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Impacts of resource access and use on sustainable land management: an analysis of two contrasting cases in South Benin

M. K Kodjo, H. E. Jahnke and I. Dieter-Gillwald

Institute of Economic and Social Sciences in Agriculture, Development Planning and Project Management. Im Dol 27-29. D-14195 Berlin, Fax: (030) 314 71 284
Email: MKodjo@agrar.hu-berlin.de
Email: HEJahnke@agrar.hu-berlin.de
Email: IDGillwald@agrar.hu-berlin.de

Abstract
The sustainability of smallholder farming systems continues to be a challenge for Sub-Saharan African countries. Population pressure on the land increases. Answers to long-term sustainability are not always at hand for the different production systems. In this article, an attempt is made to analyse the issues of resource access and resource uses in the perspective of a sustainable production, taking into account the cases of two villages in southern Benin. The results show that the goal of sustainable intensification of smallholders farming systems is not easily achievable.

Keywords: Benin, Farming system, Land use system, Land tenure, Sustainability.

Introduction
The agricultural sector in Benin (West Africa), other than numerous countries in the tropics, involves a majority of small producers. More than 70% of the whole population depend on farm activities. Export of agricultural products have always been the most important way to earn foreign exchange. In the 60s, the export of oil palm trees products provided up to 70% of the currency earnings (Adegbidi A. and al 1995). The expansion of oil palm plantations was ineffective due to insufficient rainfall for improved varieties. Since the 70s, cotton crop has been and remains the major export product and its development has been supported through appropriate institutional policies (extension services, inputs deliveries, credit, marketing and stabilisation price) with financial support of the World Bank. Cotton production is concentrated in the middle and east-northern areas of Benin (within the parallel 8 and 11). The cropping systems here are then characterised by the prevalence of cotton and the corresponding use of chemical fertilisers and pesticides (see note 1 at the end).

In contrary, in the most southern plateau area, the cotton crop is limited, due to non-suitable environmental conditions. The cropping systems are here dominated by maize and cassava and the presence of traditional oil palm trees. In this region, the land availability is limited (average of 1ha per rural household member versus 5ha in the North), due to higher demographic pressure. Despite the lack of a lucrative export crop (e.g. cotton crop), urbanisation would provide incentives for intensification in the cropping systems. As this process evolves, the problem of maintaining soil fertility takes on increasing importance.

In this paper, an attempt is made to clarify this question, taking the cases of two villages in South Benin. The specific matter of access and uses of production resources is dealt with. The question is to know if the current recorded situation is in accordance with sustainable increase in the agricultural production.

Theoretical Framework

The theoretical base supporting the previous hypothesis is related to Boserup's theory (Boserup E.1970), reviewed after by Malassis (1973) and others. Referring to these authors, one can say that, the high demographic pressure in Southern Benin is incentives to achieve a real intensification in the cropping system. Taking into account the development trend of the 90s, the sustainability of this process has to be ensured. It is therefore necessary to clear up the theoretical contents of "sustainability". This is done below in three steps, leading to the definition of a sustainable intensification, which appraisal is our ultimate purpose in this paper.

First, it is useful to mention the definition of the World Commission on Environment and Development (Brundtland Commission) (1987), which has made the term popular. According to the late, sustainable development is a development that meets the current needs without jeopardizing the ability of future generations to meet their needs. This definition was difficult to operationalize, as it is also difficult to specify the needs of the future generations. However, many attempts have been done in this way. The review of some attempts needs a longer conceptual analysis as in this work. However, it is clear that the concept is used in various ways according to the kind of countries (industrialised versus developing) and the fields. Therefore it is necessary to limit our concern on agriculture.

Second, regarding the agriculture, one can refers to the FAO (1997) – avoiding an exhaustive development – which uses the concept of "sustainable agriculture and rural development (SARD)" with three implications: (1) sufficient increase in agricultural production, (2) the improving of the living conditions (cultural and social) of rural populations and (3) the natural resources conservation. This definition involves economical, social and ecological aspects. These three components are nowadays at least given to the sustainability (also by the World Bank, see Serageldin 1995). All these three points are not dealt here. Then, the restriction of the analysis scope is done at a third step.

