International Scholars Journals

African Journal of Agribusiness Research Vol. 9 (2), pp. 001-007, February, 2021. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

Use of models in assessing the impact of cropping system, land types and suitability on land degradation in Southwestern Nigeria

Aruleba, J. Olusegun* and Ajayi, A. Samuel

Department of Crop, Soil and Environment Sciences University of Ado-Ekiti, Ekiti State, Nigeria.

Accepted 14 September, 2020

Two sites (Apomu and Alabata) measuring 10 ha and representing rainforest and savannah agro-ecological zones, respectively in South Western Nigeria were chosen to evaluate the influences of cropping system, suitability and land types on the degree of land degradation. Multiple linear step-wise forward elimination regression was use to measure the interrelationships of the land parameters measured. The result using the model Y = 0.99 – 0.21CS + 0.10LT + 0.36S showed that for Apomu, the cropping system contributed 30% to the degradation as indicated by bulk density. Organic matter, conductivity and land suitability contributed more than 15% in terms of bulk density and permeability while land type contributed 17.5 and 2% of the degradation due to permeability and organic matter respectively. At Alabata, the model that best describes the relationships is Y = 0.17 + 0.09CS + 0.23LT + 0.31S. Cropping system contributed 10 - 12% degradation while land type contributed between 6.5 – 17.3% due to organic matter content, ESP, exchangeable K and bulk density. Land degradation models were also developed for each nutrient based on the cropping system, suitability and topographic land types. Appropriate cropping systems such as alley cropping, organic farming, contour farming, and rotational cropping etc. are recommended for the defined soil / land types to minimise land degradation in the study area.

Key words: Land degradation, cropping system, land type, model and suitability.

INTRODUCTION

The need to achieve sustainable land use has been an increasing concern to decision and policy makers in most developing countries and indeed in Nigeria, in the last couple of decades. This derives from the realization that land degradation is increasing with use of land and shortened fallow periods that restore soil fertility just as desertification, menace of soil erosion, deforestation, commercialisation of land threaten the future availability of land.

The susceptibility of land to degradation depends on land qualities and land type (Ciha, 1984; Hannal et al., 1982). Although cropping system and soil constraints are site specific, their effects and other derivatives militate greatly against soil sustainability and have severe ecological, environmental and socio-political implications. The major cause of soil degradation in the tropics is soil erosion which occurs at a very high rate when inappropriate farming and cultivation practices are adopted into marginal land and steep hill side (Glantz, 1994; Lal, 1997). Soil productivity declines rapidly when these soils are eroded, overgrazed or cropped intensively without appropriate inputs (Abubakar, 1997; Azadu et al., 1999).

The physical, chemical and biological qualities of the soil depreciate with use. In the tropics the misuse of land causes an annual average loss of about 400,000 ha of agricultural land. About 25% of the soil is degraded by water and wind erosion, more than 20% by salinization and almost 50% by other sources (Snaking et al., 1996). The degree of land degradation due to misuse of land is very high and is on the increase (Ayouba, 1994; Aruleba, 2004) hence the amount of good agricultural land is dwindling away with time.

*Corresponding author. E-mail: arulebaunad@yahoo.com

Presently in Nigeria, there are no substantial studies on causes of land degradation and there is need for detail information on degradation due to cropping system, suitability and land type. Attempts have only been made in some region to study the causes of erosion and its control as a form of land degradation (Armon, 1984). Apart from this information on the choice of appropriate cropping system and / or suitable land use to minimize degradation is not available.

Information is therefore required on the type and extent to which a combination of cropping systems and topography can influence land degradation, so as to guide farmers in the choice of appropriate cropping system and suitable land use for a given site with little or no degradation.

This study examines the influence of cropping system, topographic land types and suitability on land degradation in two agro ecological zones of South Western Nigeria, establishes land degradation models and recommends appropriate cropping systems for defined soil / land types to minimize land degradation and ensure soil sustainability.

MATERIALS AND METHODS

This study took place in two agro-ecological zones in Southwestern Nigeria. Apomu-rainforest and Alabata- forest savannah fringe.

