Implications of ecosystem amenities as drivers for urban development: a social-ecological system model for Stockholm, Sweden
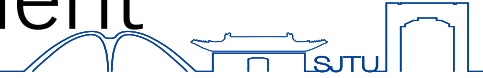
Haozhi Pan

Shanghai Jiao Tong University

Cong Cong, Le Zhang

University of Illinois at Urbana-Champaign

Jessica Page, Zahra Kalantari

Stockholm University, Sweden

Ecosystem Amenities and Urban Development

- Natural Amenities have been important factors for locational choices of companies and residences.

- Compared to traditional modelled drivers for urban growth (such as density/agglomeration, transportation, commuting), how does natural amenities play a role in driving urban growth?

- By understanding the "natural drivers", can we design policy instruments with NBS to promote more sustainable urban transition?


Photo courtesy of CNBC.COM

Social-Ecological Models

- One of the major framework to analyze and assess the impacts from urban growth and policy instruments (for example, nature-based solutions) is through social-ecological models.

- A social-ecological model needs to find the interface between social and natural systems and their feedbacks.

- Methods include land use/cover models, augmented input-output models/CGE, behavior models, etc.
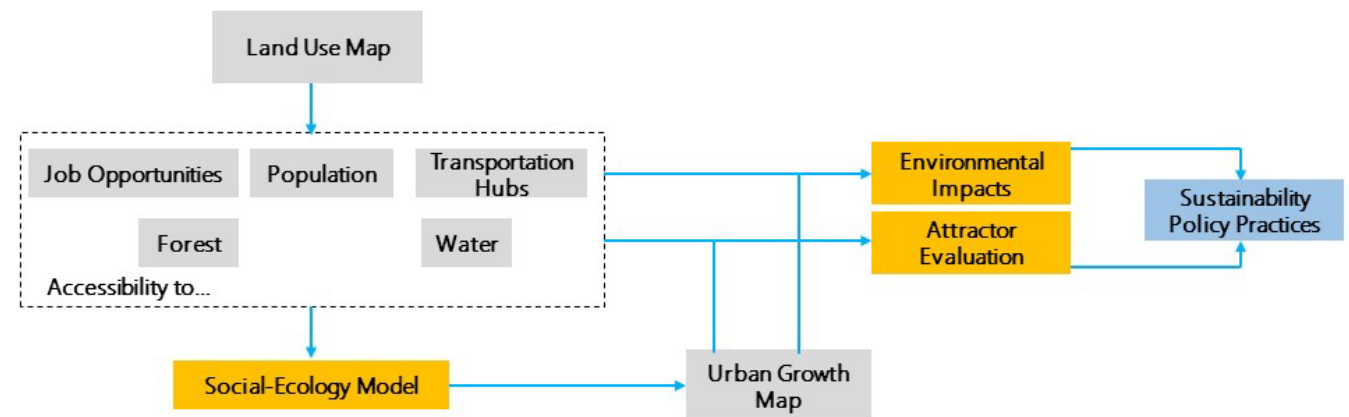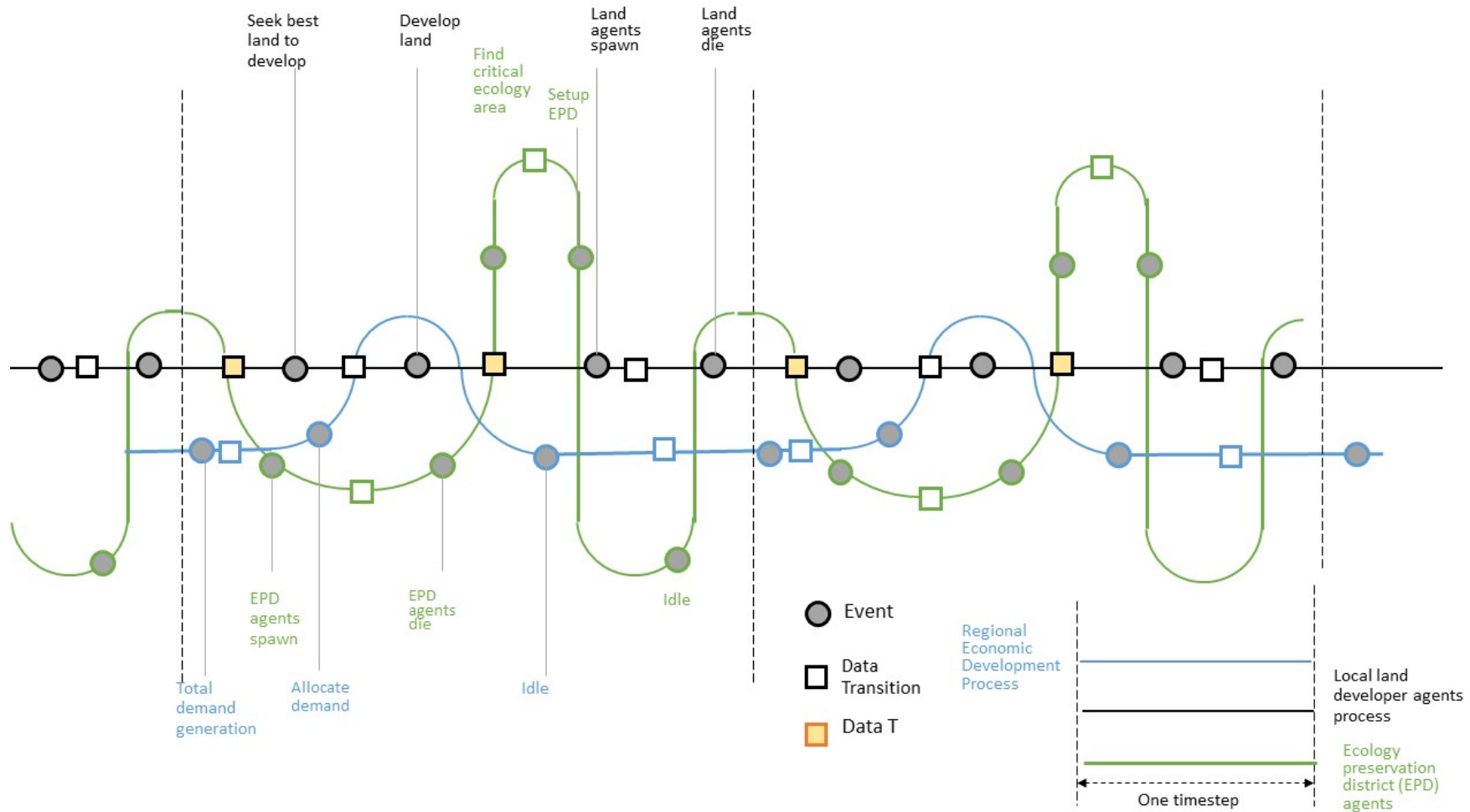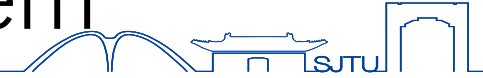
Feedback-loop between economy-land-ecosystem

