Physical and Economic Suitability Evaluation for Crop cultivation in Kyangwali Refugee Settlement in Hoima District, Uganda

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Abstract

The increasingly protracted nature of refugee problems implies that land and its use to meet their livelihoods remains the only plausible option especially in the face of dwindling humanitarian and relief aid, yet crop production and sustainability in yields is influenced by multiplicity of factors chief among them: the size of land; the qualities of the land resources; and, the land utilisation type. The objective of this study was to assess the land qualitative suitability for crop cultivation of maize, beans, rice and bananas in Kyangwali Refugee Settlement. The study focused on the physical and economic suitability to establish the potentiality of the different land mapping units. Climatic, land characteristics and soil requirements data for selected land utilisation types in the surveyed area were obtained. Suitability classes were generated using the computer based Automated Land Evaluation Systems and classified using the FAO method: S_1 for highly suitable, S_2 for moderately suitable and S_3 for low suitability. Using the four land mapping unit the study established that, the vertisols (2%) were of high suitability for all cropping activities while the acric ferralsols (Rukiri series) (62%) and acric ferrasols (Bugangari) (12.8%) were of moderate suitability (S_2). The gleyic arenosols (24%) recorded marginal suitability (S_3) for almost all cropping activities in the settlement. The results of qualitative land suitability classification shows that, most areas in the settlement fall under moderate suitability (S_2) class with a small proportion of high suitability (S_1). The study established that by far, Kyangwali Refugee Settlement is largely suitable for arable farming. However, land shortages and soil exhaustion as a result of poor and over use of the land resource threaten self-sufficiency in food production.

Key words: Protracted, suitability, land characteristics and land use requirements

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Introduction

The increasingly protracted nature of refugee problems implies that land and its use to meet refugee livelihoods remains the only plausible option especially in the face of dwindling humanitarian and relief aid. Self-reliance predicted on land use in refugee settlements in Uganda has been the major response to the increased delayed return of refugee to their home country or third country resettlement as a durable option. Under the self-reliance model, land remains a central resource. It is expected that output from subsistence crop farming would render the refugees self-reliant in food and other non-food items. However as is often the norm, the local settlement of refugees and subsequent allocation and distribution of land is often not rationalised to take cognisance of the quality of land resources, the limits and sustain of a particular use over a duration of time, rather, it is based on the existence of an expense of land often devoid of settlement. The problem is that, in the long-run it presents intractable challenges to its continued use in food production. Therefore prior to settlement of refugees, land evaluation in support of rational land – use planning is of absolute importance.

The need for land evaluation arises from intense competition and pressure on the land resource by various land uses and also because increasingly the population growth presents a threat of how resources can best be optimally managed and used sustainably. This is further coupled with the fact that resources are scare and with an ever increasing population, maintaining a balance on resource use, conservation and management is an interesting quandary. Owing to such situations, there is need to match land types and uses in the most rational way possible so as to maximize sustainable optimum productivity of the resources, while at the same time conserving the fragile ecosystems. To reduce the effects and possibilities of inappropriate land use that leads to inefficient exploitation of natural resources, destruction of resources, degradation and exacerbating poverty. Rossiter (1996) suggests land evaluation be adopted as an antidote to the unsustainable use of land and the usually anthropogenic - induced problems of the ecosystem. It is therefore important that sustainability in land use can be realised if lands are categorised and utilised based upon its capacity (FAO, 1983), therefore land evaluation is acritical link to sustainable management of land resources (FAO, 2007).

Land evaluation is the selection of sustainable land, and suitable cropping, irrigation and management alternative that are physically and financially practicable and economically viable (FAO, 1985) and it is also involves making prediction of land performance in the passing of time centred on land use types (Al-Mashreki *et al*.,2011). These predictions are used as a guide in strategic land use decisions making (Yitbarek *et al*, 2013). Most traditional land evaluations have tended to focus on physical and suitability only. Advocates of this traditional approach argue that it identifies the levels and geographical patterns of biophysical constraints and evaluates potential capacity of land and its sustainable use (Yitbarek et al, 2013) and that if well executed, physical land suitability assessment has the ability of contributing towards improved land management, mitigation of land degradation, and designing land use patterns that prevents environmental problems through separating competing land sues (Ziadat and Al-Bakri, 2006 in Yitbarek et al, 2013).

The traditional approach in itself has constraint in articulating the economic viability of an area. Despite land physical viability, socio-economic factors may be deterministic in its overall productivity and thus the notion that physical suitability is a sufficient predictor of land potentiality is not exhaustive in understanding the broader picture within the lexis of soil and land resource productivity. It therefore can be argued that, evaluation in itself should not only be limited to the potential of land characteristics in support of a particular land use type but rather it should also take cognizance of the economics of a proposed activity and the social consequences for the people of the areas concerned. Dent and Young (1981) further contend that, even where the evaluation is qualitative, it is still necessary to give some consideration to both the social and the economic consequences of the various types of land use. The principle of economic suitability evaluation according to Rossiter (2005) is about finding the cost of the inputs, the prices, and later computing the net returns in money terms.

Farmers in the past have relied on indigenous technical knowledge on what land use type fits, what type of land characteristics is required. Through their own experiences and experiences passed from one generation to another, farmers have developed land use systems that are sometimes well adapted to the potentials and constraints of their land (Cools *et al*, 2001). Though must times informal, it has worked in situations where data there is dearth of data tp predict weather and soil productivity. However, the weakness of indigenous knowledge is that often it failure to assess and project long-term effects of poor land management which has usually resulted degradation of land resources in some areas (Mugisha, 1994). This notwithstanding, the comparative advantage of indigenous knowledge in assessing land use system they are familiar with in a highly data challenging environment is worth appreciating. For instance in Uganda, data on land availability, productivity, potential, capability and sustainability for agriculture are not adequately known. Soil maps are most times out-dated and not detailed enough for land use planning (National Land use Policy, 2007). Such situation often leaves farmers particularly in rural areas, in a situation where they make uninformed land use decisions.

