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Research Article

Land Suitability Evaluation for Tea and Food Crops in Kabarole District, Western Uganda

Expedito Nuwategeka[1], Robert Ayine[2] & Denis Thaddeus Ofoyuru[3]*

Faculty of Education and Humanities, Gulu University, P. O. Box 166, (Uganda).

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Corresponding Author
Denis Thaddeus Ofoyuru
E-mail: *denisofoyuru@yahoo.com*

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ABSTRACT

The study was conducted in Busoro Sub County in Kabarole District to assess the physical and economic suitability of the land for Tea, Maize and Bananas. Physical suitability was evaluated using a soil map of the study area. Soil types with their parameters of Cation Exchange Capacity, base saturation, pH, organic matter, nitrogen, potassium, and phosphorous were studied. The climate of the area was studied using annual monthly rainfall and temperature values for the area for more than thirty years. Production costs, market prices and annual yields per hectare for tea, maize and bananas were computed. Using Net Present Value approach, the economic suitability of each crop was computed. The economic and physical parameters were entered into a model built in Automated Land Evaluation System (ALES) software using the decision trees. Overall suitability evaluation results were produced for each of the respective crops. The results of the study indicated that different soil types (management units) had varying suitability among the three crops. Tea registered higher overall economic suitability followed by Bananas and then Maize. However, Bananas presented a higher overall physical suitability on all soil types followed by Tea and Maize. The study recommends conducting a mini agro-ecological zonation in planning and decision for maximum utilization of the land resources for a potential LUT is an important tool in ensuring improved agricultural livelihoods and household income.

INTRODUCTION

Uganda is well endowed with natural resources on which her economy is essentially based. However, despite this endowment, pressures arising out of the country's quest for economic development and poor land use planning practices are putting serious strain on the land and its resources (Ministry of Lands, Water and Environment, 2007). This has led to inappropriate decisions in the allocation of land use activities that are manifested among others in form of conflicts over land use and land productivity. Because land and land resources constitute the most important natural resources in the country, proper evaluation of the land should be carried out in order to ensure continued and sustainable productivity of the resource, thereby continuing to support the population economically without its degradation. Evaluation takes into consideration the economics of the proposed enterprises, the social consequences for the people of the area and the country concerned, and the consequences, beneficial or adverse, for the environment (FAO, 1976).

Land has been put to various uses ranging from arable farming, commercial agriculture to livestock farming. There are limited or no sources of information to guide farmers on the best land use type for a given piece of their land. Information on soil types and on crop requirements (land qualities) is virtually nonexistent (National Land Use Policy, 2007). In cases where it is available, rural farmers have not gotten access to such information. In many cases farmers have made wrong decisions for land uses.

Vink (1975) points out that for the purpose of judging "land suitability", both for land use and improvement, a systematic land evaluation is necessary. Vink (1975) defines land evaluation as the process of collating and interpreting basic inventories of soil, vegetation, climate and other aspects of land in order to identify and make a first comparison of promising land use alternatives in simple socio-economic terms. Land evaluation therefore bridges the gap between the physical, biological and technological means of land use and its social and economical purposes.

Brinkman and Smith (1973) in Vink (1975) define land suitability as the fitness of a given tract of land for a defined use.

Assessment of the physical and economic suitability of the land for specified uses is based on the FAO (1976) Framework for Land Evaluation. The Framework is a set of principles and concepts, on the basis of which local, national or regional evaluation systems can be constructed. Thus, the Framework is not an evaluation manual
(FAO, 1976). Dent and Young (1981) argue that even where the evaluation is qualitative, it is still necessary to give some consideration to both social and economic consequences of the various types of land use. Land suitability evaluation includes, costing the inputs, pricing the benefits, and calculating the net returns in money terms (Rossiter, 2005).