- We propose a model that integrates land use, regional economics, and most important, ecosystem as drivers of land use growth, and assess the impacts on ecosystem.
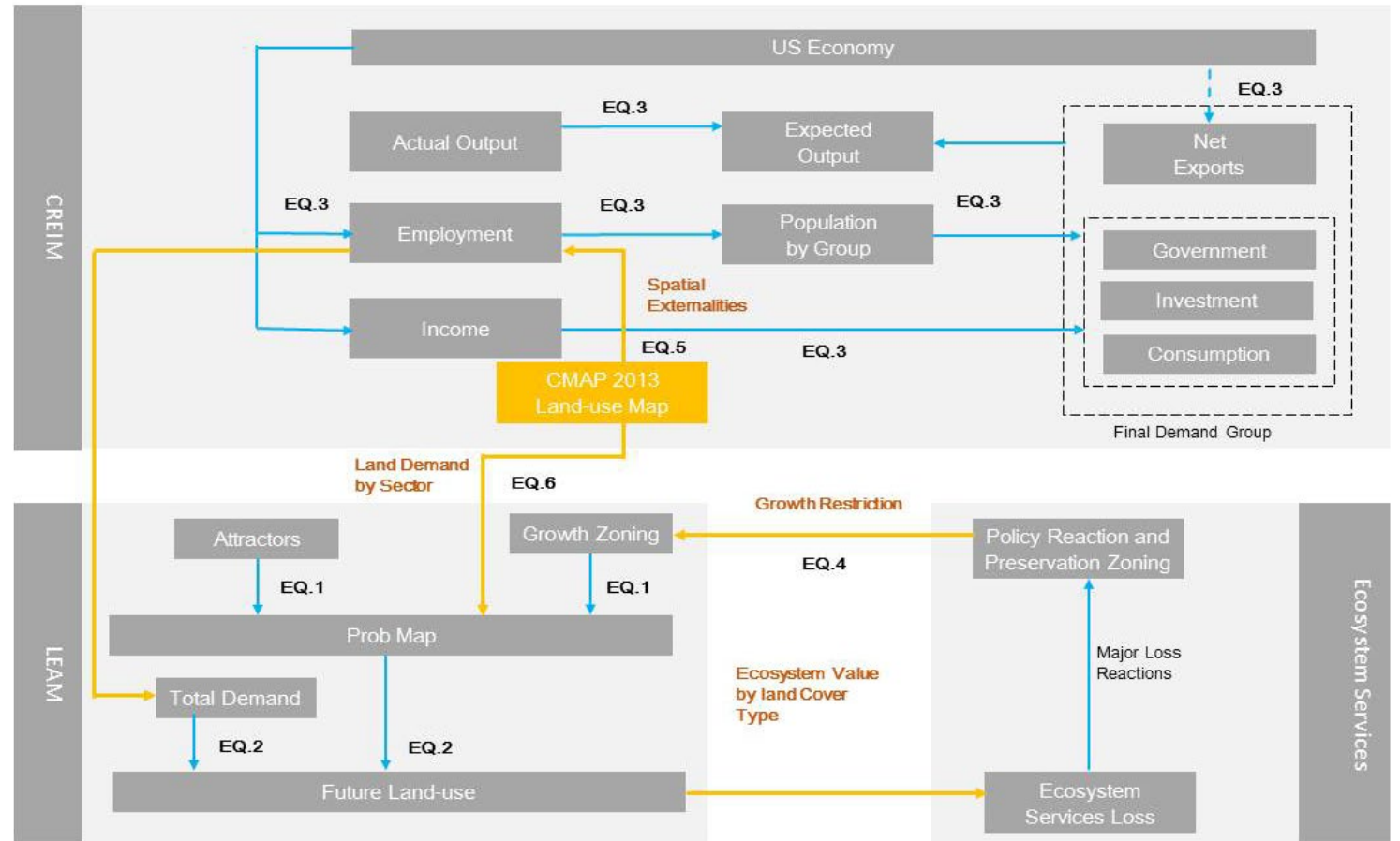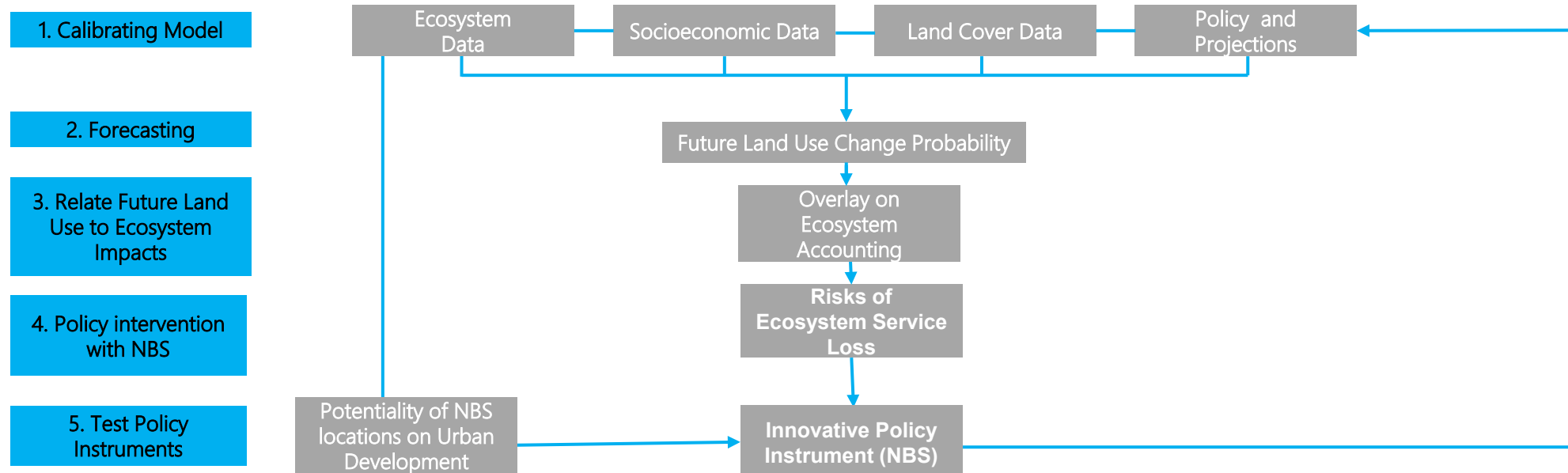
System process of economy-land-ecosystem

