A HarvestChoice Primer on

Geographical Targeting/Segmentation & Development Domains

(Version 1.0, May 2007)

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TABLE OF CONTENTS

FIGURE

TABLE

Glossary

AEZ	Agroecological Zone
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
CAADP	Comprehensive Africa Agriculture Development Program
CGIAR	Consultative Group on International Agricultural Research
CORAF	Conseil Ouest et Centre Africaine pour la Recherche et le Dèveloppement Agricole (West and Central African Council for Agricultural Research and Development)
DFID	Department for International Development (UK)
DRC	Democratic Republic of Congo
ECA	Eastern and Central Africa
FARA	Forum for Agricultural Research in Africa
GIS	Geographic Information System
GPS	Global Positioning System
LGP	Length of Growing Period
NDVI	Normalized-difference Vegetation Index
NEPAD	New Partnership for Africa's Development

Spatial Segmentation of The Regional Evaluation Of Agricultural Development Intervention Opportunities

1: Introduction

1.1 Context and motivation

Strategic agricultural development policy and investment studies make growing use of geo-referenced data and spatial analysis methods. Spatial perspectives appear to provide decision makers with intuitive entry points for examining the performance of agriculture, a physically-extensive, economic undertaking that owes much to spatial patterns of natural and human-endowed assets. Spatial characterization helps to distinguish and target geographical areas that are more likely to face certain types of agricultural development constraints (drought, soil erosion, pests and diseases, and isolation, for example), or those more or less suited to specific opportunities (such as dairy farming, irrigation investment, and improved extension services). Consistent and comparable characterization of economically-relevant location attributes is particularly important in evaluating the potential for spillovers and economies of scope and scale in a cross-country setting, e.g., in the scaling up and scaling out of beneficial knowledge and technologies across large geographical extents.[1] Most spatial datasets, even those of global or regional coverage, portray location attributes in highly spatially-disaggregated ways compared to the geopolitical units generally used in national policy and investment

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[1] "Cross-country" can be interpreted in several ways. Some agencies invest in regional initiatives and assess the regional costs and benefits of investment alternatives, but always with an eye to national implications (e.g., agricultural research entities such as the CGIAR and ASARECA). Other agencies target investments at a national scale, but often wish to evaluate their portfolio of country investments through a consistent multi-country framework (e.g., most development donor and lending agencies). In yet other cases, enlightened countries may chose to develop their own investment strategies informed by potential interaction with other countries through trade, technology spillover, human and animal migration, epidemiological risk, and so on.

studies. Visually, at least, such data reveal patterns of spatial heterogeneity of land use, transportation networks, population density and other factors that have a direct bearing on development.

To illustrate a specific, if perhaps not typical, strategic use of regionally-derived, spatially-referenced data (henceforth called *regional spatial data*), Figure 1 portrays a *development domain* characterization for Eastern and Central Africa (ECA) (Omamo et al. 2007). Development domains are spatial constructs gaining currency, particularly in sub-Saharan Africa, through their incorporation into "evidence-based" approaches to the formulation of development strategies and policies, and to investment decision making.[2] Development domains are constructed by the intersection of three spatial variables; agricultural potential, market access and population density, using a geographic information system (GIS). Through a currently cumbersome conceptual-cum-empirical rationalization it is argued that these domains and their geographic extents can be interpreted as representing distinct bundles of agricultural development constraints and opportunities. Domains offer a compact way of delineating relatively few bundles of development conditions on the one hand (only eight domain classes in the example), while exhibiting a relatively complex spatial pattern of the location, extent and degree of fragmentation of individual domains. Thus, while intuitively simple, the domain approach appears to capture some measure of the heterogeneity of agricultural development conditions known to exist across the ECA region. Furthermore, on the basis of (still limited) empirical evidence, hypotheses can be formulated about specific agricultural development constraints and strategic opportunities associated with each domain class. A partial summary of such hypotheses for 4 of the 8 domains is presented as Table 1.