Apomu

Apomu lies approximately between latitude 7°141 - 7°20 North and longitude 4°15[1] - 40°20 East. Apomu is in the low land semi deciduous forest of the humid zone. The dry season extend from November to March. Monthly rainfall is variable ranging from 204.40 to 5.60 mm, the air temperature range between a minimum of 28.8 and 34.80°C and solar radiation range between 9.49 cal. Cm / day to 17.81 cal. Cm day. The geology of Apomu is pre-Cambrian crystalline metamorphic rock of the basement complex. The soils belong to the Egbeda Association (Smyth and Montgomery, 1962). The predominant cropping system types are fallow, cocoa/oil palm/banana, cassava/yam/maize/ oil palm / kola, maize / pepper / vegetables. The current vegetation consists of secondary forest, which has been formed for some 80 to 100 years with oil palm, cocoa and kola as the dominant crops.

Alabata

Alabata lies approximately between latitude 7.35 - 7.40 North and longitude 3°45' - 3°35' East. Alabata is in the forest – savannah fringe. The mean monthly rainfall is 213.10 - 3.00 mm, air temperature is10.35 - 24.50 cal. Cm / day. The geology of Apomu consists of pre-Cambrian crystalline metamorphic and igneous rocks of the pre-cambrian basement complex. The impact of cultivation and burning has affected Alabata vegetation to form forest - savannah mosaic.

The principal arable crops are maize cassava and vegetables within the predominant cropping system types of fallow cocoa/oil palm/banana, cassava/yam/maize, oilpalm/kola, maize pepper/vegetable. The topographic land types found at both sites are upper and middle slope, lower slope and valley.

Field sampling

At each site, an area of 20 ha was chosen and each site was divided into two locations of 10 ha each, for a good representative coverage of the area. Each 10 ha area was divided into 10 units of 1 ha each. The predominant current land use/cropping systems, land degradation types and topographic land types were recorded. Bulk samples consisting of 10 surface [0 – 15 cm] and sub surface [15 – 30 cm] for core samples were collected randomly in each 1 ha area for physical, chemical, and analysis.

Laboratory analysis

The soil samples collected were air dried and crushed to pass through a 2 mm sieve and some of the soil samples were further passed through 0.5 mm sieve for organic matter and total N. Soil samples were analysed using procedures described in IITA (1979) for the following parameters.

Particle size distribution analysis was by the hydrometer method, soil pH was by potentiometrically in water using a 1: 1 soil/water ratio, organic matter was determined by the dichromate oxidation method, phosphorus by the ammonium molybdate, blue method.

Exchangeable cations were extracted with INH40AC (pH. 7.0), calcium and magnesium were determined by atomic absorption spectrophotometers. Exchange acidity was extracted with 1NKCL. Effective cation exchange capacity [ECEC] by summation of the exchangeable cation and the exchange acidity determined. Base saturation was calculated as the sum of the bases [TEB] divided by CEC.

Statistical analysis

Data collected on all parameter taken were ranked following Aruleba (2004) and subjected to multiple linear step-wise forward elimination regression analysis, which allows estimation of the relative contribution of each factor: cropping system, suitability and land type to land degradation. This involved a step up model, which adds one variable to the regression equation at a time (SAS Inst., 1990). As each variable is entered, the model incorporates a check on the variance test and this continued until the contribution of the most recently entered variable is not significant at $P < 0.05$ by the partial F value. Any variable, which provides a non-significant contribution, is removed from the model.

RESULTS AND DISCUSSION

The multiple linear stepwise regression analysis of cropping system, land type and suitability with land degradation in the two ecological locations and the contribution of each factor at 5% level of significance with different indicators. Land degradation models were developed and summarized in Tables 1 and 2.

At Apomu (location1) cropping system contributed 30.3%; land type 9.09% and suitability (oil palm) 9.09%. They together contributed 43.17% of degradation due to bulk density. For degradation in terms of permeability, land type contributed about 17.52% and suitability (oil palm) 13.97%.

$$Y = 4.65 – 0.28LT – 0.66S$$

For humus content, cropping system contributed 39.47% and land type 2.32%.