The analysed subject here is the farming system or the cropping system (see note3 at the end). Shaxon (1998) has proposed three elements to appraise the sustainability of the land use in the cropping system: (1) the condition of the soil as rooting environment, (2) people' attitudes and capacities to continue living on the land and (3) the factors (weather, politics and markets) affecting farmers' decision on farm use. With reference to these elements, a sustainable intensification is viewed in this study as an increase of soil productivity by implementing agricultural practices and using production resources without damaging the quality of this soil (in time and space). In such process, the soil is view as a natural depleting resource (exhaustion of the nutrients), in opposition to an extractive agriculture. To achieve this result, more than one production resource (land, capital and work) have to be engaged intensively in the production process with possibilities of substitution. This can arise, only when these resources are available and accessible in the system. Thus, it is obvious that an equitable and secure access to land is prerequisites to their sustainable use.

Background information

Approach

An intensive research work has been implemented in the year 1998. The southern plateau zone of Allada was the study's area. This zone has been chosen in fact that it involves a majority of rural population with a demographic pressure above 160 inhabitants per km^2. One records in the area a very dynamic socio-economical transformation's process. Furthermore, many research and development actions have been experienced or are still experimented aim to introduce changes in the cropping systems.

The thorough surveys were concentrated in two villages. The choice of those villages has been done in relation with their experience in development programs. The first (Attotinga = V1) has been a site of continuous (1986-1998) farming system research (FSR), and the second (Dedome = V2) is since 1994 a site of one natural resource management project. Formal and non-formal surveys have been done covering a total sample of 54 households. Correlation and two-variable regression tools have been used in the further analyses.

Physical and natural characteristics of the study area

The Allada's plateau is a typical subhumide low altitude zone of Western Africa. The soils are clayey sand classified as ferrali-haplic acrisols (Leihner and al 1996) and locally called terre de barre. According to Volkoff B. and al. (1976), instead of using fertiliser, it is necessary to introduce a cropping rotation that includes a bush fallow (>5 years). It is the only way to regenerate periodically the fertility potential of the soil and to inhibit soil loss through erosion.

The primarily vegetation has been destroyed and a derived savannah dominated by oil palm trees (Elaeis guineensis) has taken over. The climate is subhumide tropical with a bimodal rainfall distribution. The rainy season last from April to July and from September to November. The average annual rainfall is 1200 mm and average annual temperature 28,6 °C. Whilst average annual temperatures do not vary much from year to year, a great variation often appears in the total annual precipitation. For instance in 1998, the total rainfall was below 900 mm in the southern zone of Benin.

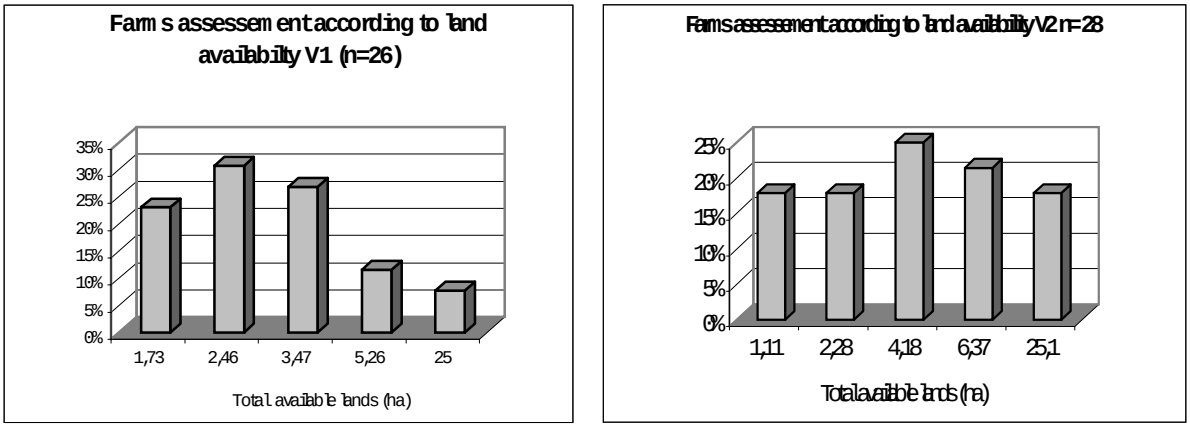
The natural and physical conditions in the two chosen villages are the same as above described. Nevertheless, little differences are apparent between them. V1 is located in the North of the plateau zone, with a homogeneous ethnical group. It is also possible to see here more close vegetation covering the soils, with greater presence of oil palm trees. V2 is located in the centre of the plateau and involves different ethnical groups. The degradation of soils and vegetation is an important feature and the oil palm trees a less abundant here.