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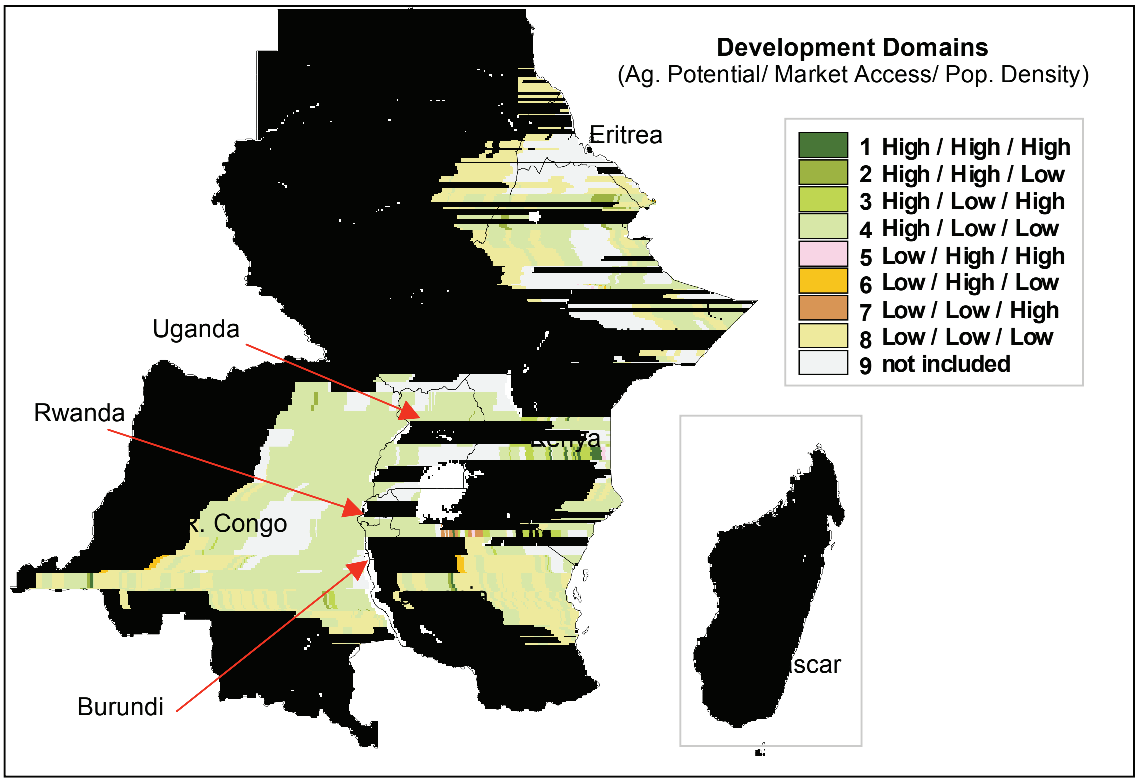
[2] At an operational level, institutions and initiatives currently incorporating the notion of development domains into their strategic targeting and evaluation processes in Africa include centres of the Consultative Group on International Agricultural Research (CGIAR), the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA), the sub-Saharan African Challenge Program coordinated by the Forum for Agricultural Research in Africa (FARA) and the Comprehensive Africa Agriculture Development Program (CAADP) of the New Partnership for Africa's Development (NEPAD).

The map and the table provide a compact conceptual framework for addressing strategic agricultural development issues that analysts and policymakers have embraced. Using other information and spatial analysis tools, domains can be further characterized in terms of the numbers of people, cropland areas, shares of production, natural resources, etc. they comprise, thus helping scale notions of the potential costs and benefits of intervention.[3] Taken together, such strategic information contributes to targeting and priority setting for subsequent, in-depth evaluation.

Figure 1. The Agricultural Development Domains of Eastern and Central Africa



(adapted from Omamo et al. 2007)

[3] In the Omamo et al. (2007) study, domains define the spatial analysis units for further economic evaluation of alternative growth strategies using a regional, agricultural sector model.