Table 1. Multiple linear stepwise regression analysis of cropping system, land type, suitability and land degradation at Apomu

Degradation indicator	Independent variable	Apomu 1		Apomu 2	
		Contribution	Cumulative	Contribution	Cumulative
		%		%	
BD	Cropping system (CS)	30.30	30.30	29.35	29.35
	Suitability (Oil palm)(S)	9.09	39.39	15.85	45.20
	Suitability (Maize) (S)	-	-	11.43	56.63
	Land type (LT)	3.78	43.17	-	-
Permeability	Cropping system (CS)	-	-	4.07	4.07
	Suitability (Oil palm)(S)	13.97	13.97	7.56	11.64
	Land type (LT)	17.52	31.49	-	-
Phosphate	Cropping system (CS)	-	-	3.73	3.73
	Suitability (Maize) (S)	-	-	3.57	7.31
Soluble salt	Cropping system (CS)	-	-	6.05	6.05
	Suitability (Maize) (S)	-	-	4.32	10.37
Conductivity	Cropping system (CS)	-	-	20.34	20.34
	Suitability (Maize) (S)	-	-	2.78	23.12
Humus content	Cropping system (CS)	39.47	39.47	-	-
	Land type (LT)	2.32	41.80	-	-

Model for Land degradation. Apomu 1; Bulk density, Y = 0.99 – 0.21 CS + 0.10LT + 0.36 S; Permeability, Y = 4.65 – 0.28LT – 0.66 S; Humus content, Y = 3.90 – 0.45 CS + 0.13 LT. Apomu II; Bulk density, Y = 0.17 + 0.09 CS + 0.23 LT + 0.31 S Permeability, Y = 3.30 + 0.04 CS – 0.23 S Phosphate, Y = 4.08 + 0.10 CS – 0.30 S; Soluble Salt, Y = 4.56 – 0.16 CS – 0.50 S; Conductivity, Y = 2.01 – 0.11 CS – 0.14 S.

Y = 3.90 – 0.45CS + 0.13LT

At Apomu (location 2) Land degradation at 56.63% due to bulk density was contributed by cropping system (11.34%), land type (29.35%) and suitability (maize) 15.85%.

Y= 0.17 + 0.09CS + 0.23LT + 0.31S

For degradation due to conductivity, cropping system contributed 20.34% and suitability (maize) 2.78%

Y = 2.01 – 0.11CS – 0.14S

While in terms of permeability, phosphate and soluble salt contents cropping system and suitability contributed ≤ 7.56%.

Y = 3.30 + 0.04CS – 0.23 S

Y = 4.08 + 0.10CS – 0.30 S

Y = 4.56 – 0.16CS – 0.50 S

At Alabata (location 1) Land type contributed 17.34% of degradation due to bulk density.

Y = 2.19 + 0.23 LT

For base saturation an indicator, cropping system and land type contributed 10.22 and 3.56% respectively.

Y = 2.92 – 0.06CS + 0.08LT

Cropping system and land type contributed 5.38% to degradation due to N and P content and also 3.54 and 10.07% to K content.

Y = 1.12 + 0.22N

Y = 1.69 + 0.19CS + 0.34LT

Y = 2.92 – 0.10CS + 0.22LT

For degradation (humus content) cropping system contributed 12.84% and land type 6.54%.

Y = 3.19 +0.11CS + 0.11LT

At Alabata location 2, cropping system and land type contributed 16.95% of degradation (bulk density) at 4.17 and 12.78% respectively.

Table 2. Multiple linear stepwise regression analysis of cropping system, land type, suitability and land degradation at Alabata.

