The Use of Modern Inputs Viewed from the Field

Megan Sheahan and Christopher B. Barrett

Overview

Common wisdom: African farmers’ use of modern inputs is dismally low.

Findings:

- Chemical input use is not as low as is often assumed.
- Irrigation and tractor use are negligible.
- Input use varies strikingly within countries.
- Modern inputs are often not combined to reap agronomic gains.
- Input intensification is happening, for maize in particular.
- Larger farms and plots receive inputs less intensively.
- Input application does not adjust to farmer-perceived soil quality.
- Few households use credit to purchase modern inputs.
- There are gender differences in input use.
- National-level factors explain the bulk of the variation in binary modern inputs use.

In sum, modern input use is not as low as is commonly believed, but there is room for considerable improvement in the level and method of input use.

Policy messages: The central message is that governments should build on and learn from achievements in promoting modern agricultural input use. The findings open a range of important new policy research questions that are amenable to further exploration.

The Issue: Do Farmers Use Modern Inputs?

Conventional wisdom holds that farmers in Sub-Saharan Africa (SSA) use few modern inputs. Yet, most growth-inducing and poverty-reducing agricultural growth in the region is expected to come largely from expanded use of inputs. These inputs embody improved technologies, particularly improved seed,
fertilizers, other agrochemicals, machinery, and irrigation. After several years of high food prices, concerted policy efforts to intensify the use of fertilizer and hybrid seed, and increased public and private investment in agriculture, does modern input use continue to be negligible in Africa? Amid the many changes in policy priorities and the overarching environment within which smallholder farmers make input decisions, it is time to check the accuracy of the prevailing beliefs about African agricultural inputs.

**The Analysis: Measuring and Understanding Input Use**

This study revisits Africa’s agricultural input landscape, exploiting unique and recently collected survey data: the nationally representative, agriculturally intensive, and cross-country comparable Living Standards Measurement Study–Integrated Surveys on Agriculture (LSMS-ISA). LSMS-ISA covers six countries in the region (Ethiopia, Malawi, Niger, Nigeria, Tanzania, and Uganda). The study used LSMS-ISA data from more than 22,000 farming households and 62,000 plots not only to produce national-level statistics derived from household responses but also to study within-country and within-household variation in input use.

**The Results: 10 Key Messages**

This section summarizes 10 important or surprising findings that may help to guide policy choices, serve as an empirical check on conventional wisdom about modern input use in SSA, and motivate a new wave of research to further understanding of agricultural practices in contemporary SSA.

1. **The use of chemicals is not as low as is often assumed.**

   **Inorganic fertilizer.** Using data from FAOSTAT, Minot and Benson (2009) found that households in SSA apply an average of 13 kilograms (kg) of inorganic fertilizer nutrients per hectare (ha) of cultivated land. This statistic has endured and prompted considerable pressure on African governments to stimulate fertilizer use and reinstate input subsidies. From the LSMS-ISA data, it is clear that although many smallholders still use rudimentary technologies on the farm, inorganic fertilizer use has picked up to significant levels in some countries. Over three-quarters of all cultivating households in Malawi, half in Ethiopia, and around two-fifths in Nigeria use inorganic fertilizer (figure 10.1). Indeed, Uganda is the only country in the sample where the percentage of farming households using inorganic fertilizer is still in the single digits. The observed average application rates are well above the widely quoted 13 kg/ha statistic, including 25 kg/ha in Ethiopia, 56 kg/ha in Malawi, and 64 kg/ha in Nigeria. These three countries happen to have some form of national fertilizer subsidy program, although the descriptive analysis is unable to suggest a causal relationship.

   **Agrochemicals.** The use of other agrochemicals has also increased. Zhang, Jiang, and Ou (2011) find that only 3 percent of global pesticide consumption takes
place in Africa, with 2 percent in South Africa, leaving only 1 percent for the remainder of the continent. But most such analyses rely on official government estimates using outdated data. These oft-cited figures might dramatically understate pesticide and other agrochemical use in SSA. The LSMS-ISA data reveal that over 30 percent of households in Ethiopia and Nigeria use pesticides and herbicides, with a simple average of about 16 percent of households across the six countries (figure 10.1).

2. **Irrigation and tractor use is negligible.**

   **Irrigation.** The lack of irrigation is often a starting point in the discussion of low input use in Africa. In a recent analysis of irrigation across the region, Svendsen, Ewing, and Msangi (2009) use AQUASTAT data from the Food and Agriculture Organization (FAO) to show that Sub-Saharan Africans withdraw about one-quarter as much water as the per capita global average. Similarly, Rosegrant, Ringler, and De Jong (2009) claim that less than 3.5 percent of all agricultural land in SSA is irrigated. Across the six LSMS-ISA countries, about 5 percent of households use some form of water control on their plots, covering only about 1–3 percent of the land under cultivation. Although they are slightly higher than the macro statistics, the micro estimates still show a very low incidence of irrigation across these countries.

