Building on diversity: pathways to agricultural intensification in Burkina Faso

Ole Mertz & Anette Reenberg

Abstract

Aimed at identifying appropriate pathways to enhance and diversify food production, this study analyses land use patterns and agricultural practices in a community in Boulgou province, Burkina Faso. Currently, almost all suitable land is permanently cultivated and fallow is rare. Diversity in terms of many field locations, crop choice, and intercropping is high, but rotation of major crops is seldom practised which may cause lower yields. The use of animal traction for ploughing and weeding is widespread, and compost and manure are used on fields close to compounds; inorganic fertilizer is only used on cash crops. Options for intensification are discussed. Labour availability is considered an important constraint to area expansion and intensification by farmers. Investment in intensification measures and maintenance of diversity are, however, important household strategies if resources are available. Improved intercropping systems that include secondary crops such as vegetables should be part of extension programmes, and, generally, agricultural diversity and labour availability assessment need to be further integrated into development efforts as these are key parameters in the agricultural strategies of rural communities.

Keywords

Aerial photos, Boulgou province, crop diversity, cash crops, intercropping, labour availability, land use, traditional crops.

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Increased agricultural production is one of the main concerns in the Sudan-Sahel zone of West Africa where populations grow at a rate which will double the number of inhabitants in 20-30 years and the natural agricultural production potential is modest. Governments struggle to alleviate famine and rural poverty, supply urban populations with food, and improve the national economy through export of agricultural products. Different means have been used in order to address such objectives: On the national scale a number of policies have aimed at stimulating production of major crops through sector interventions in various commodity chains such as the main cereals, cotton, oil plants, etc. (DANIDA/MAE, 1997) while more direct interventions through agricultural development projects have been a typical course of action taken on the regional level.

The concern for agricultural production strategies is, however, not only forwarded in the context of providing food and potential sources of foreign exchange. It also emerges in relation to the increasing awareness of the efficient use of production factors that has followed the enhanced focus on sustainable use of natural resources such as land and water. This has been a natural result of the strong attention in the Sudano-Sahelian region to issues raised in connection with, for example, national environmental action plans (Marcussen, 1998) and the international convention to combat desertification (Rasmussen, 1998).

The gradient of agricultural potential in the West African Sudan-Sahel zone is significant. The Sahelian agroecological zone is normally defined as the area receiving 100-600 mm precipitation per year and the Sudanian zone 600-1200 mm per year. The drier parts in the Sahel do not offer promising opportunities for agricultural intensification. Precipitation is not only scarce but also highly unpredictable, and it is well documented that water supply and water losses constitute serious bottlenecks for intensification of agriculture in this zone (Wijngarden, 1988; FAO, 1991).

Several studies (Ramaswamy & Sanders, 1992; Barbier & Benoit-Cattin, 1997; Shapiro & Sanders, 1998) stress the scope for considering agricultural intensification primarily in more humid areas where poverty and poor productivity coincide with an acceptable production potential, i.e in the Sudanean and Guinean zones of West Africa. Experience from case studies conducted in those regions suggests that farmers may actively - and successfully - respond to changed environmental or demographic conditions by increasing land productivity, if the external conditions such as access to markets and available agrochemical inputs provide sufficiently favourable incentives for farmers to intensify (Harris, 1996; Adams & Mortimore, 1997). Yet, others suggest that the current pace of population growth and land degradation requires considerable external assistance in terms of financial and technology transfers as farming communities themselves are not able to sustain a sound resource management (Ramaswamy & Sanders, 1992).

Different possible pathways to intensification are well described in the literature. They include mechanization, usually ploughing and weeding by animal traction (Nicou et al., 1990; Tersiguel, 1995), soil and water conservation methods such as stone bunds in fields (Vlaar, 1992; Ouedraogo & Bertelsen, 1997; Maatman et al., 1998), and, in combination with the above, increased use of manure, compost, inorganic fertilizers and pesticides (Ramaswamy & Sanders, 1992; Taonda et al., 1995; Shapiro & Sanders, 1998). The long term sustainability of these measures, specifically in terms of economic viability and demand for the scarce labour resources in the farming communities, may, however, vary. Whether applied individually or in combination and whether adopted spontaneously or through active development intervention their feasibility is much dependent on the natural and socio-economic conditions present in the local agricultural and natural resource management systems which are targeted.

The aim of this paper is to discuss potential intensification pathways for agricultural systems in semi-arid parts of Burkina Faso through a characterization and analysis of the diverse production strategies and resource management practices in the traditional land use system. In this context, we define intensification as increased area productivity and diversity relates mainly to crop choice, crop combinations (intercropping), and field locations. Basic characterization of a land use system is presented in order to get to grips with forces that drive agricultural intensification. This includes investigations of the spatial room for manoeuvring within the current land use strategy and the possible trends of saturation of arable land. Furthermore, farmers' traditional crop choice, location of fields, field size determinants, and the use of technology are analysed in order to discuss options for agricultural intensification. Elements of the local strategies related to crop selection are investigated, notably the importance of crops usually considered secondary to the main cereals, e.g. vegetables and condiments.

Study area

The material presented below aims at describing the village of Silmiogou in the Boulgou province, Burkina Faso, (Figure 1) and providing a model case for the land use systems in the region. The village is comparatively small with a territory of 6.7 km^2, but within the last decades, Silmiogou farmers have started cultivating land in a neighbouring village which adds approximately 20% to the size of their actual territory (Reenberg & Lund, 1998). The new land is located in the vicinity of an extensively used river valley and is labelled *Gabon* by local people because of its fertility. The valley belongs to the large network of low lying areas which has recently become attractive to farmers as river blindness has been largely eradicated by the WHO/Onchocerciasis Control Programme (WHO/OCP/CTD, 1994; McMillan, 1995; Yaméogo et al., 1996).

