Understanding the Efficiency of Conservation Investments in Payments for Ecosystem Services

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Introduction
Efficiency of Global Conservation Investments

- Conservation investments are far below the requirements for conserving ecosystems globally.

- The efficiency of conservation investments has been a great concern to conservation policies.

- One approach to improve the efficiency of conservation investments is through Payments for Ecosystem Services (PES).
Payments for Ecosystem Services (PES)

- Under this approach, economic incentives are provided directly to ecosystem services providers to undertake actions that are desired for conservation.
PES Programs Worldwide

- Conservation Reserve Program (US)
  - Objective: agricultural land set aside
- Permanent Cover Program (Canada)
  - Objective: agricultural land conversion
- Agri-environmental regulation (EU)
  - Objective: agricultural land set aside
- Pagos de Servicios Ambientales (Costa Rica)
  - Objective: agricultural land conversion
- Grain-to-Green Program (China)
  - Objective: agricultural land conversion
Reasons of the Grain-to-Green Program in China

Major flood in the Yangtze River (1998)

Major droughts in the Yellow River Basin (1997)
Grain-to-Green Program (GTGP)

- Main objective: increase forests and grassland to prevent soil erosion
- Secondary objective: restore ecosystems and provide habitat to wildlife
- Criterion: slope > 25° in southwest
  slope > 15° in northwest
- Payment: 3450 yuan/ha in southwest
  2400 yuan/ha in northwest
- Duration: Started in 2000 for up to 8 years
  Renewed for another up to 8 years
Case study 1: GTGP at FNNR
Location of GTGP

- FNNR focuses on the experimental zone (yellow)
- Total non-forested land: 1258.133 ha, including farmland 1042.6 ha.
Incentives

- **Grain:** 150 Kg/mu/year wheat or rice (1 mu = 666.67 m²)
- **Cash:**
  - Yearly: 300 Yuan/mu/year ($1 = 6.2 Yuan)
  - One-time payment: 750 Yuan/mu for seedling and labor
- **Time span:** 5 (“economic” plantation) or 8 (“ecological” plantation) years
Participants’ responsibilities

- Plant trees in returned land
- Maintain the plantation
- No farming, mining, any unapproved activities (e.g., collection of fuelwood, fire use in farmland)
Villager reliabilities

- In what places, what activities are prohibited, and penalty if violation occurs
- Carved on a monument
FNNR Staff Supervision

Photo Courtesy: Mr. Yeqin Yang
GTGP Achievement

# 324.57 ha returned (all greater than 25°)
- 224.57 ha ecological forest
- 100 ha bamboo/tea/conifer plantations

Photo Courtesy: Mr. Yeqin Yang
Conifer plantation
Bamboo plantation

Photo Courtesy: Mr. Yeqin Yang
Problems

- Reconvert returned land to farmland
- Convert non-farmland (e.g., forestland, shrub land) to farmland, then return such land
Case study 2: Re-enrollment intentions of land that have been enrolled in the GTGP after the current contract matured
Policy Scenarios Design

Policy Attributes

- Payment: 100, 200, 300 yuan per mu
- Duration: 3, 6, 10 years
- Other people’s behavior in the same group:
  25%, 50%, 75% that would reconvert land back to agriculture
- 3 scenarios randomly chosen for each interview
## Effects of Policy Attributes

<table>
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<tr>
<th>Independent Variables</th>
<th>Parameters</th>
<th>Marginal Effects</th>
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<tbody>
<tr>
<td>Social norms and conservation payment</td>
<td>Neighbors’ behavior</td>
<td>-1.662***</td>
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<tr>
<td></td>
<td>Conservation payment (Yuan)</td>
<td>0.020***</td>
</tr>
<tr>
<td>Program durations</td>
<td>3-year duration (dummy, reference = 6 years)</td>
<td>-0.598**</td>
</tr>
<tr>
<td></td>
<td>10-year duration (dummy, reference = 6 years)</td>
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Re-enrollment under different payment and neighbors’ behavior

![Graph showing re-enrollment percentage (y-axis) against payment (X-axis) for different neighbors' reconverting rates: 75%, 50%, and 25%. The graph illustrates how re-enrollment increases with payment, with higher reconverting rates leading to a higher re-enrollment percentage at the same payment level.](image-url)
Conclusions

- If more people can be encouraged not to reconvert their GTGP plots, others will follow.

- Conservation policies with larger payments and longer durations increase re-enrollment of GTGP plots.

- Off-farm employment through labor migration tends to increase re-enrollment of GTGP plots.
Case study 3: Applying cost-effective targeting to improve the efficiency of conservation investments in Payments for Ecosystem Services
Efficiency of Conservation Investments in Payments for Ecosystem Services

- Payment schemes
  - Flat payment scheme: all participants are paid at the same price
  - Discriminative payment scheme: payments differ according to the opportunity costs

- The cost and benefit of obtaining ecosystem services through PES are spatially heterogeneous

- Cost-effective targeting can improve the efficiency of conservation investments in PES
Cost-effective Targeting in PES

- Land plot that supplies an additional unit of environmental benefits with the least cost is obtained first (also known as optimal targeting)

- Environmental benefits often measured by observable proxies

- Cost-effective targeting for one type of environmental benefit is optimal for the targeted environmental benefit but is usually sub-optimal for other types of environmental benefits
Quantification of Environmental Benefits

$$\text{SoilBenefitIndex}_i = \left( \frac{\text{Slope}_i - \text{Slope}_{\text{min}}}{\text{Slope}_{\text{max}} - \text{Slope}_{\text{min}}} \right)^2$$

$$\text{HabitatBenefitIndex}_i = \left( 1 - \frac{\text{Distance}_i - \text{Distance}_{\text{min}}}{\text{Distance}_{\text{max}} - \text{Distance}_{\text{min}}} \right)^2$$

Each type of environmental benefit of a plot is measured by multiplying the benefit index by the area of the plot
Opportunity Cost Estimation

\[ P(reenroll_j) = 1 - P(reconvert_j) + P(reconvert_j) \times P(reenroll_j \mid pay > 0, reconvert) \]

- \( P(reenroll_j) \) is the probability the \( j \)th GTGP plot is re-enrolled
- \( P(reconvert_j) \) is the probability the \( j \)th GTGP plot is reconverted to crop production after the payments end
- \( P(reenroll_j \mid pay > 0, reconvert) \) is the probability of re-enrolling the \( j \)th GTGP plot under a new payment program, for plots that will be reconverted to crop production after initial payments end
Opportunity Cost Estimation

- \( P(\text{reenroll}_j) \) is estimated at different payments

- The per hectare opportunity cost of a land plot is the payment level at which the land plot will be re-enrolled
Environmental Benefits Targeting Approaches

- **Soil benefit maximization approach**
  - Soil benefit-to-cost ratio

- **Habitat benefit maximization approach**
  - Habitat benefit-to-cost ratio

- **Land benefit maximization approach**
  - Cost per ha
Environmental Benefits Obtained from Different Targeting Approaches
Conclusions

- The cost difference between payment schemes is substantially larger than differences due to choosing which environmental benefit to target.

- When all GTGP plots are considered, cost-effective targeting with discriminative payments is over 10 times more efficient than with flat payments.
Acknowledgments

## People
- J. Liu – Michigan State University
- Z. Ouyang – Chinese Academy of Sciences

## Financial Support
- National Science Foundation
- National Institutes of Health
- National Aeronautics and Space Administration