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Ethno-pedology Surveys in the Semi-arid Savanna Zone of Northern Ghana

An ILEIA initiated project

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SOIL RESEARCH INSTITUTE KWADASO KUMASI GHANA

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ABSTRACT

The semi-arid savanna zone of Northern Ghana covers approximately 97,700 km^2. The area is underlain by a wide range of rock types which vary in physical and mineralogical properties within and between rock types. The major rock types are granite, phyllite, sandstone and shale (Junner and Hurst, 1946).

The soils of the Langbensi pilot area developed from sandstone whilst those of the Wiaga pilot area developed from hornblende and biotite granites with small inclusions of greywacke/phyllite (Adu, 1969; 1995).

The soils of the Langbensi area and other areas underlain by sandstone in the Northern Savanna Zone cover about 13,000 km^2 (13% of the zone). The soils of the Wiaga pilot area and similar ones developed from hornblende and biotite granites cover about 10,000 km^2 (11% of the area).

The people of the pilot areas are made up of Mamprusis for the Langbensi area who speak the *Mampruli* language, and of Builsas for the Wiaga area who speak *Buli*. The Mamprusi and the Builsa areas cover approximately 8 and 2% of the Northern Savanna Zone, respectively.

The soils of the pilot areas vary in quality and extent. However, nearly all the soils are low in nutrient reserves due to strong weathering and very low organic matter content.

In the Langbensi pilot area, 59% of the soils are moderately suitable for growing sorghum, millet, maize, groundnut, cotton, bambara bean, cowpea and soybean, the main crops in the area. They are limited by low nutrient reserves, moderate sheet erosion hazard and, occasionally, slow runoff. 22% of the area is only marginally suitable while about 24% are not suitable for cultivation.

The suitability of the soils in the Wiaga pilot area shows a similar pattern. About 68% of the soils of the pilot area are moderately suitable for the cultivation of sorghum and millet and, sometimes, groundnut. They are mostly limited by low nutrient reserves and, occasionally, by moderate sheet erosion hazard and imperfect drainage. About 7% of the area are marginally suitable. Valley soils, occupying approximately 18%, are only marginally suited for upland crops, but moderately suitable for wetland rice production. About 7% of soils in the pilot area are not suitable for cultivation.

The farmers mapping using indigenous knowledge gave similar outputs as the results of the formal studies. A fair correlation was established between the scientific and farmers' independent perceptions of the soils in the two pilot sites. General observations made in comparing the two soil mappings are:

- farmers have reasonable awareness of the soils they use for their farming activities;
- farmers mostly rely on physical properties in classifying their soils;
- farmers' mapping units were found to be very small because they usually consider many details irrespective of the extent;

- farmers are able to evaluate the land by experience. They rely on topsoil colours and crop performance to assess the nutrient level, and use texture to assess the soil moisture relationships;
- although the farmers recognize differences in soil types, they farm across their boundaries, because most soils have similar constraints.

It is recommended that farmers are assisted in improving practices to maintain soil fertility, since present practices (application of animal waste manure, inorganic fertilizers, crop rotation and fallow) are found to be inadequate. Also kraal methods and agroforestry techniques should be encouraged.

Other recommendations are the use of bullock plough for land preparation rather than the tractor, and to refrain from burning plant residue to clean fields.

This ethno-pedology pilot study has revealed that farmers have ample knowledge of the soil resources in their environment. This knowledge must be tapped by scientists, in their efforts to improve and sustain the crop production potential of rural communities. To this end, the present study may be extended in the future to cover other areas with different ethnic communities or different soils.

1 INTRODUCTION

The Information Centre for Low External Input and Sustainable Agriculture (ILEIA) and the International Soil Reference and Information Centre (ISRIC) have signed a Cooperation Agreement (no. 18) to carry out a number of investigations in pilot areas located in:

- Ghana: a semi-arid savanna zone in the north of the country near Langbensi and Wiaga;
- Peru: high mountain valleys in the Andes in Cajamarca and Huancajo;
- Philippines: sub-humid low lying floodplains in the broad alluvial plain of Central Luzon.

The main issues to be addressed in this collaborative project are:

(1) Correlation of traditional farmer's knowledge of soil and land suitability with internationally accepted systems of soil and land suitability classification, in order to identify main constraints and to propose possible solutions.
(2) Assess the geographical representativeness of the pilot areas for the agro-ecological zone and district in which they occur.
(3) Presentation of the project results to farmers and NGO's in participatory meetings.
(4) Establish linkages for international collaboration on developing a sustainable basis for agro-technology transfer, in a participatory framework.

This Country Report covers the work carried out in Ghana. It has been distilled from the base document prepared by the subcontracted agency, the Soil Research Institute (SRI), Kwadaso-Kumasi (Asiamah *et al.*, 1996) and field trip reports (Spaargaren, 1996).

Chapter 2 describes the climate, soils and cropping systems in the pilot areas. The procedure developed for the farmer-based classification system and results of the soil mapping exercises by farmers and scientists are discussed in Chapter 3, in which the results of the two approaches to soil characterization and appraisal are also compared. In Chapter 4 the representativeness of the two pilot areas is assessed in relation to the soils of Northern Ghana. Chapter 5 gives an account on the two workshops held to present the findings of the present study to the farming communities. Conclusions and recommendations for further work are made in Chapter 6.

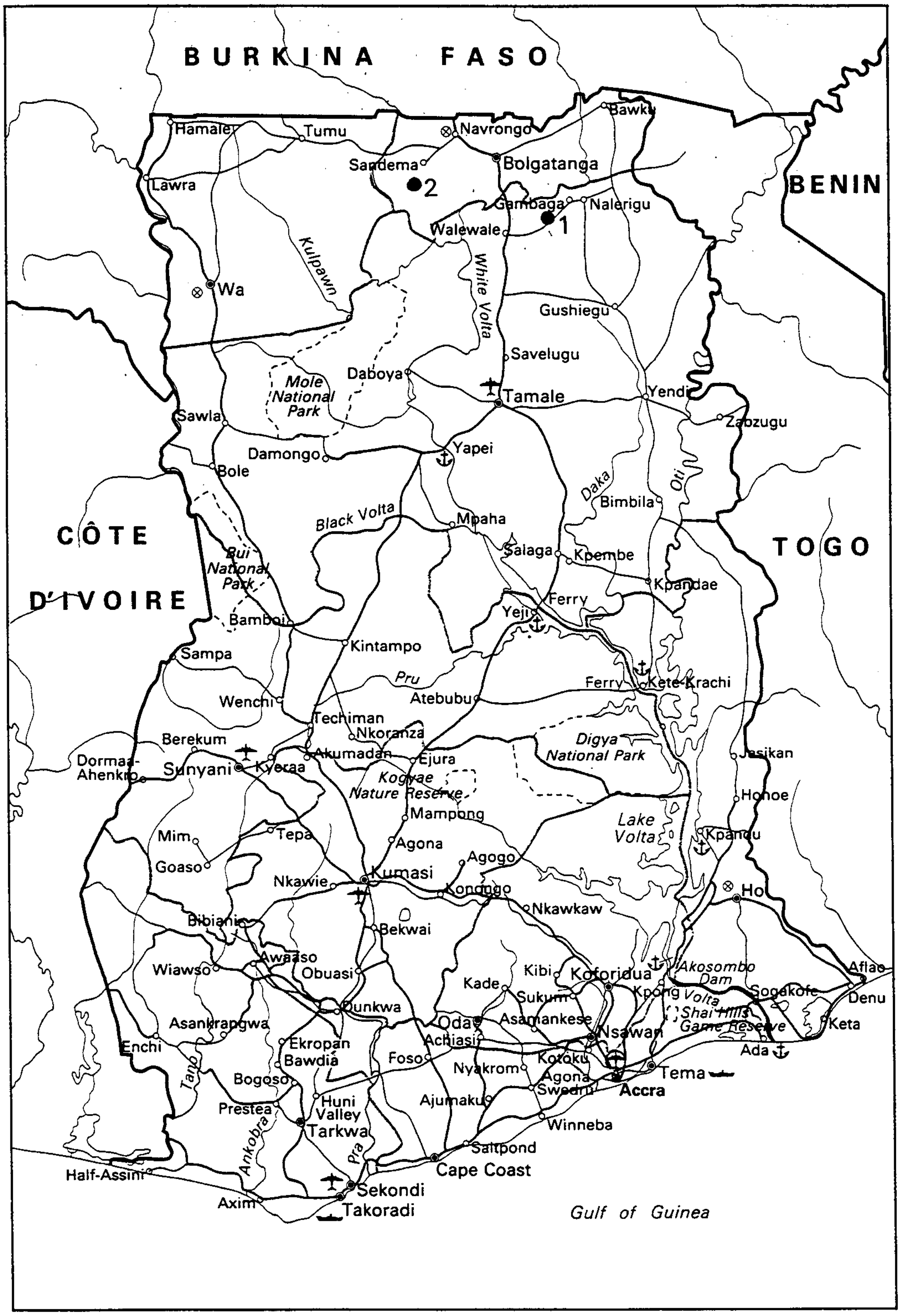


Figure 1. Project location map: 1. Langbensi pilot area; 2. Wiaga pilot area

2 THE PILOT AREAS

2.1 The selection

The selection of the pilot areas has been a joint effort of ILEIA staff, local NGO's and governmental extension staff, farmers, the Ghanaian Soil Research Institute (SRI), and an ISRIC representative during a mission in February 1996. The pilot sites are located in the Northern Region of Ghana, East Mamprusi District, approximately 5 km N of Langbensi on the route from Walewale to Gambaga (the Langbensi pilot area), and in the Upper East Region of Ghana, Builsa District, approximately 40 km SW of Navrongo just south of Wiaga on the road to Kadema (Wiaga pilot area). The Langbensi site comprises half the watershed of the Nasisi (or Warri) River and covers about 2,550 ha, while at Wiaga the pilot area is sited as a strip across the several tributaries of the Atimbele stream, totalling approximately 1,400 ha (figure 1).

