2 Methods and data sources

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Key messages

- This book applies a unique, structured, systems methodology for characterizing and grouping large populations of farm households with broadly similar livelihood, production and consumption patterns, and for whom similar development strategies would be appropriate.
- As a result African households across the continent are grouped into 15 major farming systems and 58 subsystems.
- The farming systems analysis integrates an extensive range of spatial data, administrative statistics, assessment reports and expert knowledge, in order to update the African component of the 2001 FAO/World Bank farming systems analysis.
- Pattern recognition is key to teasing out the diversity inherent in African agriculture and in understanding common livelihood patterns (derived from crops, trees, livestock, fish and off-farm income), constraints and opportunities which define each farming system.
- The principle of central tendency is used to identify the core length of growing period and travel time to the nearest market town, which are two key indicators of access to agricultural resources and access to agricultural services, respectively, that shape livelihood patterns in each farming system.
- The method allows farming system drivers, trends and strategic interventions to be identified for policymakers, investors and research planners, using a synthesis of UN statistics, assessment reports and expert knowledge.

Summary

This chapter describes the farming systems analysis methodology used to characterize African farming systems in this book, in particular the methods for identifying a common livelihood pattern (derived from crops, trees, livestock, fish and off-farm income) and the constraints and development opportunities for each farming system. The analysis integrated a wide range of data and information from spatial databases, administrative statistics, assessment reports and expert knowledge of the particular farming system characteristics, drivers and trends, constraints and development opportunities. The skill of

pattern recognition is essential for identifying common mixes of system livelihoods. The farming system is shaped by access to agricultural resources (a basic indicator is length of growing period) and access to agricultural services (a basic indicator is travel time to the nearest market town), and these factors underpinned the mapping and characterization. The management and development of farming systems depend on the strategies of farm households for escape from poverty or improvement of farm incomes. The multidisciplinary analysis teams who identified the farming system constraints and opportunities, and the household strategies, subsequently wrote the relevant farming system chapters.

Overall approach

This chapter describes the methodology used for the characterization of the farming systems which are profiled in Chapters 3–16. The broad analytical approach is provided in the next section; thereafter the principal sources of data are listed and then the methods for delineation, characterization and grouping of farming systems and subsystems are presented.

The purpose of the farming systems framework is to inform science leaders and policymakers about the best options to accelerate the improvement of household livelihoods, food and nutrition security in the context of changing socioeconomic and climatic conditions. A number of principles underlie the analysis to ensure it is 'fit-for-purpose' for the farming systems framework.

These principles are:

- The analysis is at the African continental rather than national or sub-national levels.
- The analyses are based on rigorous, up-to-date and fit-for-purpose data and expert knowledge, for the nominated time period.
- There are pragmatic limits to the number of farming systems and, within each farming system, the number of subsystems.
- Information derived from spatial analysis, administrative statistics, reports, and expert and stakeholder knowledge is triangulated and integrated.
- Recognizing the natural heterogeneity in agriculture, each farming system is characterized according to its 'central tendency' in relation to livelihood pattern, access to agricultural resources and access to agricultural services.[1]
- Interpolation and extrapolation is often required to fill gaps in knowledge for the chosen base year of 2015.

Spatial framework

In practice, the approach followed in this book identifies farming systems as a series of mappable regional entities or geographic zones. Regionalization is a widely recognized and applied geographic method of providing spatial frameworks, and it has numerous applications for the management of natural resources and policy development. Boundaries between regions are based on the best available data and knowledge and are analysed within an integrated multivariate approach.

The farming systems analysis traditionally includes broadscale livelihood patterns, climate and bio-physiographic patterns, plus regional and finer scale thematic socioeconomic data such as population density and market access. These data are analysed to identify farm household livelihood patterns across a variety of spatial scales. In this context, patterns reflect a 'central tendency' for an identifiable farming system. Regionalization (which may or may not include social and economic elements) is an accepted international tool to assist in the delineation and characterization of 'farming system' level boundaries for planning, management and policy purposes (Werlen 2009).

Regions can be further differentiated into sub-regions using similar multivariate classifiers, often with a temporal and/or spatial dimension. An example of the spatial zoning process is the well-established practice of identifying agroecological zones with similar potential and constraints for use in development programs and for targeting of recommendations (FAO 1996).[2] Depending on the circumstances, zones often also relate to a period or point in time, for example areas affected by time-bound droughts. The way that a region or a farming system is differentiated depends on the parameters used, for example productivity, rainfall, farm size, crop-livestock pattern, or physical parameters such as elevation or soil type. These data are also used to identify the borders of each region or zone.

Farming systems approach

Farming generally depends on many components, including soil and water resources, plant and animal production enterprises, and the farm household. Collectively these may be viewed as an integrated system. The term farm household system is often applied to the individual farm unit, and the term farming system to collections of similar farm household units. There are always interactions between the components and with the local external environment including climate, the surrounding landscape and local institutions, including markets (Figure 1.2). Farm households are often complex and dynamic units reflecting the management of agricultural resources by farmers to produce food and fibre.

The Farming Systems Approach (FSA) used in this study had its origins in the early 1960s in Central America and Africa where it was used to examine the complexity of smallholder farming systems for both research and development (R&D) purposes. Over the past 50 years, the FSA has evolved markedly (Dixon et al. 2009), as illustrated in Table 2.1. Today the term has achieved wide currency in public policy, strategy and scientific documents. The early applications of FSA were dominated by productivity, sometimes with a commodity focus, for example rice or cattle. The scope of the FSA expanded gradually from the 1980s, placing increasing emphasis on horizontal and vertical integration, including multiple sources of household livelihoods, the role of the community, plus the biophysical environment and support services. Through incorporating these interactions, the use of the FSA as an analytical framework has contributed to a paradigm change in rural development thinking, research and policy development.

The focus on the farm household at the heart of resource allocation decisions benefited from the Sustainable Livelihoods Approach (SLA) (Ellis 2000), and thus, farm household typologies have been widely applied. During the first decade of this century there was increased interest in the use of the FSA in R&D including marked shifts towards holistic perspectives and learning approaches, improved livelihoods, and greater household food and nutrition security, whether through technology, markets or policy. New development themes have also been incorporated such as gender, indigenous knowledge, social networks, community management, local institutions, information and adaptation to climate change. Concurrently, analytical techniques have become more participatory, more interdisciplinary and transdisciplinary, with increasing attention to experimentation, monitoring and impact assessment.

Table 2.1 Evolution of the farming systems approach

Characteristics	1970's	1980's	1990's	2000's	2010's
System Level:					
Farm					
Household					
Groups/Community					
Watershed, Landscape					
National, Regional					
Livelihood Focus:					
Crops					
Crop-Livestock					
Multiple Household Livelihoods					
Value Chains					
Innovation System Focus:					
Research					
Research & Development					
Policy & Planning					
Stakeholder Focus:					
Public					
Public & Civil Society					
Public, Private & Civil Society					
Policy Focus:					
Agricultural Productivity					
Natural Resource Management & Climate					
Market Access & Trade					
Other Emphases:					
Gender					
Poverty Reduction					
Food & Nutrition Security					
Climate Smart Agriculture					

Source: Adapted from Dixon et al. (2001).

Farming systems classification

As noted in Chapter 1, systems principles have been applied to the analysis and classification of farming for at least a century. Systems thinking helps to generate typologies of farming systems and distinct zones or agricultural regions. In order to usefully inform science and policy leaders, careful analysis is required to: identify the most useful definitions of farming systems; define the core characteristics or 'central tendency' of each farming system; and identify clear spatial boundaries given the challenges presented by the high level of natural heterogeneity within any given country or area. The system boundary is a critical construct which determines the extent and subsequent characterization, description and analysis of the farming system. However, this farming systems analysis recognizes (and indicates on maps) the gradual transitional zones between pairs of farming systems.

The classification and mapping of farming or agricultural systems has a long history (reviewed in Dixon et al. 2009). Farming systems (and farming systems research) methodology has evolved and improved over time as the understanding of systems approaches has progressed (see, for example, Darnhofer et al. 2012). In this respect the FSA is often viewed as a 'soft systems' approach that spans biophysical and social science disciplines and is focused on both system resilience and productivity, and people and their livelihoods (Packham et al. 2007).

Traditionally, farming systems can be viewed as a hierarchy or set of component elements within which certain processes and interactions occur at specific levels. In the current analysis, a farming system is defined as a population of farm households, often of mixed sizes and types, that as a group has broadly similar patterns of resources, livelihoods, consumption, constraints and opportunities, and for which similar development strategies and interventions would be appropriate. In a generic sense, a farming system is a spatial concept which is located within the contexts of a wider social system (for example a village) and a wider landscape or ecosystem. Farming system zones can be nested, subsuming farming subsystems, and combined into regional groupings of similar farming systems, depending on the purpose of the analysis. With its focus on food and nutrition security, this book recognizes groups of farming systems with high, medium and low potential for improvement of household food and nutrition security by 2030 (a timeframe which aligns with several international development frameworks and the Malabo Declaration).

A central tenet of the FSA adopted for the current study is that the identification, delineation, characterization and analysis of systems within which smallholder households live and make resource management decisions, provide powerful insights for policymakers and science leaders. Results of the analysis can be used to inform the development of strategic policies and priorities for the improvement of food and nutrition security, as well as other goals (for example, rural transformation, export earnings, import substitution, poverty reduction and responding to threats such as increased climate variability). It should be noted that poverty and household food insecurity are closely associated and often correlated. In this sense, the delineation and characterization of the major farming systems provide a useful framework within which to develop and assess agricultural development strategies and interventions (including adaptation to changing market conditions and climate change).

