Ecosystem Service Accounting for Development: Valuing Pollination Services

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Expert meeting on Ecosystem Valuation
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Overview

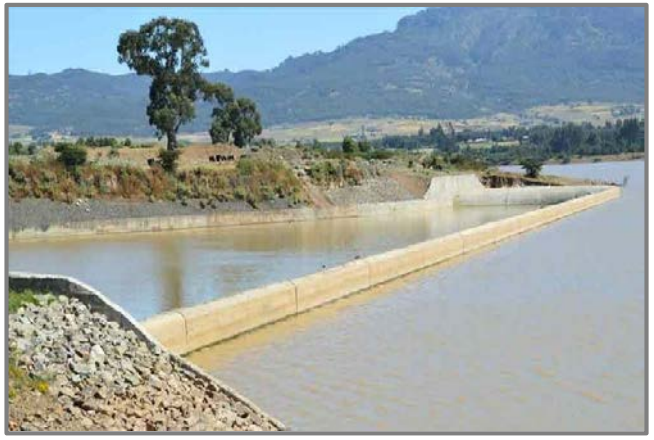
- Ecosystem Service Accounting for Development (**ESAFD**)
- **5 year multi-country** research collaboration (2015-2019)
- Funded by **Swedish International Development Cooperation Agency** (SIDA)
- Siikamäki, Academic PI

Purpose and Objectives

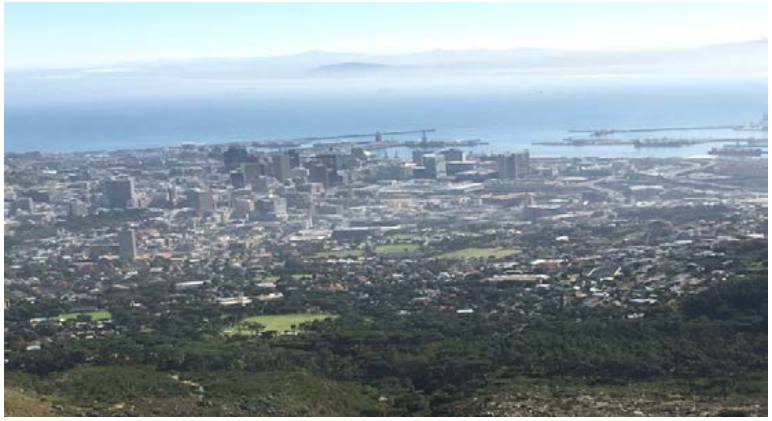
- Policy-relevant valuation of ecosystem services in developing countries
- Address spatial heterogeneity of the value of ecosystem services
- Contribute towards the development of environmental-economic accounting framework
- Advance current knowledge in
  - Natural resource management
  - Understanding of ecosystem services

Three Ecosystem Services

Crop pollination



Water purification



Urban green amenities

Seven countries

Partner Institutions

Crop Pollination
Background and Motivation

- **Pollination**
  - Transfer of pollen to fertilize the ovaries of flower
  - Some plants are self-pollinated or wind-pollinated
  - Most flowering plants require *pollinators* to produce fruit and seed

- **Pollinators include wild bees, honey bees, other insects, vertebrates**

- **Many agricultural crops require help from pollinators**
  - Wild pollinators key to agricultural production
    - Roughly 75% of the world's food crops depend at least partially on pollination, with annual value between $235 billion and $577 billion (Garibaldi et al. PNAS 2011; FAO)
    - Bees pollinate about a third of food crops consumed
    - Kleijn et al. (*Nature Communications* 2015): wild bees contribute over $3000 ha^{-1}, on average
  - Pollinators improve both quantity and quality of agricultural yields

- **Pollinators are exceedingly threatened and declining**
  - Agriculture intensification and pesticide use
  - Habitat degradation and loss reduce food and nesting resources
  - Climate change
  - Bee keeping practices and diseases
  - Air pollution