Degradation indicator	Independent variable	Alabata 1		Alabata 2	
		Contribution	Cumulative	Contribution	Cumulative
		%		%	
BD	Cropping system (CS)	-	-	4.17	4.17
	Land type (LT)	17.34	17.34	12.78	16.95
Base Saturation	Cropping system (CS)	10.22	10.22	-	-
	Land type (LT)	3.56	13.78	2.85	2.85
Nitrogen	Land type (LT)	5.38	5.38	-	-
Phosphate	Cropping system (CS)	5.29	5.29	-	-
	Land type (LT)	2.88	8.17	-	-
Potassium	Cropping system (CS)	3.54	3.54	-	-
	Land type (LT)	10.07	13.60	-	-
ESP	Cropping system (CS)	-	-	6.38	6.38
	Land type (LT)	11.39	11.39	-	-
Humus content	Cropping system (CS)	12.84	12.84	11.66	11.66
	Land type (LT)	6.54	19.38	3.02	14.68

Model for land degradation. Alabata 1; Bulk density, Y = 2.19 + 0.23 LT Base saturation, Y = 2.92 – 0.06 CS + 0.08 LT. Nitrogen, Y = 1.12 + 0.22 N Phosphate, Y = 1.69 + 0.19 CS + 0.34LT. Potassium, Y = 2.92 – 0.10CS + 0.22LT, ESP, Y = 2.42 + 0.48 LT. Humus, Y = 3.19 +0.11CS + 0.11 LT. Alabata 2; Bulk density, Y = 1.97 + 0.10 CS – 0.27 LT Base saturation, Y = 1.29 – 0.09 LT. ESP, Y = 3.97 – 0.30 CS Humus, Y = 3.35 +0.09 CS + 0.08 LT

$$Y = 1.97 + 0.10CS – 0.27LT$$

Base saturation as an indicator of degradation had 2.85 contribution for land type. Cropping system contributed 6.83% to degradation due to ESP and 11.6% to humus content while land type contributed 3.02% to degradation in terms of humus content only.

$$Y = 1.29 – 0.09LT$$

$$Y = 3.97 – 0.30CS$$

$$Y = 3.35 + 0.09CS + 0.08LT$$

Figures 1-4 show the extent of degradation of each indicator as affected by cropping system, land types and suitability in all the locations at Ayepe and the Alabata sites.

The result of the multiple linear stepwise regression analysis showed that factors contributing to various forms of degradation differ among the sites. This analysis also suggests that virtually most of the degradation forms were contributed by cropping system at both sites. The variation in percentage contribution is due to differences in intensity of arable cropping without appropriate inputs. This is responsible for considerable nutrient uptake this is evident at both sites.

Land type (slope position) contribution to degradation was not significant at Apomu site but contributed virtually to all the different forms of degradation at Alabata. This is because of the exposure of the land during the dry season period as a result of seasonal burning and the subsequent erosion from the shoulder and midslopes and deposition in the footslopes at the onset of raining season before effective ground cover. This agrees with the observation made by Ronggai and Tiessen (2002).

Land suitability either to oil palm or maize contributed significantly to some forms of degradation only at Apomu site indicating that these crops were not planted where they are best suited. Land degradation models were established for each of the indicators as a function of the factors influencing degradation. These mathematical models can be used to calculate or predict the land degradation rate for each of the land qualities. The values of the variables are mathematically determined in such a way that the equation gives a numerical indication of the degradation rate. This mathematical model describes the processes of cropping system, land type and suitability and the final result the exact magnitude due to the factors. The summation of all Y values, that is, degradation

