PN-AAV-76
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Land Regeneration and Agricultural Intensification in Senegal's Groundnut Basin

An analysis of ecological and developmental relationships between food and fuel self-sufficiency, agricultural intensification, and land regeneration.

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September, 1982

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A. Introduction

Background to the Paper

This presentation is intended to orient present and future development work in the Groundnut Basin, which directly or indirectly affects natural resources and the environment.

An institutional policy context already exists for AID's focus on natural resources and environmental concerns, which need not be detailed here. However the various policy statements, directives and recommendations related to natural resources and the environment 1/ taken together constitute a solid background for this present exercise.

AID's current policy (CDSS FY 83) and projects in the Groundnut Basin already address some of the important natural resources and related production issues. AID is supporting a very ambitious program to convert all farmers to improved millet varieties by 1984, is well into the development of a program of rural health care, and is funding various kinds of reforestation and energy conservation activities. These need not be detailed here. Also, AID is on record in its FY 83 CDSS to regenerate the land in the Groundnut Basin (pp 44 CF.):

> "USAID/Senegal proposes that the U.S. take the lead with the Government of Senegal in organizing a concerned multi-donor reclamation operation in the Peanut Basin over the next decade. The objective of this undertaking will be to develop sustainable land-management systems in the Basin which can increase the productivity of soils, while diversifying sources of food".

Specific actions contemplated were:

> "... replanting of proven varieties of trees and shrubs for groundcover, forage and firewood"

1/ Regulation 16.22 CFR, Part 216 (environmental procedures) and sections 103 and 118 of the FAA (now International Security and Development Cooperation Act, 1981) give AID authority to assist developing nations to address their environmental and natural resources management problems. Both Sections were strengthened in Sections 307 and 308 of the 1981 Act (amended Section 118, Environment and Natural Resources).

"explore new plant resources for designing new systems...".

"Labor-intensive public works scheme. (Small dams and tree planting in the Sine Saloum)".

"... integration and support of livestock production in the Peanut Basin" (by shifting focus of the livestock program from open range to the Sine Saloum).

"... USAID/Senegal will seek to organize within the Sine Saloum zone a working body of PVO's (American and Senegalese), together with Peace Corps... to assist villages with wells, tree and shrub plantings and other conservation measures, and vegetable planting".

In general the CDSS statement vis-a-vis the Groundnut Basin remains valid. However, the accuracy of some of the proposals were not borne out by the analysis behind the present policy recommendations. "Reclamation operation" is a confusing term that limits one to only the areas devastated by drought or over-cultivation, mainly in the north and in parts of Diourbel and Thiès. "Labor intensive public works" do not hold much promise except in a few select regions of the basin, where dams and erosion control structures are evidently beneficial (southern Sine-Saloum). Given the difficulty and impracticality of isolating degraded areas for special attention, this paper broadens the purview to resource conservation and management.

The principal natural resources of concern in this paper are soils, water, and trees (or other perennial woody vegetation). All are renewable resources. However, their renewability after use is relatively slow in the semi-arid climate of the Groundnut Basin. The rate of replenishment of soil water and groundwater, the growth of trees and the restoration of soil fertility through fallowing parallel the rainfall regime, which is highly variable. Nevertheless, the demands on these resources are constant and rising with population growth. Herein lies one of the difficulties of semi-arid zone resource management... that of adjusting intensity of use to fluctuations in productivity and resource renewability caused by fluctuations in rainfall.

The Groundnut Basin

Intensification and diversification of agriculture are the principal development thrusts in the Groundnut Basin. In traditional agriculture, intensification of agriculture involves continuous cultivation or lands, i.e. no fallowing, through manuring, composting, and irrigation of water conservation. It is a response to land constraints. In Senegal, it is evidenced historically by the Serer who, hemmed in by the dominant pastoral peoples (before the introduction of the peanut), evolved strategies for using manure and trees, especially the Acacia albida, to maintain land productivity. Agricultural intensification is not, however, a traditional response to land degradation. Rather, it would be "counter-intuitive".

Fallowing for many years or indefinite abandonment of exhausted cropland has been the traditional response to loss of productivity, where uncultivated reserves exist and where cattle are not integral to farming systems. Until approximately 1950, "bush" fallowing was practiced. Now with population growth (See tables 1 and 2), fallowing, if practiced at all, is no more than one or two years. It no longer serves to restore nutrient and organic matter to soils.

Groundnut Basin farmers are now faced with a situation that is historically unprecedented, that is, for which there has been no traditional response developed. The land is losing its natural productivity (except in the most heavily manured toll keur lands immediately surrounding villages), but adequate fallowing is no longer possible, because of the land constraint. At the same time, however, the land constraint has not become sufficiently severe to stimulate intensification. That moment has been postponed by a combination of factors: temporary or permanent out-migration to cities or to Senegal Oriental, the use (albeit sporadic) of fertilizers during 1965 to the present (though distribution fell drastically in the Groundnut Basin in 1980/81 and 1981/82), and the effects of the drought, which have been so large they have masked the trend in fertility loss. Moreover, animal husbandry has not become sufficiently integrated into cereals and peanuts farming to make intensification of outfields technically possible. The

Table 1: Population a/ and man/land ratios, 1980 and 1995

Region	1980 Population	1980 Cultivated has.per person b/	1995 Population	1995 Cultivated has/person
Diourbel	476,000	0.7	718,000	0.5
Louga	468,000	0.85	707,000	0.7
Thiès	783,000	0.45	1,182,000	0.3
Sine-Saloum	1,129,000	0.77	1,705,000	0.7
TOTALS	2,856,000	0.70	4,313,000	0.55

a/ Assumes 2.8% annual growth rate since 1976 to 1995.

b/ Based on data from the VIth Plan for cultivated and cultivable land. By 1995 it is assumed here that all cultivable land will be cultivated.

