Poverty and Land Degradation in Ethiopia: How to Reverse the Spiral?

Concept Note

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I. Overview and Rationale

Land degradation is one of the major causes of low and in many places declining agricultural productivity and continuing food insecurity and rural poverty in Ethiopia. Achieving sustainable pathways out of the downward spiral of land degradation and poverty requires that farmers adopt profitable and sustainable land management practices, or pursue alternative livelihood strategies that are less demanding of the land resource. Although there has been a great deal of effort to address land degradation problems in Ethiopia, these have failed to reverse the downward spiral in much of the worst affected areas of the country. Part of the reason for this has been the promotion of practices and technologies that were not well suited to the conditions facing farmers in their particular location, and hence not profitable or excessively risky. Recent research has shown that other factors—such as population pressure and small farm sizes, land tenure insecurity, land redistribution, limited access to credit, limited education, and others—also inhibit adoption of sustainable land management practices in some areas. However, the impacts of such factors are very context-specific, making generalized prescriptions ineffective.

It is not feasible or necessary to develop different technical assistance strategies for every farmer’s situation. Nevertheless, more targeted guidance would be very helpful regarding where particular land management approaches are likely to be successful, what are the most binding constraints to adoption of potentially successful approaches, and what strategies can be used to address these constraints, as well as to improve the options for other areas where available technologies are less promising.

The key objective of the proposed study is to identify effective and realistic pathways out of the downward spiral of land degradation and poverty in Ethiopia. This means to understand and to quantify the main factors leading to land degradation, to comprehend the reasons for farmers adopting or not adopting conservation and productivity enhancing technologies, and to identify the results of such strategies in terms of poverty reduction. This will be done by focusing on opportunities for investments in land conservation and productivity enhancing land management technologies that are profitable and at the same time of acceptable risk. Underlying the choice of such objective is the understanding that the lack of progress in solving the land degradation problem in the country is not due either to lack of awareness or lack of effort to try to solve it.
Rather, the ineffectiveness of past efforts is likely due more to promotion of technologies that are not profitable, too risky, or ill-suited to farmers’ resource constraints.

The proposed research project seeks to develop a more effective set of targeted recommendations for strategies to address land degradation and poverty in Ethiopia, focusing on the northern Ethiopian highlands, where problems of land degradation and poverty are very severe. It envisions a two-step approach to identifying location-specific strategies. First, domains of potential profitability and risk of the major land management technologies used in the northern Ethiopian highlands will be predicted using simplified biophysical and economic models and available data, and then mapped using a geographic information system. Second, key opportunities for and constraints to more sustainable and poverty reducing land management approaches will be identified, and targeted strategies will be defined for the different domains.

A kind of “triage” approach to strategies will be used. In areas where available technologies are highly profitable and of acceptable risk, the focus will be on identifying the most binding constraints limiting their adoption, and the strategies that can most effectively relax these constraints. In areas where available technologies are only marginally profitable or close to profitability, the strategy will focus initially on the most feasible means of improving profitability and reducing risks, whether by improvement of the technologies, improving the market environment and institutions, or both. In areas where available technologies are far from profitability, the strategy will focus more on opportunities for alternative livelihood strategies that are less dependent on intensive land use, especially where land degradation is severe.

The approach of this research project has not been previously applied on a wide scale in sub-Saharan Africa, although there are several examples of bio-economic modeling efforts that address similar issues on a small scale. A novel aspect of this project will be its effort to adopt a more extensive approach to bio-economic modeling, using simple models and available data to predict broad domains of profitability and risk, without trying to assess every farmer’s individual constraints. Also novel will be the use of information on profitability and risk in the investigation of constraints to technology adoption. Most studies of adoption of land management and other technologies simply investigate a wide array of factors affecting adoption, without considering the profitability and risk of the technologies. Yet, unless a technology is profitable and of acceptable risk, other constraints to adoption are irrelevant. This project will thus develop a methodology that can be used more broadly to identify options and strategies for improved land management and reduced rural poverty in sub-Saharan Africa. This methodology may be helpful to guide investments in improving land management through the new TerrAfrica program and other investment programs.

II. Objectives and Expected Output

The key objective of the proposed study is to identify effective and realistic pathways out of the downward spiral of land degradation and poverty in Ethiopia. This means to understand and to quantify the main factors leading to land degradation, to comprehend the reasons for farmers adopting or not adopting conservation and productivity enhancing technologies, and to identify the results of such strategies in terms of poverty reduction. This will be done by focusing on
opportunities for investments in land conservation and productivity enhancing land management technologies that are profitable and at the same time of acceptable risk.