One of the ways to provide food for the human being is to increase production in area unit and to utilise the land with respect to its potentiality in an appropriate way. Any utilisation of the land over its capability will cause degradation and yields reduction in long – term duration (Saheb *et al*, 2011). Therefore the need for optimum use of land has never been greater than that at present because of rapidly growing population. Land evaluation deals with two major aspects of land; physical and social economic resource (Sys *et al*., 1991a).Several procedures have been used for physical land evaluation (Sys *et al*., 1991b; Van Drepen *et al*., 1991; Van Lanen, 1991; Salah, 1998; 1999), ranging from expert knowledge based on farmer's experience to process oriented simulation models based on generally applicable physical and biological laws, which are derived from extensive laboratory and field experiments (ESRI, 2000). The physical land evaluations are particularly attractive when quick results are required or when the data available are not sufficient for quantitative methods based on computer simulation models (Liu *et al*. 2005). This is also in part important because biophysical factors tend to remain stable unlike socio-economic and political settings (Dent and Young, 1981). Several land evaluation approaches exist; the qualitative approach, the parametric and process based models (Rossiter, 1996, Van Lanen, 1991) example illustration (Baja *et al*, 2002).

One of the methods of land qualitative suitability of crops increasingly capturing attention is done using Automated Land Evaluation Systems (ALES) software of Rossiter and Van Vamyk (1995). Other computer-aided methods that have been used include the CRIES (Comprehensive Resource Inventory and Evaluation System), WOFOST (World Food Studies), ILWIS (Integrated Land and Water Information Systems) and the LECS (Land Evaluation Computer Systems). The ALES and LECS are considered more advanced with this regard because they are capable of integrating soil and land characteristics to provide a detailed agro-ecological and agro-economical suitability assessment (Rossiter, 1995).

The ALES is a computer based program that allows land evaluators to build their own knowledge-based systems with which they can computer the physical and economic suitability in accordance with FAOs framework for land evaluation (FAO, 1985). ALES is not itself an expert system; it does not include by itself knowledge about land and land use, it is merely a framework built within which it is possible to build an evaluation model suited to the prevailing local conditions. Saheb (2011) describes it in the analogy of a knowledge-based system where it simply provides a reasoning mechanism and constrains the evaluator to express inferences using this mechanism.

Material and methods

Description of study area

The study area, Kyangwali Refugee Settlement is located 105Kms south west of Hoima town in Kyangwali sub-county. It covers an area of 90 km^2 sq. km. The district lies within an altitude range of 621 m and 1,158 m above sea level, making parts of the district the lowest and hottest areas in the country (Hoima District Profile, 2012). Kyangwali receives annual rainfall ranging between 700 and 1,000 mm with a bi-modal distribution, March-May and August-November. This means that it presents a possibility of two growing seasons in a calendar year. The western areas bordering the rift valley are usually the driest and hottest. The rain is associated with the northern and southern movement of the inter-tropical front. Daily temperatures vary between 15^0 C and 32^0 C with annual mean of 28^0 C. Relative humidity is high during rainy seasons, reaching maximum levels in May with lowest humidity in the dry season with minimum levels usually in January (UBOS, 2013).

Land Utilization types and Land use requirements

The land use types considered for this study were under rain-fed conditions cultivation and these included low input maize, beans, upland rice and bananas. Maize and beans were the most pre-dominant crops in the settlement upon which attaining food self-sufficiency depends while rice and bananas though relatively new, more and more refugees reported interest in its cultivation. The agro- socioeconomic data base for each land use type was compiled and presented in tables showing annual production inputs, outputs and market prices. This data was sources from field (farmers) as primary data as well as desk reviews of existing literature on market surveys for the surrounding markets in Hoima district. The maize considered was of 90 – 140 days of growing period and beans of 85-115 days.

The agro-climatic requirements for the considered land Utilisation Types were temperature, length of growing period (days) and moisture availability. The length of growing period was determined by comparing dekedal rainfall with reference evapotranspiration (ETo) (Sys etal, 1993). The climate data was obtained from the Department of Meteorology, Hoima Station. The rainfall and temperature data covered the period from 1983 and 2012.

For soil and landscape attributes drainage class, texture, rooting depth (cm), pH, base saturation (%), sum of basic cation (emol(+)kgs^{-1}soil), organic matter, top soil nitrogen (0-200cm), top soil available phosphorous (0-200cm) , oxygen availability, salinity (ECe,dSm^{-1}) and alkalinity (ESP,%) were considered. The crop requirements were established following the approach of FAO (1983), FAO/UNDP (1984) and Sys et al. (1993). Nitrogen, Phosphorous and Potassium are most considered in this study because they are the major nutrient requirement by a plant but also because they exist within the range for fibrous root system like cereals which is predominantly grown within the settlement. The soil nutrients within the top soil depth where the major Nitrogen, Potassium and Phosphorus are found are usually fixed. The P^H here is usually low as a result of a lot of aluminium and iron concentration. Nitrogen and Potassium, which are easily leached, are fixed (Okalebo et al, 1993).

Compilation and rating of land use requirements for each crop

Land use requirement of the selected crop (low input maize, rice and beans) 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 (^oC), 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 (S_1), moderately suitable (S_2), marginally suitable (S_3) and not suitable (n) basing on the level of land quality required by each crop (FAO, 1995).

Compilation of soil characteristics

A soil map for the study area was obtained from the National Agricultural Research Laboratories (Kawanda) showing types of soils with their profile description. The soil map was for the entire Kyangwali Sub County. From the Sub County soil map, the soils for the refugee settlement were got. Soil parameters in the map included soil depth, chemical properties of pH, phosphorous, nitrogen and potassium, CEC, organic matter and base saturation.