Land availability, tenure and use

Land availability

The availability of the land is the most important factor affecting the structure of the small farms (Doppler 1991). The economic and strategic choices of the peasants depend on its abundance or scarcity. Its availability varies from 1,40 to 28,97 hectares and from 0,53 to 66,87 hectares in each sample respectively in V1 and V2. Five categories have been distinguished as showed in the graphs1. The three lower classes include farms with land availability less than 5 ha and represent 80% (V1) and 61% (V2) in the samples. This corresponds to 0,26-0,66 ha available land per household member (include children). Roughly, 50 to 88 % of this availability are cultivated annually. The high use rates are observed on the farms with female manager and by the non-native population (only in V2). The cultivated area per household member varies from 0,42 to 0,52 in V1 and from 0,44 to 1,07 in V2.

Graphs 1: Proportion of farms according to the available lands



Correlation analysis has been used to identify the kind of relations within different factors. It appears, that the increase in soil availability is positively correlated with the age of the farm managers (R^2=0,79 with the polynomial model) only in V1. In the same village, the relation between the annual cultivated area and the available lands is positive but weak (R^2=0,21). In V2 we have a positive higher relation (R^2=0,62).

Land tenure system and its influence on land use

The available lands have been divided into:

1) Lands hold with ownership property rights. This fact is possible through legacy – not accessible to women – or/and purchase. Subsequently, the term of direct access (DA) is used referring to these access ways.

2) Lands hold under the right of temporary farm. This is possible through the renting (financial cost to be paid in advance cash), the borrowing (free of charge) and the share tenancy (share cropping). The term of non-direct access (NDA) is used hereafter to indicate these access ways.

Correlation and regression analyses have also been made. The results have showed an influence of the land tenure on the quantity and/or the quality of cultivated lands. This influence varies in each village. In both villages, soil availability expansion depends primary on the DA. In V2 this access way is quite limited to inheritance, since the sale of arable land is prohibited

In V1, the two-variable regression analysis (between the annual cultivated area in one hand and the available lands under DA and NDA in the other hand) has given a coefficient of determination of 0,62. The NDA available surfaces are the heaviest in this relation (partial R^2=0,51). The renting is the most dominant practice, as that gives opportunity to access soils that are more fertile (after fallow).

In V2, one observes a contrary fact. The two-variable regression analysis (same factors) has led to wicked results. The previous one-variable regression analysis (annual cultivated areas versus total land available) offers the best R^2. Therefore, it is clear, that both DA and NDA available land have an equally influence on cultivated areas. The first is just profitable to a part of the population, who likewise can use the second opportunity. On the other hand, the others groups (women and emigrated peasants) are discriminated. The access to fertile lands is possible only through renting. But the costs are very expensive in comparison with V1.

When the availability of financial resource is scarce, the farmer is obliged to remain on very poor borrowed plots or to accept the conditions of share cropping (50%-50%). Thus, it is obvious in V2, that the land tenure system does not offer equal access to a great part of the population. This fact is a source of non-sustainability.

