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MINISTERE DU DEVELOPPEMENT RURAL
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DIRECTION DE LA RECHERCHE AGRONOMIQUE

OAU / STRC / SAFGRAD
FARMING SYSTEMS RESEARCH PROJECT
U. R. P. - INA

POTENTIALS OF AGROFORESTRY IN NORTHERN BENIN

Otsyina R. M, M. Kamuanga and R. Dovonou

DRAFT

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POTENTIALS OF AGRO-FORESTRY IN NORTHERN BENIN.

Introduction.

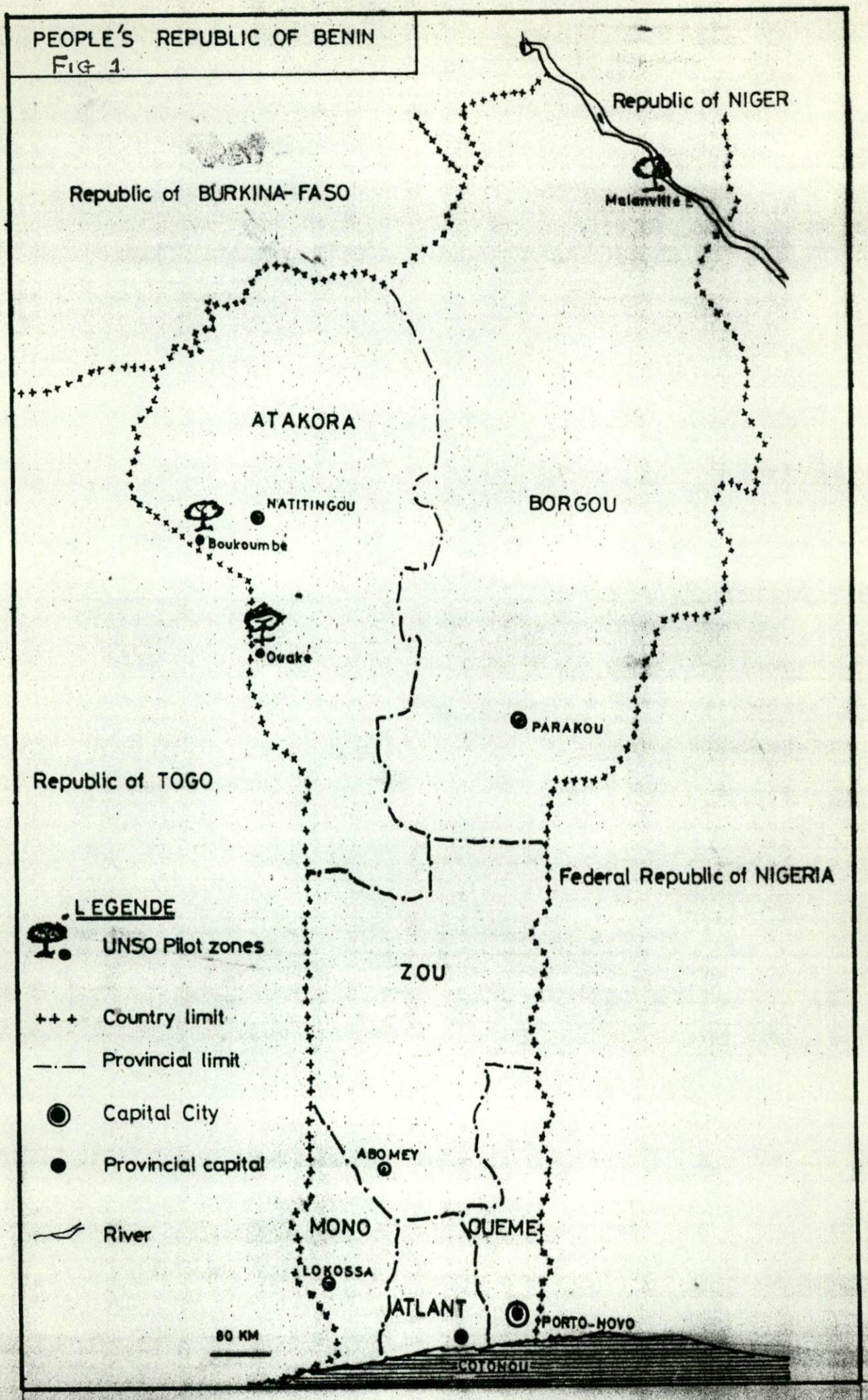
Northern Benin comprising the two provinces of Borgou and Atacora (Figure 1) is the zone of intervention of the Farming Systems Research (FSR) supported through SAFGRAD. Project activities are integrated into the national agricultural system as part of the Unite de Recherche et de Production (URP) at Ina.

The zone was selected for its high potential for agricultural production; it has however, been lately affected by unfavorable agroclimatic conditions that induced desertification in the extreme north. In certain areas poor soil fertility and intense deforestation have resulted in soil degradation, reducing the potential for increased agricultural output.

The SAFGRAD/FSR project focus is to improve the national Farming Systems Research (FSR) capacity so as to develop a method of production that integrates trees, crops and livestock as well as to utilize techniques that could conserve soil moisture and other resources.

Since 1985, the FSR team has been engaged in reconnaissance surveys to identify constraints to increased production and farmers' strategies to cope with them. In 1987, the programme launched a series of researcher and farmer managed trials to address the constraints to increased crop production (SAFGRAD/Benin Annual Report 1986).

Agroforestry -- the practice of associating trees in crop and livestock systems, is now one of the major aspects of the FSR research activities in Northern Benin. Before improved


PEOPLE'S REPUBLIC OF BENIN
FIG 1
Republic of NIGER
Malanville
Republic of BURKINA-FASO
ATAKORA
NATITINGOU
Boukoumbé
BORGOU
Ouaké
PARAKOU
Republic of TOGO
Federal Republic of NIGERIA
LEGENDE
UNSO Pilot zones
ZOU
Country limit
Provincial limit
Capital City
Provincial capital
ABOMEY
River
MONO
OUEME
LOKOSSA
ATLANT
PORTO-NOVO
80 KM
COTONOU

agroforestry practices can be introduced and/or in order to propose modifications to traditional agroforestry systems, knowledge and understanding of the present land use systems, their functions and interactions, as well as major constraints in the farming systems is necessary to determine posibilities and potentials for agroforestry solutions.

This report therefore reviews background information and results obtained in previous diagnostic surveys as well as available literature on agroforestry in northern Benin and suggests probable agroforestry solutions to some of the major identified constraints.

