Developing Testable Hypotheses with Compelling Conceptual Framework

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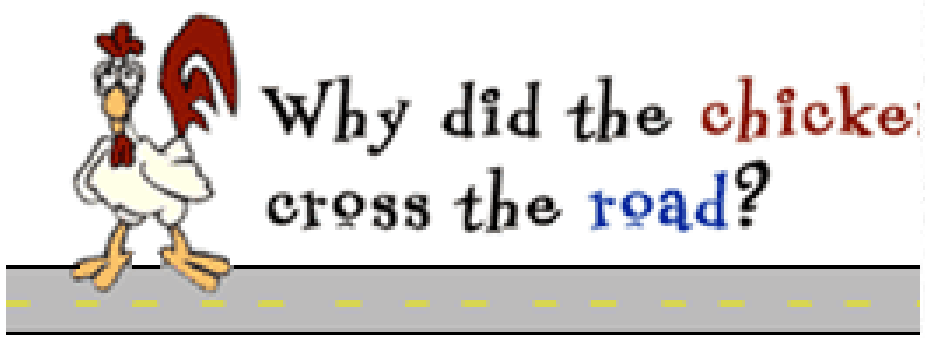
The 16th USCCC Annual Meeting
Inner Mongolia; July 25, 2019

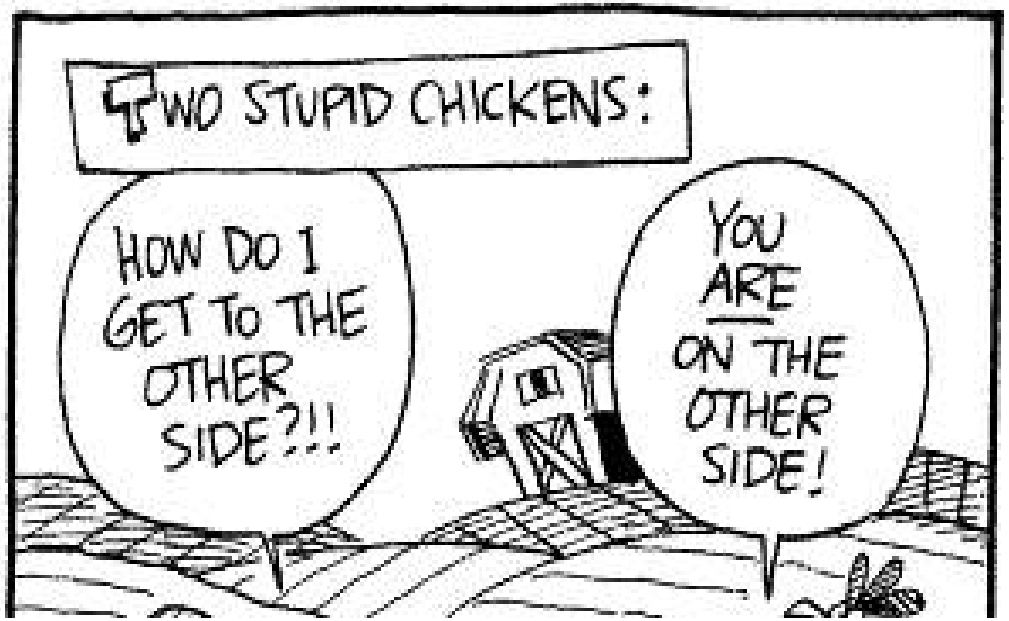
Questions, Hypotheses & Conceptual Frameworks

- Modern science is advan
  hypotheses!
- A hypothesis isn't an edu
  observation, phenomen
  further investigation.
- Hypothesis is often too g
  or a statement of truth!
- Developing testable hyp
  landscape research is pe

Scientists have discovered that the moon is moving away from the earth at a tiny yet measurable distance every year. If you do the math, you can calculate that 85 million years ago the moon was orbiting the earth at a distance of about 35 feet from the earth's surface. This would explain the death of the dinosaurs. The tallest ones, anyway....

There's Science and There's Sound Science...





- ✓ To cross or not to cross, that is the question (Shakespeare)
- ✓ Why would he be one a road, I thought chickens lived in the ocean? (Jessica Simpson)
- ✓ This is not about whether inspectors made sure the chicken crossed the road, it's about the willingness of the chicken to cross the road voluntarily (Colin Powell)
- ✓ It was the logical next step after coming down from the trees (Darwin)
- ✓ The news of its crossing has been greatly exaggerated (Mark Twin)

Example I: Bridgham, S. J. Pastor, and J. Chen. 1997. National Science Foundation

Global Warming and Ecosystem Responses in Peatlands

- Feedback between biotic processes and climate
- Alteration of energy flows through an ecosystem
- Relationship between energy flows & biotic processes

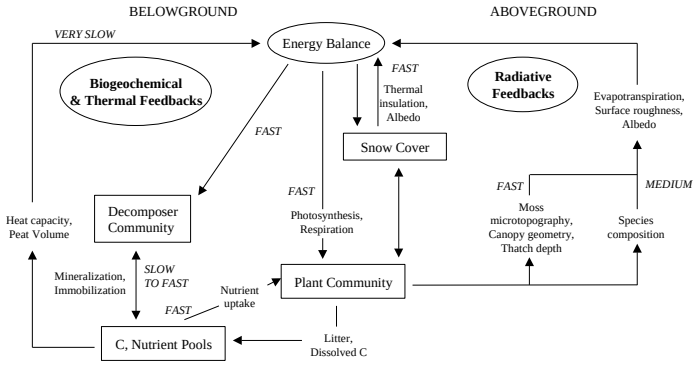
Develop hypotheses

This complex behavior suggests two hypotheses to be tested by our current mesocosms:

- As the water table rises or falls, peat either accumulates or decays, respectively, until it's thickness *H* reaches a new equilibrium with the water table;

- There will be alternative stable states of peat thickness (*H*) and water-table depth (*W).*

A conceptual model of feedbacks among ecosystem energy balance, plant community structure, snow cover and carbon and nutrient pools in peatlands.



