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FARM MANAGEMENT SYSTEMS AND FOOD PRODUCTION

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SUMMARY

Growth in farm income and household food security has lagged behind the expectations of participants in the World Food Summit, who committed to the halving of the number of the under-nourished by 2015. The increases in agricultural productivity, which are required to boost farm income and food security, depend ultimately on farm management decisions in relation to, inter alia, choices of enterprises, production technologies and agricultural inputs. These decisions are strongly influenced by the particular farming systems in which the household operates as well as the individual circumstances of the household. An understanding of the wide spectrum of farming systems which exist across the developing world can contribute to effective rural development strategies and agricultural development policies.

The FAO/World Bank Global Farming Systems Study delineated from 8–16 separate farming systems in each of the six developing regions of the world (a total of 72 systems, or 44 systems when comparable systems in different regions are consolidated). These were subsequently grouped into eight broad global farming system types, according to their resource and production focus, land use intensity and degree of market linkage. The evolution of farming systems over time, and hence their changing contribution to food security, is considered to be influenced by five main drivers, *viz*: population and natural resources; technologies; trade liberalisation and markets; policies and institutions, and; information and human capital. These factors establish the environment in which individual households within each farming system function, and together with individual household asset endowments and objectives, determine the strategies which each household will follow in seeking increased food security and income growth. Drawing from sustainable livelihoods concepts, the study grouped possible household strategies into five types, comprising: intensification of existing patterns of production; diversification; increased farm or enterprise size; increased off-farm income, and; exit from agriculture. The relative importance of each strategy (more than one may be combined within a single household) was then estimated for different farming systems, providing predictions as to the key sources of future change in each system.

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With regard to current levels of production intensity, the farming systems fall into four classes: low production intensity, market-oriented medium production intensity, food crop oriented medium production intensity and high production intensity. The last class accounts for the major part of the current demand for inorganic fertiliser in developing countries.

It is believed that the farming systems perspective can be applied to the consideration of food security and sustainable fertilization at several levels. As the initial study was undertaken at a global level, considering regionally defined farming systems, the focus until recently has been primarily on macro-level uses, including such areas as determining regional priorities for rural investment and research, identifying and disseminating best practices across a farming system, and for monitoring and impact assessment. Nevertheless, future applications may be equally important at a more local level, including sub-regionally and nationally. Key applications are likely to include national rural development strategies, such as the Poverty Reduction Strategy Papers (PRSPs), financing agency strategy documents (e.g. CAS and COSOPs) and operational considerations, such as the development of technology menus and technical assistance packages for extension services. In order for the farming systems approach to yield useful results at these finer scales, however, the coarse delineations of the original study will have to be further refined through the definition of sub-systems at national and even sub-national level. Not only can such meso-level analysis take greater account of climatic, natural resource and population variations within a single system, but – unlike the broader regional systems – they can also reflect the varying influence of factors that may change across political boundaries, such as government policies and institutional development.

The farming system approach may also be useful for private sector and non-governmental groups. For example, by looking at existing and forecast intensification and diversification levels by system, it is possible to identify areas of likely future strong demand for fertilizers. Globally, more than 1,500m hectares of cultivatable land fall within predicted high growth systems, encompassing an agricultural population of over 500m people, while more than 2,000m hectares are classified within low intensification systems. The farming systems perspective may also help determine other privately-financed activities, such as the location of fertilizer and seed trials and technology demonstrations.

INTRODUCTION: GLOBAL FOOD SECURITY AND FERTILISER USE

Substantial progress has been made in global food security in the past 40 years, and further steady progress in the reduction of under-nourishment is forecast by FAO (2002). However, the achievement of the 1996 World Food Summit of halving the number of hungry by 2015 (subsequently endorsed in the first International Development Goal) would require an acceleration of development efforts. FAO (2002) projections suggest that there may be 610 million under-nourished people in 2015 compared with the WFS target of 410 million.