Because each soil type had various soil profiles sampled at different depth for each of the parameters in the chemical analysis, averaging of each of the soil chemical properties was done. This was done using the stratified mean method given by the formula below.

$$\text{Stratified mean } X = \frac{X_1D_1 + X_2D_2 + X_3D_3 \ldots}{D_1 + D_2 + D_3 \ldots}$$

Where X = any chemical parameter

D = soil depth

Constructing decision trees for Land use types in ALES model

Physical land data was entered into ALES for each land Management Unit (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.

Land use requirements 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).
S2 (moderately suitable)
S3 (marginally suitable)
N (not suitable)

Hence, land classed as highly suitable is best conditioned for the particular crop production, moderately suitable land is fir for the use but has limitations, and marginally suitable has severe limitation but can still be used preferably with lots of improvement.

Description and characteristics of Land Mapping Unit (LMU)

Land Mapping Units are areas that possess a degree of uniformity or homogeneity and their physical characteristics and when subjected to particular land utilization type are expected to more less generate similar results save for local contextual difference that may in a negligible way affect the results (Mwango, 2000). The FAO (1983) Guidelines outlines the following in identifying LMU: land mapping units should be as homogeneous as possible; grouping should have practical value, in relation to the proposed land use; units should be defined as simply as possible and based on properties, which are readily observable in the field with the use of remote sensing techniques; and units should be defined according to relatively stable properties of the soil and land surface, which are likely to change rapidly in response to management practice.

The identification of Land Mapping Unit was based on slope, soil depth and soil texture. The entire study area was categorised into four (4) Mapping units of Glyic Arenosols, Acric ferralsols (Rukiri series), Acric ferralsols (Bugangari series) and the Vertisols as shown in Fig. 1.0. (*see appendix*)

Land Suitability Evaluation and Mapping

The land suitability classification was derived from the FAO classification and descriptors (FAO, 1976, 1983; 2007). ALES (Rossiter and Van Wambeka, 2000) was used in the evaluation. The suitability map for each of the considered Land Utilisation Type was made using ArcGIS 10.0. The estimates for the economic productivity of land use type on a particular land mapping unit was established using gross margin method. The factors required for economic suitability of the land utilisation types were obtained through market surveys to determine farm-gate prices for the four crops. Input costs for the production of the four crops were also determined. Production output data was obtained by reviewing existing literature on optimum yield per hectare for the four land utilisation types. Market prices were obtained from data compiled by Hoima District Production Department through market surveys. Gross margin method was employed in ALES to study economic suitability, that is, the cash flow into the land utilisation type, less the cash flow out of the land utilisation type on aggregate (Per farm) basis, in one accounting period, that is, one year (Rossiter, 1995). For each land utilisation type, the crop output and the gross margin was analysed for economic suitability in ALES. In the study, only two classes were considered, 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

Suitability was assessed for the major land utilization types which included maize, beans, beans rice and bananas. Suitability for each land utilization type was assessed in a land mapping Unit. The land mapping units in Kyangwali Refugee Settlement include; Gleyic Arenosols, acric ferralsols (Rukiri series), acric ferralsols (Bugangari series) and the vertisols.

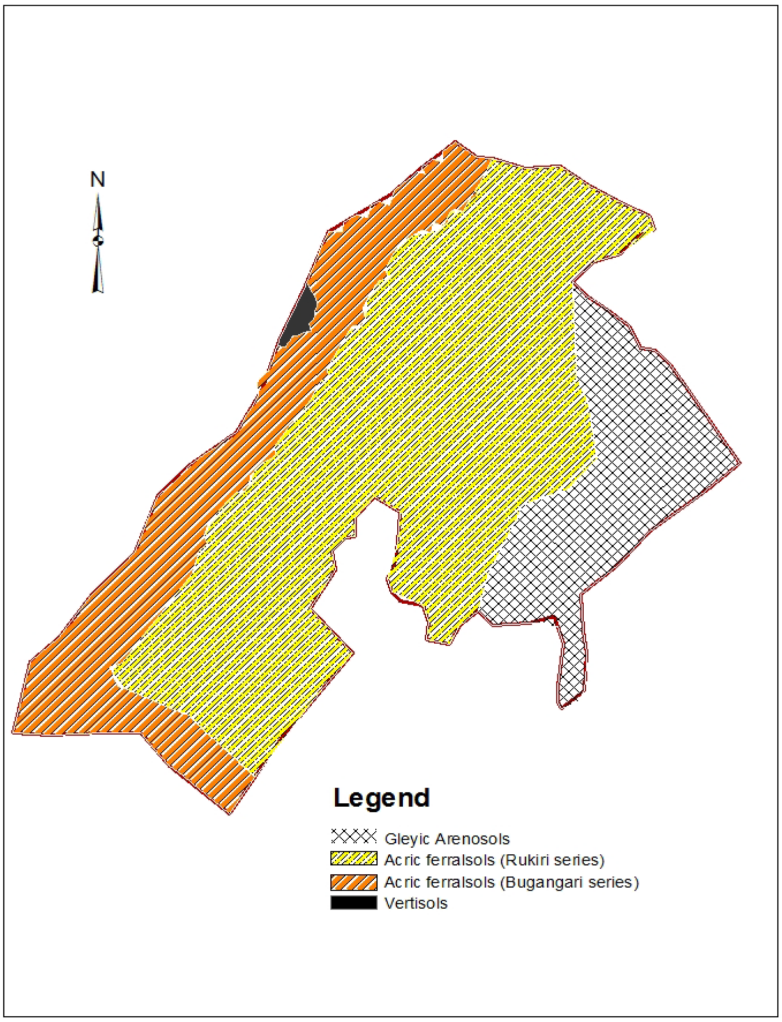

Fig . 1.0 Soils of Kyangwali Refugee Settlement.

Description and characteristics of land mapping units

The study shows that land mapping units were considered to be homogeneous because of being covered largely by the same soil type. Four mapping units were generated. Table 1.0 shows the descriptions of the four land mapping units.