1. The Project area

1.1. Location, Topography, and Climate

The West African People's Republic of Benin covers an area of 112,600 km2 with a population of 3.6 million (Adam and Boko,1983).

Benin is situated between latitudes 6°30' and 12° 30' north stretching across five agro-ecological zone (Figure 2) :(1) coastal forest zone, (2) Southern Guinea Savanna, (3) Northern Guinea Savanna, (4) the Sudan Savanna and (5) the Sudano Sahelian Savanna in the extreme north.

The SAFGRAD/Benin Project mandate covers the two northen provinces of Borgou and Atacora with a total area of 82,200 km2 (73 % of Benin total area) and a population of 1,001,500 inhabitants (28 % of total).

The topography of the Atacora province is characterized to the north by two parallel mountain chains rising between 400 and

600 m above sea level and separated by the Panjari river. South Atacora consists of moderately undulating plains between 150 and 200 m. The Borgou province is dominated by a peneplain sloping northwards and southwards from the watershed situated around the 10 th parallel. The relief ranges between 200 and 500 m above sea level.

As shown in Figure 2, the project area stretches over three agro-ecological zones namely the transition from sudan to Sahel savanna (long term mean annual rainfall of 900 mm), the Sudan Savanna in the middle belt (1100 mm) and the Northern Guinea Savanna on the southern part (1200 mm). Rainfall figures for the past 10 years indicate a subtantial decrease of about 400 mm in the extreme north and 200-300 mm in the south.

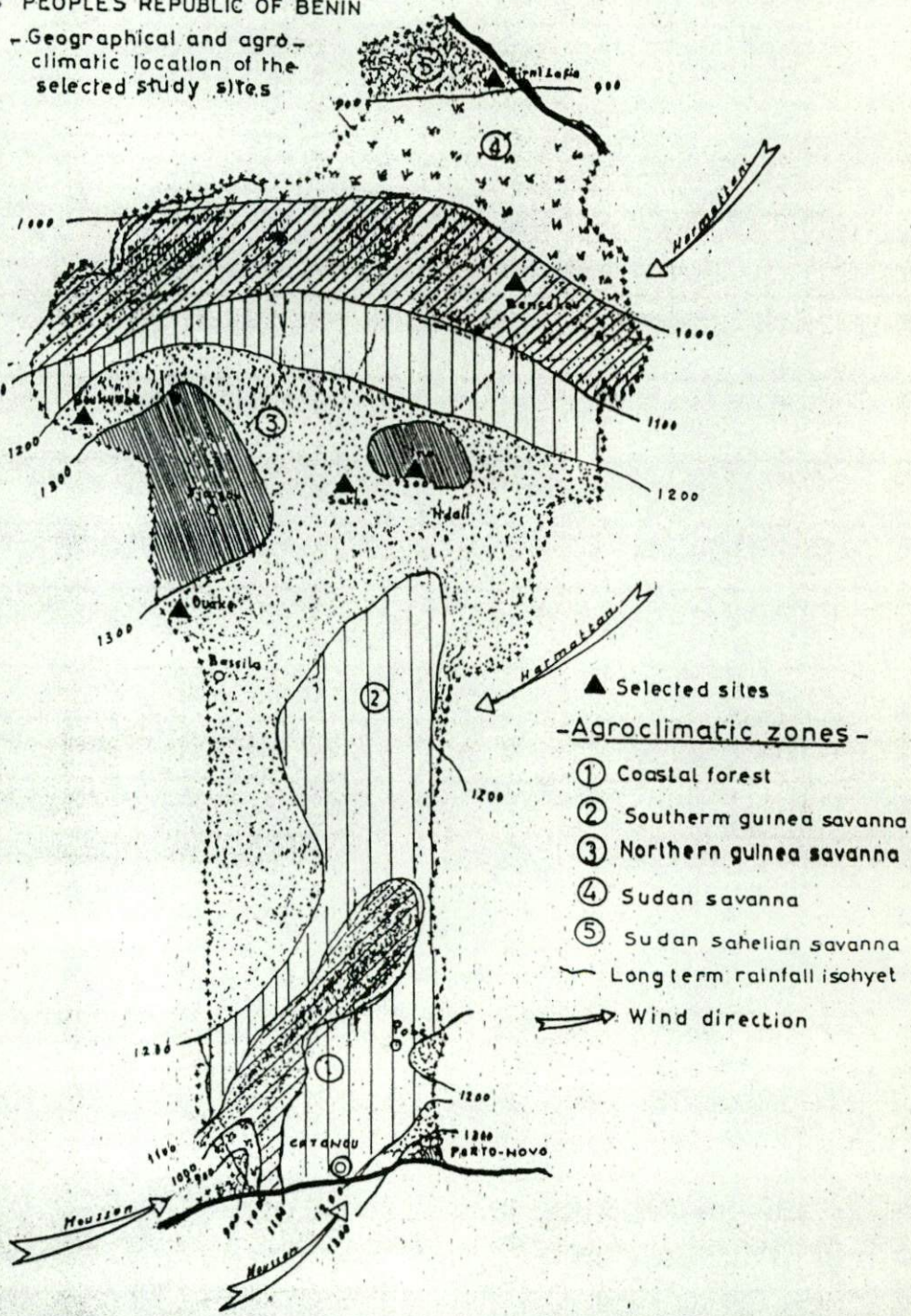
Rainfall distribution in the north is unimodal. It starts in March/April in the three zones but may not stabilize until May. Rainfall peaks occur in August and drop gradually until the middle of October. The dry season goes from November through March and is characterized by strong Harmattan winds blowing from the northeast.

The short duration and irregular rainfall distribution patterns coupled with high evapotranspiration, especially in the Sudan and Sudano-Sahel Savannas further limit moisture availability for crop growth (CARDER/Borgou 1986, figure 3).

Temperatures average 27° C annually but the range varies considerably. In January, the hotest month, diurnal temperatures may rise to 43°C in the Sudan - Sahel transition zone.