On the demand side, dollar poverty (persons living on less than $ 1 per day) has been reducing slowly – presently around 1.1 billion; but increasing average incomes have increased, and changed the composition of, demand for food. On the supply side, the growth in cereal production has slowed from 1.9 % p.a. during the 1970s to 1.0 % p.a. during the 1990s. Interestingly, yield increases have accounted for two-thirds of the growth, which underlines the importance of a sufficient supply of plant nutrients.

This paper considers one aspect of global food security and sustainable fertilization, namely, farm management decisions and the usefulness of a farming systems framework created during the FAO/World Bank Global Farming Systems Study (which contributed to the updating of the World Bank Rural Development Strategy (see http://wbln0018.worldbank.org/ESSD/rdv/vta.nsf/Gweb /Strategy).

FARM MANAGEMENT DECISIONS

The increases in agricultural productivity, which are required to boost farm income and food security, depend ultimately on management decisions on millions of individual farms in relation to, *inter alia*, choices of enterprises, production technologies and agricultural inputs. These decisions are strongly influenced by the particular farming systems in which the household operates as well as the individual circumstances of the household. In fact, these two factors account for most of the observed variation in farm management decisions.

The circumstances of individual farm households vary significantly even within any given broad farming system, and they also vary over the family life cycle of households. Within the one village there is generally a range of farm and household sizes that may still produce a similar range of agricultural products, albeit using different technologies.

Differences in the farming system account for a major part of the variation in farm management decisions. In this paper we adopt a livelihoods approach to the definition of farming systems, i.e., multiple sources of livelihoods are recognized including auto-consumption, cash crops, aquaculture, extractive activities from natural resources and off-farm income. We consider the local institutional environment, including farm gate price ratios, local markets, credit availability to farmers and arrangements for resource sharing as an integral part of the local farming system. In this way, a large proportion of the variation across farming within any particular country or region is represented by a classification of farming systems. A useful framework of farming systems will be considered in the next section.

FARMING SYSTEMS FRAMEWORK

An ideal framework would allow the tremendous diversity of agricultural settings to be simplified and codified, without eliminating important differences that need to be taken into account by development practitioners; and would be hierarchical (see Fresco and Westphal 1988 and Conway 1997) in order to meet the different needs of decision makers at different levels. An FAO/World Bank Study (Dixon *et al* 2001) identified generic farming systems categories and, at a lower level of aggregation, broad farming systems, defined as populations of individual farm household systems with broadly similar resources, livelihoods and vulnerabilities (see Ellis 2000), similar opportunities and constraints, and for whom similar development strategies and interventions might be appropriate. Following the tradition of Ruthenberg (1980), the broad farming systems defined in this Study encompass many millions of households.

Farm household systems and their immediate external rural environment (including local effects of policies and institutions, markets and information linkages) are inter-dependent[1] and, over time, co-evolve in response to changes in population, markets, technologies, policies, institutions and information flows.

To develop the farming systems knowledge base, the Study team blended information from global Geographic Information Systems (GIS), farming system studies, decentralised administrative data and expert knowledge. After the global forces driving change in farming systems were identified, small multidisciplinary teams identified the characteristics and extent of each farming system zone. For this purpose, the teams used the FAO Agro-Ecological Zone (AEZ) maps as a base and added other GIS layers as relevant, including irrigation, environmental constraints, cultivated extent, livestock (in some regions) and human population[2]. In addition, decentralised administrative data from selected units were tabulated within each zone, supplemented by estimates from local farming system studies where available. Taking into account the broad trends documented in FAO (2000), the teams identified the specific trends, emerging constraints and strategic development priorities for each farming system. The results were presented in regional stakeholder consultations[3] and the feedback incorporated in the analysis. In addition, the analysis was extended in two ways: estimating the relative importance of household strategies ('backcasting' from the target of halving the number of poor people by 2015), and consolidating the findings across all regions (see Dixon *et al*. 2001). The analysis drew on the knowledge of more than 50 experts with more than 1 000 person years of practical development experience from a wide variety of disciplines.

The eight generic farming system categories defined across the developing regions of the world are:

- irrigated smallholder farming systems (in large irrigation schemes);
- wetland rice-based farming systems;
- rainfed farming systems in humid areas;
- rainfed farming systems in steep and highland areas;
- rainfed farming systems in dry or cold areas;

[1] Important linkages include labour markets (for example, off-farm employment), capital markets, informal safety nets, information exchange and social networks.