Table 2: Agricultural Land Resource, Groundnut Basin (Source: VIth 4-year Plan)

(hectares)

Region	Cultivated	Cultivable	Difference ¥	Percent
Louga	390,000	500,000	110,000	22
Diourbel	310,000	350,000	40,000	11
Thiès	360,000	370,000	10,000	3
Sine-Saloum	860,000	1,150,000	290,000	25
TOTALS	1,920,000	2,370,000	450,000	23

¥ A population density of 40 persons per square kilometer, or 2.5 hectares per person, would be optimal for small mixed farming in the areas not yet cultivated, (according to Mr. Pochtier of ISRA). This would indicate that the uncultivated surface in the Groundnut Basin could comfortably accomodate a population of 180,000, or an approximate equivalent of the next 30 months of population increase in the Groundnut Basin.

exceptions among Serers and in parts of the Sine-Saloum prove the generality.

A major challenge is therefore posed to development assistance. Namely, how to motivate farmers to apply techniques of agricultural intensification to degrading or degraded lands? Research in Senegal and elsewhere in Africa has shown that degraded lands can be restored by means of techniques which are also associated with agricultural intensification -- manuring, and composting -- as well as through new techniques; liming of acid soils, application of micro-nutrients where needed, deep plowing, plowing under of manure or compost immediately after spreading on the fields, post-harvest plowing, and techniques of soil erosion control (windbreaks, diquettes or bunds)

These are "radical" innovations that require a substantial investment of human and animal energy, time, and capital which may not yield returns for a number of years. A sustained effort of land productivity management and conservation will also require the integration of livestock into farming operations as well as the development of various credit, marketing and similar mechanisms that are normally involved in production oriented agricultural development. Thus, these actions must be supported at least initiall by public or private non-profit agencies, through research and development, demonstrations, extension activities, and appropriately scaled and timed incentives or subsidies. The point to be made is that restoration of degraded or degrading lands will at this moment in time require the supportive context of an effective agricultural development program aimed at intensification and diversification of production in the Groundnut Basin.

The following pages describe an important dynamic which links agricultural intensification with food and fuel self sufficiency in the Groundnut Basin. Intensification of production is needed to attain food self-sufficiency, or to obtain crop surpluses. Fuelwood self-sufficiency has become a necessary condition for intensification, in that crop residues, manure and other organic matter must be available for land treatment. Thus, food self-sufficiency (as well as production surpluses) depends upon

intensification which depends upon land regeneration, which depends upon fuelwood self-sufficiency. These key relationships and their implications for land regeneration strategies are explored further in this paper.

In as much as land regeneration and intensification must proceed hand in hand, except perhaps for the most degraded areas, their achievement should be conceived as a single strategy. Specific land regeneration techniques are known; how to introduce them successfully must be determined within the context of an overall strategy for agricultural intensification in the Groundnut Basin. The planning context for this work could be the Groundnut Basin Master Planning exercise soon to be undertaken under AID auspices.

B. Fuel Self-sufficiency - Necessary Condition for Intensification

Agricultural intensification in heavily settled semi-arid zones such as the Groundnut Basin cannot be achieved unless fuelwood self-sufficiency is also realized. This is because intensification requires the incorporation of organic matter (manure compost, crop residues) into the soil, and the rational use of crop residues and browse for fodder.

The attainment of fuelwood self-sufficiency in areas where natural forests no longer suffice, requires the cultivation of fuelwood trees. Tree cultivation and management for this purpose is a major new endeavour. The cultivation of certain fruit trees (mango especially) and neem trees in the environs of villages, the use of living hedges to protect fruit trees and fields, and the selection of Acacia albidas are well known, but the establishment of tree plantings to supply fuel is a new idea that is just beginning in the Groundnut Basin. It is true that village woodlots of several hectares of eucalyptus are increasingly being planted in the region, but these are invariably viewed as potential sources of construction poles, or of revenue, by the men who plant them. Women up 'til now have had no voice in the matter.

It is important to recognize that whereas the achievement of agricultural intensification requires the parallel development of fuel sources, the goal of fuelwood self-sufficiency is not perceived as a reason for intensifying agriculture, given the fact that women are the fuelwood gatherers, while men are responsible for major agricultural and landuse decisions. And men in general do not perceive a fuelwood shortage in the Groundnut Basin.

Food vs. Fuel?

