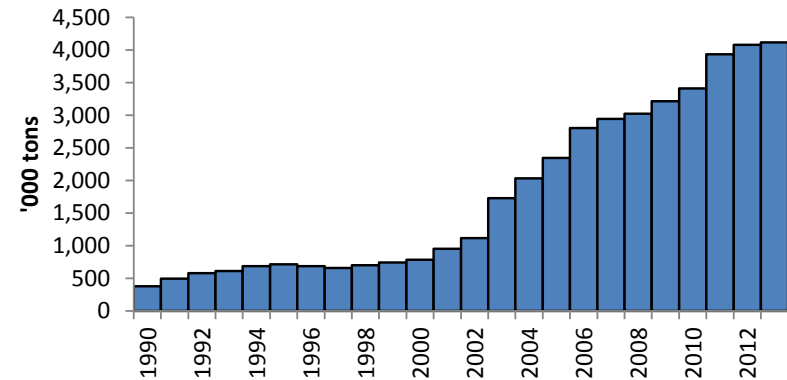
Diversity of production systems within the same landscape
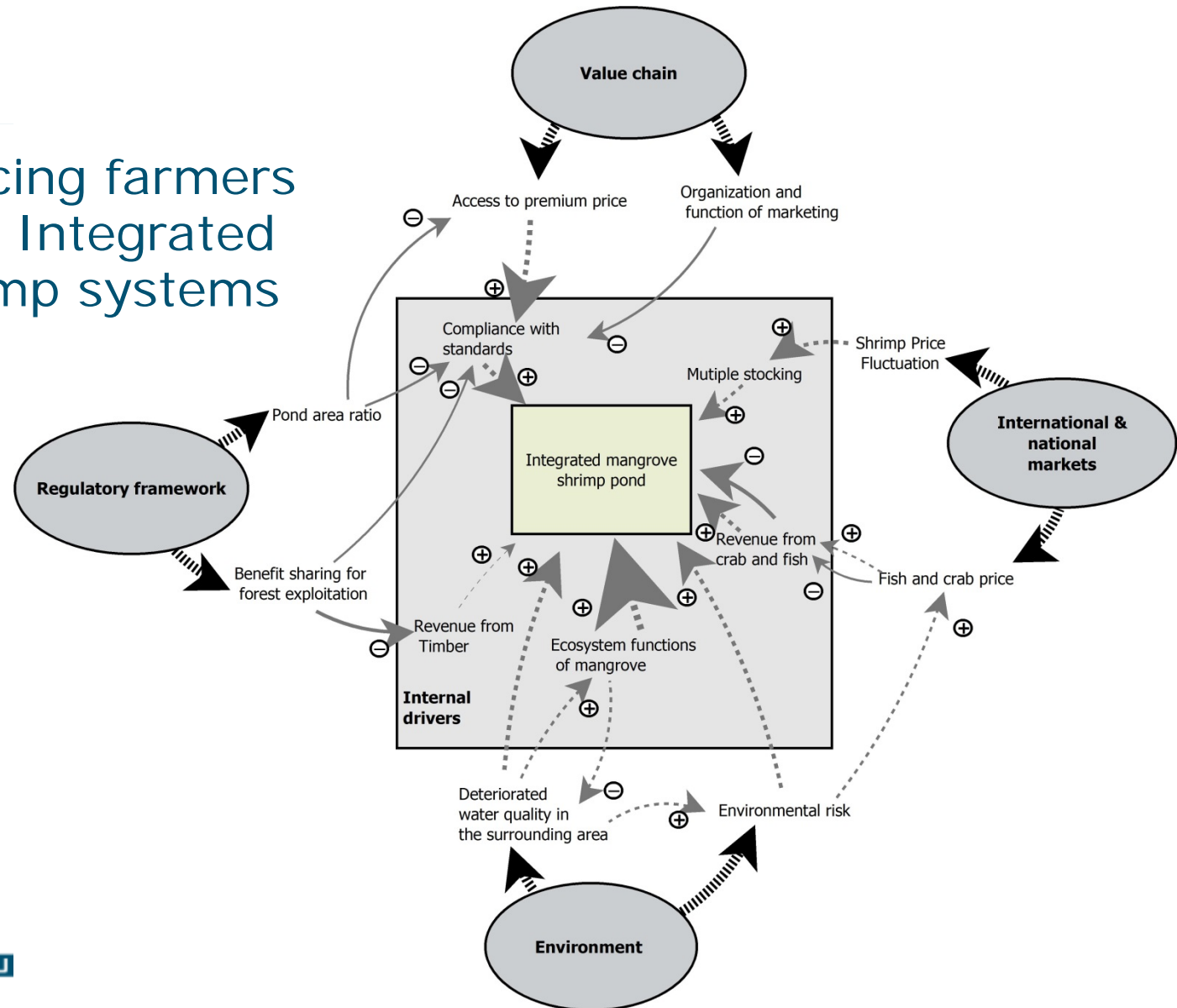