Fig.2 PEOPLE'S REPUBLIC OF BENIN

- Geographical and agro-climatic location of the selected study sites



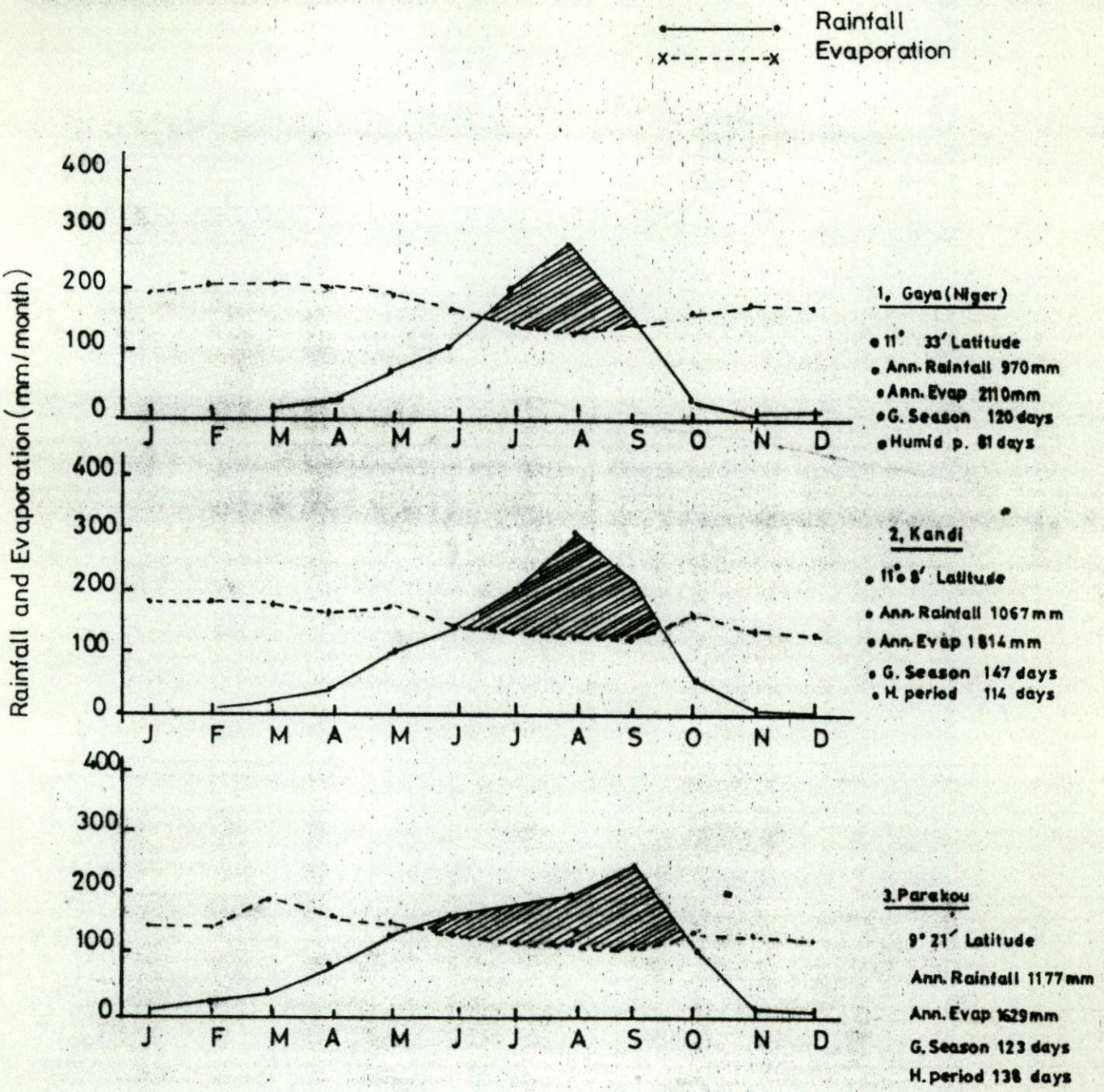


Fig.3 Agro-climatic data of Gaya(Sudan Sahel)
Kandi(Sudan Savanna) and Parakou(Northern guinea)

Source: Borgou II 1986

1.2. Vegetation and soils.

1.2.1. Vegetation

Vegetation in the two provinces ranges from the Sudano-Guinean forest Savannah in the south to the short grass Savanna in the north. (FAO 1980).

a. Sudano-Guinean Savanna (Woodland Savanna).

This formation is characterised by an open or closed ligneous upper story of small trees, 8-15 meters tall and an understory of tall and tufted grasses.
Woody species most frequently encountered include : Isoberlinia, Vapaca, Daniellia Terminalia, Cussocria, Vitex, Parkia, Lophira and Butyrospermum. Herbacious grass species include :Andropogon gayanus A. seudoporicus, Bechropsis uniseta, Cternium elegans, Hyparrhenia spp and Pennisetum pedicillatum.

b. Short Grass Savanna. (Shrub Savanna)

This is found in zones of less than 1000 mm rainfall (Malanville 850 mm). It is characterised by short and widely dispersed trees and shrubs. The most common trees include Anogeissus leiocarpus and Afzelia africana. Thorny shrubs are more frequently found in this zone notably Acacia pennata, Aacia marcrostachya, and Ziziphus spinachristi.

The understory is dominated by setaria sphacelata, S. anceps, Hyperrhenia ssp. Andropogon spp. and Aristida spp. Equilibrium between the ligneous species and the grasses is maintained by the annual bush fires resulting in a fire sub - climax formation. In between these two formations is the scattered tree savanna, characterised by tall grasses and tall but scattered trees.

1.2.2. Soil

The wide spread soil group in the project area is ferruginous tropical (80% of area in Borgou province) generally classified into sub-groups according to degree of leaching. Then follows (in order of importance) for the Atacora province the ferruginous,weakly developed, raw mineral and hydromorphic soils. Their agricultural potential is fair and under existing techniques, the soils of Atacora cannot stand continous cropping. Also represented in the Borgou province are ferralitic weakly developed soils (3 %) including alluvial soils of the Niger Valley. The soils of Borgou are generally considered to be fairly productive.

1.3. Land Use and Agricultural Economy.

1.3.1. Land under cultivation.

Borgou has 13 600 km2 of forest reserves covering 27 % of its area. Over half the total area (27,500 km2 or 54 %) is arable. However only 6.9 % of it is currently under cultivation. About 48,300 ha are under fallow. Half the total area of Atacora (31,200 km2 is arable land of which only 11.5 % is under cultivation. About 834 230 ha are under forest reserves, and fallow land covers 54 700 ha. Areas under major crops, yields and relative importance in both provinces in 1985 are shown in table 1 below.