Policymakers and science leaders, who are a major target audience of this analysis, often need relatively broad and large-scale findings (and insights on trends) to guide policy, planning and program development. Scientists and modellers investigating alternative technological and institutional pathways to sustainable development at the continental or national levels (and the Sustainable Development Goals (SDGs)) also need a broad framework for their analyses. Similarly, academics and educators can benefit from a simple, consistent continent-wide classification system enabling cross-border comparisons. As such, many high-level users demand a structured farming systems framework with a workable number of broad farming systems defined at the continental level. Logically, such a farming systems framework would contrast resource access, market access, livelihood patterns and strategic interventions. Such a farming systems framework across Africa fosters the exchange of relevant research results and policy experience across countries for any particular farming system.

In addition, for some audiences, a disaggregation of each broad farming system is valuable for further analysis. Therefore, for most of the farming systems, a number of subsystems were identified based on relevant parameters such as combinations and proportions of crops in the cropping system, level of intensification, access to agricultural services, agroecological conditions, or clusters of countries (as a potential basis for support to national policymaking). In nine farming systems the subsystems are mapped, but in six of them (including the urban and peri-urban farming system) the subsystems are defined and characterized but not mapped due to issues of scale, ease of implementation and spatial data availability.

Sources of information

One of the core principles of the analysis is the integration (or triangulation) of information derived from several sources, for example spatial analysis results, administrative and survey data, and expert and stakeholder knowledge. Triangulation has many advantages, not least to deal with gaps in datasets and different measurements used by the variety of sources of data and other information. The updating of the 2001 farming system characterization and trends (from Dixon et al. 2001) was undertaken by multidisciplinary teams, one for each farming system, involving a total of 65 scientists and development professionals with in-depth, field knowledge of relevant African agricultural systems who integrated data from different sources.

The analysis reported in this book sourced the best available spatial data from FAO, IIASA, IFPRI, University of Minnesota, CIESIN, ITC, ICRAF, AfriPop and the Centre for World Food Studies at Vrije University, Amsterdam (Merbis and Wesenbeek 2012). FAO's Global Agroecological Zones (GAEZ) and IIASA's databases provided agricultural resource quality data. IFPRI and the University of Minnesota's Harvest Choice database and IIASA's spatial databases contained crop extent and production. Human population density was derived from CIESIN and AfriPop. Livestock distributions were derived from FAO and Oxford University. Other critical spatial data included transport infrastructure to estimate travel time to markets, and poverty. The core spatial databases used in the analysis are listed in Table 2.5.

In the process of characterizing the selected farming systems, a considerable amount of reconciliation across datasets was required. There were often anomalies between variables, for example between spatial and administrative datasets at national and regional levels of aggregation, and between computed ratios from datasets such as population density, farm and herd size, and crop-livestock ratios, especially when computed for pixels (small land areas of approximately 8–10 km^2) from the original spatial surfaces. Anomalies sometimes required reference to third sources of data. Computations assisted with the assessment and correction of the original datasets – a process often appreciated by the institutional owner of the dataset. Collectively the above data were used to check the spatial information for the characterization of farming systems and subsystems. Compared with the original study in 2001 (Dixon et al. (2001), which delineated the original geographical boundaries of farming systems, the checking and revision of farming system characterization, boundaries and trends were much simpler tasks in this analysis.

A second source of information was a series of outlook, synthesis and foresight documents and thematic and panel reports (Table 2.6). These data and knowledge sets were sourced from AU, NEPAD-AU, UNECA, FARA, African Development Bank, and the World Bank, IFAD, CGIAR and other international development organizations.

The third major source of information was the expert knowledge of a large number of individuals. These experts included members of multidisciplinary systems analysis teams who had personal experience with the farming systems under consideration (see list of Contributors), other experts who offered project maps at national or regional scale and who provided advice in relation to the delineation of farming systems (Table 2.7), and the book editors. Experts provided access to crop distribution, agroecological zone and farming systems maps developed by secondary sources such as national or regional projects. The Famine Early Warning Systems Network (FEWS NET) livelihood zone maps provided valuable references for system delineation and characterization in eastern and southern Africa. FEWS NET's definition of a livelihood zone – an area within which people share broadly the same pattern of livelihood, including options for obtaining food, and income and market opportunities – correlates with the definition of farming systems used in this book. The collective expert judgements informed identification of drivers, trends and strategic interventions for each farming system.

The current farming system analysis highlighted a number of critical weaknesses in datasets. For example, there is low coherence and consistency across datasets which were collected for specific purposes, often using different metrics. Variable trends and system development pathways are rarely well documented. The distinction between, and comparison of, cropping systems under single-season and bimodal rainfall patterns are often challenging. There are differences between datasets from interpolated data (such as the P/PET and length of growing period (LGP) datasets) and sensor-based products (noting that the rigour of sensor products in areas with less than LGP 90 days, or in areas with very high cloud cover, is limited). Sensor products can provide good bimodal information that may not be found within the interpolated datasets.[3]

Methods for characterizing African farming systems

Overview

A multidisciplinary team of experts with personal knowledge and on-the-ground experience was appointed to author the updates to the characterization and analysis of each farming system, with the support of the data analysts and book editors. When necessary, other key informants were also involved to fill gaps in knowledge and to advise on local system trends. The focus in this analysis was the revision of 2001 farming systems, rather than the identification of new farming systems. A three-step, iterative, expert-driven process incorporating underlying thematic datasets and expert knowledge was used to update and refine the spatial delineation of systems identified in 2001 (Figure 2.1). The same process was used to identify, delineate and characterize subsystems.

Dixon et al. (2001) identified 15 discrete farming systems within sub-Saharan Africa (SSA) and 8 within North Africa based on the concept of central tendency (see earlier). With the exception of urban-based farming systems (and coastal artisanal fishing in

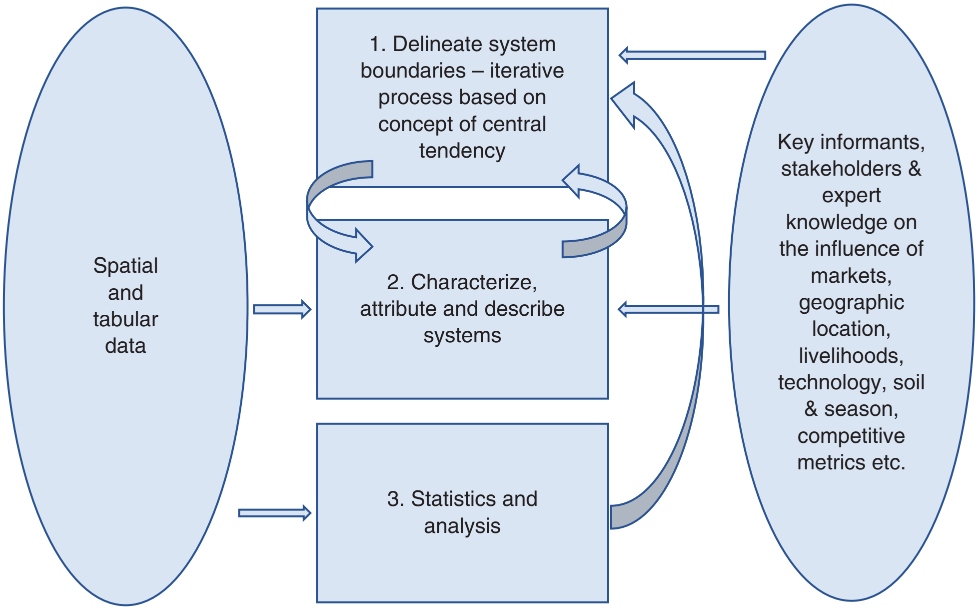

Figure 2.1 Approach to farming systems identification and characterization.

North Africa), all were spatially delineated and mapped (Figure 2.2a and b). The 2000 farming system boundaries were delineated based on the following parameters:

- Dominant pattern of farm household livelihoods, including field crops, livestock, trees, aquaculture, hunting and gathering, processing and off-farm activities. These are shaped, in turn, by the following two parameters:
    - Access to agricultural resources – including water, land (including farm size), grazing areas and forest (extent and type); climate, of which altitude is an important determinant; landscape, including and land tenure and organization.
    - Access to agricultural services, including input and produce markets, notably access to seed, agrochemicals, machinery and information, financial, insurance and veterinary services, as well as outlets for surplus grain and livestock produce, and off-farm employment opportunities.

The present study commenced by checking the characterization of the 2000 farming systems against the realities on the ground in 2015. The check drew on spatial databases of crop and livestock distributions (from FAO and the IFPRI/University of Minnesota Harvest Choice databases) and administrative statistics (from FAOSTAT and key informants – see information sources in Table 2.7). Over the period from 2000 to 2015, there were many changes in rural population density, access to agricultural services and technology choices. It is for this reason that the analysis devoted considerable effort to understanding and documenting the seven drivers of change and trends in farming system characteristics (see discussion later). Many farming systems had evolved in a predictable fashion with increased population density, reduced farm size and changed cropping pattern – in other words, the characterization needed to be updated. In other farming systems the institutional or market access conditions had changed so much that the livelihood pattern, constraints and opportunities had changed significantly. In these cases, the farming systems were apportioned to other existing farming systems, or new systems were created. In the process, most of the North African farming systems were associated with one or another of the 2001 SSA farming systems because of similar livelihood patterns, agricultural resources and access to agricultural services. As Figure 2.1 indicates, the steps for identification and characterization were iterative.