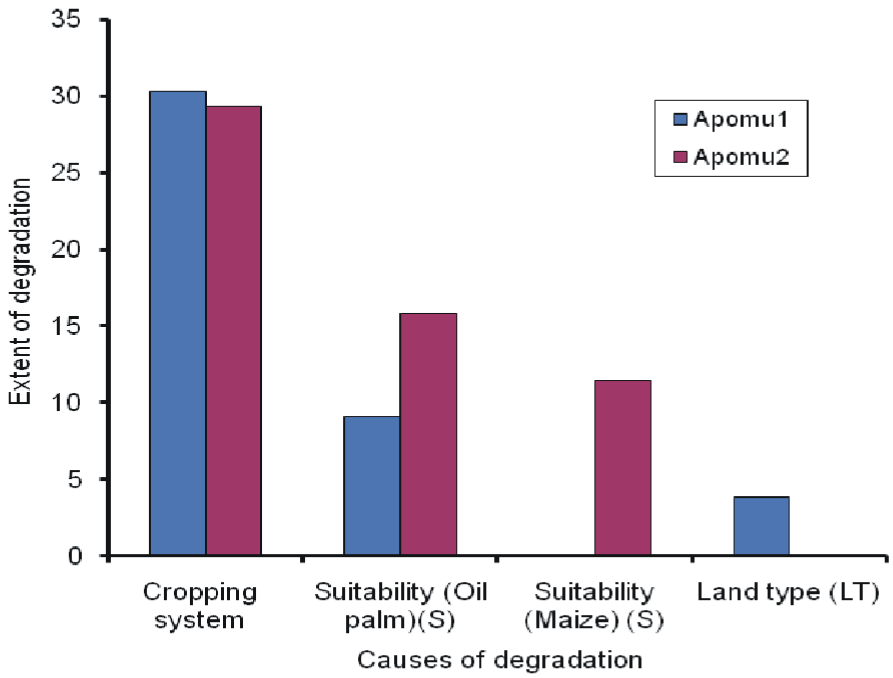

Figure 1. Degradation in terms of bulk density as affected by cropping system, land types and suitability at Apomu.

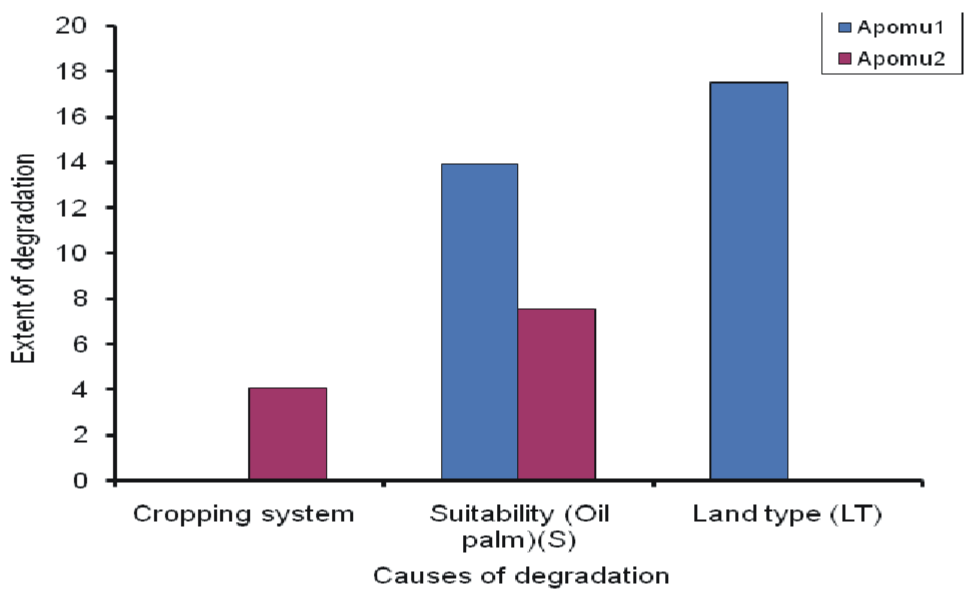

Figure 2. Degradation in terms of permeability as affected by cropping system, land types and suitability at Apomu.

from all qualities affected, gives the exact degradation rate for a particular location.

With this mathematical model, we can understand the dynamics of the soil degradation. It is important that specific measures for soil remediation require knowledge on the intensity and trend of the degradation process. The decline of soil properties in a unit of time is one measure of the rate of degradation. In order to unify all the indicators, the rate of degradation could be expressed as the rate of decline from one degradation degree to another.