2.2 Climate

Both pilot areas are located in the semi-arid zone of northern Ghana with alternating wet and dry seasons. Rainfall averages about 900-1000 mm and is concentrated in the period from April to October, during which period 95% of the precipitation occurs. It reaches its peak in August with about 1/4th of the total annual rainfall. Temperatures are high throughout the year, averaging about 28°C and ranging from approximately 26°C during December and January to 32°C in early spring before the onset of the rains. Relative humidity (RH) is strongly fluctuating, less than 35% during the dry season, and more than 70% during the rainy reason. Diurnal fluctuation is large as well. In Navrongo, for example, the lowest RH occurs early afternoon (less than 20% during the months of December through to February). The highest RH is found during the early mornings (more than 90% from July to September). Some selected climatic data for Gambaga, Walewale and Navrongo are given in Table 1. Gambaga and Walewale meteorological stations are closest to the Langbensi pilot area, Navrongo may be taken as representative for the Wiaga pilot site.

The length of growing period for rainfed crops is 5 - 6 months. The total length for Navrongo has been calculated on 163 days, starting early May and lasting to half of October (FAO, 1984). For Mango (Togo), which is closest to the Langbensi pilot area, the total length is 174 days, starting end of April and lasting to the second half of October.

Table 1. Selected climatic data for Gambaga, Walewale and Navrongo

Rainfall mm

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Gambaga	0	1	16	54	99	123	179	221	191	55	6	5	950
Walewale	1	3	16	56	98	119	184	210	141	46	5	2	881
Navrongo	1	3	18	55	93	123	190	268	165	50	4	3	973

Temperature °C

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Walewale	26.5	28.1	29.1	30.6	29.4	28.2	27.0	26.6	26.7	27.7	27.7	26.5	27.8
Navrongo	27.3	29.9	32.1	32.2	30.5	28.3	26.9	26.4	26.7	28.2	28.2	27.1	28.6

Relative humidity %

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Walewale	26	31	42	55	61	65	72	74	75	69	50	36	55
Navrongo	24	24	34	51	64	72	78	82	80	70	45	30	54

2.3 Vegetation

2.3.1 The Langbensi pilot area

The original vegetation in this area falls within the Guinea Savanna Zone which is characterized by a predominantly tall grass savanna with widely spaced, fire resistant short trees and shrubs (Taylor, 1952). However, the original vegetation has been replaced in many areas by a woodland savanna with fire resistant trees and cultivated farm sites. Important economic trees are the sheanut *(Butyrospermum parkii)* and the Dawadawa *(Parkia clappertonniana)*.

2.3.2 The Wiaga pilot area

The original vegetation in this area falls within the Sudan Savanna Zone which consists of short, fire resistant deciduous trees of open canopy with shrubs and grass undergrowth (Taylor, 1952). However, the original vegetation has been replaced in approximately 60% of the area, mainly in the north and north-east by continuous stretches of farmland with scattered trees and widely spaced houses. Important trees are the baobab *(Adansonia digitata)*, neem *(Azadiracta indica)*, sheanut *(Butyrospermum parkii)*, Dawadawa *(Parkia clappertonniana)*, mango *(Mangifera indica)* and *Acacia albida*.

2.4 Physiography and geology

2.4.1 The Langbensi pilot area

The pilot area is undulating with long slopes, often more than one kilometre, and broad summits. It is situated in the foothills at the western edge of the rather rolling Gambaga Scarp. In most parts slopes are between 2 and 5%. Streams are slightly incised and have formed narrow valleys.

The area is underlain the Upper Voltaian sandstone which is medium grained and slightly different from the fine- and coarse-grained types that occur elsewhere (Junner and Hurst, 1946).

2.4.2 The Wiaga pilot area

The Wiaga pilot area has the gently undulating topography of a peneplain-like landscape with elevations ranging from 185 to 215 m a.s.l. Slopes rarely exceed 4%. Valleys are broad and not incised.

The area is almost entirely underlain by hornblende-biotite granite, except for a narrow strip in the southwest, where Birrimian rocks occur, comprised of greywacke and quartz-sericite schist (Junner and Hurst, 1946; Adu, 1969).

2.5 Land use

2.5.1 The Langbensi pilot area

A large proportion of the land suitable for agriculture is cultivated. Crops grown are sorghum, millet, maize, groundnut, bambara bean, cowpea and cotton. Occasionally yam and soybean are grown. Fallow is short, normally not more than a couple of years. A normal, 4-year rotation after the fallow comprises maize - groundnut - sorghum or millet - cotton. Compound farms near the settlements are intensively cultivated to maize and sorghum, while bush farms, which generally occur within a 2 km radius of the settlement, are more frequently used for yam and cotton. Animal husbandry is practised on a limited scale, however, a few farmers have large herds of cattle, goats and sheep. During the farming period animals are kept confined, but they are allowed to graze freely during the dry season.

Charcoal production is a common practice, particularly by the inhabitants from the Tangbini village in the northern part of the pilot area.

2.5.2 The Wiaga pilot area

The main land use systems are compound farming, bush farming and animal husbandry. The main crops grown are millet, sorghum, groundnut and rice. Animals reared are cattle, sheep and goats. Some of the farms use a kraal to collect organic manure for the farmland.

2.6 Soils

2.6.1 The Langbensi pilot area

The uniform geology of Voltaian sandstone has given rise to a series of soils which are strongly related to the physiography. Technically, the soils belong to the Mimi Association established by the Ghanaian Soil Research Institute (Adu, 1963), which is the common soil association found between Gambaga northeast of the pilot area, and Mimima in the southwest along the Gambaga-Walewale road. The soil series members of this association found in the survey area are known as the Kintampo, Techiman, Wenchi, Mimi, Murugu and Yaroyiri Series.

The **Kintampo** Series (23% of the area) comprise areas of rock outcrops and boulders as well as shallow soils (<30 cm deep) over hard rock. Sites with rock outcrops and shallow soils occur irregularly in the survey area and are found in all physiographic positions, i.e. on the watershed, on the slopes and near to stream valleys. These soils are generally not suitably for cultivation mainly due to rooting limitations. Where soil cover is near to 30 cm, some shallow rooting crops as groundnut, cowpea or bambara bean may be grown with care.

The **Techiman** Series (19% of the area) are found on summits and upper slopes. They are moderately deep, well drained, reddish brown soils of sandy loam to sandy clay loam texture with many large iron-manganese concretions, ferruginized sandstone gravels and pieces of indurated ironstone. These soils are marginally suitable for agriculture because of the abundance of coarse fragments which influence strongly the workability, the nutrient supply and retention, and the moisture retention. Chemical analyses of these soils indicate very low amount of available plant nutrients like phosphorus and potassium. Soil management practices to maintain or increase productivity on a sustainable basis include application of organic and inorganic manures, and use of cover crops. Suitable crops are groundnut, bambara bean, sorghum, millet and cotton.

The **Wenchi** Series (1% of the area) occurs in patches usually on upper slopes and summits. A relative large extend is found in the northern part of the pilot area. It comprises a shallow soil over indurated ironstone less than 30 cm deep, often with outcropping ironstone boulders. They are not suitable for agriculture but where soil thickness is near to 30 cm, root crops such as groundnut or cowpea may be grown.

The **Mimi** Series (48% of the area) is the dominant and most widely cultivated soil in the pilot area. It is mainly found on the middle slopes but sometimes extend to the upper and lower slopes. These soils are (moderately) deep, well drained, dark red to red and have a sandy loam to clay loam texture, almost free of iron-manganese concretions and gravels. The physical properties (effective soil depth, texture, near absence of gravel, stones and iron-manganese concretions, moisture retention) are favourable for agricultural production, however, these soils are prone to sheet erosion due to the limited structural stability in the topsoil. The soil nutrient reserve is generally low, with low levels of nitrogen, potassium and phosphorus. Soil productivity can be greatly enhanced through careful soil management and water harvesting techniques. Anti-erosion measures such as contour cropping and ridging are critical to prevent loss of topsoil, but also contribute to increased water infiltration. Application of organic and inorganic fertilizers are advisable to maintain or increase soil productivity. Mimi soils are suitable for a wide range of climatically suitable crops including maize, sorghum, millet, groundnut, bambara bean, cowpea, yam, cotton and sunflower, although the latter one is not grown in the region.

The **Murugu** Series (6% of the area) is an imperfectly drained, yellowish brown version of the Mimi series. These soils occupy upland depressions and lower slope sites bordering valleys. This physiographic position gives this soil an advantage over the Mimi series in terms of a higher moisture content which makes these soils less drought-prone during short dry spells in the rainy season. Chemically, however, they are less favourable. In addition to the low inherent fertility similar to the Mimi series, these soils are more acid, which makes liming essential to produce good crops.

The **Yaroyiri** Series (3% of the area) is the dominant alluvial soil found in the narrow valleys. These soils are deep, often poorly drained, light coloured soils of sand or loamy sand texture. Its use for agriculture is limited due to flooding hazard in the rainy season and low inherent fertility. Nutrient retention, nitrogen, phosphorus and potassium levels are all very low. These soils retain a reasonable amount of subsoil moisture throughout the year and may be used for dry season vegetable production. Where extensive, sugar cane may be grown.

Correlation between these soils and the FAO-Unesco Revised Legend FAO, 1988; Nachtergaele *et al.*, 1994) and Soil Taxonomy (Soil Survey Staff, 1996) is given in table 2. A schematic cross section showing the relations between the soils is given in figure 2.

2.6.2 The Wiaga pilot area

The uniform geology of hornblende-biotite granite, except for a narrow strip in the southwest, where Birrimian rocks occur, comprised of greywacke and quartz-sericite schist, has given rise to a sequence of soils which are strongly related to the physiography. Technically, the soils belong to five main Soil Associations as established by the Ghanaian Soil Research Institute (Adu, 1969), namely the Tanchera, Pusiga, Wenchi, Kupela-Berenyase and Bianya Associations. The main soil

Table 2. Correlation between the Ghanaian Soil Series in the Langbensi pilot area, the 1988 FAO-Unesco Revised Legend, and the 1996 Soil Taxonomy.

Ghanaian Soil Series	1988 FAO-Unesco Revised Legend	1996 Soil Taxonomy
Kintampo Series	Lithic / Eutric Leptosol	Lithic Ustorthent
Techiman Series	Chromi-Plinthic Lixisol	Typic Plinthustalf
Wenchi Series	Lithic / Eutric Leptosol, petroferric phase	Typic Ustorthent
Mimi Series	Chromi-Haplic Lixisol	Typic Kandiustalf / Kanhaplic Haplustalf
Murugu Series	Areni-Ferric Lixisol	Oxyaquic Haplustalf
Yaroyiri Series	Areni-Eutric Fluvisol	Oxyaquic Ustifluvent

series encountered in the survey area are known as the Kolingu, Puga, Pusiga, Tanchera, Wenchi, Chuchuliga, Pu, Kupela, Berenyase and Bianya Series.