Table 1. Major crops, yields and relative importance in Borgou and Atacora

	A R E A (ha)					
CROP	Borgou	%	Yield (t/ha)	Atacora	%	Yield (t/ha)
Cotton	44,300	23	1.2	2100	1.4	1.1
Groundnuts	7,200	4	0.9	7400	5	0.5
Maize	35,100	19	0.8	15,700	10	0.8
Surghum/millet	57,300	30	0.7	59,600	40	0.6
Rice	1,600	1	1.3	4,600	3	1.0
Manioc	7,200	4	5.6	9,600	6	8.8
Yams	21,500	11	8.3	36,300	24	9.1
Cowpea	13,900	7	0.5	10,800	7	0.5
Others	1,800	1	-	4,600	3	-

Source : Borgou II, CARDER/Atacora.

1.3.2. Crop yields, farm sizes and population

Most food crops are grown in association. The most frequent mixtures are sorghum/maize, sorhum/millet, yams/beans, and yams/millet/beans. The yields of most cereals are low (less than 1.0 t/ha) as fertilizer and improved seeds are not generally used. Since 1981 the land area planted to cotton has steadly increased as a result of increased use of inputs such as fertilizer and better cultural practices. Yield as high as 1.7 ton/ha is currently obtained by farmers.

There are about 64 640 rural households (non-Peulhs) in Borgou making up some 39 820 farms with about 9 to 10 members and 5

active workers on average. Farm sizes range between 3 and 7 hectares and currently just over 50 % of farmers in Borgou grow cotton using animal traction.

The number of farms in Atacora is higher and estimated at 61,000 (CARDER/Atacora,1985). This is partly due to the structure and functioning of Somba families whose widely scattered housing arrangements lead to increased household autonomy. Farm sizes range between 2.7 and 3.3 ha with 4.8 and 3.1 active workers,respectively. Animal traction use is not yet wide spread.

1.3.3. Livestock

Livestock plays an important role in the traditional production systems of Northern Benin. Borgou province is the major producer of livestock in Benin providing some 560,000 head of cattle (62 % of the national heard), 451,000 sheep (41 %) and 351,000 goats (33 %). In the Atacora province the livestock population is estimated at 185,000 cattle and 250,000 small ruminants. The most important cattle breeds are Somba and Borgou (a cross between Somba and Zebu).

Although a great majority of cattle and small ruminants is managed by Fulani herdsmen,, small holder farmers also own and manage small numbers of cattle and small ruminants for draught, manure, milk, farm transport, meat and cash. Survey data showed that 100, 78, and 12 % of families in the Sahel, Sudan and Guinea Savanna zones respectively own and manage livestock for animal traction. Interactions between livestock, crops and trees are very pronounced. Animals provide labour and manure to increase crop production while crops, in the form of residues, provide a significant amount of fodder for animals during the season. Trees

at the same time are a good source of browse and tools.

Most farmers keep small ruminants (5-10 per farm),poultry and 2-6 cattle for traction. Compound management consists of keeping herds permanently on natural pasture with little or no supplementary feeding. The great majority of these however are in herds of up to 200 head enthrusted to Peulh (Fulani) herders. They subsist on natural vegetation, crop residues and salt. Transhumance becomes a necessity during the long dry season because of the scarcity of water.

1.3.4. Trees and forest products

Trees and shrubs also play a significant role in the traditional farming systems of the northern region through the restoration of soil fertility, provision of fruits, wood and fodder. It is reported, for example, that marketing of karite nuts has generated some 137.8 million CFA over the last 9 years in Borgou province. The production of cashew nuts, 688,305 tonnes between 1978 and 1986 was estimated at 41.6 million CFA (CARDER/Borgou 1986).

Firewood and wood for construction (ie. timber poles etc.) constitute the major demands for wood and wood products. Until 1984, all wood consumed for firewood and construction came from natural forests and savannas. Although precise data is not yet available on the demand and consumption of firewood in the north, estimates based on surveys in the south (Tchiwanou 1987, Personal communication) indicate a basic need of 2.4 M3 of wood per person per year. On this basis, about 138,000 and 139,680 m2 of firewood would be required for the Borgou and Atacora provinces respectively in 1987. Other estimates, expecially for

construction based on contrywide averages are presented in table 2. There is a clear indication of significant and increasing wood product deficits in Northern Benin. The situation seems more critical with increasing populations, cultivation and deforestation.

Recent studies on charges in vegetation cover in two districts in the north (Malanville and Djougou FAO/PNUD 1980) as a result of deforestation and cultivation are presented in tables 3 and 4.

Table 2 : Estimated minimum annual wood production and requirements for construction in Benin.

	1977	1987	1997
Production	8.000	21.300	12.400
Requirement	15.800	11.700	26.200
Deficit	7.800	12.800	13.800

Source : MDRAC 1978.
Note : Data is available only for construction , however some of this wood is also used for fuelwood and charcoal.

Table 3. Changes in vegetation cover during a 25 year period in the Malanville district (Extreme north).

	1950		1975		
Vegetation type	area ha	% of total	area ha	% of total	Rate of Charge (1) ha/yr
Woodland Savanna	2481	6.20	53	0.13	- 97.8
Scattered tree Savanna	26197	65.52	3,234	8.09	- 918.0
Shrub Savanna	59	0.14	23,306	58.30	+ 929.8
Galery Forests	643	1.60	641	1.60	- 0.08
Rocky formations	147	0.36	434	1.08	+ 11.5
Flood plains	6509	16.28	4929	12.33	- 63.4
Cropland,fallows and habitations.	2600	6.50	6806	17.02	+ 264.2
Bare Soils	66	0.16	56	0.14	- 0.4
Water	584	1.46	522	1.31	- 2.48
TOTAL Surface	39981	100	39981	100	---

Source FAO/PNUE 1980

(1) + Increasing trends
- Decreasing trends

Table 4. Changes in vegetation cover as a ressult of deforestation and Agriculture in the Djougou District (South Atacora).

	1950		1975		
Vegetation Type	area ha	% of total	area ha	% of total	Rate of Change ha/yr
Semi decidious forest	306	0.4	225	0.3	- 3.24
Degraded forest	4450	5.8	62	0.1	- 175.5
Woodland Savanna	17734	23.0	2991	3.9	- 589.7
Shrub Savanna	10419	13.5	14722	19.1	+ 547.2
Galery Forest	4,125	5.4	1534	2.0	- 103.64
Rocky formations	103	0.1	737	1.0	+ 25.36
Bare soil	200	0.2	41	0.05	- 6.36
Crops, fallows and habitations	38937	50.5	56803	73.6	+ 714.64
TOTAL	77118	100	77118	100	

Source : FAO/PNUE 1980.
1) (+) Increasing rates (-) Decreasing rates.