Silmiogou lies in the semi-arid Sudanean agro-ecological zone with an approximate average yearly precipitation of 905 mm (1922-1992, CRPA-CE, Tenkodogo) and significant inter-year and intra-seasonal variations. The natural vegetation belongs to the transition zone between bush and woody savanna, but the land is relatively intensively cultivated. Rough estimates for the entire Boulgou province suggest that around 50% of the total area is currently under cultivation or fallow (DANIDA/MAE, 1997). Yet, land use statistics on which such estimates are based are scarce and unreliable. Regional estimates of the variation in land under cultivation have been derived from SPOT satellite images based on a 25 km^2 grid which indicate that cultivation ratios (cultivated land/total area) vary throughout the region between approximately 14 and 74% (Reenberg & Dybkjær, 1996). The greatest pressure on the land is found in the area around the Garango-Tenkodogo road and towards the North. Silmiogou can be characterized as being located in a transition zone, with the main territory

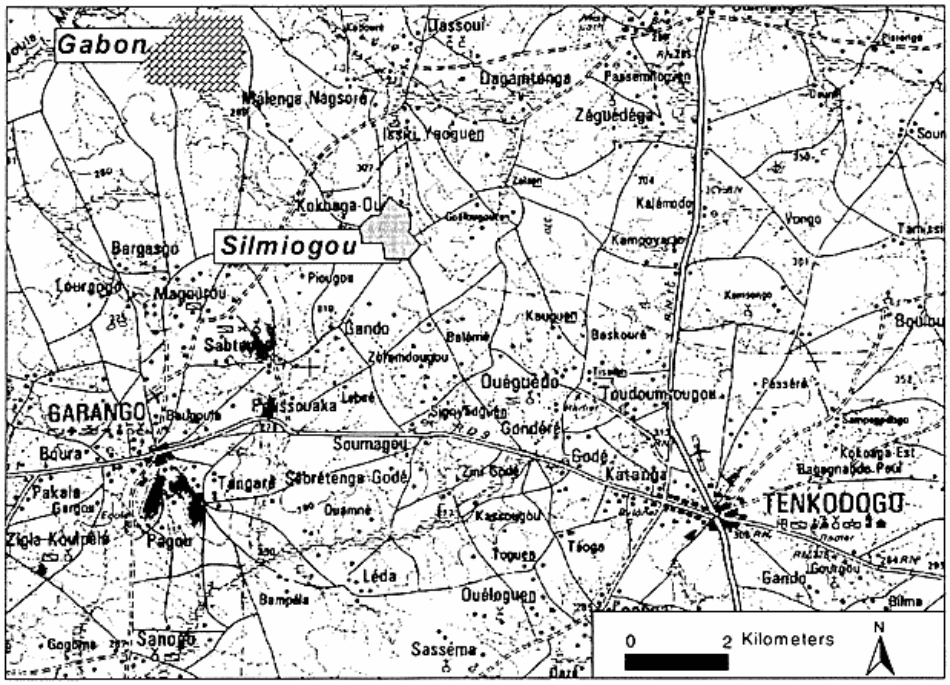

Figure 1: Section of topographic map 1:200,000 with indication of the Silmiogou main village territory and the approximate location of Gabon shown as a grid. The exact area of Gabon is not known but main fields were positioned with GPS.

lying in the zone of high cultivation intensity, but bordering regions under less pressure.

In a regional context, Silmiogou represents a relatively enabled village. It has a favourable location with easy access to the regional markets in Tenkodogo and Garango, approximately 10 km to the north of the Tenkodogo/Garango road. Furthermore, it has benefited from the support of the local extension service, with the result, for example, that ploughs and cattle needed for traction are widespread among the households. All households are engaged in farming and obtain income from livestock, cash crops, or from family members working in Abidjan.

The dominant ethnic groups are Bissa and Mossi, but ethnic differences do not influence the prioritization of agricultural activities, a situation known from other parts of Burkina Faso (Claude et al., 1991; Guillaud, 1993; Reenberg & Paarup-Laursen, 1997). The 35 households in the village live in four distinct village parts: Natenga, Danpore, Nintore, and Signonguin. Furthermore, one Fulani (French: Peuhl) family lives separately in Lawedgo. According to the official statistics, Silmiogou has a population of 208 persons (1985), but our enumeration in 1996 showed 575 persons staying permanently in the village. A further 80 persons were considered Silmiogou inhabitants but were not living in the village. Many young family members are more or less permanently employed in Côte d'Ivoire.

Methods

In order to characterize the farming system and assess possible intensification scenarios in Silmiogou, a combination of interviews and field registrations were carried out at household, village, and provincial level during five field visits between 1996 and 1998.

At household level, baseline information on the village was obtained through structured interviews with all households including key parameters influencing land use decisions, such as family composition (number of persons, sex, age, presence), division of agricultural labour (sex, age), field characteristics (size determinants, number of fields, land use practices, land rights, etc.), livestock (type, number, grazing patterns), and off-farm employment (number of persons, type of work). Informal interviews were also carried out with key informants. Moreover, for each household the centre of their main field was registered with a hand-held GPS (location accuracy 20-30 m).

