Environment for Development

POLICY BRIEF

Where Does Sustainable Land Management Practices Work: A comparative study[1]

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The Ethiopian economy has its foundation in the agricultural sector. This sector continues to be a fundamental instrument for poverty alleviation, food security, and fueling economic growth. However, the sector continues to be undermined by land degradation (LD) in the form of depletion of soil organic matter, soil erosion, and lack of adequate plant-nutrient supply (Pender et al., 2006). There is evidence that these problems are getting worse in many parts of the country, particularly in the highlands. Furthermore, climate change is anticipated to accelerate LD in Ethiopia. Over the last few decades, as a cumulative effect of LD, increasing population pressure, and low agricultural productivity, Ethiopia has become increasingly dependent on food aid. In most parts of the densely populated highlands, cereal yields average less than one metric ton per hectare (Pender and Gebremedhin, 2007). Such low agricultural productivity, compounded by recurrent problems of famine, contributes to extreme poverty and food insecurity.

Over the last three decades, the government of Ethiopia and a consortium of donors have invested substantial resources to develop and promote sustainable land management (SLM) practices as part of efforts to improve environmental conditions, ensure sustainable and increased agricultural production, and reduce poverty. However, due to low rates of adoption, most of the promoted practices have been only partially successful. In some cases, dis-adoption or reduced use of technologies has been reported (Tadesse and Belay, 2004). Past efforts to develop and promote these practices neglected the pronounced regional diversity of the country. For example, the distribution and amount of rainfall vary greatly both in spatial and temporal terms across Ethiopia. Nevertheless, similar SLM practices such as soil and water conservation technologies (e.g., stone bunds, soil bunds), reduced tillage, and chemical fertilizer have been promoted in all agro-ecologies regardless of their performance under different environmental conditions.

Key Points

- Productivity impact of SLM practices vary by agro-ecology types.
- Reduced tillage and stone bunds lead to statistically significant positive agricultural productivity gain in the low rainfall areas compared to high rainfall areas.
- Chemical fertilizer leads to statistically significant positive agricultural productivity gain in the high rainfall areas compared to in the low rainfall areas.
- On the whole, results suggest that one-size-fits-all recommendations are not appropriate, indicating a need for careful agro-ecological targeting when developing, promoting, and scaling up SLM practices.

[1] This brief is produced by Menale Kassie based on

1) Kassie, M., Pender, J.,Yesuf, M., Köhlin,G., Bluffstone, R., and Mulugeta, E. *"Estimating Returns to Soil Conservation Adoption in the Northern Ethiopian Highlands,"* Agricultural Economics Journal. Vol. 38:2008, pp. 213 – 232
2) Kassie, M., Zikhali, P., Pender, J., and Köhlin, G., "Sustainable Agricultural Practices and Agricultural Productivity in Ethiopia: Does Agro-ecology Matter?" EfD Discussion Paper 09-12, a joint publication of Environment for the Development Initiative and Resources for the Future (www.rff.org), Washington DC, April 2009.

To ensure sustainable adoption of SLM practices and beneficial impacts on productivity and other outcomes, rigorous empirical research is needed on where particular SLM interventions are likely to be successful. The objective of this brief is to exhibit the performance of reduced tillage, stone bunds, and chemical fertilizer by agro-agro-ecology types, defined here as rainfall abundance. This information would assist policymakers and development practitioners in their efforts to reduce poverty and promote natural resource management strategies.

The Data

Our empirical analysis was based on two sets of plot level data-one form a low rainfall region (Tigray region) and another from a high rainfall region (Amhara region) of the Ethiopian highlands. The surveys were conducted in 1999 and 2001 to formulate policies related to sustainable land management practices in these two regions. The Amhara region dataset includes 435 farm households, 98 villages, 49 peasant associations and about 11434 plots, while the Tigray dataset includes 500 farm households, 100 villages, 50 peasant associations and 1797 plots. The mean rainfall data based on long-term (50 years) rainfall data is 648 mm and 1981 mm in Tigray and Amhara regions, respectively.

