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Adaptive Management of Natural Resources by Small Farmers in the Sahel

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The Sahel since the Great Drought

During the past four decades, and in particular since the Great Drought ravaged the region in 1969-74, the Sahel of West Africa has experienced significant environmental and socio-economic change. There has been a decline in the average rainfall, an increase in its variability and in the incidence of drought, some deterioration in surface and groundwater availability, a rapid expansion of cultivation, much removal of woodland and some changes in the floristic composition of grassland vegetation; and reports of widespread soil erosion and degradation (Raynaut, 1997). Concurrently, rural population densities have risen, urban populations have increased, migration between rural and urban areas has intensified, and there have been major changes in agricultural marketing. Farming, livestock and livelihood systems have changed in complex ways.

Beginning with emergency interventions in the 1970s, the period since the Sahel Drought has seen many failures of development projects based on new technologies. Yet, paradoxically, the peoples of the Sahel, and rural communities in particular, have succeeded in adapting to change, much of it adverse. Analyses of long term trends in population growth, migration, urbanisation and investment by small producers (both in cities and on farms) suggest adaptive management, at least in some areas (Snrech et al., 1994). There are now more people, living at higher rural densities, keeping more livestock and producing more food than before.

In the West African Sahel (the Sahelian and Sudanian ecozones), development interventions need to be designed to support and enhance indigenous capabilities, and take advantage of the capacity of rural smallholders to adapt positively, and dynamically, to exogenous change; rather than merely to transform existing systems by promoting new technologies.

Adaptive Resources

A series of linked research projects funded by the National Resource Systems Programme (NRSP) focusing on the semi-arid zone of northern Nigeria, have looked at these adaptive resources and their potential as a basis for development policies or interventions (Harris, 1996; Harris, 1998; Adams and Mortimore, 1997). A major impediment to a gradualist and adaptive approach to development intervention is an inadequate understanding of how such diverse, complex, multisectoral and dynamic household systems work. The project studies therefore took a systems approach to the whole, and adopted the household as its unit for analysis.

There has been a tendency for economic and technical diagnoses of smallholders' management of natural resources to proceed independently of one another. Thus, the profitability considerations which increasingly drive primary producers' choices of livelihood options can be analysed without taking into account their impact on ecological sustainability, and technical prescriptions for improved management can ignore their economic costs for households. However, smallholders must consider opportunity costs and synergies amongst the constrained resources available to them.

Households work with key constraints that define the options available to them. These were identified as 1) labour, 2) rainfall, 3) soil fertility (or nutrients), 4) biodiversity (natural and agricultural), and 5) livelihood options. While these constraints may also operate in other systems, they take specific forms in semi-arid environments. West African households are responsive to markets; but the response is highly variable from place to place, from time to time, and from household to household, so that merely to promote markets as a development strategy cannot be expected to benefit everyone equally. A better understanding is needed of the key constraints affecting semi-arid systems, and how people manage them (or fail to do so).

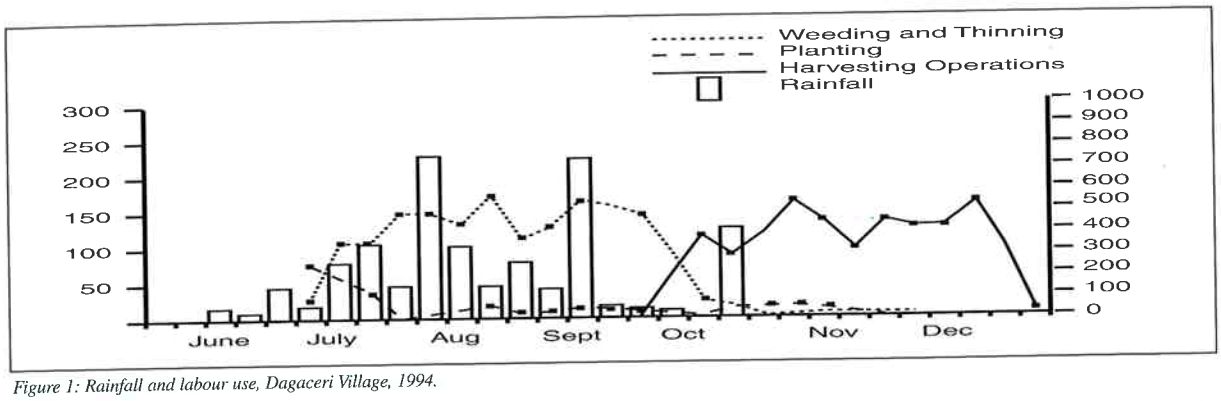

Figure 1: Rainfall and labour use, Dagaceri Village, 1994.

Decisions about the use of scarce resources, and in particular family labour (Stone et al. 1990; Netting; 1993), are small in scale, frequent in occurrence, and sequential in pattern (that is, decisions taken on one day form a part of the decision-making matrix later). Decisions are responsive not only to the resource endowments of the household (e.g., labour, livestock and arable land available), but to exogenous events in the natural and economic environment (especially rainfall) over which smallholders have no control. Each year must be negotiated, and the 'accounting' of food stocks, income, etc. forms the starting point for the next one. Households are flexible in their treatment of the resource endowment at their disposal, and adapt from one year to the next as opportunities change.