HYPOTHESIS

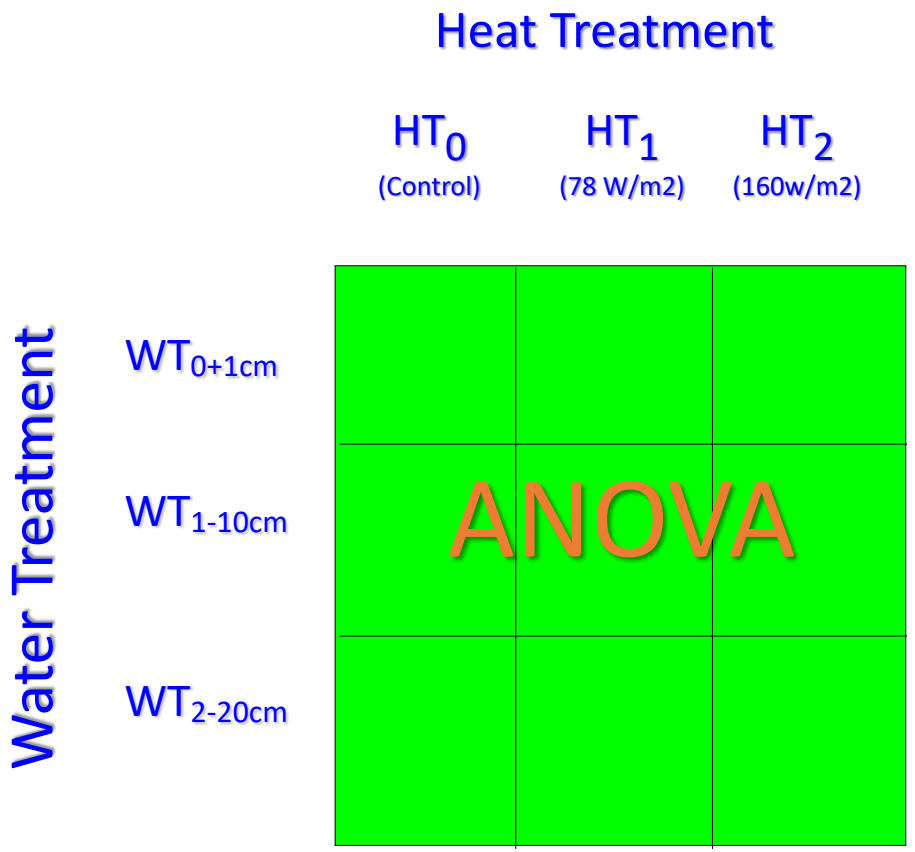
Climate forcing of heat loading and water-table depth determine plant community and ecosystem structure in northern peatlands, which in turn have a feedback effect on the thermal and radiative energy budgets of the system.

Experimental Design

The Mesocosm Facility

54 minimally disturbed soil monoliths of 2.1 m^2 (85 cm in diameter) surface area, 60-cm depth placed in insulated plastic tanks in a large field.