The results of this analysis show the magnitude of degradation due to different soil qualities and the part played by each factors. With them the appropriate

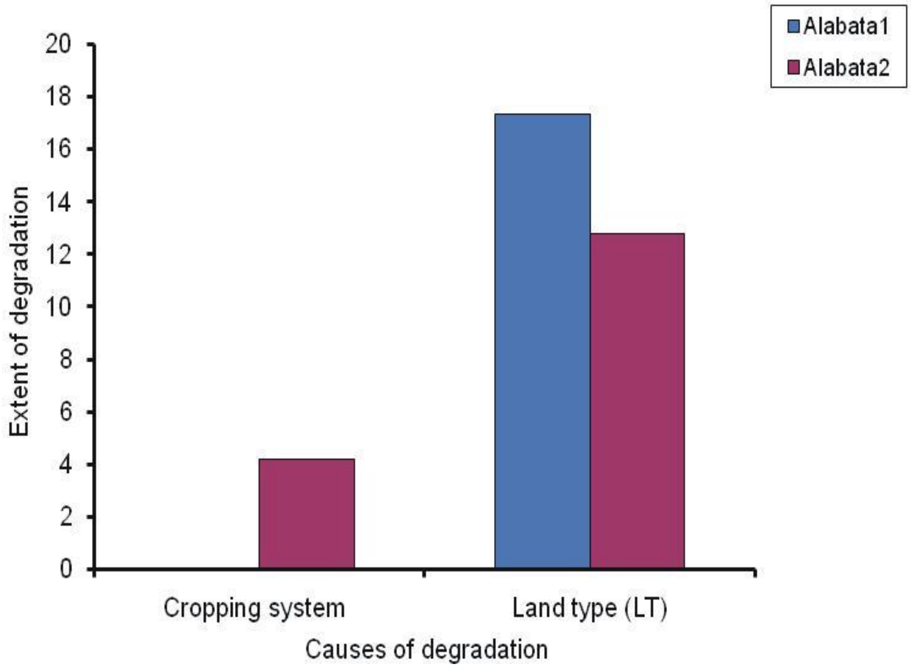

Figure 3. Degradation in terms of bulk density as affected by cropping system, land types and suitability at Alabata.

approach to the soil rehabilitation and management technique for agricultural uses and sustainability can be predicted.

Based on the indicators given by this study, the soils of the sites can best be restored and managed in the following ways:

The land types or sloping croplands can be maintained by employing ecological strategy such as: using the toposequence land types according to their capability classification and use of appropriate terraces. There would be appropriate management practices for different land types. The upper slope can be cultivated with arable crop where there are no rock outcrops and where crop outcrops are present, permanent tree crops are recommended. In the middle slope; grass/legume mixture and contour farming in which alley crop legumes feature permanently on the contour are to be adopted. In the lower slopes, creeping plants such as melon, gourds, pueraria etc would be planted while at the valley bottom, arable crops and vegetables are preferable, especially in the dry season.

A detailed soil survey and land evaluation would precede these recommended appropriate land use. Thus crops most suitable for the land are cultivated as indicated by its capability and constraints.

The land agricultural uses must include natural fallows (Johnson and Bradshaw, 1979) in order to guarantee replenishment of organic matter and nutrients from the litter and roots of plants. Apart from this, the following cropping systems are recommended to minimize land degradation in the two sites.

(1) Crop rotation which is a scientific system of cropping that provides cover, maintains organic matter and aggregate formation (Quarisah et al., 1989).

(2) Alley cropping system in which food crops are planted in the alleys of leguminous shrubs, the shrub fixes atmospheric N and produces roots that bind the soil particles together.

(3) Organic mulching which conserves soil moisture, improves infiltration rate and the activity of soil micro organisms, humus content and EEC in the soil

(4) Contour farming involving the ridge and furrow system has proved to be a useful erosion control measure, if the ridges are aligned parallel to the contour. This system is effective on soils with relatively stable structure and for slopes up to 7%.

Conclusion

Cropping systems and land types contributed immensely to land degradation at both sites while suitability in addition contributed to degradation only at Apomu site. The magnitude of the degradation as caused by factors was quantified by the established mathematical models, which predict the exact management technique. The appropriate approach to rehabilitation or improvement of degraded soil for sustainable agricultural uses in the sites studied must consider cropping systems, land types and suitability for specified crops.

