Sustainable land management practices improve agricultural productivity:

Evidence on using reduced tillage, stone bunds, and chemical fertilizer in the Ethiopian highlands

BY MENALE KASSIE, JOHN PENDER, MAHMUD YESUF, GUNNAR KÖHLIN, RANDY BLUFFSTONE, PRECIOUS ZIKHALI, ELIAS MULUGETA, DECEMBER, 2008

The agriculture sector in Ethiopia is the most important sector for sustaining growth and reducing poverty. It accounts for 50% of GDP, 88% of export value, and is a source of employment for more than 85% of the country's population of more than 70 million. However, lack of adequate nutrient supply, the depletion of soil organic matter, and soil erosion are major obstacles to sustained agricultural production.

In response, considerable public resources have been mobilized to develop soil and promote productivity enhancing and natural resource conserving technologies or practices to farmers. The current practice is to promote the same technology in all agro-ecology types as assuming one size fits all. It is not clearly known, however, which technology works where. The objective of the paper is to investigate the impact of different sustainable land management practices on crop productivity, with a particular focus on reduced tillage and stone bunds in two different agro-ecology zones, defined here with reference to rainfall abundance. This information would assist policymakers in their efforts to reduce poverty and promote natural resource management strategies. This brief is based on a study that used rural household survey data to analyze the impact of sustainable land management (SLM) practices on agricultural performance in the Ethiopian highlands.

The Data

We use two sets of plot level data-one form a low rainfall region (Tigray region) and another from a high rainfall region (Amhara region) of Ethiopia for our empirical analysis. The surveys were conducted 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 rainfall averages (50 years), spatially interpolated using a climate model is 648 mm and 1981 mm in Tigray and Amhara regions, respectively.

Key Points

- Productivity impact of Sustainable Land Management practices vary by agro-ecology type.
- Reduced tillage and stone bunds lead to statistically significant positive productivity gain in the low rainfall areas compared to high rainfall areas.
- Chemical fertilizer leads to statistically significant positive productivity gain in the high rainfall areas compared to in the low rainfall areas.
- It is very important to develop and disseminate SLM practices that are appropriately tailored to agro-ecological zones instead of making blanket recommendations that promote similar practices to all farmers to increase agricultural productivity and acceptance of these practices by farmers.

The survey results indicated that the per hectare costs of fertilizer and draft animal use is lower on reduced tillage plots compared to non-reduced tillage plots. There is, however, no statistically significance difference in labor use between the two plots.

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).

In addition, 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 to address this challenge.

Findings

The results showed that there is indeed strong evidence that adoption of stone bunds and reduced tillage have impact on 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.[1] 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 to conserve moisture and soil and increase soil fertility, which is a very significant amount of money compared to the average value of crop production in the Tigray highlands, which averaged ETB 1614 per hectare in the survey 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 our 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. However, even though the use of stone bunds and reduced tillage for soil and moisture conservation in high rainfall areas may not increase short-term productivity, this does not mean that no conservation techniques are required. In fact, placing appropriate conservation measures could help protect soils during extreme rainfall.

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 profitable in moisture adequate environments than in semi-arid

[1] The official exchange rate averaged about 7 ETB per U.S. dollar in 1998.

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. Thus, our results underscore the need to understand the role of agro-ecology in determining the profitability of farm technologies. This has particular importance in formulating policies that promote technology adoption.

Recommendations and policy implications

Our results have the following implications. First, the promotion of farming technologies should not be based on policies that fail to incorporate the impact of agro-ecology on both adoption decisions, as well as the profitability of the technology in question.

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.

ABOUT THIS BRIEF

This brief is based on results from two separate research papers: 1. Kassie, M., J. Pender, M. Yesuf, G. Köhlin, R. Bulffstone, Mulugeta, E., 2007 "Impact of Soil Conservation on Crop Production in the Northern Ethiopian Highlands" IFPRI Discussion Paper 00733,Washington, DC 20006-1002 USA and 2. Kassie, M., Zikhali, P., Pender, J., Köhlin, G., 2008 "Organic Farming Technologies and Agricultural Productivity: The case of Semi-Arid Ethiopia" Working Paper in Economics No 334, School of Business, Economics and Law, University of Gothenburg, Göteborg, Sweden.

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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