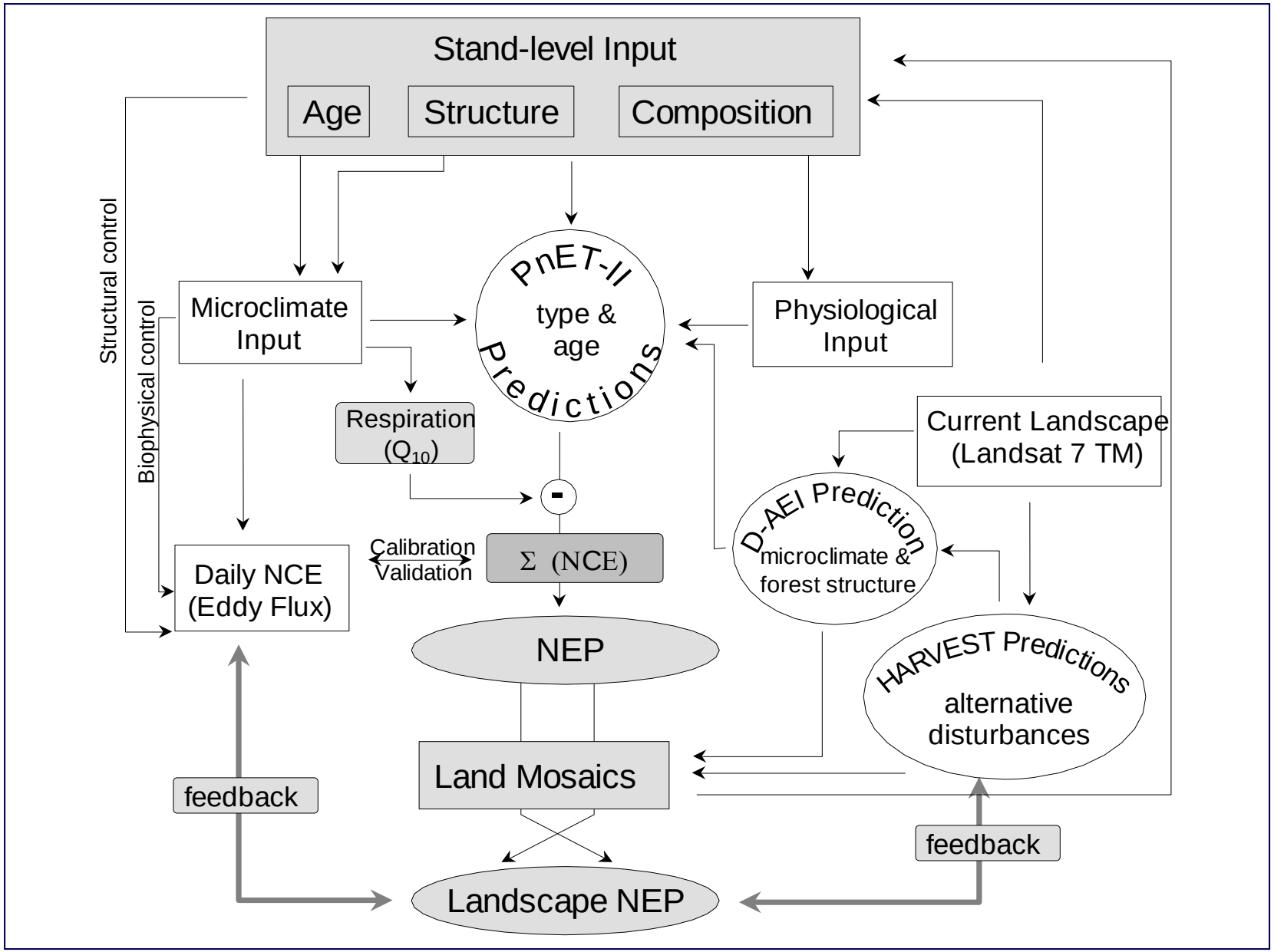
Peatland Types: bog & fen



Example II: Objective

To enhance understanding of landscape-level carbon exchange in disturbed land mosaics, taking into specific consideration of age structure and the area-of-edge-influences (AEI), which can be considerable in many fragmented landscapes. We use a combination of **flux towers, biometric estimation, chamber measurements (P_s & R), RS products and ecosystem modeling.**

Conceptual Framework



Hypothesis

Our central hypothesis is that the cumulative NEP of a landscape is determined by the land mosaic; that is, the various ages and types of ecosystems present, as well as their arrangement.

RESEARCH COMPONENTS

- **Flux Towers:** 2 permanent, 3 mobile (10 ecosystems so far, excluding the JP in UP)
- **Microclimate**: 11 stations
- **Biometric estimation:** overstory, litter, soil, CWD, etc.
- **Landsat TM**: empirical models
- **Modeling (**PnET): soil, vegetation, climate, foliar N, SLW, NDVI/LAI, etc.

Example III: Hypotheses

AEI and AMEI support different functional groups. Their ontributions to the cumulative species pool at the landscape level exceeds their proportional area in the landscape. This can be stated as:

$$\frac{Area_i}{\sum_{i=1}^{n} Area_i} \neq \frac{\sum_{Area_i} (species)}{\sum_{i=1}^{n} \left[\sum_{Area_i} (species) \right]}$$

Chen et al. 2001

Example IV: Coupled Natural and Human Systems (CHN)
NH on Mongolia Plateau

Objective: to examine and model the interactive changes of the *NS* and *HS* at different temporal and spatial scales for use in recommending plans to increase the success of ecosystem and human adaptation to the changing climate and land use on the Mongolian plateau. Specifically, we aim to understand how global climate and land-use change regulate both biophysical and socioeconomic functions by exploring the major underlying processes and conducting a vulnerability analysis pertaining to IM, MG, and the plateau.