[2] In all 15 GIS layers were combined, under the supervision of C. Auricht.

[3] See consultation documents: Africa, Carloni (2001); Middle East and North Africa, Gibbon (2001); East Europe and Central Asia, Tanic & Dauphin (2001); South Asia, Weatherhogg *et al.* (2001); East Asia and Pacific, Ivory (2001); Latin America and Caribbean, Gulliver (2001); Global Synthesis – Dixon *et al.* (2001).

- dualistic farming systems with both large-scale commercial and smallholder farms;
- coastal artisanal fishing mixed farming systems; and
- urban-based farming systems.

Within these eight categories a total of 72 broad farming systems were identified and mapped (varying from 8 to 16 per region). Because equivalent farming systems exist in different regions, the total number of different farming systems at the global level is 44. In each region there are more than a dozen thematic layers which have been overlaid on the farming systems maps (including AEZ, rainfall, environmental constraints, altitude, cultivated extent, livestock population, human population), resulting in more than 100 regional maps which are available through the FAO website www.fao.org/farmingsystems/. The six regional maps and systems were subsequently consolidated, taking into account the equivalence of some farming systems in different regions, to produce a global map with 44 farming systems. The global and Africa maps are annexed. It should be noted that the farming systems of the OECD countries have not yet been defined or classified in this system (although national classifications do exist).

As shown in Table 1, the six irrigated and rice based wetland systems[1] contain an agricultural population of nearly 900 million people with some 170 m ha of cultivated land, of which nearly two-thirds is irrigated. There are three major categories of smallholder rainfed farming system (in humid, highland or dry/cold areas), which together contain an agricultural population of more than 1 400 million people with around 540 million ha of cultivated land. Dualistic systems comprising farms of mixed size contain a further 200 million farm people with a cultivated area of 11 million ha. Finally, two further minor categories of smallholder system – four coastal artisanal fishing mixed and six urban based systems – contain a combined total of about 100 million people.

[1] One irrigated farming system in Eastern Europe and Central Asia has relatively large farms and, for the purpose of the present discussion, is included in the category of dualistic systems.

Table 1: Comparison of Global Farming Systems Categories								
Category characteristic	Small-Holder irrigated schemes	Wetland rice based	Rainfed humid	Rainfed highland	Rainfed dry/cold	Dualistic (large/ small)	Coastal artisanal fishing	Urban based
No. of Farming Systems	3	3	11	10	19	16	4	6
Total Land (m ha)	219	330	2013	842	3478	3116	70	n.a.
Cultivated Area (m ha)	15	155	160	150	231	414	11	n.a.
Irrigated Area (m ha)	15	90	17	30	41	36	2	n.a.
Agric. Population (m)	30	860	400	520	490	190	60	40
Market Surplus	high	medium	medium	low	low	medium	high	high

Source: Dixon *et al.* 2001, based on FAO data and expert knowledge.
Note: Cultivated area refers to both annual and perennial crops.

The above Table contrasts two important attributes of farming systems: the underlying natural resource endowment; and access to agricultural services, notably input (including fertiliser) and produce markets. This two-variable simplification of the domains covered by the farming systems categories echoes Boserup (1965) and some recent studies of smallholder development (see Wiggins 2002). Average household resource endowments underpin the supply side potential for intensification and for diversification (e.g., irrigated cf. dry rainfed systems). The access to agricultural services influences the different opportunity sets with which farm households are confronted (e.g., rainfed highland cf. urban farming systems).

Farm households pursue a number of poverty reduction strategies which differ depending on the farming system and circumstances of the household. The responses of farm households can be categorised into five livelihood strategies:

- intensification of existing patterns of farm production;
- diversification of production, including market-oriented, value-added and post-harvest activities;
- increased operated farm, herd or enterprise size, including consolidation of existing holdings and the expansion of the agricultural frontier;
- increased off-farm income to supplement or replace farming activities; and
- exit from agriculture within the farming system, often involving migration from rural areas.