Land Mapping Unit- Acric ferralsols (Bugangari series):

The unit is characterised by good physical properties but are chemically poor. They are of low natural fertility and the tendency to 'fix' phosphates is serious limitations. The soils have low organic carbon (1.1%) with a low soil pH and low concentration of dissolved weathering products. The soils are largely weathered soils and considered immature. The acric ferralsols cover 11.52 Km ^{2} of the total land area in Kyangwali Refugee Settlement.

Table 1.0. Land mapping units and qualities used for physical suitability assessment

Mapping unit/Series	Soil type (FAO-UNESCO classification)	pH	Organic carbon (%)	Nitrogen (%)	Potassium (%)	CEC	Base saturation (%)	Potassium
Bugangari series	Acric ferralsols	5.8	1.1	0.195	0.16	21.5	60.6	13.5
Rukiri series	Acric ferralsols	5.7	1.91	-	0.45	13.1	65.2	26.8
Wasa complex	Vertisols	6.3	2.9	0.260	1.04	38.5	6.3	216
Kifu series	Gleyic arenosols	4.3	1.08	0.548	0.23	7.0	6.6	8.2

NARLS- Kawanda Averaged-Obtained from excel raw data.

Land Mapping Unit- Acric ferralsols (Rukiri series)

The acric ferralsols (Rukiri series) have similar characteristics to the Bugangiri series. The difference is that they have higher concentration of Potassium (%), Base saturation and organic carbon (%). However in terms of fertility they are generally poor in chemical properties and therefore are poor soils. The exchange properties of the soil are contingent on quantities of clay minerals, oxides and organic condition which are usually low. This land mapping unit covers a total of 55.8 Km^2 which is the largest proportion of 62% of the entire 90 km^2 of the settlement area.

Land Mapping Unit - Vertisols

The vertisols cover a small proportion of Kyangwali Refugee settlement. They have clayey textures and dark in colour. The soils are largely very productive with soils of more less neutral acidity level. The vertisols have high mineral fraction and are therefore chemically rich making them the most fertile soils in the settlement. The soils have high organic carbon (2.9%), nitrogen of 0.26%, potassium of 1.04 and CEC of 38.5. The soils are alluvial in nature and usually occupy the low lying area. However they present a challenge in tillage for they are heavy and often crack in dry spells. The vertisols are the smallest in terms of coverage with 1,08km^2 representing a proportion of only 2% of the entire land in the settlement.

Land Management Unit- Gleyic Arenosols

The gleyic arenosols have loamy sand texture. The soils are deeply leeched and decalcified with low capacity to store bases. The organic matter is less than 1% and CEC is very low. The soils generally are of high acidity. The gleyic arenosols are generally classified as soils of low productivity levels. The gleyic arenosols cover 21.6 Km^2 representing 24% of the land size of the settlement.

Agro-climatic Analysis and suitability evaluation

The study established that the area has a double maxima type of rainfall distribution, with peaks in April and November. Only two months of January and February are dry (recording less than 50mm), allowing continued crop growth in the rest of the year. Fig 2.0 shows the averaged monthly rainfall curve for Kyangwali.

The temperature regime also favours crop growth, with the coolest months coinciding with the rain season. For example the highest average min-max monthly temperatures are recorded in the dry months of January and February (when there is no crop growing) and the coolest temperatures recorded in the August-November period (during crop growth). Fig 3.0 presents the temperature curve for the area.

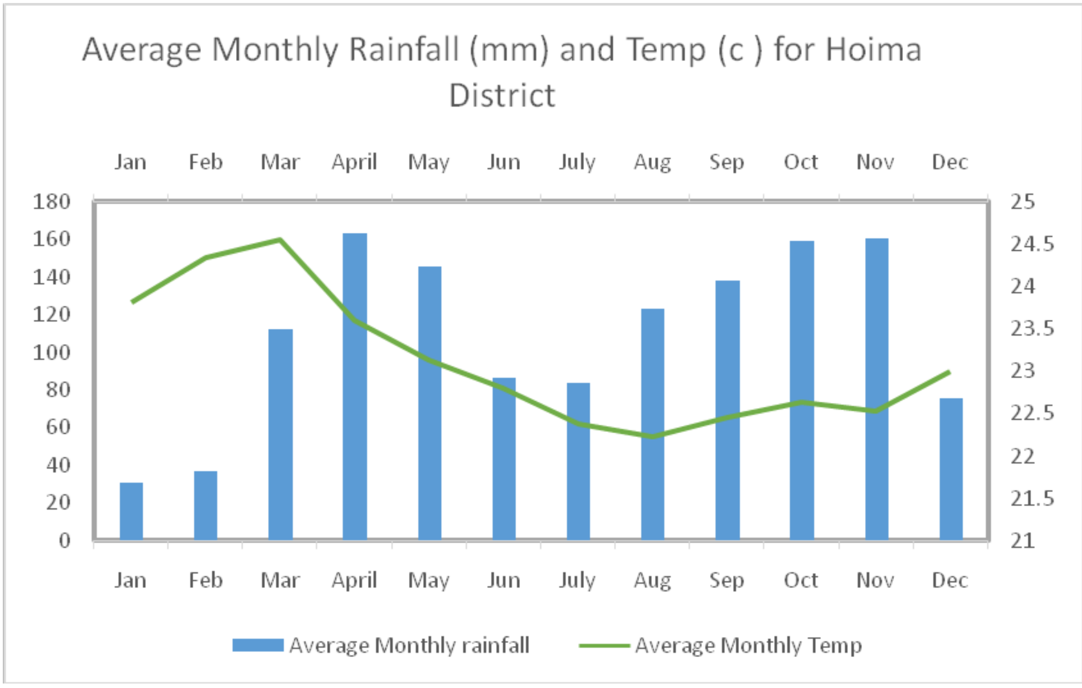

Fig 2.0. Averaged Monthly Rainfall and temperature ^{0}C patterns.