Table 1. Agricultural Development Priorities and Options within ECA Development Domains

Agricultural potential	Market access	Attributes/ Priorities	Example Locations in ECA and Potential Agricultural Development Options	
			Population Density	
			HIGH	LOW
HIGH	HIGH	*Greatest commercialization and diversification options* *Productivity Growth* • Agricultural research and extension systems • Weed and pest control • Soil and water management • Awareness raising, consensus building on biotechnology-related opportunities & risks *Market Improvement* • Market intelligence (domestic, regional and international) *Linkages with non-agriculture* • Storage, processing, distribution, agro-industrialization	*Example Locations:* Parts of central and western Kenya, Uganda's Lake Victoria Crescent, parts of central and southwestern & southeastern highlands of Ethiopia, parts of Rwanda & Burundi. *Options:* • High input cereals (e.g., maize, rice, wheat) - Perishable cash crops (e.g., vegetables, fruits, flowers, ornamentals) - Intensive livestock (e.g., dairy, chicken, pig) - Non-perishable cash crops (e.g., coffee, tea)	*Example Locations:* Isolated areas scattered throughout region *Options:* As for high population density plus more extensive high-value options, e.g., cotton, tea, oil crops, fruits
	LOW	*More limited technology adoption and commercialization* *Productivity Growth* • Agricultural research and extension systems • Weed and pest control • Soil and water management • Awareness raising, consensus building on biotechnology-related opportunities & risks *Market Improvement* • Market development – i.e., infrastructure, market info systems, credit institutions, etc. *Linkages with non-agriculture* • Storage, processing, distribution	*Example Locations:* Southwestern Uganda, parts of central and western Kenya, much of the Ethiopian highlands, northern Tanzania, Rwanda and Burundi. *Options:* - High input cereals (e.g., maize, rice, wheat) - Non-perishable cash crops	*Example Locations:* Large areas of all countries: most of central DRC, southern Sudan, parts of central Uganda, Kenya and Tanzania, widely scattered areas in Ethiopia and Madagascar. *Options:* - Intensification in non-perishable crops—cereals, oilseeds, tea, coffee - Livestock intensification; improved grazing areas

Source: Adapted from Omamo et al. (2007)

1.2 Relevance, Reliability, and Explanatory Power?

The extent to which development domains have been perceived to provide intuitively logical and useful spatial stratifications for policy and investment purposes suggests that there are purposes and scales for which they add new insights. Establishing what spatial variables are most useful, at what scale, in helping explain which key agricultural development issues or processes, remains a substantial challenge.

Factors that favour addressing the challenge of enhancing the role of spatial perspectives in agricultural development planning now include: a rapidly expanding capacity to generate, manage and integrate a broader range of regional spatial data - including weather, crop and livestock system distribution and performance, land cover, human settlements, infrastructure, population and health; a growing capacity to share, manage and utilize such data cost-effectively; a growing range of analytical tools that might foster creativity in generating spatial variables of greater economic relevance; the increasing availability of household and community survey data in spatially-referenced formats, allowing them to be directly juxtaposed with traditional sources of GIS data; and new econometric tools for performing spatially-explicit regression analysis.

Making progress on filling these knowledge gaps would be valuable for several reasons. It would provide analysts with better guidance on which spatial variables to select and how best to utilize them in addressing specific agricultural development questions posed at specific scales. It would also increase confidence amongst analysts and decision makers in the reliability of analytical results that rely heavily on regional spatial data (such as the development domain approach). Other benefits might include improved acceptance of "spatially-enabled" perspectives in mainstream economic analysis, and greater awareness by and responsiveness of the spatial data community to the needs of agricultural development investors and decision makers. The spatial data community must also recognize their obligation to provide better information on the reliability and availability of spatial data and on its constantly evolving richness. Ironically, although regional spatial data are expensive to compile, process and manage, their development is usually publicly funded and, as a consequence, the data are often freely available.[4] Thus, with access to sufficiently specialized human skills, location attributes can be generated consistently across very large geographic areas, making their use well-suited to the demands of low cost, short-timeframe strategic planning studies. For both economists and spatial data specialists, another outcome might be greater opportunity for creativity in the generation of economically relevant measures of location, with clearly established relevance and explanatory power.