The **Kolingu** Series (38% of the area) is the most extensive soil. It occurs on the broad, almost flat summits and extend in some cases to the middle slopes. Associated with these soils are patches with common to many quartz gravels and stones on the surface in the soil itself. Kolingu soils are imperfectly to moderately well drained, dark brown to yellowish brown soil with a loamy sand/sandy loam topsoil abruptly overlying a sandy clay loam to clay subsoil. Commonly, a stoneline occurs between 15 and 30 cm depth. Upon drying, the subsoil develops wide and deep cracks, enhancing infiltration at the onset of the rainy season. Physical properties are favourable, with an easy-to-till topsoil and a subsoil retaining reasonable amounts of soil moisture. However, where the stone line comes close to the surface, it may affect tillage operations. The clayey subsoil may impose internal drainage problems in years of exceptionally high rainfall. Nutrient (N, P, K) levels are generally very low. Part of the Kolingu soils have an alkaline soil reaction and moderately high sodicity in the subsoil, with magnesium and sodium dominating. Sorghum and millet are the crops most widely grown on these soils.

The **Puga** Series (16% of the area) comprises imperfectly to moderately well drained, brown soils in upper and middle slope positions with a sandy clay loam texture and a loamy sand/sandy loam topsoil. Characteristically, the subsoil consists of iron-manganese concretions which are cemented together to form a massive structure. Due to this concretionary and cemented subsoil, only a shallow plough layer (<30 cm thick) exists. The soils are low in nitrogen, phosphorus and potassium, and fertilization, both organic and inorganic, is required for optimal production. Apart from its use for cultivation - shallow rooting crops such as groundnut, bambara bean and sorghum are grown in places - Puga soils are used by the local population to construct their houses.

The **Tanchera** Series (2% of the area) occurs in patches in upper and middle slope positions. These soils are deep, imperfectly to moderately well drained, brownish yellow to light olive soils of variable texture (loamy sand to silty clay) and mottling

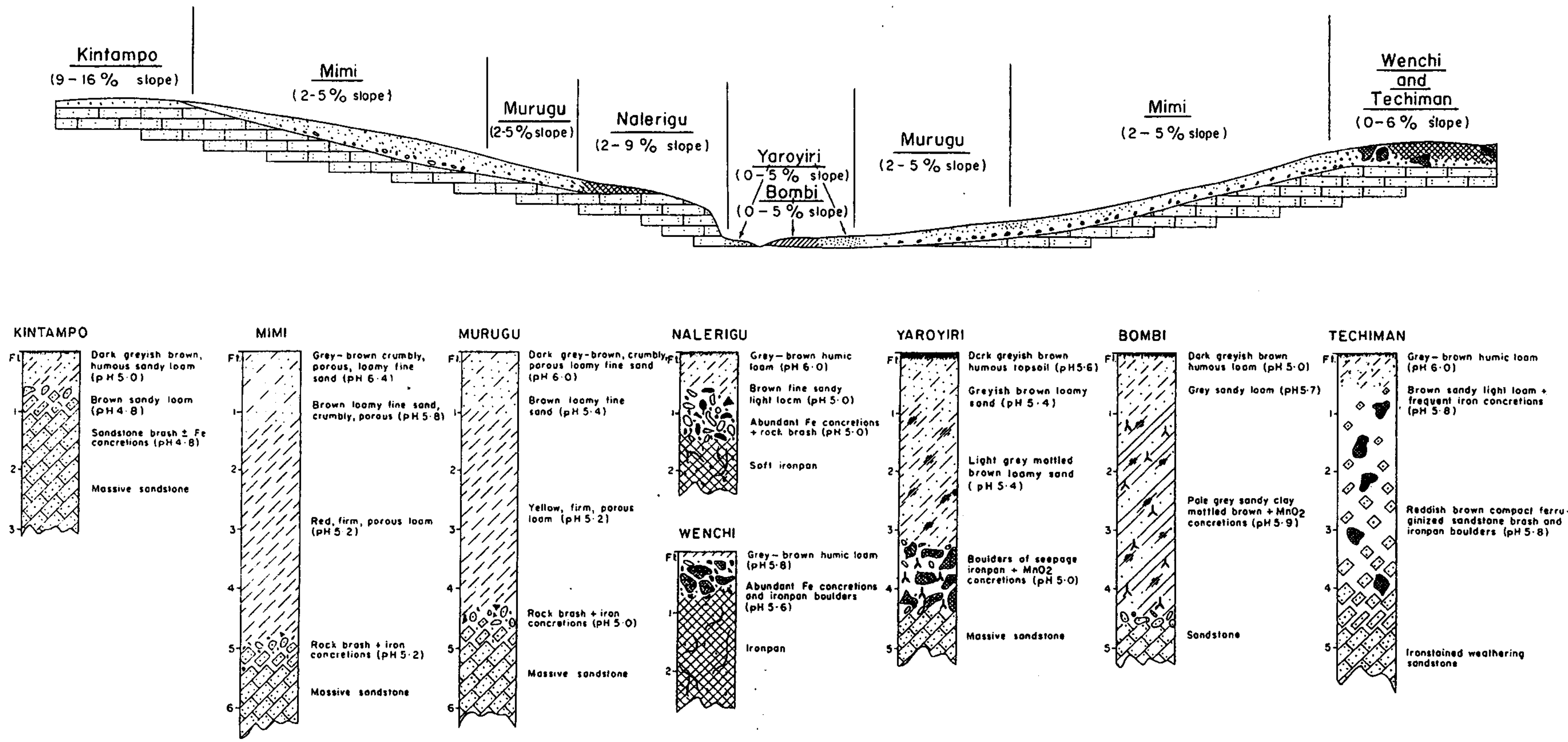
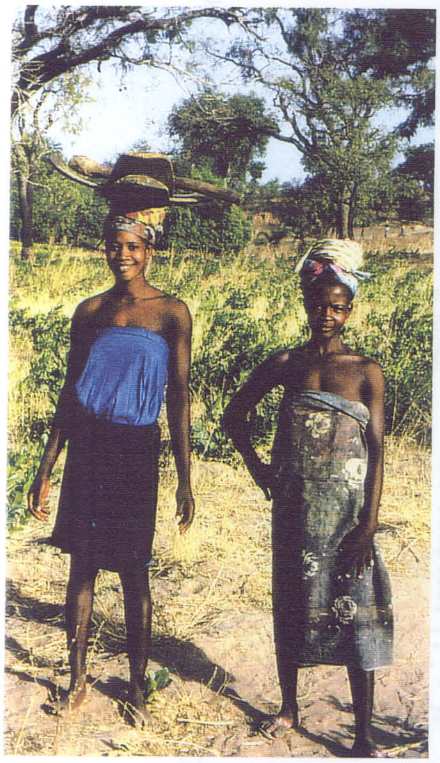


Figure 2. Schematic cross section showing the relations between the Kintampo, Techiman, Wenchi, Mimi, Murugu and Yaroyiri soils (Nalerigu and Bombi soils were not identified) (Adu, 1969).

5

LANGBENSI

6



7

1. Kokua sabli (local) or Techiman soil (official) (FAO-Unesco: Chromi-Plinthic Lixisol)
2. Bihigu sabli (local) or Mimi soil (official) (FAO-Unesco: Chromi-Haplic Lixisol)
3. Ridging on Kokua sabli or Techiman soil to collect sufficient soil for root development and prevent waterlogging.
4. Sorghum stalks left on the field to be collected as building or fencing material.
5. Cattle grazing during the dry season.
6. Farmers' participation during the workshop. Here they assess the distribution of the types of land using stones to estimate the different proportions.
7. Women *en route* to tend their fields.

in the subsoil. Sodium content in the subsoil increases to almost toxic levels. Due to the sandy nature of the topsoil, these soils are easy to work. However, the same texture limits its moisture and nutrient retention. With appropriate soil management practices (organic manuring, fertilizer application and erosion control measures). Tanchera soils are suitable for a wide range of crops such as sorghum, millet, groundnut, bambara bean and cowpea.

The **Pusiga** Series (2% of the area) occupies upper and middle slopes and comprises essentially moderately well drained, brown soils of sandy loam texture overlying hard rock within 30 cm depth. Hand cultivation is possible where enough soil can be collected to form ridges or where decomposing rock is penetrable beyond 50 cm depth. When reasonably deep, Pusiga soils can be cultivated to sorghum and millet.

The **Wenchi** Series (6% of the area) occurs in all physiographic positions. A relative large extend is found in the northern part of the pilot area. It comprises a shallow soil over indurated ironstone less than 30 cm deep, often with outcropping ironstone boulders. These soils are not suitable for agriculture but where soil thickness is near to 30 cm, root crops such as groundnut or cowpea may be grown. Otherwise they are recommended only for forestry (fuelwood production), pasture and sites for building structures.

The **Chuchuliga** Series (1% of the area) consists of granitic rock outcrops, large boulders and pockets of soil. They are unsuitable for agricultural production but may be used for extensive grazing.

The **Pu** Series (14% of the area) occupies the lower slopes on edges of valleys. These soils comprise shallow, imperfectly drained, very dark greyish brown, sandy loam soils directly overlying decomposing granite with some illuvial topsoil material. They have a low water storage capacity and careful soil management is required as erosion can easily lead to exposure of the underlying granite. However, the decomposing rock is friable and contains large amounts of nutrient reserves easy to reach for the plants. Sorghum, millet, rice and legumes such as cowpea and bambara bean may be grown.

The **Kupela** Series (18% of the area) is a deep, poorly to imperfectly drained, greyish brown to olive, mottled soil, generally of medium texture. These soils occupy the valley fringes and valley bottoms, and are subject to waterlogging during the rainy season. Subsoil sodicity is common with 10% or more exchangeable sodium. The content of important nutrients (N, P, K) is low. They may be used for growing rice and dry season vegetables, taking advantage of the permanently present subsoil moisture. The local population also uses these soils for early millet production.

The **Berenyase** Series (2% of the area) is an imperfectly to moderately well drained soil in sandy colluvial materials found on the lower slopes and in valleys. The soils are easy to till but suffer from waterlogging in years of exceptional high rainfall. Sorghum, millet, bambara bean, groundnut, cowpea and dry season vegetables can be grown.

