Production System Characterization

OUTLINE

HarvestChoice generates strategic, policy oriented information about the potential payoffs to a broad range of interventions designed to enhance the productivity of smallholder farming systems. A major challenge to evaluating the potential impacts of change is that the nature and severity of productivity constraints as well as the potential effectiveness of specific interventions are highly dependent upon the nature of the production system itself. Many assessments of agricultural production fail to recognize these complex and frequently site-specific dependencies, often only distinguishing between rainfed and irrigated systems.

Evaluating change in a regional and even a global context across very diverse cultural, environmental, and socio-economic landscapes, means that spatially characterizating dominant production systems is important. It is critical for at least two reasons. First, to provide a reliable description of baseline conditions pertaining to key variation among existing smallholder production systems across sub-Saharan Africa and South Asia and, second, to support more realistic evaluation of the potential impacts of different interventions and better assess the distribution of economic consequences among different types of farming systems and households.

For these reasons HarvestChoice is undertaking a unique and extensive data compilation, consolidation and analysis effort drawing on nationally representative production surveys and agricultural censuses. The project is using farm household scale data to empirically define the distribution and nature of dominant production systems and to better calibrate and conduct our strategic evaluation work. The initial set of characterization criteria include;

- the structure of outputs (which outputs are produced, in which combinations?),
- the extent to which productivity enhancing services and production inputs are already being utilized,
- the nature and type of farmer practices such as germplasm choice, cultivation, nutrient, water, and pest and weed management, and
- the prospects for participating in commercial markets.

What do we learn from production system characterization?

Consider the case of maize production throughout Africa, or even maize production within one country. Production is likely to involve a range of single crop, sequential cropping and intercrop systems using both traditional and hybrid varieties of maize and grown in a mixed cropping patterns with a range of legumes and root crops. Typically, subsistence smallholder systems will apply very limited quantities of inorganic fertilizer, but might apply animal manure or green manure. Few farmers irrigate, but may use various techniques of soil water conservation such as mulching or conservation tillage.

By compiling farm (and plot) level production data for all households producing maize, harmonizing and extracting data for key characterization criteria, and using statistical grouping techniques, it is possible to identify the most commonly occurring *combinations* of classes of each of the criteria that represent the major maize production systems (e.g., crops grown in combination with maize, typical amounts and mixes of inputs associated with those combinations, and the extent to which outputs from such a combination are marketed). These "homogenous" clusters can be considered prototypical production (or farming) systems. It is possible, using this approach, that a single farm household might simultaneously be engaged in a number of production systems. HarvestChoice has opted to identify the dominant maize production systems (e.g., those that account for the production of at least 10 percent of maize output) to create production typologies that facilitate the analysis of change strategies at different spatial scales, e.g., AGRA countries, sub-Saharan Africa, or Ethiopia.

A considerable effort is being made to compile and process data from nationally representative production surveys or agricultural censuses to construct production typologies in ways that improve the evaluation of interventions that may have different effects on different typologies. Differentiating between subsistence and commercial production, for example, will enable HarvestChoice assessments to better calibrate technology uptake, spillover and market share attributes for each production typology.

How will HarvestChoice use these data?

There are at least three ways in which characterizing production systems will greatly enhance the HarvestChoice evaluation effort.

1. **Improving the spatial allocation of crop production.** Identifying the most common crop associations and cropping patterns will further improve HarvestChoice's hallmark crop distribution assessment (SPatial Allocation Model, SPAM). Knowledge of common crop associations will allow the SPAM allocation to jointly allocate crops from observed cropping patterns into the same cropland areas. For example a prescribed share of maize and beans will be grown in the same physical location, if maize-beans are identified as a major production system. This will improve SPAM in two ways. First it improves SPAM's ability to spatially locate the production of individual crops, and, second it allows SPAM to better assess the spatial and temporal intensity of crop production (see box).

SMALL BOX
SPAM Allocation Arithmetic

If a SPAM run were to allocate 100,000 ha of maize and 60,000 hectare of beans it presently sets aside 160,000 hectares of land since, lacking cropping pattern data, SPAM cropping intensities default to 1 (crop intensity is the ratio of harvested area to physical area in a single calendar year. An irrigated rice area cropped 3 times in a year has a cropping intensity of 3). Knowing that 40,000 ha of land were farmed as a maize-bean system, means that 40,000 hectares could be allocated to the joint production of maize

and beans in a single year, not only correctly co-locating the production of those two commodities, but also reducing the aggregate land needs for their production. In this case, the aggregate demand for land for maize and bean production would drop from 160,000ha to 120,000ha. Improving the data underlying the SPAM allocation process will help resolve the present tendency for SPAM to overestimate the land area required for crops that are generally grown in combination which in turn can push SPAM toward violating the total cropland area constraint.