Figure 2.2a and b contrasts the map of the 23 farming systems in 2000 (15 in SSA; 8 in North Africa) with the map of the 15 revised, consolidated and updated farming systems in 2015. The distributions of cultivated land, particular crops and livestock, and forests across the African landscape, sourced principally from spatial datasets, administrative data and key informants, were particularly important elements to guide the understanding of livelihood patterns by farming system in 2015 – and the changes from 2000. A number of other indicators of livelihood patterns were also useful, including crop and livestock

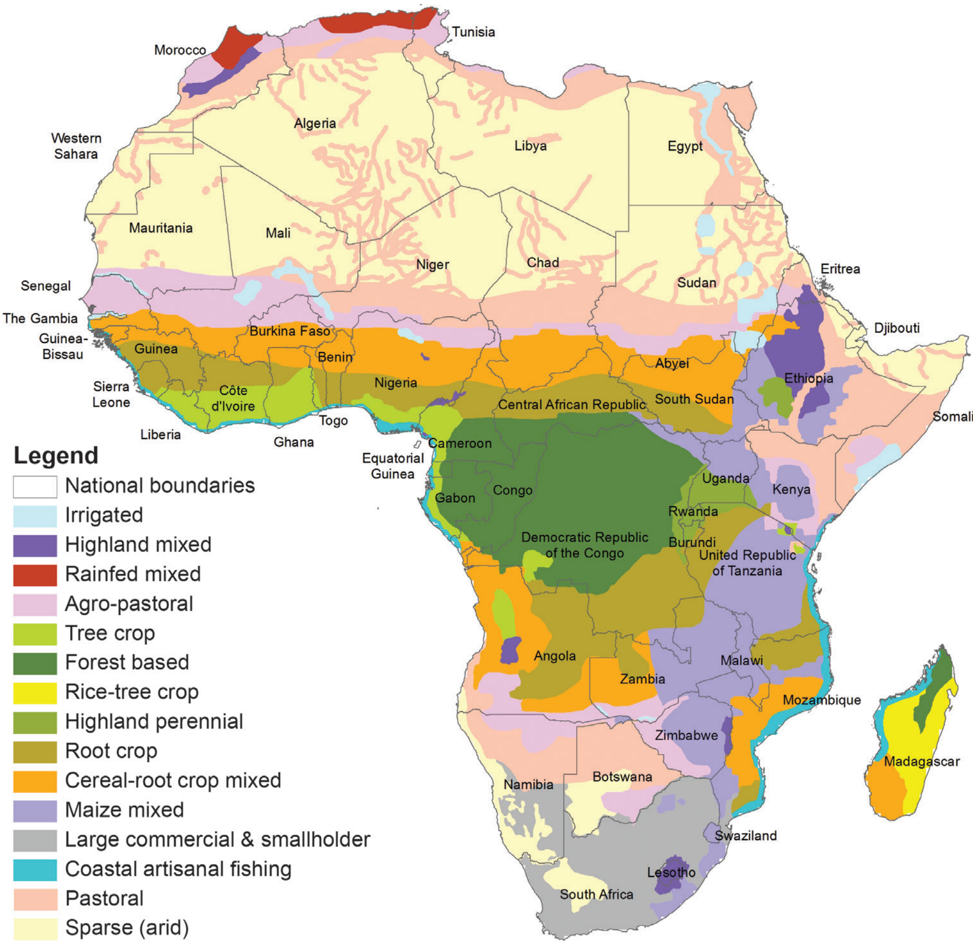

Figure 2.2a Map of farming systems of Africa in 2000.

Note: The 2000 map is a composite of SSA and North Africa maps in Dixon et al. (2001).

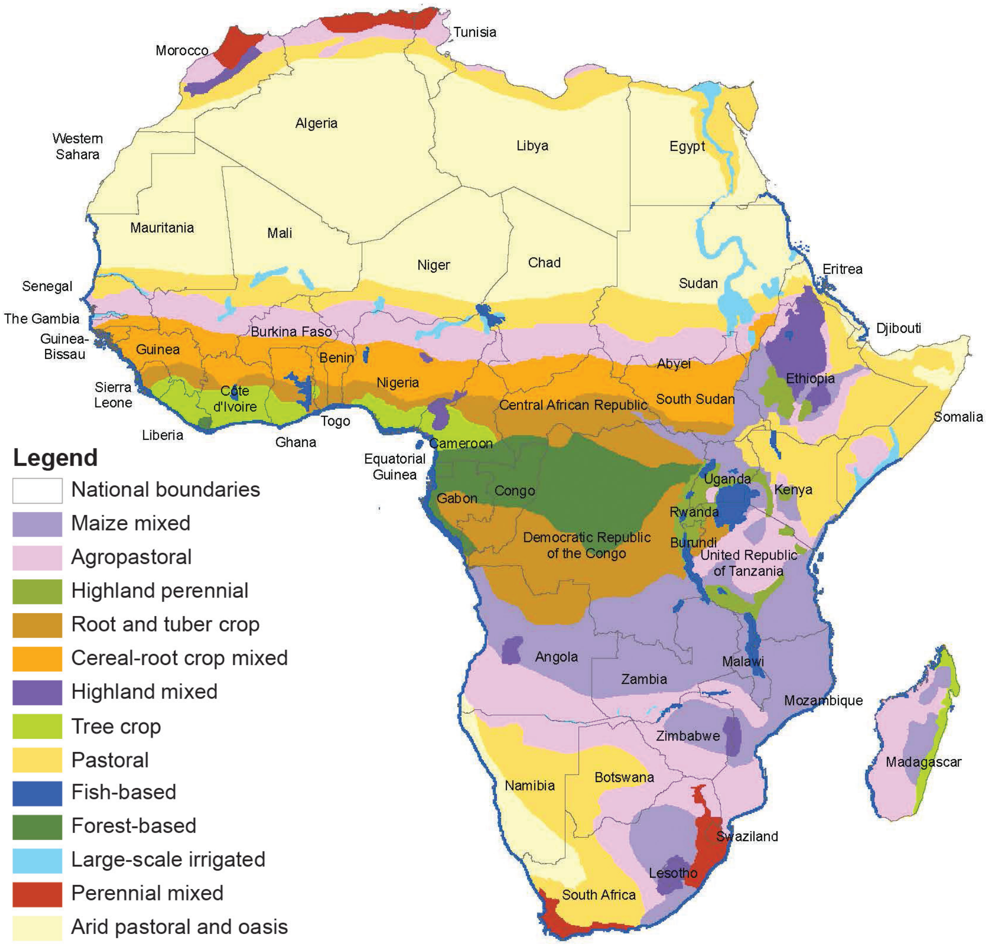

Figure 2.2b Map of farming systems of Africa in 2015.

Source: GAEZ FAO/IIASA, FAOSTAT, Harvest Choice and expert opinion.

Note: Because of lack of comparable data, the urban and peri-urban and the island farming systems were not mapped in either 2000 or 2015.

production levels. The urban and peri-urban and the island farming systems were characterized but not mapped in 2015. In the 2015 analysis, a total of 58 subsystems were named and characterized briefly or fully; and of these 42 were delineated and mapped in 10 farming systems (as will be described in Chapters 3–16).

The main changes were the merger of the North African systems with equivalent SSA farming systems; the reclassification of the dualistic smallholder and large commercial farming in southern Africa to, largely, maize mixed and perennial mixed farming systems; and the reduction in extent of the forest-based farming system because of population pressure, loggers' tracks and demand for root crops. The maize mixed system has expanded into coarse cereal and root crop farming in Central Africa, and the cereal-root crop mixed farming system has contracted to its heartland in the west and central African savannah.

Because of the expansion of population and cropping in pastoral areas, the agropastoral system has expanded in several parts of Africa. Similarly, the strengthening of markets has led to the conversion of some maize mixed farming to the commercial smallholder highland perennial system. Thus, as livelihood patterns evolved, the system boundaries had to be checked and revised where appropriate.

Access to agricultural resources

The first of two major factors shaping the livelihood patterns of farming systems was access to agricultural resources within the farming system (Dixon et al. 2001). Both quantity and quality of access, and the resources themselves, need to be considered. The combination of population density and agricultural resource availability shape farm size, or family access to grazing land. While population has grown by about one-third during the period 2000 to 2015, farm size has diminished (Chapter 1). Population density varies considerably across Africa, as shown in Figure 2.3. There are hotspots of high density in the Ethiopian highlands, around the East African Rift Valley Lakes, and in western and in north-western Africa; these place great pressure on farm land and water resources.

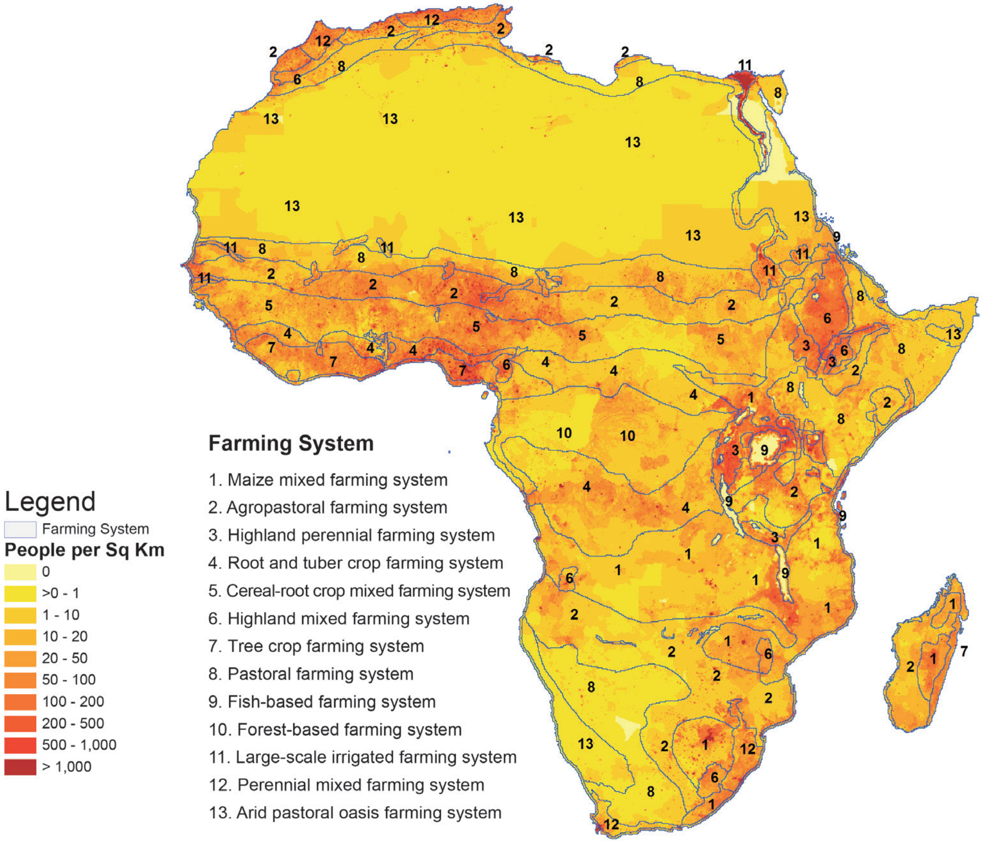

Figure 2.3 Map of total population density in Africa in 2015.