Intensive pond

Extensive pond

Integrated mangrove–shrimp pond

Limited area in the Mekong Delta
Considered as less risky and more resilient

Complexity in decision making

- Drivers influencing farmers to adopt or not Integrated mangrove shrimp systems

Value chain

Access to premium price

Organization and function of marketing

Compliance with standards

Shrimp Price Fluctuation

Mutiple stocking

International & national markets

Pond area ratio

Regulatory framework

Integrated mangrove shrimp pond

Benefit sharing for forest exploitation

Revenue from crab and fish

Fish and crab price

Revenue from Timber

Ecosystem functions of mangrove

Internal drivers

Deteriorated water quality in the surrounding area

Environmental risk
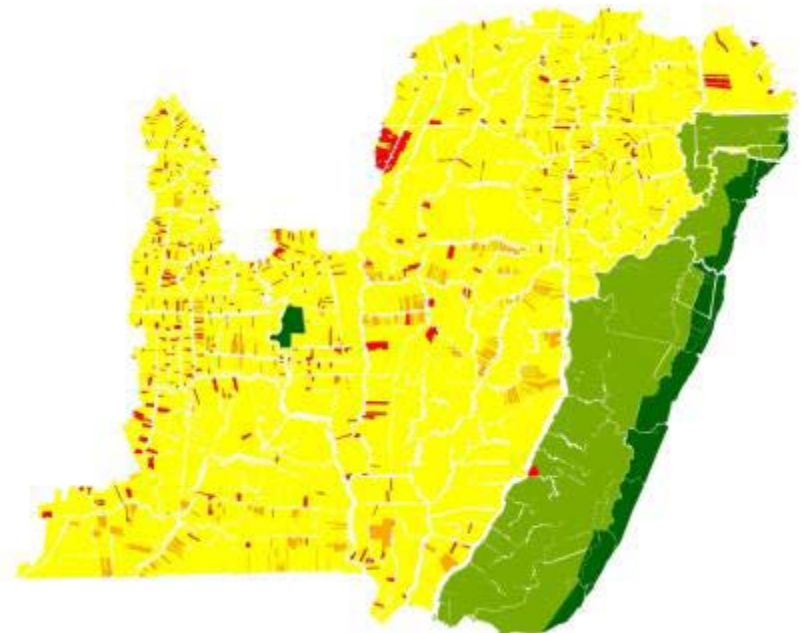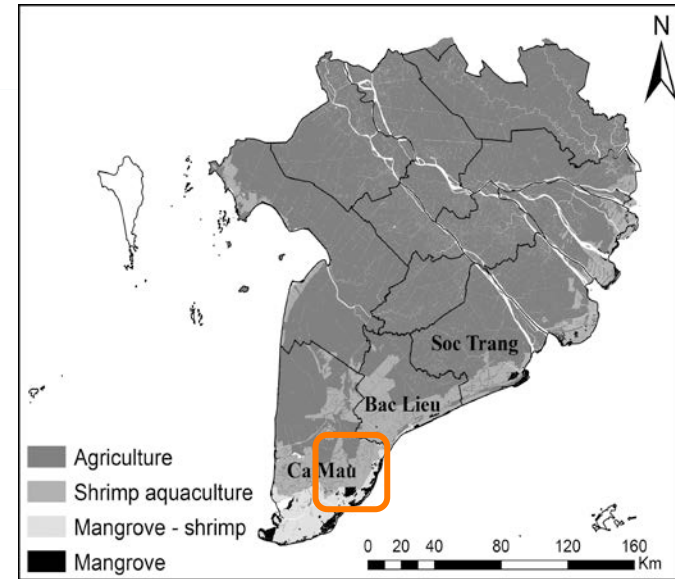
Environment

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An approach to integrate this complexity

- **Role Playing Games (RPGs)** to understand farmers decision making and influence of drivers

+

- **Agent Based Model (ABM)** to simulate action and **interactions** between heterogeneous farmers (individuals) and environment at landscape level

+

- **Scenario** development with policy maker

to **explore future policies** for better land use planning

Case Study – Dam Doi district Mekong Delta, Vietnam

- **Government plans to :**
  - increase intensive shrimp farming
  - promote integrated mangrove shrimp farming

- **but limited response to policies**
  - *What are possible scenarios for the future of shrimp farming ?*

Agriculture
Shrimp aquaculture
Mangrove - shrimp
Mangrove

Soc Trang
Bac Lieu
Ca Mau

0 20 40   80   120   160
Km

N

Our approach: from farmers to policy makers
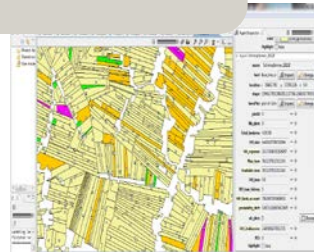# Using Role Playing Games & Agent Based Model

Farmers

Policy makers

Heterogeneity of agents & Spatial interactions

Design ABM and validate/calibrate with RPGs

Scenario development with policy makers
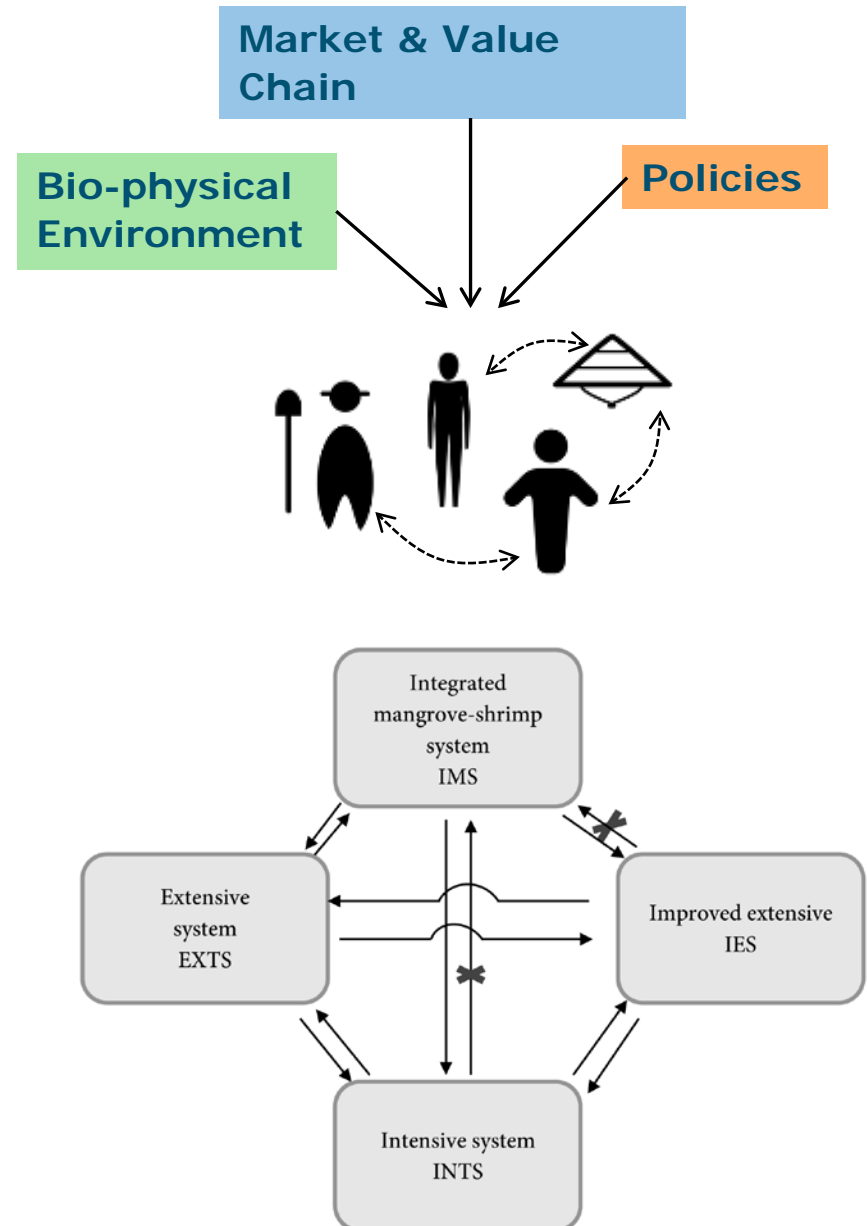
Explore future policies