Many of the specific opportunities and challenges presented by this research relate to the improved utilization of spatial (geo-referenced) data and spatial analysis that link geographical information systems with statistical methods in order to address socioeconomic questions. Opportunities include the increasing capacity to access and utilize geo-referenced data at high levels of spatial resolution, more cheaply, and to combine and interpret the data in ways that better serve the needs of strategic investment decision making and economic development.[5] One way to do this is to assemble geo-referenced, *location attribute* data from a geographic region of interest, and to explore relationships between these data and policy-relevant socioeconomic data derived from agricultural households and communities. Socioeconomic data are almost invariably more limited, often to a specific subset of locations within the focus region (e.g., derived from field sampling and survey methods). As long as the geographic coordinates of the households and communities are recorded, however, the GIS-derived location attributes and socioeconomic data can be linked and analyzed jointly. A powerful analytical option conferred by the use of geo-referenced data is that of creating new variables to account for the spatial *arrangement* of locations, for example, distance and neighbourhood attributes (e.g., distance or time of travel between farms and towns, the potential diffusion of information and technology from farmer to farmer, and the potential spread of pests and disease from region to region). This research is aimed, from a methodological standpoint, at learning more about the extent to which the economic

[4] Another irony is that some regional and global spatial datasets, e.g., elevation, slope, land cover, and population density sometimes have higher resolution and are often much easier to obtain than data from national sources

[5] Witness, for example, the rapid advances in and adoption of global positioning system (GPS) technology, and the popularity and utility of Google Earth™ (http://earth.google.com/).

evaluation of agricultural development options might be enhanced through improved integration of spatial analysis.[6]

1.3 Development Domains: Opportunities and Challenges

A development domain is defined as a geographical region, or set of non-contiguous geographic areas, exhibiting broadly homogeneous comparative advantage with regard to the pursuit of one or more specific economic enterprises or livelihood strategies (Wood et al. 1999, Pender et al. 1999). By virtue of their conceptual ancestry, development domains are biased toward consideration of agriculture-based or agriculture-focused enterprises, and have been constructed operationally through the spatial intersection of three factors; agroecological conditions, access to markets, and population density. As shown in Figure 1, even a simple characterization schema that partitions each of the above three factors into just two categories ("high" and "low", resulting in just eight unique domain classes) is capable of highlighting a great deal of spatial complexity and heterogeneity within and across countries when mapped. Furthermore, this type of domain characterization and mapping has proven to be readily communicated, and to partition regions into geographical areas that reflect informed intuition about opportunities for agricultural development within them.

Indeed there are other things to like about the development domain approach, particularly in a multi-country setting. Thanks to the existence of a number of global and regional geo-referenced databases, a range of proxies of agricultural potential, market access and population density can now be mapped and analyzed over large geographical areas. The approach moves beyond traditional biophysical perspectives such as the Agroecological Zone (AEZ) method (FAO 1978, Fischer et al. 2001) and highlights the need for simultaneous focus on market and demographic factors when thinking about potential agricultural development outcomes. This is timely, since there appears to be an emerging synergy between the accelerating capacity to better utilize spatially

[6] Economists often equate "spatial" to "more disaggregated". Thus, many economic models described as spatial simply use a greater number of geographical units of disaggregation than is the norm for that particular field. While the potential for increased spatial disaggregation is indeed a key opportunity provided by geo-referenced data, the true notion of spatial is that the analysis contains terms dependent upon the spatial arrangement of the units of analysis. If the units of analysis were to be rearranged geographically, and this brought no consequence for the results of the analysis, this would signal that the analysis was not truly spatial.

disaggregated information in ways that are policy relevant, and the growing awareness of the potential strategic value of such information by decision makers, analysts, and researchers.

Development domains are a by-product of a series of research studies conducted on sustainable livelihood options, particularly in less-favoured lands, much of which was originally undertaken in Central America (Scherr et al. 1996, Templeton and Scherr 1999, Barbier and Bergeron 2001). This research was built around an induced-innovation framework (Boserup 1965, Hayami and Ruttan 1984) suggesting that degradation may be self-correcting, as resource scarcity or rising private and/or social costs from degradation induce new agricultural and resource management practices. The conceptual framework adopted for these studies (Scherr and Hazell 1994) included market-induced and population-induced pressures that can drive both resource degradation as well as incentives to innovate in the management of natural resources and in the adoption of new technologies.

The focus, approaches and findings of the Central America studies were by no means unique, and succeeded others on production intensification and innovation linked to both population pressures and, to a more limited extent, market development. Ruthenberg (1980) provides many examples of agricultural innovations historically associated with increasing population density and increasing market integration for a range of tropical farming systems. Major studies by Pingali et al. (1987), McIntire et al. (1992) and Turner et al. (1993), all focused on sub-Saharan Africa (SSA), added to the weight of evidence compiled by Ruthenburg and others in identifying predominantly positive relationships between increased population and a range of agricultural intensification responses. We focus on the Central America work, however, since this is the most proximate route to arriving at the emergence of development domains.