Chen et al. 2008

Example IV: Coupled Natural & Human Systems (CHN) on Mongolia Plateau

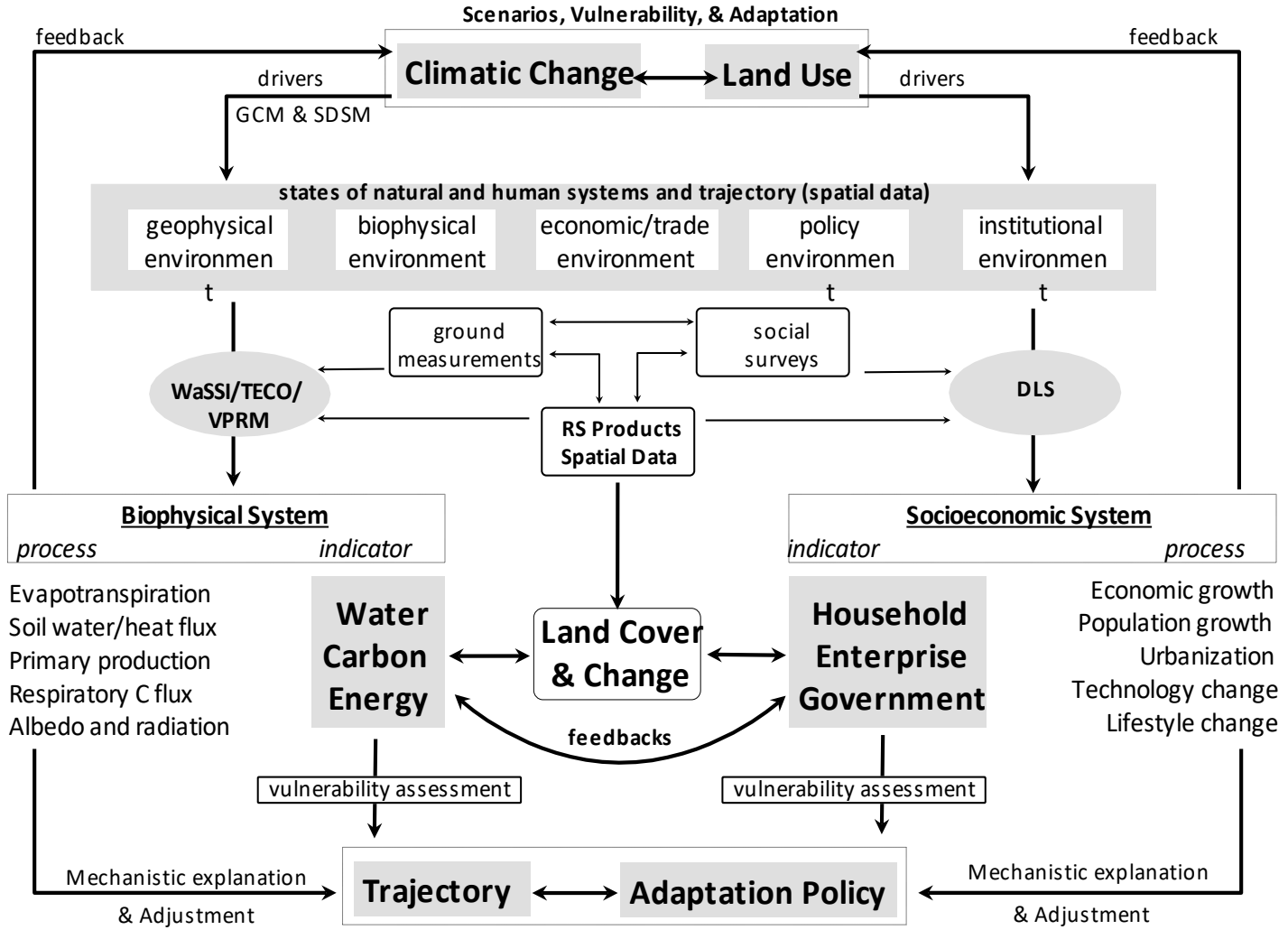


Figure 2. Proposed research components and their linkages for process-based predictions of the ***HS*** and ***NS*** on the Mongolian Plateau using "Land Cover & Change" as the intermediate variable. Five environmental variables through ground/field measurements and/or satellites will be used as the primary input for biophysical (WaSSI/TECO/VPRM) and a socioeconomic (DLS) models to predict system functions. The statistical downscaling modeling (SDSM) will be used to predict future local climate (county level) from GCM predictions. Vulnerability analysis will be performed using Bayesian models for trajectory and developing adaptation plans.

Example IV: CNH on Mongolia Plateau

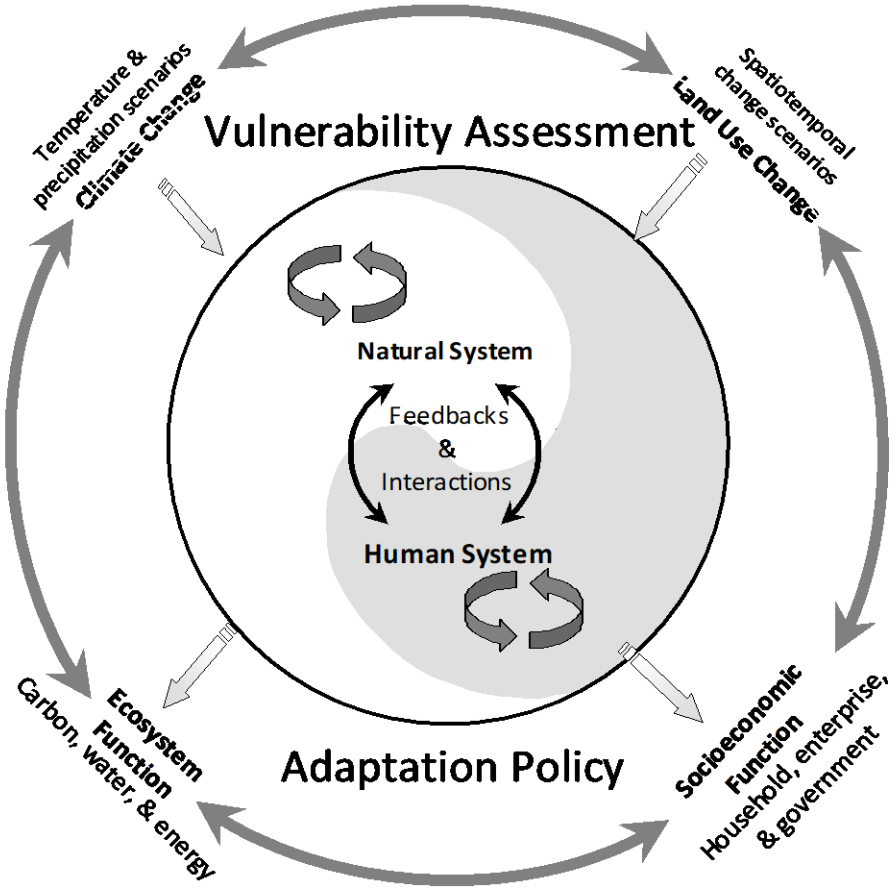
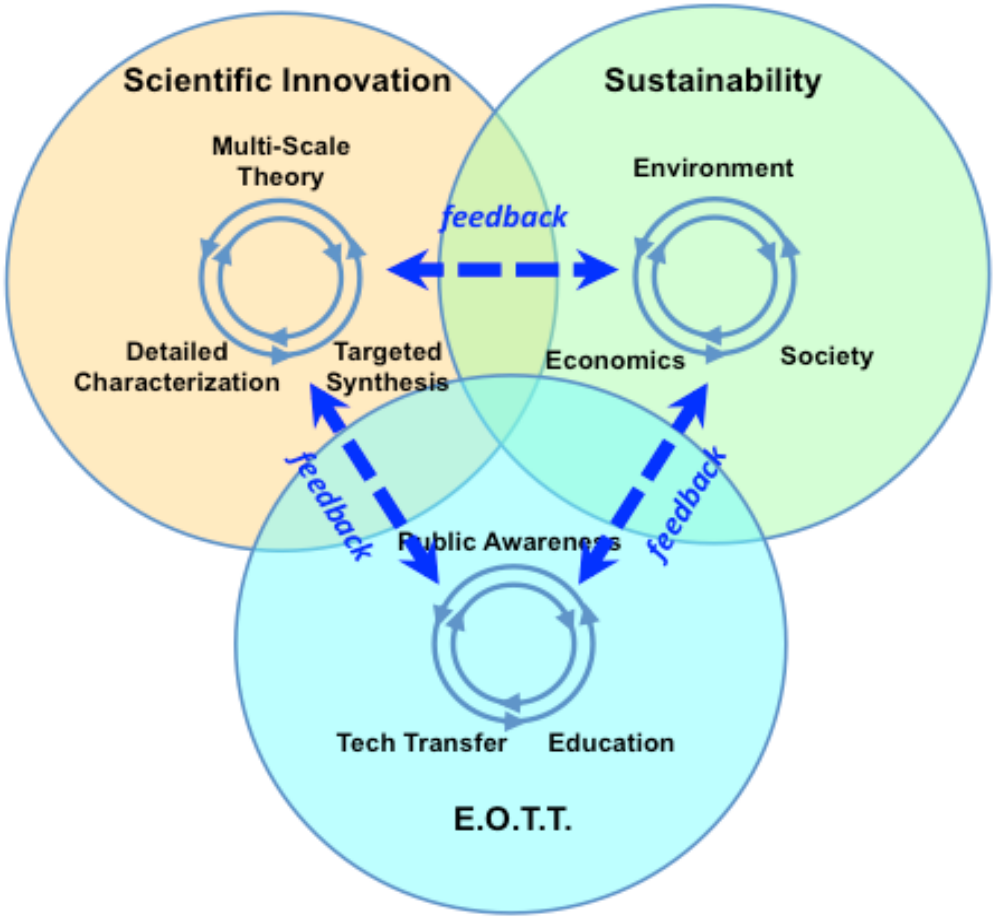