More detailed information on agricultural practices needed for identifying specific crop and variety compositions,

crop and field rotation, mechanization and fertilization was collected by visiting all fields of 34 households (97% of all households). With a member of the household as informant, the owner, approximate distance to settlement, crops, crop varieties, use of fertilizer, tillage, fallow, and cultivation in the two previous years were recorded.

At village level, the general land use pattern in Silmiogou (cultivated vs non-cultivated land, location of land) was characterized by use of information from aerial photos (acquired in 1994, scale 1:20,000) and measurements in the field with GPS. Measurements carried out by GPS of the delimitation of the village territory can directly be overlayed on to the topographic map (Figure 1). Aerial photos offer good opportunities to map out the cultivated land, based on a visual interpretation of the geometrically corrected images. Merging field history information from the household survey with geo-referenced identification of fields further provides a rough picture of the spatial encroachment of fields in the village territory.

Group interviews in each of the four village parts were employed to determine farmer assessments of crops. Major crops were evaluated by farmers with respect to labour demand, soil requirements, importance as food supply, and contribution to income. A participatory rural appraisal (PRA) scoring method was used by creating a matrix on the ground assignment of 1-5 stones to each species or species group depending on its desirability.

Finally, at provincial level, interviews were conducted with representatives from the Rural Development Project-Boulgou and the Provincial Agricultural Extension Services - Services Provincial d'Agriculture, SPA, in order to correlate the priorities of farmers' choice of crops and crop varieties with the agronomic solutions diffused by the extension services.

Results and discussion

Current land use in Silmiogou

The aerial photos and field recordings allow for a reasonably up-to-date mapping of field locations in the main village territory and in the recent expansion of the territory into *Gabon*. Approximately 3.9 of 6.7 km^2 are identified as fields in the main village territory (Figure 2). The areas outside the field clusters are either fallow/grassland or forest/bushland. Large proportions of the presently unused parts of the territory were reported to be very old fallow, cultivated more than 30 years ago, but they are not considered as potential expansion areas by the farmers for the time being. Within the last 15-20 years the main sphere of interest in terms of field expansion has been to the north of the Silmiogou territory in the neighbouring village of Malenga Nagsore. Hence, Silmiogou has had a unique opportunity to expand (see Reenberg & Lund (1998) for further description), though with the cost of considerable extra time needed for travelling to and from fields located at a distance of about 10 km from the main compound (Figure 1).

The historical field pattern dynamics at village level were not monitored comprehensively. A rough indication of the

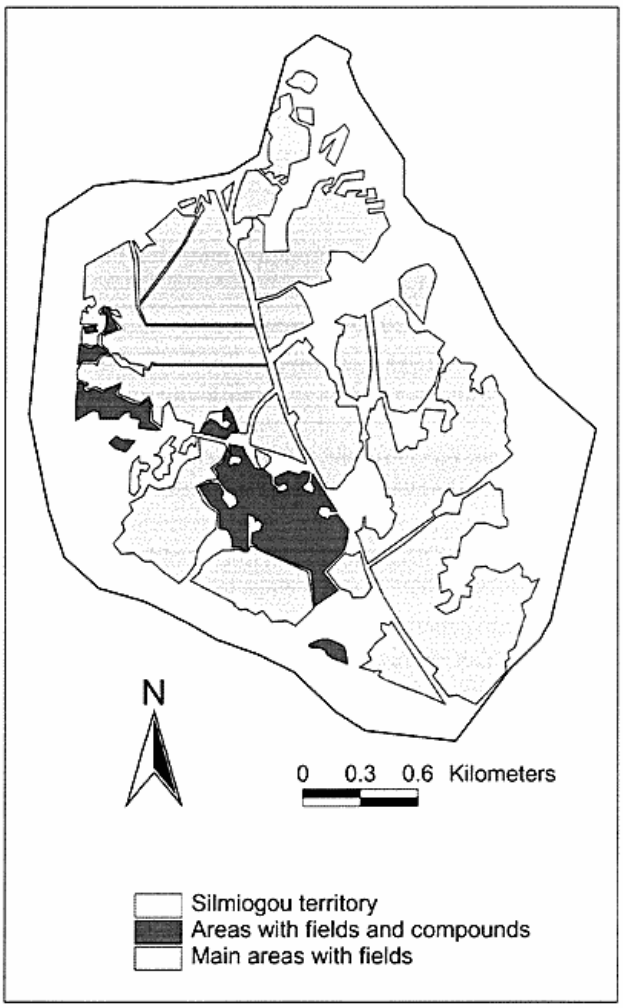

Figure 2: Cultivated parts of the village territory identified from aerial photos. About 3.9 of 6.7 km^2 are classified as fields.

