CIMMYT
International Maize and Wheat Improvement Center

Sustainable Agricultural Intensification in Ethiopia: Achieving maximum impact through adoption of suites of technologies

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Overview

To achieve sustained high productivity food systems, application of adequate amounts of fertilizer and high standards of agronomic practices are crucial. In Ethiopia (and similarly across Sub-Saharan Africa (SSA), high-input production systems have not become entrenched. This is due to a number of reasons not limited to the high costs of inputs and underdeveloped agricultural markets. Is there a middle ground which can raise yields and sustain the resource base (maintain ecosystem services) without imposing high capital requirements that farmers cannot afford?

In this brief, we report a set of results from an economic study which shows that adopting a set of sustainable agricultural intensification (SAI) practices together with complementary inputs such as improved seeds can raise the net maize income by 47 to 67 percent and reduce fertilizer and chemical application without compromising farmers' earnings. (Net maize income calculated by deducting cost of fertilizer, hired labor, seed and pesticides). These results show that while the high input mono-cropping systems have been the basis for a prospective Green Revolution in the country, there are alternative production systems that can deliver increased productivity and ecosystem health. The needed increases in inputs and production should take place within a framework of system diversification and sustainable intensification.

Background to the study

The low agricultural productivity in SSA is a matter of national and international concern. Yet the degradation of the resource base and related reduction in ecosystem functioning across agricultural landscapes means that producing more food will be ever more difficult. These ecosystem functions include nutrient recycling, nitrogen fixation, soil loss mitigation and natural control of pests and diseases. In complex farming systems in which much of the production is subsistence, mono-cropping based on high inputs may end up undermining sustainability.

Recently, the International Maize and Wheat Improvement Center (CIMMYT) working with the Ethiopian Institute of Agricultural Research (EIAR) initiated research projects to study the adoption patterns of improved agricultural practices such as conservation agriculture, which were just being introduced. The main aim of this undertaking was to understand farmers' adoption decisions concerning portfolios of practices. This was a break from past research which simply looked at individual farming practices in a stand-alone formulation. In this study, the adoption decision was modeled as the implementation of a package (portfolio) of technologies. Why is this approach superior to those commonly used to date? As the results will show, successful farming outcomes depend on (among other things) the successful combination of technologies/practices such as crop varieties and agronomy and resource management practices.

Sustainable Agricultural Intensification practices considered

Crop diversification: Growing multiple crops as crop rotations and intercropping can have many benefits. Diversification essentially acts as an insurance scheme (hedge) against price and weather fluctuations, pests and diseases. This is because one crop may fail but the others survive adverse conditions including unfavorable market outcomes. Maize is often rotated and intercropped with legumes such as haricot beans and soybeans. In this brief crop diversification refers to maize-legume rotation.

Conservation tillage: Conservation tillage is a relatively new concept for many farmers in Ethiopia. It involves minimizing (and sometimes eliminating altogether) the number of plough passes on a field. The advantage is that this reduces cost, mitigates soil loss and conserves soil moisture especially in moisture-stressed environments. The common practice in many maize growing areas is to plough multiple times, a costly undertaking which also has detrimental effects on soil health because the soil surface is left largely exposed. Farmers in the study area combine conservation/minimum tillage with residue retention.

Improved seed varieties: Improved seeds are one of the core pillars of SAI. Moreover, varieties that are more productive and resilient to climatic stressors are going to be very important under changing climatic conditions. The most successful improved varieties in many of the maize growing regions of Ethiopia were hybrids, namely; BH-660, BH-543, BH-540 and BH-140. According to our data, these four varieties constitute nearly 49 percent of all maize varieties planted in the areas studied, 60 percent of hybrids and open pollinated varieties and 68 percent of all hybrids. Maize is an important crop covering 22 percent of the production area allocated to cereals (9.6 million ha) as well as 28 percent of the total amount of cereal production (188 thousand tons).

Combining strategies

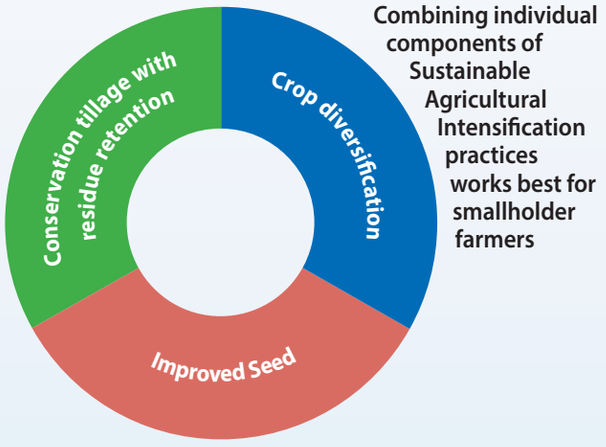
In this brief, we argue that it is the combination of the above strategies that will yield the most benefit and put Ethiopian smallholder agriculture on a more sustainable pathway. During the study, we noted that this element of adopting suites of technologies is not well studied in the literature on this issue. Yet understanding the farmers' complex decisions to combine practices and diversify crop production is important. This is because SAI will have to be based on existing practices that farmers have built over generations. Strategies that unnecessarily disrupt this body of knowledge and system functioning will in many cases lead to disappointing results. This brief makes the case for this approach by showing that:

a. Adopting portfolios of practices offers superior yield and income to farmers.

b. Government policies, advisory services and social networks are part of the software needed for SAI.

