# Identifying Tipping Points in the Supply of Ecosystem Services in a Mountainous Watershed in South-East Asia Using Spatially Explicit Modelling

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## Introduction

The cultivation of cash crops has expanded at unprecedented rates in South-East Asia in recent decades. This led to substantial declines in the sustainable supply of ecosystem services (ESS). We use the ESS concept in a modelling context to assess a rural socio-ecological system with regard to sustainable ESS supply. The ability of a system to generate ESS may shift from desired to less desired states as external pressures increase and the system may reach a tipping point. The geographical focus of this study is the Nabanhe National Nature Reserve in Xishuangbanna prefecture (Yunnan province, PR China). This region has seen the rapid expansion of rubber plantations and major declines in forest areas in recent years. Nabanhe Reserve spans an area of 271 km².

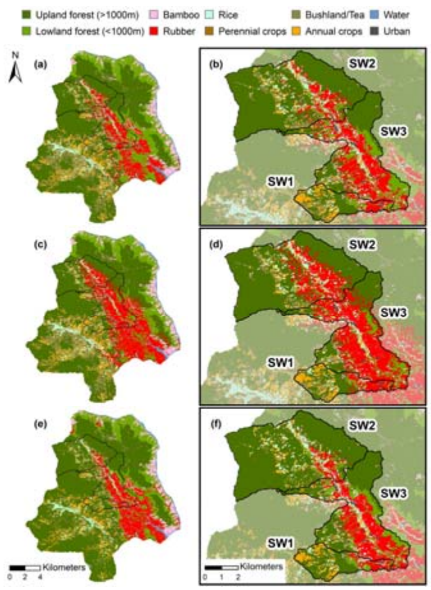


**Fig. 1: Land use in Nabanhe Reserve for the initial condition of 2015 (a,b), as well as in the BAU scenario (c,d) and the BTO scenario (e,f) at the end of the simulation in 2040.**

## Material & Methods

Together with regional stakeholders we developed multiple future land use scenarios and assessed their potential impact on the supply of ESS using InVEST (Integrated Valuation of Ecosystem Services and Trade-Offs) [1]. We combined the model results with a sequential algorithm [2] to identify potential tipping points in the supply of ESS under two scenarios of varying rubber expansions for small (sub-watershed) and large (watershed) spatial scales. The scenarios are: "Business-As-Usual" (BAU), in which rubber expansion rates are linearly continued based on past rubber expansions in Xishuangbanna; and "Balanced-Trade-Offs" (BTO), in which conservation measures are introduced, such as riparian-buffer- and water-protection-zones as well as prohibited rubber expansion to unsuitable cultivation areas. The simulation is set from 2015 to 2040 in both scenarios.

## Results

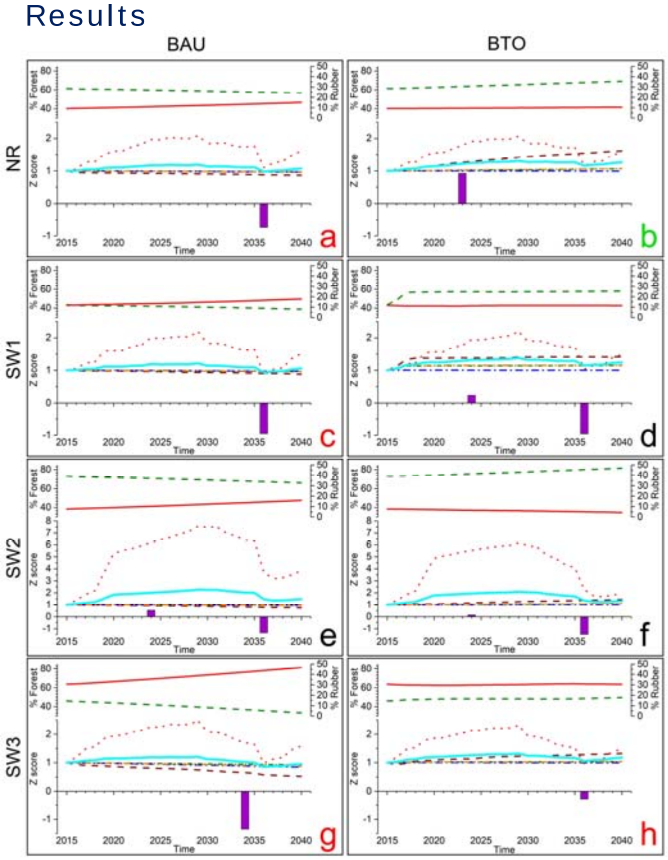


**Fig. 2: Tipping points are indicated by purple columns (RSI: Regime Shift Index). The ESS z-score is the annual arithmetic mean of the normalized values for every ESS.**

## Conclusions

- The inclusion of feedback from stakeholders is crucial to ensure the validity of assessed land use change scenarios.
- We conclude that sophisticated land use planning is able to provide benefits in the supply of ESS at watershed scale, but that trade-offs at sub-watershed scales should not be neglected.
- With this study, we provide a method for regional policy making and land use planning to reduce the risk of traversing future tipping points in ESS supply for rubber producing land use systems.
- The method is easily adaptable to other rural areas facing comparable land use conditions.

**Fig. 3: Typical landscape in Xishuangbanna Prefecture, Yunnan Province, PR China. Photograph Source: SURUMER (Sustainable Rubber Cultivation in the Mekong Region).**

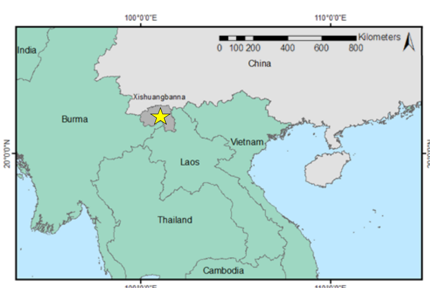


**Fig. 4: Location of the study area: The Nabanhe Nature Reserve.**

References

1. **Sharp, R. et al. InVEST 3.3.3 User's Guide (2016).**
2. **Rodionov, S. N. A sequential algorithm for testing climate regime shifts. Geophys. Res. Lett. 31, L09204 (2004).**

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