In the Groundnut Basin the provision of fuel is in conflict with the provision of food, both presently and potentially in future developments. Where villages are far from Forêts Classées or other reserves -- largely the situation in the central portion of the region -- a hectare planted in fuelwood species means one less hectare in crops. In fact, even without woodlots, the provision of fuel is indirectly undermining food production, to the extent that manure and crop residues that should be

used to restore soil productivity are being diverted to cookstoves. According to the Plan Directeur de Développement Forestier 1/2 to 3/4 or more of the rural fuel in the Groundnut Basin is from sources other than forest areas, namely trees on the agricultural landscape such as Acacia albida (cad), brush cleared from fallowed fields (where this is still practiced) such as the Gueira senegalensis, crop residues and manure.

In considering how to achieve fuel self-sufficiency, the availability of land and the rate of tree growth (as determined by groundwater or rainfall), become key issues. In Thies and Diourbel, where village woodlots are most needed, the land is scarcest and rainfall is only marginal for eucalyptus. Louga has sufficient land but inadequate rainfall for fast tree growth, so relatively more land is needed. The Sine-Saloum has the best combination of land availability in an around communities and rainfall adequate for eucalyptus and other fuelwood species. In fact, SODEVA has achieved relatively greater success in the Sine Saloum in village forestry than in other regions (See Appendix A

Fuel Self-sufficiency in Diourbel

To test the likelihood that the more heavily populated portions of the Groundnut Basin could not achieve fuelwood self-sufficiency by means of woodlots, several calculations were made of the situation in Diourbel *, first at the level of a typical village and second at the regional level. A "typical" village of 125 people was used, which at the present arable land/man ratio of 0.75 ha. per person would occupy one square kilometer or 100 has. A total of 25 hectares of woodlots would be needed to supply the village fuelwood, assuming consumption of 0.6 m^3/person per year, and production of 3 m^3/ha/year (assumptions taken from the Plan Directeur de Développement Forestier). This would lower the area cultivated per person

* Data from the VIth Plan, SODEVA and the Plan Directeur de Développement Forestier (Vol. A, Ressources Forestières).

to 0.6 has, with 0.3 has in millet, which at 800 kg/per ha. yield would provide 240 kg/person, or a reasonable margin of surplus over the 158 kg/person food requirement used by SODEVA. The surplus would cover seed, drought insurance, and losses from pests or spoilage. In fact, at 770 kg/ha average production in 1981/82 (a good year), Diourbel produced a millet surplus estimated at 70,219 m.t.

Only a few tens of hectares of village woodlots have been planted in Diourbel, compared to an estimated 82,600 has. that would be required to supply the 413,000 rural inhabitants in 1982 (the 1976 rural population projected a 2% growth rate). At a planting rate of 10,000 has per year (a very optimistic estimate) 8 years would be needed, during which the rural population would have increased by another 80,000 at the same growth rate, and who themselves would need an additional 16,000 hectares of plantations, as well as 48,000 has of farm land. Would there be enough land if interim sources of fuelwood could be obtained to cover deficits until plantations come into production ?

The Sixth Plan for Economic and Social Development estimates that there are 350,000 hectares of arable land in Diourbel, 300,000 has. of which were cropped in 1981, according to SODEVA. About 10,000 has. were fallowed. The remaining uncultivated 40,000 has. would absorb an additional 52,000 rural people, whether entirely in cropland, at ·75 has. per person, or one quarter in woodlots and 0.6 cultivated hectares per person . In any case, the land is needed to accomodate the next six years of population growth.

It seems clear that Diourbel would have to make an extraordinary effort to plant woodlots, in terms of rate of planting as well as land adjustments, in order to achieve fuel self-sufficiency from this source. There is no basis to assume that such an effort would or could in fact be made. Peace Corps forestry Volunteers working in Diourbel under the aegis of the Africare Village Reforestation Project have had to confront the reality of insufficient land for single purpose woodlots. They have

found that unused lands are scarce, far from villages and important as wet season grazing reserves (when livestock must be kept out of fields). Furthermore they are of poor quality soils as a rule, with inherently low productivity for trees.

Review of Alternatives to Woodlots

There are several alternatives to single purpose woodlots. Some are more promising than others:

(1) The periodic harvesting of old Acacia albida (Cad) trees for fuelwood (1 mature tree per hectare per year would yield at least 1.0 m^3 of fuelwood). (2) The purchase of fuelwood or charcoal, imported from elsewhere, and paid with crop surpluses. (3) The reduction in fuelwood consumption through improved stoves.

Line plantations of trees other than A. albida do not evade the land constraint since lines of trees such as Eucalyptus or neem will still require at least 2 meters of land on all sides for root room. Leguminous trees with lighter shade would perhaps be a better choice for windbreaks and field boundary lines. Also the very low number of stabled animals in the Groundnut Basin makes biogas production an impractical alternative to fuelwood, though it could hold promise in the future. In fact, CNRA biogas researcher Ganry hypothesizes that biogas production could further motivate farmers to stable and stall feed cattle.

Ban-ak-suf. The success of the improved cookstove, or Ban-ak-suuf, and its general acceptance in the countryside establishes it as a proven alternative that will surely spread, with or without government support, (although faster with than without), and whether or not additional fuelwood supplies are developed. It eases the women's work by lessening the frequency with which fuel must be collected. It could reduce fuelwood consumption by 40%.