To facilitate policy interventions, and given the crucial importance of the location-specific aspects of the problem, particular attention will be given to the spatial dimension of land degradation, for example, by mapping the recommendation domains of desirable land management technologies. In principle, there are three types of domains:

1. In some areas, existing land conservation and/or productivity enhancing technologies may be found to be profitable and of acceptable risk. In this case, the main constraints to their adoption or adaptation have to be identified. In addition, recommendations have to be made for priority actions to address the most binding constraints (e.g. land tenure insecurity, lack of credit, labor and information constraints).

2. In some areas, existing land conservation or productivity enhancing technologies may be found to be at best of marginal profitability relative to their risks. Under such circumstances priority actions to increase profitability and reduce risks have to be identified (e.g. promotion of higher value commodities, investments in infrastructure, market development, insurance, credit mechanisms, and technology improvement).

3. In domains where no technologies are found to be close to profitability and acceptable risk, alternative strategies will need to be pursued (e.g. promotion of alternative livelihood strategies or resettlement).

The proposed project on “Poverty and Land Degradation in Ethiopia” will produce five main working papers, according to research questions which are discussed in the following section. The findings will be summarized in a less-technical policy report that is easily accessible to policymakers, after discussion with local stakeholders, the Ethiopian government and the academic community. The overall timeframe is expected to be 18 months.

III. Research Questions and Methodology

The broader activity will consist of five related activity-blocks, most of which leading to a specific paper, which should form the basis of five main chapters of the final report. The five main activities will be: (1) review of literature; (2) synthesis of the macroeconomic costs of land degradation; (3) a methodology workshop; (4) mapping feasibility domains of selected conservation technologies based on the refined methodology; and (5) identification of key constraints to adoption or to increasing profitability of technologies. The paragraphs below discuss pertinent questions and the envisaged methodology for these five activities.

1. Literature review

What relevant and robust research findings can provide guidance for policymakers and help to refine this research proposal?
The main objective will be to generalize lessons from individual studies and identify common lessons, trying to come up with more robust and consistent findings. Such a review will aim to (i) identify what are the key decision parameters of farmers regarding soil conservation under different risk, agro-ecological and socioeconomic endowments; (ii) synthesize findings regarding impacts of soil conservation and fertility management practices in Ethiopia and their recommendation domains.

This review will be led by the Environmental Economics Policy Forum of Ethiopia (EEPFE) and IFPRI, in collaboration with other Ethiopian partners, and will draw upon work already developed as part of this research proposal, as well as previous work in Ethiopia led by the main institutions analyzing the soil degradation problem in Ethiopia\(^1\). A working paper is expected within 3-4 months of initiating the project.

2. Macroeconomic costs of land degradation

_How large are the costs of land degradation in Ethiopia at the regional and national levels? How do these costs compare with other countries in sub-Saharan Africa?_

The social costs of environmental degradation—in particular the costs of soil erosion—have been addressed in different studies for Ethiopia. This expected working paper will in principle synthesize the works of Bojo and Cassels (1995), Sonneveld (2002) and others. Bojo and Cassels values the costs of soil erosion by estimating functions relating to soil loss by erosion and dung quantities removed for burning to nutrient content, and relating nutrient loss to crop loss. In his analysis, Sonneveld applies a combination of a soil and water erosion model with a spatial agricultural yield function under alternative scenarios of soil conservation, migration and technology changes. Depending on the existence of additional studies identified in the literature review, alternative valuation approaches might also be included.

The original contribution of the summary will be (a) to make the different approaches comparable by relating the costs estimates to a common numéraire; (b) to provide an illustration of the regional magnitude of the land degradation problem in Ethiopia; (c) to review the assumptions and data sources underlying the estimates; (d) to assess potential criticisms on the magnitude of such costs, e.g. Dejene 2003; (e) to evaluate whether the costs of environmental degradation have increased over time; (f) to compare the results with other estimates for sub-Saharan Africa countries, e.g. based on FAO 2001 data.

At this point in time, it appears that the social costs of land degradation are high and may justify future investment. This work will be led by the EEPFE, in collaboration with the World Bank, IFPRI and other Ethiopian organizations. A working paper is expected within 4-6 months.

3. Methodology workshop

The broader modeling exercise will consist of linking up two models in a GIS. The first is a biophysical model which simulates crop productivity and soil fertility, being also capable of

\(^1\) Among such institutions are the Soil Conservation Research Program of the Ministry of Agriculture, IFPRI, ILRI, Wageningen University Research Center, Göteborg University, the Agricultural University of Norway, and the CDE in Bern.
simulating the productivity effects of different land conservation technologies, the second is a location specific input/price model (such prices will be assessed on the basis of observed prices in key market locations, adjusted by transport costs). Linking these models will allow one to predict profitability and risks of technologies spatially.