The **Bianya** Series (< 1% of the area) is a soil developed on phyllite, which becomes the main parent rock towards the southeast of the pilot area. These soils are moderately well drained, very compact, brown soils of silty clay loam texture with a sandy loam topsoil. The compactness impedes internal drainage (slow infiltration) and enhances runoff leading to erosion where slopes get too steep. Manual cultivation is difficult and mechanical cultivation is limited by rock outcrops. Sorghum and millet may be grown using management techniques as manuring and planting on mounds.

Correlation of these soils with the FAO-Unesco Revised Legend (FAO, 1988; Nachtergaele *et al.*, 1994) and Soil Taxonomy (Soil Survey Staff, 1996) is given in table 3. A schematic cross section showing the relations between the soils is given in figure 3.

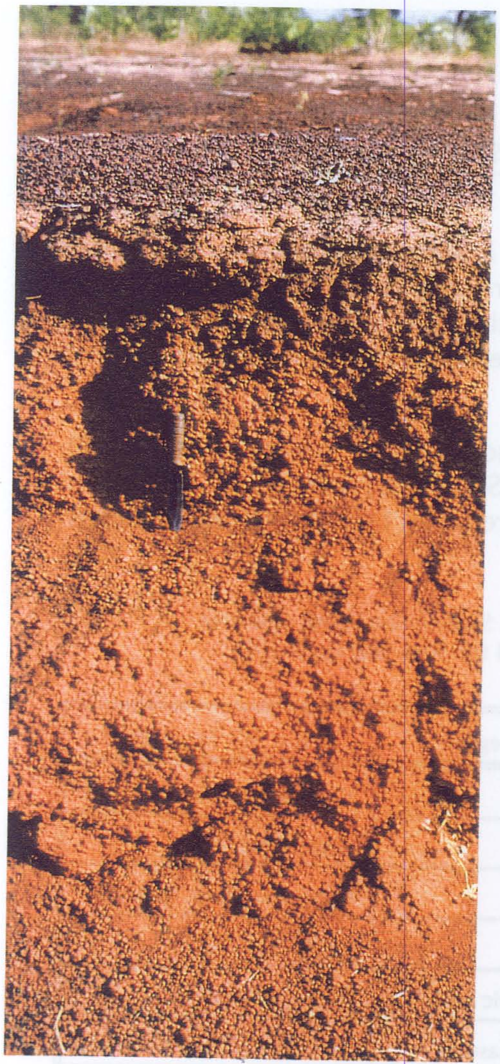
Table 3. Correlation between the Ghanaian Soil Series in the Wiaga pilot area, the 1988 FAO-Unesco Revised Legend, and the 1996 Soil Taxonomy.

Ghanaian Soil Series	1988 FAO-Unesco Revised Legend	1996 Soil Taxonomy
Kolingu Series	Sodi-Eutric Planosol	Oxyaquic Vertic Paleustalf
Puga Series	Acri-Eutric Plinthosol	Typic Plinthustalf
Tanchera Series	Sodi-Eutric Planosol	Oxyaquic Vertic Paleustalf
Pusiga Series	Lithic / Eutric Leptosol	Lithic Ustorthent
Wenchi Series	Lithic / Eutric Leptosol, petroferric phase	Typic Ustorthent
Chuchuliga Series	Lithic / Eutric Leptosol, rudic phase	Lithic Ustorthent
Pu Series	Verti-Eutric Regosol	Typic Ustorthent
Kupela Series	Sodi-Eutric Gleysol	Vertic Tropaquept
Berenyase Series	Orthi-Eutric Gleysol	Aeric Tropaquept
Bianya Series	Orthi-Haplic Lixisol	Typic Kandiustalf

2.7 Cropping systems

2.7.1 Millet - maize - sorghum mixed cropping

These crops are grown on ridged fields (usually ploughed using bullocks) with low capital investment and recurrent expenditures. Limited amounts of animal waste and compost are applied. The crops are grown concurrently and, with the exception of early millet, are harvested around the same period about 120 days after planting. Family hands is the main source of farm labour. Grain yields are generally low. Labour requirements are high during planting and harvesting.



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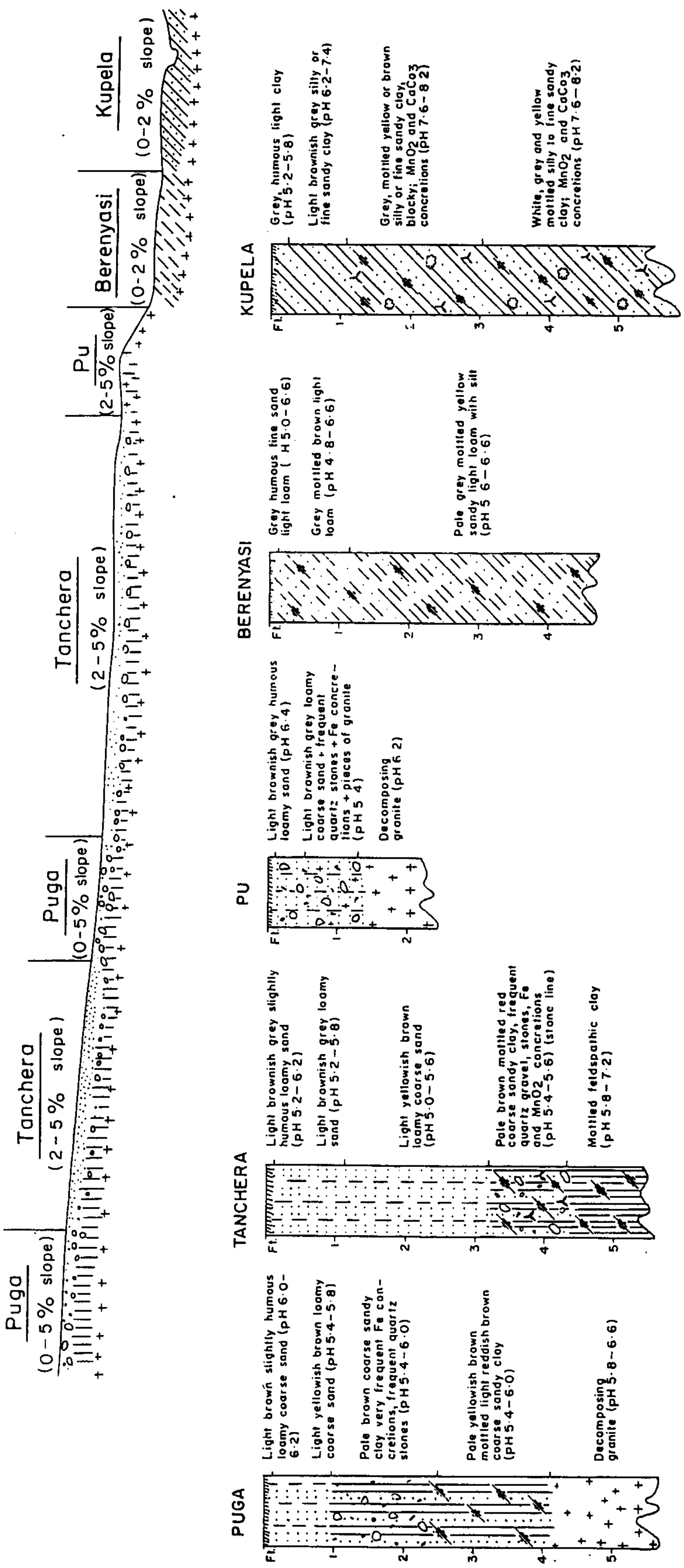

Figure 3. Schematic cross section showing the relations between the Puga, Tanchera, Pu, Berenyasi and Kupela soils (Adu, 1969).

2.7.2 Cotton monocropping

Cotton is grown as monocrop usually at the end of a cropping cycle before fields are left fallow. It is grown on ridges made by bullock ploughs using moderate crop management practices. Capital investment is very low but recurrent expenditure is medium. Inorganic fertilizers are used through an assistance programme offered by the cotton agencies. Yields (flint and seed cotton) are moderately high. Family hands is the main source of farm labour. Peak labour periods are at planting and harvesting.

2.7.3 Bambara bean and groundnut monocropping

These crops are grown on ploughed fields under limited crop management practices with low capital investment. Yields are moderately high. The main source of labour is family labour. Bambara bean and groundnut are usually incorporated in the crop rotational system.

2.7.4 Soybean and cowpea monocropping

These crops have similar attributes as bambara bean and groundnut, except labour requirements are higher during planting and harvesting.

2.7.5 Onions

Onions are grown on ploughed land on small holdings just outside the Langbensi survey area usually by settler farmers from the Bakwu area in northeast Ghana. It is labour intensive. Both organic and inorganic manures are applied.

2.7.6 Rice

Wetland rice is grown in valley bottoms and upland depressional sites by small scale farmers. Rainfed local rice varieties are grown with very little doses of fertilizers and organic manure. The rice farms are small, usually less than 0.25 ha.

2.8 Farming practices

2.8.1 Land preparation

Bullock ploughing and ridging are the most common form of land preparation in both pilot areas. On few occasions the hoe is used for making small beds for groundnut or bambara bean. Yam mounds are also constructed using hoes in the Langbensi area. Animal or refuse-derived manure is normally spread over the field before ploughing. In the Langbensi area, some farmers hire the services of tractors for ploughing.

2.8.2 Planting

Early millet is usually the first crop harvested to overcome the lean period in the growing season. The crop is sown between May to June, depending on the onset of the rains. Other crops like sorghum, late millet, groundnut and bambara bean are sown in June and early July. Intercropping is practised in both pilot areas.

2.8.3 Agronomic practices

Weeding is promptly done after planting. Soil fertility improvement practices are mainly application of animal manure. The amount though is inadequate. Limited application of fertilizers and crop rotation is also practised.

2.8.4 Other practices

Burning of the crop residue is a common practice because leaving cereal stalks on the field is felt to cause nuisance during weeding and it also enhances termite infestation.

Planting of trees was recognised as important by farmers but they found the implementation difficult. The constraints noted by them were the short rainy season and the time of planting interfering with land preparation. Termite attack on young trees was also mentioned.

Use of animal manure is widespread but amounts applied are low and inadequate because of insufficient animals. Distant farms may not get any supply of manure due to constraints in carting. Inorganic fertilizers are used by only few farmers. Normally the applied amount is very low because of the high costs, which are not affordable to the farmers.