In Malanville (extreme north) the woodland Savanna has almost disappeared in 25 years between 1950 and 1975 while the tree Savanna decreased at a rate of 85 % per year. These vegetation formations have been transformed into grassland and shrub Savannas. There was a two and half times increase in croplands fallows and habitations during the same period. Similar trends have been observed in Djougou (Table 4). In general, a serious degradation of forests and woodlands and a significant increase

in cultivated land have been observed for the past few years. Forest and woodland resources have decreased from 34 % in 1950 to only 6.3 % of total area in 1975, while the shrub lands increased by 19 %. Cultivation increase by 29.3 % of the total area. It is very clear that if these deforestation trends continue at the same rates (tables 3 and 4), all woodlands and forests will disappear in these zones by the year 2000. In consequence, the protective capacity of soils will be lost resulting in rapid soil degradation, erosion and adverse environmental changes.
Intensification of agriculture coupled with improved agroforestry practices seem to be an alternative for better management of the land to stabilize the fragile ecosystem and to provide basic wood needs.

1.3.5. Marketing of Food Cash crop and Livestock products.

Cotton is the only cash crop for which a marketing organization exists in the two provinces under the responsibility of CARDER. CARDER's activities extend to: (a) extension and provision of inputs (fertilizer, improved seeds equipments credit), (b) the purchase of cotton grain and its transport to ginning centers, (c) storage and ginning of cotton grain. Producer prices of cotton increased from 100 to 110 F/kg (first quality) in recent years. CARDER's role in the marketing of groundnuts is still minimal (IRFECO/CARDER, 1987).
There are no official marketing channels for foodcrops. Farmers sell their cereals in local markets or contract with private transporters. Reliable data regarding surpluses of foodcrops products are difficult to find. Recent estimate indicates that 42 % of the maize, 68 % of the cassava and 15 % of the yams produced

reach the market (FAO/World Bank, 1986). Cereal prices vary according to season and location. The price of sorghum for instance can increase from 30 F to 200 F/kg.

Marketing of livestock products is organized from Northern provinces to the south. The demand for livestock products is low generally as a result of low level of farm incomes. Meat consumption is estimated at 6 to 7 kg per capita (Louis Berger,1987), official prices for "boneless" meat are 700 F/kg in Borgou and 500 F/kg in Atacora.

1.3.6. Income

Farm incomes are largely dependent on the use of modern inputs, animal traction, and access to markets. In both provinces the average manual farmer (3 to 5 active workers) has net returns of about 93 000 F per year. Estimates of farm income with the use of animal traction, fertilizer, herbicides for cotton, improved seeds and proper work organization indicate that net revenues of up to 330.000 F.CFA can be earned. The sales of cash crops,such as cotton , groundnuts, tree products and livestock constitute major sources of farmer income.

1.4. Population

The last natural population census was carried out in 1979. The rate of population grouth is belived to be at 2.8 % per annum. On this basis current Borgou and Atacora populations are estimated at 575 000 and 582 000 inhabitants respectively with densities of 11.3 and 18.7 per km2 (Table 5). In comparison with the southern provinces, Borgou and Atacora have the lowest population

densities in Benin.

Table 5. Estimates of total population and densities by province 1986.

Province	Population	Area (km2) km2	Density km2
Atacora	582 000	31,200	18.7
Atlantic	855 000	3,230	264.7
Borgou	575 000	51 000	11.3
Mono	578 000	3 800	152.1
Oueme	762 000	4 720	161.4
Zou	691 000	18 700	36.9
T O T A L	4.043 000	112 650	645.1

* the 1979 census gave a population total of 3.6 million

Source : Louis Berger 1987.

The Bariba, a Voltaic speaking group is the major ethnolinguistic group in the north. Others include the Somba who live between Atacora and Togo, the Pila Pila, the Dendi who are associated with the valley (North Borgou) and the nomadic Fulani (Peulh). All religious groups are represented in Northern Benin. About 15 % are Christians. The great majority of the population adheres to traditional religions while 15 % is muslim.

The rural population in Borgou and Atacora represents 72 and 95 % of the total, respectively. In both provinces half the agricultural population is under 15 years. It has been noted that

immigration to urban centers has adversely affected the amount of labour available for agricultural work in recent years.

2.0. Research Organization Developement and Extension Institutions

2.1. Agricultural Research .

Benin's agricultural research is under the responsibility of the Direction de la recherche Agronomique(DRA) of the ministry of Rural Development and Cooperative Action (MDRAC). The DRA plans and manages the execution of national agricultural research programmes through 13 unites de recherche et de production(URP) comprising research stations laboratories and centers.

Food crop research is concentrated at Niaouli (southern provinces)and Ina (northern provinces. Other URPs are concerned with industrial crops such cotton (RCF) coconut (SRCOCO) cocoa/coffee (URCC) and palm oil (SRFH).

Agroforestry Research.

Agroforestry research in Benin is under the Unite de Recherche forestiere (URF) one of the 13 units under the DRA.

Effective research in agroforestry and experimentation started in 1980 at Pahua, South - west Benin. Initial trials were designed to evaluate the potentials of 3 multipurpose trees Leucaeuna leucocephala, Acacia auriculiformis and Eucaliptus torreliana for improving productivity of planted fallows and provision of firewood. Preliminary results from these trials show significant increases in the major soil nutrients as affected by the planted fallows over three years. However, no significant

differences were observed among tree species. under Pahua conditions Acacia auriculiformis showed the best growth. (Agbahungba 1984). Result are not yet conclusive.

Preliminary trials on the evaluation of Gliricidia sepium in an alley cropping system were also established by CARDER Atlantique.

Although Agroforestry research efforts started all the way back in 1980 in the south of Benin, there has not been any research done in the North.

The major factor limiting agroforestry research in Northern Benin include (a) lack of research facilities and (b) lack of trained personnel.

Recently the CARDER Borgou and UNSO Project in collaboration with SAFGRAD, have initiated trials to evaluate local and introduced multipurpose trees and various agroforestry practices in Northern Benin.

2.2 Institutions

2.2.1 CARDER

The CARDER (Centre d'actions Regionale pour le Developpement Rural), an agricultural development organisation was created in 1977-1978 for the six provinces in the country.

The objectives of CARDER are :

1. To expand the extension service to all agricultural commodities.
2. To promote the creation of farmers' organisations and cooperatives.
3. To assure provision of inputs to farmers and organise marketing for farm produce.