System modeling to reach innovative policy instruments (NBS)

1. Calibrating Model

2. Forecasting

3. Relate Future Land Use to Ecosystem Impacts

4. Policy intervention with NBS

5. Test Policy Instruments

Ecosystem Data → Socioeconomic Data → Land Cover Data → Policy and Projections

Future Land Use Change Probability

Overlay on Ecosystem Accounting

Risks of Ecosystem Service Loss

Potentiality of NBS locations on Urban Development

Innovative Policy Instrument (NBS)

Data

1. Calibrating Model

2. Forecasting

3. Relate Future Land Use to Ecosystem Impacts

4. Policy intervention with NBS

5. Test Policy Instruments

Table 1. Explanation of variables (attractors)

| Attractor	Data Value	Data Source
Population Center	Number of Population	Chicago: US Census Stockholm: TRF
Employment Center	Number of Employment	Chicago: D&B Hoovers Database Stockholm: TRF
Transportation Network	Posted Speed	Chicago: US Census Stockholm: TRF
Forest	Area of Forest	Chicago: NLCD Land Cover Stockholm: TRF and Swedish Land Survey Authority
Water	Area of Water Surface	Chicago: NLCD Land Cover Stockholm: TRF and Swedish Land Survey Authority

Calibration
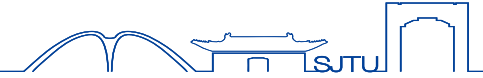
1. Calibrating Model

2. Forecasting
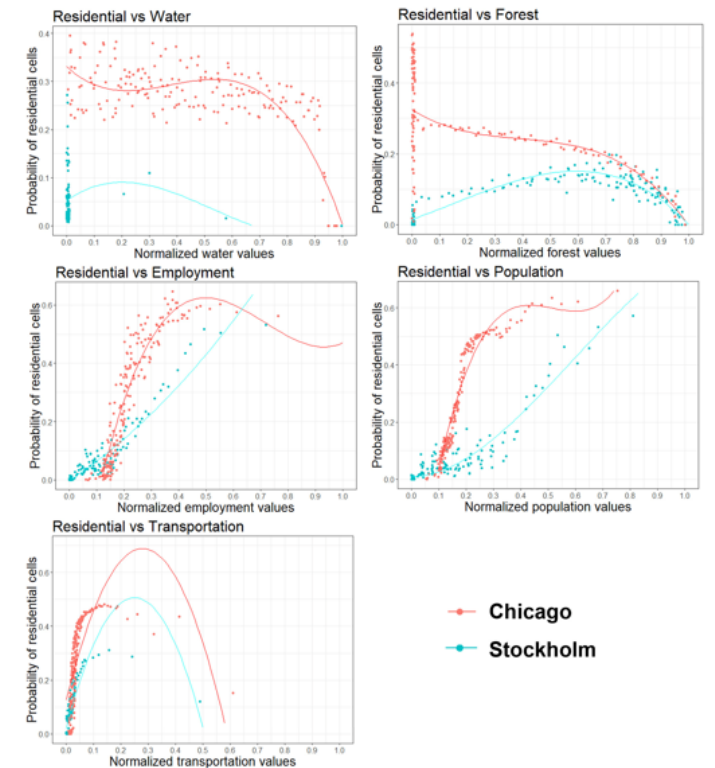
3. Relate Future Land Use to Ecosystem Impacts

4. Policy intervention with NBS

5. Test Policy Instruments
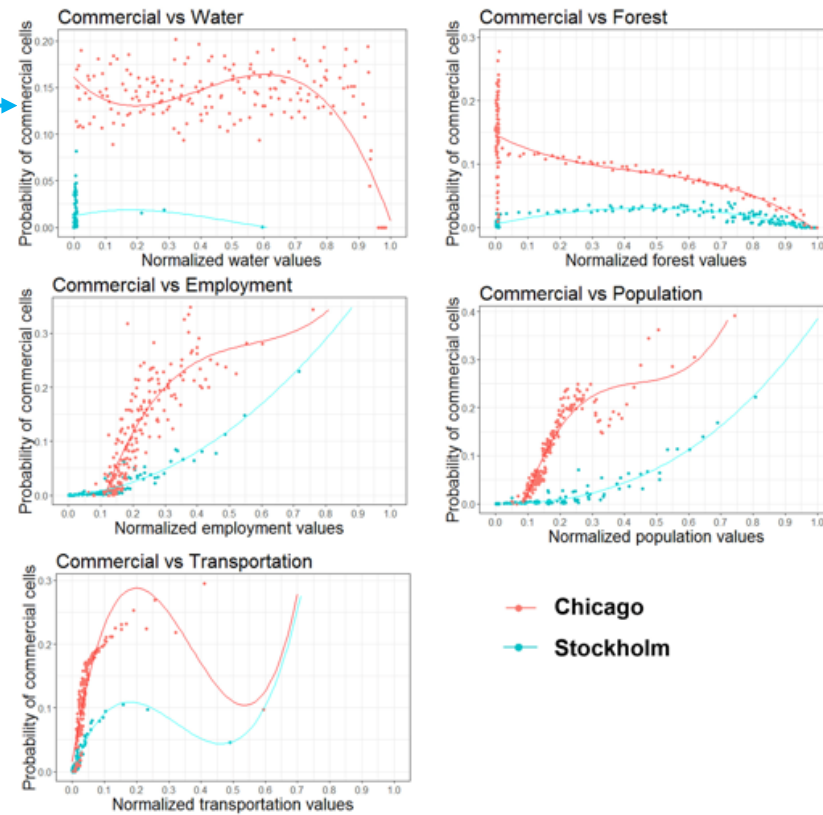
Figure 2. Relationships between connectivity to attractors and commercial developments for Chicago and Stockholm.

