Economic Analysis for Targeting SLM Intervention

By

Mahmud Yesuf

(Based on a Proposal for a Cost-Benefit Framework to Support Pro-SLM Decision-Making in Ethiopia, by M. Yesuf, G.Zeleke, G. Köhlin and G. Björklund)

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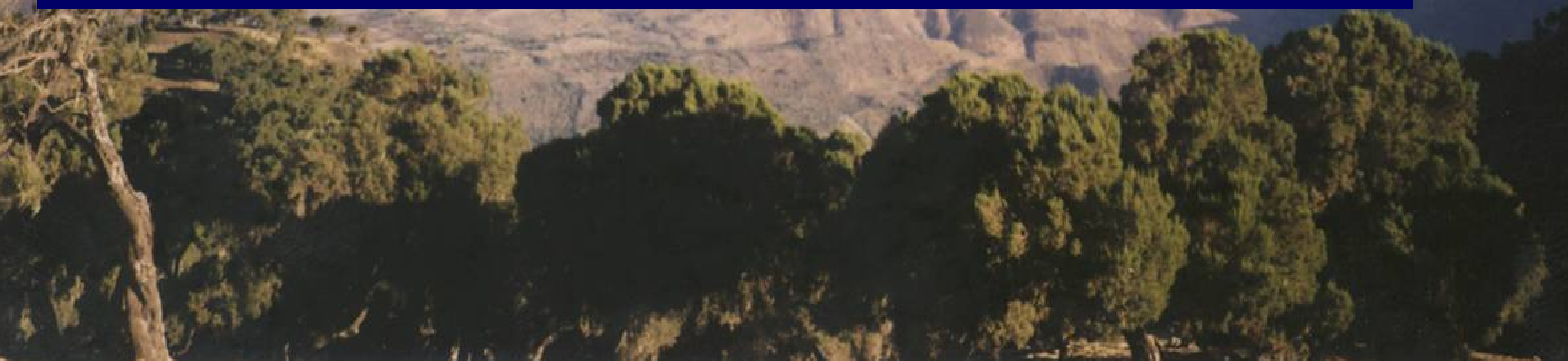
Objectives

i. **Outline economic approaches to assess the cost of land degradation or benefit of SLM intervention.**

ii. **Outline how these economic approaches (CBF) could be used to prioritize SLM intervention using available data in Ethiopia**

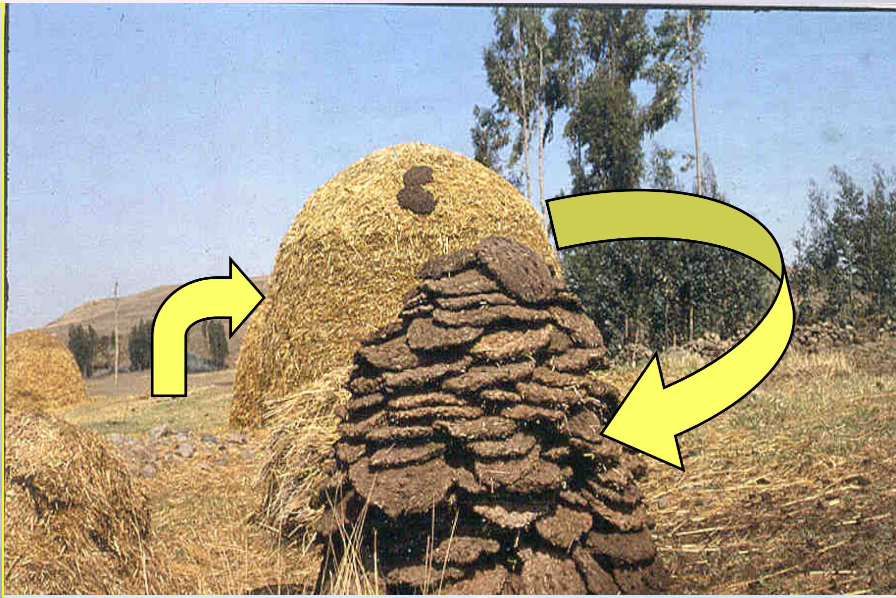
Economic Impacts of Land Degradation



1. Loss of agricultural production due to removal of top soil by soil erosion

2. Loss of nutrients : The invisible threat (Biological and chemical)

- All soils in the country (except pastoralist areas) suffer from soil nutrient mining: Open nutrient cycle!
  - Use of cow dung and crop residue as a source of energy.