Economic Valuation of Crop Pollination Services

- **Pollination dependency ratios**
  - Widely used method (e.g. Kleijn et al.)
  - Involves determining to what extent different crops depend on pollinators
    - Measure yields in absence of pollinators
    - Various dependency ratios: none, <10%, 10-40%, 40-90%, over 90%, complete dependency
  - Crop prices multiplied by their yields and dependency ratios determines the value of agricultural production dependent on pollinators
  - Informative approach
  - All-or-nothing approach limits applicability when the availability of pollinators declines by less than 100%

- **Production function approach**
  - Economists view agricultural production as a process combining different resources, such as land, water, seed, labour, fertilizers, and so forth
  - On the margin, most inputs are to some extent substitutable
  - Farmers also adapt by changing crop mix
  - For example, if the price of labour goes up, farmer may increase fertilizer use or move to a less labour intensive crop
  - Economic value of the input can be determined as the change in profit relative to change in input, after adjusting for all adaptation in input use and crop mix

Study Purposes

- **Develop a conceptually consistent economic valuation approach**
  - Production function method

- **Measure study crop pollination in "real" production systems**
  - Available evidence regularly from experimental settings, specific places
  - Controlled experiments helpful but can involve limitations in generality
  - Evaluating actual farming environments helps
    - account for varying environments and farmer adaptation
    - generate complementary evidence of the importance of pollination

Production Function Approach

- $y = \mathrm{f}(\mathbf{x}, \mathrm{q}(\mathrm{h}), \mathrm{k})$

  where

  y is agriculture output

  $\mathbf{x}$ is a vector of inputs and costs

  $\mathrm{q}(\mathrm{h})$ is the pollination service

  h is the availability of pollinator habitat

- Profit = price * y – production costs
- Value of pollination $\partial Profit/\partial q = price\ (\partial y/\partial q)$