At the district and village level CARDER is represented by the Responsable de developpement rural (RDR) and the Agent de Vulgarizasion agricole (AVA) who are directly responsible for extention training and also interact with local mass organisations . Unlike other countries in West Africa, Benin has a very strong well organised and decentralised extension service. There are at least one or two extension agents in every village.

2.2.2. U N S O (Project).

The United Nations Sahelian Organisation project, UNSO PNUD/BEN/82, is an afforestation project jointly financed by UNEP and the Government of Benin as a contribution towards the prevention and control of desertification.
The project was established in 1982 and has its seat at Parakou in the Borgou province. It covers the districts of Ouake, and Boukoumbe (Atacora province) and Malanville in the Borgou province. Its activities include :

i) establishement of multipurpose tree nurseries;

ii) supply of tree seedlings to farmers;

iii) education of farmers on the roles of trees in controlling desertification and

iv) helping farmers to estabish individual and communal woodlots.

For the past three years, the project has generated considerable interest in tree planting among peasant farmers. This is seen through the high and increasing demands for tree seedings (mostly fruit trees). The establishement of the National tree planting day, supported by the government, has greatly helped in creating

considerable awarness in the values of trees amoung peasant populations in the project area.

3.0. Traditional Agroforestry Systems.

3.1.The traditional land use system in Northern Benin is characterised by (1) the presence of economic trees, which are deliberately left on crop fields and fallows, (2) shifting cultivation and specialised crop rotation systems.

Tree species most often left on fields include : Butyrospermum parkii (karite),Parkia biglobossa (nere),Adanisonia Petandra (kapokier), Acacia albida and Khaya senegalensis (kayacidra). These valuable trees are usually associated with crops and constitute an important natural and economic resource . The most important crop association and uses of the various tree species are shown in Table 6.

Fruits and leaves of trees are most useful to farmers.

The nut of karite is an important source of fat and oils (50% of fat material) for most peasant families. It is also an important source of revenue. The fresh fruits are consumed by both man and animals. The wood is used for different types of wooden tools and furniture. The bark and roots have important pharmacological properties.

The néré produces long brown pods containing a yellow pulp and seeds. The pulp, rich in sugars and vitamin C, is used in fresh local drinks and as condiment. The seeds are fermented and used as food additives. They also constitute an important source of revenue for peasant families.

Acacia albida and Khayasidra are often retained primarily for browse during the dry season and for pharmacological uses.

3.2. Structure and composition of system.

Crops.

The most common incidental tree crop associations found in Northern Benin are indicated in table 6. Crops traditionally associated with the various trees vary with agro-ecological zone. In the Guinea Savanna zone, maize sorghum and yams associated with nere and karite are the most common. Sorghum and groundnut-tree associations are common in the Sudan savanna zone while in the drier sudano-sahelian zone, millet,sorghum, groundnuts and their associations with trees are most prominent. Cotton, a major cash crop, is associated with all trees in all zones . Frequently, Pigeon pea, an adapted grain legume is found planted on boundaries to demarcate farm limits. It is also planted in association with maize and sorghum, to a small extent in the Guinea savanah zone to provide food grain and fodder for animals in the dry seasons.

Tree Component

The tree component is dominated by the karite and the nere. They form the upper story with heights ranging from 2 - 50 meters. Densities are variable depending on their values to the individual farmer and agroclimatic conditions. Thus they range from 50 - 100 trees per hectare in the Guinea savanah zone to less than 20 trees in the extreme North.

Acacia albida is found only in the Sudano-sahelian zone, however, due to severe grazing pressure and frequent bush fires, its densities have been reduced considerably.

Traditionally these trees are not planted but are left, protected

and managed for sustained productivity of fruits and firewood. Management practices include polarding and prunning of branches to reduce shade for crops and induce flowering.

Important characteristics of the common trees are given below.

Butyrospermum parkii (G.Don.) Kotszchy : Karite

A perennial fruit tree often up to 15m tall. Growth is slow and very much affected by the repeated annual fires. The tree matures and begins bearing fruits in 17 -20 years. It flowers during the dry season and produces fruits at the begining of the rainy season. Fruit harvesting and processing continues through the months of May -August. Production is irregular and varies from year to year as a function of climate, soils and fire. Yields of dry nuts per year average 5 to 12 kg pre tree (20 - 48 kg of fruits) for mature trees. (Agbahungba 1984, personal communication.)

Parkia biglobosa (Jacq.) Benth.: Néré

The néré grows under the same ecological conditions as the karité. Both species are found almost always together but densities of néré are often lower (5-20 trees per ha.).

Tree management is the same as for karité, older trees are cut or prunned at the end of the dry season to induce regrowth and to reduce shade for crops.

It is estimated to produce 20-100 kgs of pods, 50% of which is grain, per tree per year. The useful lifespan of a néré tree is estimated at 25-30 years.

Table 6. Common tree species encountered on farmers' fields and their uses in Northern Benin.

Name	locality	crop assoc.	Usages: fruit/ leaves	stem	roots
Acacia albida (Acaci	Borgou Atacora	cotton sorghum millet G'nuts	fodder med.	med. fuel const tools	med
Butyruspermum parkii (nere)	"	cotton sorg. millet Maize yams G'nuts beans	food cosmetic	fuel wood const. tools and crafts	med.
Parkia biglobossa (karite)	"	same as above	fodder medic. dietary additive	fuel const.	med.
Khaya senegalensis (Kyacidra)	"	same as above	fodder	fuel, const craft tools	med.
Adansonia petandra	Atacora	millet sorghum g'nuts beans			

source:Exploratory survey SFGRAD,1987.

Acacia albida (del).

Acacia albida (albida) is a large tree often 15-25 tall. It is characterised by the white color of trunk and sharp thorns. It is found in semiarid regions with 400-900mm of rainfall per year. However, it could tolerate rainfall regimes from 300 mm to 1,800 mm per anum. Due to its long rooting system, Albida turns to be independent of surface water and soil fertility conditions, Above all, it is believed to compete very little with cultivated crops.(Kirmse and Norton 1984 ; Felker 1978). Albida has a unique physiology where it drops its leaves in the wet season and remains dormant until the begining of the dry season. The advantages of this tree include :

a) soil fertility improvement through nitrogen fixation, litter fall and nutrient recycling.
b) production of fodder during the dry season ; using both leaves and fruits.
c) wood for construction, crafts and fuel.
d) pharmacological properties.
e) shade for livestock during the dry season.

Other agroforestry systems.