Cad. The harvesting of cad trees is a possibility suggested by the observation that at about age 40, the cad produces fewer leaves and pods, therefore should be replaced. About 50 large cad trees with unpruned crowns would provide fairly complete coverage of one hectare, with spacing of approximately 14 meters (e.g. allowing 7 meters for crown radius).

That many could permit at least one to be harvested per year. Eventually an uneven age stand of cad would develop, requiring that planting or regeneration be planned so as to maintain maximum crown cover and closure. More than 50 trees would probably exceed groundwater resources in the dry season, though this can only be hypothesized.

Charcoal. Even if available for sale in rural areas, charcoal would have to be subsidized, as at present, in order to compete with locally grown fuelwood, and even then it would not be a wise choice. The Plan Directeur de Développement Forestier estimates that a rural person consumes 0.85 kg of charcoal per day, or 310 kgs. per year, costing 9,300 CFA at controlled prices of 30 CFA the kilo. If net returns on millet were 60 CFA per kilo, the harvest of approximately 1/4 hectare would be needed to buy charcoal. The same 1/4 hectare planted in fuelwood species growing at the rate of 3 m^3/ha/year, would yield .75 m^3 of fuelwood, or more than a person's annual fuel needs, and a far better choice for a daily need given the independence from market uncertainties.

It is doubtful that charcoal would become a widely used substitute for wood in rural areas without a very considerable and favorable change in the returns on peanut and millet farming. This means that until larger numbers of useful trees such as the cad are established on the rural landscape in plantings that do not compete with food crop production, rural fuel self sufficiency will continue to be at the expense of organic matter that should be returned to the soil.

The Outlook

The predictable increasing difficulty of finding sufficient fuel for cooking and browse for livestock, the slowly diminishing yields of crops as soil fertility continues to decline, and the steady decrease in available land will all combine to lower the standard of rural life and make women's work in particular more difficult. The consequences will be an increasing flow of young people to cities, and eventually the refusal of young women to fulfill their traditional roles of finding fuel and preparing and cooking meals.

There will be exceptions to this general trend of course, where communities have enough land for fuelwood plantations*. But, except for portions of the Sine-Saloum (especially to the east), land and vegetative resources are being surpassed by population growth.

If cities or other regions prove unable to absorb the excess people, there will be strong motive to intensify agricultural production to meet subsistence needs. If cities succeed in accomodating the urban migration, the resulting urban market for rural products could provide an economic incentive for intensification. In neither case, however, is there a strong incentive for rural folk to grow fuelwood trees rather than crops. Whatever the case, however, the cad would be a desirable tree to grow in fields, since it contributes to production of crops and livestock.

Conclusions

Fuel self-sufficiency in general will not be possible to achieve through block plantings of single purpose fuelwood species (woodlots), for lack of adequate land. An analysis of the situation in Diourbel shows that the there is little scope for supplying rural fuel needs through eucalyptus woodlot plantings.

Fuel self-sufficiency can be achieved by reducing consumption through the widespread use of the ban-ak-suf, and by:

- cyclical harvesting of the cad in farmers' fields after establishing densities of 50 per hectare.
- planting and harvesting of other leguminous tree species serving the multiple purpose of fuelwood windbreaks, field boundaries and sources of fodder (e.g. *Prosopis juliflora*).

Eucalyptus planted for polewood and sold for cash may become a pattern in the Basin. In the Sine-Saloum, the Unités Expérimentales found this to be a profitable alternative to cropping. In many of the small eucalyptus plantations in the process of being established in the Groundnut Basin, village men almost invariably state the intention of using them as "bois de service", for local use of sale. This emerging pattern reflects the relative scarcity of straight poles for construction.

The harvesting of cad will require a change in laws governing tree cutting.

Eucalyptus plantings in villages are more likely to serve the needs for polewood, for local use or for sale.

C. The Manure Linkage

As elsewhere in Africa and the developing world, the stabling of livestock along with an increase and improvement in the use of manure are among the first steps of agricultural intensification. Manure is especially important in the Groundnut Basin because of the cation exchange capacity it confers to the light, sandy dior soils. Manure or compost is also needed to restore soil productivity in degraded sites. Is it used now? Is there enough? If not, is it possible to produce more? Can the additional livestock be supported and can farmers be motivated? These are some of the principal development questions that arise and which are explored below.

Present use

Manure is used mainly for millet, but also sorghum and winter vegetable production, the latter being of increasing importance in Thiès. Manure may also be applied to peanut fields, but it is burned along with other vegetative matter just prior to the rains, a practice which makes K and P more available -- perhaps too quickly -- and which is consistent with nutrient needs for peanuts.

Traditionally, fields have been manured by temporarily corraling herds (parquage) on fields to be planted. This practice results in greater losses of nitrogen to the atmosphere than when the manure is plowed in after spreading. But surprisingly CNRA soil researchers have found no significant differences to millet production between surface application of manure and plowing it in (Ganry & Bertheau, 1980) If, however, nitrogenous fertilizer is also used, the manure must be plowed under to obtain the greatest combined benefit and conserve the soil. 1/

1/ "Agricultural intensification which calls for nitrogenous fertilizer, induces mandatory turning under of transformed organic matter in order to maintain the fertility potential of this type (dior) of soil". (Ganry, F. and Guiraud, G. 1978. Method of Manure Application and the Nitrogen Balance in a Sandy Soil/Millet System of/Senegal - A study performed with N_{15}. (Paper presented at International Colloquim on the Use of Isotopes and Radiation in Phytopedological Research, Colombo, Dec. 11-15, 1978).