Research process

The data used in this analysis was obtained from original household surveys involving 900 households from nine districts in the following regions: Amhara, Oromia and Southern Nations Nationalities and Peoples (SNNPR). Between October and December 2010, the survey team collected data on 1,644 maize farm plots from a sample of three to six Peasant Associations in each district in the three regions. This data covered several aspects including social networks (membership in farmers' groups, number of traders and relatives farmers know) and trust (farmers' confidence in the extension workers' skills and government support in the event of crop failure) and demographics (age of household head, number of children, occupation, etc.). Farm data included crops grown, amount of inputs used, farm/plot sizes and characteristics and the types of SAI practices implemented. In order to answer the question as to what drives technology portfolio selection and diversification, the data was analyzed using advanced economic choice analysis methods (multivariate choice models) combined with counterfactual analysis on the impact of adopting combinations of SAI. This approach yielded scientifically (statistically) testable results which are summarized below.



Key results

- In households where the *female (as a spouse) had more formal schooling*, the model reported that these households had a higher statistically significant chance to be the ones using improved varieties and conservation tillage.
- The probability of adopting most of the SAI practices increase with social networks and personal relationships. This suggests that in the presence of multiple market failures, local rural institutions and service providers need to be supported because they effectively assist farmers in providing credit, inputs, information and stable market outlets.
- Concerning the *role of extension*, the results showed that among the households that reported positive impressions about local agricultural extension agents also tended to have tried improved varieties or conservation tillage.
- On *government support*, the study found that those who believed they could receive government support in the event of crop failure also tended to be the ones who used improved varieties. It is a well-known fact that many high-yielding varieties are also risky when weather conditions are not good. A fallback position afforded by government support is important to enable farmers to try new varieties.
- Households that owned *larger plots (and therefore needed more labor, all else equal)*, were shown to have adopted all three packages. The labor saving advantage of conservation tillage may help explain this outcome.

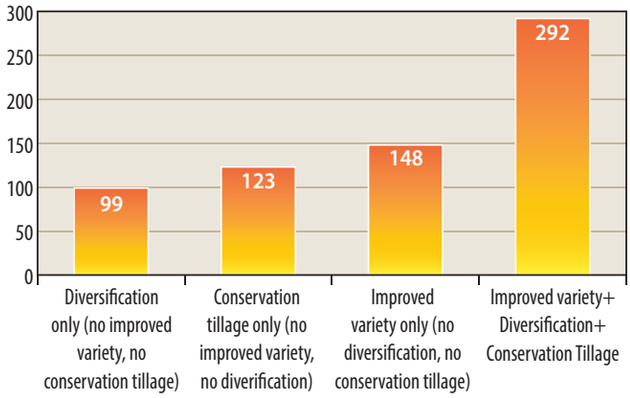
Impacts of SAI practices

- Adopting elements of the various SAI practices were associated with a number of positive outcomes judging from the counterfactual analysis (what would be the outcome if the same adopting households had not adopted the SAI). Importantly, *net maize income* was 5.6 thousand birr/ha (USD 292.1/ha) when all the packages were adopted. The impact analysis model used here determined that this was the highest income achieved in any class of farmers.

Fatuma Hirpo, a model farmer who has adopted sustainable agricultural intensification practices such as intercropping and improved maize varieties such as Melkassa II.

An EIAR researcher listens to a farmer (with scarf) speaking about his experience with sustainable intensification practices which he had recently adopted.

Researchers from the Ethiopian Institute of Agricultural Research interacting with farmers. The government supports farmers to access new technologies.



Adoption of sustainable intensification practices in Ethiopia: Impacts on net maize income ($/ha)

- *Female farm labor* tended to increase when at least one of the SAI practices was implemented by the household. This suggests a future challenge. Efforts seem to be needed to rebalance household labor so that female labor time is not diverted from critical activities such as household food preparation and nutrition, child care and the need for recuperation from the daily chores characteristic of rural households.
- Concerning input use, promoting legume-maize rotation and conservation tillage either in combination or individually reduces fertilizer use or at least keeps it constant. Conservation tillage increased pesticide application and labor demand, perhaps to compensate for reduced tillage. However, when it is used jointly with system diversification, it did not have a significant impact on pesticide and labor use.

Policy lessons learned

The adoption and impact results presented above suggest several policy lessons for smallholder agricultural development. These can be summarized as follows:

- Female education is an important aspect of agricultural technology adoption and development. Therefore equitable access to schooling and agricultural and general advisory services is important.
- Local institutions that enable farmers to connect with their peers and other actors along the value chains should be supported and encouraged by government whenever needed. This support can take the form of training sessions, exchange visits, coordination and facilitative processes in registration and recognition.
- The fact that perceived support from government provides some assurance to farmers to try new technologies means that providing safety nets can help build farmers' confidence to try new varieties and practices because there is considerable learning processes and perhaps risks (real or perceived) that can discourage farmers from trying new crop varieties, practices and farming methods. They may be willing to take a chance if they know there is a reliable safety net to fall back on.
- The study showed that the best outcomes in terms of income were related to simultaneous adoption of SAI practices. The lesson being that appropriate promotion of better agronomic practices and crop varieties should be done as a *package,* not one element at a time – to achieve maximum impact. The package approach should be used in adaptive research, extension messaging, policy support and public investments. In each case, specific packages suitable for particular locations and groups of farmers should be researched, disseminated and supported.

This brief is based on Teklewold, H., Kassie, M., Shiferaw, B. and Köhlin, G. (2013) Cropping Systems Diversification, Conservation Tillage and Modern Seed Adoption in Ethiopia: Impacts on Household Income, Agrochemical Use and Demand for Labor. Ecological Economics, 93: 85-93.

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