There is substantial literature on population driven intensification, mostly based on the pioneering work by Boserup (1965) and Ruttenberg (1980) and carried forward by various researchers including Pingali *et al.* (1987) and Smith *et al.* (1993) – and a considerable proportion of development effort is directed to sustainable intensification. Farm enterprise and income diversification is a common farmer response to changing resource ratios and market access (Delgado and Siamwalla 1999) and many governments support farm-level diversification. There is widespread recognition of the growing importance of off-farm income for smallholder households. While the strategies of increasing farm size and exit from agriculture were common in the evolution of agriculture in many OECD countries, they have received less attention in developmental literature. What is missing from knowledge bases supporting development practitioners is the contextual analysis of the factors influencing the merits and feasibility of these different strategies for farmers in the different major farming systems of the world.

Table 2 shows the relative importance of these household strategies – which also correspond to rural development strategies on a wider scale. The relative potential impacts suggest the mixes of strategies that would be required to close the gap between the 'business-as-usual' projections and the International Development Goals (of halving hunger and poverty) in each of the major farming system categories.

Table 2: Relative Importance of Different Poverty Reduction Strategies by Farming System Category

Poverty Reduction Strategies	Small-holder irrigated schemes	Wetland rice based	Rainfed humid	Rainfed highland	Rainfed dry/cold	Dualistic (large/ small)	Coastal artisanal fishing	Urban based
Intensification	3.4	1.7	1.9	0.9	1.5	2.8	0.7	1.3
Diversification	2.9	3.4	2.7	2.7	2.3	2.0	2.5	2.7
Increased Farm Size	1.2	0.9	1.7	0.6	0.9	2.0	0	1.7
Increased off-farm Income	1.9	2.8	2.2	3.0	2.2	1.8	4.2	3.6
Exit from Agriculture	0.6	1.2	1.4	2.8	3.1	1.3	2.6	0.8

Source: Dixon *et al.* (2001), based on expert panel judgements.
Note: The total of scores for each farming system category equals 10.

In aggregate terms, on-farm improvements (i.e., intensification, diversification and increased farm size) would be a greater source of poverty reduction than off-farm sources (i.e., off-farm income and exit from agriculture). Within the category of farm improvement, diversification is expected to be the key strategy in a majority of farming systems – benefiting from the higher income elasticities and expanding local demand for many non-traditional and processed agricultural products. The intensification of existing patterns of production, which has traditionally dominated the agenda of research institutions, will continue to be an important source of farm income growth in a majority of system categories. Finally, a certain proportion of poor farmers will also benefit by expanding their operational asset base through increased farm size as land is consolidated, the agricultural frontier expands in some rainfed humid farming systems (notably in Latin America and Sub-Saharan Africa), or land rental markets improve[1].

Apart from farm improvement options, off-farm income already contributes a major part of the household income of poor farmers, and further increases are expected to be the second greatest source of aggregate poverty reduction in future years. The exit of farmers from agriculture within a particular farming system is expected to be an increasingly common phenomenon, and forecast to be of particular importance among smallholders in rainfed highland and dryland areas. Globally, diversification (including on-farm processing and other value added activities) turned out to be a much more important household strategy than intensification. However, the great variability in the relative importance of these strategies across farming systems needs to be recognized by policy makers.

APPROACHES and ACTIONS

The value of any new tool or perspective must lie in its ability to provide additional insights to those utilising it. As the initial study was undertaken at a global level, considering regionally defined farming systems, the focus until recently has been primarily on its application as a framework for large-scale regional analysis and strategy development. Two broad approaches have been used. In the first, data developed from other technical fields has been overlaid on, or compared with, farming systems occupying the same areas to see possible relationships and extrapolate data across systems. This has been the case, for example, for studies on disease occurrence and on carbon sequestration. A second approach has been to use defined farming systems as guidelines for developing data and approaches, as occurred in the development of a long term strategy for management of African forestry resources, which looked at land use pressure and predicted intensification in farming systems across the continent, and used these as contributions to identifying different levels of pressure of forest resources in future decades. For both of these approaches, the FS perspective can help determine regional priorities for rural investment and research, the identification and dissemination of best practices across a farming system, and for monitoring and impact assessment.