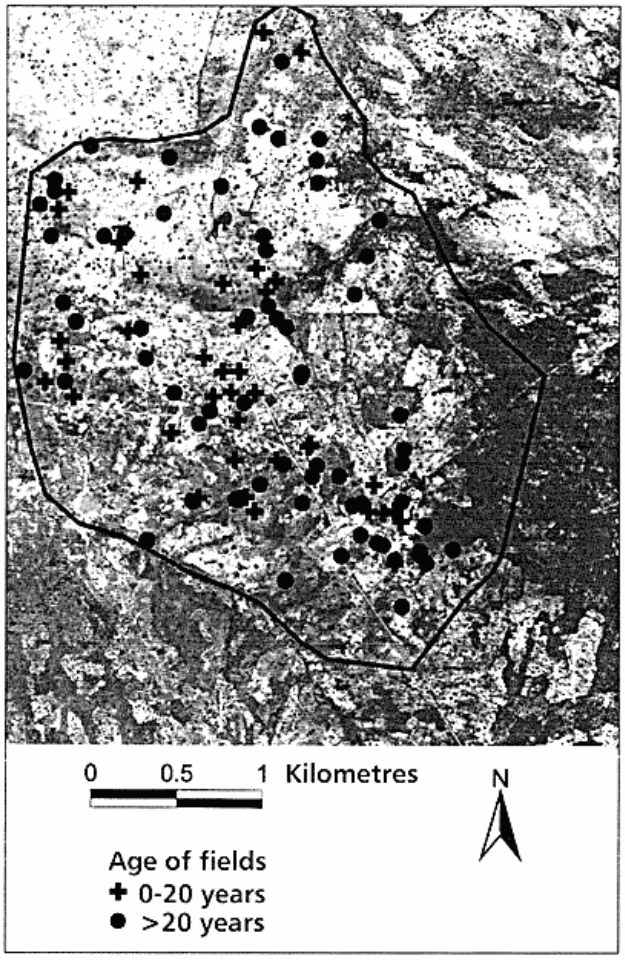

Figure 3: Centre positions of fields acquired with GPS in the main village territory classified according to duration of cultivation.

spatial dynamic can, however, be read from Figure 3. Farmers' information on the age of their main field constituted the basis for a crude classification into new and old fields, i.e. cultivated for less or more than 20 years respectively. Taking into account that short term rotational fallow is relatively insignificant, the map can be used to illustrate the spatial expansion trends. New and old fields occur side by side in all parts of the territory, which has been cultivated more or less evenly in the time of living memory. The gradual saturation of arable land has taken place in all parts of the territory as an extension of fields already in use. This pattern differs from other villages in the same region where idle land in formerly unused parts of the territory was gradually colonized (Hansen & Reenberg, 1998), and from the so-called "ring management system" in

Table 1: Fallow occurred previous to cultivation in fields farmed in 1996 and 1997 in Silmiogou.

Fallow period, years	*No of fields*	*% of total*
0	*627*	*94.1*
1	*12*	*1.8*
2	*13*	*2.0*
3	*3*	*0.5*
5	*2*	*0.3*
6	*1*	*0.2*
10	*1*	*0.2*
20	*1*	*0.2*
30	*6*	*0.9*

which only out-lying fields are fallowed (Prudencio, 1993).

Subsequent detailed records from the field survey confirm that the use of rotational fallow is very rare in Silmiogou as more than 94% of the fields cultivated in 1997 had not been fallowed in the past two seasons (Table 1). When new fields are taken into cultivation they are generally maintained for permanent cultivation. In cases where fallow is used, there is no correlation between fallowing and crop choice or location of the field. Smaller fields close to the compounds are just as (un)likely to be fallowed as large fields in the distant *Gabon*, and in most cases it is not a true fallow for restoration of fertility, but reflects a wish to have small pastures distributed over the territory. The micro-rotation known from other parts of the region with less pressure on the land (Hansen & Reenberg, 1998) is very rarely found in Silmiogou.

Farmers in Silmiogou emphasize that expansion which has hitherto been the main strategy for increased production can no longer be considered a viable option. In spite of the presence of idle land, most of the land considered suitable for cultivation in the main village territory is already in use and the possibilities for further extra-territory expansion in *Gabon* are drying up, not least due to gradually changed perceptions of land rights (Reenberg & Lund, 1998). Consequently, intensification of agricultural practices and/or further engagement in off-farm activities will be needed if food supply to an increasing population and increased welfare in general are to be achieved.

Agricultural practice

The farmers of Silmiogou cultivate a wide variety of fields and crops. A total of 666 fields was recorded during field visits in 1997, and the distribution of fields and the level of

technology are presented in Table 2 for the village parts. Although the village part Danpore seems to be the least enabled in terms of available ploughs, labour present, and - as a natural consequence hereof - absence of fields in the expansion area *Gabon*, only few major differences appear. With the exception of cash crop cultivation (cotton, commercial vegetables), crop and field diversity is just as high in Danpore and compost and/or manure is used as frequently as in the other village parts.

The adoption of improved technologies such as compost making and animal traction is partly a result of extension efforts by the Provincial Agricultural Extension Service (SPA). Fertilization is, however, restricted to the most intensively cultivated fields close to the settlement with 85% of the 229 fields fertilized with compost and/or manure located less than a 5 minute walk from the compound. About 60% of the fields was not fertilized in 1997 and as they are almost all permanently cultivated, lack of soil nutrients could be a constraint to increased production. Data for fertilization in previous years was, however, not obtained. Inorganic fertilizer is rarely used and then mostly for cash crops such as cotton and vegetables (see Table 3). Farmers recognize the utility of inorganic fertilizers, but state that they do not have the means to purchase the necessary quantities.

Field types, as defined by their main crop in 1997, are shown in Table 3. In this context, a field has been defined as a clearly distinct area separated from other fields either by ownership, significantly different crop composition, or location. The number of groundnut fields, for example, is relatively high as most women in a household own their own individual fields although these may appear as one or two large fields. A list of crops with scientific and vernacular names is provided in Appendix 1.

It is obvious that only identifying the main crop of the field conceals that intercrops such as roselle, kenaf, and calabash gourd occur very frequently; in fact, cowpea occurs more often than any other crop despite the small number of fields with cowpea as the main crop. Shea nut (*Vitellaria paradoxa*) and African locust bean (*Parkia biglobosa*) occur spontaneously in many fields (shea nut in 51% of all fields, locust bean in 18%) and are managed for their production of oil and food flavouring which are of major importance for food as well as income. Deliberate intercropping is practised on 85% of the fields in Silmiogou. Cotton and rice are the only cultures which are predominantly monocropped. The farmers perceive intercropping as a tradition which has proven that certain plants thrive well together. Cowpea, for example, appears in 259 cereal crop fields (62% of all cereal fields) as it is a hardy

Table 2: Households, fields, and level of mechanization in Silmiogou, by village part.

	Natenga	*Danpore*	*Nintoure*	*Signonguin*	*Lawedgo*	*Silmiogou, Total*
No of households (hh)	*7*	*7*	*11*	*9*	*1*	*35*
Average no of persons per hh	*21.9*	*15.5*	*19.8*	*15.0*	*n.a.*	*17.6**
Average no of persons present per hh	*19.4*	*11.5*	*17.9*	*14.0*	*n.a.*	*15.4**
No of fields	*167*	*111*	*231*	*145*	*12*	*666*
No of fields per hh	*24*	*16*	*21*	*16*	*12*	*19*
No of field types (Table 3)	*15*	*12*	*13*	*14*	*5*	*18*
*No of fields with inorganic fertilizer application***	*5 (3%)*	*0*	*4 (2%)*	*22 (15%)*	*0*	*31 (5%)*
No of fields with compost and/or manure application	*65 (39%)*	*35 (32%)*	*81 (35%)*	*40 (28%)*	*8 (67%)*	*229 (34%)*
Households that own:						
Field in Gabon	*5 (71%)*	*0*	*5 (46%)*	*7 (78%)*	*0*	*17 (48%)*
Plough for weeding	*5 (71%)*	*2 (33%)*	*6 (55%)*	*9 (100%)*	*n.a.*	*22 (63%)**
Plough for soil preparation	*5 (71%)*	*4 (66%)*	*7 (64%)*	*9 (100%)*	*n.a.*	*25 (71%)**

** excluding Lawedgo*
*** alone or in combination with compost/manure*

Table 3: Fields and gardens of Silmiogou and associated farming practices.

Main crop 1997	No of fields	% of total	No of fields with crop	% ploughed	% with fallow	% with compost or manure	% with inorganic fertilizer	% with intercropping
Pearl millet	205	30.8	281	68.3	2.4	19.0	0.5	94.6
Groundnut	133	20.0	161	84.2	15.8	6.8	3.7	86.5
Sorghum, red	87	13.1	116	82.8	0	79.3	0	87.4
Maize	64	9.6	100	81.3	1.6	76.6	12.5	95.3
Okra	46	6.9	94	15.2	0	63.0	0	80.4
Rice	25	3.8	39	68.0	12.0	16.0	20.0	28.0
Chili	22	3.3	43	31.8	0	68.2	13.6	59.1
Bambara groundnut	22	3.3	146	90.9	18.2	13.6	0	77.3
Sorghum, white, large grain	20	3.0	102	90.0	10.0	10.0	5.0	90.0
Sorghum, white, medium grain	14	2.1	30	85.7	7.1	28.6	0	85.7
Cowpea	11	1.7	283	63.6	18.2	9.1	0	72.7
Cotton	7	1.1	12	100	0	0	100	28.6
Egg plant, local	4	0.6	15	50.0	0	50.0	25.0	100
Sweet potato	2	0.3	7	0	0	100	0	0
Black nightshade	1	0.2	1	0	0	0	100	100
Roselle	1	0.2	139	0	0	100	0	100
Soy bean	1	0.2	5	100	0	0	0	100
Cabbage	1	0.2	2	0	0	0	100	0
TOTAL	**666**	**100**		**71.2**	**5.9**	**34.4**	**4.7**	**85.1**
Other crops								
Amaranth			2					
Calabash gourd			36					
Cassava			4					
Egg plant			5					
Kenaf			87					
Lettuce			1					
Marrow, pumpkin			2					
Sesame			4					
Sorghum, white, small grain			4					
Tobacco			6					
Tomato			12					
Water melon, local			2					

See Appendix 1 for a list of recorded species with English, French, Moré, and Latin names

plant that easily competes for nutrients and its growth is not hampered by the taller cereal crops. Other typical crop combinations include edge-planting of groundnut and bambara groundnut fields with roselle, and the vegetable gardens around the homesteads contain large numbers of species, dominated by roselle, okra, bottle gourd, and several spontaneous, leafy vegetables such as jute (*Corchorus* spp.), amaranth (*Amaranthus* spp.), and cat's whiskers (*Cleome gynandra*).

The results of the crop scoring (Table 4) supplement the detailed field information in Table 3 and allows for an analysis of the relative importance of different types of crops. The most important subsistence crops are pearl millet and sorghum, but farmers mentioned that maize and rice are gaining importance. Improved varieties of maize and rice are part of government extension programmes, whereas no improved pearl millet varieties and only one sorghum variety were reported by the Provincial Agricultural Extension Service to be diffused in the region.