Pollination Dependent Tanzanian Small Holder Farm

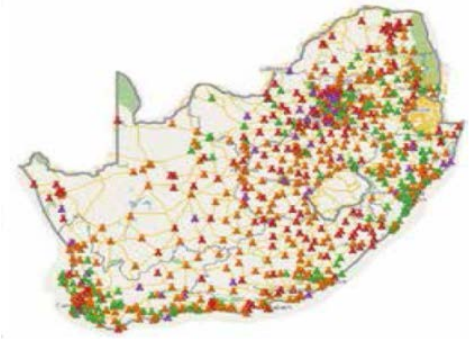
Water for Crops

Family labor

Diversified Crop Portfolio

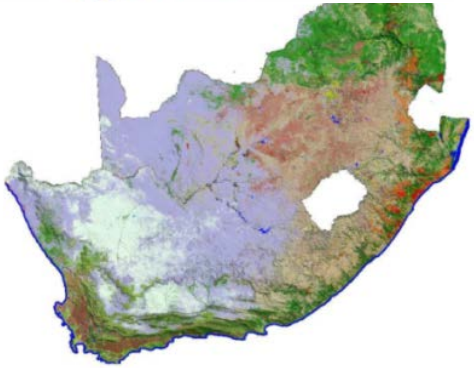
General approach