The proposed modeling exercise can be data demanding and technically complex, particularly as two types of models have to be combined and integrated under a GIS. For this reason, the team has already invested a significant amount of time consulting with various institutions working on modeling soil degradation issues in Ethiopia. It is therefore envisaged that the first step of the modeling exercise has to be an assessment of existing models to select the best approach given the data, time and budgetary constraints of the project. This initial activity will thus involve, in addition to the extensive contacts already made, (i) a review of available crop and soil simulation models, which will be used to assess the impacts of alternative technologies on crop production; and (ii) a review of spatial market price models, used to assess the spatial variation of input and output prices across domains in Ethiopia.

A small methodology workshop will be conducted within the first 3-4 months, bringing together modelers from the World Bank, Ethiopian collaborators, academic and applied research institutions, and other stakeholders in the project. A report on the methodological approach and data selected will be completed and circulated for comment within a month after the workshop.

4. Mapping feasibility domains of selected conservation technologies

The modeling approach selected in the previous block will be used to address three subsets of questions:

(i) To what extent is soil conservation a profitable investment in the short, medium or long run? How risky are soil conservation measures and soil fertility management practices at present in Ethiopia?

This is the core part of the research proposal. No known studies today can provide a good answer to these questions on a spatial basis. Existing information is only sparsely available for different technologies, although this is critical to adoption of improved practices. Other factors identified in technology adoption studies (e.g. land tenure, credit access) may be irrelevant if sufficiently profitable options with acceptable risk are not identified.

As just indicated, modeling the profitability of land management technologies will involve three steps: (1) modeling the expected impacts of the technologies on agricultural productivity, i.e., input-output relationships; (2) modeling the input costs and output prices in a spatial framework;

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2 This work will in principle build upon crop and soil modeling research being led by the Wageningen University and Research Center in Tigray. Available crop and soil models that will be considered and possibly adapted for this research include the Erosion Productivity Impact Calculator (EPIC) (Williams and Sharpley 1989), WOFOST (Boogard, et al. 1998), and DSSAT (Tsuji, et al. 1994).

3 This part will basically rely upon a market modeling research in Ethiopia being led by IFPRI’s Spatial Analysis Research Group (SPARG) and the International Fertilizer Development Center for the East African Highlands.
and (3) integrating these models into a GIS to allow assessment of the profitability and the risks of selected technologies.

For example, the crop and soil models will be used to predict the expected impacts of inorganic fertilizer use – a control technology – on productivity of different crops in different spatial locations, taking into consideration soil, climate, and other biophysical characteristics of each location. Market models with transport costs can be used to predict spatial variations in crop and fertilizer prices in different production areas. Combining these two models, one can estimate the incremental value/cost ratio (VCR) of fertilizer use on different crops and identify the relative profitability under each condition.\(^4\) It is thus possible to construct a feasibility map for different domains (e.g., high profitability areas with VCR > 2, marginal profitability areas with 1 < VCR < 2, and unprofitable areas with VCR < 1).\(^5\)

Impacts of other land management technologies, such as terraces or application of organic materials will also be similarly modeled. In the case of investments – such as terracing – construction and maintenance costs and impacts on productivity over time will be estimated, so that net present values of investment per hectare or internal rates of return can be calculated and then mapped. Data on the costs of such investments are available from the land management surveys conducted in the Ethiopian highlands by IFPRI and ILRI, and from other surveys on land management in Ethiopia. Estimates of productivity impacts of such investments are also available based upon econometric analysis of such surveys, though these estimates are not spatially explicit. Additional econometric estimation of such impacts with more spatial information will be conducted using available data, and such estimates will be used to help validate the predictions of productivity impacts from the biophysical models.

Production risks due to weather variability can be modeled by investigating how profitability would vary as a result of variations in weather, based on information on rainfall distribution.

The modeling approach is summarized in schematic form in Figure 1. Biophysical data will be used by the crop and soil models to predict input-output relationships for different land management technologies, while socioeconomic and some biophysical data (e.g., on topography) will be used by the spatial price model to predict input-output price relationships. These predictions, together with data on the costs of investments from available surveys will be used to predict profitability and risk of different land management technologies. These predictions will be spatially explicit, and will be used to define feasibility domains of the technologies considered.

The crop and soil modeling work will be led by WUR, in collaboration with Ethiopian research organizations. This work will be the object of discussion and greater definition in the proposed methodology workshop.

\(^4\) The incremental VCR of fertilizer use is equal to the incremental output per unit input ratio (e.g., kg. of additional maize per kg. of inorganic fertilizer), which will be predicted by the biophysical model, divided by the input output price ratio (e.g., kg. of maize output needed to purchase one kg. of fertilizer), which will be predicted by the market price model.