3. Siltation of lakes, rivers, and reservoirs

4. Gravel Redeposition to down stream productive crop lands

5. Other Offsite Impacts (not considered in our framework)

- Hydrologic drought: in many places of the country springs, water wells and even permanent rivers are dried. Some wetlands shrinked, some totally dried up (Adele, Alemaya, etc)
  - Problems in recharging of ground water and aquifers
    - Reduction of infiltration caused by land degradation (soil & vegetation)
    - Deterioration of soil hydrologic properties
- High flooding: extreme floods and land slides are getting common in many parts of the country
  - Destroy many structures and farm lands
- Water pollution: surface water bodies of various size are being seriously polluted by sediment and chemicals (fertilizers, pesticides, factory effluents, solid wastes, etc)

Economic approaches

- Replacement cost approach (RCA)
- Change of productivity Approach (CPA)
- (Others: CVM, Hedonic Pricing)

Economic approaches (con't)

- **RCA: The cost of LD damage equals the cost that would be incurred to replace a damaged asset (soil).**
  - **Eg: cost of fertilizer application to compensate for the loss of soil nutrient (N and P)**
- **CPA: The cost of LD damage equals the value of the lost crop production valued at market price.**
  - **Eg. Cost of Soil Erosion**
  - **Relies on projected yield with and without soil erosion.**
- **Others:**
  - **<u>CVM</u>: WTA as compensatation for the LD damage or WTP for better SWC management**
  - **<u>Hedonic</u>: Uses land prices to impute cost of LD.**

Economic approaches (con't)

- Major weaknesses of RCA:
  - Original good and replaced good may not be perfect substitutes
  - Assumes lost nutrients were readily available for plant growth
  - Soil nutrients may not be the limiting factor in crop production
  - Fertilizer may not be the most cost effective way of replacing nutrients.

Economic approaches (con’t)

- **Weaknesses of CPA:**
  - Yield decline is not always ascribable to land degradation, especially in rain feed agri. Thus need to control other factors or apply it on an assumed average situation.
  - Yield declines are compared with hypothetical benchmarks of undegraded soils. The question of what production would be in the “without land degradation” case is not obvious in most studies.
  - Ignores rediposition

Applications of CPA

- **On-site cost of sheet erosion:**
  - **We used projected yield with and without soil erosion measures to impute the on-site cost of SE. Differences in yields are then multiplied by their unit price to get the value of lost production due to soil erosion damage.**
- **Off-site costs:**
  - **<u>Hydro power generation, fishery and other water storage</u>: Income lost due to reduced capacity or increased cost of production due to sedimentation**

Applications of RCA

- **On-site cost of nutrient depletion:**
  - **Annual costs of fertilizer applications to compensate for the loss of soil nutrients due to breaching of nutrient cycles**
- **Off-site costs:**
  - **<u>Hydro power dams or water storages</u>: The cost of replacing the live storage lost annually or the costs of constructing dead storage to anticipate the accumulation of sediments (defensive expenditure).**
  - **<u>In terms of eutrophication of fishing lakes</u>, the replacement cost would become the costs of removing water hyacinth or pollutants in the lake.**

CBF for ETH

BASIC IDEA:

- Use available info (such as SCRPs' station gauged data set, woody biomass data set, river basin data set and other available data sets from different sources) to design analytical framework to guide SLM intervention in most (if not all) of the country.
- Characterize SCRP stations (in terms of altitude, major crops, rainfall, LGP, and level of LD) to identify recommendation domains (mapping units) that could be represented by these stations
- Using GIS tools, develop national layers for each factor to define homogeneous recommendation domains that can be represented by each station.
- Use the SCRP data set to generate both biophysical and economic parameters for each station.
- Extrapolate their results to homogenous land units (map units) represented by each station.

CBF for ETH: Methodological Steps

- A production function will be estimated for each treatment in each recommendation domain using SCRP data.
- These estimated coefficients (for each treatment, each domain and each major crop) will then be the basis for the simulations of impacts of treatments in the various mapping units *i*.
- The production function coefficient estimates, combined with, the generated explanatory variables from the GIS layers on each mapping unit will be used to predict crop yield change due to a particular treatment.
- For SLM treatments that would save dung and crop residue into the nutrient cycle (more progressive and elaborated intervention), these benefits would be computed for each mapping units using RCA and using woodybiomass data
- SWAT model would be used to compute Siltations on water storage and other offsite impacts for selected areas.
- On gravel deposition, we no of no model but use simple method to compute area/production lost due to deposition.