Physical suitability for each land mapping unit

Using ALES analysis factoring in all the rating levels for maize, the study showed that maize as a land use type recorded marginal suitability on land mapping unit of gleyic arenosols (S_3). Moderate suitability for maize was recorded on the acric ferralsols of the Rukiri series. High suitability (S_1) was recorded on vertisols and the acric ferralsols of the Bugangari series. The study showed that 14.8% of the land in the Settlement was of high suitability for maize cultivation and 62% of moderate suitability. While 24% of the area of was of low suitability of maize cultivation as shown in Fig.4.0. However maize by far can thrive well in the settlement depending on other conditions.

Table 2.0 Suitability ratings for maize, bananas, beans and rice for Kyangwali Refugee Settlement

Soil type	Suitability rating				
	Bananas	Maize	Beans	Rice	Suitability
Acric Ferralsols (Bugangari Series)	S2	S1	S1	S2	Moderate
Acric Ferralsols (Rukiri Series)	S1	S2	S2	S1	Moderate
Vertisols	S1	S1	S1	S1	High
Gleyic arenosols	S1	S3	S3	S3	Marginal

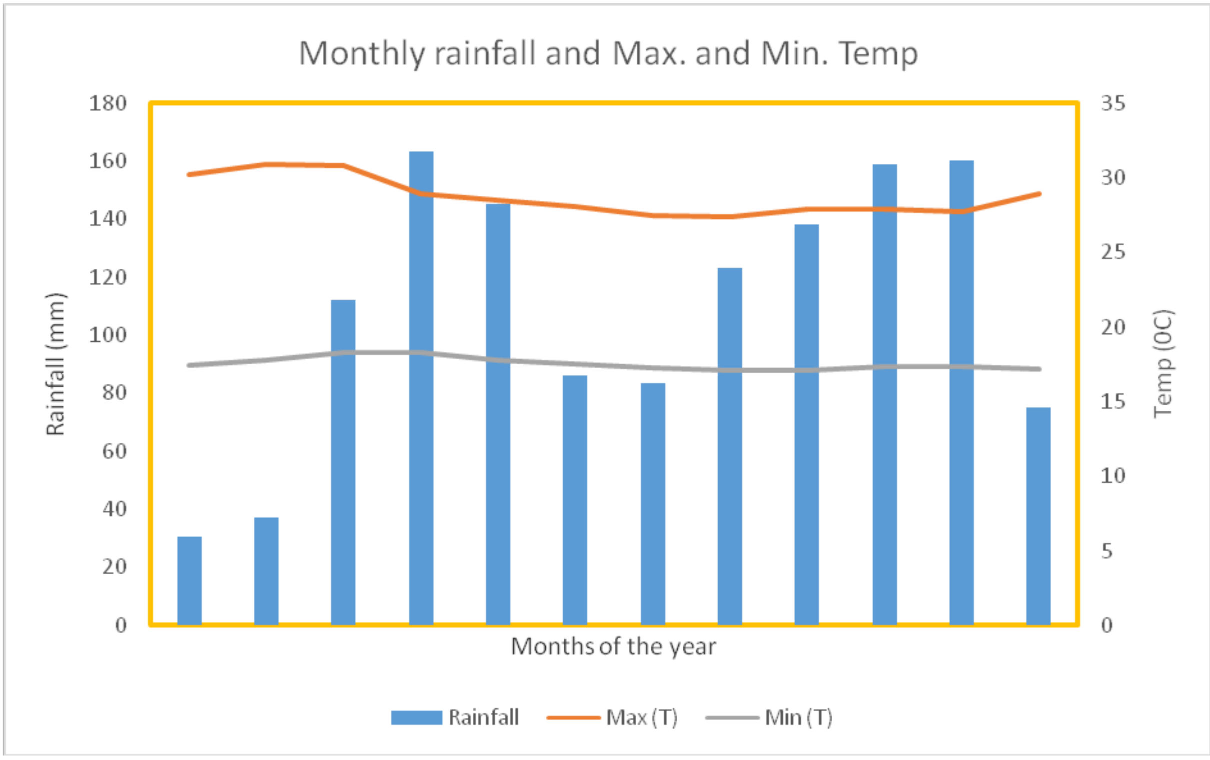

Figure 3.0 Monthly rainfall and maximum and minimum temperature ^{0}C.

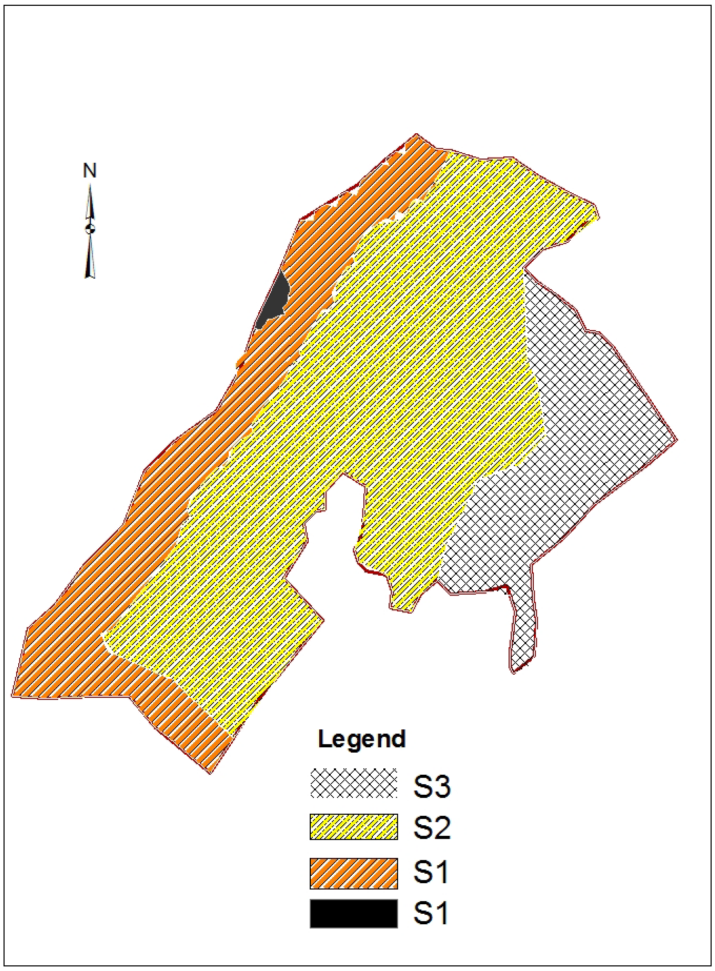

Fig. 4.0 Suitability for maize.