Other than the traditional agroforestry systems, there are plantations and individual plantings of trees for wood and fruits, in and around compounds. During the early years of establishment, fruit trees are often associated with food crops such as yams, maize, sorghum, millet and vegetables.

Tree species often planted include Anacardium ocidentale, Magnifera indica, Tectona grandis and Tamarindus indica.

3.3. System function, Interactions and Management.

Sustained food production is attained through systematic rotation of crops and fallow periods, usually 2-5 years where there is no shortage of arable land. In some districts of Atacora, where land is in short supply, continous cropping with fertilizer and manure inputs support crop production. The tree component is regularly cut or prunned to allow enough light for crops while rejuvinating the trees and inducing nutrient cycling (litter fall).
This practice allows a more favorable association with crops and maintainance of the system. The trees thus play an important role in providing economic products as well as maintenance of total equilibrium. The extent of this role depends greatly on the density and arrangement of the trees. Presently, trees are left at random and are irregularly spaced at variable densities; thus their true impact on the system is not well understood.

Regular cropping and crop husbandry pratices such as weeding, seem to be beneficial to trees as well. Farmers interviewed (SAFGRAD Surveys 1987) clearly indicated that trees regularly associated with crops yield much higher than trees in the wild.
However, farmers pay very little attention to trees while determining appropriate crop rotation sequencies.

3.4. Specific constraints in agroforestry system.

<u>Crop production subsystem.</u>

- Decreasing soil fertility resulting in low yields.(Atacora province).
- Lack of labour during peak labour demamd periods. (land

preparation and weeding).

- Lack of marketing organisations.

Livestock subsystem

- Low fodder quantity and quality during the dry season. This is further agravated by repeated annual bush fires.
- Poor health and condition of work animals at the beging of the rainy season.

Forestry and Agroforestry sub system

Recent socio-economic surveys on the impacts of the pilot re-afforestation and extension efforts by UNSO in its zone of intervention pointed the following as the major problems facing tree planting and management in the northern provinces (Attolou 1986.)

- Competition for land ; between food crops and plantations, expecially in the Boukoumbe distrct of Atacora province.
- Low soil fertility
- Insufficient rainfall
- Protection of young trees against animal damage.
- Destruction of plants by termites expecially in the extreme north (Malanville).
- Competition in the demand of labour for tree planting and cropping.

Despite these problems, the UNSO project has been able to creat considerable awareness in tree planting and the usefulness of trees to provide basic needs and fight against desertification.

4.0. Agroforestry Opportunities and Available Interventions.

Agroforestry has the potential to make major contributions in aleviating critical production constraints in the traditional farming systems (Lundgren and Raintree, 1983 Huxley. 1983, Nair 1984). Trees can be introduced on arable areas in association with crops, on grazing areas (natural rangelands and artificial pastures), and in homegardens. The main objective of tree introductions is to improve and stabilise productivity of the systems by :

- providing food and fuelwood.
- providing high quality feed for livestock during the dry season.
- ameliorating soils by recycling nutrients, fixing nitrogen, adding organic matter, and reducing erosion, which in combination with livestock manure would minimise cash inputs (Nair 1984).
- providing permanent fencing for protection of crop fields, grazing areas and homesteads.
- improving the microclimate against desertification in semi arid regions.

4.1 Available Interventions

In view of the agroforestry potentials discussed above, several interventions leading to the solution of problems and constraints could be proposed for Northern Benin conditions.

1. Fuelwood and wood for construction

With increasing populations and severe deforestation for agriculture, scarcity of wood for fuel and construction is

becoming more and more improtant in Northern Benin. Areas most affected include the Ouake, Materi and Boukoumbe districts of Atacora province and the extreme north districts of Borgou.
Fuel wood inerventions can be visualised at two levels. a) Regional and b) farm level.

Regional

- Improvement and supplementation of existing wood stocks by planting new trees on grazing lands.
- Establishement of communal wood lots close to villages.
- Management of existing woodlands for sustained productivity.

Farm level

- Establishment of trees (notably leguminous) on improved fallows to provide wood and fodder as well as improve and conserve soil fertility.
- Boundary planting of trees to serve both as wind breaks and source of wood.

2. Soil fertility and fodder production.

This involves interventions by which trees could be integrated into cropping systems for soil protection, fertility improvement fodder and provision of fuel wood.

<u>Hedgerow inter-cropping (Alley cropping):</u> This is a system where arable crops are grown in the interspaces (or alleys) between rows of planted trees or woody shrubs, which are prunned

periodically during the cropping season to prevent shading and to provide green manure and mulch to the arable crop.

(Wilson and Kang 1981 ; Hartmans 1981). The trees also provide fuel wood and quality fodder for livestock during the dry season. Leucaena leucocephala, Cajanus cajan and Glicidia sepium are the legume species most widely evaluated in the high rainfall areas of the region (Kang et al, 1981 ; Wilson and Kang 1981). Preliminary evaluation of these species show considerable growth potential, especially in the Northern Guinean zone, and could thus be intercropped with grain cereals and legumes.

The alley cropping systems along with efficient crop rotation patterns and mininum fertilizer inputs would be suitable for areas with adequate rainfall and high intensity of cultivation.

Mixed intercroping.

In this system, trees are planted in regular or irregular patterns in association with food crops for the value of their fruits, soil conservation properties, fodder, fuel wood and cash. A good example of such systems is the acacia albida/millet associations in the Sudano Sahelian zone of West Africa. Reports prepared by Felker (1978) in Senegal noted 500-900 kg/ha yield increases in groundnut, and millet yields under albida. This he attributed to 50-100 % increases in soil organic matter and nitrogen content, soil microbial activity and water holding capacity.

In areas, such as the Boukoumbe district of Atacora, where land is in short supply and fallow periods are short mixed intercropping with species such as Acacia albida and locally

available fast growing leguminous species have a high potential in soil stability and productivity sustainance.

3. Browse planting.

Browse grazing systems in which woody perennials provide fodder as a protein rich supplement during the dry season(s) are especially suitable in the semi arid and arid zones of Northern Benin. Two techniques of introducing browse into the present systems seem promising :

i) Planting multipurpose fodder trees in grazing areas, and as hedgrows in and around crop fields. (Pigeon peas and leucaena).

ii) Establishement of fodder trees and shrubs in feed gardens close to the homesteads for supplementary feeding of stock.

These two techniques coupled with sound management practices could provide all year round high quality fodder for small holder herds (animals for traction).