Source: AfriPop.

The second aspect of agricultural resources is quality. A number of key parameters were used to define the quality of resources of a farming system (including LGP,[4] elevation, environmental constraints), and to inform each farming system expert group during the process of identifying the system's 'central tendency' and the location of its boundaries. LGP is a fundamental component of agroecological zones (AEZ)[5] that reflects aspects of climate, soils and landform, and may be considered a surrogate for farm natural resource quality. In this respect, LGP was a key defining parameter for a number of farming systems. The ranking of systems by 30-day LGP intervals gives an intuitively expected sequence in many instances (Figure 2.4). In some cases different farming systems have similar distributions of LGP, for example root and tuber crop farming system and the highland perennial system, where the difference is explained by completely different land use and livelihood patterns – the highland perennial farming system has greater elevation, better access to agricultural services and higher population density than the root and tuber crop system. Similarly, elevation and terrain explain the differences in livelihood pattern between the highland mixed and the maize mixed farming systems which have similar LGP distributions.

As shown in Figure 2.5, boundaries of some farming systems such as arid pastoral, pastoral, agropastoral, forest-based farming systems align rather neatly in many, but not all, areas, with the underlying 30-day interval LGP dataset from IIASA/FAO, indicating a similar progression for the second classification indicator, access to agricultural services. In other farming systems, for example the highland perennial farming system, the access to agricultural services was a stronger determinant of livelihood patterns and boundaries than LGP.

As explained earlier, characterization of areas with bimodal growing cycles is more difficult. A separate data source, other than the LGP layers from IIASA/FAO, was used to inform parameters in areas that experience a bimodal growing cycle such as in the Horn of Africa (Vrieling et al. 2011, 2013). Satellite remote sensing data was used

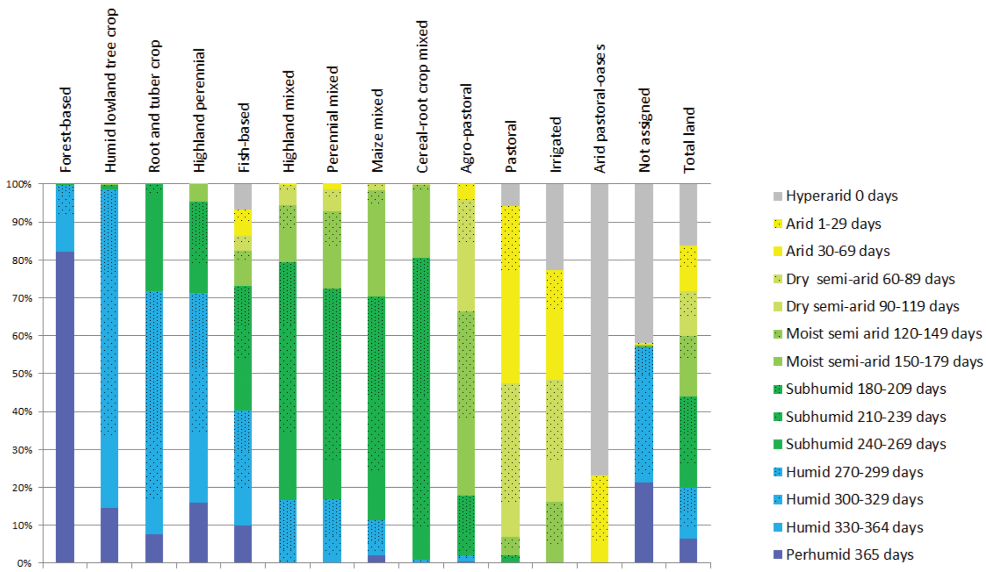

Figure 2.4 Distribution of length of growing periods by farming system (%) in sub-Saharan Africa.
Source: van Velthuizen unpublished (2015) and van Velthuizen et al. (2013).

to provide bimodal information that was not found within the interpolated datasets. Figure 2.6 shows the average LGP for uni- and bimodal growing cycles for Africa based on this data. Note that areas along the Guinea Coast considered bimodal were masked out due to cloud contamination which impacted the accuracy of LGP values.

Several other parameters including irrigation, elevation (for example, in the case of highland systems), net primary productivity and environmental criteria such as soil type and depth (in the case of tree crop systems) also assisted with system characterization and delineation. In all cases, datasets and maps were subjected to extensive peer review to assess their fitness for purpose and confirm their utility. Consultations took place during several project workshops, email communications as well as numerous Skype and telephone consultations. As a result, in many cases no single dataset was used to define farming system boundaries, but rather a combination of different datasets, supporting maps, administrative statistics and expert knowledge were used iteratively to characterize and delineate farming systems.

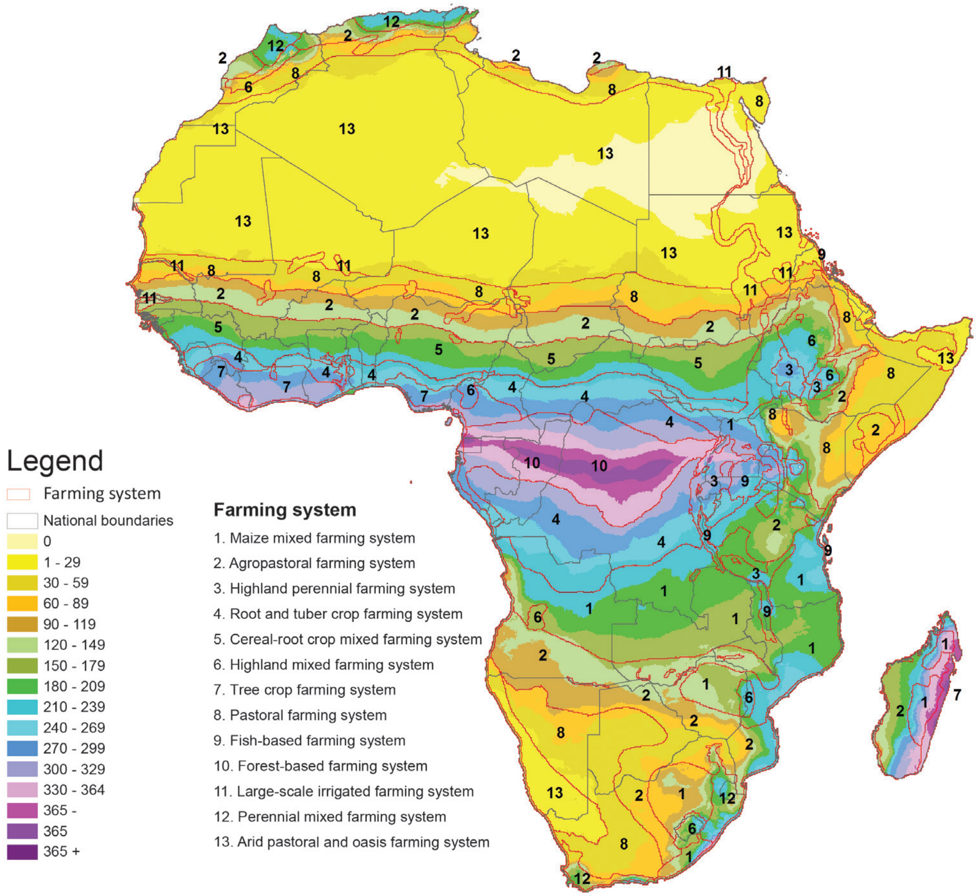

Figure 2.5 Map of 30-day interval LGP with farming systems delineated by a red line.

Source: van Velthuizen unpublished (2015) and van Velthuizen et al. (2013).

Note: Numbers denote different farming systems.

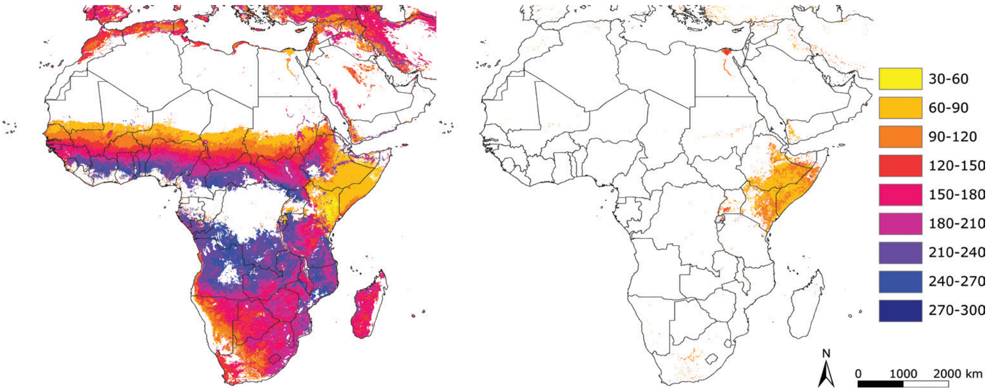

Figure 2.6 Remotely sensed (1981–2011) derived average 30-day length of growing season data for two growing cycles. First season on left and second season on right.