Beans is a widely grown crop in the settlement with majority of refugees involved in its cultivation. Beans are also largely suitable in the entire refugee settlement, with vertisols and acric ferralsols of Bugangari series being the highly suitable mapping units (S_1). Gleyic arenosols and acric ferralsols of Rukiri series were of moderately suitable for beans (S_2). The settlement was of high and moderate suitability with no area in marginal suitability. The spatial suitability map for beans is presented in Fig. 5.0 below.

The study shows that for bananas, on average all mapping units are suitable for its cultivation in all the areas of the settlement. There are no areas in the settlement which rated ‘N’ (not suitable). However, suitability ratings differ according to soil types. Gleyic arenosols, vertisols and acric ferralsols of the Rukiri series are of high suitable (S_I) compared to acric ferralsols of Bugangari series which rated moderate suitability (S_2).

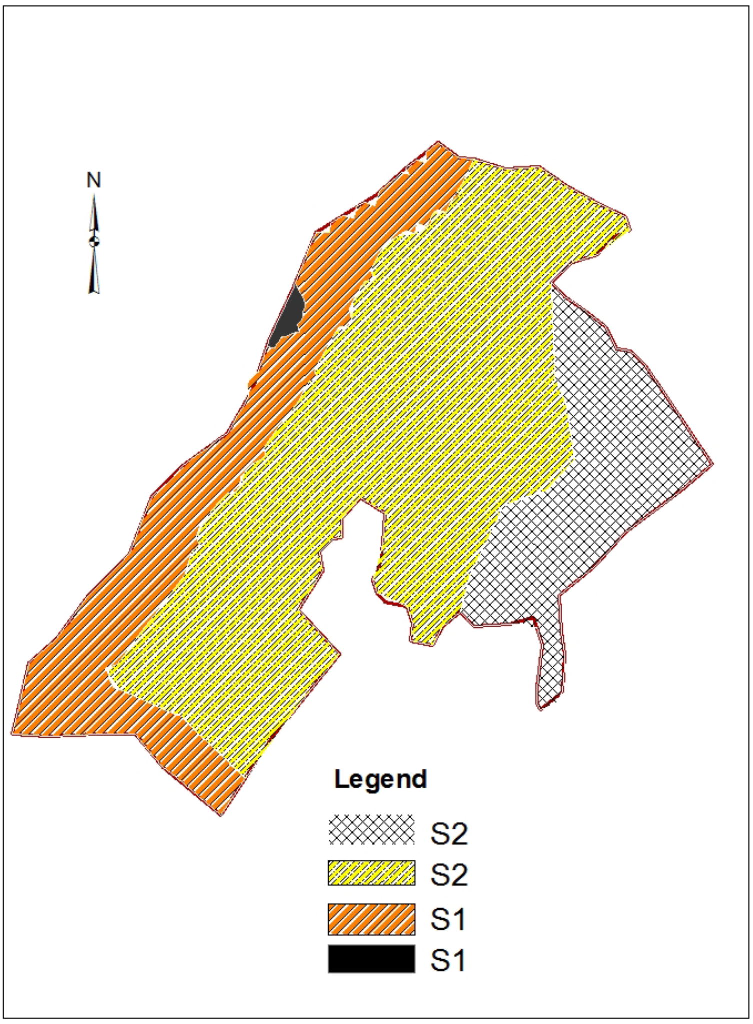

Fig. 5.0 Suitability for beans.

Rice is a relatively 'new' crop in the settlement and is more prominent among the Congolese refugees. Rice also presented varied suitability ratings, with vertisols and acric ferralsols of the Rukiri series being highly suitable (S_1), followed by acric ferralsols of the Bugangari series where it rated moderate suitability (S_2). The crop is marginally suitable (S_3) on gleyic arenosols.

Overall suitability

Table 2.0 shows that vertisol land mapping unit was the most suitable for all cropping activity. Vertisol soils have high suitability but coverage a very small area (2%) towards the northeast of the settlement. Vertisols are therefore the most productive soils for their richness in chemical composition. Acric ferralsols (Bugangari and ferralsols (Rukiri) had moderate suitability (74.8%) overall for crop cultivation and the gleyic arenosols (24%) had marginal suitability Kyangwali refugee settlement settlement was by far arable for crop cultivation**.**

The gleyic arenosols are of marginal suitability because they are poor in organic matter with a low organic carbon content and cation exchange.