\(^5\) A VCR of 2 is often seen as threshold for substantial adoption of fertilizer use, because of considerations of risk, learning, etc.
Figure 1. Overview of modeling approach and linkages

Biophysical data
- Climate
- Soils
- Topography
- Crop data

Biophysical crop/soil model

Spatial input-output relationships of technologies

Spatial estimates of profitability and risk of alternative technologies

Maps of feasibility domains of technologies

Socioeconomic data
- Crop prices
- Input prices
- Investment requirements
- Market/road access

Spatial price model

Spatial input-output relationships

Investment costs of technologies
(ii) How sustainable over time are the different technologies and in different development domains in Ethiopia?

Existing land conservation and productivity enhancing technologies focus on certain characteristics of the production system but tend to “leave open” other features which are also critical contributors to land degradation. This may become a problem for the longer term sustainability of the proposed technology. For example, what is the impact of depletion of soil organic matter on the profitability and risk of using inorganic fertilizer? If organic matter depletion is reducing the return to application of inorganic fertilizer, focusing on subsidies or other interventions to promote inorganic fertilizer use will not be sufficient to address the long-term problem.

This type of questions will be addressed as part of the crop and soil modeling work. These models will account for interactions between land degradation and response to land management practices, and interactions among different types of land management practices, e.g., among soil and water conservation measures, and organic and inorganic sources of nutrients.

(iii) What are the socio-economic factors that determine profitability, risk and feasibility of various soil conservation and fertility management practices across development domains in Ethiopia?

Unlike many past studies that only analyzed factors affecting adoption of improved technologies, this study would analyze the determinants of profitability and risk of different practices. This analysis will be used to design strategies for increasing profitability and hence adoptability and sustainability of the practices.

The impact of socioeconomic factors on profitability will be through their effects on prices of inputs, outputs and wages, which will be assessed through the spatial price model. Given the data requirements, this exercise will in principle only be made for selected technologies and in specific crops and production zones. The technologies will include at least stone and soil bunds and inorganic fertilizers and their possible interactions. The focus area will be the cereal production zones of the northern Ethiopian highlands of Tigray and Amhara regions. These are the areas where land degradation problems are most severe and more data may be available to support the modeling effort. The risk assessment will include the impacts of rainfall-related production risk. Future work could also seek to incorporate other production risks (e.g., frost and pests) and market price risks, but these may be too ambitious to include in this project.

Validation of the models will primarily draw upon the availability of land management, inputs and production data from the IFPRI-ILRI land management project, and erosion data from the Soil Conservation Research Project (SCRP). A working paper based on this work is expected within 15 months of initiating the project.

5. Identification of key constraints to adoption or to increasing profitability of technologies
What are the key constraints inhibiting soil conservation adoption in domains of high potential for adoption? What are the most promising interventions to increase profitability and/or reduce risk of technologies in areas of moderate potential for adoption?

Once the recommendation domains have been identified, a targeted study will be conducted to (a) identify the key constraints inhibiting adoption in domains of high potential for adoption, and (b) assess the most promising interventions to increase profitability and reduce risk of technologies in areas of moderate potential for adoption. These issues will be addressed by:

- Reviewing the findings of available studies within the geographic context provided by the recommendation domains\(^6\);
- Conducting targeted field appraisals and key informant interviews to assess local perceptions about key constraints and promising interventions in different domains; and
- Econometric analyses of available primary survey data to assess constraints to adoption in different domains.

Prior research on factors affecting adoption of land management technologies in Ethiopia has not focused on the role of factors conditional upon the level of profitability and risks of technologies, limiting their ability to draw clear policy conclusions. The econometric analysis can draw upon the extensive household and plot survey data available from the IFPRI/ILRI sustainable land management project in Tigray and Amhara (survey of over 900 households in 1999 and 2000), as well as a very large panel survey of land management conducted by Göteborg University in one high and one low potential zone of Amhara (over 1500 households with two rounds of data in 2000 and 2002, and a third round expected to be collected in early 2005). Analysis of available data from other surveys (e.g., the Ethiopian Rural Household Survey or the baseline survey of the USAID FANTA project) may also be used to complement analysis of these surveys to assess constraints to adoption in particular domains.

This targeted empirical research will also serve to validate the results of the modeling and mapping effort, investigate local variations in profitability and risk of technologies and the key factors responsible, and make recommendations on key data needs to improve the models.

This component will be led by IFPRI and EEPFE, in collaboration with other Ethiopian organizations. A report identifying key constraints to adoption of technologies in areas of high potential and making recommendations of promising interventions will be completed within 12 months of initiation of the project.

\(^6\) Including Percy (2003); Admassie (1995); and some hints in Bekele (2004); Adenew (2000); Amede et al. (2001).
References


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