Figure 3. Relationships between connectivity to attractors and residential developments for Chicago and Stockholm.
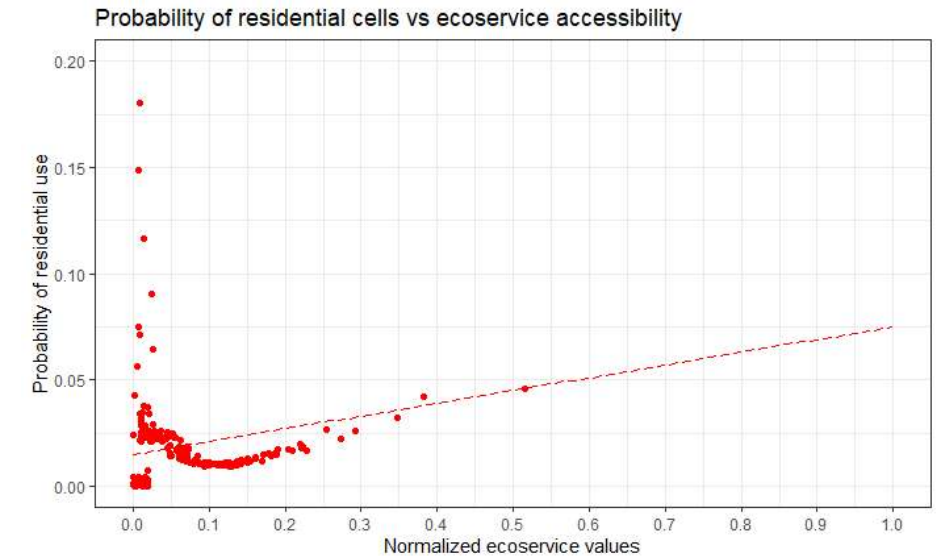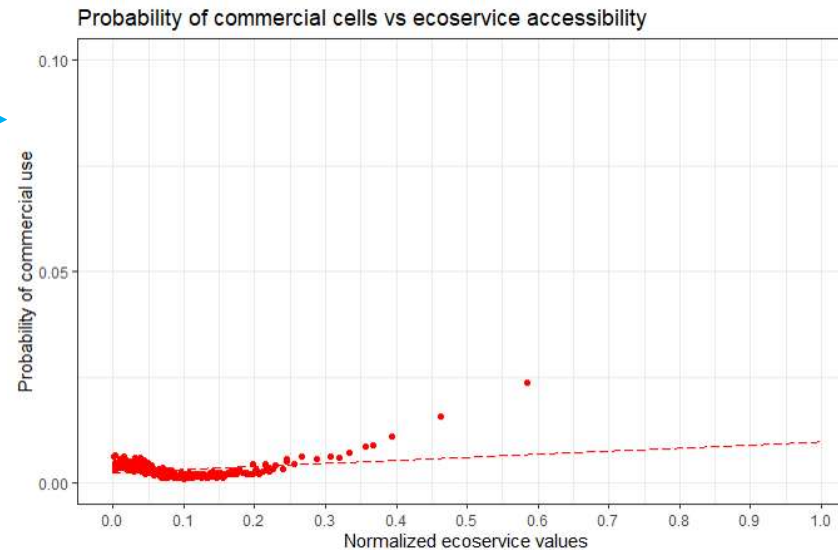
What about ecosystem drivers?

Probability of commercial cells vs ecoservice accessibility

Probability of residential cells vs ecoservice accessibility

Commercial: Better ecosystem services strongly attract commercial development.

Residential: Better ecosystem services has a even stronger draw to residential development. However, there are significant development within very low ecosystem service values

Forecast Probability of Urban Development
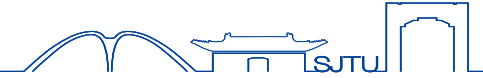
1. Calibrating Model