   **Tractors.** Using FAOSTAT/AGS data, Mrema (2011) finds that there were 2 tractors per 1,000 ha of arable land in 1980, but only 1.3 in 2003. Ashburner and Kienzle (2011) also show a decrease in mechanization over time in SSA, claiming that primary preparation carried out by hand tools is currently
80 percent, with draft animal technology only at 15 percent, and the remaining 5 percent using tractors. The LSMS-ISA data confirm these claims by showing that tractor ownership at the household level remains quite low, with around 1 percent of households across all countries claiming to own a tractor. Tractor and oxen utilization in Ethiopia, Niger, and Nigeria is not as insignificant, implying that community-level rental or sharing schemes help to facilitate mechanization.

3. Input use varies strikingly within countries.
One of the welcome features of nationally and regionally representative household survey data is the ability to break down these statistics at lower levels of geography. Doing so reveals a great deal of heterogeneity across subnational regions, agroecological zones, and underlying soil types, as well as according to the characteristics of individual households and plots. Analysis of the marginal costs and benefits of using modern inputs—which is not feasible in this descriptive, cross-sectional work—may help to explain the considerable variation observed among and within regions intranationally. Map 10.1 shows how binary inorganic fertilizer and agrochemical use varies within the LSMS-ISA countries.
4. Modern inputs often are not combined to reap the gains from joint use.
It is commonly thought that modern inputs are rarely adopted in isolation, since the complementarity between particular sets makes adopting them together advantageous for farmers. For example, some modern seed varieties are bred to respond better when paired with inorganic fertilizer. The use of inorganic fertilizer may increase the presence of more weeds on the plot, necessitating the combined use of herbicides. Irrigation systems help to secure the necessary soil moisture for efficient inorganic fertilizer use and improved seed varietal growth.

The LSMS-ISA data show that even when households pair modern agricultural inputs together on the farm, there is surprisingly very little correlation in the use of modern inputs at the plot level where known agronomic and biophysical complementarities arise. The example of Ethiopia is illustrated in figure 10.2. This finding implies that households are spreading inputs across the farm rather than concentrating them on single plots. This behavior has gone largely unstudied to date and raises important questions about prospective untapped productivity gains from the coordinated use of modern inputs, with implications for extension programs and policies aimed at promoting efficient input uptake and use.
Input intensification is happening for maize. A major strongpoint of the LSMS-ISA data is the assembly of detailed plot-level information, including on all crops and their relative share of plot area. When isolating the “most important” crop on the plot by area, the study finds that modern input use is generally higher on plots where maize is dominant. Average fertilizer application rates are higher on plots where maize is grown than on plots where it is not. Among maize-cultivating households, 25–40 percent purchased new maize seed in the last main agricultural season, while nearly one-quarter of the maize-cultivating households in Ethiopia and over half in Malawi use improved varieties.

These findings suggest that there is more widespread participation of African agricultural households in modern input distribution systems than has been widely recognized. The weight of the evidence suggests that maize may be “on the move” in Africa. This finding is especially important given the significance of maize as a food security crop for many households in the region. Niger is largely not included in this discussion, given the very small contribution of maize to its household production and consumption.

Larger farms and plots receive inputs less intensively. The inverse relationship between farm size and productivity has been well studied. What has been less well documented is the relationship between input use intensity and farm size. The LSMS-ISA data show that this inverse relationship...
is robust even when controlling for farm-level effects and possible self-reporting measurement error (corrected using Global Positioning System measurement of plots). That this relationship is in most cases more exaggerated at the plot level means that interhousehold variation in the shadow price of inputs and outputs based on household endowments, distance to market, and so forth cannot explain the relationship. Thus, the relationship raises novel puzzles about farmers’ behavior that have yet to draw much research attention.

7. Farmers do not adjust input application to perceived soil quality.
It would be expected that farm management practices would follow from the knowledge farmers have about their farming environs. An important characteristic of the operating environment that should affect input use decisions is soil quality. It is well known, for example, that the responsiveness of crops to fertilizer application depends on the quality and fertility of the soil. Even within a given farm, the evidence suggests that productivity can vary enormously between plots, as would fertilizer use. Household perceptions of soil quality may influence fertilizer application rates and be influenced in turn by previously observed crop yields. The study tested these claims in three countries—Malawi, Tanzania, and Uganda—where the LSMS-ISA surveys report farmer perceptions of soil quality by plot. The plots that the respondents considered “average” or “poor” in quality are statistically significantly more likely to receive inorganic fertilizer applications than are plots categorized as “good” quality, all else equal. However, these variables explain only a tiny amount of within-household fertilizer allocation decisions, and this relationship does not hold over self-reported erosion status. If “poor” and eroded plots have suffered serious nutrient mining, then this surprising finding may signal a knowledge gap among farmers, and it raises important questions about the accuracy and drivers of farmer perceptions of soil quality.