Poverty and developmental needs have to be brought down to the level of the household, where diversity, complexity, and fluidity are fundamental characteristics.

Research Methods

The four villages studied in Kano, Jigawa and Yobe States of Nigeria, describe a profile of diminishing rural population density (from very high - > 200/km^2 - to very low - < 20/km^2), diminishing average rainfall (from moist to dry semi-arid - > 500 mm to < 350 mm), and more difficult access to markets (Adams and Mortimore, 1997; Mortimore and Adams, in press; Harris, 1996). Field studies were carried out by a team of researchers at Bayero Universities. There were 12-13 collaborating households in three of the villages, and 8 in the fourth. An integrated programme of work on rainfall, labour allocation, and the management of soil fertility, biodiversity and livelihood options was carried out over four successive farming years (1993-1996).

In two of these villages, analytical studies of nutrient cycling were carried out. These villages were (a) high population density, moist semi-arid (Harris, 1996; 1998) and (b) transitional population density, dry semi-arid (Harris, 1999). Village (a) operates a very high intensity system with annual cultivation, heavy manuring, and no fallowing. Village (b) operates a lower intensity system which includes some land under annual cultivation, much more under grass/shrub fallow cycles, and rangeland, protected from cultivation, on up to half of the total area. On-farm sampling (three holdings in village (a) and six holdings in village (b)) of the soils, crops and other vegetation, inputs and exports resulted in the quantification of nutrient balances and the identification of nutrient cycles in the farming systems.

Rainfall and Labour Use

Rainfall data were collected at each village using automatic gauges, and farm labour data were collected on a daily basis for each individual, by task and by place. The observations permit analysis during the season on a week-by-week (or day-by-day) basis, providing new insights into the challenges of managing household (and some outside) labour as the uncertain pattern of rainfall unfolds (Figure 1). The analysis has shown the linkages between the rainfall patterns and farming activity, and the effects of variability on the major operations of planting, weeding, and harvesting in four differently configured rainy seasons. Although inputs of labour are controlled by the farmer, its useful limits, its efficiency and productivity are actually controlled by the rainfall. The trade-offs between major operations also call for flexibility in week-by-week or day-by-day operations. Every year is different.

It is worth understanding the complexities of managing fluctuating rainfall with a fixed supply of labour, before inserting innovations into the system.

Biomass and Biodiversity

Even in an apparently degraded environment, having a relatively low population density (by Nigerian standards), smallholders' management does not conform to a stereotypic destructive image. Under a high population density, conservation strategies are obviously important, for example in the protection and planting of trees, the harvesting of weeds, or the maintenance of a large number of cultivars. In either case, the 'biodiversity regime' represents a balance between ecological potential, product demand, and the

labour or technologies available with which to manage it. Analysis of the genetic diversity in some pearl millet cultivars (by John Innes Centre, Norwich) shows how farmers, acting as breeders through selection and seed management, aim to contain within acceptable limits the diversity, outcrossing and degeneration which occurs in their chosen 'landraces'.

Small farmers' management of biomass and biodiversity needs to be understood as a resource for development rather than dismissed, because they do not simulate scientific research programmes.

Soil Fertility and Nutrient Cycling

Soil fertility parameters under a range of land use regimes can be assessed in order to evaluate the impact of management on soils which are inherently of low productivity. As the ratio of cultivated land to natural vegetation changes through time, and one regime is substituted for another, the effects of demographic and economic change can sometimes be discerned.

Quantifying balances and flows, nutrient by nutrient, showed that the short run sustainability of nutrient management varies from farm to farm. Nutrient balances varied from field to field, and from year to year, as they are controlled by the variability of inputs (nutrients, rainfall) and of the labour needed to input those nutrients, which include organic manure from animals. Rainfall variability affects biomass production, directly affecting the output of nutrients in the harvest. Farmers' resources (animal traction, livestock) affect their ability to recycle nutrients within the landholdings, and particularly in the short fallow farming system, these resources also enable farmers to transfer nutrients from common access pools to private fields (Figure 2) (Harris, 1999). The level of intensification and crop-livestock integration achieved in the high intensity system (the Kano Close-Settled Zone) calls into question some estimations of cropland:rangeland ratios necessary to maintain annual cultivation (Powell et al., 1996, Harris, 1996). The management of intensification (which depends little on the use of inorganic fertilisers) is thus shown to be dependent on crop-livestock integration, rainfall, and labour.

Low external input intensification, which is linked in complex ways with social and economic variables, has not yet run its course, and recommendations for wholesale resort to chemical fertilisers are premature.