Source: Vrieling et al. (2011, 2013).[6]

Most farming system zones span a range of values for key selected parameters, for example annual LGP days. Figure 2.7 shows that the LGP central tendency for the maize mixed and agropastoral farming systems clearly lies in given intervals, whereas other systems, for example the fish-based system, are less influenced by LGP (rather, they are influenced by access to fishing waters and markets). In this context, when dealing with parameters which are monomodally distributed and not excessively skewed, authors have

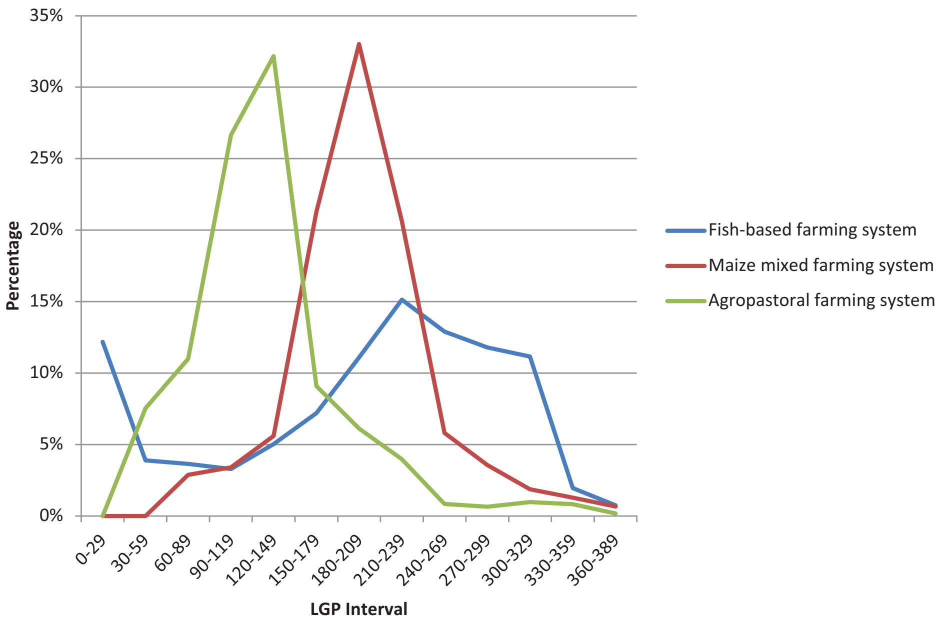

Figure 2.7 Relative distribution of 30-day LGP intervals in selected farming systems.

generally characterized the farming system by parameter values which embrace approximately two-thirds of the parameter observations.

Access to agricultural services

The second major factor in the identification of farming systems was access to agricultural services (Dixon et al. 2001), in particular value chains, and access to markets for inputs such as seed and fertilizer and to produce such as grain or livestock. This variable also includes aspects of market quality such as diversity of inputs or produce marketed, competitiveness of markets, integration with national and regional markets, degree of organized group marketing and finance availability, as well as diversity and quality of public and private service provision, such as mobile phone coverage, market information availability, extension and veterinary services.

Using spatial data on roads of various standards and town populations, it was possible to estimate approximate travel time to major market towns such as cities with a population of 50,000 or more, as shown in Table 2.2, as well as the overall access to agricultural services for each farming system.

There is a wide variety of agricultural services which are essential for the development of farming systems. Knowledge of technologies and market prices is as important as access to inputs or produce markets. Increasingly, information services such as mobile phones, other ICT services, TV or radio are a critical determinant of livelihood options. These communications technologies supplement, and might in time supplant, traditional public agricultural extension services. Such services complement the physical access to markets for inputs and produce. In this analysis, one quantitative indicator of access to agricultural services is travel time to major market cities with a population

Table 2.2 Access to agricultural services for African farming systems

Farming system	*Access to agricultural services*	*Average travel time to nearest town with population 50,000 or more (hrs)*
Maize mixed	Medium	8.3
Agropastoral	Low-medium	7.1
Highland perennial	Medium-high	5.6
Root and tuber crop	Medium	8.8
Cereal-root crop mixed	Medium-high	7.3
Highland mixed	Low-medium	7.1
Tree crop	High	4.7
Pastoral	Low	8.3
Fish-based	Medium-high	5.0
Forest-based	Low	13.7
Irrigated	High	3.8
Arid pastoral and oasis	Very low	20.8
Perennial mixed	High	3.8
Island	Medium	na
Urban and peri-urban	Medium-high	na

Sources: Joint Research Centre – Global accessibility data (travel time to major cities) and expert judgements.

Notes: na = not available.

of 50,000 or greater. These estimates are based on composite maps of infrastructure but face the challenges of lack of standard classification for rural markets and types of roads across Africa. Moreover, the level of competition in rural markets is often low, and thus market agents often exert asymmetric power over farmers so that they drive down grain and livestock prices and elevate prices for uncontrolled inputs. All considered, the authors have provided low/medium/high ratings for overall access to agricultural services, which are guided by, but not exactly correlated with, the estimated travel times to market cities. For instance, although road density indicates moderate proximity of the pastoral farming system to markets, this has not necessarily led to competitive markets for a broad range of agricultural inputs and other agricultural services, and thus the system is rated as low access to agricultural services.

Figure 2.8 plots the values for travel time to market (a town with 50,000 population) within selected farming systems, by frequency of values. The actual travel time spatial layer (map) used in the farming system analysis is presented in Figure 2.9.

Key characteristics of farming systems in 2015

Fundamental to purposeful classification is the identification of the users and their needs – in this case agricultural policymakers and science leaders – and the way in which a defined

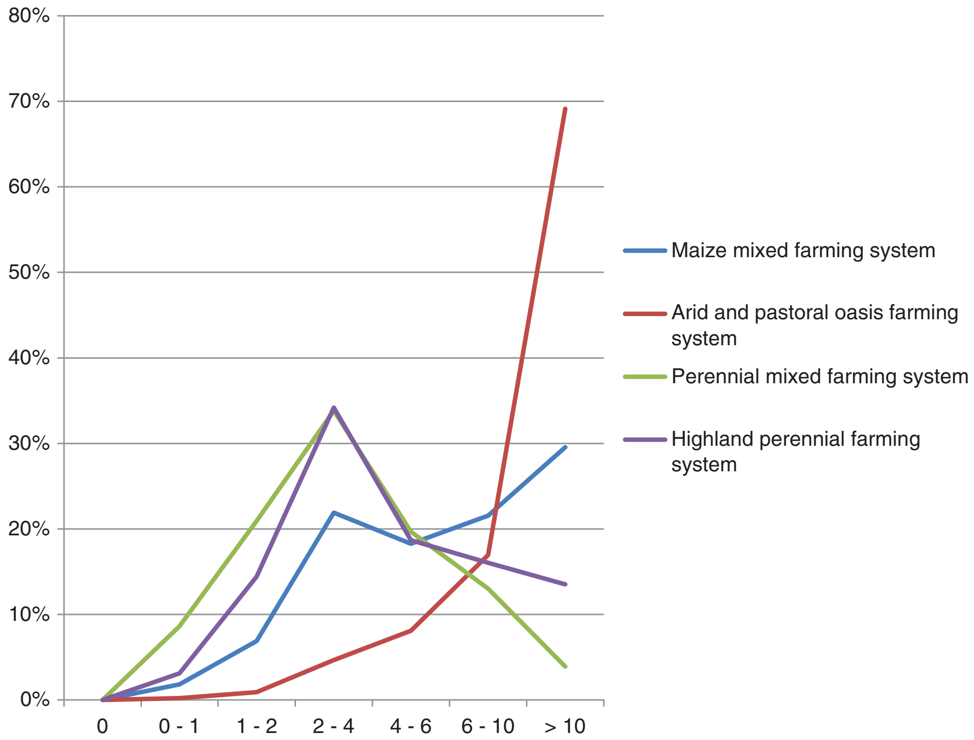

Figure 2.8 Travel time to town with population of 50,000 in selected farming systems.

Source: Joint Research Centre – Global accessibility data (travel time to major cities).

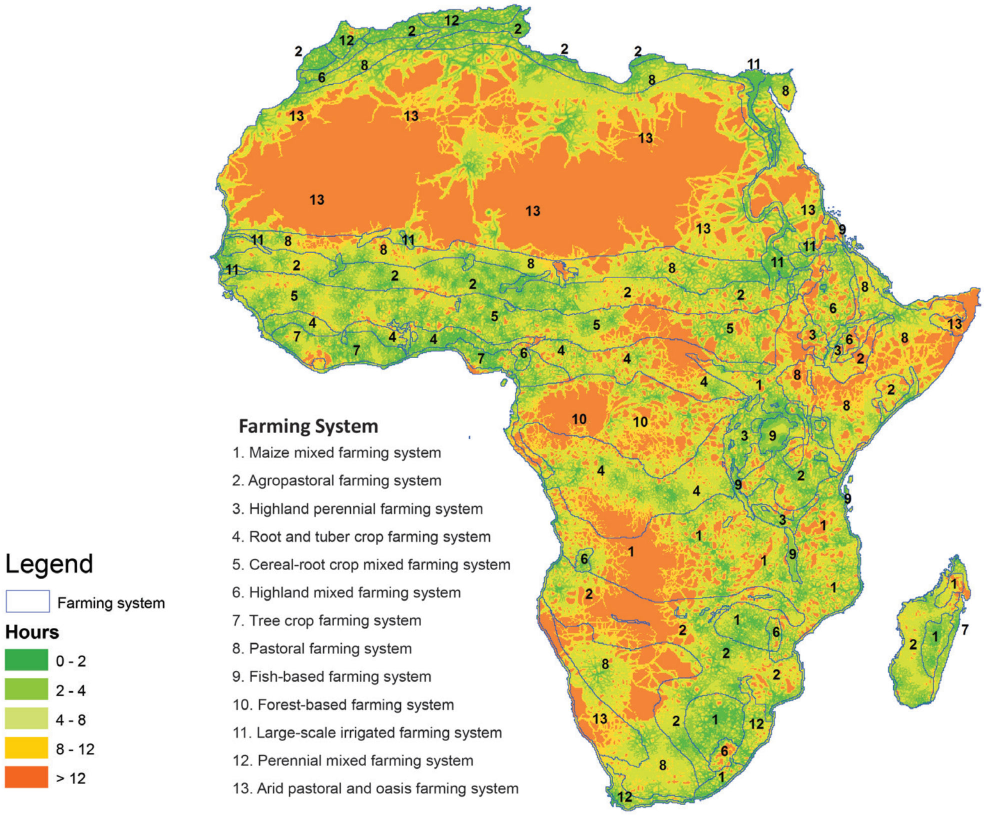

Figure 2.9 Map of travel time to 50,000 town and farming systems boundaries.