Agents Behavior

Market & Value Chain

Bio-physical Environment

Policies

■ Probability to Shift:

Baseline probability X land suitability X neighbor's influence X policies

■ Example of rules

-Shifting rule (path dependent)

- Rule of Abandonment

Integrated mangrove-shrimp system
IMS

Extensive system
EXTS

Improved extensive
IES

Intensive system
INTS

Agents Behavior
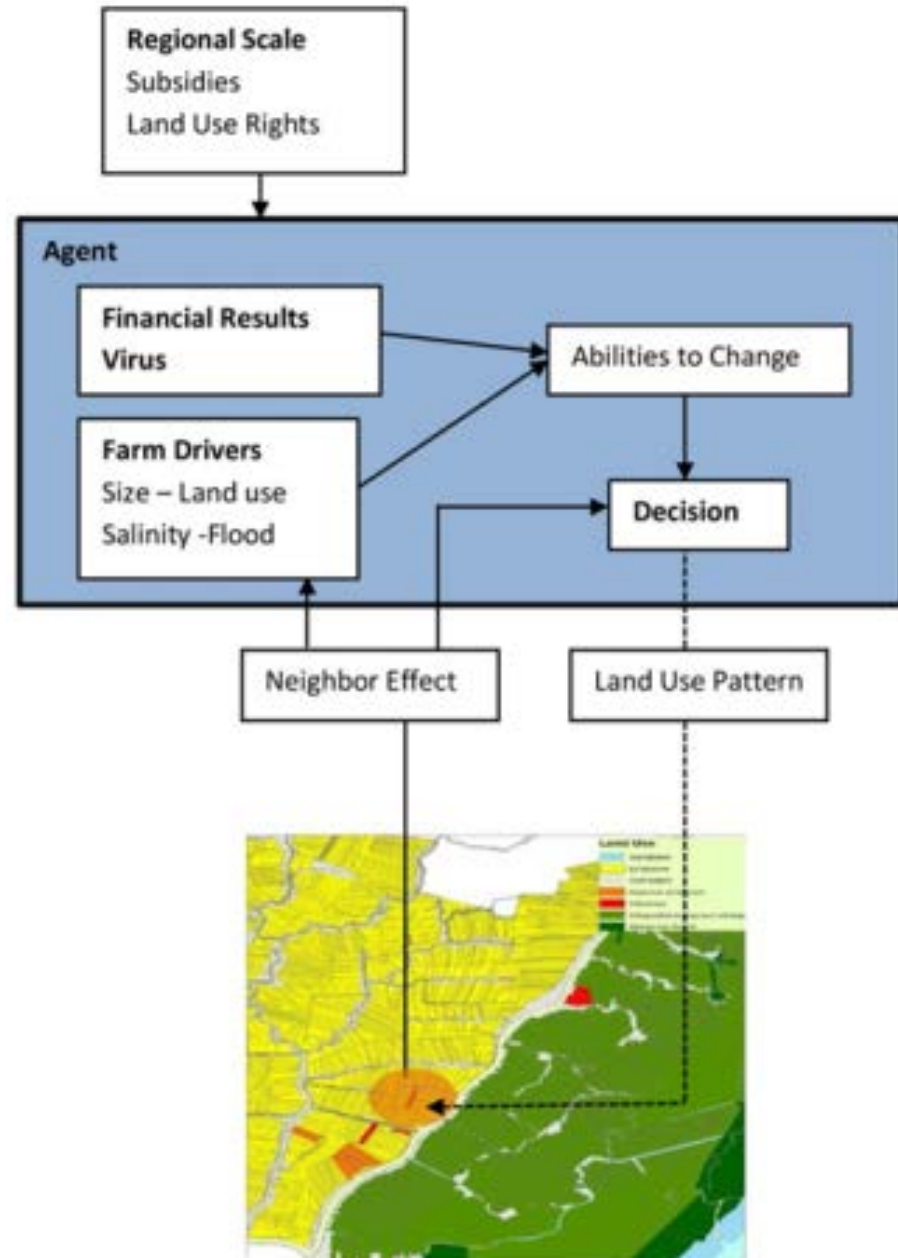
■ Probability to Shift:

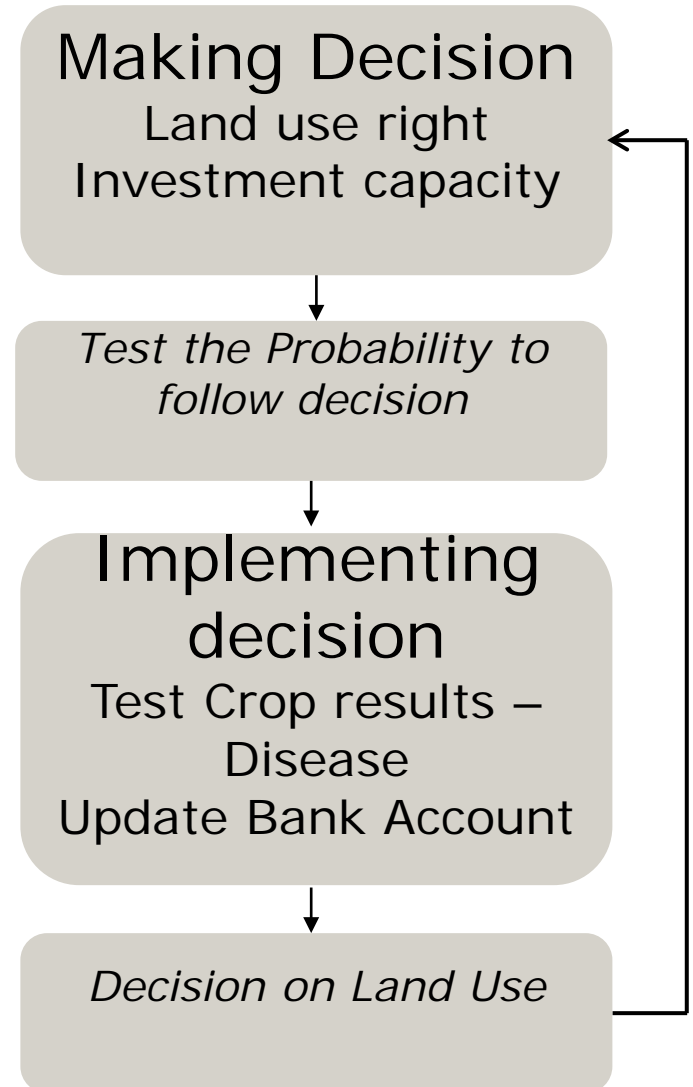*Baseline probability X land suitability X neighbor's influence X policies*

