6.1 Intensification vs. Extensification

When use of a practice, technology, or policy option was modeled, we defined two generic ways in which it could occur. Intensification involves exercising the option on land areas currently used in production of the relevant commodity(s) — creating more product with the same land area in the same location. For purposes of our analysis, we defined intensification to include the displacement of one commodity by another within existing land areas suitable for production of both commodities. Displacement in these models occurs when the technology or policy option causes a more favorable economic outcome relative to current land use. Extensification is the process of introducing production into land areas that were previously unused or used for less intensive purposes. In practice, to meet the demands for food imposed by an increasing population, extensification has often involved exploiting marginal lands with resultant degradation and/or desertification. These terms define the limits of a continuum of land use change resulting from outcomes driven by technology or policy options.

6.2 Geographical Equivalence and Use of Spatially Explicit Analysis

The term “geographical equivalence” in its simplest manifestation describes the ability to create an empirical model of a select location and identify all areas similar to that location. Geographical equivalence specifically relates to the observation-environment relationship and its spatial analogue. In many ways, the crudest forms of adaptation zones are those areas that are geographically equivalent to a location where a given technology appears well suited. However, geographical equivalence relates also to other characteristics that may not be fully part of a technology or policy-level adaptation zone.

Closely related to the idea of geographical equivalence is the term “adaptation zone.” In the case of new technology, this means geographically equivalent areas in which, as a first approximation, the technology might be adaptable. For example, a specific maize germplasm may have characteristics that loosely describe its adaptation zone (temperature, rainfall, and soil requirements). Geographical equivalence is the term used to describe a series of spatial tests relating other important characteristics to the initial adaptation zone. Perhaps the germplasm is not tolerant of a certain disease — a disease that has its own set of characteristics for which geographic equivalence might be identified. In these studies, we distinguished between the terms adaptation and adoption. Adaptation was a first-order approximation of areas of geographic equivalence to which new technology may be adapted. The precision of this estimate is dependent on the extensiveness of the analysis of geographic equivalence. We used the term adoption to mean the actual use of new technology, both in terms of the location and the extent of utilization. We recognized that the analysis of adaptation in ex ante analysis would be different from actual adoption as a result of factors that were not completely represented in our models.

Geographic equivalence was used in these studies as a fundamental part of establishing an objective method for determining spatial sampling frames that required spatially explicit analysis to assess the impact of new technology or policy. Objectively defined sampling frames provide a very important tool to improve the efficiency of research on impact assessment. Knowing how often and where to sample to acquire representative data avoids either over or under investing in detailed research. A spatial sampling frame not only sets up the rigorous examination of predictive data but also sets in place an understanding of how far (and how representative) results can be applied. We exercised two different spatial sampling mechanisms in our case studies.
For Kenya, the complexity of the local environments, extensive use of an established agro-ecological zoning scheme, and the steep local environmental gradients encouraged the following steps in establishing our sampling frame. First, we used the Jaetzold and Schmidt zones from the “Farm Management Handbook of Kenya” to better communicate with our local collaborators and to ensure sampling across all ecotypes. We then took GPS (latitude and longitude) readings of actual smallholder dairies in each ecotype. We linked these locations to our spatial databanks, and built a quantitative characterization of each dairy. A principle component analysis on these climatic characteristics produced groups of similar smallholder dairies. We took the mean characteristics of these groups and found areas of geographical equivalence for each. This technique differs markedly from the published agro-ecological zoning scheme because that scheme attempts to amalgamate a wide range of agricultural activities into one coherent scheme. Our system rapidly assembled even more data than the Jaetzold and Schmidt study but then built a smallholder dairy-specific spatial sampling frame of the target environments. We named them in a similar fashion to the Jaetzold and Schmidt scheme to better communicate the ecotype, but the spatial manifestation of the ecotype was specific to smallholder dairies. The underlying purpose of this quantitative method was to allow development of quantitative environment characteristics and seek similar areas throughout East Africa (Uganda and Tanzania). This step would have been impossible following the more traditional Jaetzold and Schmidt approach as their method was specific to Kenya.

In Mali, the approach we used reflected the relatively simpler environmental gradients found in West Africa—a steep north-south rainfall gradient and a single rainy season. We used the climate surfaces in our foundation database, extracting the monthly data for the 5 consecutive months that maximized the moisture availability (defined by the precipitation to potential evapotranspiration ratio). Then we ran a cluster analysis on these variables. The resulting clusters set the sampling frame for both the representative farms in Mali and for the next step, the linkage between these climate clusters and the soils database. Once linked to the soils database, we created simulation zones for which yields were simulated for six crops and a variety of management conditions. This sampling frame allowed us to verify the simulated yields using data from Mali but then cross political boundaries and produce simulated results in Burkina Faso and Senegal. Extrapolation of the simulations into other related but non-verified areas helps define the adaptation zone for agricultural technology. The economic refinement of these zones leads to identification and characterization of adoption zones.

Problems with spatially explicit analyses often stem from limitations in the resolution of the data available. High-resolution soil maps could add tremendous value in further targeting of agricultural technologies as would high-resolution land-cover databases probably based upon remotely sensed imagery. These data would help, for example, understand soil fertility constraints, identify areas of intense striga infestations, and even allow for real-time monitoring. Most economic and crop simulation models can be improved by further linking them to the relevant spatially explicit data in an iterative manner. Earlier methods often involved rather tedious steps necessary to push data from spatial sources through these models and then back to a spatial frame. Technologies are rapidly evolving to reduce these constraints, and it is likely that future impact assessments of agricultural endeavors will link seamlessly to spatial models and spatial database and decision support mechanisms.

A spatial information system like the ACT enables characterization of target environments to be far more specific than was possible using analogue (paper maps) methods. We are able to mix spatial data of both qualitative and quantitative origin, of various scales, and from multiple sources and disciplines. Our results have sufficient spatial resolution to greatly facilitate implementation steps for the transfer of technology and for the evaluation of technology developed in one place carried to other, similar locations.