Environmental and Socio-Economic Characteristics of the Kpene Catchment in Northern Ghana: Implications for Soil and Water Conservation

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Abstract: A detailed agro-ecosystem characterization was carried out in the Kpene catchment of the Jolo-Kwaha watershed in Northern Ghana at a scale of 1:5000. The objective was to examine the environmental and socio-economic characteristics of the Kpene area and identify the constraints on sustainable agricultural production, especially soil and water management. Environmental data, particularly land use and soil types were obtained through transect surveys while socio-economic data through participatory rural appraisal (PRA) techniques. The area falls within the Guinea Savanna agro-ecological zone of Ghana with a unimodal rainfall regime. With a Land Use Ratio (LUR) of almost 100%, land use is very intense and fallow is almost non-existent the farming system. The uplands have mainly deep, well – drained and non-concretionary Lixisols, and the lowlands, deep and imperfectly to poorly drained Planosols and Gleysols. The Kpene community has an average of 40 persons per household, with majority (45%) being between 15—45 years of age. The major occupation is farming with land ownership being entirely through inheritance. Major crops grown are maize, yam, rice and groundnuts. In soil fertility management, 70% apply mineral fertilisers, especially to rice. Some constraints on agricultural production are erratic and unreliable rainfall, low soil fertility and poor water management. Levelling for proper water conservation in the valley bottoms and water harvesting can enhance agricultural production.

Keywords: Environmental, kene catchment, soil, water conservation

1 Introduction

Most countries in sub-Saharan Africa use inland valleys for agricultural production on a very limited scale. In some cases, increased and intensive cultivation of the lowlands, especially the valley bottoms of the inland valleys is restricted by severe weed infestation, inappropriate water management technologies, lack of purchased inputs, labour shortage and unfavourable socio-economic conditions (Windmeijer and Andriesse, 1993). Estimates show that inland valleys cover about 700,000 hectares in Ghana (Wakatsuki, 2001) and majority of these are in Northern Ghana (Senayah and Dedzoe, 1997).

Crop production, especially rice, in inland valleys has a high potential in ensuring food security in Ghana, in particular, and in sub-Saharan Africa, in general. Knowledge about the biophysical and socio-economic characteristics of inland valleys is very limited. This, therefore, calls for their characterisation so as to facilitate their development and improve on the productive systems within these agro-ecosystems (Windmeijer and Jamin, 1995).

Food insecurity is severe in the rural areas of northern Ghana. Availability, access and utilisation of food are areas of concern and periods of food shortages commonly last from two to five months. This situation is worsened by the difficult climatic and environmental conditions within the interior savannah (Guinea and Sudan) agro-ecological zone of Ghana. The incidence of poverty is increasing among families who operate at the subsistence level. The objectives of this study were to provide a comprehensive description of the biophysical characteristics of the Kpene key catchment and also identify the constraints on sustainable agricultural production. This will generate a database for further studies on agronomic and soil management research in the Kpene community and subsequent agro-technology transfer to similar environments.

2 Materials and methods

2.1 Soils of the catchment

The soils in the area are developed from clay shale geological formations with lenses of micaceous sandstone, siltstone and mudstone. The valley bottoms soils are derived from alluvial deposits of these material (Adu, 1957).

2.2 Field survey

Transect surveys were carried out on a regular grid of 100 m × 50 m (scale of 1:5,000) to describe the physical environment of the area. Soil types were identified and described along transects. Through participatory rural appraisal techniques (PRA) such as semi — structured interviews and transect walks with volunteer farmers, information was obtained on the community's profile, land use and management, and any constraints on agricultural production.

2.3 Data analyses

Land use was quantitatively characterized using the parameters described by van Duivenbooden and Windmeijer (1995). Land use intensity was expressed in terms of land use ratio (LUR). Rainfall data was analysed to determine rainfall characteristics and return periods. This was done to assess the effect of rainfall amounts on the overall agricultural production of the community.

3 Results and discussions

3.1 Land use

Land use is very intense in the area. In terms of relative importance, the slopes and fringes are the most intensively used. Each has an LUR value of 100% with the valley system average being 90.0%. Annuals are the dominant crops grown. The valley system has a very high annual crop ratio (ACR) of 89%. The major annual crops are yam, rice, maize millet, cassava and cowpea,

3.2 Soils

The dominant upland soil is deep, well – drained and non – concretionary Lixisol. The lowlands have deep imperfectly to poorly drained Planosols on the lower slopes and very poorly drained Gleysols on the valley bottoms.