8. Few households use credit to purchase modern inputs.
Because of the poorly developed financial markets and the high risks associated with providing credit to smallholder farmers, credit is widely thought to be used only minimally throughout Africa, and to act as a major constraint on input use. In all the countries except Ethiopia, the LSMS-ISA data show that less than 1 percent of cultivating households used credit—either formal or informal—to purchase improved seed varieties, inorganic fertilizer, or agrochemicals. This finding corroborates evidence about the weakness of agricultural input credit markets in the region (see chapter 4 for more on this). Much scope remains for deepening rural financial markets, despite recent advances in money transfer systems based on mobile phone platforms, the proliferation of microfinance institutions, and similar interventions.

9. The gender of the farmer matters.
The headship of the household is a characteristic that is often believed to limit modern input use. Male-headed households in the LSMS-ISA sample
are indeed statistically significantly more likely to use modern inputs across almost all the countries and input types. This result is found in simple descriptive statistics and multivariate regression analysis, holding other important covariates constant. Similarly, plots owned or managed by women (who control less than a quarter of all cultivated plots) are less likely to receive modern agricultural inputs and receive lesser amounts when applied. Gender differences in modern agricultural input use, both among and within households, merit more attention, as they may lead to needless productivity losses and food insecurity.

10. *Mostly national-level factors explain modern input use.*
A huge body of literature promotes one set of variables as the most important reason for the “adoption” of a particular input, be it biophysical, infrastructure, market, socioeconomic, or otherwise. Having so many observations across multiple countries with similar covariates allows the rare opportunity to test which of these variables or classes of variables is most strongly associated with variation in input utilization (box 10.1). This analysis shows that most of the variation in the decisions to use inorganic fertilizer and agrochemicals comes from the *country level*, even after controlling for a range of important household-level and agroecological variables. This is an especially striking finding that signals the importance of the policy and market environment beyond the observed variables and what we can control for statistically.

**Box 10.1 Identifying the Main Correlates**

Based on standard ordinary-least-squares regression, the Living Standards Measurement Study–Integrated Surveys on Agriculture data are used to estimate separate binary linear probability models for inorganic fertilizer and agrochemical use at the household level, pooling observations across all six countries. Shapley values are calculated, which decompose the explained variance (measured by $R^2$) of the regressions into contributions over groups of regressors. In other words, the study calculates the mean marginal contribution of each variable or group of variables to the overall regression model $R^2$. The variables represent the following:

- **Biophysical**: rainfall, elevation, soil nutrient availability, greenness index, and agroecological zones.
- **Sociodemographic**: consumption quintiles, gender of the household head, household size, and household dependency ratio.
- **Farming operation**: total hectares under cultivation, number of crops cultivated by household, maize production, and cash crop production.
- **Market and infrastructure**: distance to nearest market, distance to nearest road, price of fertilizer, and price of the main grain.
- **Country-level dummy variables**: overarching policy and institutional environment variability.

*box continues next page*
For inorganic fertilizer, the overwhelming amount of variation—indeed, nearly half (45 percent)—is accounted for by the country dummy variables. Even controlling for a wide range of important observable household-level variables, some combination of other policy, institutional, or macroeconomic variables explains most of the micro-scale variation in inorganic fertilizer use in this unprecedentedly large sample. Since the dependent variable is the binary input use decision, differences in survey design, which may lead to differences in the measurement of continuous input volumes, cannot plausibly account for the importance of the country-level variables. This is an important finding, as clearly the policy and operating environments facilitated by governments matter.

Biophysical variables account for 24 percent of the explained variation in fertilizer use, followed by farm operation characteristics (16 percent), market and accessibility variables (nearly 10 percent), and socioeconomic variables (less than 4 percent). That geography and biophysical characteristics (accounting for a combined 70 percent of variation) matter so much to the fertilizer use decisions mirrors, to a large extent, the findings of McCord and Sachs (2013) on the importance of the same factors in explaining variations in macroeconomic development conditions across countries. The percentages are virtually the same for the agrochemical model. Together, these findings suggest the need for broad-based policy reforms at the country level, which are likely to have tangible impacts on spurring input use and staple grain productivity.

The Implications

Policy Agenda

Two central messages that emerge from the findings of the study have profound implications for current policy. First, in the aggregate, modern input use is not as dismally low as is commonly assumed. Nonetheless, for some countries—Uganda, for example—input use is quite low across the board. Governments should build on and learn from the gains where input use has increased over time (findings 1 and 5). Second, the importance of the national-level policy and socioeconomic environment is hugely important for input use (finding 10). Implementing policy that encourages efficient modern input use and techniques is crucial. This finding also underscores the importance of regional processes, such as the Comprehensive Africa Agriculture Development Programme initiated by the New Partnership for Africa’s Development.

The following specific micro messages emerged from the study for the design of extension services:

- There are lessons for encouraging farmers to apply modern inputs in more effective and productive combinations that raise their returns (finding 4).
- Extension services might also focus on improving farmers’ perceptions about soil quality and input use outcomes (finding 7).
- Finally, rural credit markets need to be deepened to serve farmers better, especially with respect to modern input use (finding 8).
Research Agenda

The following areas for further research are suggested by this study:

- Input use, farm and plot size, and farmer behavior (see finding 6)
- Gender correlates with input use (finding 9).

Additional Reading

This chapter draws on:


Other key references:


