Agricultural Land Use Dynamics in a Sahelian Environment – Does Reality Match Hypothesized Trends?

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Anette Reenberg: Agricultural Land Use Dynamics in a Sahelian Environment – Does Reality Match Hypothesized Trends? Geografisk Tidsskrift, Danish Journal of Geography 94:xx-xx. Copenhagen, Dec. 1994.

The commonly held notion that marginal land, grazing areas or fallow land in the Sahel are increasingly brought into cultivation is discussed. Based on empirical evidence from three villages in the Oudalan Province, Burkina Faso, land use at the local level is discussed. Commonly accepted theories concerning forces driving land use changes are compared to observed trends. The key issues addressed are the change in acreage and location of cultivated land and the use of fallow in the agricultural system. It is concluded that land use dynamics at local level cannot be summarized as one single trend; that land use pattern has a strongly random element; and that only a multidisciplinary and hierarchical framework will really suffice to analyse land use dynamics.

Key words: *land use, fallow, intensification, Oudalan Province, Burkina Faso.*

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Land Use Dynamics in the Sahel

Concepts such as land degradation and sustainability have almost inevitably been an integral part of any discussion concerning land use and its changes since the beginning of the 1970s in the Sahel, where poverty, inadequate food supply and security are fatal problems.

Land use changes are relevant indicators for the radical modifications of the traditional agricultural systems in the Sahelian region as it has been demonstrated by Scott (1979). Such changes include the shift in emphasis from pastoral production systems towards systems relying more on cultivation or replacement of subsistence crops with cash crops (Copan, 1974, Reenberg, 1981). Thus, land use patterns certainly deserve attention from those engaged with agriculture and its influence on the environment in the Sahel.

It has been a commonly held notion that the change of land use pattern is an important cause to as well as result of the environmental degradation observed in the Sahel. Thereby the expansion of agriculture generates a vicious circle (e.g. Claude et al., 1991, Krings, 1980, Groten, 1991). This has often been related to the increased economic poverty and the rapidly increasing population pressure (e.g. Snrech, 1994). Due to the poverty of the renewable resources, yields have declined, and to counteract this, marginal land and grazing areas are brought into cultivation and the fallow period is shortened or no longer existent (Milleville, 1980, Stroosnijder, 1994, Fussel, 1992).

It is often assumed that the linkage between population pressure and degradation is scientifically proven beyond any need for debate, but this rests on a weak empirical foundation and impedes improved scientific understanding (Mortimore, 1993). Many reports indicate substantial changes in land cover and land use in the Sahel, although systematic studies are still lacking (Prince et al., 1990). How land use patterns are actually formed as enabled and constrained by a number of factors (environmental, socio-economic, political and cultural) is much less well researched.

Thus, a detailed monitoring of the land use change and of its relation to soil, landscape and climate is needed. It could contribute to the evaluation of the sustainability of the Sahelian agricultural system (Reenberg & Rasmussen, 1992, Reenberg, 1994).

Issues related to land use and land cover are frequently suggested as indicators or possible causes of the non-sustainability of the agricultural production, e.g.

- Increasing population pressure and less favourable climatic conditions force peasants to cultivate soil types that are more susceptible to exhaustion and to wind erosion, which results in permanent loss of fertility (Krings, 1980, Milleville, 1980);
- Increasing population pressure has caused disappearance of the fallow, with a decline in soil fertility as a consequence (Fussel, 1992, Stroosnijder, 1994);
- Expansion of cultivated land into pastures may have upset the essential symbiotic linkage (stubble grazing vs. manure) between peasants and pastoralists (McCrown et al., 1981, Sandford, 1989);
- Excessive fuelwood cutting has caused deterioration of the natural vegetation (Groten, 1991).

Yet, even the establishment of an adequate and reliable mapping of land use and land cover changes does not suffice to analyze the process of change addressed. The set of factors driving land use changes is very complex as sketched in Fig.1, and the various factors are influencing the land use patterns on different spatial scales (Reenberg,

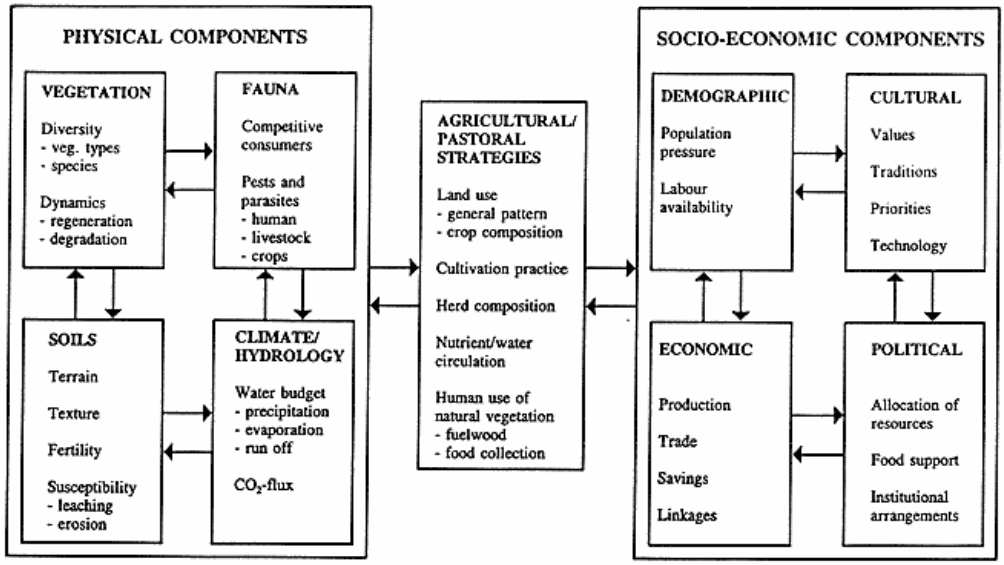

Fig. 1. Land use changes have to be analysed in a multidisciplinary framework. The diagram is modified from Young & Solbrig (1991).

1993). Consequently, only a holistic approach will provide the necessary understanding of the relative importance of the forces driving the land use decisions – and thereby the background for anticipating development scenarios under various preconditions and suggesting culturally, economically and environmentally acceptable improvements of the system.

This paper does not aim at providing a thorough and holistic analysis of land use changes. Merely, it discusses the applicability of prevalent theories on land use changes in three villages, all of which are located in the Oudalan province in Northern Burkina Faso, within a mutual distance of less than 30 kilometres.

A Few Facts About the Study Region

The Oudalan province constitutes the northern part of Burkina Faso. It belongs to the Sahelian zone, with an average yearly precipitation around 400 mm (1971-1991) (Reenberg & Rasmussen, 1993). The dominating landscape elements are: vast, ancient pediplains, cut by temporary river valleys, a few inselbergs and two "generations" of longitudinal E-W oriented dune systems superimposed on the pediplain (Krings, 1980, Rasmussen & Reenberg, 1992, Claude et al.,1991).

The land use patterns are closely related to these landscape elements. Almost only sandy surfaces are cultivated. The older dunes are best-suited for cultivation because of the finer texture of the soils (Krings, 1980), but also parts of the younger dunes are cultivated, yet not used to the same extent as the old ones. Millet is the only crop of great significance in the region, supplemented by sorghum, which is mostly grown in the lower lying areas. Non-cultivated land on the dunes and the pediplain is used as pastures by local peasants as well as nomadic pastoralists.

The population in Oudalan is almost exclusively rural. Even in the province capital, Gorom-Gorom, a large proportion of the population is more or less dependent on the outcome from their cultivated fields. Population figures available show an increase of 2.8% per annum and a total in 1985 on 106,023 persons, but they should be considered as approximations only. Firstly, because population censuses in general are not very reliable. Secondly, because the relevant population figure may be very difficult to define and assess in a very mobile society as the one in question. There is a well-established tradition for long distance migration of men to the large cities, or to the coastal countries towards the South. Recently, also the local goldmines in Northern Burkina Faso have attracted a considerable amount of workers in the dry season. The problem of estimating the population actually residing in the village is important for the analysis of the agricultural system, as the very variable short- and long-term migration makes it very difficult to estimate key parameters such as labour availability during the agricultural year, local demand for food during the year, etc.

The ethnic composition in Oudalan is rather complex.

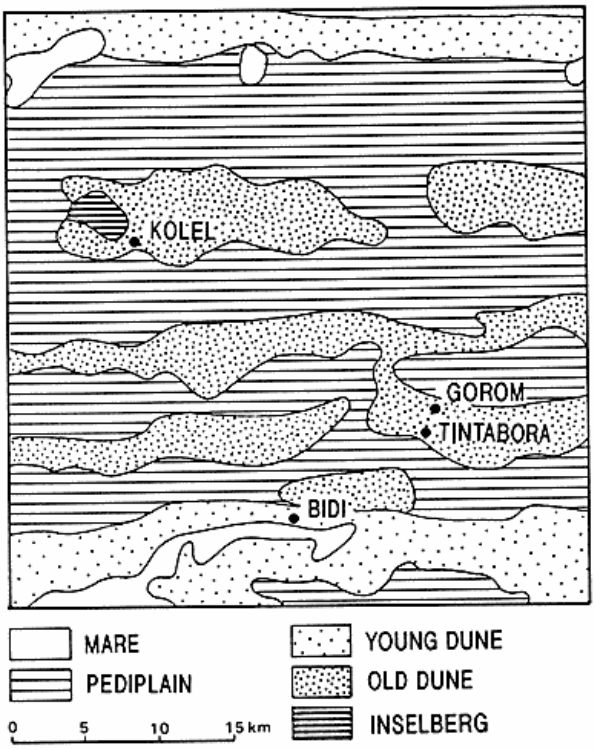

Fig. 2. Location of villages studied: Kolel, Tintabora and Bidi.

Several different ethnic groups are present (Claude et al., 1991, Krings, 1980) and the previous division between slaves and masters is still felt. The general picture is that one ethnic group is represented in each village. Twin villages with slaves in one village and the former masters in another one close by is a frequent phenomenon. Ethnic variations are known as an important factor influencing agricultural strategies, and they should be included as an important parameter in regional studies of the agricultural system (Harts-Broekhuis & de Jong, 1993). Yet, as the people in the three villages selected all belong to the same ethnic group, Peul Rimaibé (former Peul slaves), it will not be considered further in this study.

The villages

The locations of the three villages included in the study are shown in Fig. 2. Generally speaking the villages selected, Bidi, Tintabora and Kolel, are typical for the region, in the sense that the main activity is millet and sorghum cultivation.

Bidi is located approximately 12 kilometres south-west of Gorom-Gorom. It is as many other villages in the region situated on the young longitudinal dunes, and surrounded by a more or less continuous area of fields as it is sketched in Fig. 3 (Reenberg & Rasmussen, 1992). The fields, mainly cultivated with millet and a little sorghum, are located on the young dune as well as on the older dunes or on pediplains with a sandy cover. A very important asset in the land use). Likewise, theardens, which are found at the fringe of the young dune.

Kolel is located approximately 25 kilometres north-west of Gorom-Gorom, and it is thus what regards distance and accessibility (poor road connection) very remote. It is located on one of the ancient dune bands, in a region also dominated by large erosion valleys (fr.: bas-fonds) mainly suited for sorghum cultivation.

Tintabora is a small village, located only a couple of kilometres from Gorom-Gorom and within the larger region with continuous millet fields around Gorom-Gorom. As it was the case in Kolel cultivation takes place on one of the ancient dune bands, and the limit of the cultivated area is determined by the transition to the

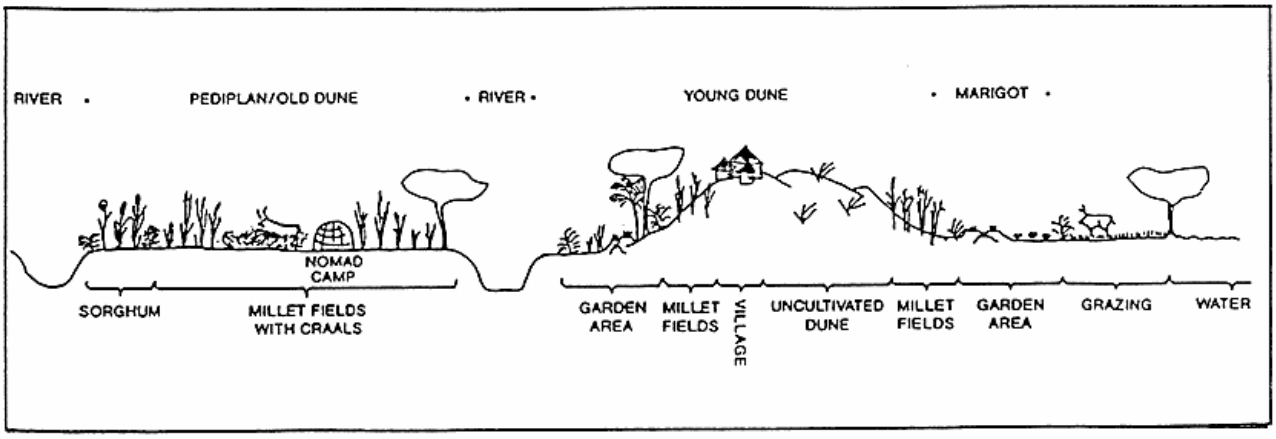

Fig. 3. Sketch of the North-South profile of the landscape around Bidi village. From Reenberg & Rasmussen (1992).

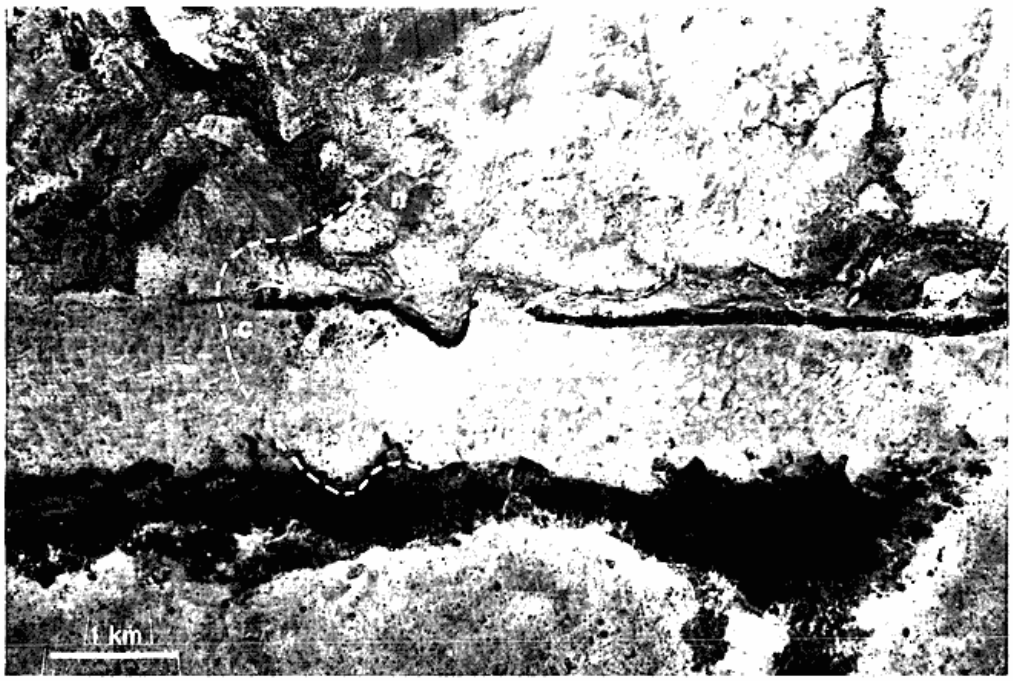

Fig. 4. Aerial photo from Bidi (original 1:50.000, from 1981). The history of cultivation is indicated for the areas within the dotted line as follows: n = fields taken into cultivation within the last 40 years; c = areas on the dune, still not cultivated; x = fields abandoned 6 - 8 years ago; y = fields abandoned more than 15 years ago; z = fields abandoned in 1990.

pediplain surrounding the dune landscape. However, if we look closer into the access to various natural resources, especially cultivatable soils, the villages represent three different situations with regard to potential for land use changes: no space for expansion available; space available for expansion on alternative soil types; and space available for expansion on one type of soil only. Although precise population figures from the villages could not be obtained, enumeration sheets from the region support the hypothesis that the rural population has increased also at village level. According to e.g. Milleville (1980), Peretti (1977), Claude et al. (1991), this has led to an expansion of the cultivated land into more marginal land, strongly correlated with manpower availability and food requirements.

Material and Methods

The study has been carried out in the form of a number of independent field investigations.

The information concerning land use changes and their relation to landscape and soil types has been obtained from a combination of mapping based on satellite images (SPOT), mapping of village territories in the field by GPS (Personal Navigator), mapping of individual fields , and interviews with village chiefs, households and individual peasants in the field. The key questions of the interviews related to issues such as: factors determining the cultivated area (household size and manpower availability during fieldwork); potential bottlenecks for expanding or intensifying the cultivation; possible changes as to the importance of fallow; factors determining location of new fields; priorities given to millet and sorghum cultivation compared to other types of work, e.g. gardening, gold mines, long distance migration etc. (Reenberg & Rasmussen, 1990, 1992, 1993, HFK, 1993, Rasmussen & Reenberg, 1992).

Results

Bidi

In Bidi land use changes have been investigated for a large part of the village territory. Observations were made in the field and in cooperation with the village chief, who has spent more than 40 years of his adult life in the area. The history of cultivation is indicated in the aerial photo Fig. 4. It illustrates how the location of fields has gradually

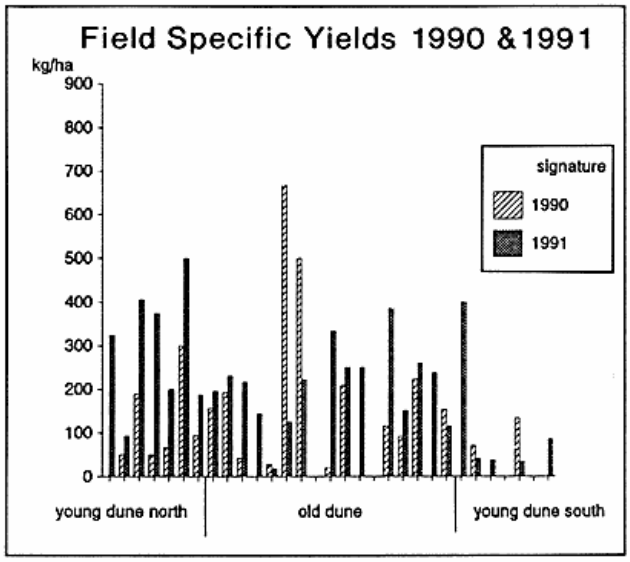

Fig. 5. Histogram showing the field specific yield on selected test fields in Bidi. The fields are sorted with respect to landscape units. Starting from the left are shown fields on the northern fringe of the young dune, fields on the old dune and fields on the southern fringe of the young dune. From Reenberg & Rasmussen (1993).

changed within the last 20 years. From being almost exclusively located on the young dune, fields have gradually spread towards the north. It is noticeable, however, that the new expansions have been followed by abandonment of fields of similar acreage on the dune.

In contrast to what might be expected, the reason given by the local peasants was that the recently cultivated fields were basically more fertile. The hypothesis that still more marginal land is cultivated was thus not supported in the interviews, neither was the hypothesis that the increase in cultivated land corresponded to the population increase. According to the peasants the decisions concerning site selection for the fields are determined by individual and subjective priorities, based on former experience, on household specific manpower, bottlenecks for weeding, evaluation of the acceptable travel distance to the fields, etc.

The correlation between yields and landscape type has been investigated for 31 fields in the village territory. The fields have been mapped with compass and meter, and information on yields in terms of bundles of millet harvested in 1990 and 1991 was obtained from interviews. An overall average of 10 kg grains per bundle was determined from a sample of bundles, which normally do not vary much in size. This figure was used to calculate the field specific yield estimates in Fig. 5. As expected great variation in the yield per hectare occurs, and the few observations do not suffice for a statistical evaluation of the variation of yields within the different landscape types. Yet, no simple relation between soil and actual yields exists. What really matters – according to the peasants – to the yields and the prevention of exhaustion of a certain field is the intensity of manuring. Well-kept fields in the area have been cultivated continuously every year for 40 year, and are still considered fertile.

The relations found between acreage, man power and household size for 11 investigated households in Bidi are shown in Fig. 6 and 7. Both sets of observations reveal a considerable variation and provide no documentation for a relatively close correlation between cultivated acreage, food production and population as it has been suggested by e.g. Claude et al.1991.

In Fig. 7 the results are furthermore compared to an equivalent study performed in the region in the 1970s. The comparison reveals that the surface cultivated per capita is much smaller in the Bidi study. Whether this reflects a significant change in the entire region or an interregional difference, which also existed ten years ago cannot be concluded from the limited observations available. The study does not, however, confirm the hypothesis often stated (e.g. Krings, 1980, Groten, 1991) that exhaustion of the land – from more permanent cultivation to compensate for lower yields – and the increasing population density led to an almost equivalent increase in the cultivated surface.

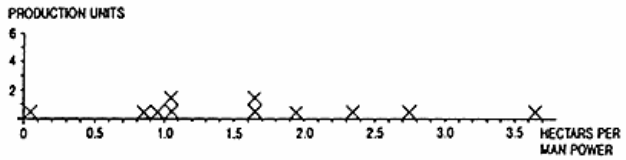

Fig. 6. Hectares cultivated per adult man in the household. Results from the Bidi survey 1991. From Reenberg & Rasmussen (1993).

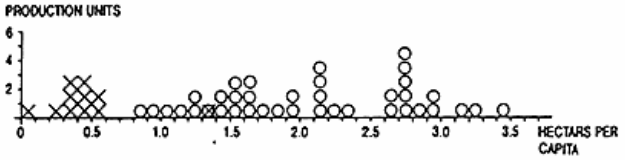

Fig. 7. Hectares cultivated per capita (adult equivalents) in Bidi households (indicated by an x) and the equivalent figures from the study by Claude et al. (1991) in the Kolel region in the 1970es (indicated by an o). From Reenberg & Rasmussen (1993).

Fig. 8. The maximum extent of fields cultivated by Kolel peasants, 1994, mapped in the field with a GPS. Here drawn in a black-white print of a SPOT satellite image (first principal component of three spectral bands). From HFK-1993.

Kolel

The land use dynamics in Kolel has been investigated by the use of a series of satellite images in Rasmussen & Reenberg (1992). The main findings concerning the land use were: In the vicinity of the village there was little or no use of fallow. At some distance from the village a less intensive land use pattern was observed, probably to be explained as a random "fallow" determined by labour availability for weeding. At the fringe of the village territory, new cultivation on darker soils has recently taken place.

Subsequent field work (HFK, 1993) has largely confirmed these findings. The limit of the village territory was mapped in the field by use of a GARMIN GPS with an average accuracy of 30 metres. The result is indicated in the black-white print of the SPOT satellite image in Fig. 8. An interview in the field with the village chief confirmed that the sorghum fields in the southern part of the region were recent expansions (1 to 5 years old). Large parts were often abandoned after seeding because of lack of time for weeding. The large travel distance to the village constitutes a problem, in some cases solved by a temporary shift of the household to the field during the rainy season. The reason given for the expansion was a need for an increase in food production, beyond the one that compensates for abandoned fields or fallow of extraordinary magnitude elsewhere in the village territory.

The development in Kolel resembles the areal extensification, which has often been accentuated as the typical development in the Sahel. Whether the recently cultivated fields are located on soils more susceptible to degradation has not been investigated, but it is probably not the case. What matters to the peasants, however, may be the fact that the new, low lying fields are only suited for sorghum cultivation. Millet is preferred to sorghum in the daily diet, and the change towards sorghum is considered a loss of quality of life.

Tintabora

In Tintabora the area potentially available for cultivation is much more restricted than it is the case of the two villages considered above. The village territory is quite well-defined with established boundaries to the surrounding village territories (Fig. 9). Only towards the west will it be theoretically possible to expand, but in reality even this possibility is very limited because of the highly unsuitable soils on the pediplain. It has been tried to ameliorate the

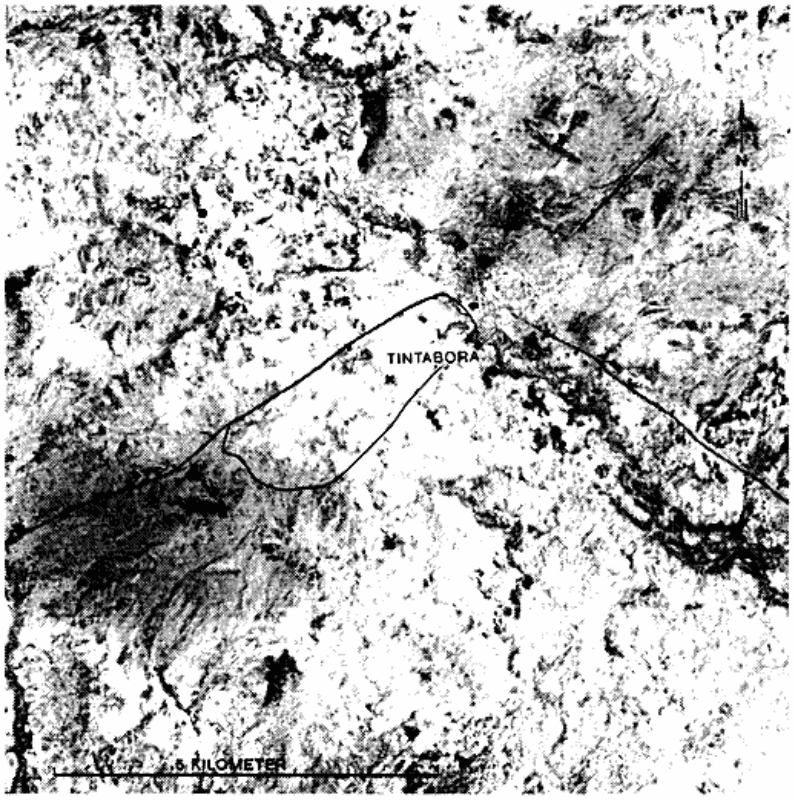

Fig. 9. The maximum extent of fields cultivated by Tintabora peasants, 1994, mapped in the field with a GPS. Here drawn in a black-white print of a SPOT satellite image (first principal component of three spectral bands). From HFK-1993.

conditions for the cultivation of soils on the pediplain by fencing with acacia-branches. In this way it is hoped to further the deposit of a sufficient amount of sand on the pediplain to enable cultivation. But the effect is too small to change the fact that generally speaking there is no room for expansion.

The permanent cultivation without fallow as it is practised now has been going on for many years. Manuring is generally recognised by the peasants to be a very important determinant for the yields – as it is also the case in Bidi and Kolel. The manure is brought by donkeycart or carried to the fields, but according to the peasants the amount is not sufficient, mainly due to the lack of manpower during the dry season.

Field areas were not estimated in the Tintabora study, and a direct comparison to the productivity figures shown for Bidi cannot be made. The available information allows, however, for an indication of the labour-productivity as well as food sufficiency at household level. The village consists of seven major households, e.g. one to five male family members living together with their respective wives and children in one compound. Household size, assessed in consumer units (adult equivalents) as well as in labour force for field work (adult men), are shown in Fig. 10 in relation to the total harvest in the household. The degree of autosufficiency of the millet production at household level differs cconsiderably, and all are far below the 200-250 kilogrammes normally used as the estimated per capita need in the region (Milleville, 1980, Claude et al., 1991). Likewise, the productivity per man varies considerably. Whether this variation relates directly to a more intensive manuring of the field has not been investigated in details.

Discussion

The information presented in the three case studies has initially been collected for different purposes, consequently the information obtained varies in accuracy, so a precise quantitative comparison between the villages is not possible. Yet, the information is accurate enough to show that land use trends do not follow an easy predictable pattern.

At local level the observable land use dynamics cannot be summarised as one single development trend, such as: expansion of the cultivated surface, intensification in the sense of shorter fallow, etc. It seems as if many of the generally accepted theories, some of which are mentioned in the introduction, linking agricultural strategies to e.g.

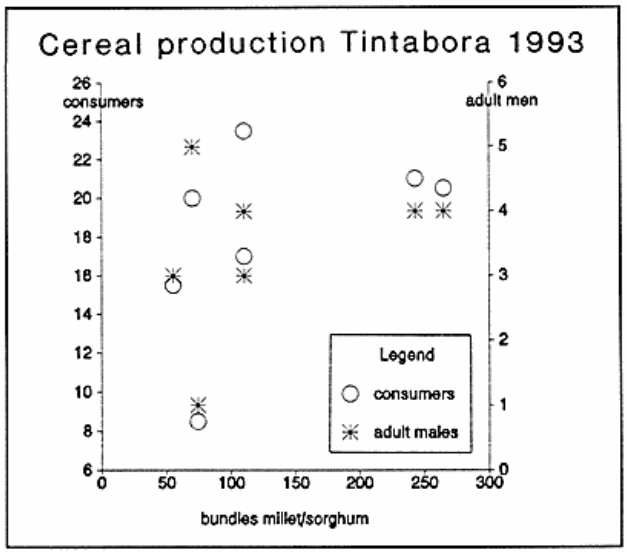

Fig. 10. Relations between food production and consumers/ labour potential at household level. Each circle or asterix represents one of the seven units (family living together in a compound) in Tintabora. Consumers are defined as adult equivalents. The labour potential is defined as equal to adult males in the household, as males are the major responsible for the field work (figures from survey in 1993, HFK-1993).

population increase or a depleted natural resource base, do not suffice to explain what is actually happening at village level.

When analysing the long term changes in land use patterns, it will be necessary to consider the correspondence between culture and technology (tools available) and the natural resources preferred for food production. Guillaud (1991) has demonstrated how new tools have reversed the priorities of the different soil types and caused substantial alteration of the land use pattern around Aribinda (Northern Burkina Faso).

It is difficult to establish a generally valid description of the development of the spatial pattern of cultivation, even within a relatively homogeneous and small region and at a short term basis. In the study a few parameters have been used to characterise land use dynamics: change in acreage and location of the cultivated land; and use of fallow.

The abundance and present state of the natural resources available (in this context especially soils suitable for cultivation) do have some influence on the decisions made concerning how much and where to cultivate. The comparison of Bidi and Kolel reveals very different patterns for the expansion of fields even in villages where space is available. Such differences have to be referred mainly to the socio-cultural sphere of the analytical framework not included in this study.

Peasants in Oudalan do not conceive fallow as a regular element of the agricultural strategy, as it is known from many other types of agricultural systems. No specific pattern for the alternation between cultivation for some years followed by a certain period of fallow has been recorded. "Tired" soils are occasionally fallowed, but the immediate cause for this is more often lack of proper and continuous manuring (and thereby closely linked to the labour availability at crucial times of the year) than the inherent quality of the soils.

It has been put forward that agricultural intensification starts earlier in areas with relatively land shortage (Stroosnijder, 1994), and that increasing population pressure might be the driving force in a long term perspective for the intensification of the agricultural system (Boserup, 1965).

At local level the former thesis cannot be confirmed. The strategies followed in Tintabora where no idle land is available do not differ significantly from those in Kolel. An increased investment in collection and distribution of manure would be an obvious yield-enhancing method. Although the importance of proper manuring is generally recognised, this type of intensification is rarely adopted. The interviews revealed a general impression that allocation of labour in the dry season to collect manure will result in a yield increase of a magnitude which from an economic point of view would constitute a comparative advantage to other types of traditional off-village labour. Thus, in this case we do not observe the intensification likely to happen when agricultural production is a more profitable use of labour than outmigration (Tiffin et al., 1994).

Conclusion

In general land use changes may not be simple to explain and predict (Naveh, 1989). Changes in the land use pattern should not only be analysed and understood as a relationship between population pressure (or need for food) and the potential of the natural resources. Where land is still available, invention, change, adaptation and other elements of developments take place, thus indicating that population pressure is not the only stimulant for change (Brouwers, 1993).

The land use pattern has a strongly random element. The farmer does not exactly know which field he will cultivate throughout the entire growing season. The initial field pattern might even respond to short-term fluctuations in precipitation levels (Reenberg, 1994). The final field pattern depends on the climate variability (early or

late rains, drought spells, flooded fields, etc.) and the availability and strength of labourforce, especially for weeding. Such conditions might change any time (Brouwers, 1993).

It will be necessary to include many facets in order to fully understand what determines agricultural strategies and thereby land use dynamics. Mortimore (1993) stresses that income diversification may relieve the farming system of the necessity to feed all its population at all the time, especially during food emergencies, and provides a potential source of investment funds for technical change, land conservation and yield improvement. This mechanism is not dominating at present in the study region. Salaries from work outside agriculture or earnings from marketing garden products are used for consumption and not invested in technical change or land conservation. Labour bottlenecks are another serious issue (Nébié 1992), especially related to the strong regional traditions for long- and short-distance migrations for work.

Finally, the selection of scales, in time as well as in space, deserves specific attention when land use dynamics and sustainability of agricultural strategies are in focus. What is catastrophic when looking at the agroecosystem on a small scale may be part of a sustainable system on a larger spatial scale (Fresco & Kroonenberg, 1992). It might often be useful to look at agroecosystems as a series of levels in a hierarchy, with temporal and spatial scales increasing at each level (e.g. field, village, landscape, national level) (Lefroy, 1993, Reenberg, 1993). In this way it can be taken into account that constraining and enabling conditions shaping the structure and development of the system will vary from one level to the other.

Acknowledgement

The majority of the reseach, on which the present paper is based, has been funded by the Danish Council for Development Research (RUF). Supplementary information has been gathered as part of a field course for geography graduate students supported by the Institute of Geography. The author would like to thank colleagues involved in these projects for stimulating discussions during fieldwork as well as the students for their engagement during the work "en brousse".

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