Integrated assessment of agricultural land use policies aiming at reducing nutrient pollution in Taihu Basin, China

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Case study definition

Pre-modelling: Problem definition

Stakeholders

Case study description

System definition

Problem

Causal chains

Context

Sectors & scales

Data

Water pollution in Taihu Lake Basin

Legend

Boundary of cities

Waters

Boundary of Taihu Lake Basin
Land Use Policies and Sustainable Development in Developing Countries

Sectors & scales

Region
- North-west Taihu Lake Basin

Municipality
- Wuxi
- Changzhou
- Zhenjiang

Agricultural sector
- livestock
- perennial
- arable
- fish

Farm type
- off-farm employment
- size: low, high
- small, large
- 1, 2, 3, 4

Agricultural activity
- soil rotation technology
- clay, loam, sand, rice-wheat, rice-rapeseed, single crop
- current
- mechanical transplanting rice
- formula fertilizer
- site-specific nutrient management

Notes
- Boundary of Taihu Lake Basin
Scenarios: Policy options

Agricultural sector

1. Mechanical transplanting (MT)
2. Formula fertilizer application (FF) & Site-specific nutrient management (SSNM)
3. Buffer zones: change arable land to trees

Considering institutional context: policy evaluation, policy forum, stakeholders
Modelling

Pre-modelling: Problem definition
- Case study description
  - Problem
  - Context
- System definition
  - Causal chains
  - Sectors & scales
- Indicator selection
  - Land Use Functions
  - Indicators
- Scenario description
  - Base year
  - Baseline
  - Policy options

Modelling: Assessing impact of policy on indicators
- Review & selection of assessment tools
  - IA of land use
  - Regional problem
- Adaptation and/or development of assessment tools
  - TechnoGIN
  - FSSIM
- Apply assessment tools
  - Parameterization
  - Simulation

Stakeholders
- Data

Land Use Policies and Sustainable Development in Developing Countries
Modelling: Technical Coefficient Generator

- TechnoGIN, South East Asia (Ponsioen et al. 2006)
- Technical Coefficients:
  - Parameters describing Inputs & Outputs of Agricultural activities
  - Inputs: fertilisers, biocides, water, labour, etc.
  - Outputs: yield, income, pollution of fertilisers & biocides, etc.
- Base year
  - Averages of survey data: 320 farms
- Baseline
  - Continuation of trends in yields, prices
- Policy options
  - Technological innovations, based on “best farmer practice” from survey, literature, models ...

Farm type

Bio-economic model

TCG: Input-output relationships

Data → Model/Software

Agricultural activity
Modelling: Bio-economic model

- Farming Systems Simulator (FSSIM)
- Developed for European context in SEAMLESS (Van Ittersum et al., 2008; Louhichi et al., 2010)
- Optimization model
- Positive mathematical programming (PMP)
  - Calibration to current situation
  - Forecasting, not optimizing, future
- Programmed in GAMS
- Can be adapted to other conditions
Modelling: Structure FSSIM China

FSSIM-AM\(^1\)

**FARM SURVEY DATA**

**DATA BASE**
Farm resources (land, labour, ...), policy constraints, ...

**INPUT/OUTPUT COEFFICIENTS**

FSSIM-MP\(^2\)

**DECLARATIVE PARAMETERS, VARIABLES AND EQUATIONS**

**INCOME** ➔ **OBJECTIVE FUNCTION** ➔ **RISK**

**INSTITUTIONAL** ➔ **CONSTRAINT SYSTEM**

**AGRONOMIC** ➔ **POLICY**

**ECONOMIC** ➔ **FEEDING**

**FINANCIAL**

**FSSIM-OUTPUT**
- Farm income
- Positive/negative externalities
- Agricultural activity levels...

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*TechnoGIN-3* © 2010 V1.4
Technical Coefficient Generator for cropping systems in East and Southeast Asia
Post-modelling: LUF values

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Post-modelling: Evaluating impact of policy on Sustainable Development
- Multi-criteria analysis
  - Land Use Function Values
  - Land Use Function Weights
  - Effective & feasible policy options

Land Use Policies and Sustainable Development in Developing Countries
Results at farm level: Wuxi farm type 1

- **Baseline:**
  - Available labour days limited
  - As labour wage ↑

- **Policy option:**
  - Stimulate SSNM by training & dissemination
  - Increase responsiveness to prices and yields (elasticity)

<table>
<thead>
<tr>
<th></th>
<th>Base year</th>
<th>Baseline</th>
<th>Policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total area used</td>
<td>0.32</td>
<td>0.28</td>
<td>0.24</td>
</tr>
<tr>
<td>Single crop area</td>
<td>0.17</td>
<td>0.27</td>
<td>0.22</td>
</tr>
<tr>
<td>Double crop area</td>
<td>0.15</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Conventional</td>
<td>77%</td>
<td>61%</td>
<td>28%</td>
</tr>
<tr>
<td>Formula fertilizer</td>
<td>18%</td>
<td>33%</td>
<td>4%</td>
</tr>
<tr>
<td>Site-specific nutrient management</td>
<td>5%</td>
<td>7%</td>
<td>68%</td>
</tr>
<tr>
<td>Mechanical transplanting</td>
<td>15%</td>
<td>45%</td>
<td>64%</td>
</tr>
</tbody>
</table>
Results at farm level: Wuxi farm type 1

Policy option:
- Stimulate SSNM by training & dissemination
- Increase elasticity x 10
Post-modelling: effective & feasible policy options

- Site-specific nutrient management
  - Large potential to reduce nutrient leaching, higher yields
  - In 2008: FF used, but not according to SSNM principles
  - In 2015 baseline: SSNM not much adopted, higher labour use, knowledge needed
  - In 2015 policy: training required, subsidies, even then little increase

- Mechanical transplanting
  - In 2008: not always profitable
  - In 2015 baseline: reduces labour use, so high adoption
  - In 2015 policy: with more subsidies also profitable, can stimulate adoption of SSNM

- Buffer zones along water courses
  - In 2008: compensation payments do not always cover agricultural income/ha
  - Effective: 80-90% reduction in nutrient leaching

- General
  - Labour wages ↑ & off-farm employment ↑ -> labour availability ↓
    - From double to single cropping
    - Maintaining food production levels: subsidies needed

- Adoption & SD impact depends per farm type
- Regional impacts: aggregation
Concluding remarks

- Strong points of the approach, linking TechnoGIN-FSSIM:

  - Integrated assessment
    - of effects of technological and policy changes
    - on farming systems
    - i.e. economic, social, environmental
  - Analysis of trade-offs
    - for such changes in farming systems
    - e.g. pollution vs gross margins
  - Analysis of potential and constraints
    - for possible changes in farming systems to support policy implementation
    - e.g. labour, financial
Thanks for your attention

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