As research progressed during the 1990s, livelihood dynamics (that is, changes in livelihood strategies) were increasingly cast in terms of both comparative advantage and "development pathways" (e.g., Pender et al. 2001a). Development pathways were defined as common sets of causal and conditioning factors shaping household and community choices about livelihood strategies, whose inspiration owed much to the work of Morris and Adelman (1988) on comparative patterns of economic development.[7] By the late 1990s empirical work pointed to three broad rural development axes as consistently shaping observed livelihood strategies; agricultural potential, market access and population density. And research findings with regard to the role of land tenure, NGOs, public policies on crop, technology, and land management choices were increasingly presented and interpreted in this three dimensional framework (Pender 1998, Templeton and Scherr 1999, Barbier and Bergeron 2001, Pender et al. 2001a, 2001b).

Agricultural potential largely conditions the absolute advantage of locations with respect to the production of particular agricultural commodities, while access to markets and infrastructure, and population pressure help shape the extent to which absolute advantage might be realized as comparative advantage (Pender et al. 1999, Pender et al. 2004). For example, an area with suitable climate and soils may have an absolute advantage in producing high-value perishable vegetables, but little comparative advantage if it is remote from markets and roads. In such circumstances, improvements in roads or market access might be expected to favour production of more commercial commodities as well as non-farm activities, and contribute to higher incomes and welfare (Pender et al. 2001a). Improved access to markets and infrastructure has more ambiguous theoretical impacts on land use, land management practices and resource conditions, depending upon the relative impacts on the costs of productive factors (Angelsen 1999, Pender et al. 2001a), and because of ambiguous effects of output prices on incentives to conserve land (LaFrance 1992, Pagiola 1996). Population density is expected to influence the labour intensity of agricultural production, including the choice of commodities as well as production technologies and land management practices, by affecting the land-labour ratio (Boserup 1965, Pender et al. 2004). Population growth may drive expansion of agricultural production into forest or grazing areas, reduction in fallow, or induce adoption of land-saving commodities or technologies, investments in land improvement, and adoption of labour-intensive land management practices, among other changes.

[7] Examples of development pathways identified in Central Honduras were; basic grains expansion, horticultural expansion, coffee expansion, forestry specialization, and non-farm employment (Pender et al. 2001a).

Without improvements in technologies, markets or infrastructure, population-induced intensification is unlikely to improve welfare, though it may improve resource conditions by inducing land conservation (Pender et al. 2004, Pender 2001a, Tiffen et al. 1994).

Empirical insights from Central America were then applied to issues of sustainable land management in the context of agricultural development in the East African Highlands (Pender et al. 1999). A set of hypotheses was formulated about alternative development pathways within the region, cast within the three-dimensional typology defined by the interaction of agricultural potential, access to market, and population pressure. This typology was identical in structure to that shown in Table 1, utilising a simple two-way classification for each variable.

Areas of high agricultural potential, high market access and high population density were noted as existing in Central Kenya, parts of Western Kenya and Eastern Uganda. In such areas, according to prior empirical results, investments in appropriate forms of infrastructure, human capital and institutions appear to yield higher social returns and to facilitate sustainable agricultural development. Here, potential development pathways of high input cereals, perishable cash crops (such as horticultural crops), dairy and other forms of intensive livestock, non-perishable cash crops and rural non-farm development were hypothesized as being of greatest comparative advantage.

Areas of low agricultural potential, more remote from markets, and with higher population densities were identified in Northern Kenya and Northern Ethiopia, and development pathways were hypothesized to depend on irrigation investment, without which low-input cereal, livestock intensification and improved grazing areas, woodlots and rural non-farm development were hypothesized as most advantageous (Pender et al. 1999).