Vegetables are important for income, but are rated below the cereals as food suppliers although vegetables occur in almost all meals. Most households do not mention any of the other subsistence crops as major contributors of cash income but groundnuts and cereals are occasionally sold. It should be noted that the ratings of products according to importance for income may indicate actual as well as

Table 4: Farmers' scoring of major crops in terms of labour and soil requirements and importance for food supply and income. Figures indicate averages of rankings in the four village parts. 1=low, 5=high.

Labour requirements		*Soil requirements*		*Importance for food*		*Importance for income*	
Vegetables	*4.5*	*Maize*	*5.0*	*Pearl millet*	*5.0*	*Shea nut*	*4.3*
Shea nut	*4.5*	*Sorghum*	*4.5*	*Shea nut*	*4.3*	*Vegetables*	*3.7*
Cotton	*4.3*	*Vegetables*	*4.5*	*Locust bean*	*4.0*	*Cotton*	*3.7*
Pearl millet	*3.5*	*Cotton*	*4.3*	*Sorghum*	*3.8*	*Rice*	*3.5*
Rice	*3.5*	*Pearl millet*	*2.3*	*Maize*	*3.0*	*Sorghum*	*3.3*
Locust bean	*2.8*	*Rice*	*2.0*	*Vegetables*	*3.0*	*Locust bean*	*3.0*
Sorghum	*2.5*	*Groundnut*	*1.8*	*Cowpea*	*2.5*	*Groundnut*	*2.5*
Groundnut	*2.3*	*Bambara gr. nut*	*1.5*	*Rice*	*2.5*	*Pearl millet*	*2.5*
Bambara gr. nut	*2.3*	*Cowpea*	*1.5*	*Groundnut*	*2.3*	*Bambara gr. nut*	*2.3*
Cowpea	*1.3*	*Shea nut*	*n.r.*	*Bambara gr. nut*	*2.0*	*Cowpea*	*2.3*
Maize	*1.3*	*Locust bean*	*n.r.*	*Cotton*	*n.r.*	*Maize*	*1.5*

potential income generation. Rice, for example, was not mentioned to be sold by any farmers, but the prices are considered good and it may be a cash crop in the future.

Cotton is exclusively a cash crop and is clearly distinguished by the use of inorganic fertilizer. A few households also rent dry-season vegetable plots in the neighbouring village Malenga for commercial production of cabbage, black nightshade, tomatoes and other vegetables.

The crops most frequently cultivated on previously fallowed land are cowpea, groundnut, bambara groundnut and rice. As the pulses are very tolerant of poor soils, this supports the farmer statement that new land taken into cultivation within the main village territory is of marginal quality. Rice is cultivated in low-lying areas unsuitable to most other crops due to periodical water-logging.

The main staple crops are almost exclusively cultivated on permanent fields and crop rotation is not practised to any significant degree. More than 80% of the pearl millet, red sorghum, and maize fields had been cultivated with the same crop in the two previous seasons. Groundnut and bambara groundnut are more frequently rotated but even for groundnut more than 50% of the fields had been farmed with the same crop during at least one of the two previous seasons.

Crop rotation is often considered an essential element of permanent farming systems without significant inputs of pesticides and fertilizers to avoid accumulation of pests and diseases and mining of certain nutrients (Tivy, 1990; Cattan & Schilling, 1992). However, the farmers do not report any serious pest attacks and even the spread of the parasitic weed striga (*Striga gesnerioides*) is largely contained. The reason given by farmers for maintaining the same crop on the same fields is that certain crops are adapted to certain soil types and that crops such as maize and vegetables requiring high labour input must be cultivated close to the settlement to facilitate work in the field. On the other hand, farmers do complain that notably cereal yields are often insufficient to meet household demands. Yields were not measured in the present study and while reasons for low or unstable yields are very complex, soil mining of nutrients due to lack of crop rotation could be part of the explanation.

Incentives for intensification

A direct, quantitative assessment of the extent to which increasing population pressure is reflected in changing land use practices cannot be derived from the current analysis. We do not, for example, dispose of reliable population statistics from a series of years, neither do we have data on possible increases in field sizes or alterations of fallow lengths over longer periods of time. Thus, it is not straightforward to test the existence of the frequently cited, and often theoretically argued vicious circle that links population increase to field expansion onto marginal land, re-

duced fallow, and environmental degradation (Vierich & Stoop, 1990; Greenland et al., 1994). An approximative evaluation of population driven field encroachment has, however, been conducted (Table 5). It is based on qualitative information derived from the household survey during which farmers were asked to define whether selected factors determined the total cultivated area.

The results reveal that farmers do not see any strong relationship between food needs (and hence population growth) and area cultivated. They do not plan cultivated area to meet a certain level of food supply. Availability of idle land was seen by half of the households as a limitation for total cultivated area. However, as mentioned earlier, key informants all indicated in informal interviews that this is going to be a major issue in the near future. In addition, a few households mentioned agricultural equipment as an important constraint, but it was not a major issue. This may be explained by the fact that agricultural equipment is widespread in Silmiogou. Lack of manure is also not considered important.