■ Example of rules

-Shifting rule (path dependent)

- Rule of Abandonment

Regional Scale
Subsidies
Land Use Rights

Agent

Financial Results
Virus

Abilities to Change

Farm Drivers
Size – Land use
Salinity -Flood

Decision

Neighbor Effect

Land Use Pattern

Model Structure

- 1 Cycle = 6 months

- >20,000 farm plots

Making Decision
Land use right
Investment capacity

↓

Test the Probability to follow decision

↓

Implementing decision
Test Crop results – Disease
Update Bank Account

↓

Decision on Land Use

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Using the ABM with local policy makers

Three scenarios for 2030 develop & tested

Climate change
No adaption measures
 Increasing cost & risk of disease outbreak

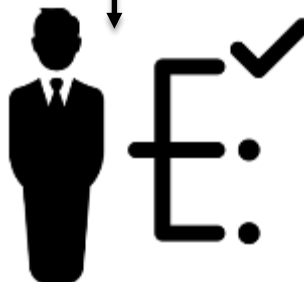**Intensification**
Access to capital

Dissemination of knowledge

Organic coast
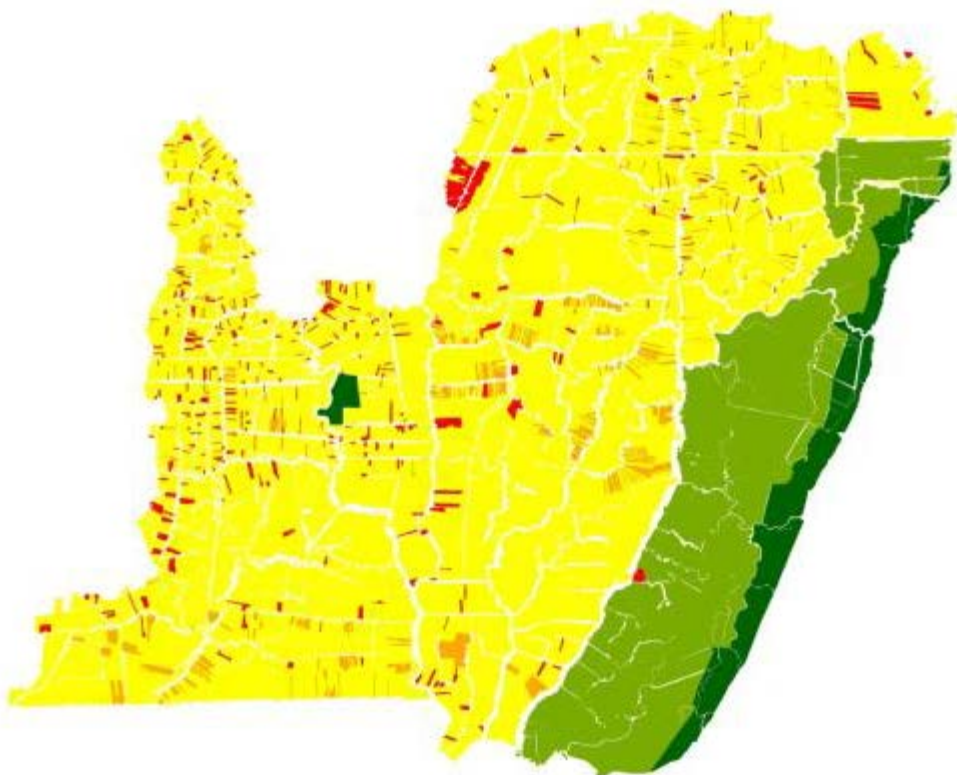Access to PES
Organic value chain
Higher revenue from timber

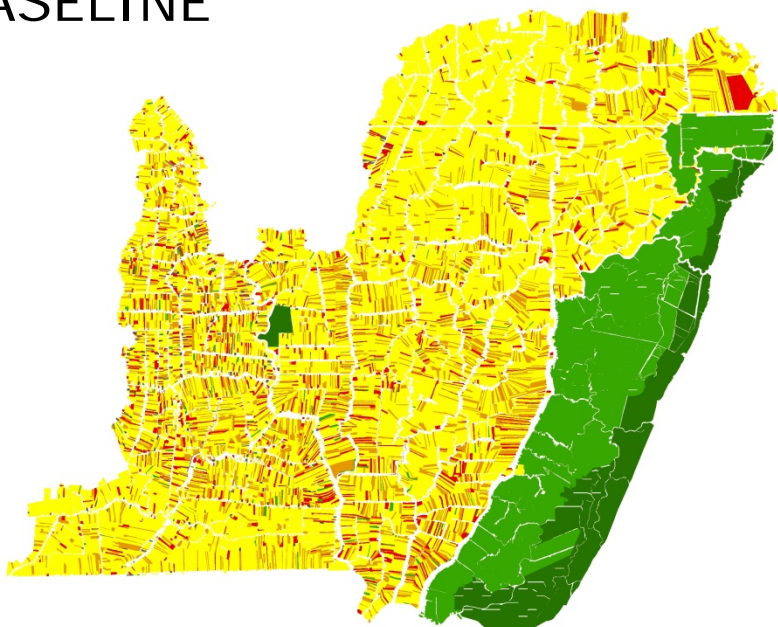**Baseline Scenario**
Current policies & bio-physical conditions