Kabarole district produces both food and cash crops. Madeley (2002) points out that with much of the best land under export crops, land for food crops has always come under pressure. Apart from growing Tea, smallholder farmers also use their land for food crop production. The local people base land resource use in rural areas of Uganda on accumulated experience. This indigenous technical knowledge on how to use land worked practically well in the past, though long-term consequences of land management are often not evaluated and may have resulted in deterioration of the land resources in some areas (Mugisha, 1994). In Uganda, Land availability, productivity potential, capability and sustainability for agriculture is not adequately known. Soil maps are outdated and not detailed enough for land use planning purposes (National Land Use Policy, 2007). The available land resource information for Kabarole area include the reconnaissance soil survey at 1: 250,000 done by Radwanski (1960) and a land use map compiled by Parsons from 1955 aerial photographs which was produced in the Atlas for Uganda (1967) at a scale of 1: 5,000,000 (Mugisha, 1994). The technical scale of the mapping at 1:250,000 using series as the mapping unit limits its use at larger scale. This kind of survey cannot be used to elucidate taxonomic units that can be defined and named in detained surveys (Abongo, 2008). This has affected planning and maximizing the use of the land resources for a particular land utilization type. The study therefore sought to evaluate the suitability of Busoro Sub County land for Tea, Maize and Bananas.

The study was guided by the following specific objectives:

1. To assess the physical suitability of Busoro sub county land for Tea, Maize and Bananas.
2. To assess the economic suitability of Busoro sub county land for Tea, Maize and Bananas.

MATERIALS AND METHODS

Research Design

The study used the experimental and survey design. Whereas the experimental design was used in assessing the physical suitability of land, survey was used in obtaining data on economic suitability for particular LUTs.

Sample Size and selection

A total of 60 farmers involved in the growing of the three crops: Maize, Bananas and Tea were purposively-randomly selected using Krejcie and Morgan Table (1970).

Study area

Kabarole district is located in western Uganda. It lies between $0^0$15" N and $1^0$00" N latitudes and $30^0$00" E and

$30^0$40" E longitudes. It receives annual rainfall ranging between 1200mm – 1500mm, with mean temperatures ranging between 18^0C – 30^0C. It has a total land area of 1814.44km^2, of which 1,569 km^2 is covered by land and 198 km^2 covered by open water. The area under cultivation is 1,307km^2. The district has a total population of 383,000 people (UBOS, 2002). Busoro Sub County has a total population of 22,755 people (UBOS, 2002) and the leading economic activity is Tea growing and processing. The sub county is covered by the Saaka, Fort Portal and Kiamara soil series classified under andosols and ferralsols in the FAO – UNESCO (1988) legend. Natural vegetation on most hill sides has been replaced by Tea plantations and food crop gardens, mostly consisting of Bananas, Maize and Millet (NEMA, 1997).

Identification, compilation and rating of LUTs and LURs

Three Land Utilization Types (LUTS) were studied. These are: low input banana (*Musa spp*), maize (*Zea mays*) and tea (*Camellia sinensis).* The agro-socio-economic database for each LUT was compiled and presented in tables showing annual production inputs, outputs and market prices. This data was sourced from the field (farmers) as primary data as well as desk review of existing literature on market surveys for Kabarole district.

Three parameters were considered in the assessment of physical suitability of the land, namely, soil physical properties, chemical properties and climate. The parameters were compiled into a land resource database specific to Busoro Sub County.

Land Use Requirements (LUR) of the selected LUTs (low input maize, banana and tea) were obtained through desk review of the existing publications and reports. These requirements are for rain-fed agriculture.

Land use requirements with their diagnostic criteria included: temperature regime (mean temperature) during growing season (°C), moisture availability (mean annual rainfall and rainfall in growing season), nutrient availability (pH, N, P, K, organic matter, and base saturation), nutrient retention capacity (cation exchange capacity) and rooting conditions (soil effective depth).

Each criteria of the land quality was rated as highly suitable (S1), moderately suitable (S2), marginally suitable (S3) and not suitable (n) basing on the level of land quality required by each LUT (FAO 1995).

A soil map for the study area was obtained from Kawanda Agricultural Research Institute showing types of soils with their profile description. These included soil depth, chemical properties of pH, phosphorous, nitrogen and potassium, CEC, organic matter and base saturation.