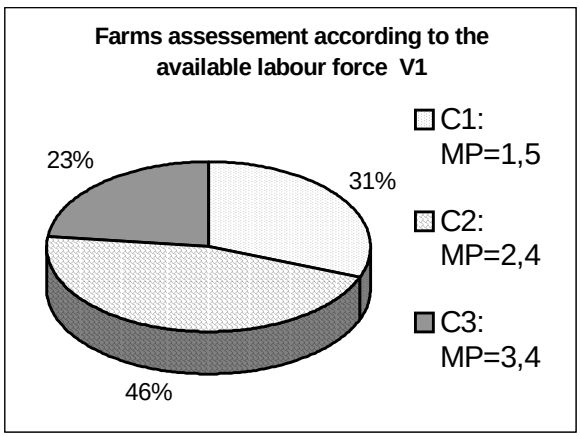
In the two villages, the soil regeneration is subordinated to the fallow period. The principle is the same as in the shifting cultivation, although the soil use intensity (R) is higher in these cases – 0,40<R<0,50 (i.e. 2-4 years of cultivation versus 2-6 years of fallow). We have typically fallow cropping systems according to Ruthenberg (1980). However, permanent uses (R>0,66) already appear in abundance on plots held under property right. Those lands are devoted to the pure plantation of oil palm trees (see note3 at the end).

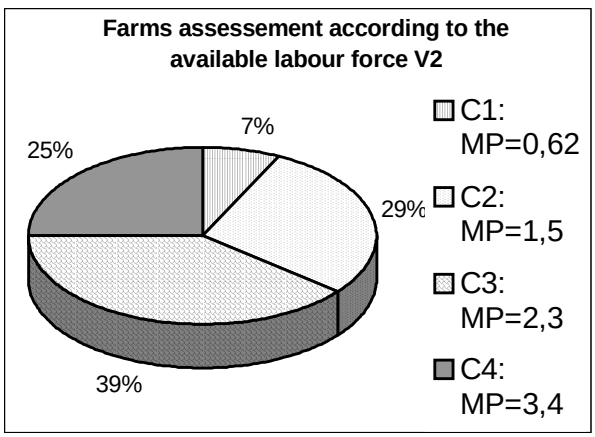
A variance comparison analysis has shown that the rented plots offer the lowest R-value (2-3 years of cropping, after 3-6 years of fallow). Then, the peasants seek fertile arable land to rent outside their village. This fact is much observed in V1. In the same area, one notices a practice of land borrowing for long duration. It consists of borrowing and farming a plot with obligation to plant and keep palm trees (sometimes additional fruit trees or forest trees) until obtaining a forest (this period can reach 10 years). After which, the plot is abandoned to the owner who can only decide to exploit the forest. This practice is interesting for sustainable management of soils, e.g. the implementation of agroforestry innovations by a tenant farmer. This fact is not possible in V2. In opposition, the short-term farming right leads the farmer to seek a maximum profit at a minimal financial cost on the land. This practise, which is more important in V2 due to the presence of an important number of tenant farmers, is one of the main causes of intensive land degradation in this locality. In fact, one observes a low productivity level here: 450 kg/ha versus 1100 kg/ha in V1 for maize during the year 1998.

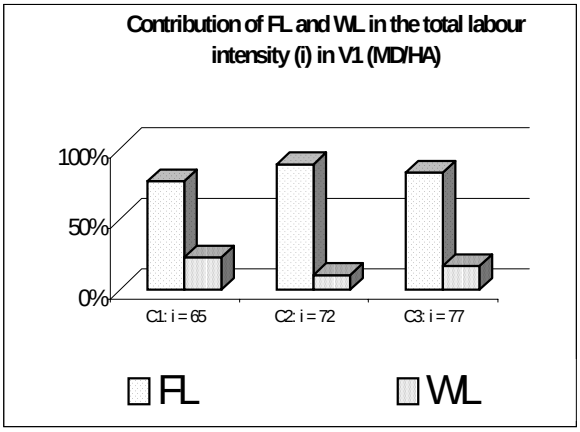
Availability and use of the labour force