Figure 1. Conceptual framework to examine the coupled effects of climatic change (variability) and socioeconomic shifts on the interactions and feedbacks within and between the ***HS*** and ***NS***.

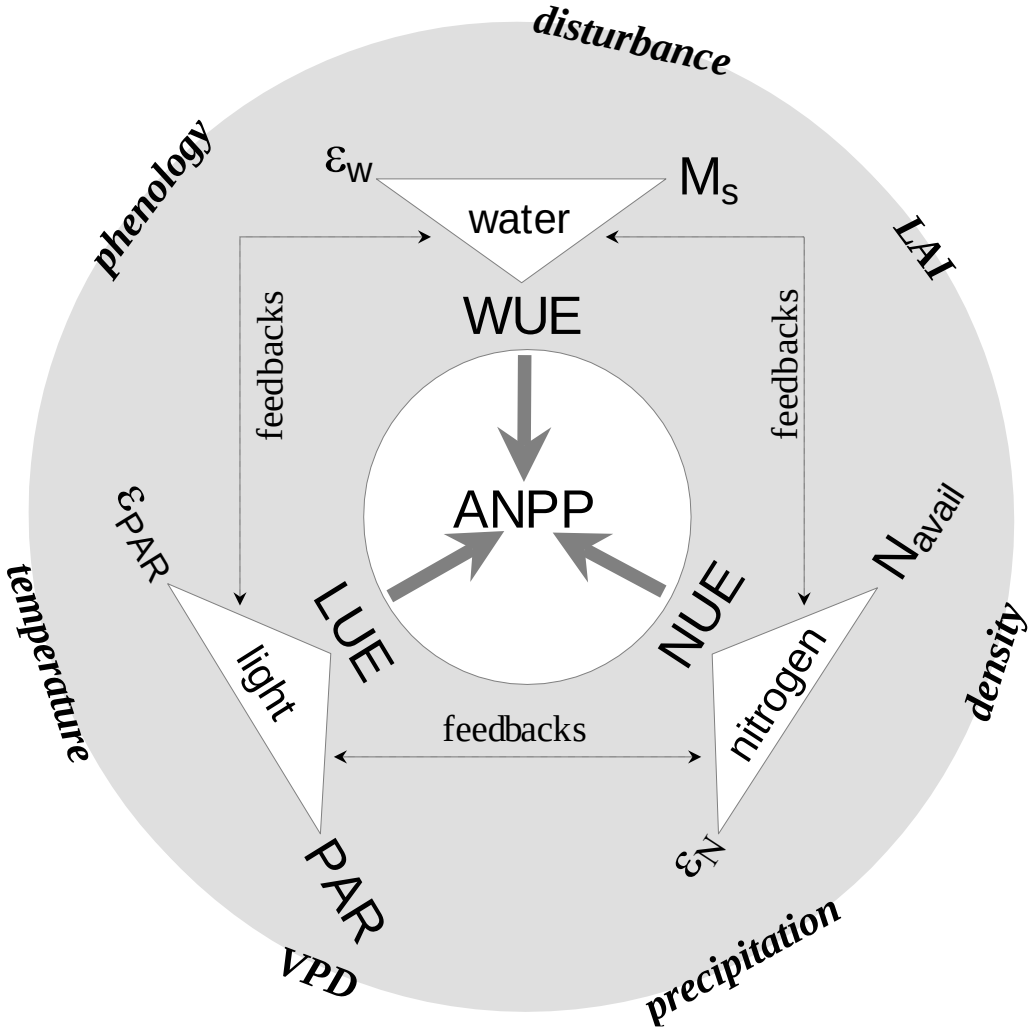
Chen et al. 2008

Example V: The Conceptual Framework for Sustainable PV System

We hypothesize that the trade-offs among the options of sustainable aspects may be off-balance or might appear to compete over short timelines, but could positively correlate over long time scales. This transformative research will assure the development of a truly sustainable PV technology.