2. **Improved assessment of the productivity consequences of intervention.** Improving the identification of cropping systems and their associated farm management practices greatly enhances the capacity to assess the potential impacts of change. This is especially so for the application of regionally calibrated crop growth models that are a distinctive feature of the HarvestChoice approach. Properly parameterizing crop growth models requires explicit quantification of a large number of management related choices and practices. These choices can have profound consequences on the potential relevance and impact of any proposed intervention and the ability to assess those impacts.

Thus, for example, if five key types of maize-based production systems emerge from the empirical analysis, then the defining characteristics of those five systems will be used to parameterize five runs of the crop-growth model. Running each of the five specification of the crop growth model will then determine, for instance, the impacts of adopting an improve seed variety under each of the five production systems. Production system characteristics that will be used to parameterize the crop growth model could include:

- Number of growing seasons in a year
- Cropping patterns and crop rotations,
- Germplasm selection/adoption (e.g., traditional, improved, hybrid)
- Planting dates
- Cultivation practices (e.g., hand, animal, machine, zero till)
- Nutrient management practices (nutrients applied [animal, vegetable, mineral], how much and when)
- Water management practices (irrigation? How much, when?)
- Pest/disease (integrated pest management or pesticide use)
- Weeds (weeding practices, herbicides)

It is highly unlikely that data on all these attributes are uniformly available. One part of the HarvestChoice analysis is to construct a core set of characterization data that can be compiled from accessible the survey and census data. Once the major production systems have been characterized for use in the crop models, HarvestChoice will be uniquely placed to make location-, crop system- and intervention- specific assessments of change with a degree of detail never before attempted at across such broad geographic scales.

3. **Improved assessment of the scale and distribution of economic benefits.** Beyond improvements in locating production and assessing the on-site productivity effects of

change, production system characterization will assist in parameterizing the market level *economic* evaluation of change. It will do so by providing better translation of on-site productivity impacts into potential economic benefits, both in aggregate and for specific producer/production system categories. Insights into the structure of production systems helps calibrate a range of important economic evaluation parameters, including:

- The share of production attributed to different production systems
- Status of and attitudes to adoption of new technologies and practices (that directly effect adoption lags and levels)
- Level of participation in commercial input and output markets
- Ability to respond to changing market signals (e.g., price elasticities of supply)

Getting Started

Production system characterizations will be based on household surveys (usually nationally representative, collected as part of an ag census). Data from six countries are in hand, and we expect to receive more data. Our initial goal is to take inventory of what relevant information is available for each country, harmonize information and variable definitions across data sets, and summarize the data briefly.

Household survey data preliminary analysis

Our approach to these initial goals is likely to evolve as we learn more about the data, initial steps include:

- Complete an inventory of files received with the data. For most data sets, we received many raw data files, and many files with other content (with very little documentation). It is important to be sure that we have a sense of what information we have access to. In addition, some of the non-data files may have relevant information about how the survey was collected.
- Describe original data sets in terms of the number of observations and variables, level of observation, and basic analysis of responses (frequency tables).
- Harmonize data variables within each country (or at least each data set). As part of the harmonization, we need to identify overlaps between data files, define variables consistently, and combine data files to the extent possible. Any changes we make to the original data files need to be carefully documented.
- Condense data sets so as to reduce the number of files.
- Write a brief summary of data collection procedures and data availability.
- Write a series of short "briefs" describing agriculture in each country. We will want to use a fairly consistent format. The idea is to have a series of one-page summaries for each country (or, four-page summaries in a format similar to that being used for pest summaries posted to the HarvestChoice web site). These briefs will be mostly frequency tables and graphs with short narrative. In order to write them, we will need to do lots of frequency tables and cross tabs and look for information that seems relevant and interesting (e.g., variables where there is a lot of variation across districts).

Ideas for One-Page "Briefs" include

- Land holdings
- Use of inputs
- Use of technology
- Crops and livestock produced
- Household consumption
- Market participation

We'll probably get more ideas as we familiarize ourselves with the data sets.

Other data sources to be explored

The household-level data described above will be used to define production systems, and to estimate the likelihood of each type of production system as a function of household and GIS characteristics. In order for the models to be revised and applied to countries where household-level data are not available, we must have a sense of what data are available to be used as right-hand side variables.

In order to find additional data on these countries, we will explore several potential sources. These include the International Household Survey Network, the World Bank's PovertyNet, IFPRI, and the Data Rescue Inventory, for which Michelle Hallaway is our contact. Work is underway to document all potential sources of additional data and pursue any promising leads.

Additionally, information on methods used by others to classify production systems may be useful in guiding our approach to classifying production systems and estimating a model to predict their prevalence. To do so, we will conduct a review of the academic literature via databases such as Econlit, Agricola, and AgEconSearch, potentially with the assistance of the library staff at the University of Minnesota, where AgEconSearch is based.