2. Forecasting

3. Relate Future Land Use to Ecosystem Impacts

4. Policy intervention with NBS

5. Test Policy Instruments

High

Low

Probability of commercial growth

High

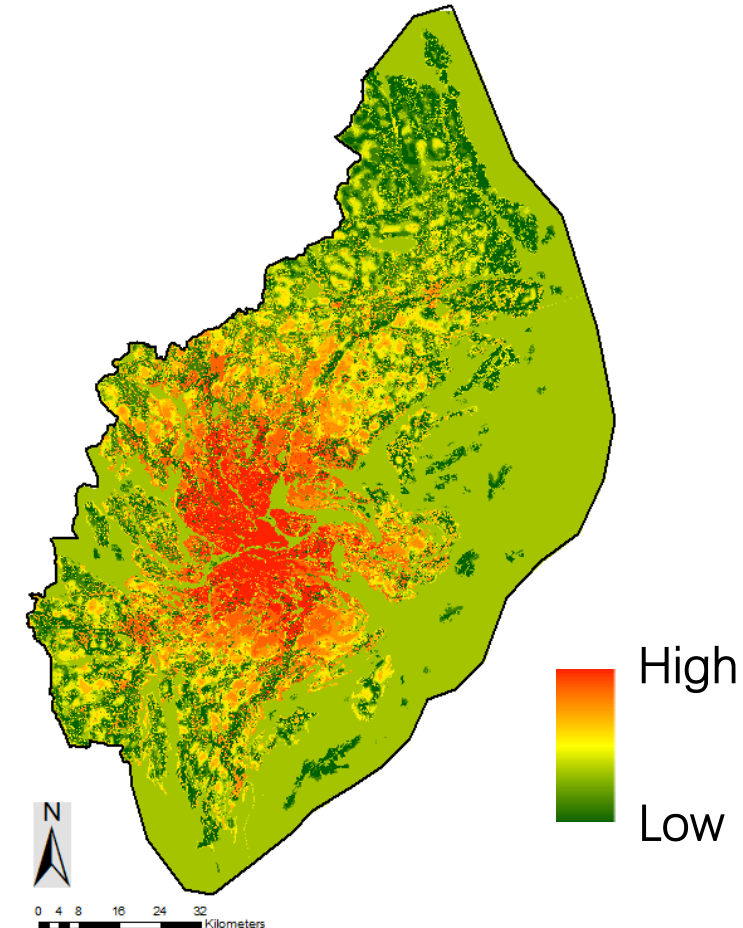Low
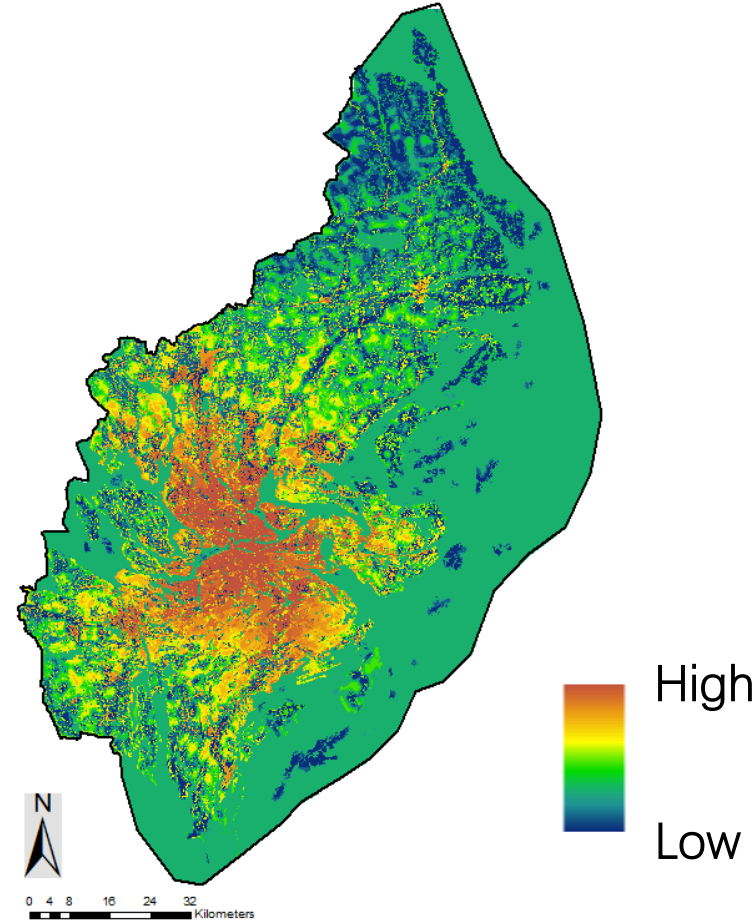
Probability of residential growth