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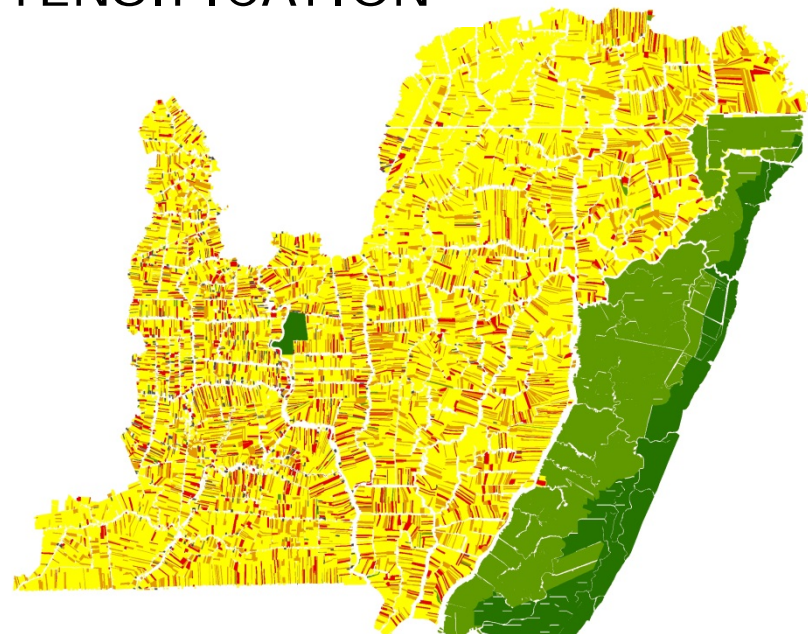
Land Use map 2015–2030 : Baseline Scenario

Legend:
- Abandonned farm
- Extensive (EXTS)
- Improved Extensive (IES)
- Intensive (INTS)
- Integrated mangrove shrimp (IMS)
- Mangrove forest

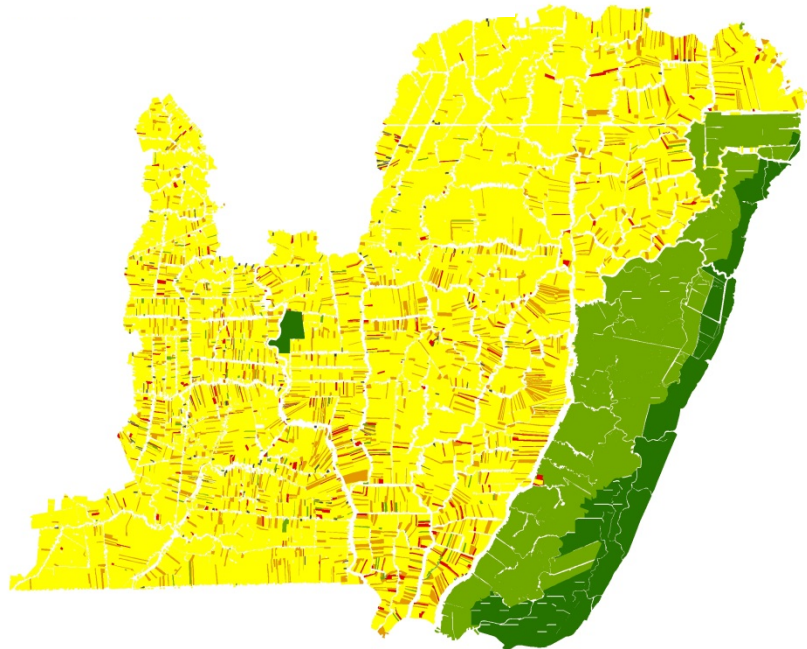WAGENINGEN UR
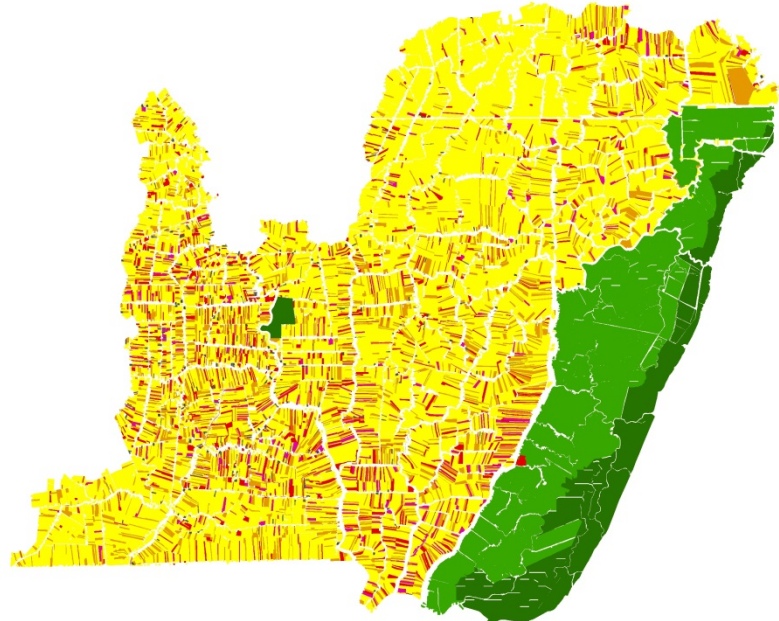For quality of life