Labour was, however, considered a very important constraint to expansion of land by all but one household. This exception was the traditional village chief who still benefited from help offered by other villagers, emphasizing the close relationship between labour and wealth. A large family is able to overcome major bottlenecks in the expansion onto new land or intensification of current land use, and also has a better capacity for obtaining off-farm income. Labour availability was seen as an important determinant for the amount of land that can be dealt with by the farm unit, as illustrated by Danpore farmers' lack of capacity to expand in *Gabon* as well as the smaller households in the other village parts (Reenberg & Lund, 1998). We also looked at different field locations and diverse crop choices as indicators of a diversified farming strategy. However, there is no apparent correlation between available labour (persons present) and the number of fields cultivated (Figure 4), although such spatial diversification of cultivation could be expected to be more labour demanding. Nor is the priority given to labour intensive vegetables and crops such as cotton and rice related to household size. Figure 4 reveals, however, a tendency for households with many persons living abroad (mostly working in Côte d'Ivoire) to have a higher number of fields. The same households also appear to have higher incidence of fertilized and ploughed fields. This may indicate that households which are likely to receive cash income from persons abroad invest in technology for intensification of farming practices and increase the number and diversity of fields.

Table 5: Determinants for total size of cultivated area in Silmiogou, by village part.

Village part	Labour		Food demand		Available land		Available manure	
	yes	no	yes	no	yes	no	yes	no
Natenga	5	1	1	5	1	5	0	6
Danpore	6	0	0	6	2	4	0	6
Nintore	11	0	1	10	6	5	0	11
Signonguin	9	0	0	9	6	3	0	9
Lawedgo	1	0	0	1	1	0	0	1
Total	32	1	2	31	16	17	0	33

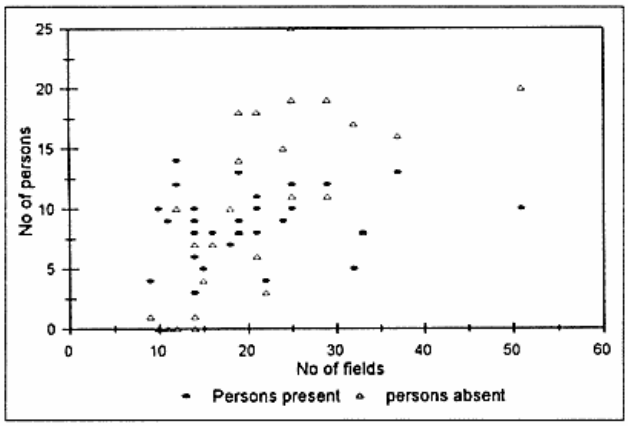

Figure 4: Number of persons present and absent in the households related to the number of fields farmed.

Options for intensification - concluding remarks

The farmers in Silmiogou base their livelihood on a diversity of subsistence and income generating activities which is characteristic of most rural societies in the region (Reardon et al., 1992; Faure, 1994; Noordwijk et al., 1994; Carter, 1997). Within a given household, subsistence farming, cash cropping, collection of wild plants, off-farm work, education, etc. are all part of an overall livelihood strategy, usually aimed at reducing risks before maximising profits. Intensification scenarios of farming systems must be analysed within this context as agricultural pro-

duction in some farming communities could be decreasing in importance to an extent that off-farm activities become the major indirect food supplier (Reardon et al., 1992; Carter, 1997). In Silmiogou this trend is not yet clearly visible, as money sent from relatives away from the village seems to have been invested in the farming system through increased use of mechanization and diversification of fields and crops.

Based on information from the Provincial Agricultural Extension Service, local extension programmes aim mainly at strengthening cereal and cash crop production. Improved cereal varieties, fertilizers, and pesticides are often put forward as the only genuine solution to agricultural intensification (Borlaug & Dowswell, 1995; Shapiro & Sanders, 1998), and we agree that, in time, the use of agro-chemicals should be a more integral part of farming in the Sudano-Sahelian region. Yet, at present, even the relatively enabled farmers of Silmiogou seem very reluctant to invest in such inputs as climatic uncertainties override other concerns. A minimum requirement for such technology packages to be successful will be their integration into extension programmes that consider all aspects of traditional risk management and diversification. Well-known intensification measures such as stone bunds and other soil and water conserving measures, training programmes for increased use of manure and compost, and diffusion of ploughs and other agricultural tools are often not part of the same extension programmes that diffuse improved varieties and inorganic fertilizer. This reduces the benefit which could have been obtained from using several or all of these measures at the same time (Taonda et al., 1995; Shapiro & Sanders, 1998). Moreover, we have shown that wealthy as well as poor farmers in Silmiogou traditionally maintain a high diversity in the farming system in terms of field locations and crop choice. Any of the development efforts mentioned above should also take this into consideration.

The secondary crops such as roselle, kenaf, jute, bottle gourd, local water melon, etc. as well as the numerous wild or semi-wild species are cultivated extensively and mostly intercropped with cereals or pulses as a result of local farmer experimentation. Considerable research has been carried out on intercropping in semi-arid zones demonstrating the benefits and shortcomings of such systems and many studies have suggested valuable system improvements (Francis, 1986; Tivy, 1990; Ntare & Williams, 1992; Ndunguru & Williams, 1993; Zongo et al., 1993). More specifically, studies on the effects of parkland trees on field crops indicate that reduced cereal yields under and around tree canopies are relatively small and easily off-set by the value of the tree products (Kater et al., 1992; Wilson et al., 1998), notably when trees are coppiced (Tilander et al., 1995).

However, the results of improved system development do not seem to have entered into extension programmes in the Boulgou province. While it is understandable that these programmes, severely limited by low budgets, have prioritized the main staple and cash crops, it should be recognized that successful cultivation and gathering of secondary crops and wild species are just as essential for survival and nutrition as cereal crops. The traditional farming system is based on such diversity, and self-sufficiency in fresh or dried vegetables, condiments and oil may be considered even more crucial because the markets for these products are not as well developed as cereal markets.