Livelihood Diversification

Livelihood options outside farming begin with livestock keeping, which has important feedback effects on farm intensification, and extend to business activities (trading, manufacturing and services) in the local area, and from there to outside activities including migration and marketing. Diversification is a year-round activity and common to almost all households. There is a trade-off between farming, livestock work, business and outside activities during the farming season when labour is scarce. The data collected allowed analysis of women and children's work, both on and off the farm, and the place of housework (including fetching water, threshing grain, and cooking) in the overall labour budgets of households.

Nowhere is the need for skilful allocation of labour more apparent than in choosing between agricultural and off-farm work. Amongst the variables taken into consideration are: grain stocks, anticipated harvest, investments made (or needed) in tools and equipment, skills, networks for accessing income sources or for marketing outputs, the time of the year when decisions are taken, alternative labour (or managers) for absentees, travel costs, age and sex, etc.

In pushing for increased farm production, development agencies must not neglect the interactions between the farm and non-farm sectors at the level of the household - or even the individual.

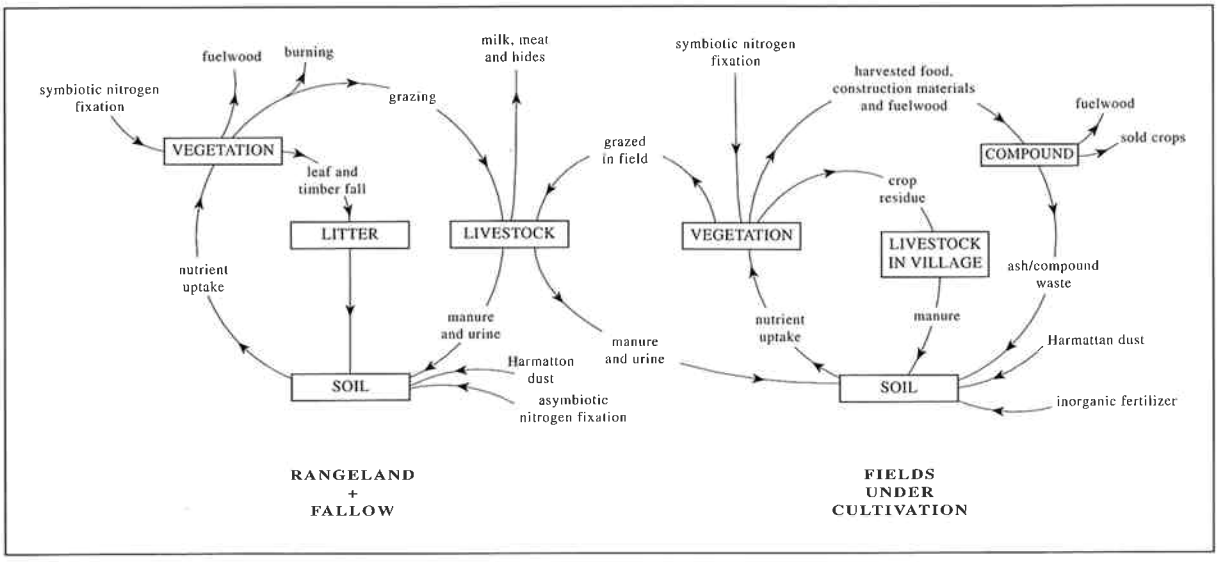

Figure 2: Nutrient flows within the short-fallow farming system

Inequality

An enquiry into inequality was carried out by analysing households with differing endowments of labour, cultivated land, or other assets. This exposed both the difficulty of ranking households and the complexity of individual poverty, where social institutions such as kinship, clientship, and religious duties cut across households. Differentiation affects not only the aggregate status of households or individuals, but also the minutiae of resource management. For example, the possession of a cart may give access to common middens for manure which can be transported to private farms, differentiating ownership of the nutrient cycling system. The best insurance against disadvantage remains access to family labour (in practice, having several sons) - in which all households are hostages to demographic fortune.

Poverty alleviation programmes have to take into account the complexity and fluidity in the definition, targeting and helping of beneficiaries.

Conclusions

The allocation of labour (most of it family labour) amongst farming, livestock and other tasks plays a central role in the diversity, flexibility and adaptability of household behaviour in a Sahelian environment. Plant resources (natural vegetation and cultivated plants) are still central to household reproduction. The environmental resource of nutrients, in both the soils and the vegetation, are the centre-piece of this conjunctive relationship between the people and the land. Their management of these resources, in the face of changing and fluctuating rainfall regimes, and under changing conditions of land use, labour supply, demand and technology, will determine the sustainability of their natural resource management system. These local resource management systems, however, are not the whole story, for they are integrally linked with processes of income diversification and processes of economic change which pull the local system into the wider regional, national and even international economy.

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[NRSP Semi-Arid Projects:
R5719 - Soils, Cultivars and Livelihoods in North-East Nigeria;
R6051 - Nutrient Budgets in Relation to the Sustainability of Indigenous Farming Systems in Northern Nigeria;
R6603 - Nutrient Cycling or Soil Mining? Agropastoralism in Semi-Arid West Africa]

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