3 FARMERS' SOIL MAPPING AND CLASSIFICATION

3.1 Introduction

In most cases, especially in developing countries, farmers use their own knowledge and experience in selecting suitable soils for their activities. This selection is mostly based on indicator features such as plants, topographical sites or proximity to natural features such as rivers, lakes and highlands. Accessibility and socio-economic conditions, e.g. marketing facilities, credit, etc., are also an important factors. The knowledge of farmers will therefore help greatly in appropriate use of the soil resource to maintain and increase yields.

This chapter deals with the ways farmers in the two pilot areas perceive soils and use them for their agricultural activities.

3.2 Procedure

The exercises in each pilot area were conducted by a team of soil scientists from the Soil Research Institute (SRI), Extension Officers from the Ministry of Food and Agriculture and the Langbensi and Sandema Agricultural Stations respectively, and local farmers. The team was divided into two groups, each with three farmers.

The groups followed the traverses previously used for the conventional mapping. Farmers themselves indicated points of soil change along the lines and named the soils in their local dialect, Mampruli for Langbensi and Buli for Wiaga. Other farmers who had their compounds traversed were also interviewed for an independent assessment of the correctness of the identification and mapping exercise. The cross-checking was very essential for areas where people with experience on the land were required to classify the soils especially when the subsoil was considered. They explained the basis of their identification.

Questions asked to the farmers during the interviews include:

a. their awareness on the different soil types they identified during the traverses, the soil types around their compounds, their distribution, and soil variability present;
b. the main diagnostic factors and observable features of the soil types identified;
c. synonyms given to same soil type;
d. the potential and limitations of the soil types;
e. the appropriate land use considered and acceptable alternatives;
f. present local soil management practices; and
g. their knowledge on other agronomic practices which are not currently adopted and the reasons for not adopting them.

The farmers ability to react to the questions was enhanced by the contributions from the Extension Officers who have worked with them in the field for a long time.

3.3 Farmers' soil mapping and classification at Langbensi

The main diagnostic factors used by farmers in the Langbensi pilot area are: texture, mineral nodules, soil depth, surface features (rock and ironstone outcrops), physiography and colour of the topsoils (Table 4). Table 5 shows the important soils identified by farmers, the main diagnostic factors, potentials and constraints. Some local units have been combined on the soil map because they were often not extensive and not mappable at the scale of 1:10,000. This holds especially for factors related to topsoil colours. The combination was done after discussions in the group with the farmers' consent.

Table 4. Soil properties, local names and their meanings (Langbensi)

Soil properties	Local names	Meanings	Comments
Texture	Bihigu Bihi Korre Tam	Sand Sand Clay Earth	"Tam" is sometimes used instead of "bihigu"
Depth	Tampitia Bilinga Bilin	Very shallow to rock Shallow to rock and poor	Usually identified by stunted vegetation and limited plough depth
Mineral nodules	Kokua	Iron-manganese concretions	Kokua is also used to indicate "upland" (see Physiography)
Colour	Sabli Zie Pieli	Dark Brownish or reddish Pale or whitish	Believed to be natural colours and to reflect fertility status of soil
Soil surface features	Tampisie (Tampia) Namorri	Rock exposures Ironstone exposures	
Physiography	Kokua Baa Kulo Nagli	Upland Valley Stream course Depression	Usually used as adjectives

3.3.1 Description of the soils

Kokua soils are upland concretionary soils usually found on summits and upper slopes. The amount of concretions may vary from common to dominant and usually occur within ploughing depth. It is difficult to recognize them if the soil has not been ploughed or if the concretions are relatively deep. In such instances it requires those who have experience on the land to be able to identify the soil.

Kokua soils are divided on the basis of surface colours - which farmers claim to be natural - as *Kokua sabli* (dark topsoil), *Kokua pieli* (whitish or pale coloured topsoil), and *Kokua sie* (brown topsoil). The term Kokua also refers to uplands and may be

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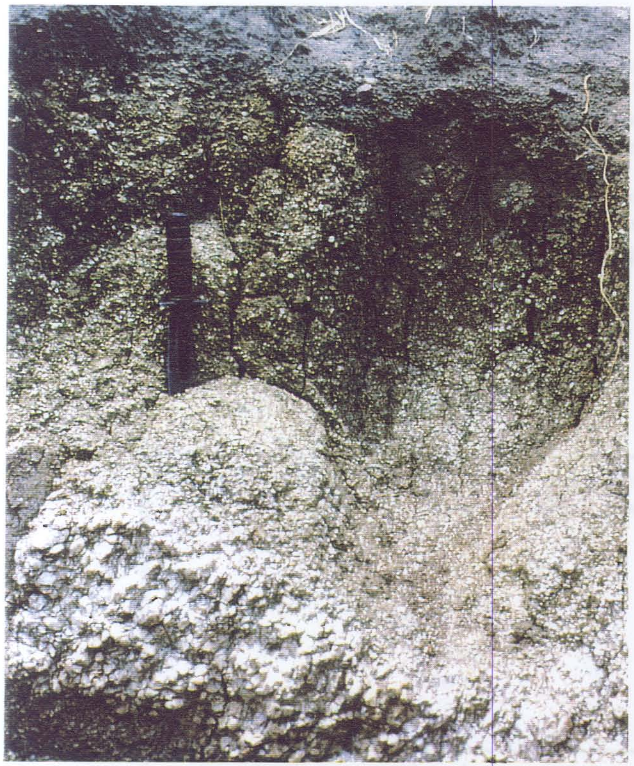

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1. Yak-tang (local) or Pu soil (official) (FAO-Unesco: Verti-Eutric Regosol)
2. Yak (local) or Kolingu soil (official) (FAO-Unesco: Sodi-Eutric Planosol)
3. Weakly undulating terrain of Wiaga.

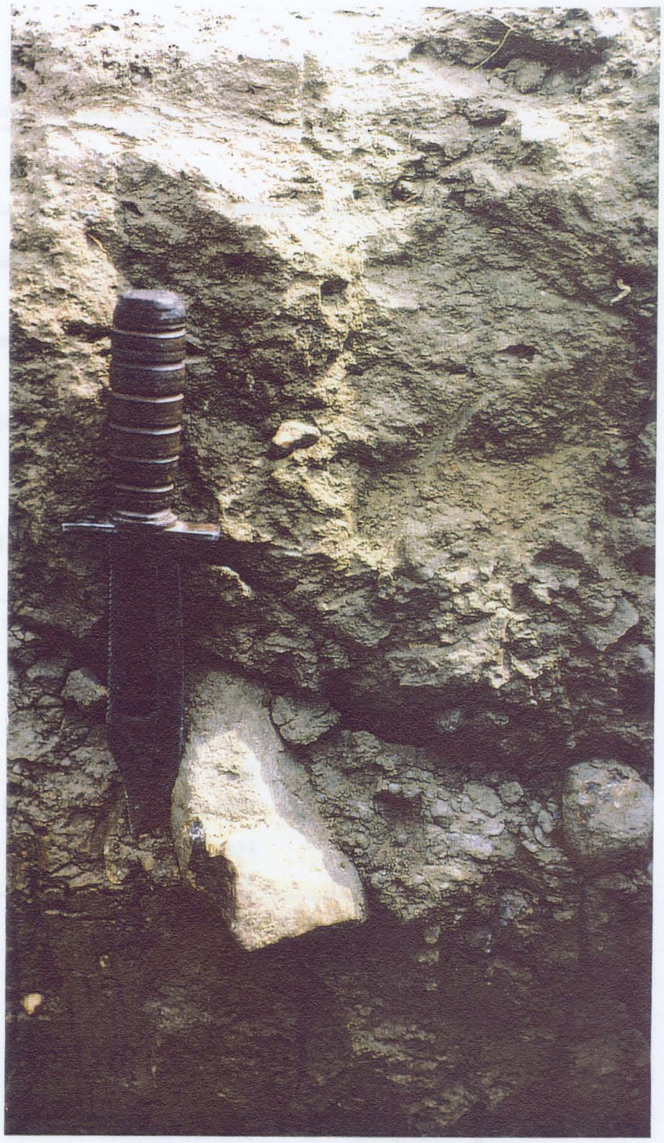

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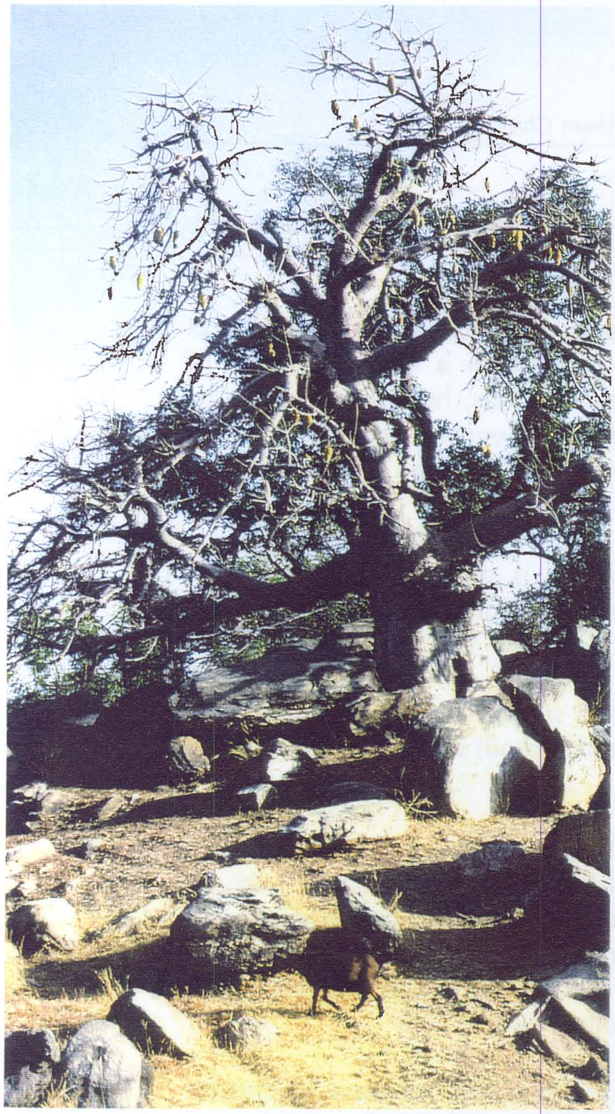
Table 5. Farmers' soil units, main features, their suitability and constraints (Langbensi)