The practice of corraling herds means that manure will be deposited towards the end of the harvest season and immediately following when herds are still in the vicinity of the villages, consuming crop residues. Towards the end of the dry season, they must be herded to the forêts classées or other range areas where there is browse. Therefore, manure deposited by parquage remains on the surface during the driest months, prior to the onset of rains, when it is subject to maximum dessication and vaporization.

In practice, the plowing in of manure would require that it be held in a manure pit throughout the dry season until the first rains, when the soil becomes humid enough to plow. In other words, the technique of plowing in manure necessitates a considerable effort and represents a major innovation that is seemingly not justified on the basis of increased nitrogen content to the soil alone. Other benefits must be mentioned however: the organic matter and its provision of minor nutrients (S and Mg) its enhancement of cation exchange capacity, of soil tilth, and of soil water holding capacity. Consequently, on the basis of CNRA's experimental work using no less than 10 m.t. of manure per hectare, SODEVA recommends that same level of application to farmers throughout the Peanut Basin. Ten tonnes is the amount produced in a year by one stabled ox.

Manure supply

Is there enough manure in the Groundnut Basin to provide the necessary amounts? The answer is, "Not at 10 tons/hectare". SODEVA undertook to examine this question in a review of the integration of livestock into agriculture ("Integration Elevage-Agriculture"; individual mineographed reports were produced for each of the four departments, on the basis of 1981 data.) Results are summarized in the Programme Technique (SODEVA, March, 1982, p.68).

Table Manure Production from Stabled Livestock Groundnut Basin, 1981 (Source: SODEVA)*

	Yearly manure production/head (m.t.)	Numbers	Tonnes manure
Draft oxen	10	71,932	719,320
Stall feed beef cattle (4 mo. program)	2.5	10,437	26,092
Horses	2.5	222,817	557,042
Donkeys	1.0	112,992	112,992
			1,415,446 tons = 141,544

Stabled livestock in the Groundnut Basin could supply manure for 141,544 has at 10 Ts per hectare or about 15% of the area planted in cereals (millet and sorghum)*. Sine-Saloum Delegation estimates that herd cattle yield about 2.5 tonnes of manure per head per year. This would correspond to the manure deposited by corralled animals. Numbers of herd cattle were 131,000 in Thiès and 461,650 in Sine-Saloum, yielding 327,500 m.t. and 1,477,280 m.t. respectively. Herd cattle in Diourbel and Louga were not estimated. Herd cattle produce a far greater quantity corresponding to 32,750 has in Thiès, or 27% of the 1981 cereal land, and 148,000 has. in Sine-Saloum, or 34% of the land planted in millet and sorghum in 1981. To what extent this manure is in fact applied to cereal fields was not ventured in the SODEVA reports.

SODEVA's Sine-Saloum delegation estimated that at an average rate of 4.25 tons per hectare, there would be enough manure for Sine-Saloum's 490,000 has. of cereals land (millet, sorghum and corn). In 1981, almost 443,000 has. were planted in cereals in that region. Experimental data have not yet been developed for application rates lower than 10 T. per hectare, so the benefits of lesser amounts cannot be projected.

Fodder supply, Thiès

More manure means larger numbers of livestock who in turn require greater amounts of feed. Are there sufficient fodder resources? Only SODEVA's Thiès delegation attempted to analyze the availability of fodder and compare it to needs. The energy and protein value of forage in fallowed fields (127,000 has.) and of the following agricultural by-products were tabulated: millet stalks (2/3 of total stalks), peanut and cowpea vines, and millet bran. Domestically produced peanut cake, widely used for cattle feeding, and browse resources were not calculated, however.

* SODEVA's figures for manure output correspond with estimates by FAO of manure production per day of 8% of live weight, assuming about 70% water. The SODEVA Thiès delegation reports that CNRA in Bambey has measured the daily manure output including litter, of a pair of stabled oxen totalling 800 kgs as 13 kgs. or only 1.6% of live weight. The discrepancy needs checking.

Peanut and cowpea vines provide an almost complete ration of energy and protein; cowpea vines are more nutritious than peanut vines. The cowpea vines from one hectare weigh about one metric ton and would virtually suffice to fatten a steer for four months.

These various by-products were computed to have a total energy value of 144 million forage units and 10,846 m.t. of digestible protein in 1981. This was more than sufficient for the department's domestic livestock (draft oxen, fattening beef cattle, horses and donkeys), whose combined needs were 97 million forage units and 8,779 m.t. of digestible protein. However, the additional needs of the herd cattle, sheep, and goat populations far exceeded the available agricultural by-products. Total needs are more than double the supply of agricultural by-products in Thiès (Table).

Table Thiès, Livestock Nutritional Requirements and Feed Supplies, 1981.

