Changes in environmental and economic benefits caused by land use policies in the East Asian monsoon region

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Integrated Climate Process (ICP) Lab

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1 Introduction

- Terrestrial ecosystems are important carbon sinks for climate change mitigation.
- Anthropogenic land cover and land use (LCLU) changes affect vegetation carbon storage and the global carbon balance.
- The East Asian monsoon region has undergone extensive LCLU changes, but their environmental (carbon budget) and economic impacts remain insufficiently understood.

We aim to quantitatively evaluate the environmental and economic benefits of China's large-scale reforestation policy, *the Grain for Green Program*, by analyzing changes in the vegetation carbon budget across the Sichuan and Loess Plateau regions.

2 Methodology

- **Detect regional LCLU change associated with the Grain for Green Program.**
  - **Data**: Annual LCLU fraction data (0.5°)[1]
  - **Comparison**: Pre-policy period (1982–1998) vs. post-policy period (1999–2015)
- **Assess environmental benefits (carbon budgets) associated with the Grain for Green Program.**
  - **Data**: Vegetation carbon density[2] and monthly GPP[3]
  - **Carbon Estimation**: Quantified vegetation carbon storage changes based on IPCC guidelines[2]
  - **Environmental benefits**: Calculated the ratio of regional carbon gains to China's total national carbon emissions
- **Assess economic benefits associated with the Grain for Green Program.**
  - **Data**: Market-based carbon price data[4] (e.g., Voluntary and Forest Carbon Markets)
  - **Valuation**: Estimated total monetary gains by multiplying carbon prices by regional carbon storage changes

3 Results

- Both the Sichuan and Loess Plateau regions experienced a significant increase in forest fraction and a subsequent increase in vegetation productivity after the implementation of the Grain for Green Program in 1999 (**Figs 1 and 2**).

