

Nature-based solutions



Assessing Socio-Ecological Systems (SES) Modeling Approaches for Fuelwood Harvesting in Mangroves of the Keta Basin

The Keta Basin Context-The Keta Lagoon Complex Ramsar Site (KLCRS) is the largest wetland in Southeastern coast Ghana, covering approximately 1,200 km². The lagoon complex is characterized by swamps, scrublands, and mangrove forests, which serve as vital ecological and socio-economic Hub for six districts in the Volta Region.

Mangrove ecosystems in the Keta Basin are vital socio-ecological assets, providing fuelwood, fisheries support, and coastal protection. However, increasing fuelwood harvesting has led to degradation, threatening both ecological integrity and community livelihoods.

Understanding this dynamic requires an integrated approach that captures feedbacks between ecological processes, governance systems, and human behavior. The Socio-Ecological Systems (SES) framework, developed by Ostrom (2009), offers a structured lens to analyze these interactions.

This project will assess and compare qualitative and quantitative SES modeling approaches to determine which better represents sustainability thresholds for fuelwood harvesting in mangrove ecosystems.



Mangrove Forest at Keta Basin

Research Objectives

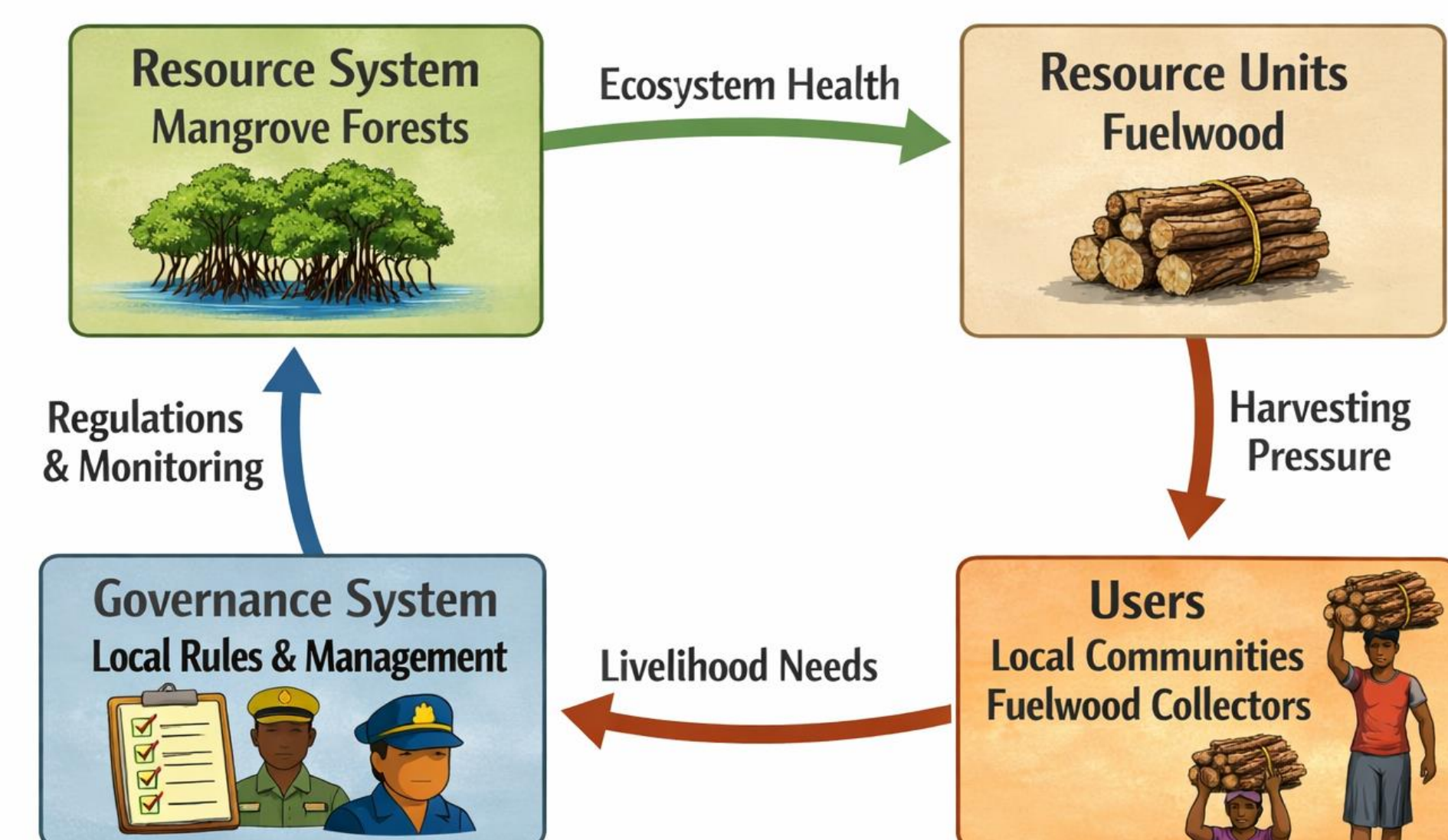
1. Map mangrove extent and degradation using satellite-based land-use/land-cover analysis.
2. Characterize fuelwood harvesting patterns through community surveys and local governance data.
3. Develop SES models linking ecological, social, and institutional components.
4. Identify sustainability thresholds and propose management strategies for sustainable exploitation.