In applying the three dimensional framing typology in East Africa, Pender et al. gave indicative thresholds for cut-offs between "high" and "low" values of agricultural potential, market access, and population density, recognizing that *"there is an unavoidable element of arbitrariness in defining these terms"*. This included a characterization of high/low agricultural potential based on an annual mean rainfall threshold of 1000 mm (at mid-altitudes), as well as some qualitative criteria for soil fertility, and a population density high/low threshold of 175 persons per km^2.[8] These threshold values clearly satisfied the mental model of the authors who are very familiar with the conditions of the agriculture in the region, but they do not provide a transparent or repeatable basis on which to satisfactorily evaluate the development pathway approach more rigorously.

The notion of a *mapped* expression of the Pender et al. tabular presentation of the agricultural potential, market access, and population density typology was proposed and implemented by Wood et al. (1999) and dubbed “development domains”. Figure 1 provides an example of a subsequent development domain map prepared to support strategic planning for agricultural R&D in the ECA region (Omamo et al. 2007). That map uses different measures of agricultural potential, market access, and population density from that of Wood et al. (1999), as well as some new sources of spatial data. Maps of the individual development domain component measures used in Omamo et al. are presented in Figure 2. The criteria and datasets used in the preparation of these layers were defined through a series of technical consultations in the ECA region (e.g., the agricultural potential measure included consideration of rainfall, access to surface water, elevation, and a soil quality index).

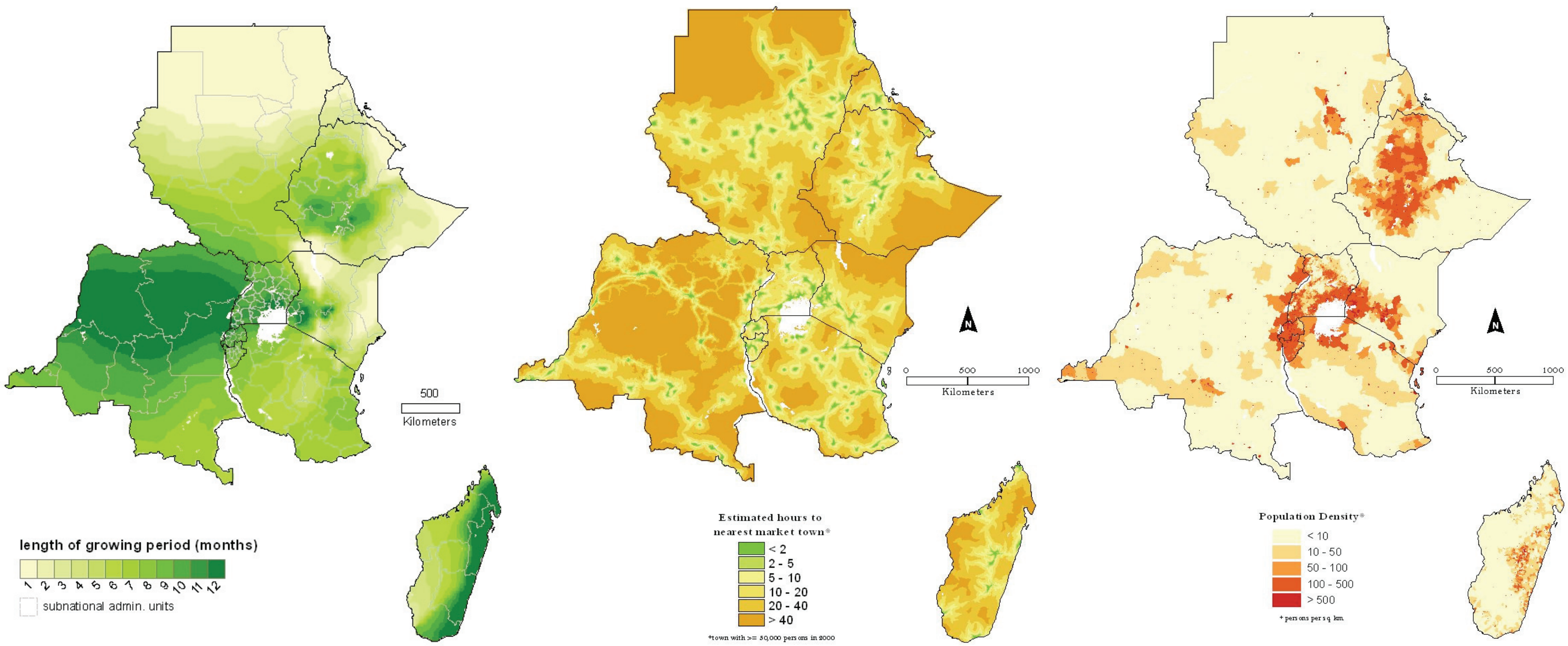
[8] It is, under any circumstances, difficult to be precise about the implications of selecting one threshold value versus another, particularly in terms of assessing the *economic* implications of such a choice. In the absence of a formal conceptual basis for determining what “high” and “low” represent, the next logical step would be to turn to the empirical literature to establish whether thresholds have been established under given circumstances. One example is the estimated upper limit of 20-50 persons per km^2 maximum carrying capacity of swidden agriculture in Indonesia (Geertz 1963). And Turner et al. (1993) conditioned their comprehensive assessment of population pressure and agricultural development linkages in Africa to the study of areas of greater that 200 persons/km^2.