	Energy needs	Protein needs
	10^6 forage units	Digestible protein in metric tons
Domestic livestock		
draft oxen, cattle for fattening, horses, and donkeys	96.80	8,799
Grazed livestock		
cattle	119.3	7,074
sheep, goats	81.1	6,906
Total needs	297.2	22,759
Available fodder (millet stalks, millet bran. peanut and cowpea vines)	144.04	10,846

Animal Feed Requirements and Supply, Thiès, 1981

(Source: SODEVA, Delegation Thiès. 1981. Integration Elevage-Agriculture)

	No Head	Requirements Energy a/	Requirements Protein b/	Amount Available from crop residues Energy a/	Amount Available from crop residues Protein b/
Domestic Livestock					
Mbour					
Draft oxen	707	1.4	103		
Beef cattle	462	0.36	33		
Horses	15,700	25.7	2,292		
Donkeys	10,600	5.7	583		
Subtotal		33.16	3,011	32.41	2,827
Thiès					
Draft oxen	1,045	2.1	152		
Beef cattle	663	0.51	37		
Horses	12,000	19.7	1,752		
Donkeys	6,500	3.5	357		
Subtotal		25.81	2,308	36.53	2,350
Tivaouane					
Draft oxen	374	0.76	54		
Beef cattle	610	0.47	43		
Horses	16,900	27.7	2,467		
Donkeys	16,300	8.9	896		
Subtotal		37.83	3,460	75.10	5,669
Totals' Domestic livestock		96.80	8,779	144.04	10,846
2. Additional animals					
Herd cattle	131,000	119.3	7,074		
Sheep, goats	222,800	81.4	6,906		
3. Grand Total		297.2	22,759	144.04	10,846

a/ Millions of forage units b/ Tonnes digestible protein

It is impossible to estimate to what extent other sources of feed provide for the computed additional food needs of Thiès' herd cattle. Thiès Department has about 300,000 has. of wooded of savannah land that is non-agricultural, including classified forests, which are generally browsed and grazed, as well as periodically exploited for fuelwood or charcoal. (Presently cutting has been entirely halted). Transhumance, or seasonal migrations of herds, is practiced but no information was obtained on the geographic scope and pattern of herd movements. It would seem, in any case, that the Department's livestock population in 1981 was very close to, if not in excess of available food resources.

The demand in nearby Dakar for beef and mutton insures that in Thiès populations of cattle and sheep will probably remain at the limit of food resources. Also Dakar's consumption of fresh fruits and vegetables will continue to stimulate the steady conversion of cereal and peanut lands nearest Dakar to horticultural crops. These apparent trends and resources use patterns comprise the dynamic context for viewing soil resources and related fertility management in Thiès. In considering the prospects for increasing stabled livestock, (which would be needed to increase effective manuring of fields), the economic incentive to fatten cattle or sheep for the Dakar market may be greater than the desire to have draft oxen in place of the horse or donkey. However, both may be needed (i.e. fattening cattle as well as draft oxen) to the extent that a fodder would have to be produced. This means that part of the land resource would have to be devoted to fodder production. This would require intensification of production to achieve higher yields per unit area, thus plowing in of organic matter, either compost or manure, to complement the application of chemical fertilizers and better crop management techniques.

It might be economical, to develop small plots or irrigated forage grasses or legumes, for making silage, provided ground water is not too deep. Such forage crops would have to be very high yielding in order to compete with the possibility of irrigated vegetables. In addition, peanuts and cowpeas with higher yields of vines can be considered. A "forage" cowpea has been developed but not diffused widely, mainly for lack of sufficient seed.

Finally, composting of millet stalks as well as weeds and other vegetative trash could be done to supplement manure. Manure pits could be large enough to contain quantities of millet stalks, which require five or six months of natural composting due to their high initial carbon to nitrogen ratio (100:1). (Nitrogen in compost is not released as nitrate assimilable by plants until the C:N ratio is reduced to 1:15).

Further analysis is not necessary to make the point that the restoration and maintenance of organic matter in Groundnut Basin soils is inextricably related to the further integration of livestock into agriculture in the region. It should also be very clear that agricultural residues are by no means an unused resource. In fact the increased amounts of residues accompanying higher production will be necessary to feed the work animals that make intensification possible, or to restore organic matter to the land. Finally, near Dakar, the commercial drive to intensification will provide a profit motive for soil fertility maintenance.

The Unique Role of Manure and Its Significance for Intensification Strategies

The use of manure and draft animals in the Groundnut Basin seems to present an exception to the model of agricultural intensification that has evolved from observation elsewhere in Africa and the developing world. In general that model declares that because returns on labor expended in manuring fields are less than returns on labor in extensive production systems, the use of manure becomes generalized only at the point where severe land constraints develop. The exceptional case of the Groundnut Basin is explained by the very low cation exchange capacity (C.E.C.) of the light sandy, dior, soils that predominate in the GNB. The low C.E.C. is explained by the very low clay content of 4% or less, and, increasingly, the diminished organic matter content (1% or less) resulting from the abandonment of long fallows. It may be noted that soil organic matter affords 4 times as much C.E.C. as an equivalent percentage of clay. Though one or two years of grass fallow may be practiced in places, no important additions of organic matter are derived from this practice (Notwithstanding this fact, grass fallowing is recommended by SODEVA.) Thus manuring is needed to supplement chemical fertilizers, rather than to overcome land constraints.