[1] In addition, some poor pastoralists may succeed in expanding their herd size, or poor urban producers may expand their volume of production.

At the regional level also, the process of identifying and disseminating best practices can be effectively supported through a knowledge of farming systems, as best practices are normally specific to broadly similar sets of circumstances (such as natural resources, production patterns, market opportunities and population pressure) which are captured by farming system delineations. These best practices may encompass such areas as technology adoption, services (marketing, financial etc.), and institutional and policy arrangements.

In the longer run, however, it is believed that more geographically specific applications of the farming systems perspective will prove to be equally or perhaps even more, important providing insights at sub-regional, national or even sub-national levels. In order for the farming systems approach to yield useful results at these finer scales, however, the coarse delineations of the original study will have to be further refined through the definition of sub-systems which not only take greater account of climatic, natural resource and population variations within a single system, but – unlike the broader regional systems – can also reflect the varying influence of factors that may change across political boundaries, such as government policies and institutional development[1]. In particular, statistical and biophysical data collected in censi and rural surveys will have to be re-aggregated to reflect farming system rather than political boundaries. The increasing use of GPS references for such data will make this increasingly easy to achieve in the future.

Key meso-level applications are likely to fall into three broad categories: (a) input to strategy development, in a similar manner to those developed on a regional basis; (b) identification and development of rural investments, and; (c) as tools in developing operational guidelines and support materials. Examples where improved meso-level farming systems data would provide significant benefits include national rural development strategies, such as the Poverty Reduction Strategy Papers (PRSPs) and other documents prepared by Ministries of Agriculture, Natural Resources and similar agencies, as well as guidance and discussion documents prepared by international financing institutions; e.g. the World Bank Country Assistance Strategy (CAS) and the International Fund for Agricultural Development's Country Strategic Opportunities Papers (COSOP). The identification and design of rural investments comprises a logical next step to these strategy exercises, and provides a similar demand for an improved perspective on patterns of household livelihoods in these areas.

In the absence of well developed national and sub-national farming systems definitions, the range of operational guidelines that may be of value is more difficult to predict. However, it is clear that extension and advisory services could benefit heavily from the ability to target technology menus, technical assistance packages, field trials and similar activities by farming system. These applications are likely also to be of interest to the private sector and other non-governmental users. But the private sector – including the

[1] Regional-level farming systems tend to use the predominant or 'average' policy and institutional environment in defining system characteristics and trends.

fertilizer industry – can also draw useful information from the more macro-scale data already available. For example, by looking at existing and forecast intensification and diversification levels by system, it is possible to identify areas of likely future strong demand for fertilizers. Globally, more than 1,500m hectares of cultivatable land fall within 15 predicted high growth systems, encompassing an agricultural population of over 500m people, while more than 2,000m hectares are classified within low intensification systems. Of the high growth areas, the majority by area are estimated to fall within Latin America, which accounts for more than half, although the bulk of the population living in high growth systems can be found in South Asia, and in particular the rice-wheat system.

CONCLUSION

This farming systems framework has been generated from wide-ranging expert judgement, selected secondary data and the latest available spatial data on population, resource use and climate. It comprises characteristics, trends, emerging constraints and strategic priorities of some 72 broad farming systems identified in six developing regions, organised around five leading areas of rural change, viz, natural resources, technologies, markets, policies/institutions and information/human capital. Building on the sustainable livelihoods concepts of multiple assets and vulnerability, the study proposes poverty escape pentagons for each broad farming system, and estimated the relative importance of intensification, diversification, increased farm or enterprise size, increased off-farm income and exit from agriculture.

Initial applications of the farming systems perspective have focused on the available global and regional analyses, and have generally utilised the resulting framework to assess other data across farming systems (e.g. forest cover, disease risk) or to guide data extrapolation. Future uses are more likely to focus on sub-regional or national applications, as more refined sub-system analyses become available. Use at national level and below are likely to focus on strategy development, investment planning and in developing operational guidelines for the provision of technical assistance, technology and services in rural areas.

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ANNEX: Map of Farming Systems of Sub-Saharan Africa