Figure 2. Development Domain Component Layers: Eastern and Central Africa

(a) Agricultural Potential (LGP)

(b) Travel Time to Regional Market Centres

(c) Population Density



Source: Adapted from Omamo et al. (2007)
Notes: Each component map was reclassified into just two categories ("high" and "low") and then overlain in order to produce the eight class development domain map presented in Figure 1.

The innovation of providing a mapped representation of development domains in addition to a tabular description provided a number of advantages. First, it requires explicit decisions to be made on the empirical basis for defining agricultural potential, market access and population density. Second, it allows those empirical metrics, once defined, to be scrutinized and validated individually (e.g., by mapping and inspection of their spatial variation, but also by more formal econometric means). Third, it focuses attention on the need to establish a plausible rationale for classifying variables, e.g., to define the basis on which values are assigned as being "high" or "low". As Wood et al. (1999, p34) state in describing the creation and classification of an agricultural potential metric based on the Pender et al. (1999) livelihood strategy hypotheses, *"It is possible, and almost certainly desirable, to significantly improve this agricultural potential definition, both by being more specific in terms of production systems* [livelihood strategies], *as well as by including additional conditioning variables and more discriminating value ranges"*. The fourth advantage, which has become evident with usage, is the ability of development domains to engage analysts and decision makers.[9]

These potential benefits, however, have countervailing costs. First, it is not trivial to characterise agricultural potential, market access and population *pressure* (returning to the original Boserupian conceptual underpinnings) nor to categorize these factors (be they quantitative or qualitative) into specific classes. And to do so might run the risk of over-simplifying concepts endowed with rich and economically-important subtleties. For example, areas of "low" agricultural potential for banana production may be of "high" agricultural potential for wheat production. Second, the push for specificity in these three

[9] It is not central to this thesis to analyze the reasons why decision makers and analysts alike become engaged with mapped development domains. Part of the reason is surely the old adage of a picture telling a thousand words as well as, for some at least, the seductive power of maps. But other factors are also likely to be important. The development domain schema is parsimonious in variables and, by design, typically relies on few domain classes (8 in the case of the map highlighted in Figure 1). Despite the simplicity of this characterization schema, however, the domain map can be relatively complex, illustrating strong heterogeneity across relatively small geographic extents. We postulate there are lessons in these patterns. Implementing policy, investment, institutional or technological change in areas where domains are very diverse is likely quite a different development challenge than that posed where domains are more uniform. Some aspects of spatial complexity may be positive, and others negative. And there is likely much to discover about the development constraints and opportunities that more- and less-fragmented domain extents might present. In a regional context, it also becomes clear that the same domains and similar patterns of domains repeat across countries. The visual depiction of such cross-country similarities is a small but significant step toward enhancing awareness of the potentially large economic benefits of regional collective action.

conditioning factors begs a similar level of clarity and rigour in defining explicit metrics of livelihood strategies themselves. Even if a solid empirical proxy for each factor is found, there is no proposed theoretical basis on which the three variables *interact* to generate a new (dependent) variable that reflects the feasibility or attractiveness of specific livelihood strategies. While the conceptual approach to livelihood strategies is built around the notion of comparative advantage, insufficient attention has been given to articulating any formal *measures* of comparative advantage by which one livelihood strategy might be considered superior to another. One objective of HarvestChoice is to help address that deficiency.

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