Particle size distribution shows that the upland soils are dominantly sandy, with sandy loam textures throughout. Per cent sand ranges from 57.5 — 73.0 throughout the profile. With the Planosols, per cent sand ranges from 12.5 — 45.5. However, per cent clay is fairly moderate with levels increasing from 10.5% — 28.5%. Textures range from silt loam to clay loam. The Gleysols have higher per cent clay content. Values range from 17.5% — 35.0% and textures vary from silt loam at the top to silty clay loam in the subsoil.

The soil are generally acidic and most of the plant nutrients are low. Soil reaction in the Lixisols range form strongly acid (pH 5.4) conditions in the top to extremely acid (pH < 4.5) conditions within the profile. The Planosols, on the other hand, are slightly acid (pH 6.1) at the top and become very strongly acid (pH 4.6 — 5.1) with depth. The valley bottom soils (Gleysols) are very strongly acid (pH 4.5 — 4.7) throughout the profile. Organic matter levels are very low in all the soils. However, the levels are moderate (2.1% — 3.1%) in the top 10cm of the Planosols and Gleysols. Available P is very low in all the soils (< 3.0 mgP/kg). Available K also follows a similar trend (the levels range from 50.0 mgK/kg — 100.0 mgK/kg.

3.3 Hydrological characteristics

Analysis of hydrological climate of the area shows that no rains are received between December and March. Monthly rain days increase towards the cropping season with the monthly mean values being around 180 mm. The main rainy season is from mid-May to mid-October. Seasonal rains are very important in the cropping system of the area. Analyses show that from May to September, 80% of these seasonal rains contribute 70% — 90% of the annual amounts received. No seasonal rain contributes less than 50% of annual expectations (Table 1).

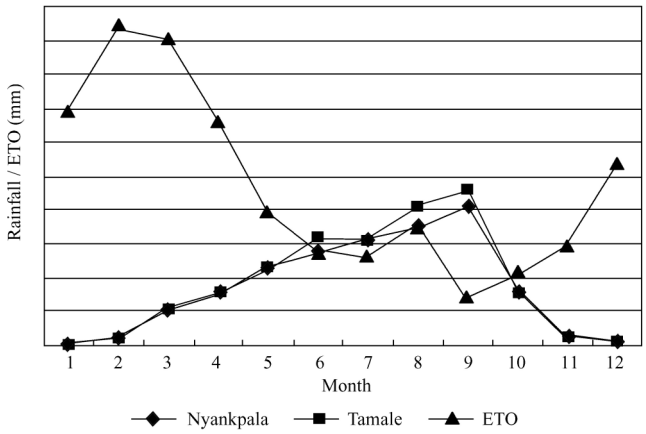

Fig.1 Hydrological climate for Tamale-Nyankpala area

Table 1 Relationship between seasonal rains (mm) and annual rainfall (mm) for Tamale

Year	Season	Annual	% of annual rain	Year	Season	Annual	% of annual rain
1	604.0	831.1	72.7	19	885.0	1226.1	72.2
2	869.2	1163.4	74.7	20	834.5	1049.1	79.5
3	1390.6	1545.2	90.0	21	859.9	1131.1	76.0
4	729.5	1053.8	69.2	22	707.9	1181.7	59.9
5	1088.3	1380.3	78.8	23	505.5	748.9	67.5
6	747.0	1003.8	74.4	24	734.0	925.9	79.3
7	812.7	1128.4	72.0	25	862.5	1034.3	83.4
8	1083.0	1465.9	73.9	26	777.0	1082.3	71.8
9	677.8	959.5	70.6	27	786.6	956.9	82.2
10	733.6	837.5	87.6	28	888.7	1123.9	79.1
11	632.7	1064.0	59.5	29	1242.2	1456.8	85.3
12	735.8	1063.7	69.2	30	760.8	1036.8	73.4
13	742.7	933.5	79.6	31	1048.5	1580.0	66.4
14	884.0	1056.6	83.7	32	524.6	695.3	75.4
15	824.0	1159.0	71.1	33	839.2	1000.4	83.9
16	716.7	1018.3	70.4	34	840.9	1158.9	72.6
17	907.7	1139.0	79.7	35	834.8	996.1	83.8
18	628.8	1000.0	62.9				