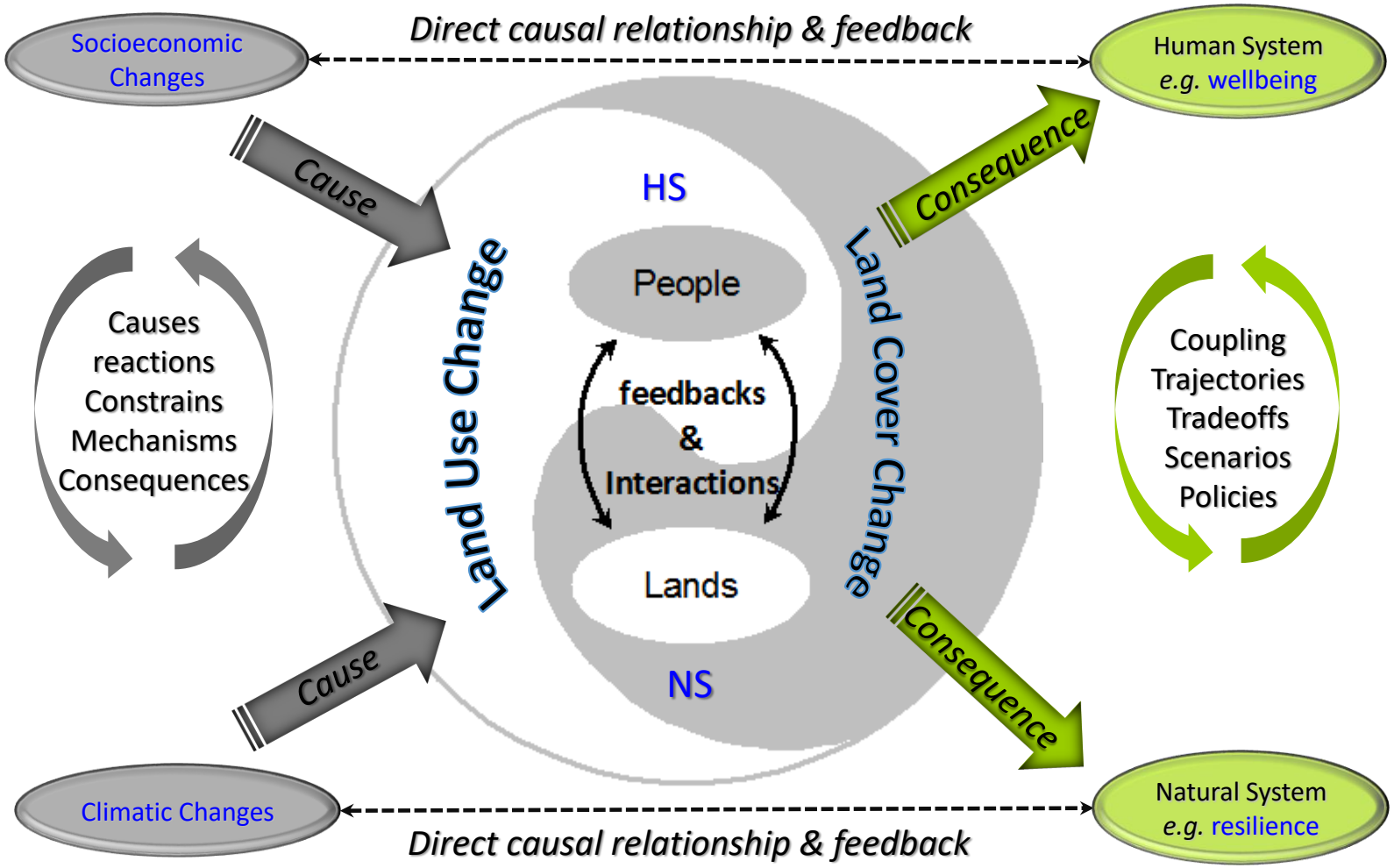


Example VI: Multiple resource use (mRUE) in bioenergy systems

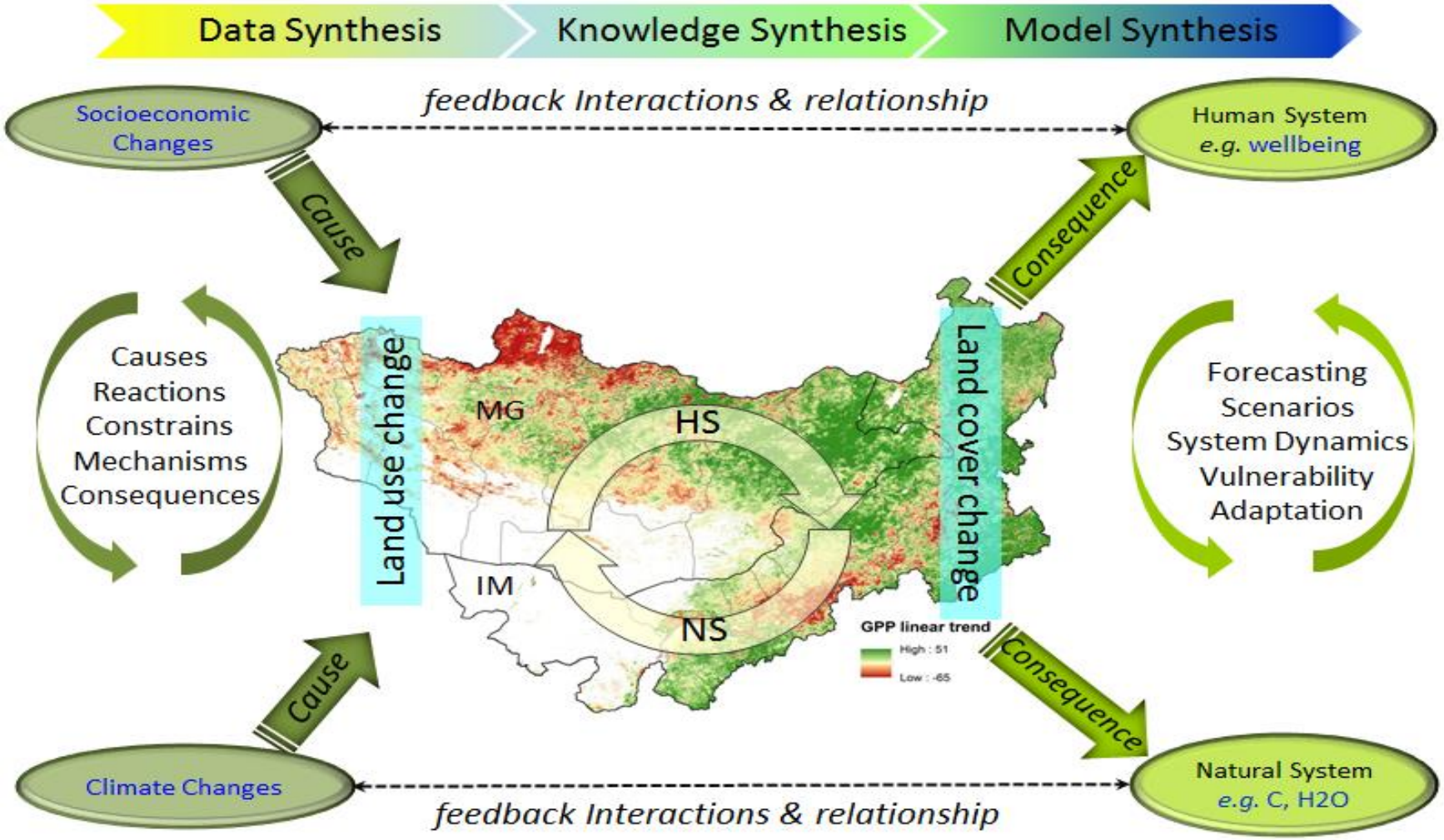


A new concept of resource use and limitation by Chen will be applied. Within the matrix of the biophysical environment (soil, vegetation and microclimate), the resource use matrix of [ε, RUE, R_{avail}] and their complex interactions determine the magnitude and dynamics of