Local soil name	Main features	Physiographic position	Land use / crops	Constraints[1]
Kokua	Concretionary soils	Summit to upper slope	Sorghum, maize, millet, groundnut, soybean, bambara bean, cowpea	- Low fertility - Drought - Erosion
Kokua sabli	Dark concretionary topsoil			
Kokua zie	Brown concretionary topsoil			
Kokua pieli	Pale concretionary topsoil			
Bihigu	Very deep to deep, sandy upland soils	Middle to lower slopes	Maize, yam, millet, sorghum, cotton, groundnut, bambara bean, cowpea	- Low fertility - Drought - Erosion
Bihigu sabli	Dark sandy topsoil			
Bihizio	Brown sandy topsoil			
Tamsabli	Dark earth / topsoil			
Tambizio	Red earth / brown topsoil			
Tandigili	Hardened or compacted soil			
Tampisi	Rocky lands	Summit to lower slopes	No cultivation. Used for grazing, thrashing ground and sharpening of cutlasses	- Root zone limitations - Rock outcrops - Erosion
Tampitia	Shallow to rock	Upper to lower slopes	Sorghum, millet, cotton, groundnut, cowpea	- Rooting depth - Drought - Infertility
Bilinga	Moderately deep soils surrounding rocky land			
Bilinga sabli	Bilinga with dark topsoil			
Bilingnagli	Poor depressional soils			
Bilinkunkune	Poor soils with stunted trees			
Bihipieli	Pale (white) sand	Valley edges and bottoms	Early millet, vegetables	Flooding hazard
Tampieli	Pale earth/soil			
Kulobihigu	Alluvial (river) sand			
Namorri	Ironstone soils	Summit to lower slopes	No cultivation	Root zone limitation
Gbingbirinzieri	Severely eroded land with or without ironstone boulders	Erosional terraces on lower slopes	No cultivation but reclamation possible	Erosion

[1]All these soils are deficient in nutrients.



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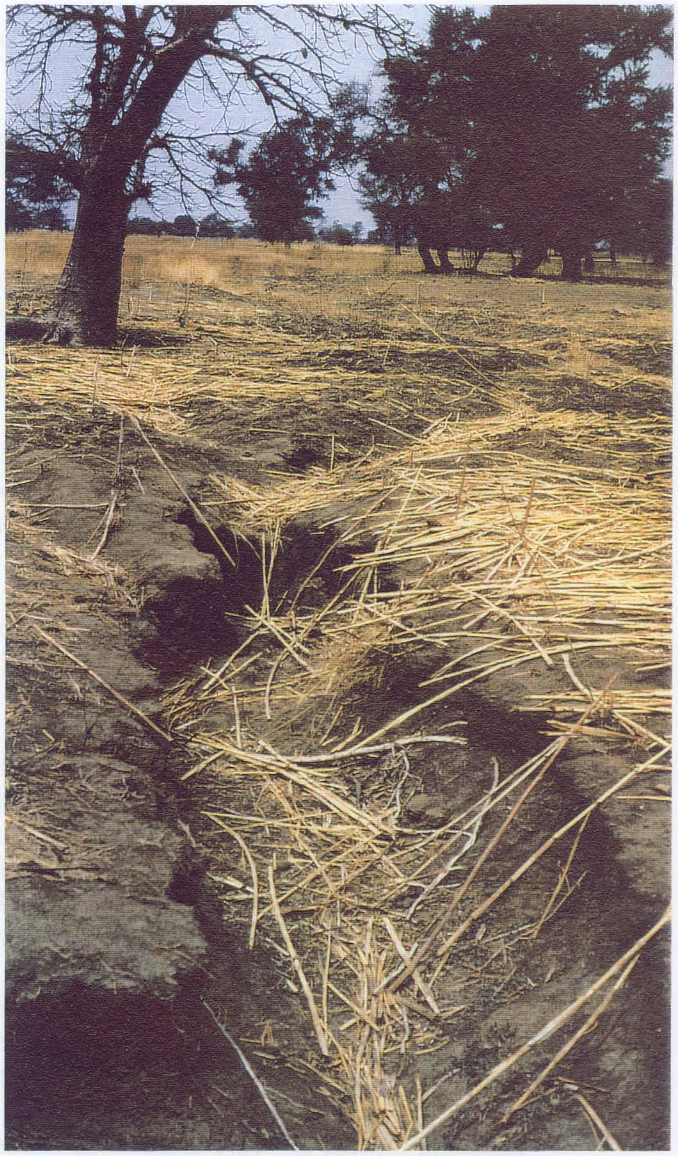

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4. Granite outcrop with *Baobab* tree.
5. Gully erosion on lower slopes in Bauk (local) or Kupela soil (official).
6. Village interest in soil description.

6

used to qualify soils which are free of concretions e.g. *Kokua bihigu* (upland sandy soils).

Kokua soils were described as not very fertile and droughty. Early planting was generally not favourable because crop establishment under a limited amount of moisture is poor. The fertility status of the dark topsoils was, however, rated to be slightly better than that of the paler ones with the brownish versions as intermediates. Farmers may grow sorghum, maize, millet, groundnut, bambara bean, soybean, cotton and cowpea on these soils.

Bihigu soils is usually refers to sandy upland soils. It is sometimes called Kokua bihigu. They are found on upper to lower slopes but predominantly occur on middle slopes.

The Bihugu soils may also be divided according to surface colour as *Bihigu sabli* (dark topsoil), *Bihigu Pieli* (pale or whitish coloured topsoil) and *Bihizio* (brownish sandy topsoil).

These soils are the most important agricultural soils in the area especially the Bihigu sabli which are believed to be very fertile and to give reasonable yields even without fertilization. The brownish and paler coloured topsoils, however, have low inherent fertility and require reasonable doses of fertilizers (both organic and inorganic) in order to increase the soil productivity. The farmers recommended maize, yams, millet, sorghum, groundnut, bambara bean and cotton for this soil.

Tampisie is rocky land. They occur irregularly in the landscape as exposed clusters of sandstone rocks. They are not cultivated but used for rough grazing, to sharpen cutlasses, as threshing floors and sacred groves.

Tampitia-bilinga are very shallow to moderately deep soils adjacent to rocky lands. They are identified by presence of rock within plough depth *(Tampitia)*, stunted woodland vegetation or poor crops performance under continuous cropping *(Bihigu)*. Divisions are sometimes made on differences on topsoil colours e.g *Bihigu sabli*. Other local names used with slight differences are *Bilingnagli* which are Bilinga in a very shallow upland depressions and *Bilinkunkune bilinga* with stunted vegetation.

Kulobihigu are alluvial sands found along stream courses. They are pale coloured and sometimes referred to as *Bihigupieli* or *Tampieli*. They are not widely used for agriculture because of flooding hazard and its limited extent. Crops such as early millet and vegetables are grown on this soil.

Namorri are ironstone soils characterized by a surface litter of ironstone boulders and fragments. They are not suitable for cultivation and usually left under natural vegetation.

3.3.2 Correlation between "formal" and "farmers'" soil maps of Langbensi

The two soil maps ("formal", based on the Ghanaian soil series, and "farmers'") were compared through map overlaying. It showed a fair correlation, however, the farmers' soil map seemed to be more detailed and to consist of many small soil units.

The problem of multiple relationship by superimposing one taxonomic system over the other was realised in this exercise. Nonetheless, this appeared to be minimal probably because scientists and farmers in the Langbensi area coincidentally used common diagnostic features. The similarities were so close that if the "formal" approach had been mapped at phase level, most of the local classification units had been catered for. For example, *Bilinga* can be considered as a shallow phase of the Mimi Series, while *Tampitia* could be deep phase of Kintampo Series as indicated in Table 6.

Table 6. Correlation between the farmers' and soil series classification in Langbensi.

Farmers' classification	Equivalent soil series	FAO-Unesco Revised Legend
Kokua	Techiman Series	Chromi-Plinthic Lixisol
Bihigu	Mimi Series Murugu Series	Chromi-Haplic Lixisol Areni-Ferric Lixisol
Tampisi	Kintampo Series	Lithic Leptosol
Tampitia bilinga	Kintampo Series, deep phase Mimi Series, shallow phase	Eutric Leptosol Chromi-Haplic Lixisol
Kulobihigu	Yaroyiri Series	Areni-Eutric Fluvisol
Namorri	Wenchi Series	Lithic / Eutric Leptosol, petroferric phase
Gbingbirinzieri	Mimi Series, eroded phase	Chromi-Haplic Lixisol

3.4 Farmers' soil mapping and classification at Wiaga

Farmers in the Wiaga pilot area used texture, coarse fragment content and surface features as the main diagnostic factors in identifying soils (Table 7). They usually referred to subsoil textures which sometimes required people who have experience on the land to confirm the identification.

Table 8 shows the important soil units identified by the farmers, their potentials and constraints. In naming the soils, the properties diagnosed by the farmers as indicated in Table 7 were either solely used or combined.

It was generally observed that the farmers units were too detailed with some of the units being very limited in extent. Some of the related or similar units were therefore combined with the farmers' consent to make them mappable. For example, the farmers identified three forms of sandy soils viz. *Mwang*, *Tambusung* and

Tampeoling, which have been mapped under one name, Mwang. Other not extensive units were considered as soil inclusions after discussions with farmers.

Table 7. Soil properties, local names and their meanings (Wiaga)

Soil property	Local Names	Meanings	Remarks
Texture	Yak Mwang Tambusung Tampeoling	Clay Sandy loam Sandy Loamy sand	Different forms of sandy soils are not easily distinguished
Coarse fragments	Zingi Tang	Iron-manganese concretions Stones and gravels (quartz)	
Surface features	Pina Pung mona	Rocks Ironstone	

3.4.1 Description of the soils

Yak and related soils are clayey soils which occur in various physiographic positions from the summit to lower slope. The Yak may occur with or without coarse fragments. In case it contains coarse fragments, names given reflect the constituents. For example *Yak-tang* and *Yak-zingi* refer to stony clay and concretionary clay respectively.

Bauk are black, heavy clay soils found in valley bottoms. They are poorly drained and get waterlogged in the rainy season. They are quite distinct from the Yak by colour and the physiographic position they occupy. In a typical *bauk* area, gilgai and surface cracks may be present. The soil is not easy to work due to the heavy texture. In several places, they are used for rice and early millet. Early millet is grown and harvested before the rainfall intensifies.