BASELINE

INTENSIFICATION

CLIMATE CHANGE

ORGANIC COAST

Results of scenarios testing

Total shrimp production per cycle
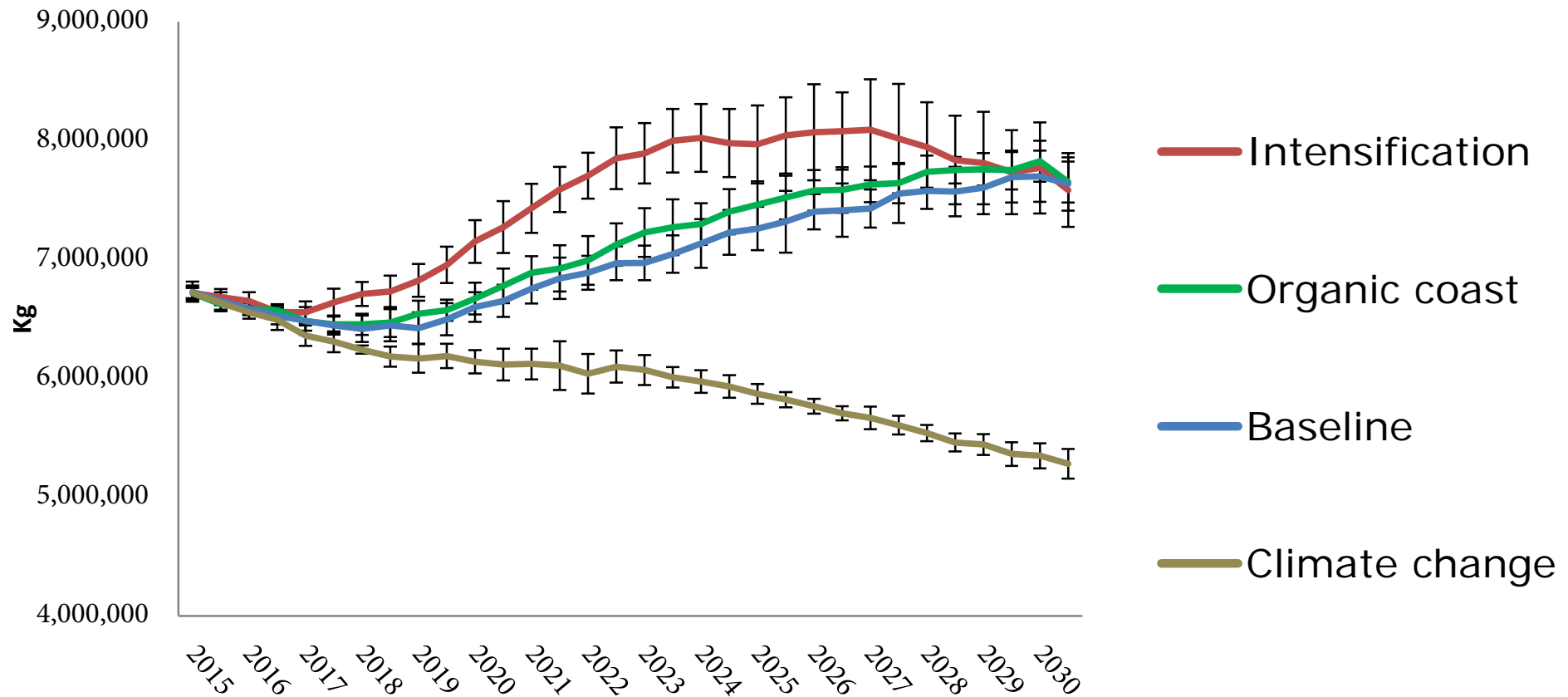
Results of scenarios testing
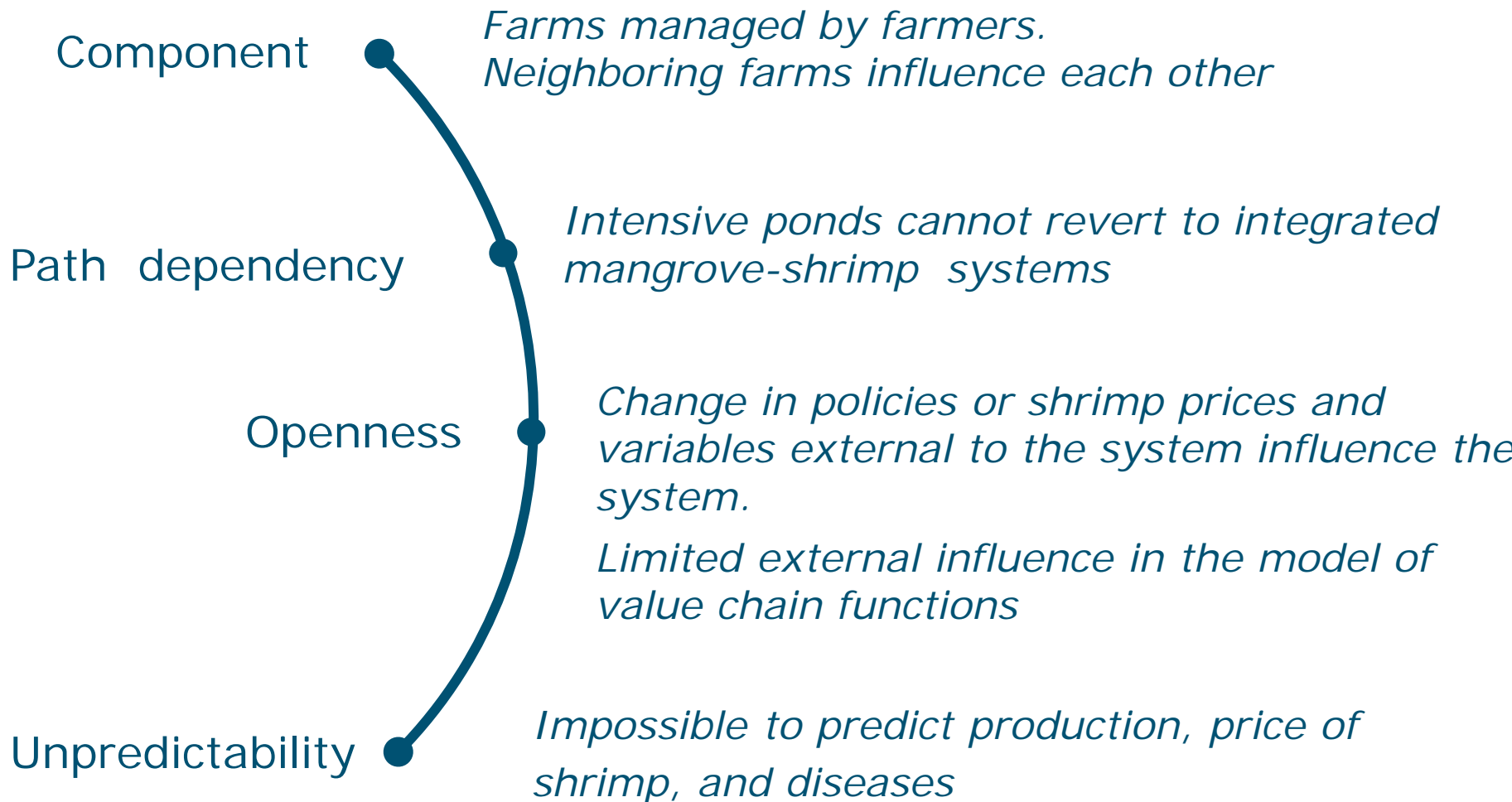
Number of abandoned farm per cycle
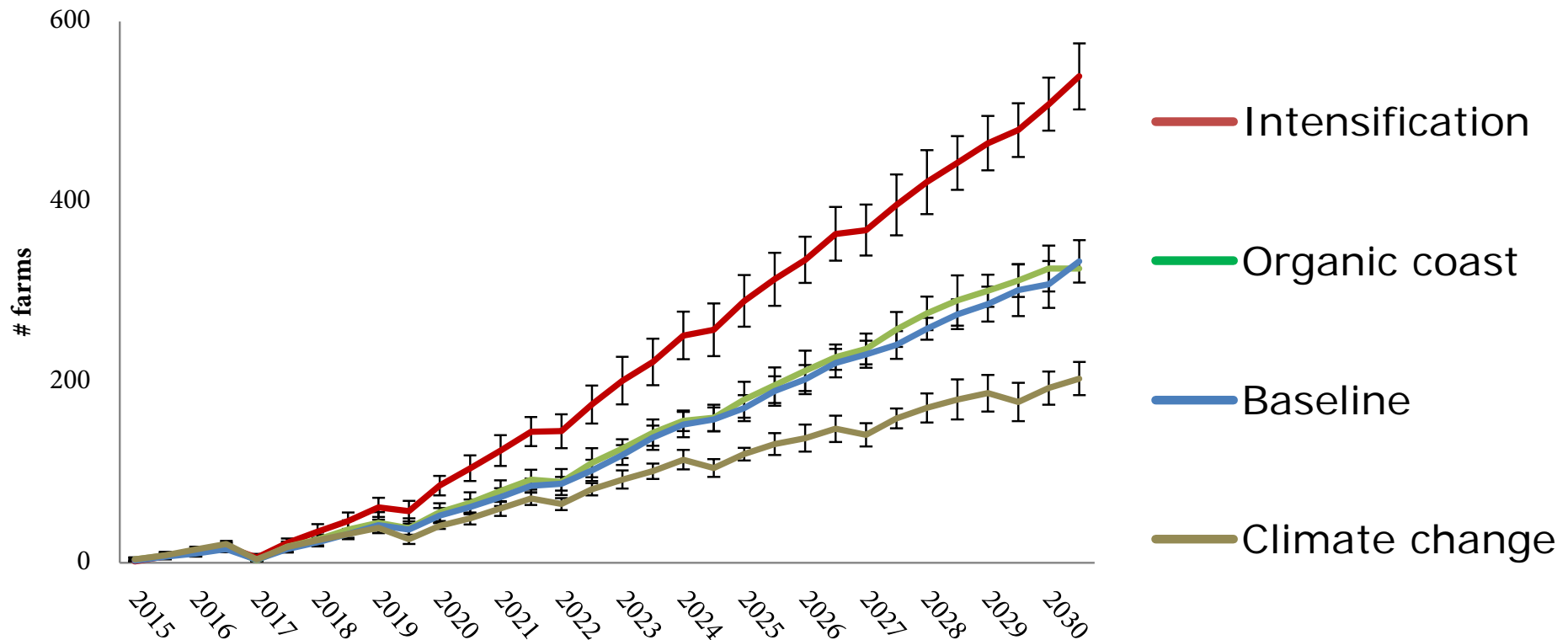
Conclusion - *from the simulation*