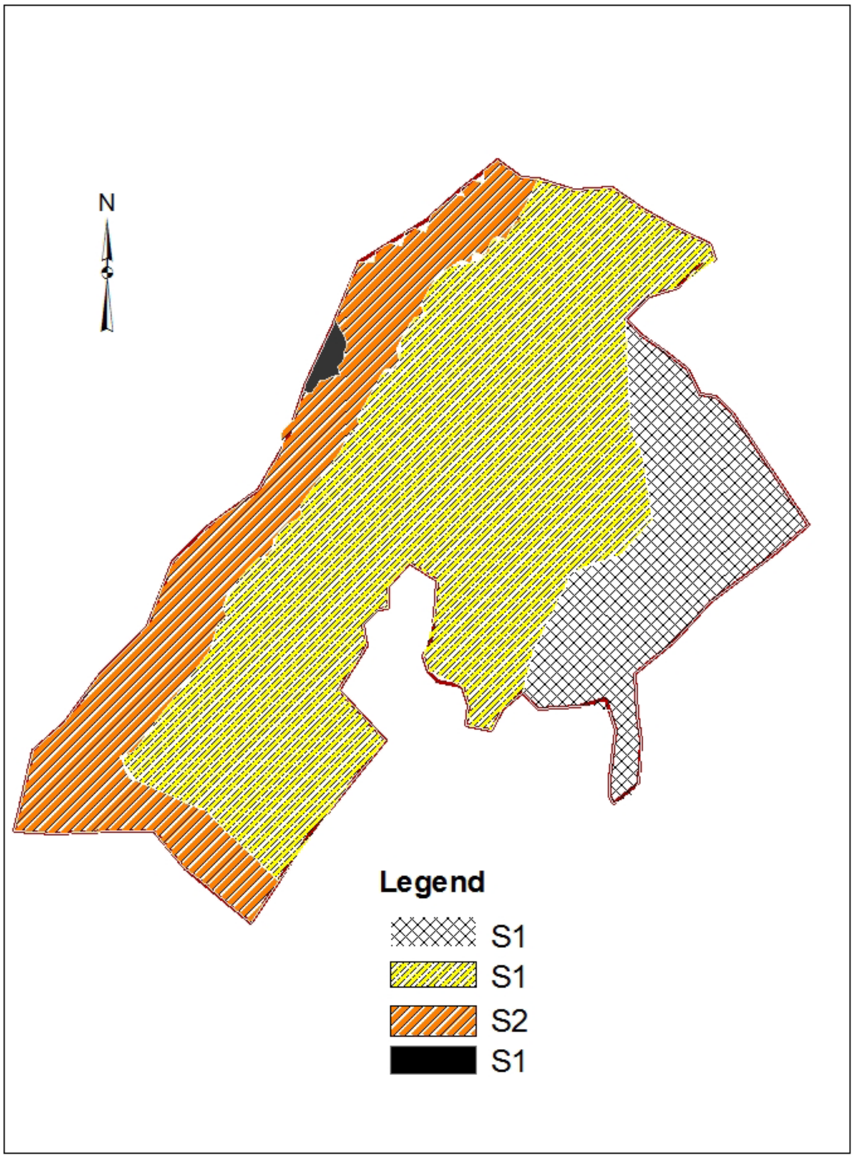

Fig 6.0. Suitability map for Bananas.

Economic suitability

Using ALES, the study also undertook economic suitability analysis with results presented as suitable or unsuitable. The viability of land use type for a particular land mapping unit was assessed on the basis of gross margin. Results were analyzed on the basis of Agro-socio-economic survey for the major land use types of maize, beans, rice and bananas as shown in Table 3.0. The net present value method of economic suitability was used. The data was input into ALES and Net Present Value method selected for the analysis and the results is as shown in Table 4.0.

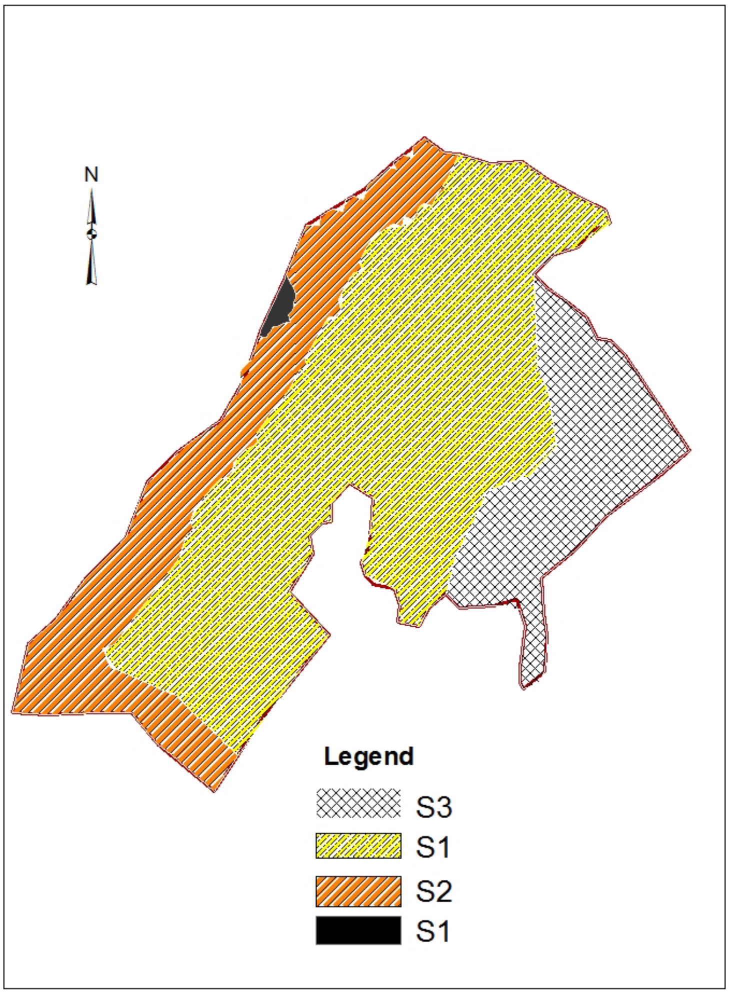

Fig .7.0 Suitability for Rice.

Table 4.0 indicated that relatively, bananas have a higher gross margin, compared to other crops. This is because bananas have a longer planning period (20 years). Secondly, the initial investment costs for banana production like buying planting materials (plantlets), ploughing, labour for planting are fixed and not recurrent. The rest of the crops have a one year planning period. The next time a crop is planted; all the costs have to be incurred again. The results shows that maize has relatively lower gross margins; this could be explained by the higher costs of post-harvest processing (storage, shelling the grain from the cobs, drying). Meanwhile gleyic arenosols have the lowest gross margins for annual crops (beans, maize and rice). This compares well with the results of the physical suitability (S3) throughout for all the three crops. This means the land would require a lot of fertility improvements to realize higher yields.