Tampeoling, Tambusung and **Mwang** are the various forms of sandy soils distinguished by farmers. Only the topsoil is normally used. It was found out that loamy sands were usually called *tampeoling,* or *tambusung,* and sandy loams *mwang.* An easy distinction between these forms of sandy soils could not be made. To make their mapping meaningful, they are shown under the unit *Mwang.*
Mwang soils are constrained by drought during dry spells due to the sandy textures. Main crops grown on them are sorghum, millet and groundnuts.

Zingi are concretionary soils usually on upper and middle slopes. The topsoils to a depth of about 25-30 cm contain only few to common iron concretions. Below, the concretions become many to abundant. Two types of Zingi were identified: *Zing-bulim* (fine to medium iron concretions) and *Zing-kpang* (coarse iron concretions).

Table 8. Farmers' soil units, main features, their suitability and constraints (Wiaga)

Local soil name	Main features	Physiography	Land use / crops	Constraints[1]
Yak	Clayey soil	Summit to lower slope	Sorghum, millet	Erosion Infertility
Bauk	Heavy black clay	Valley bottom	Rice, early millet	Waterlogging in rainy season Difficult to work
Yak-tang	Stony clay soil	Summit to lower slope	Sorghum, millet	
Zingi	Concretionary soil	Upper to lower slope	Sorghum, millet, bambara bean, groundnut; house construction	Drought Shallowness Concretionary subsoil Infertility
Yak-zingi	Concretionary clayey soil			
Yak-tang-zingi	Stony concretionary clayey soil	Upper to lower slope	Sorghum, millet	
Tampeoling	Loamy sand soil	Upper to lower slope	Sorghum, millet	Drought
Tambusung	Sandy soil (sand)			
Mwang	Sandy loam (loamy soil)	Summit to lower slope		
Tambusung-yak	Sandy clay soils	Summit to lower slope	Sorghum, millet	
Tang	Mainly stony and gravelly soils	Middle slope	Sorghum, millet	Drought Stoniness
Kampuring	Not cultivable, eroded soils	All physiographic positions	Extensive grazing	Shallowness Erosion
Pina	Rocky land		Uncultivated	Shallowness
Pung-mona	Ironstone soils		Uncultivated	Shallowness

Tang are soils with a thin, humus-stained topsoil over a dominantly stony and gravelly subsoil. The soils are loose and very permeable. Their use for agriculture is highly limited by poor rooting conditions and drought. Farmers complain of mechanical damage to tools and dislocation of crops during weeding. However the soils are occasionally used for the cultivation of sorghum and millet. Stones are quarried on a small scale along the Wiaga-Kadema road, for construction works.

[1]All these soils are deficient in nutrients.

Millet and sorghum are grown on these soils, but the farmers frequently refer to Tang as soils good for groundnut. The concretionary layer is also excavated for the construction of houses.

3.4.2 Correlation between "formal" and "farmers'" soil maps of Wiaga

A fair correlation was established in comparing the formal, using the Ghanaian soil series, and local classification systems both during field observations and map overlaying. Some of the boundaries of the two maps do not coincide because of slight differences in diagnostic criteria. For example, *Yak* (clayey soils) occurs on all physiographic sites according in the farmers' perspective. The farmers only consider texture as differentiating criterion, not physiography, drainage and depth.

Another factor is the drawing of boundaries based on surface features such as concretions and stones, which may result from ploughing of the same soil or transitional soils, thus yielding several soil units in the farmers classification.

Some of the soils, however, showed distinct physiographic positions and correlated well. For example, the *Bauk* (heavy black clays), which occupy valley bottom sites, was always found to coincide with the Kupela Series whilst the highly concretionary soils *Zingi*, which occur on the slopes of the upland, correlates with the Puga Series.

The general relationship between the farmers' and formal classification is given in Table 9.

Table 9. Correlation between the farmers' and soil series classification in Wiaga.

Farmers' classification	Equivalent Soil Series	FAO-Unesco Revised Legend
Yak	Kolingu Series Pu Series Bianya Series Kupela Series	Sodi-Eutric Planosol Verti-Eutric Regosol Orthi-Haplic Lixisol Sodi-Eutric Gleysol
Bauk	Kupela Series	Sodi-Eutric Gleysol
Mwang	Tanchera Series Pu Series Berenyasi Series	Sodi-Eutric Planosol Verti-Eutric Regosol Orthi-Eutric Gleysol
Zingi	Puga Series	Acri-Eutric Plinthosol
Pina	Chuchuliga Series	Lithic/Eutric Leptosol, rudic phase
Pung-mona	Wenchi Series	Lithic/Eutric Leptosol, petroferric phase
Yak-tang	Kolingu Series Pu Series	Sodi-Eutric Planosol Verti-Eutric Regosol
Tang	Kolingu Series (stony)	Orthi-Eutric Leptosol

4 REPRESENTATIVENESS OF SOILS IN THE PILOT AREAS RELATED TO SOILS OF NORTHERN GHANA

The semi-arid savanna zone of Northern Ghana covers three political regions namely, the Northern, Upper East and Upper West Regions. The area covers approximately 97,700 km^2 (Macmillan, 1995). A little over 80% of the area falls within the Guinea savanna ecological zone. The remaining part falls within the Sudan savanna ecological zone which fringes the upper most part of Ghana (Ewer and Hall, 1973). Over 80% of the semi-arid savanna lies north of the Black Volta River and the Volta Lake.

The region is underlain by different rock types from which the soils are developed. These are:

1. Granites - hornblende, biotite, muscovite granite;
2. Birrimian rocks - phyllite, greywacke tuff;
3. Voltaian sedimentary rocks - sandstone, shale/mudstone; and
4. Materials of alluvial origin - mixed materials, old terraces.

These rocks have variable chemical and physical properties and have resulted in a variety of soils. Earlier soil survey work in the region by the Soil Research Institute have grouped the different soils into associations, consociations and complexes to facilitate mapping at the reconnaissance level. About 70 of such map units have been documented for the area (Adu, 1969; 1995; Scott, 1962).

The Soil Association related to soils of the Langbensi pilot area cover an estimated area of about 13,000 km^2 or about 13% of soils of the Northern Savanna Zone. This includes all soils developed over sandstone and others which contain extensive proportions of Wenchi Series.

The Soil Association related to soils of the Wiaga pilot area cover an estimated area of about 10,000 km^2 or about 11% of soils of the Northern Savanna Zone.

5 THE FARMERS' WORKSHOPS ORGANIZED IN THE PILOT AREAS

5.1 Introduction

A workshop following the compilation of a draft report was held in the ILEIA pilot sites of Langbensi and Wiaga with the aim of discussing the results of the study with the farmers. The workshops were held on 6 and 7 June, 1996 at Bunbuazio in the Langbensi pilot site and Muteensa in the Wiaga pilot area, respectively. The workshops were attended staff of Presbyterian Agricultural Stations, a representative of the Agricultural Information Service of the Presbyterian Church, an ILEIA Consultant, an FAO (Accra) staff member, staff of the Soil Research Institute, ISRIC project coordinators, and members of the farming community, 35 men, 55 women and 50 children in Bunbuazio, and 35 men, 32 women and 26 children in Muteensa. The latter workshop was also attended by a representative of Builsa District Assembly and the District Pastor of the Presbyterian Church.

5.2 Activities at the workshops

5.2.1 Introduction of subject matter to farmers

The project was presented to the farmers as part of the efforts made by the Presbyterian Agricultural Stations to enhance their crop production capabilities. The main objectives of this activity are:

a. To consolidate the function of the Agricultural Stations in offering technological assistance to farmers in agricultural production;
b. To present a "bottom-up" approach, whereby the indigenous mode of farming practices are given priority consideration;
c. To increase and substantiate the awareness of the local population on the importance of their land resources through the land resource surveys. These include soils, vegetation, physiography, etc.;
d. To improve upon the farmers' resource management capabilities so as to enable them to conserve their resources for their own use and safeguarding them for future generations;
e. To assist in increasing agricultural productivity in the pilot areas on a sustainable basis.

5.2.2 Technical discussions with the farmers

The Langbensi pilot area

The workshop was held at Bunbuazio, where two presentations were made, the first on physiography and land use, and a second on the results of the ethno-pedology studies.

The soil units identified by the farmers during the mapping and classification exercise were presented to the community. Farmers were asked to provide descriptions, land use and constraints of these soils.

The process generated a healthy discussion among the entire meeting. In general, there was no major difference between the information collected during the mapping exercise and that of the workshop.

Issues for discussion after the presentation were:

a. The farmers recognized that one soil, locally known as *Bayare*, was not mentioned during the presentation. This is a clayey soil found in valleys and used for plastering their buildings. Its limited extent was the cause of this omission.
b. The farmers identified *Bihigu sabli* to be the most productive agricultural soil in the Langbensi area.
c. The discussions showed that farmers are aware of some measures for soil fertility restoration. Some applied limited doses of chemical fertilizers, animal waste manure and practised crop rotation including leguminous crops and fallow period. They further agreed that bush burning was harmful and should be avoided.
d. Farmers also mentioned some limitations to their farming activities. These are:
    - the high cost of fertilizers, which were not affordable to them.
    - inadequate supply and application of farmyard manure attributed to the small amount of livestock. A suggestion on housing the animals in kraals for easy collection of their waste triggered additional discussions. Some of the farmers complained about labour and financial resources for building kraals and cutting fodder for the confined animals. It was explained to the farmers that traditionally animals are kept confined during the cropping season and that it was only a matter of improving upon the housing conditions of the animals. In effect, no new practice is being introduced.
    - Drought was also recognised as a common problem by the farmers.
    - The farmers identified the occurrence of soil erosion particularly on slopes. They recommended tree planting as a way of controlling soil erosion.

The Wiaga pilot area

The workshop procedure had similar proceedings as at Langbensi. Soils identified during the farmers mapping exercise were presented and discussed. Additionally soil samples taken from the soil profiles were each arranged into improvised monoliths for farmers to identify. Results of the workshop compared very well with the information obtained during the mapping.

The following observations and comments were made:

a. Drought, low soil fertility and soil erosion were mentioned as the main farming related problems. The farmers could identify solutions to some of these problems. Low soil fertility could be solved by application of organic manures, fertilizers, planting of trees, the practice of crop rotation and putting a stop to frequent bush burning.

b. Tree-planting has been difficult because the growing season is short and competes with time for land preparation. Termite attack on young trees was also mentioned as a problem.
c. On bush burning, the farmers remarked that it was difficult to stop because it has been a long tradition within the community and are usually set by hunters.
d. Fertilizer application has been inadequate due to high cost.
e. On controlling soil erosion some farmers indicated that rock boulders could be used as barriers.