Source: Joint Research Centre – Global accessibility data (travel time to major cities).

Note: Numbers denote different farming systems.

group of farming systems could inform and improve agricultural policymaking, research and investment priorities.

Bringing together the information on livelihood patterns, access to agricultural resources and access to agricultural services enables readers to understand the core characteristics of the 15 farming systems depicted in Figure 2.2a and b for 2015. Key characteristics of the farming systems are presented in Table 2.3, with emphasis on access to agricultural services and agroecological zones.

Following the style of the 2001 FAO/World Bank study, the names of farming systems are broadly based on the main household livelihood resources (crop type and reliance on livestock (including fish), supplemented by other salient characteristics such as rainfed or irrigated production, agroecology (perennial, arid), altitude (highland or lowland) and location/infrastructure (urban).

In Chapters 3–16, each of the 15 farming systems is characterized, in summary form, by one basic data table. Table 2.4 lists the data sources for the 'basic data' tables and the methods used to estimate or compute the information for each of the farming systems. In many instances, combinations of spatial data and administrative statistics were effective in

Table 2.3 Key characteristics of 2015 African farming systems

Farming system	*Travel time to 50,000 town*	*Access to agricultural services*	*LGP core range (days)*	*Average LGP*	*Agricultural population (million)*	*% poor (SSA)*
Maize mixed	8.3	Medium	Sub-humid 150–240	196	107	22.0
Agropastoral	7.1	Low-medium	Moist semi-arid 75–165	130	98	18.6
Highland perennial	5.6	High	Sub-humid/ humid 240–330	267	61	11.0
Root and tuber crop	8.8	Low-medium	Sub-humid/ humid 210–300	269	50	10.9
Cereal-root crop mixed	7.3	Medium-high	Moist semi-arid/sub-humid 150–210	187	43	10.3
Highland mixed	7.1	Low-medium	Moist semi-arid/sub-humid 150–270	183	45	6.2
Tree crop	4.7	High	Humid 270–330	299	30	6.0
Pastoral	8.3	Low	Arid/dry semi-arid 30–90	64	38	4.5
Fish-based	5.0	Medium-high	Various 150–330	197	22	4.1
Forest-based	13.7	Low	Humid 330–365	343	12	2.5
Irrigated	3.8	Medium-high	Irrigated 0–90	54	48	3
Arid pastoral and oasis	20.8	Very low	Arid 0–30	12	8	0.5
Perennial mixed	3.8	High	Moist semi-arid/sub-humid 150–240	185	12	0.6
Island	na	Medium	Various	–	4	–
Urban and peri-urban	na	Medium-high	Various	–	–	–

Sources: Based on existing data and author expert judgments.

Table 2.4 Data source and estimation methods for basic farming system data tables

Item

- Data source
- Estimation method

Total human population (million)

- Source: UN Pop Div, CIESIN, FAOSTAT and others.
- Projections for 2015 were based on linear regression using data points from 2000, 2005, 2010 and 2014.

Agricultural population (million)

- Source: Computed from rural population (UN Pop) and FAOSTAT.
- For North Africa (NA), AfriPop 2010 was used as a spatial footprint, and agricultural population was estimated from rural population with the following coefficients: 0.9 for NA pastoral and arid pastoral, and oasis farming systems (low population density); 0.85 for NA highland mixed, rainfed mixed and dryland mixed farming systems (medium population density); and 0.8 for NA large-scale irrigated farming systems (high population density). High population density areas have relatively greater size and prevalence of rural towns. In contrast, low population areas have fewer rural towns and a higher proportion of agricultural population.
- For sub-Saharan Africa FAOSTAT and Harvest Choice data were used.

Total system area (million ha)

- Source: system generated.

Cultivated area (million ha; % of total)

- Source: FAO/IIASA GAEZ version 3* – Harvest Choice, IFPRI and Ramankutty.

Irrigated area (million ha; % of cultivated)

- Source: FAO Global Map of Irrigation Areas – version 5, Harvest Choice and IFPRI.

Total livestock population (million TLU)

- Source: FAO Gridded Livestock of the world, FAOSTAT FAO/IIASA GAEZ version 3 – Harvest Choice and IFPRI.
- Tropical Livestock Units (TLU) are livestock numbers converted to a common unit. Conversion factors are: cattle = 0.7, sheep = 0.1, goat = 0.1, pig = 0.2, chicken = 0.01. Factors taken mostly from www.lrrd.org/lrrd18/8/chil18117.htm, except for cattle. See also http://en.wikipedia.org/wiki/Livestock_grazing_comparison.

Major agroecological zone

- Source: FAO/IIASA GAEZ version 3 – Harvest Choice and IFPRI.

Length of growing season (average, days; core range, days)

- Source: FAO/IIASA GAEZ version 3.0 – Harvest Choice.
- Average LGP is the average length of growing period tied to pixels where a given farming system occurs.
- Core range refers to the boundaries of contiguous 30-day LGP intervals where at least two-thirds of the farming system occurs.

Access to services, including markets (low/medium/high)

- Source: Author estimates of general access to services in the farming system based on market access and quality, and other services such as diversity and quality of public and private service provision, such as mobile phone coverage, market information availability, extension and veterinary services, availability of finance.

(continued)

Table 2.4 (continued)

Time to market (average, hours; core range, hours)

- Source: Joint Research Centre – Global Accessibility map for continental Africa. Harvest Choice and IFPRI for sub-Saharan Africa.
- Average distance is the average travel time to a town of 50,000 inhabitants tied to pixels where a given farming system occurs.
- Core range refers to the boundaries of travel time intervals (0; 0–1; 1–2; 2–4; 4–6; 6–10; > 10) where at least two-thirds of the farming system occurs.

Agricultural population density (persons/total ha; persons/cultivated ha)

- Agricultural population divided by total and cultivated area.

Livestock density (TLU/total ha; TLU/cultivated ha)

- Computed from above data;
- TLU tropical livestock unit conversions are cattle 0.7, sheep 0.1, goat 0.1, pig 0.2, chicken 0.01.

Standard farm household size (cultivated ha; TLU)

- Source: same as above.
- Farm size: cultivated area divided by number of households (agricultural population divided by mean household size of 5.5).
- Herd size: livestock population divided by number of households (agricultural population divided by 5.5).

Extreme poverty (approx. % of rural population)

- Source: Harvest Choice for SSA; World Bank for national data in North Africa.
- Spatial data on poverty incidence in North African systems were not available, thus administrative data and other estimates were referred to in the characterization of the farming systems.

* FAO/IIASA GAEZ version 3.0 was used for all analyses except for Figure 2.4.

deriving robust parameter estimates. In some instances, the convergence of several spatial databases (or administrative statistics databases) underpinned estimates for the basic data table. Where ratings are given (such as low/medium/high market access), the underlying parameter ranges are given in the relevant section or table.

Approaches to the analysis of drivers and trends

As shown earlier, there have been major changes over the period between 2000 and 2015. In order to characterize the drivers of change and the implications for farming systems, Dixon et al. (2001) identified six major drivers of change in farming systems. The present analysis added one additional driver, namely energy, to make seven drivers in all. These are:

1 population
2 natural resources and climate
3 energy
4 human capital, information and gender
5 science and technology

6 trade and markets
7 policies and institutions

Chapter 1 discussed the foresight studies, assessment reports and trend analyses which can inform the strength of the drivers and the trends and the implications for the farming systems. There is a paucity of detailed analyses or modelling of future trends. In reality, farming systems and rural economies are inherently complex, and so the focus in this analysis has been on identifying major drivers and the implications for strategic interventions for rural development.

With changes in population, infrastructure and technology, both the classification and the extent of several farming systems have changed since 2001. For instance, the area in the rice tree crop farming system in Madagascar has now been distributed between the tree crop and various other systems. Similarly, and for the purpose of consistency in approach to farm enterprise patterns, access to agricultural resources and access to agricultural services were the basis for other farming systems changes noted in Figure 2.2.

Taken together, the seven drivers of change are also causing incremental adjustments to system structure and composition, many of which were anticipated in Dixon et al. (2001). Some changes are visible in terms of new livelihood patterns (for example, adoption of pigeon pea, small-scale irrigation or tree establishment in food crop fields in the maize mixed system). Some other changes might be largely invisible (for example, declining soil fertility in the perennial mixed system, and the strengthening of social capital with farmer-managed natural regeneration in the Sahelian agropastoral system). For example, the combination of accessible and well-developed markets for maize, lower labour requirements for its production and processing, lower bird depredation, and its suitability in the staple dish has stimulated expansion of maize in the eastern and southern agropastoral and other farming systems. Market development has expanded the opportunities for smallholders in East Africa, in particular in horticulture and dairy. Careful observers and analysts can predict future changes.