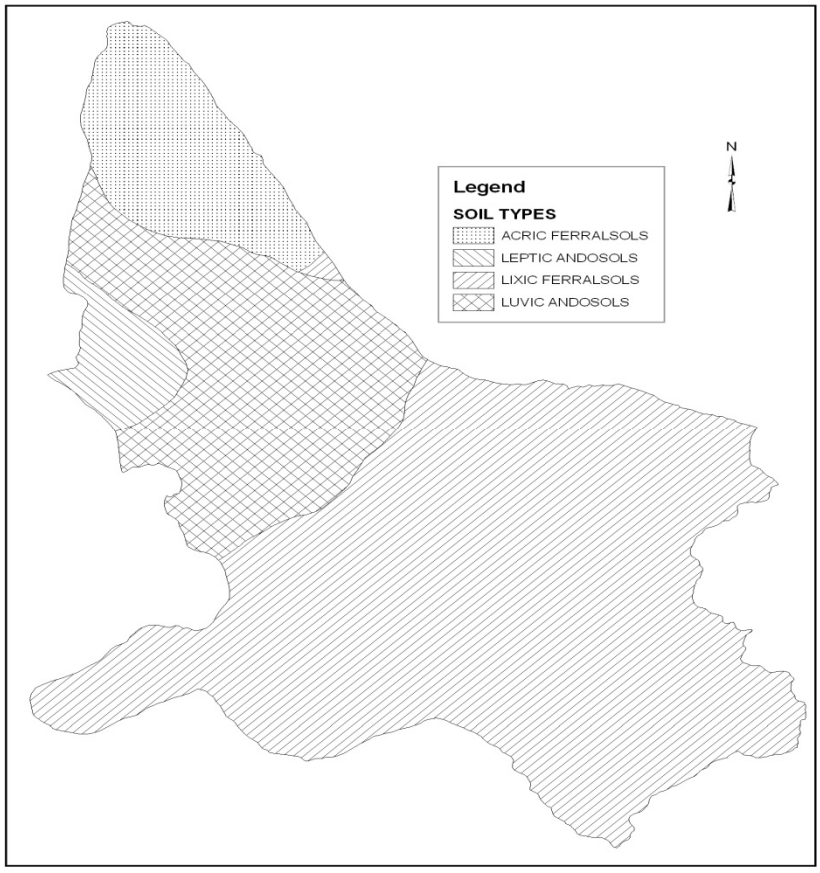

Figure 1. SoilsType in Busoro Sub County
Source: National Agricultural Research Laboratories, Kawanda (2012)

Generation of land mapping units for ALES

Land mapping units were considered to be homogeneous because of being covered by the same soil type. Four mapping units were generated. The table below shows the descriptions of the four land mapping units.

Table1. Land mapping units and qualities used for physical suitability assessment

Land mapping unit	Code	Depth	N	P	K	pH	%Base	CEC	OM
Acric Ferralsols	**AF**	vd	vi	vi	A	ma	MdA	h	A
Leptic Andosols	**LeA**	vd	vi	vs	NA	n	A	vh	MdA
Lixic Ferralsols	**LF**	vd	vi	vs	A	ma	MdA	l	A
Luvic Andosols	**LuA**	vd	vi	vs	A	ma	MdA	h	MdA

Source: National Agricultural Research Laboratories, Kawanda (2012)

Codes for the LC: vd= very deep, vi= very insufficient, vs= very sufficient, A = adequate, NA= not adequate, n= neutral, ma= moderately acidic acid= acidic, vh= very high, h= high. MdA= moderately adequate.
N=Nitrogen, P= Phosphorous, K= Potassium, Ph= Soil reaction, %Base= base saturation, CEC= cation exchange capacity, OM= organic matter.

Climate Resources

Data was obtained for the parameters of rainfall and temperature. Rainfall data recorded since 1968 to 2007 (forty years) was obtained from the weather station for Tooro- Kahuna Tea Factory at Kijura in Hakibaale Sub County. This Sub County borders Busoro Sub County (the study area) in the north. Temperature data was obtained from TAMTECO- Kiamara weather station found in Busoro Sub County. Mean minimum and mean maximum daily monthly recordings since 1988 - 2000 were obtained.

Constructing decision trees for LUTs in ALES model

Physical land data was entered into ALES for each LMU. The area covered by a given soil type was treated as a management unit. This data included soil type, Land Characteristics (LCs) and Land Use Requirements (LURs). The LURs included nutrient availability 'n', nutrient retention capacity 'nrc' and rooting conditions 'r'. LCs for soil fertility was nutrient (N, P, and K) availability, soil organic matter, soil pH and base saturation. The LC for nutrient retention capacity was CEC. LC for rooting condition was soil depth.

LURs were used as the basis for the determination of severity levels. Severity levels were determined on the basis of an extra cost that would accrue to the land user in order to correct the inadequate LUR. Finally, suitability ratings were entered into ALES and physical suitability assessed. The suitability ratings were defined as follows:

S1 (highly suitable) - best condition in terms of performance.
S2 (moderately suitable)
S3 (marginally suitable)
N (not suitable). These ratings are the ones recommended by FAO (1993).
The process was repeated for each of the LUTs of tea, bananas and maize.