Management techniques such as understanding the soil adequately through detailed soil survey and land

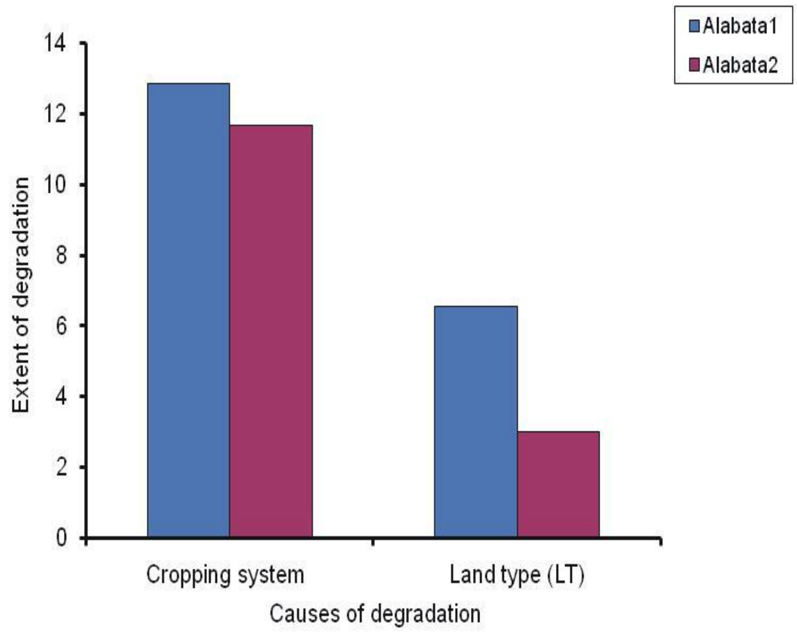

Figure 4. Degradation in terms of humus content as affected by cropping system, landtypes and suitability at Alabata.

evaluation, planting appropriate cropping systems such as rotation, alley cropping, organic mulching and use of contour ridges must be adopted. Also topographic land types or sloping lands must be used according to their capability classification and the use of appropriate terraces should be encouraged.

REFERENCES

Abubakar SM (1997). Monitoring land degradation in the semi arid tropics using inferential approach. The Kabomo basin case study, Nigeria: Land Degradation Dev., 8: 311-323.

Armon MN (1984). Soil erosion and degradation in South Eastern Nigeria in relation to Biophysical and Socio-economic factors. PhD Thesis of Univ. of Ibadan.

Asadu CLA, Ike O, Uguoke BO (1999). Cattle grazing and environment in east ern Nigeria. Impact on soil physical properties. Outlook Agric., 28: 103-107.

Aruleba JO (2004). Influence of cropping system, land type and suitability on land degradation in South Western Nigeria. A PhD Thesis of University of Ibadan, pp. 244

Ayoub AT (1994). Human induced soil degradation in Africa in 8th ISCO conference. New Delhi India p. 34-42.

Ciha AJ (1984). Slope position and grain yield of soft white winter wheat. Agron. J., 76: 193-196.

Glantz MH (1994) Drought follows the plough cultivating marginal areas Cambridge University Press, Cambridge U.K.

Hanna AY, Harlan PW, Lewis DT (1982). Soil available water as influenced by landscape position and aspect Agron J., 74: 999-1004,

Lai R (1997). Deforestation, tillage and cropping systems, effect on seepage and runoff water quality from a Nigeria Alfisol. Soil Tillage Res., 41: 261-284.

Ronggai Wu, Tiessen H (2002). Effect of land use on soil degradation in Alpine grassland, China. Soil Sci. Soc. Am. J., 66(5): 1648-1655.

Statistical Analysis System (SAS) (1990) Carry, North Carolina.

Smyth AJ, Montgomery RF (1992). Soil and land use in central Western Nigeria. Govt. Printer. Ibadan Western Nigeria, 264 p.

Snakin VV, Krechetov PP, Kuzovnikova TA, Alyabina IO, Gurov AF, Stepichev AV (1996). The system of assessment of soil degradation. Soil Technol., 8: 331-343