- Widespread intensification : cascading effect.

- Policies to expand Integrate mangrove shrimp are not effective because farmers :

  - Lack of knowledge about such policies.

  - Associate system with submission to Forestry Services

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Does the ABM reflect the features of a Complex Adaptive System?

Component — *Farms managed by farmers. Neighboring farms influence each other*

Path dependency — *Intensive ponds cannot revert to integrated mangrove-shrimp systems*

Openness — *Change in policies or shrimp prices and variables external to the system influence the system.*

Limited external influence in the model of value chain functions

Unpredictability — *Impossible to predict production, price of shrimp, and diseases*

Does the ABM have behaviors as a Complex Adaptive System?

Adaptability — *Adaptability of the agent to disease, water level, neighbor influence and, to a lesser extent, market price changes*

Self-Organization — *No. The structure of the components is fixed*

Nonlinear behavior — *External and internal factors affect agent in a nonlinear way*

Cascading effects

Feedback loop mechanism — *Limited feedback loops*
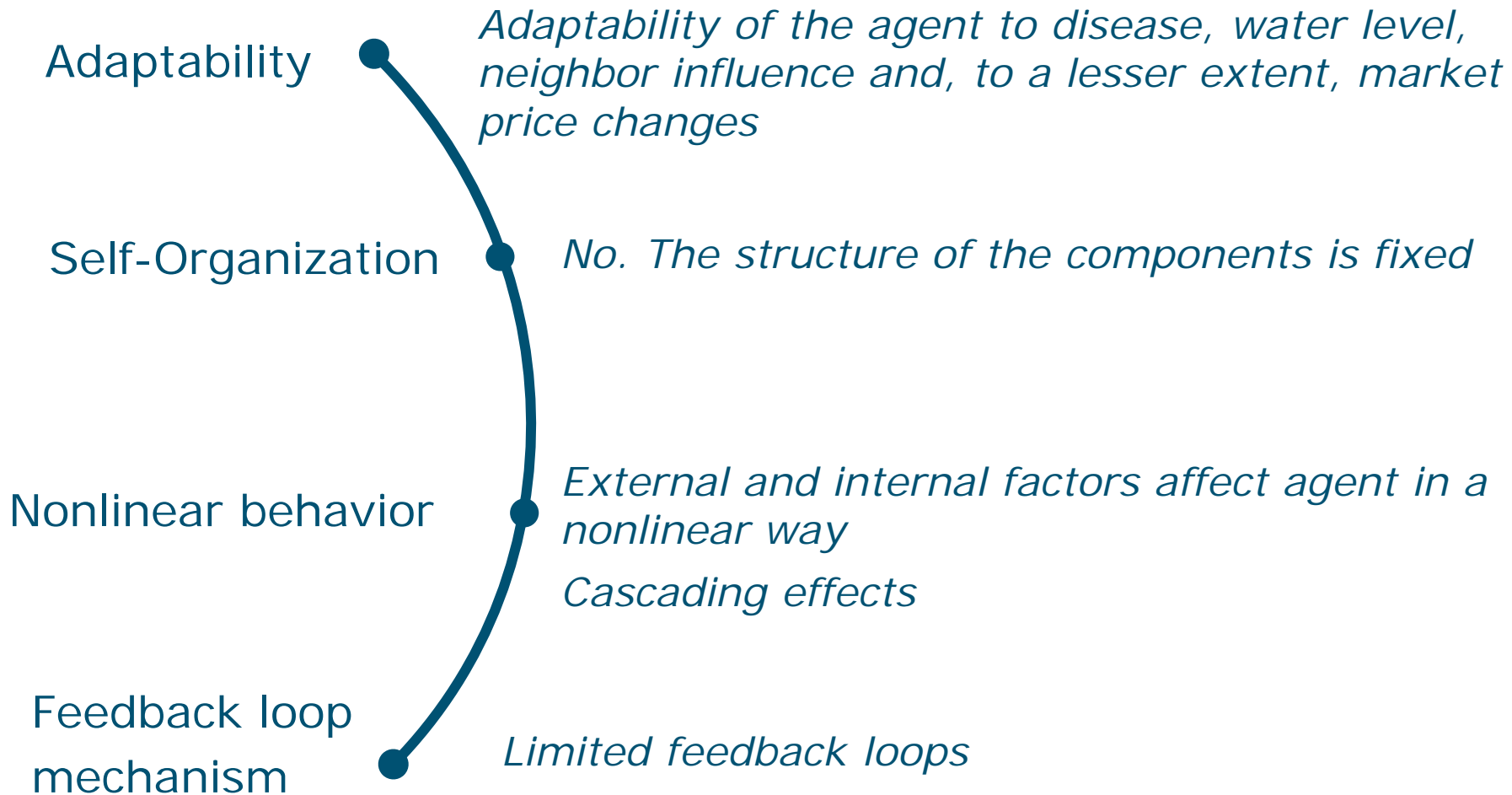
Conclusion - *from the approach*