Forecast Probability of Urban Development

1. Calibrating Model

2. Forecasting

3. Relate Future Land Use to Ecosystem Impacts

4. Policy intervention with NBS

5. Test Policy Instruments

Low development low ecosystem services

High development low ecosystem services

Low development high ecosystem services

High development high ecosystem services

High

Low

Probability of commercial growth

Ecosystem service value accounting

Policy Interventions with NBS

1. Calibrating Model

2. Forecasting

3. Relate Future Land Use to Ecosystem Impacts

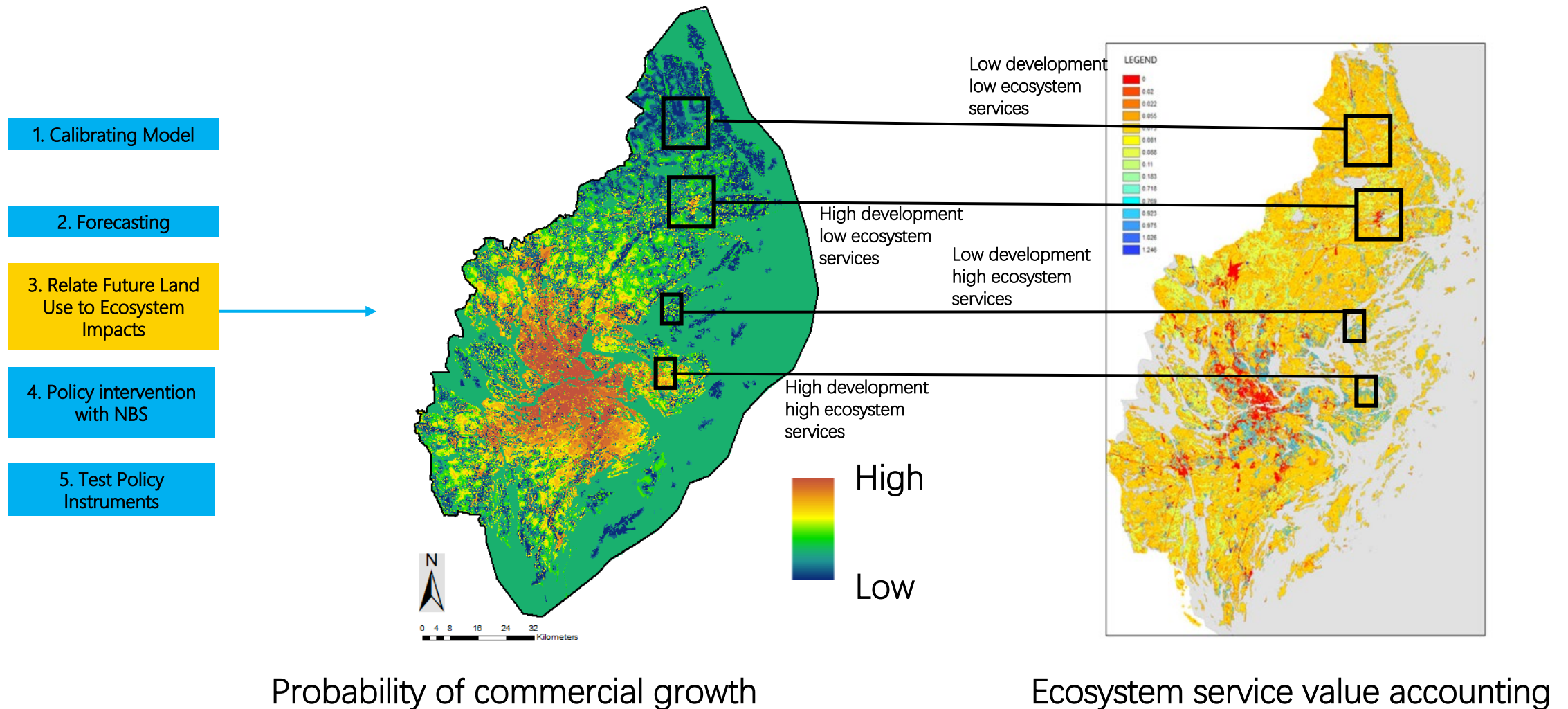4. Policy intervention with NBS

5. Test Policy Instruments

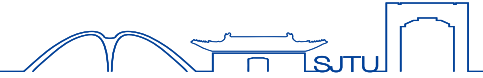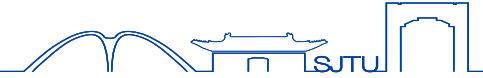- **For high development high ecosystem services areas:** ecosystem services need to be protected with natural buffers to avoid future development (such as greenbelt); also other strategies need to be used to attract these developments to other areas.

- **For high development low ecosystem services areas:** these areas need to be provided with artificial forestry&greening and recreational activity opportunities in the limited ecosystems.

Policy Interventions with NBS

1. Calibrating Model

2. Forecasting

3. Relate Future Land Use to Ecosystem Impacts

4. Policy intervention with NBS

5. Test Policy Instruments

- **For low development high ecosystem services areas:** These trends are preferred and should be implemented in planning