The soil identification exercise by the farmers was carried out at the end of the discussion. Samples taken from the profile pits of the soils identified in the area were built into provisional monoliths. Farmers moved from soil to soil, identified them and gave the potential land uses and constraints. This exercise confirmed earlier soil identification and mapping as well as descriptions, potential and constraints given at the workshop.

However, there was slight change involving the Kolingu stony subseries which originally was mapped as Mwang (loamy soils) but at the identification exercise was unanimously named as Tang (stony soil). Its major limitation is drought. There was also a modification of the Pu series which could either be Yak or Yak-tang depending on the presence or absence of quartz gravels and stones in the decomposing rock.

5.3 General observations on the workshops

It was generally observed from the proceedings of the workshop that farmers at each of the pilot areas had a common understanding and perception of soils in their respective environments. Almost all the soil types identified, their land use and constraints derived during the farmers mapping exercise were confirmed by the general farming population at the workshops.

It also came out clearly that the farmers have great expectation from the project in the form of technical assistance and the supply of inputs to address their numerous agricultural problems.

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

6.1.1 Geographical representativeness

The semi-arid savanna zone of Northern Ghana covers approximately 97,700 km^2. The area is underlain by a wide range of rock types, which vary in physical and mineralogical properties within and between the rock types. The major rock types are granite, phyllite, sandstone and shale (Junner and Hurst, 1946).

The soils of the Langbensi pilot area are developed from sandstone, whilst those of the Wiaga pilot area are underlain mainly by hornblende - biotite granite with a small inclusion of greywacke/phyllite (Adu, 1969; 1995).

The soils of the Langbensi and other areas developed from sandstone in the Northern Savanna Zone cover about 13,000 km^2 or 13% of the zone. The soils of Wiaga pilot area and similar ones over hornblende - biotite granite and greywacke in the Northern Savanna Zone cover about 10,000 km^2 (11% of the area).

The people of the pilot areas are made up of Mamprusis for the Langbensi area who speak the Mampruli language and of Builsas for the Wiaga area who speak the Buli language. The Mamprusi and the Builsa areas, however, cover only about 7640 km^2 (8%) and 2200 km^2 (2%) of the Northern Savanna Zone respectively. Other ethnic groups in this geographical region, some of which settle on similar soils include the Frafras centred around Bolgatanga, the Dagombas, Nanumbas and Konkombas around Tamale and Yendi, the Gonjas around Damongo, Bole and Salaga, the Dagartis and Lobis around Lawra and Nandom, the Sissalas around Tumu, the Walas around Wa, the Kassenas around Navrongo, and the Kussasis around Bawku and Zebilla (Macmillan, 1995).

The soils of the pilot areas cut across some of the area of these ethnic groups for which their classification in the respective local dialects may be required for effective communication and agrotechnology transfer. In addition, not all the major soils in each ethnic group area is covered in the present survey. Further studies on soils developed over shale, mudstone, siltstone and claystone may be required for total coverage of the Mamprusi area. Some alluvial soils around Wiasi near Fumbisi in the Builsa area are also important to have a complete coverage of the Wiaga area.

Existing soil information at the Soil Research Institute reveals that many more important soil associations in the Northern Savanna Zone are not covered by the present study. These include soils developed over granite (the Varempere, Tanina and Kagu Associations), soils over Birrimian rocks (the Wenchi-Pale and Yagha Associations), soils over shale (the Kpelesawgu and Volta-Lima Associations), and alluvial soils (the Dagare, Siare and Nterso-Zaw Associations).

6.1.2 Potential and constraints of the soils studied

The soils of the pilot areas vary in quality and extent. However, nearly all the soils are low in nutrient reserves due to strong weathering and very low organic matter content.

In the Langbensi pilot area, **Mimi** and **Murugu** soils, which together constitute about 1377 ha (59% of the area) are moderately suitable for the present-day crops, sorghum, millet, maize, groundnut, cotton, bambara bean, cowpea and soybean. They are limited by low nutrient reserves, moderate sheet erosion hazard and, occasionally, slow runoff.

Techiman (19%) and **Yaroyiri** soils (3%) are marginally suitable for cultivating the above crops, because they are limited by abundance of ironstone concretions (Techiman) or flood hazard (Yaroyiri). About 24% of the Langbensi pilot are comprise **Kintampo** and **Wenchi** soils, which are not suitable for cultivation. These soils are limited by very shallow depth, usually less than 10 cm, and abundant rock and ironstone outcrops.

The suitability of the soils in the Wiaga pilot area shows a similar pattern. **Kolingu, Puga, Bianya** and **Berenyasi** soils, which together constitute about 68% of the pilot area, are only moderately suitable for cultivation of sorghum and millet and, to some extent, groundnut. They are mostly limited by low nutrient reserves and, occasionally, by moderate sheet erosion hazard and imperfect drainage.

About 7% of the soils, the stony **Kolingu**, the **Pusiga** and **Tanchera** soils are marginally suitable for sorghum, millet and groundnut production. Tanchera soils are limited by abnormally nutrient retention probably because of the sandy nature of the top layers, while Pusiga and stony Kolingu soils have root zone limitations due to extreme stoniness and shallow depth.

Kupela soils, which comprise 18% of the area, are only marginally suitable for cultivating upland crops because of severe drainage problems. However, they are moderately suitable for the production of wetland rice. They are limited by low nutrient reserves.

Other soils, the **Chuchuliga** and **Wenchi** soils, which cover about 7% of area are not suitable for cultivation. They are highly limited by shallow depth (<10 cm) and abundant rock and ironstone outcrops.

6.1.3 Soil correlation

The farmers' mapping using the indigenous knowledge gave similar outputs as the results of the formal pedological studies. A fair correlation can be established between the scientific and indigenous perceptions of the soils of the two pilot areas.

The general observations which can be made in comparing the two independent soil mappings are:

a. Farmers have reasonable awareness of the soils they use for their farming activities;
b. Farmers mostly rely on physical properties to recognize the soils, which are often surface features such as texture, depth, colour, mineral nodules, stones and coarse fragments, and, occasionally, the physiographic position.
c. Farmers' mapping units were found to be very small because they usually consider many details irrespective of the extent.
d. Farmers are able to evaluate the land by experience. They rely on topsoil colours and crop performance to assess the nutrient level of the soils, and use texture for assessment of the soil moisture relationships.
e. Although the farmers recognize differences in soil types, they farm across the soil boundaries. The reason may be that most of the soils have similar constraints. The farmers are also limited in the choice of crops to grow, since they all have to produce crops as millet and sorghum for their household consumption. The market is also limited for the production of alternative crops.

6.2 Recommendations

On maintenance of soil fertility
The most common problem expressed by farmers is low soil fertility. Present practices to improve soil fertility include application of animal waste manure (cow, sheep, goats and poultry), inorganic (chemical) fertilizers, crop rotation and fallow.

These practices are found to be inadequate for optimum soil productivity. Farmers are aware of the importance of these practices for increasing yields, but they are unable to fully or efficiently administer them because of:

- highly demanding labour involved in some of the practices, e.g. transporting manure to farm sites far away from the supply source;
- lack of funds to purchase enough fertilizers;
- limited availability of manure; and
- problems of compost preparation.

As awareness is there and practices in place, it is now needed to educate, encourage and monitor the farmers to be more effective in their operations. Crop rotation practices may benefit from research results. A study (Schmidt and Frey, 1988) in the northern savanna has shown the advantage of an appropriate sequence of crops in a rotation of grain legume (groundnut, cowpea) - cereals (maize, sorghum, millet) - root crops - cereals. This order of rotation demonstrated to increase supply of nitrogen available to the cereals. It further observed a reduced risk of pests and diseases or parasitic weed infestation (striga).

Farmers should be assisted and encouraged to use kraal methods to facilitate the accumulation and collection of animal waste to fertilize their fields. This will have to be integrated with planting leguminous trees e.g. *Lucaenia*, to provide fodder for the animals.

Chemical fertilizers are easier to apply and give rapid results. However, their cost is not affordable to farmers. Therefore, a fertilizer supply scheme should be put into practice with redemption after harvest. Such a system will have to embrace other sectors such as marketing, preservation/storage, etc. to enable farmers to derive a reasonable income for repayment.

The possibility of composting household refuse may supplement other soil fertility maintenance or restoration practices.

Farmers in the Wiaga pilot areas must be made aware of the subsoil sodicity, which is present in a number of soils. The emerging local irrigation schemes to grow vegetables, as has been observed near Sandema, may suffer from sodification if water quality is nor regularly checked.

On agro-forestry
Promotion planting of leguminous trees will, apart from serving as fodder for animals, improve soil fertility and, in addition, provide domestic fuel. Domestic fuel will be a pressing demand particularly in the Wiaga area and an early development is necessary. Farm edges and community lands are possible areas where they can be planted. Community woodlots can be established using suitable tree species for household fuel.

On land preparation
The use of bullock plough should be encouraged rather than the tractor. This is to protect the soil from disturbance and subsequent degradation. However, the provision of tractors with trailers are desirable in any assistance package to ease the burden of carting farm produce and animal manure.

On burning
Farmers must be encouraged not to remove or burn plant residue in an attempt to clean fields as was observed in the area. They may educated to collect and burn only the cereal stalks which they consider a nuisance during land preparation and weeding after planting. Research has shown that decomposing maize or sorghum residues may cause a period of severe nitrogen shortage to subsequent cereals (Schmidt and Frey, 1988).

On indigenous knowledge
This ethno-pedology pilot study has revealed that farmers have ample knowledge of the soil resources in their environment. This knowledge must be tapped by scientists, in their efforts to improve and sustain the crop production potential of rural communities. To this end, the present study may be extended in the future to cover other areas with different ethnic communities or different soils.

On extension work

Results of the soil and agronomic research carried out in the region hardly reaches the local extension workers. Moreover, extension workers have difficulties in understanding the research findings and translate them to the local farmers. It is therefore recommended that short training courses are organized for the extension staff to familiarize them with the local soil conditions as perceived by the soil researchers in order to better understand each other. Moreover, it is recommended that extension staff be equipped with simple soil tests to better advice farmers on agronomic measures.

The Ghanaian Soil Research Institute is now in the position to carry out the same studies in other areas. The Institute is prepared to assist the communities to learn and adopt recommended practices to improve agricultural production while safeguarding their environment. Training of extension staff must be integrated in further research.

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