CBF for ETH (con’t)

1. **On-site impacts: Loss of agricultural production due to soil erosion and nutrient depletion:**
   - **The difference between farm profit with and without SLM practices (off-site impacts excluded)**

$$\pi_t^c = P_{it} f_t \; (x_t^c, q_t^c, A_t^c, S_t^c, C_t^c) - \left(\sum_{i=1}^{n} e_{it} x_{it}^c - MC_t \right)$$

$$\pi_t^0 = P_{it} f_t \; (x_t^0, q_t^0, A_t^0, S_t^0, C_t^0) - \sum_{i=1}^{n} e_{it} x_{it}^0$$

$$NPV^p = \sum_{t=0}^{T} \left[\left(\pi_t^0 - \pi_t^c \right) + \eta_t \right] (1 + r)^{-t}$$

CBF for ETH (con’t)

2. Offsite impacts and social net costs/benefits of SLM:

$$NPV^{s} = \sum_{t=0}^{T} \left[\left(\pi_t^0 - \pi_t^c \right) + \eta_t + \omega_t \right] (1+r)^{-t}$$

Economic Criteria

- NPV and IRR
- Earlier strategies were based on physical criteria that classified the whole country as “high” and “low potential”, which we believe is a partial criteria and could misguide resource allocation
- In our framework, we will use the following combination of both biophysical and economic criteria to target interventions on SLM.
  - The rate of soil erosion (EROSION)
  - Net Annual Income Gain (NAIG) from intervention
  - Net Discounted Cumulative Income Gain (NDCIG) from intervention

CBF in ETH: Cost/Benefit Categories

- Immediate income gains or losses (NAIG)
  - the immediate costs of soil erosion or benefits of conservation measures. $\sum_{i=1}^{N} \left[\left(\pi_{it}^{c} - \pi_{it}^{0} \right) + \eta_{it} + \omega_{it} \right]$
- Future income gains or losses (NDIG)
  - the loss in potential income over a number of years due to effects of one year of erosion (which are future benefits of conservation measures) $\frac{\sum_{i=1}^{N} NAIG_{it}}{(1+r)^{t}}$
- Cumulative income gains or losses (NDCIG)
  - It reflects the present value of the cumulative costs of erosion or benefit of conservation over a defined period of time. $\frac{\sum_{i=1}^{N} \sum_{t=1}^{T} NAIG_{it}}{(1+r)^{t}}$
  - .

Decision Matrix

High returns from soil conservation	Low returns from soil conservation	Unlikely cases	
Case 1: Erosion: High NAIG: High NDCIG: High	Case 4: Erosion: Low NAIG: Low NDCIG: Low	Case 7: Erosion: Low NAIG: High NDCIG: High	
Case 2: Erosion: High NAIG: Low NDCIG: High	Case 5: Erosion: Low NAIG: High NDCIG: Low	Case 8: Erosion: Low NAIG: Low NDCIG: High	
Case 3: Erosion: High NAIG: High NDCIG: Low	Case 6: Erosion: High NAIG: Low NDCIG: Low		

Targeting priorities

- Top priorities (case1):
  - Areas with high soil erosion rates and high NAIG and NDCIG
- Second priorities (case 2):
  - high risk of soil erosion, low short term returns from SLM intervention but high long term returns from intervention
- Third priorities (case 3):
  - high soil erosion risk, with high short term returns but small long term gains.
- Cases 4 and 5 are not at risk of soil erosion and hence returns from SLM intervention are smaller .
- Case 6, no conservation (except area closure) is recommended on economic grounds. Alternative livelihood strategy should be sought.

Policy implications on private adoption of technologies

- In areas where available technologies are highly profitable with high NAIG and NDCIG (such as case 1 in the decision matrix table 2), the focus should be on identifying the most binding constraints limiting their adoption, and the strategies that can most effectively relax these constraints (such as low cost credit provision).
- In areas where available technologies are far from profitability with low NAIG and low NDCIG, despite high risk of soil erosion (such as case 6 in table 2), the strategy should focus more on opportunities for alternative livelihood strategies that are less dependent on intensive land use. In these areas, since the technology is far from profitable, other constraints to adoption are irrelevant.

Concluding Remarks: Why CBF?

- CBF fulfils a number of important functions:
- Compile and utilize much of the existing relevant data
- Provide info on areas facing largest short and long term costs of LD
- Show how SLM treatments could prevent losses productivity in hydro and other water storages and lakes.
- Indicate the relevant size of investment in SLM
- Prioritize areas and treatments in order to maximize social welfare
- Support the up-scaling of promising SLM practices


Thank You!