ECONOMIC SUITABILITY EVALUATION

Compilation of socio-economic database for each LUT

Factors required for economic suitability of the LUTs were obtained through market surveys to determine farm-gate prices for the three crops. Input costs for the production of the three crops were also determined . The compiled economic factors from the farmers included: Annual production inputs and input costs. Production output data

was obtained by reviewing existing literature on optimum yield per hectare for the three LUTs. Market prices were obtained from data compiled by Kabarole District Production Department through market surveys. The price of green leaf per kilogram was obtained from three tea factories of Kiamara, Mpanga Growers and Rwenzori Commodities- Buzirasagama tea factory. Because each factory had its own price at which it buys green leaf from farmers, averaging of the prices was done.

Analysis of data on economic parameters

Gross margin method was employed in ALES to study economic suitability, that is, the cash flow into the LUT, less the cash flow out of the LUT on aggregate (Per farm) basis, in one accounting period, that is, one year (Rossiter,
1995). In the study, only two classes were considered in economic suitability, i.e. 'S' Suitable and 'N' Not suitable. There was no sub division of the two economic classes. For gross margins which were positive, the area was considered economically suitable, hence falling into the 'S' category. However, for the negative gross margins, the area was considered economically not suitable, hence in economic class 'N'. Economic suitability assessment was carried out on that land that was only physically suitable.

RESULTS AND DISCUSSION

Physical suitability

Climate resource

The results of the analysis of the climate resource show that the area is climatically suitable for the growth of all the three crops. Mean annual rainfall was found to be 1549mm and mean temperature during growing season to be 21℃. The lowest mean minimum temperature is 14.1℃ while the highest mean maximum is 28.8℃. Figure 2 shows annual rainfall distribution for the Sub County.

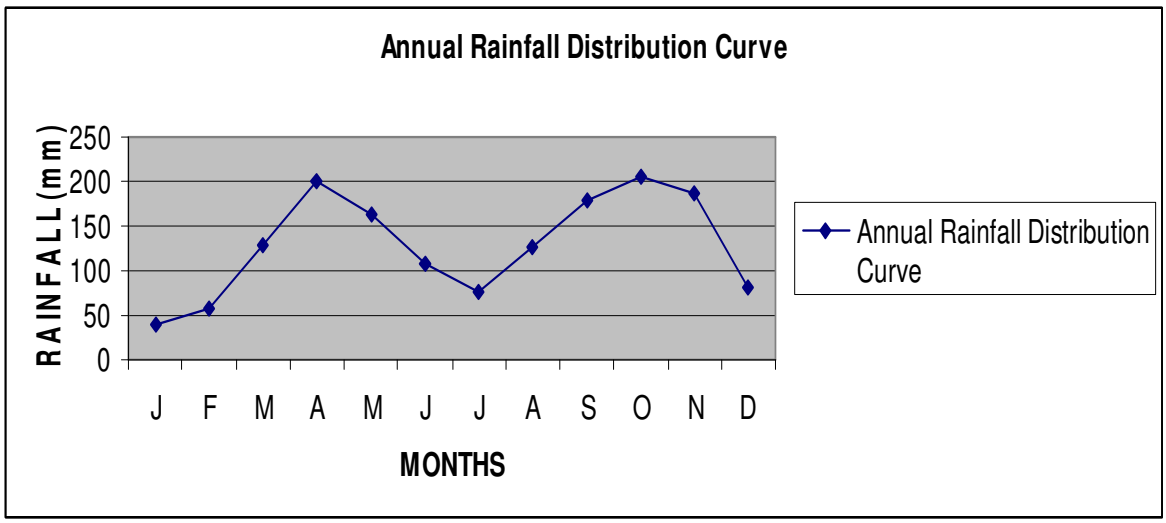

Figure 2. Annual Rainfall Distribution Curve for Busoro Sub County
Source: Primary Data

The area experiences a double maxima type of rainfall distribution, meaning there are two growing seasons in a year. The on-set of the first growing season is at the beginning of March, through April and May. The second growing season starts in September, through October to November. October is the wettest month, experiencing over 200mm of rainfall.