The methodological approach

Although there are many theoretical reasons why agricultural technologies should enhance farm productivity, it is difficult to assess empirically productivity effects from technology adoption based on non-experimental observations. Farmers are likely to select land management practices on their plots based on endowments and abilities of the farm household and the quality and attributes of their plots (often unobservable). Additionally, farmers might be systematically selected by policy makers and development practitioners to adopt the technology based on their propensity to participate in the adoption of technologies. Given that adoption is endogenous simple comparisons of mean differences in productivity on plots with and without use of particular land management practices has no causal interpretation and are likely to give a biased estimate of the actual impacts of these practices on productivity. This is because this productivity difference may not be the result of particular land management practices adoption, but instead may be due to other factors such as differences both in observed and unobserved household and plot characteristics of adopters and non-adopters. Measuring the productivity gains associated with adoption of sustainable land management practices using survey data therefore requires to create comparable observations of adopters and non-adopters in term of their characteristics. We use a technique called propensity score matching method and a switching regression approach to address this challenge.

Findings

A simple mean comparison test indicated that chemical fertilizer use and draft animal use per hectare are lower on reduced tillage plots than on non-reduced tillage plots. There is, however, no statistically significant difference in labor use between the two types of plots. In order to take into account input use differences in the empirical analysis, the costs of the above inputs were deducted from the total value of crop production.

The empirical results showed that there is indeed strong evidence that adoption of stone bunds and reduced tillage have impact on net value of crop production per hectare (hereafter agricultural productivity) on low rainfall areas compared to high rainfall areas. The impact of stone bunds on agricultural productivity ranges between Ethiopian Birr (ETB) 299 to 412 per hectare.[2] Similarly, the productivity impact of reduced tillage in low rainfall areas ranges from ETB 606 to 921 per hectare. These are the opportunity cost of not using stone bunds and reduced tillage, which is a very significant amount of money compared to the average net value of crop production in the Tigray highlands, which averaged ETB 1614 per hectare in the survey

[2] 1USD = 7 ETB in 1998.

sample. All else equal, the total benefits that would have been obtained had the matched non-conserved and non-reduced tillage plots been treated with stone bunds and reduced tillage was about between ETB 38 to 52 million and ETB 109-112 million, respectively. By contrast, we do not find significant productivity differences between conserved and non-conserved plots as well as between reduced tillage and non-reduced tillage plots in high rainfall area, which is the Amhara region. We believe this productivity difference is emanated due to greater benefits of moisture conservation in low rainfall areas, whereas moisture conservation in high rainfall areas may contribute to problems such as water-logging, increased weed growth and enhanced pest infestation. On the other hand, using chemical fertilizer was more productive in the high rainfall area of the Amhara region where the benefit is in the range of ETB 977-1113 per hectare. This shows that chemical fertilizer is more productive in moisture adequate environments than in semi-arid environments such as Tigray region. Conditional on other factors, the total benefits that would have been obtained had the matched non-chemical fertilized plots received chemical fertilizer was about ETB 369-421 million per year. These results are not sensitive to hidden bias due to unobserved variables. Thus, our results underscore the need to understand the role of agro-ecology in determining the productivity of farm technologies. This has particular importance in formulating policies that promote technology adoption.

Conclusion

Our results have the following implications. First, a one-size-fits-all approach is not an advisable approach for developing and promoting technologies. It is important to develop and disseminate SLM practices or technologies that are appropriately tailored to agro-ecological zones instead of making blanket recommendations that promote similar practices or technologies to all farmers. Second, there is a need for governments and non-governmental organizations to shift their focus from chemical fertilizers to considering reduced tillage as a yield-augmenting technology in semi-arid areas. In these areas, reduced tillage not only increase yields but could also provide other benefits: farmers may also be able to cut production costs, increase environmental benefits, reduce crop failure risk due to moisture stress, and decrease financial risk associated with buying chemical fertilizer on credit.

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CONTACT

Dr Menale Kassie, email: Menale.Kassie@economics.gu.se

EfD Center in Ethiopia, www.efdinitiative.org/centers/ethiopia
alemu_m2004@yahoo.com, Phone 251 11 552 3564 /550-6066. Fax 251 11 550-5588,
Environmental Economics, Policy Forum for Ethiopia, (EEPFE), Ethiopian, Development Research Institute (EDRI). Blue Building, Near National Stadium, Office Numbers 401-409, fourth floor, P.O.Box 2479, Addis Ababa, Ethiopia

EfD, Environment for Development initiative, www.environmentfordevelopment.org
EfD Secretariat: info@efdinitiative.org, Phone: +46-31-786 2595, Fax +46-31-786 10 43, www.efdinitiative.org./efd-initiative/organisation/secretariat, Department of Economics, University of Gothenburg , PO Box 640, SE 405 30 Gothenburg, Sweden