Household strategies

All farming system chapters evaluate the relative importance of household strategies for reducing hunger and poverty, and enhancing livelihoods and incomes; these strategies directly support improved household food and nutrition security. In the relevant table in each chapter, the relative importance of household strategies for the 2000–2015 period has been drawn from Dixon et al. (2001). The multidisciplinary teams estimated the relative importance of these five strategies (Chapter 1) for reduction of poverty of the extremely poor (living on less than US$1.90 per day) and the improvement of household livelihoods for the less poor for the period 2015 to 2030. Population-weighted averages of the strategies were computed for the region and also for various groupings of farming systems (see next sub-section).

Grouping farming systems

Groupings of farming systems can serve different purposes. For example, all systems which depend on livelihoods from livestock could be grouped. The ultimate purpose of analysing such groupings is to improve food and nutrition security strategies. For ease of use by regional decisionmakers, in Chapter 17 the 15 farming systems are grouped into 3 categories (low, medium and high) of household food security potential for the year 2030, taking into account access to agricultural resources (including farm size and LGP) and access to agricultural services (including degree and quality of market access and opportunities for off-farm income).

Notes

1 In statistics a central tendency is a central or typical value for a probability distribution and relates to the tendency of quantitative data (or systems) to cluster around a central value.
2 See www.fao.org/docrep/W2962E/w2962e-03.htm.
3 A significant issue when modelling LGP from climate station data for Africa is the sparse distribution and maintenance of weather stations. This impacts the rigour and availability of consistent data and thereby limits identification and analysis of areas with bimodal characteristics. An alternative approach based on multi-temporal remote sensing data enables identification of start- and end-of-season parameters and as a result it is possible to identify and characterize areas with bimodal seasonal growing activity (Vrieling et al. 2013).
4 See www.fao.org/nr/climpag/cropfor/lgp_en.asp.
5 See www.fao.org/docrep/W2962E/w2962e-03.htm.
6 See http://link.springer.com/article/10.1007%2Fs10584-011-0049-1.

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Zomer, R.J., Trabucco, A., Coe, R. and Place, F. (2009) *Trees on Farm: Analysis of Global Extent and Geographical Patterns of Agroforestry*. ICRAF Working Paper 89. World Agroforestry Centre.

Annexes

Table 2.5 Major data sources consulted for system characterization

Item
Total, urban and rural human population • FAOSTAT – for agric, rural, urban and females employed in agriculture www.fao.org/faostat/en/#data/OA • FAO/IIASA GAEZ ver 3.0 http://gaez.fao.org/Main.html and http://webarchive.iiasa.ac.at/Research/LUC/GAEZv3.0/ • Harvest Choice Population https://harvestchoice.org/products/data/4 • CIESIN http://sedac.ciesin.columbia.edu/data/collection/gpw-v4 • AfriPop www.afripop.org/ and https://worldmap.harvard.edu/data/geonode:AfriPop1km_QCe • UN Population Division World Population Prospects 2011 and World Urban Prospects 2014 www.un.org/en/development/desa/population/publications/pdf/trends/WPP2010/WPP2010_Volume-I_Comprehensive-Tables.pdf • Projections for 2015 for individual farming systems were based on linear regression using data points from 2000, 2005, 2010 and 2014
Agricultural population • Sub-Saharan Africa only FAOSTAT www.fao.org/faostat/en/#data/OA Harvest Choice Population https://harvestchoice.org/products/data/4 AfriPop www.afripop.org/ and https://worldmap.harvard.edu/data/geonode:AfriPop1km_QCe • For North Africa (NA), AfriPop 2010 was used as spatial footprint with agricultural population estimated from rural population with the following coefficients: 0.9 for NA pastoral and arid pastoral and oasis farming systems (low population density), 0.85 for NA highland mixed, rainfed mixed and dryland mixed farming systems (medium population density) and 0.8 for NA large-scale irrigated farming systems (high population density). High population density areas have relatively greater size and prevalence of rural towns. In contrast, low population areas have fewer rural towns and a higher proportion of agricultural population
Agricultural population density • Agricultural population divided by total and cultivated area Source: same as above
Undernourished people • Centre for World Food Studies, Vrije University, Amsterdam https://research.vu.nl/en/publications/africa-in-maps-data-repository-of-the-food-economy-of-sub-saharan
Extreme poverty – SSA only • Harvest Choice https://harvestchoice.org/maps/sub-national-poverty-and-extreme-poverty-prevalence https://harvestchoice.org/data/tpov_pt125 https://harvestchoice.org/data/tpov_pd200 • Spatial data on poverty incidence in North African systems were not available and so administrative data and other estimates were referred to in the characterization of the farming systems
Total area, land area and water area • Harvest Choice https://harvestchoice.org/topics/land-cover-and-use • FAO/IIASA GAEZ ver 3.0 http://gaez.fao.org/Main.html http://webarchive.iiasa.ac.at/Research/LUC/GAEZv3.0/

(continued)

Table 2.5 (continued)

Item
Land use and land cover
• FAO Global land cover www.fao.org/land-water/land/land-governance/land-resources-planning-toolbox/category/details/en/c/1036355/
Cultivated area, crop land and pasture land
• FAO/IIASA GAEZ ver 3.0 http://gaez.fao.org/Main.html http://webarchive.iiasa.ac.at/Research/LUC/GAEZv3.0/ • Harvest Choice https://harvestchoice.org/topics/land-cover-and-use • Ramankutty www.ramankuttylab.com/data.html https://agupubs.onlinelibrary.wiley.com/doi/pdf/10.1029/2007GB002952 www.earthstat.org/data-download/
Irrigated area and area equipped for irrigation
• FAO Global Map of Irrigation Areas – Version 5 www.fao.org:80/geonetwork?uuid=f79213a0-88fd-11da-a88f-000d939bc5d8 Percentage of area equipped for irrigation www.fao.org:80/geonetwork?uuid=a6fe7f5b-b887-452b-922a-668b7771b450 Occurrence of irrigated areas (FGGD) www.fao.org:80/geonetwork?uuid=641e8b80-7592-11db-b9b2-000d939bc5d8 • Harvest Choice www.harvestchoice.org/maps/irrigated-cropland-area-ha https://harvestchoice.org/topics/land-cover-and-use
Livestock population
• FAO Livestock density www.fao.org/ag/againfo/resources/en/glw/GLW_dens.html Gridded livestock of the world 2007 http://www.fao.org/ag/againfo/resources/en/glw/ FAO/IIASA GAEZ version 3.0 http://gaez.fao.org/Main.html http://webarchive.iiasa.ac.at/Research/LUC/GAEZv3.0/ FAOSTAT www.fao.org/faostat/en/#data/QL • Harvest Choice https://harvestchoice.org/data/ad05_lu • Tropical Livestock Units (TLU) are livestock numbers converted to a common unit. Conversion factors are: cattle = 0.7, sheep = 0.1, goat = 0.1, pig = 0.2, chicken = 0.01. Factors taken mostly from www.lrrd.org/lrrd18/8/chil18117.htm, except for cattle. See also http://en.wikipedia.org/wiki/Livestock_grazing_comparison
Standard farm and herd size (cultivated area/household; TLU/household)
• Farm size: cultivated area divided by number of households (agricultural population divided by mean household size of 5.5) • Herd size: livestock population divided by number of households (agricultural population divided by 5.5) • Source: same as above
Major agroecological zone
• FAO/IIASA GAEZ version 3.0 http://gaez.fao.org/Main.html • http://webarchive.iiasa.ac.at/Research/LUC/GAEZv3.0/ • Harvest Choice • https://harvestchoice.org/maps/aez-16-class

- IFPRI
- https://dataverse.harvard.edu/dataset.xhtml?persistentId=hdl:1902.1/22616
- See also www.fao.org/docrep/W2962E/w2962e-03.htm

Length of growing period (LGP)

- FAO/IIASA GAEZ ver 3.0
- http://gaez.fao.org/Main.html
- http://webarchive.iiasa.ac.at/Research/LUC/GAEZv3.0/
- Harvest Choice
- https://harvestchoice.org/data/lgp_avg
- For more recent data see also http://harvestchoice.org/labs/measuring-growing-seasons
- See also www.fao.org/nr/climpag/cropfor/lgp_en.asp
- University of Twente – Anton Vrieling
- www.mdpi.com/2072-4292/5/2/982
- Average LGP is the average length of growing period tied to pixels where a given farming system occurs
- Core range refers to the boundaries of contiguous 30-day LGP intervals where at least two-thirds of the farming system occurs

Access to services

Author estimates of general access to services in the farming system were based on market access and quality, and other services such as diversity and quality of public and private service provision such as mobile phone coverage, market information availability, extension and veterinary services, availability of finance

Sources consulted:

- Sub-Saharan Africa – Harvest Choice distance to 20, 50, 100, 250 and 500k (population) market
- https://harvestchoice.org/labs/travel-time-major-market-cities
- Continental Africa – distance to 50k market
- Joint Research Centre – Global Accessibility map
- http://forobs.jrc.ec.europa.eu/products/gam/download.php
- Average distance presented in Table 2.2 is the average travel time to a town of 50k inhabitants tied to pixels where a given farming system occurs
- Core range refers to the boundaries of travel time intervals (0; 0–1; 1–2; 2–4; 4–6; 6–10; > 10) where at least two-thirds of the farming system occurs

Trends in biomass productivity

- FAO and ISRIC – World Soil Information, Wageningen Global change in Net Primary Productivity (1981–2003)
  www.fao.org/geonetwork/srv/en/metadata.show?id=37049&currTab=simple

Trees on farm

- ICRAF: Analysis of Global Extent and Geographical Patterns of Agroforestry (Zomer et al. 2009)
  www.worldagroforestry.org/downloads/publications/PDFs/WP16263.PDF