4. Soil conservation

Tree planting along contours to reduce runoff and protect terraces is an important soil conservation technique on shopping areas (Nair and Fernandes 1984, Young 1986). An interesting case of hillside farming in Northern Benin is presented in the Boukoumbe district.

Somba farmers in this region have a long history of terracing and tied-ridging with stones, well constructed and arranged, to control soil erosion and to conserve water. The potential of trees in protecting the soil surface against erosion and runoff as well as reinforcing the terraces and ridges is welcomed. Hedgerow planting of leguminous multipurpose trees such as Leucaena leucocephala, along contours and terraces, (figure 4.)

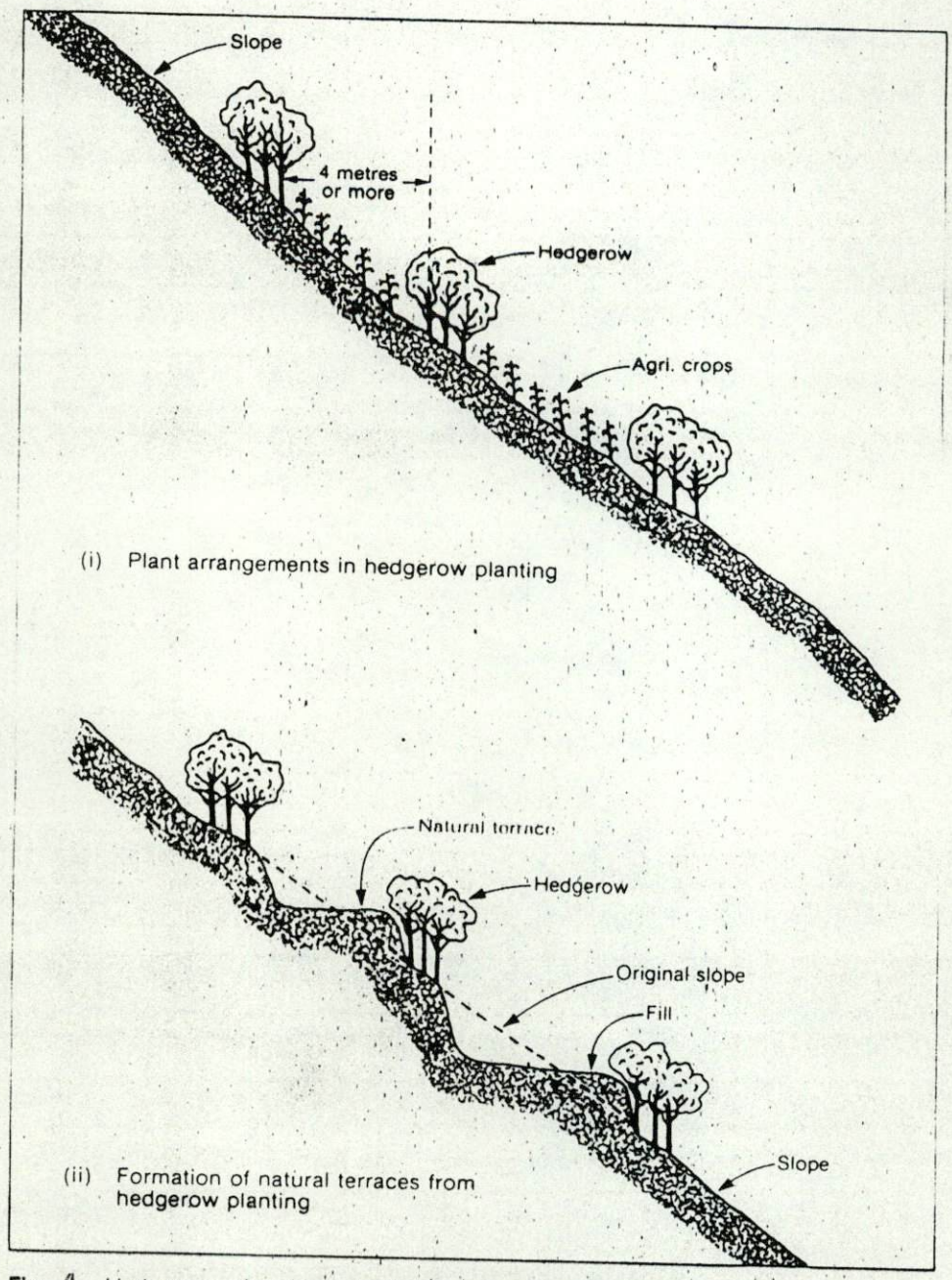


Fig. 4. Hedgerow planting for soil conservation (*adapted from Vergara, 1982*)

could greatly stabilize and sustain hillside farming.

5.0. Research needs. .

In order to improve the efficiency and productivity of the existing agroforestry systems and introduce adaptable practice more research into understanding the systems and their interactions is needed. Some of the most urgent research and survey needs are suggested below :

- Evaluation of the present status of productivity,in-depth studies on the structure, functions and interactions among all components of the system.
- Farmer management practices and strategies to maintain the systems.
- Optimum tree densities in various tree/crop associations .
- Socio-economic impacts especially on the value of trees, and possibilities of introducting other trees on crop fields.
- Processing and marketing of agroforestry products and potentials for improvement of the existing technologies and structures.
- Evaluations of various agroforestry practices developed elsewhere in the West African region, such as alley cropping with leucaena, and other fast growing legumes.
- The most suitable crop tree associations and competitive factors need to be identified.
- Evaluations of locally available and introduced miltipurpose tree species and their adaptation to various uses in the system.
- Design of efficient land use systems that include agroforestry

and other household enterprises on the same land resource.

CONCLUSION

The land use system in Northern Benin is based on a shifting cultivation and permanent agroforestry systems. Farmers are very much aware of the economic role of trees through the sale of fruits, nuts and wood. Fruit trees such as karite ,nere mangoes etc.. are managed especially, for sustained productivity even at the expense of possible yield decreases of some food crops.

Forest and woodlands are rapidly reverting into shrublands and cultivated lands through severe deforestation for wood, agriculture and the influence of bush fires. Intensification of agriculture with the introduction of trees could be an alternative for better management of the available land resources.

Potentials for improvement of the traditional agroforestry systems as well as introduction of new technologies to aleviate some of the most serious production constraints, such as soil fertlity, soil degradation and fodder needs is enormous.

Useful literature database on tree crop associations and their benefical influences on soil and water mmanagement is lacking . Much research is needed to evaluate the various roles of trees in the existing systems and to develop more biological and economically efficient systems.

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