Maize has relatively stable gross margins across all the soil types compared to other crops. Since there are no negative gross margins, it is economically viable to undertake all the land use types on all the soil types.

Table 3.0 Agro-socio-economic survey for major land use types

Crop	Maize	Rice	Beans	Bananas
Yield (tons /ha)	0.5 – 1.5	1 - 2	1.5 - 2	15-25
Plant//ha	-	-	-	1500 trees
Unit price	700shs/kg	1800Sh/Kg	1600Sh/Kg	9000 Sh/Bunch
	Maize grain	Grains	Seeds	Bunches
Planning period	1 yr	1 year	1 year	20 years
Annual cost				
	150,000	150,000	150,000	150,000
1-Ploughing	170,000	170,000	170,000	100,000
2-Planting	30,000	30,000	30,000	180,000
-weeding	130,000	130,000	130,000	100,000
-pruning	-	-	-	100,000
-harvesting	100,000	80,000	50,000	-
3-Implements	34,000	34,000	34,000	34,000
-hand hoes				
-pangas				
4-Transport:				
-to markets	30,000	30,000	30,000	60,000
Material input				
-fertilizers	-	-	-	-
-pesticide	-	-	-	-
-local seeds/planting materials	55,000	60,000	42,000	580,000

Table 4.0 Economic suitability analysis results

Soil type	Bananas	Maize	Beans	Rice
Acric Ferralsols (Bugangari Series)	33,293,911	422,345	578,799	611,000
Acric Ferralsols (Rukiri Series)	40,879,000	403,817	320,222	904,446
Vertisols	40,879,000	422,345	598,321	904,446
Gleyic arenosols	40,879,000	177,659	295,255	240,000

Discussions

The refugee settlement has a small area with high suitability for maize growing as a land use type. The vertisols land mapping unit are of high suitability (S_1) while the gleyic arenosols land mapping unit was of marginal units. The low suitability (S_3) of the arenosols is attributed to their low pH (acidity level), low phosphorous and organic matter content. Arenosols are heavily leeched soils with low water retention capacities owing to their largely sandy texture. Maize and the other cereals are by nature heavy feeders and therefore require soils of relatively good fertility. Despite the marginal suitability, refugees still cultivated maize an indicator of the importance of the crop in their socio-economic lives. This is because maize is an important crop in refugee economy for subsistence with surplus production sold to offset other non-food needs. The high suitability in vertisols and acric ferralsols of the Bugangari series is attributed to high proportion of organic matter and its high water retention abilities. Maize thrives generally better in soils of high moisture content. Given the physical limitations of arenosols in water retention capacities, output levels remain all time low among other factors.

The land mapping units unlike for maize showed that beans was by far suited for its production. None of the land mapping units posted marginal suitability for beans. The vertisols and acric ferralsols (Bugangari series) were of high suitability (14.8%) and the acric ferralsols (Rukiri) and Arenosols were of moderate suitability (86%).

Rice and bananas are relatively new crops in the settlement. The study showed that the rice grown was upland variety and the bananas are the cooking type locally known as *matooke*. A large proportion of the settlement was of high and moderate suitability for banana growing. The vertisols are the most suitable (S_1) for banana growing. This finding concurs with fact that bananas require deep, well drained loam soils with high humus content, often of volcanic or alluvial soils. The high suitability is attributed to optimal mean temperature of 27^0C and relatively adequate rainfalls received. Rice is increasingly being adopted by the refugees as a high value crop that also does play an important role in improving nutrition status and poverty reduction. The vertisols and acric ferralsols (Rukiri series) are of high suitability for rice growing while gleyic arenosols are of marginal suitability largely because of its poor chemical content and organic matter level.

In terms of economic suitability, highest Net Present Value (NPV) was recorded for bananas with high gross margins as compared to all other crops in the settlement. Bananas were largely popular among Congolese and Rwandese refugees in Musisa A, B and Kagoma villages. The high yields are attributed to deep, fertile soils in those areas. Vertisols land management units has the highest gross margins for all LUTs confirming the physical suitability results.

Suitability was assessed for the major crops which included maize, beans, beans rice and bananas. The study showed that vertisol land mapping unit was the most suitable soils for all cropping activity. Vertisol soils (2%) had high suitability but covered a very small area towards the northeast of the settlement. Acric ferralsols (Bugangari and ferralsols (Rukiri) had moderate suitability (74.8%) overall for crop cultivation and gleyic arenosols (24%) had marginal suitability. It is important to note that Kyangwali refugee settlement is by far arable for crop cultivation**.** The gleyic arenosols are of marginal suitability because they are poor in organic matter with a low organic carbon content and cation exchange. Economic suitability analysis showed a high gross margin largely for vertisols, acric ferralsols (Bugangiri series), acric ferralsols (Rukiri series) and low gross margin for gleyic arenosols for all crops. However by far, all land mapping units were considered economically suitable.

Conclusion

The study identified the different suitability classes of land cultivation of the four major crops of maize, beans, rice and banans in the study area. The methodology adopted in the study was to map the suitability clases based on each crop's edaphic and climatic suitability using th e FAO framework for land evaluation and aslo economic suitability based on gross margin. The study recommends the need to rationalise the distribution of land taking cognisance of the quality of land rather than just its size. Kyangwali Settlement may have been gazette for refugee settlement because of tsetse fly infestation during those days (hence unfit for grazing and human settlement), but the area is well endowed with agricultural resources (soil and climate). This therefore implies that if land shortages and soils exhaustion challenges were not evident, the settlement would be self-sufficient in food production.

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Authors Contributions

1. Robert Ayine : Principal researcher, data collection, generation of maps, plant requirements analysis and write-up
2. Dr. Fredrick R. Tumwine: Refined the research concepts, supported in academic mentorship, developing of ideas and critique of research work
3. Dr. Robert Kabumbuli: Developed the research ideas, supported in academic mentorship and critiquing of the research work

Conflict of Interest

We state that there is no conflict of interest whatsoever and our interests as as stated in our contributions

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