On dior soils, production increases from chemical fertilization are dependent upon manure (or compost) to store fertilizer nutrients in an exchangeable form. Without the C.E.C. returns on chemical fertilizers will be low. Therefore, the need to regularly incorporate soil organic matter levels in Groundnut Basin soils, especially the dior soils, appears to exist even for relatively extensive production systems, as long as some chemical fertilizers are used. Lastly, in terms of drought risk prevention, soils with organic matter hold moisture better and produce better yields during drought years than those without.

The use of two-oxen teams for plowing also presents an unusual case in the Groundnut Basin, in that the draught power is needed for deeper plowing than can be achieved by a single ox, horse or donkey, particularly if post-harvest plowing is to be accomplished. Deep plowing (20 cm) and post-harvest plowing both enhance water storage in the root zone. Post-harvest plowing interrupts capillary movement and resulting evaporation of remaining water from the deeper soil levels (1/2 meter to 1 meter), thereby conserving a reserve of moisture to the next crop season. It also diminishes wind erosion by roughening the soil surface, which slows the wind. Finally, the rough surface enhances rainfall percolation, provided it is not tread upon by animals during the dry season.

Post harvest plowing, has yet to be accomplished on a practical level in the Groundnut Basin also, the combination of organic matter additions, deep plowing and post-harvest plowing have not yet been researched. It is to be expected that the total benefits of these combined practices will exceed the sum of the individually researched benefits, especially in low rainfall years.

Conclusions

Manuring, along with deep plowing, and post harvest plowing are techniques that enhance the return on fertilizers and limit drought risks. They are techniques that elsewhere would probably not be adopted until greater land constraints develop than presently is the case in the Groundnut Basin. But soils conditions in the Groundnut Basin recommend their use where fallowing is no longer practiced, and especially in the middle and northern, drier, portions.

The best use of manure will require stabling of animals, and the use of manure pits, and the spreading and immediate deep-plowing of manure into the soil.

The improved and greater use of manure therefore entails the development of a package: stabled livestock, training of draft oxen, production and conservation of fodder, use of carts for transportation of manure.

Crop residues and fallow field grazing resources are approximately adequate, or slightly more than adequate, for the present population of livestock kept year around in villages. But the total livestock population including herd animals far exceeds the fodder supply provided by crop residues and fallow. Fodder resources must be developed in a way that does not compete with food or cash crop cultivation.

Manure resources are not used well and are not sufficient in quantity to be applied to cereals lands at the 10 m.t. per hectare rate recommended by CNRA and SODEVA. Stabled livestock could supply 15% of the manure needed. Free ranging herd livestock are more numerous and produce more manure, a portion of which is deposited in cereal fields, but the manure dries out and nitrogen loss by vaporization decreases its value.

The effects of less than 10 m.t. per hectare of manure have not yet been determined, nor has the combination of manuring, deep plowing and post harvest plowing been researched.

D. Development Contexts for Land Regeneration & Conservation

In the broadest sense, the context for land regeneration and conservation in the Groundnut Basin is one of agricultural intensification and, where possible, diversification of agriculture. With few exceptions, land regeneration and intensification of production entail some of the same land management techniques. Thus in terms of land management, land regeneration (or conservation) and agricultural intensification are synonymous, and certainly not mutually exclusive. In fact, agricultural intensification cannot be achieved and sustained without the application of land management techniques associated with land regeneration and conservation in the Groundnut Basin, namely,

manuring
composting
liming
crop rotation
deep plowing and post harvest plowing
contour plowing, bunds or diquettes
windbreaks

All require energy and resources, and therefore incentives. At least three specific contexts for these practices can be identified: (1) desire for food security, (2) desire for profit (cash income), (3) desire to conserve or regenerate the land. Each context would entail a slightly different development approach.

(1) Food security

Fertility maintenance through manuring on toll keur lands surrounding villages devoted to millet for food needs has made these among the richest soils, and exemplifies the food security motive for conservation and intensification. This traditional practice can be supplemented by other techniques (see above), but it must be remembered the costs if any would have to be covered by surplus generated either on the toll keur fields or on other fields.

(2) Profit

Cash income from crops in the Groundnut Basin is generated in the outfields, beyond the tell keur lands, where millet and peanuts are planted in rotation. Cowpeas may also be planted as a catch crop on millet fields. Outfields are the lands that are slowly degrading, according to farmers' accounts of yield decreases, as a consequence of the elimination of long fallows. Here agricultural intensification/land regeneration could be motivated by the desire for more profit (in which cases practices will have to be proven profitable). Practices such as manuring are not new and are of obvious benefit. Other practices which will boost production in rainfed agriculture are not so obvious: deep plowing, plowing in of organic matter, contour plowing and perhaps windbreaks.

Outfields comprise at least 70% of the cultivated land in the Groundnut Basin, so their better management and conservation is proportionately important.