- **For low development low ecosystem services areas:** ecosystem services should be designed with better recreational opportunities to attract growth that were to occurred at high ecosystem service areas.
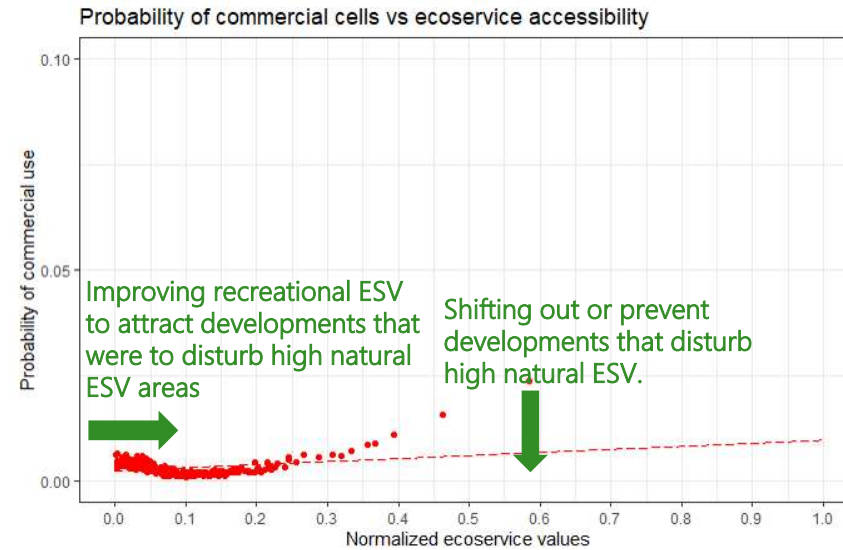
Policy Interventions with NBS
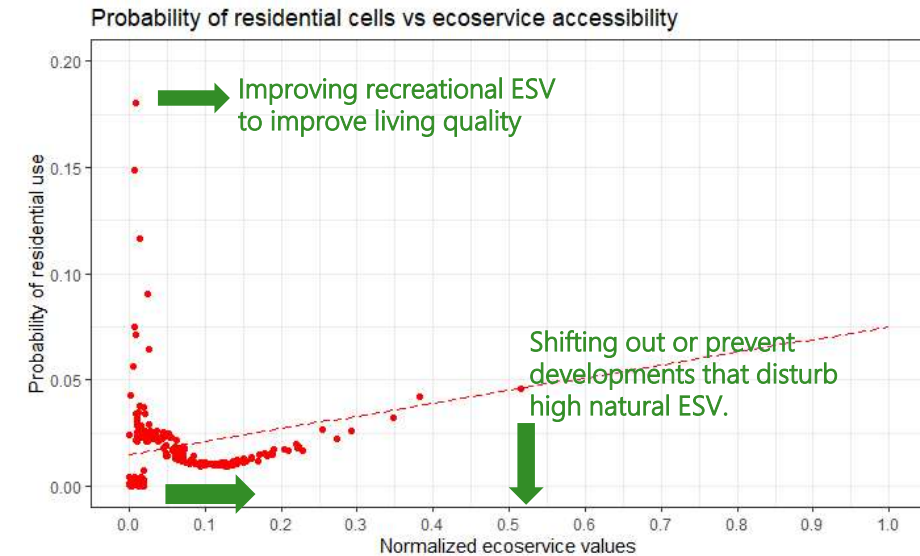
1. Calibrating Model

2. Forecasting

3. Relate Future Land Use to Ecosystem Impacts

4. Policy intervention with NBS
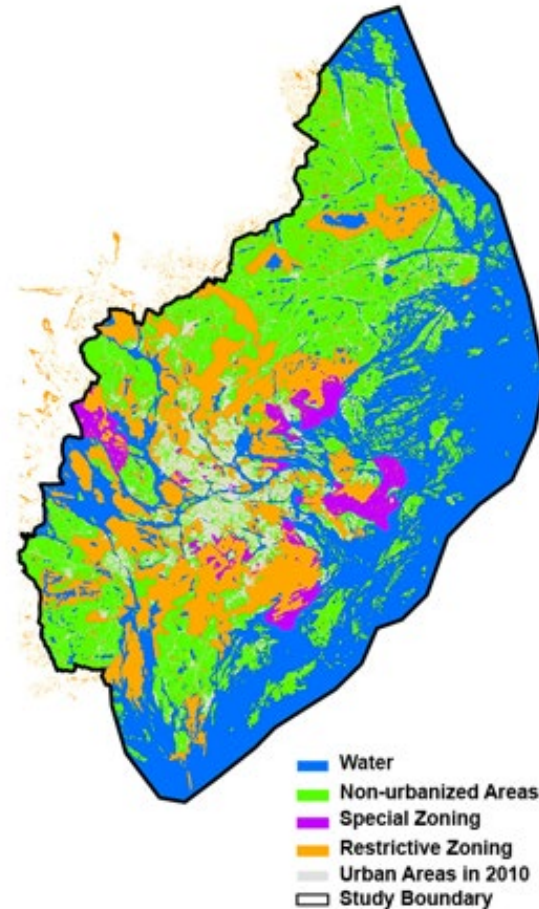
5. Test Policy Instruments

Example NBS interventions

Probability of commercial cells vs ecoservice accessibility

Improving recreational ESV to attract developments that were to disturb high natural ESV areas

Shifting out or prevent developments that disturb high natural ESV.

Probability of residential cells vs ecoservice accessibility

Improving recreational ESV to improve living quality

Shifting out or prevent developments that disturb high natural ESV.

Improving recreational ESV to attract developments that were to disturb high natural ESV areas

Test policy instruments (to be cont…)

1. Calibrating Model

2. Forecasting

3. Relate Future Land Use to Ecosystem Impacts

4. Policy intervention with NBS

5. Test Policy Instruments

Water
Non-urbanized Areas
Special Zoning
Restrictive Zoning
Urban Areas in 2010
Study Boundary

Preventive Zoning

+

Photo courtesy of timeout.com

Design, Forestry + greening, green belt