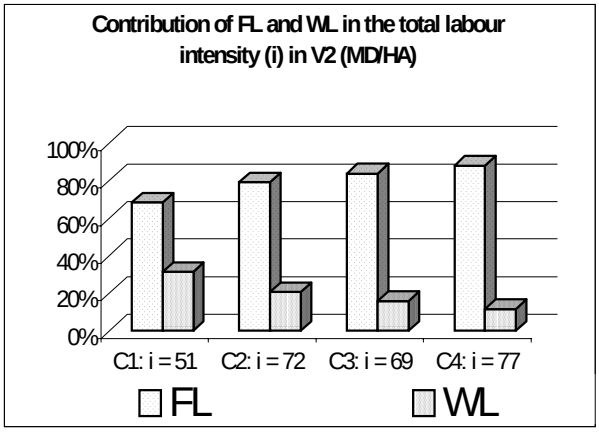
The availability and use of the labour force constitute (after land availability) the second determinant of small farms structure (Doppler 1991, Jahnke 1996). In the study area, the single source is the manpower. One distinguishes family labour (FL) and wage labour (WL). Concerning the first, its availability varies from 0,50 to 4 manpower (MP=adult force labour). In other hand, the use of wage labour is very variable. The use's situation of this factor is expressed through the graphs2. The level of total labour intensity is 71 man days (MD) – or 568 work's hours– in V1 and 67 MD (536 work's hours) in V2 per cultivated hectare.

Graphs 2: Situation of labour availability and use in the two villages









Correlation and regression analyses have been likewise done to determine the relation within different parameters. The results are discussed below.

There is in both villages a positive relation between the MD used for agricultural work and the MP available in the households (R^2 = 0,72 and 0,62 respectively V1 and V2). That indicates the importance of farm works in the two villages. The recourse to WL is not necessarily a consequence of a weak MP availability in the farm. It is required systematically to do hard farm works (e.g. land clearing and tillage). In additional it is more demanded by the farms with weak MP.

In both villages, the two-variable regression analysis (between the annual cultivated area and the amount of FL and WL) has resulted in a moderately strong relation (R^2 = 0,64 in V1 and 0,68 in V2). The weight of the WL in this relation is stronger in V2 (partial R^2=0,58), while in V1 the FL has the strongest influence (partial R^2=0,43). The first is the main cause (after the land access) of expenditures during the production process. Therefore, it is clear-cut, that the production induces in V2 higher financial costs as in V1.

Intensification and sustainability

Given the increase of the demographic pressure, one notices a subsequent shortening in the fallow period. Referring to Ruthenberg (1980) Higgins G.M. and al (1982), and Jahnke (1982), with the current intensity of land use, the maximum tolerable limit for a soil fertility regeneration through a natural fallow is already exceed. Therefore, to maintain or improve the productivity, it is necessary to carry out better ways of soil quality improvement – such as organic manure use, mulching, improved fallow with leguminous, fertiliser use, alleys cropping, etc. Unfortunately, it is not the case currently. The consequence is a normal decrease in productivity in time, due to progressive deterioration of land quality. Thus, the intensification process, as seen now in the two villages, is non-sustainable.

This process is presently unbalanced, because based only on the intensive use of the single input land. The intense use of other factors (capital and work), that are possible through the innovations is ineffective, despite the availability of numerous FSR adapted, tested and profitable technologies (see Floquet et al 1996).

The reasons of this situation are complex. The intensive use of other inputs leads to a greater financial investment on the farm. But the farm income levels are currently low and do not allow such investment. Even with an interesting credit system (at low interest rate), the risks are enormous and cover: climate uncertainties, non-secure land tenure system, advanced soil degradation, low and non-stable agricultural prices, etc. The possibilities of labour intensification, for instance in the context of mulching, are limited. The exodus of young is a reality in southern Benin's rural area. At the same time, palm trees do not lend themselves easily to mechanisation.