During the dry months, tea and bananas, being perennial in nature continue growing without irrigation (Purseglove, 1987). This is possible due to the availability of a minimum mean monthly rainfall of 50mm , a requirement for continued crop growth in the dry period. Only the month of January does not fulfill this minimum (40.1mm). This minimum ensures presence of Plant Available Water (PAW) in the soil.

The beginning of the wet season coincides with the on-set of the cold months. Mean monthly temperatures show that temperatures start to drop in March and hit a minimum in May. The month of May falls under the rainy season for the first growing season. In October, mean temperatures also fall to the lowest. October marks the peak of the rainy season for the second growing period. A similar trend is observed for the dry period and high temperatures. The hottest month is March with mean temperature of 21.6℃ while the coldest month is October with 20.1℃.

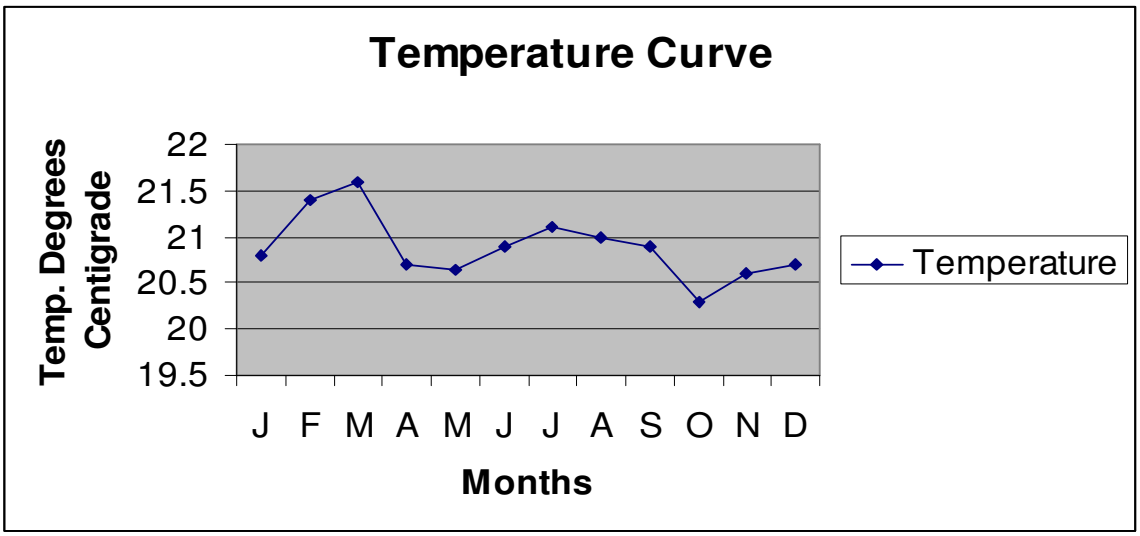

Figure 3. Mean Annual Temperature Range for Busoro Sub County

Results of the physical suitability assessment

The table below shows suitability ratings for tea, maize and bananas on the respective LMUs.

Table 2. Physical Suitability Ratings for Tea, Maize and Bananas on the Various LMUs

LMU	Tea	Maize	Bananas
Acric ferralsols	S3	S1	S1
Lixic ferralsols	S1	S3	S2
Leptic andosols	S1	S2	S1
Luvic andosols	S1	S1	S1

Source: Primary Data

Results from the evaluation revealed that luvic andosols, leptic andosols and lixic ferralsols are highly suitable for tea growing. The rating for these three soil types was S1. However, acric ferralsols were marginally suitable, with rating S3. The rating S3 is because land use requirement 'nutrient availability' is low. There was no LMU rated N because there were no LURs that were maximally limiting.

Maize is highly suitable on acric ferralsols and luvic andosols (rating SI). Leptic andosols are moderately suitable (S2) whereas lixic ferralsols are marginally suitable (S3). The reason for the marginal suitability of the lixic ferralsols is that nutrient retention capacity was very low. Like tea, there was not any LMU which is not suitable for maize (rating 'N').

Bananas were found to be suitable for all the four LMUs. The LMUs of acric ferralsols, Leptic andosols and luvic andosols rated S1, whereas lixic ferralsols were rated S2. Given the above results, the three crops are all suitable for Busoro sub county soils because they fall into the suitability order 'S' (FAO, 1993). A general observation reveals that acric ferralsols are highly suitable for food crops and marginally suitable for tea. On the contrary, the lixic ferralsols where bananas are rated moderately suitable and maize marginally suitable, tea is highly suitable. However, generally, the study revealed that luvic andosols are highly suitable for all the three crops.