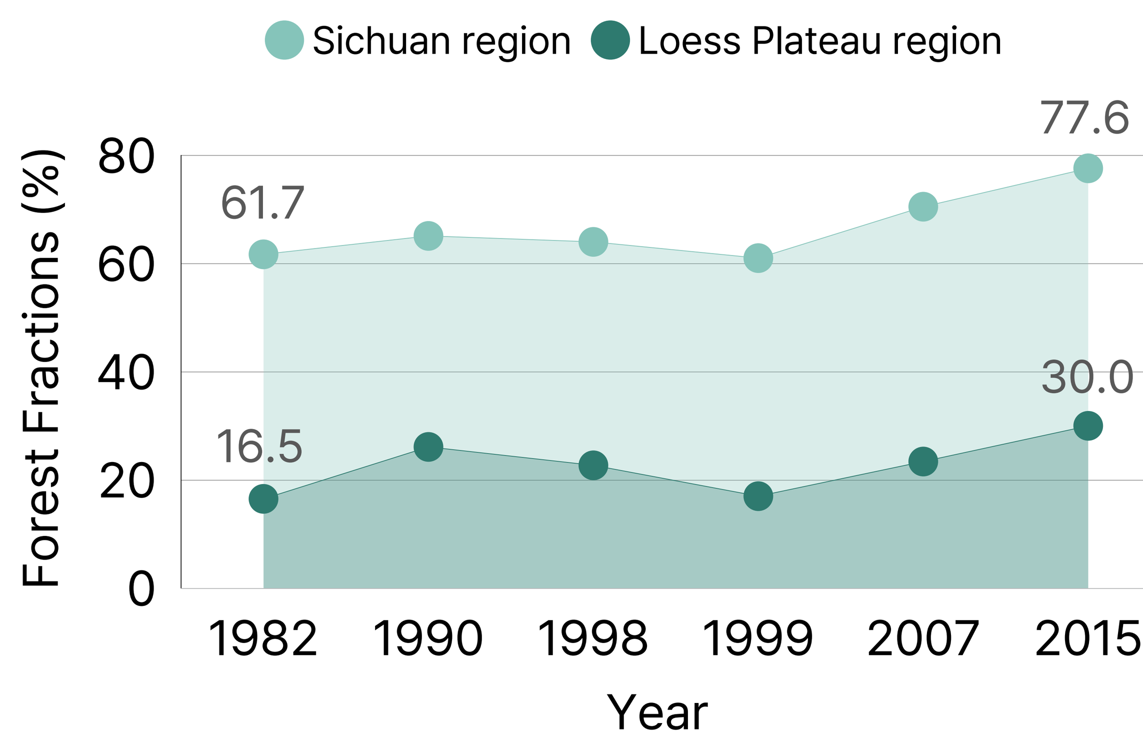

Fig 1. Time series of area-averaged forest fraction in the Sichuan and Loess Plateau regions.

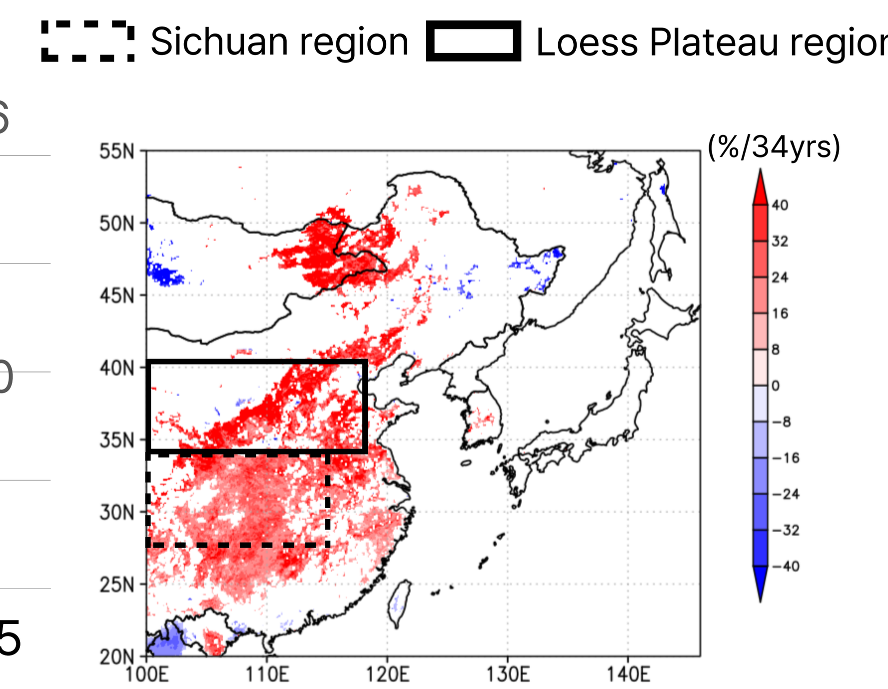

Fig 2. Trends of the average spring GPP in the East Asian monsoon region.

- After the Grain for Green Program, average vegetation carbon storage in Sichuan surged by about 8 times, whereas the Loess Plateau experienced a limited increase due to its arid climate (**Fig 3**).
- The environmental benefit, measured as China's carbon emissions offset by vegetation carbon storage, increased in Sichuan but decreased in the Loess Plateau after 1999 (**Table 1**).