Plot level data on agricultural production over time



2008, 2010, 2013

Land cover over time

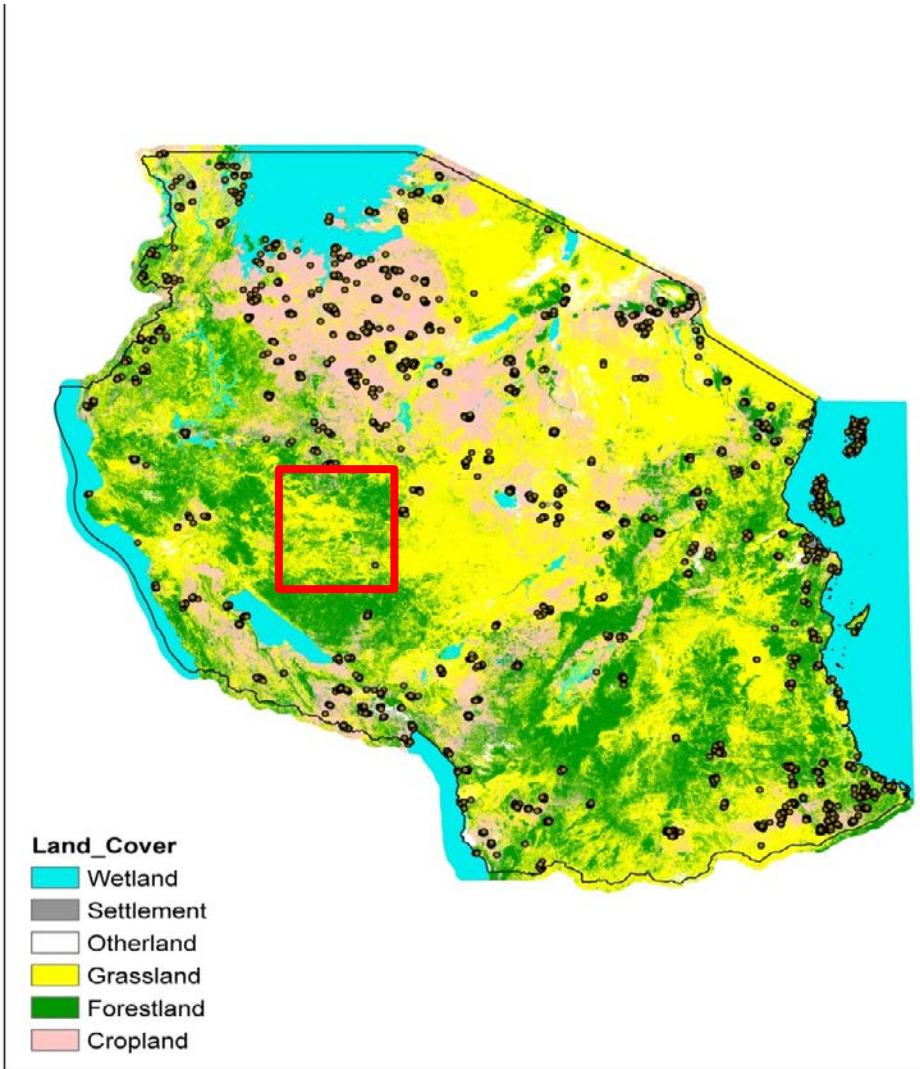


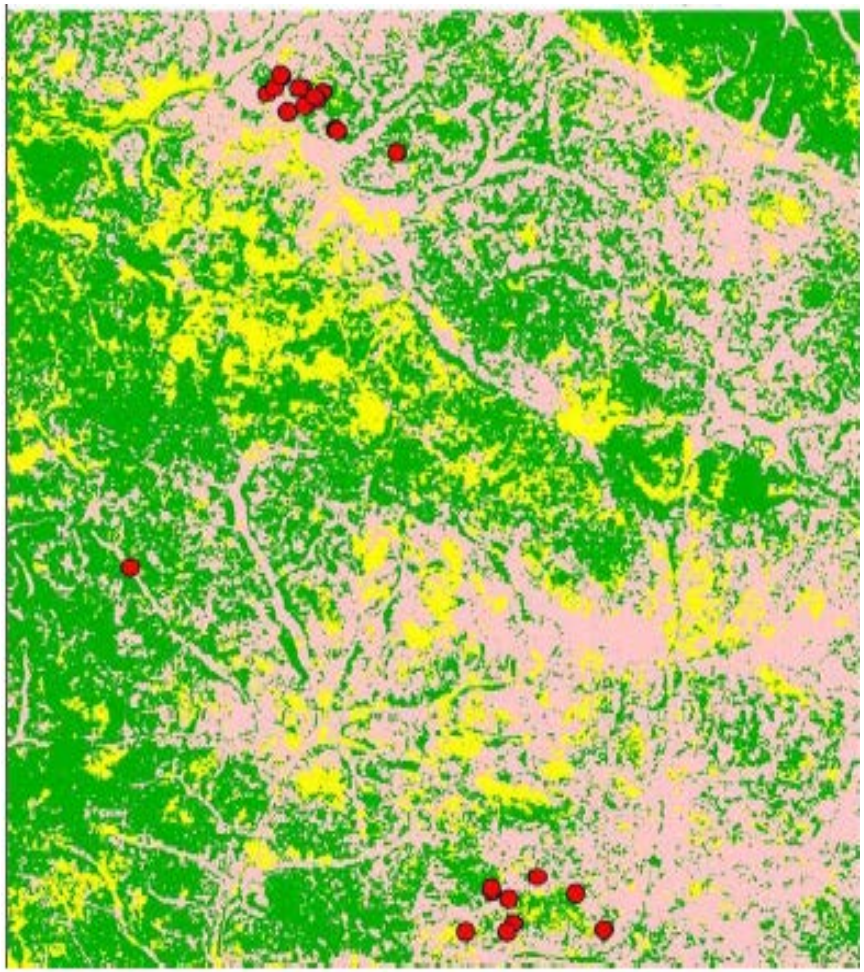
Statistically measure contribution of ecosystems to economic activities