Nevertheless, there are some facts indicating dynamism and rapid adaptation mechanisms in the system, when constraints or opportunities appear. Some examples are the intensive agroforestry cropping system with palm trees in Southwest Benin (Brouwers J. H. A. M. 1993) and the rapid development of ridge tomato cropping system in V1 (Floquet and Mongbo R. (1998). However, further improvement possibilities have to be sought and exploited.

Conclusion

Despite the difficulties and complexities of analysing sustainability of farming system, the two empirical cases from Benin allow to draw tentative conclusion and inductive theorem concerning the objective of sustainable land use system. The reality of the problem appears different according to the agricultural systems. Modern large-scale and market-oriented agriculture has to dealt with problems of over-production and environmental pollution. In the case of smallholder cropping systems, the subsistence goal remains essential, but the production leads to little surplus. Thus, the objective of sustainable production is not easily achievable. Numerous studies have pointed out constraints which are physical, technical, socio-cultural, institutional and economical (e.g. Ruthenberg 1980, Beets 1990, Jahnke 1996). Limited to the subject in this article, it is clear that institutional rules, people's attitudes and external factors are bottlenecks in the use of resources for a sustainable intensification.

Finally, it should be interesting to recall farmers' points of view obtained during an assembly meeting in each village. In V1, the farmers have argued that the human reproduction is a necessity, but that it is not possible to have the "reproduction" (sic) of land. Thus, in order to produce sufficient food to meet human requirement, it may be necessary to move toward regions with more land availability. A young person expressed strongly the opinion that one should leave Africa for better earning possibilities in Europe and come back after two years and simply enjoy life. An old farmer found the agroforestry innovation (with leguminous trees) good for soil fertility improvement, but the short-term tenure system is not favourable for the extension of such innovation. In V1, an old farmer has found the proposed FSR technologies not necessary at this time for him, as the productivity of his soil is still good. He argued that those innovations would be applied in future by others generations, when necessary. Another old farmer proposed to limit the birth rate, whereas the small pupils wished to have the chance to work in other economic branches.

Notes

(1) The development of cotton crop in the north-eastern area of Benin (Borgou department) has had both positive and negative effects. As positive effects, the farmers' incomes were secured and had raised, leading to greater purchase of equipment such as draught oxen, fastening implements, bicycles, transistors and etc. (Ton P. 1995). On the other hand, this expansion has brought environmental problems such as extensive deforestation, greater hydric erosion, and underground water pollution with pesticide.

(2) Different levels can be distinguished, making an agricultural system analysis. From upper to low, we have the national/regional, the village, the farm and the plot level. The cropping (or farm) system begins from the farm level and is defined as the plants grown and the farm management procedures to achieve human goals (See Pearson C. J. and al, 1995). A distinction is made between cropping system and farming system. The late (according to Ruthenberg 1980) is defined as a group of farms, which are similar in their structure and in their production functions. The cropping system points out the activities (crop, livestock, forestry, grazing), their interdependency and management within a farm, whereas farming system underlines the organisation and use of resources between the farms (Jahnke 1996). In practise, one uses the two terms inter-changeably.

(3) Oil palm trees are regarded as crop producing oil. This traditional function of this perennial crop has changed during the time in South Benin, as the rainfall is insufficient for a competitive productivity of palm nuts. This fact has inhibited the expansion of improved varieties. However, farmers have always planted the traditional variety (spontaneous). The main economic value comes now from the palm wine, which is distilled into alcohol (locally called sodabi). This processing, which results in the destruction of the trees, arises some years (often 10-20) after continuous economical profits of the by-products (nuts processed in oil for the local market). The cropping system of oil palm trees in South Benin has been studied by Brouwers (1994). He found that, higher yields of maize are recorded after a fallow with oil palm trees. Its presence on a plot reduces the erosion process.

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