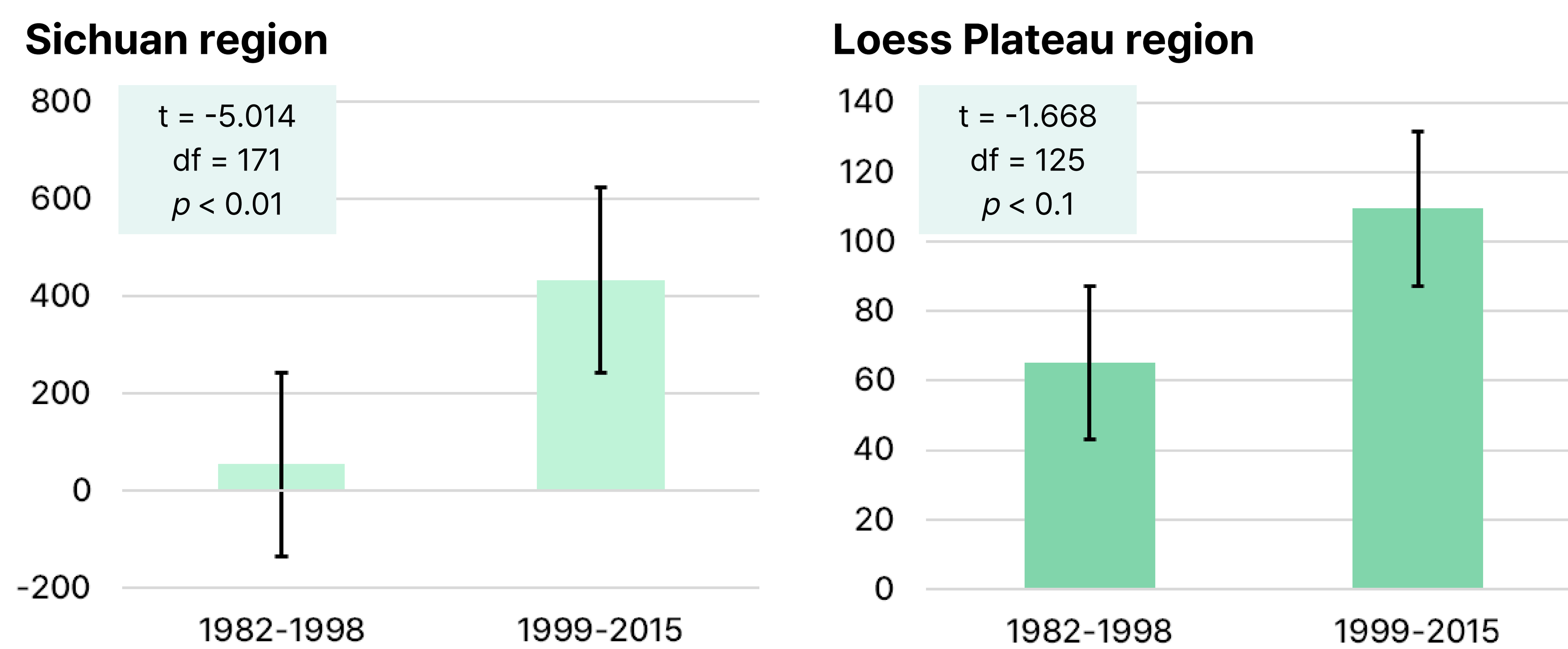

Fig 3. Average changes in vegetation carbon storage before and after the Grain for Green Program.

Table 1. Percentage of total vegetation carbon storage relative to China's total carbon emissions before and after the Grain for Green Program.

Period	Sichuan region	Loess Plateau region
1982-1998	2.80%	6.90%
1999-2015	6.03%	3.87%

Table 2. Economic benefits of average changes in vegetation carbon storage before and after the Grain for Green Program, and the differences between the two periods.

	Voluntary Carbon Market (Total)	Voluntary Carbon Market (Forestry/Land Use)	Forest Carbon Market
Sichuan region			
1982-1998	1,300.88	1,935.86	1,035.50
1999-2015	10,389.25	15,460.35	8,269.79
Difference	9,088.37	13,524.49	7,234.29
Loess Plateau region			
1982-1998	1,560.68	2,322.46	1,242.29
1999-2015	2,623.38	3,903.88	2,088.20
Difference	1,062.70	1,581.42	845.91

- **Enhanced Economic Value**: Both regions showed increased economic benefits from vegetation carbon storage after the Grain for Green Program (**Table 2**).
- **Regional Disparity**: The economic benefits were substantially larger in the Sichuan region, consistent with its extensive policy-driven vegetation carbon storage increase (**Table 2**).

4 Discussion & Conclusions

- Large-scale reforestation policies can create economic opportunities by generating substantial monetary gains alongside environmental benefits such as carbon sequestration.
- The contrasting results between the two regions highlight the need for land-use strategies tailored to regional geographic and ecological characteristics.

References

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