Elevation

- Sub-Saharan Africa
  Harvest Choice
  https://harvestchoice.org/maps/elevation-meters
- Continental Africa
  NASA Shuttle Radar Topography Mission SRTM
  www2.jpl.nasa.gov/srtm/

Yield gaps

- FAO/IIASA GAEZ ver 3.0
  http://gaez.fao.org/Main.html and
  http://webarchive.iiasa.ac.at/Research/LUC/GAEZv3.0/

Table 2.6 Selected major supporting documents, administrative statistics and assessment reports

Agency	*Main administrative statistics, supporting documents*
African	Adeleke Salami, Abdul B. Kamara and Zuzana Brixiova 2010. African Development Bank. Smallholder agriculture in East Africa: Trends, constraints and opportunities AfDB. 2014. African Economic Outlook 2014 Global Value Chains and Africa's Industrialisation African Union Commission 2017 Inaugural Biennial Review Report of the African Union Commission on the Implementation of the Malabo Declaration on Accelerated Agricultural Growth and Transformation for Shared Prosperity and Improved Livelihoods to the January 2018 Assembly AGRA. 2016. Africa Agriculture Status Report. Progress towards agricultural transformation in Africa AGRA. 2017. Africa Agriculture Status Report: The business of smallholder agriculture in sub-Saharan Africa (Issue 5). Nairobi, Kenya: Alliance for a Green Revolution in Africa (AGRA) AU. Malabo Declaration on Accelerated Agricultural Growth and Transformation for Shared Prosperity and Improved Livelihoods FARA. 2013. Summary of plenary recommendations, 5th African Science Week, African agricultural innovation in a changing global environment FARA. 2014. Science agenda for agriculture in Africa. 'Connecting science' to transform agriculture in Africa. Forum for Agricultural Research in Africa. Accra, Ghana FARA. 2015. High-level conference on feeding Africa: An action plan for African agriculture transformation Montpellier Panel Report. 2013. Sustainable intensification: A new paradigm for African Agriculture Montpellier Panel Brief. 2013. Farmers on the climate frontline NEPAD-AU 2010. Highlighting the successes NEPAD-AU. 2013. The CAADP results framework (2015-2025). Introducing the comprehensive Africa Agriculture Development Programme (CAADP) NEPAD-AU The Africa Progress Panel (APP). 2010. Raising agricultural productivity in Africa: Options for action, and the role of subsidies The Africa Progress Panel (APP). 2015. Africa Progress Report 2015. Power, people, planet: Seizing Africa's energy and climate opportunities
International	Brookings Institute. 2017. Foresight Africa. Top priorities for the continent in 2017. Director and Senior Fellow, Africa Growth Initiative, Global Economy and Development FAO. 1996. Agro-Ecological Zoning Guidelines, FAO Soils Bulletin 73, Soil Resources, Management and Conservation Service, FAO Land and Water Division, Rome, Italy FAO. 2015. Regional overview of food insecurity in Africa FAO. 2015. The state of food and agriculture 2010–2011 FAO. 2017. Regional overview of food security and nutrition in Africa 2017. The food security and nutrition–conflict nexus: building resilience for food security, nutrition and peace. Accra FAO/HLPE. 2009. The special challenge of sub-Saharan Africa IFAD. 2010. Rural poverty report 2011. New realities, new challenges: New opportunities for tomorrow's generation. IFAD. 2012. IFAD's approach to small island state development

IFAD. 2016. Rural Development Report 2016. Fostering inclusive rural transformation
John Lynam, Nienke Beintema, Johannes Roseboom, Ousmane Badiane (eds). 2016. Agricultural research in Africa: Investing in future harvests. IFPRI.
Kathleen Beegle, Luc Christiaensen, Andrew Dabalen, Isis Gaddis. 2016. Poverty in a rising Africa: Africa poverty report. Overview. World Bank
Malabo Montpellier Panel. 2017. Nourished: How Africa can build a future free from hunger and malnutrition
Namukolo Covic, Sheryl L. Hendriks (eds). 2015. ReSAKSS trends and outlook report 2015: Achieving a nutrition revolution for Africa – The road to healthier diets and optimal nutrition
Samuel Benin, Alejandro Nin Pratt, Stanley Wood, Zhe Guo 2011. ReSAKSS annual trends and outlook report 2011: Trends and spatial patterns in agricultural productivity in Africa, 1961–2010
UNDP. 2015. Africa Human Development Report (2015): United Nations Development Program
UNECA. 2015. Assessing progress in Africa toward the Millenium Development Goals. MDG Report, Lessons learned in implementing the MDGs
UNECA. 2015. Economic report on Africa
WHO/FAO. 2003. Diet, nutrition and the prevention of chronic diseases. WHO Technical Report Series Report of a Joint WHO/FAO Expert Consultation
World Bank and OECD. 2015. The Africa competitiveness report. World Economic Forum
World Bank. 2009. Awakening Africa's sleeping giant: Prospects for commercial agriculture in the Guinea Savannah zone and beyond
WWF. 2012. Africa's Ecological Footprint Report

Table 2.7 Experts consulted for system characterization and delineation in addition to chapter authors and selected list of spatial data reviewed

Country	*Experts consulted and maps and data used*
Regional	FEWS NET Livelihood zones http://fews.net/fews-data/335t
Angola	**1.** Food Security Brief, FEWS NET Angola Desk Review, 2012 http://fews.net/southern-africa/angola/food-security-brief/october-2012; **2.** Contour Map of Average Rainfall, Rainfall National Irrigation Plan (PLANIRRIGA), progress report # 2. (2010)
Botswana	Key expert inputs to FS map by Thabo Feribe; Alfred Lefaphane **1.** Annual rainfall map, 1971–2000; **2.** Harvest Choice spatial maps of crop production; LGP
Egypt (Nile River)	Key expert inputs to FS map by Ahmed Eltigani Sidahmed
Ethiopia	SIMLESA maps of: **1.** mega maize environments by altitudinal zones; **2.** maize production; **3.** legume production; **4.** livestock population
Kenya	**1.** Crop suitability maps; **2.** Agroecological zones map provided by George Mburathi; **3.** GAEZ / FAO LGP (based on 1961–1990 records); **4.** Remote sensing LGP from Anton Vrieling; **5.** FAOSTAT data on national crop areas; **6.** Harvest Choice maize and coffee-banana areas

(continued)

Table 2.7 (continued)

Country	*Experts consulted and maps and data used*
Madagascar	Key expert inputs to FS map by Volatsara Rahetlah, FIFAMANOR; Tahina Raharison, GSDM, Eric Penot, Paolo Salgado, Pascal Danthu, and Eric Enjalric, CIRAD. **1.** 2012 FEWS NET Madagascar Desk review including 2010 WFP Map of livelihood zones; **2.** 2013 FEWS NET Madagascar Livelihood Zone Map; Elevation, LGP; **3.** Harvest Choice maps for crops and livestock
Mali	**1.** Main agroecological units map of Mali
Mozambique	Key expert inputs to FS map by Joe DeVries, AGRA; Domingos Dias, IIAM **1.** Food crop production per region, World Bank 2006; **2.** Poverty, World Bank 2005; **3.** Rainfall distribution, IFPRI 2011; **4.** Land with intensification potential National Institute of Agronomic Research (NIAR) 2002; **5.** Map of agroclimatic regions and research stations, NIAR 2002
Namibia	Key expert inputs to FS map by Bertus Kruger, AGRA, Windhoek **1.** Farming Systems in Namibia, John Mendelsohn and others, 2006, RAISON, Windhoek
Nigeria	Key expert inputs to FS map by Tunrayo Alabi, IITA **1.** Mean harvested yam area (2006–2009) from Ministry of Agriculture; **2.** Mean yam production (2006–2009) from Ministry of Agriculture
Republic of South Africa	Key expert inputs to FS map by: Archer van Garderen, CSIR Natural Resources & the Environment, Pretoria and Daleen Lötter, CSIR Natural Resources & the Environment, Stellenbosch; Roland Schulze, School of Agricultural, Earth and Environmental Sciences, University of KwaZulu Natal; Anneliza Collett, Land Use and Soil Management Directorate **1.** Department of Agriculture, Forestry and Fisheries; Undated Agricultural Enterprises of South Africa Map, Department of Agriculture: Western Cape, Elsenburg, South Africa; **2.** Updated national land cover map in Updating National Land Cover, SANBI (South African National Biodiversity Institute), Pretoria, dated 13/10/2009 http://bgis.sanbi.org/landcover/project.asp; **3.** Area (km^2) Per Quinary Catchment Production Forest Plantations (Eucalyptus, Pinus, Acacia Species) from National Land Cover (2000); **4.** Area (km^2) Per Quinary Catchment Sugarcane from National Land Cover (2000); **5.** Field Crop Boundaries, 2011, Department of Agriculture, Forestry and Fisheries (DAFF)
Tanzania	FEWS NET: Preliminary Rural Livelihood Zoning Tanzania, 2008. A Special report by the Famine Early Warning System Network (FEWS NET)
Uganda	**1.** Main farming systems map of Uganda, source: www.fao.org/ag/AGP/AGPC/doc/Counprof/uganda/uganda.htm#3.%20CLIMATE%20AND%20AGROECOLOGICAL; **2.** Livestock production systems in Uganda, source: Ministry of Agriculture, Animal Industry and Fisheries, Uganda; Uganda Bureau of Statistics; Food and Agriculture Organization of the United Nations; International Livestock Research Institute; and World Resources Institute, 2010, *Mapping a Better Future: Spatial Analysis and Pro-Poor Livestock Strategies in Uganda*. Washington, DC and Kampala: World Resources Institute. **3.** Poverty rate: percentage of subcounty population below the poverty line, 2005 source: UBOS and ILRI, 2008; **4.** Poverty density by rural subcounty: Number of people below the poverty line per square kilometre, 2005
Zambia	Key expert inputs to FS map by Moses Siambi