It can, therefore, be deduced that 60% — 80% of annual rain will occur in the main farming season, notwithstanding its unpredictable distribution. Most of the low seasonal rain events (500 mm — 800 mm) (Table 1) have return periods of one to two years. This shows that planning should be done with low

seasonal rains since the area has an unreliable rainfall regime. Water harvesting techniques are also necessary to ensure maximum use of water in the area.

An important link in the seasonal water cycle is evapo-transpiration. Abstractions from rainfall exceed rain amounts received from November to April (Fig.1). This causes a moisture deficit in the soil environment. However, there is sufficient moisture from May to September to meet the full consumptive use of crops.

The foliage of the savanna vegetation, dominated by monocotyledonous crops, tends to abstract a lot of rainwater. Crops such as millet, sorghum, maize and rice, abstract rainwater and either retain it on the leaves as surface storage or within the sheath, where much is evaporated. The abstractions from seasonal rains range from 12% — 20% (Table 2). This implies that in the Kpene catchment water management strategies should be based on 20% of seasonal rainwater.

Table 2 Seasonal rainfall interception

Month	Rainy days	Interception/day	Interception/month	% of monthly rains
June	8	3.13	25.00	18.06
July	6	2.84	17.01	10.83
Aug	10	3.63	36.26	20.70
Sept	13	1.94	25.26	12.32
Oct	3	2.53	7.59	9.34

3.4 Socio-economic characteristics

The community consists of about 36 compounds with a minimum of 40 persons per household. The male is the family head and is responsible for growing food for the family. The male children in a family provide assistance on the farms. In terms of age group distribution, 45% of the inhabitants fall within the 15 — 45 year age group. This means that the community has a very high and active labour force.

There is no tenancy on land since land is owned through inheritance. Farming is the major occupation of the people. Farming is done on bush farm, which are away from the compounds. Common land preparation methods include ploughing, ridging and mounding. About 60% of respondents use tractor, 20% use bullocks and the rest, hoes and cutlasses.

In the cropping calendar, land preparation starts in January/February for yam and in May for other crops like maize and rice. Fallow is almost absent due to land hunger. Crop rotation is non—existent in the farming system. To maintain soil fertility especially in the lowlands, where rice is the main crop, about 70% of respondents apply fertilizer (mainly sulphate of ammonia). Rice yields with fertilizer application are about 2.5 tons paddy/ha. Without fertilizers, yields can be as low as 0.2 tons paddy per ha or less. In the case of the upland crops, particularly maize, cow dung is usually applied.

Farmers mentioned the following as factors, which are having adverse effects on sustained agricultural production:

(1) Poor water management in the valley bottoms

(2) Low soil fertility

(3) Very limited extension coverage of area

(4) Late land preparation which makes it difficult for them to take advantage of good weather conditions and plant in time

(5) Weed infestation — *Striga* sp. is a common and noxious weed on the rice and maize feeds in the area. *Imperata cylindrica* is another problem weed. This particular weed is prevalent due to the low fertility of the soils.

(6) Labour shortage, through the area has a very high and active labour force, it becomes scarce during land preparation and weeding when it is most needed.

(7) Bush fires — This is an annual ritual that often results in the loss of farms and human lives.

(8) Insects, birds and rodents are other pests that attack rice and reduce yields

Conclusion

The major soils in the Kpene catchment are Lixisols, Plinthosols, Planosols and Gleysols. The soils are very acidic and deficient in nitrogen, phosphorus and potassium. Available phosphorus is the most deficient nutrient in the soil. Land use is very intensive. Soil fertility can be restored through the combined use of both organic and mineral fertilisers. Rainfall is unreliable. Low seasonal rains are common in the catchment. Water management strategies should, therefore, be based on these low seasonal rains. Levelling is very important in the lower slopes and valley bottoms to ensure proper water management for the rice crop. Runoff from the uplands can be reduced by either planting vegetative barriers or constructing diversion drains. Construction of tied ridges across the slopes is recommended as these also help in moisture conservation.

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