production. For each type of resource, there exist complex interactions among [ε, RUE, R_{avail}] at various temporal scales. Alteration of any element of the resource use matrix will trigger changes in other elements. We will examine the feedback among the elements with a focus on water, light and nitrogen (N).

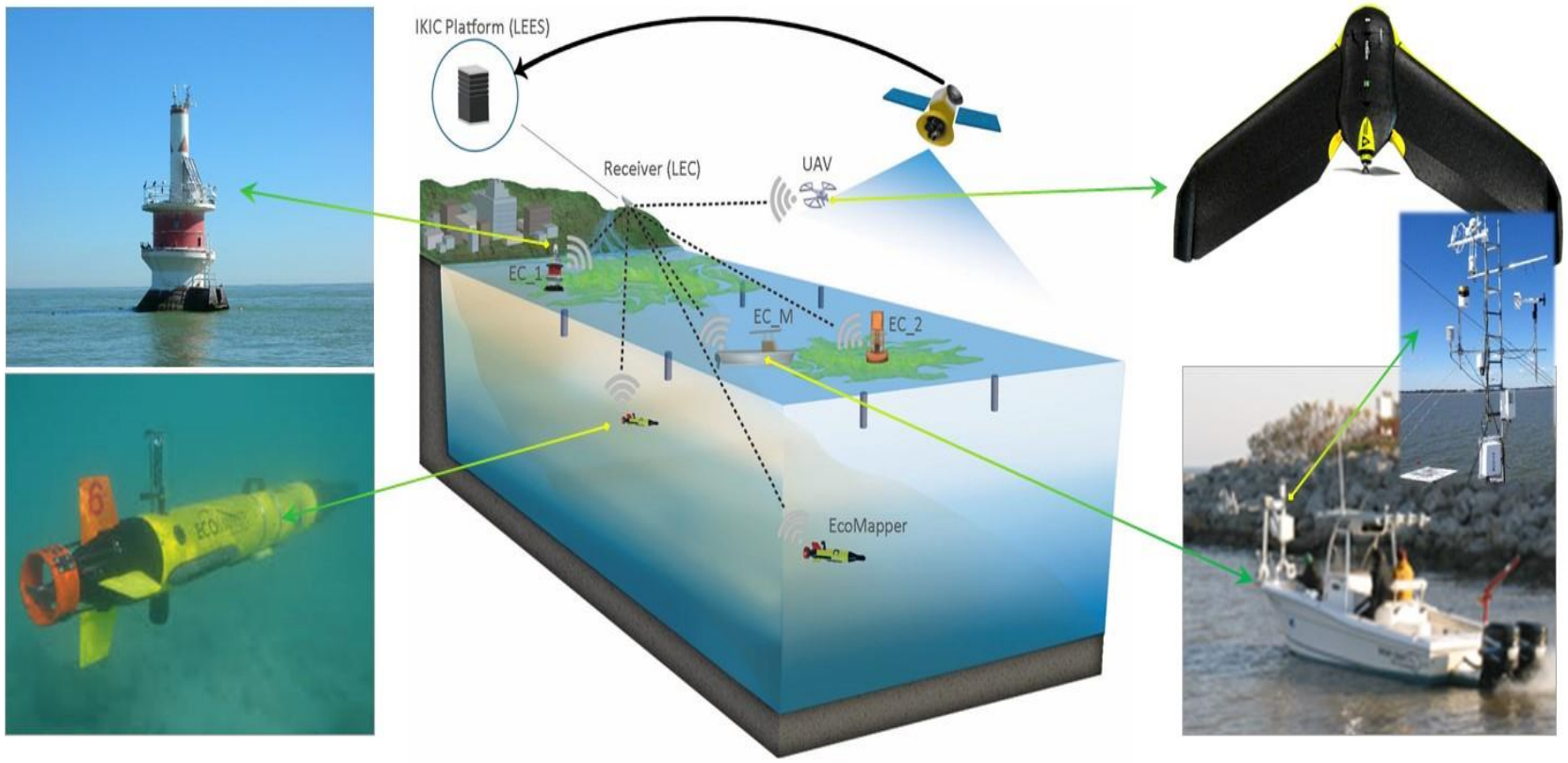
Drivers and Functions as Moving Targets (i.e. focus on the changes)