Agricultural Data in Tanzania

Tanzania National Panel Survey

- National representative survey
- 3 waves - 2008, 2010 & 2013
- About 2000 households and 4500 plots





Measuring Outcomes in Agriculture

- **Total revenue per hectare**
  - Pollinator dependent crops (FAO assessments)
  - Pollinator independent crops

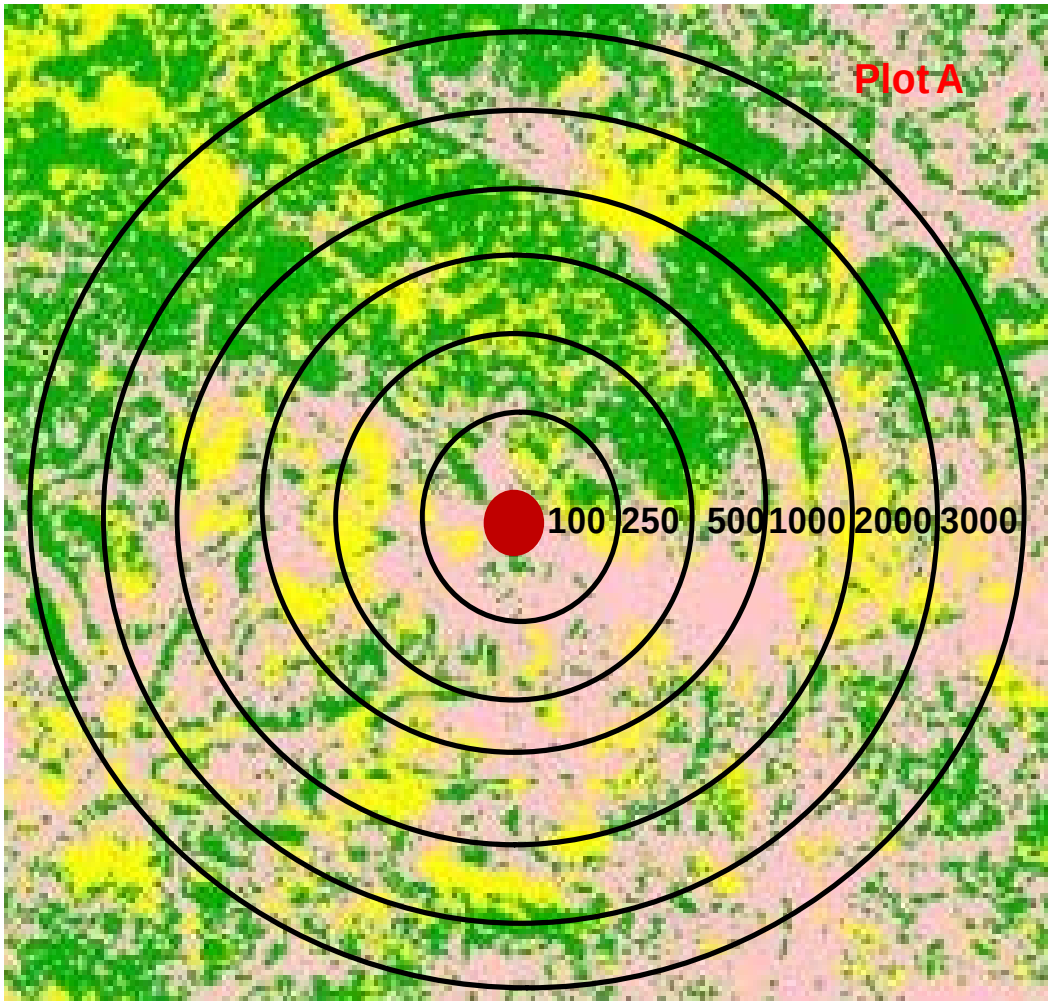
Sisal

Banana

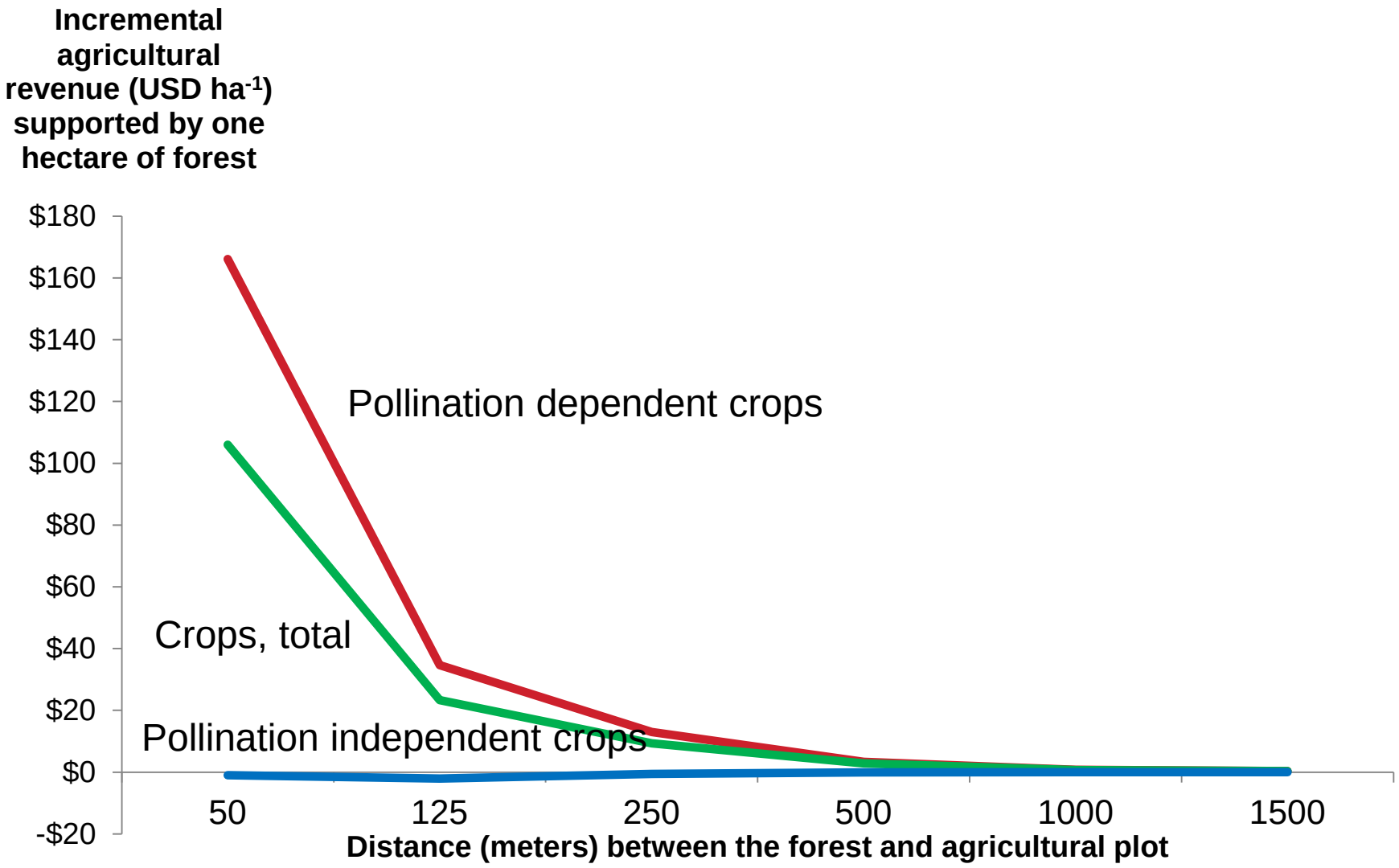
Multiple crops

Measuring Pollinator Habitats

- Relatively undisturbed ecosystems provide shelter and nesting areas for pollinators
- Pollinator foraging declines with increases in distance (flight)
- We examine how forest ecosystems near to and farther from agricultural fields support crop pollination services



Value of Crop Pollination Services from Forests



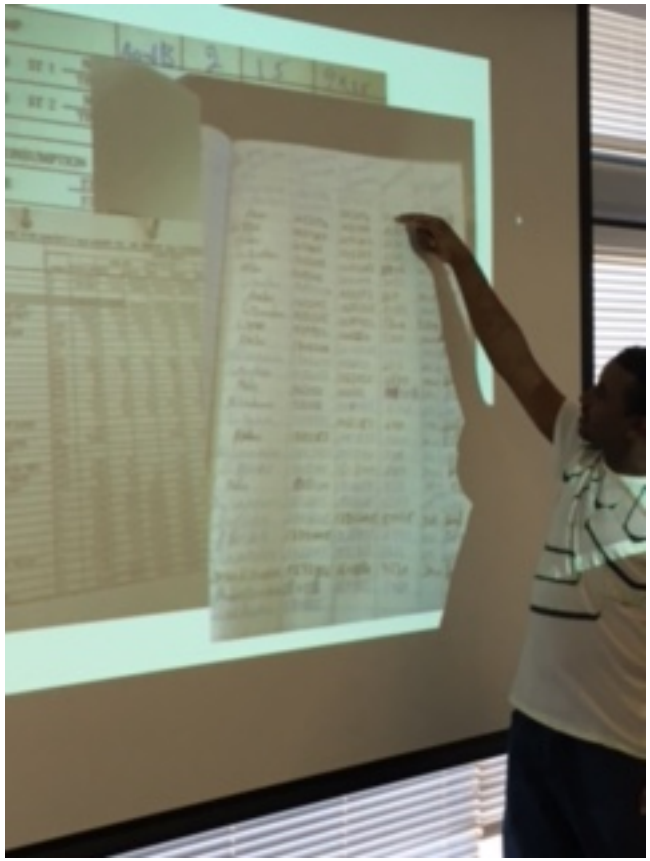
Preliminary results

Other Data to Explain Agricultural Revenues

- ***Production Inputs***
  - Labour
  - Fertiliser
  - Seeds
- ***Field Characteristics***
  - Soil quality
  - Irrigation
  - Slope and elevation
- ***Household and Farm***
  - Education, gender, age, children
  - Livestock
- ***Weather***
  - Temperature
  - Precipitation

Information needs

- Economic value of ecosystem services is location dependent
- Current information on values comes from an idiosyncratic set of studies using different
  - valuation endpoints
  - ecological conditions
  - socioeconomic conditions
  - valuation methods
  - non-representative approaches
- Accounting requires a concerted effort to develop value estimates which are
  - Representative
  - Comprehensive
  - Methodologically consistent



Regularly used valuation approaches

1.Benefit transfer (generalize results from another study and context)

2.Process-based modeling (ARIES, InVEST, other deterministic models)

3. Use data from *actual* production and consumption environments to value of ecosystem services

- *a. Production function*
- *b. Cost function*
- *c. Profit function*
- *d. Utility function*