Another aspect of the farming system that could be altered is the low level of crop rotation on permanent fields. Although intercropping is practised extensively, many fields are quasi monocropped year after year with pearl millet, sorghum, or maize. A more systematic rotation with the main pulses and cereals would increase the nitrogen supply for the cereals and, notably if part of or all crop residue is incorporated in the soil, reduce the risk of nutrient mining. Combined with an improved intercropping system, existing soil conservation measures such as stone bunds, and regular use of ploughing and manure or compost, crop rotation may well compete economically with inorganic fertilizer use.

It should also be emphasized that farmers are not reluctant to integrate new crops and crop varieties in their farming system if they see the advantage in doing so. Several varieties recorded in Silmiogou were named "extension agent" or "Chinese" or "Lamizana", the latter referring to a sorghum variety obtained in the period of President Lamizana. Such varieties are not traditional *per se* but were successfully adopted for various reasons. Numerous others have certainly been rejected and it is noteworthy that only two of the varieties (Sorghum: Fromida, Groundnut: TS B2-12) currently diffused by the SPA were cultivated in Silmiogou during the time of survey.

Finally, it must be recognised that lining up clear intensification scenarios for Silmiogou and similar villages is a very complex matter. Apparently straightforward solutions such as increased use of inorganic fertilizer are not easily

applicable given the economic situation of farmers and the climatic hazards. Soil conservation, fertilizer use, vegetable cultivation, gathering, animal production, labour migration etc. can hardly be treated as separate entities in a system where every activity is closely linked and labour availability may be more determining for decision making than the need for self-sufficiency. However, we urge that a broader range of solutions to intensified production is integrated in extension and development efforts and that future research builds on and strengthens the strategy for diversity which seems to be one of the driving forces behind the farmers' decision making process.

Acknowledgements

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English	*Français*	*Moré*	*Family*	*Species*
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Bambara groundnut	*Pois de terre*	*Suma*	*Leguminosae*	*Vigna subterranea L.*
Black nightshade		*Lido*	*Solanaceae*	*Solanum nigrum L.*
Cabbage	*Chou*	*Sou*	*Brassicaceae*	*Brassica sp.*
Calabash gourd, Bottle gourd	*Calébas*	*Wamde*	*Cucurbitaceae*	*Lagenaria siceraria (Molina) Standl.*
Cassava, Tapioca	*Manioc*	*Bãnke*	*Euphorbiaceae*	*Manihot esculenta Crantz*
Chili	*Piment*	*Kipare*	*Solanaceae*	*Capsicum frutescens L.*
Cotton	*Coton*	*Lamdo*	*Malvaceae*	*Gossypium sp.*
Cowpea	*Haricots, niebé*	*Benga*	*Leguminosae*	*Vigna unguiculata (L.) Walp.*
Egg plant	*Aubergine*	*Kumba*	*Solanaceae*	*Solanum aethiopicum L.*
Egg plant	*Aubergine*	*Bõda*	*Solanaceae*	*Solanum melongena L.*
Groundnut	*Arachide*	*Nanguri*	*Leguminosae*	*Arachis hypogaea L.*
Kenaf	*Da*	*Berga*	*Malvaceae*	*Hibiscus cannabinus L.*
Lettuce	*Lettue*	*Salaato*	*Compositae*	*Lactuca sativa L.*
Maize, Corn	*Maïs*	*Kamaana*	*Poaceae*	*Zea mays L.*
Marrow, squash	*Citrouille*	*Yogre*	*Cucurbitaceae*	*Cucurbita pepo L.*
Okra, Lady finger	*Gombo*	*Maana*	*Malvaceae*	*Abelmoschus esculentus (L.) Moench*
Pearl millet	*Petit mil*	*Kazui*	*Poaceae*	*Pennisetum americanum (L.) K. Schum.*
Rice, Paddy	*Riz*	*Mui*	*Poaceae*	*Oryza sativa L. or Oryza glaberima L.*
Roselle	*Oseille, bissap*	*Bito*	*Malvaceae*	*Hibiscus sabdariffa L.*
Sesame	*Sésame*	*Siini*	*Pedaliaceae*	*Sesamum indicum L.*
Sorghum, red	*Sorgho rouge*	*Ka-zeega*	*Poaceae*	*Sorghum bicolor (L.) Moench*
Sorghum, white, large grain	*Sorgho blanc*	*Wanga*	*Poaceae*	*Sorghum bicolor (L.) Moench*
Sorghum, white, medium grain	*Sorgho blanc*	*Baninga*	*Poaceae*	*Sorghum bicolor (L.) Moench*
Sorghum,white, small grain	*Sorgho blanc*	*Sommui*	*Poaceae*	*Sorghum bicolor (L.) Moench*
Soy bean	*Soja*	*Soza*	*Leguminosae*	*Glycine max (L.) Merr.*
Sweet potato	*Patate*	*Nayu*	*Convolvulaceae*	*Ipomoea batatas (L.) Lam.*
Tobacco	*Tabac*	*Taba*	*Solanaceae*	*Nicotiana tabacum L.*
Tomato	*Tomate*	*Tomato*	*Solanaceae*	*Solanum lycopersicon L.*
Water melon, local		*Nato*	*Cucurbitaceae*	*Citrullus colocynthis (L.) Schrad.*
		Muspoka	*Poaceae*	*Andropogon gayanus Kunth.*
		Sompido	*Poaceae*	*Cymbopogon schoenanthus ssp. proximus*
		Tugi	*Unidentified*	

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