■ Learning tool for farmers

■ Bridging communication gap between

farmers - policy makers.

ALEGAMES project

Assessing Learning Effects of Games on Attitude of Stakeholders towards Sustainable Shrimp Farming:
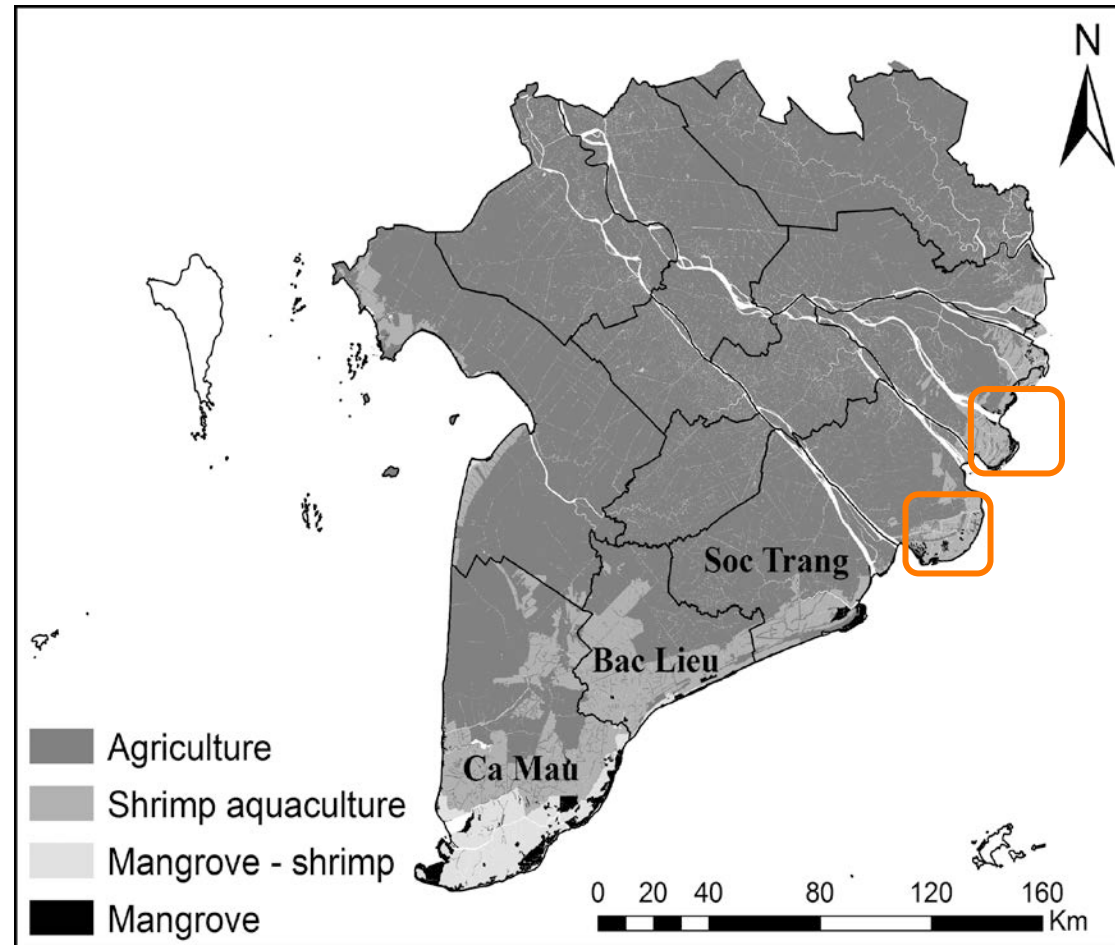
Three year project collaboration:

- *Test the learning effect of farmer's knowledge and opinion on farming practices*

- *Information flows between farmers and policy makers*

ALEGAMES

- 3 Study Sites

- Adaptation of the model to :

  - new type of agents

  - environment

  - context

Legend:
- Agriculture
- Shrimp aquaculture
- Mangrove - shrimp
- Mangrove

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ALEGAMES

- The research goals of ALEGAMS are to assess the:
  - effectiveness of Role Playing Games in triggering farmer's learning on and adoption of IMSS practices

    - Follow 3 groups of farmers with different exposure to RPGs in each case studies

  - effect on knowledge and attitude of policy-makers

    - Involve local policy makers in the RPGs and ABM

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THANKS YOU

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