Economic Suitability

Table 3. Gross margins for Tea, Maize and Bananas.

LMU	TEA	MAIZE	BANANAS
Acric ferralsols	17,268,080	392,602	36,648,000
Lixic ferralsols	42,909,106	392,602	36,648,000
Leptic andosols	42,909,106	-440,731	36,648,000
Luvic andosols	37,780,901	392,602	36,648,000

Source: Primary Data

Tea is economically suitable on all the soils of the Sub County. All the gross margins on the respective LMUs were positive. However, the gross margins vary in amount. Comparatively, acric ferralsols had the least

gross margin, followed by luvic andosols and the highest gross margin was recorded for the Leptic andosols and lixic ferralsols.

Maize is economically unsuitable on Leptic andosols. On this LMU, it recorded negative gross margin. However, the rest of the LMUs recorded similar positive gross margins.

Bananas are economically suitable on all the soils of Busoro Sub County. All the gross margins were positive and similar.

DISCUSSION

Most of the soils in Busoro Sub County are largely suitable for the cultivation of the three crops as shown by the findings. However, individual suitability classes vary according to soil types. Acric ferralsols, covering the northern part largely lie in Rwengaju parish, and are marginally suitable for tea and the same LMU has the least gross margin for tea production. This implies that Tea growing may not be the best land use option for this soil type.

Leptic andosols were found to be economically not suitable for Maize growing because they yielded negative gross margins. However, the LMU was found to be physically moderately suitable. This means that however much the Maize crop does well on this soil type, the input costs invested in its production far much exceed the profits from the sales. A similar view is held by Driessen and Konijin (1992) that on-farm production is not solely determined by biophysical factors, but also socio-economic. Dent and Young (1981) express a similar view and emphasized the need for consideration of socio-economic consequences in the analysis of LUTs. Therefore, farmers who carry out Maize growing on Leptic andosols should not do it for direct commercial benefit. Other land use options can be undertaken on this land management unit because tea and bananas are highly suitable on these soils. Still on the economic side of production, tea and bananas comparatively yield the highest gross margins on this land management unit.

Maize is marginally suitable for lixic ferralsols, meaning that the physical conditions are not good enough for its production. If production has to take place, a lot of investment in fertilizers must be made. Notwithstanding the aforementioned limitations, this LMU shows positive gross margins. The study further revealed that, it is not viable to carry out Maize growing on lixic ferralsols because to realize profits, one needs to invest a lot in inputs such as fertilizers.

Banana production in the Sub County is both economically and physically feasible. There was no area registering either marginal suitability or negative gross margin. When compared with maize and tea, bananas would be the best LUT to be carried out in the sub county. This is because its gross margin does not fluctuate on any of the LMUs, and its physical suitability rates highest on all the LMUs. The best land use option is that which maximizes and maintains economic productivity, at the same time ensuring ecological sustainability (FAO, 1997).

CONCLUSION AND RECOMMENDATIONS

Conclusions

The potential of each of the LUTs shows that, bananas is highly suitable on acric ferralsols, Leptic andosols and luvic andosols, representing about 80% of the Sub County's land. Maize is highly suitable on acric ferralsols and luvic andosols, covering approximately 40% of the land. Tea, on the other hand is highly suitable on lexic ferralsols, Leptic andosols and luvic andosols, occupying 45% of Busoro Sub County land.

RECOMMENDATIONS

- Whereas maize is not economically suitable on Leptic andosols, it is physically suitable. It is therefore recommended that if maize is to be grown on those soils, then it should be purely for subsistence or for fodder, and not for direct economic gain.
- Much as maize would economically be viable on lixic ferralsols, it is recommended that this particular LUT should not be carried out because physically, it is marginally suitable.
- Usually, decisions on land use options in most developing countries are taken without any scientific survey to assess the suitability of the land for the selected LUTs. In Busoro Sub County, if a given piece of land gives productivity for food crops is low, it's automatically relegated to tea growing. Therefore, there is need to sensitize the farmers and disseminated relevant scientific information on particular LMUs and their corresponding LUTs if maximum productivity and economic gain is to be achieved.

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