Methodology

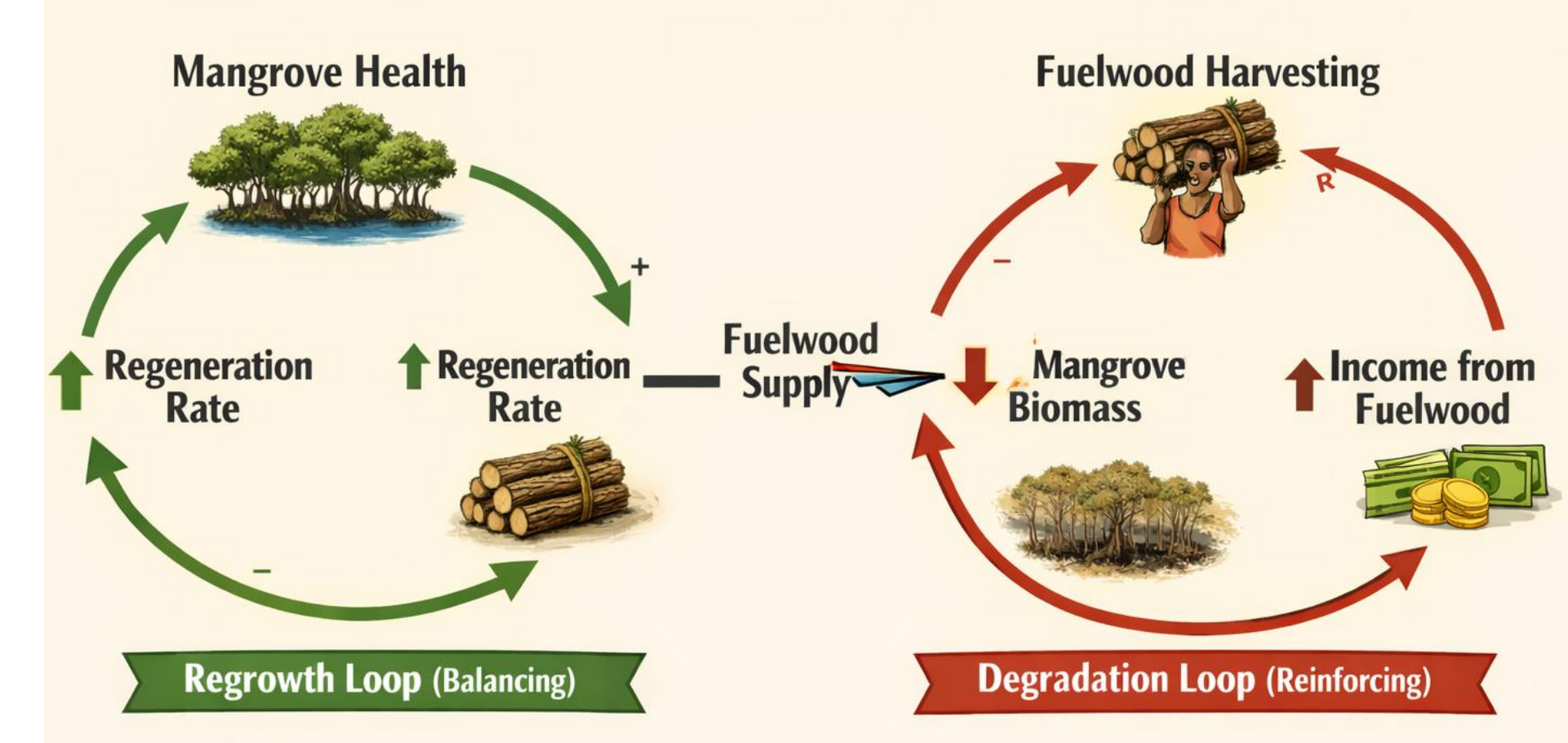
A. Data Collection

1. **Remote Sensing:** Use Landsat and Sentinel-2 imagery processed in Google Earth Engine.
2. Map mangrove extent and detect degradation trends over time.
3. **Field Validation:** GPS ground-truthing and drone imagery for canopy density and biomass estimation.
4. **Socio-Economic Data:** Structured interviews with local households and community leaders on harvesting frequency, fuelwood demand, and governance enforcement

SES Framework for Fuelwood Harvesting in the Keta Basin



Causal Loop Diagram of Fuelwood Harvesting in the Keta Basin



B. Modeling Approaches

• Causal Loop Diagram

Visualize feedbacks between harvesting pressure, mangrove health, and livelihood dependency. Identify reinforcing and balancing loops that drive degradation or recovery.

• System Dynamics Model

Quantify biomass growth and harvest rates using stock-flow equations.

Simulate scenarios to identify sustainable harvest thresholds

C. Assessment

Compare both models for their ability to capture socio-ecological feedbacks, predict sustainability outcomes, and inform policy decisions

Timeline (6 Months)

- a. Literature review and SES framework design
- b. Satellite data acquisition and preprocessing
- c. Field validation and community interviews
- d. Build causal loop diagram
- e. Develop system dynamics model
- f. Report writing, and research journal

Expected Outcomes

1. Spatial maps of mangrove extent and degradation.
2. SES diagrams illustrating ecological–social feedbacks.
3. Identification of sustainable harvest thresholds.
4. Policy recommendations for community-based mangrove management