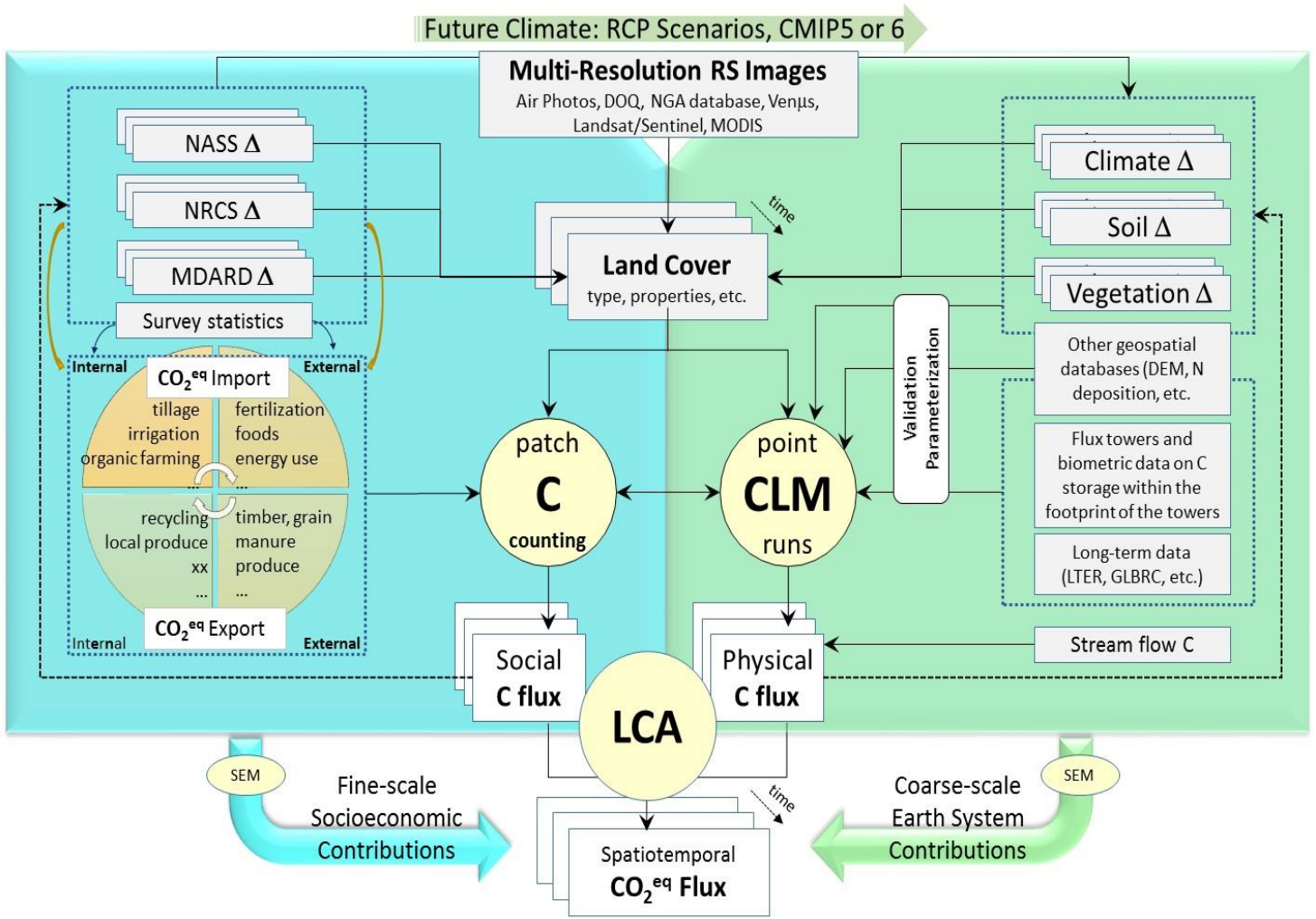
Develop hypotheses: CNH conceptual framework to understand the drivers, mechanisms, and consequences of socioeconomic and physical **changes** on the functional **changes** of the HS and NS on the Plateau. LUC and LCC will be considered as the intermediate variables facilitating the causal.



An integrated water-air sensor network for measuring and modeling the spatiotemporal changes in F_{CO2}, E, H, and the ancillary variables in WLEB will be implemented for this study. This network includes two permanent eddy-covariance (EC) systems (EC_1, EC_2) on fixed infrastructures, a mobile EC vessel (EC_M) mounted on LEC R/V Mayflies, two underwater automated vesicles (EcoMappers) owned by NOAA collaborators, an unmanned aerial vehicle (UAV) for high resolution remote sensing, nine long-term sampling locations for water quality, multiple satellites, and an Information, Knowledge Innovation Cloud (IKIC, Fig. 7).



Proposed research components and their linkages for process-based predictions of the spatiotemporal changes in CO_2^{eq} production that will be quantified by estimating "social C flux", and "physical C flux" at contrasting landscapes (i.e., different land cover compositions) within the Kalamazoo Watershed as well as the entire watershed. Life cycle assessment (LCA) will be employed for major patch types to quantify the C production at different temporal scales. The statistical downscaling modeling will be used to predict future local climate from RCP scenarios. Bayesian structural equation models (SEM) will be constructed to explore the contributions of climate change and human activities.



Chen et al. 2016