The introduction and sustained application of land regeneration and conservation techniques in outfields will probably be more difficult to accomplish than in the case of the tell keur millet producing lands, or the most seriously degraded lands which merit a single purpose regeneration effort. This is because the needed regeneration/intensification techniques in outfields must be profitable, which makes them dependent upon the smooth functioning of public and private sector agricultural support as well as the international peanut market. Moreover, the profitability of many techniques has not been demonstrated, except at experiment stations, whose soils are generally more fertile than those in villages. Yet assuming that supplies of inputs and the marketing of harvests can be achieved, innovations in intensification/regeneration should be quickly accepted and adopted as part of the agricultural techniques.

A special case is posed in Thiès by lands near to Dakar being converted to horticultural production with the aid of dry season irrigation and intensive manuring. The profit incentive generated by Dakar markets for fruits and vegetables ensures an excellent context for the introduction of improved methods of soil management and conservation.

(3) Desire to conserve or regenerate the land

This is of course the desire of AID, and the Government of Senegal and it is undoubtedly desired by the rural people of the Groundnut Basin, although it may not be well articulated to the extent that the rural peasant is not likely to articulate that which cannot be envisioned as possible to achieve. (This paper represents, in fact, an attempt to envision on the part of AID that which is possible to achieve). It is reasonable to assume, nevertheless, that rural adults and leaders wish a prosperous and stable future for agricultural activities in the Groundnut Basin. The planting of trees belies a positivistic vision of a more prosperous future, as does the protection of Acacia albida and ronier palm regeneration. A more clear vision would be held if the full range of techniques for land conservation and regeneration were effectively and widely communicated.

However clearly land conservation or regeneration motivated by long term rather than short term profit motives may be desired, it would have to be limited, in the absence of outside support, to techniques that would not require cash expenditures, or the sacrifice of food or cash crop production. Obviously the greater the population density, the more likely it is that energy expended in land conservation or regeneration work with a long term payoff will compete with energy and resources needed for immediate needs. Densely populated regions with degrading lands will need therefore some measure of outside aid in order to subsidize land regeneration work. Less densely populated areas may need only extension assistance and minor incentives. How can the most critically degraded areas be identified? Some criteria are soils analyses, yield estimates (corrected for rainfall and improved seed or fertilizer inputs), the comparison of man/land ratios with yields estimates, the condition of Acacia albida trees (e.g. large or mature trees, with severely pruned crowns, no regeneration), population composition by age group (Maison Familiale and Promotion Humaine workers commonly obtain such information), opinion surveys of C.E.R. agents and other field workers.

It is this writer's opinion that degraded areas (eroded, infertile, acid) can be regenerated if a combination of techniques is employed, and that regeneration work would not preclude production of useful, harvestable plants or plant products. A research and development approach on farmers fields is the next step.

Soil Conservation, 1982

Extension and supervision					
Manure spreading (has.)	63,334	31,903	12,320	7,075	12,035
Manure, plowing in	10,596	2,196			8,400*
Residues, plowing in	3,286			3,286	

* The report "Integration Elevage-Agriculture Delegation de Thiès notes on p. 31, however, that in Thiès,.. "l'enfouissement... n'est pas pratique". Also that there are insufficient charrettes to get the manure to fields.

Conversion factors used by SODEVA to estimates food value of crop residues and animal food requirements.

PRODUITS	VALEUR ALIMENTAIRE (Food value)		RENDEMENT Kg/ ha (yield)	DISPONIBLE A HA	
	U. F. (Forage Unit)	M.A.D. (Digestible Protein)		U.F.	M.A.D en kg
- Tiges de mil (millet stalks)	0,15	3	2.000	300	6
- Paille arachide (Peanut vines)	0,4	50	1.000	400	50
- Fanes de Niébé (Cowpea vines)	0,6	90	1.000	600	90
- Jachère (fallow growth)	0,15	15	1.000	150	15
- Son de mil (millet bran)	0,8	80	182	146	15

- Tiges de mil = 3 x le poids graines 1/3 réservé à l'usage domestique.
- Fanes arachide = Poids paille = poids coquis
- Son de mil = 20 % poids graines
- Fanes de Niébé = 1 T ha.

1.3.3.4. Estimation des Besoins

Besoins théoriques annuels des animaux

	Besoins journaliers		Besoins annuels		
	U.F.	M.A.D en gr.	Nbre jours	U.F.	MAD kg
- Bovins de trait (Draft cattle)	5,6	400	365	2.044	146
- Bovins à l'embouche (fattening cattle)	6,5	600	120	780	72
- Bovins aux troupeaux (herd cattle)	2,5	150	365	912	54
- Equins (horses)	4,5	400	365	1.642	145
- Asins (donkeys)	1,5	150	365	547	55
- Ovins et caprins (sheep, goats)	1	85	365	365	51

- Pour les bovins de trait les besoins couvrent l'entretien et la production de force de traction.

Les besoins de l'embouche sont donnés en tenant compte de la production de viande et de la durée de l'embouche qui en moyenne ne dépasse pas 4 mois.

Chez les bovins aux troupeaux il est seulement tenu compte des besoins d'entretien. L'animal de référence pris est un bovin de 250 kg (1 U.B.T.).

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