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Indigenous land suitability evaluation system of the Acholi tribe of Northern Uganda

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Indigenous knowledge has traditionally been the most important source of information about agricultural practices and production in many rural communities in sub-Saharan Africa. Modern, scientific knowledge has increasingly contested and replaced this knowledge, but has itself not always been adapted to local conditions, in contrast to indigenous knowledge that has evolved over time and is very place-specific. Since most indigenous knowledge is held in oral expressions; like proverbs, folklore and songs, documentation of the knowledge is important for its preservation and possible future use. This study documents the role of indigenous knowledge in a traditional land suitability evaluation system used by the Acholi ethnic group of northern Uganda. Farmers' traditional knowledge was elicited using questionnaire surveys and focus group discussions in Amuru district. The results reveal that all the respondents regardless of age and gender were aware of how land evaluation is assessed using indigenous knowledge. The most common indigenous land evaluation techniques and practices range from soil classification, use of indicator plants, observable soil organisms, vegetation species diversity and soil depth. Also, the long period of stay in Internally Displaced Peoples' camps did not affect the indigenous knowledge. It was noted that although indigenous knowledge is widely known, it is not applied by everyone or it plays a subordinate role in current land suitability evaluation, vis-à-vis other factors, that is, land availability constraints, unbalanced gender-based power relations in land use allocation, and land allocation between arable farming and grazing.

Key words: Indigenous knowledge, land suitability evaluation, Acholi.

INTRODUCTION

Over generations of interaction with the environment, farmers have accumulated local indigenous knowledge on soil and land suitability evaluation as documented by Buthelezi et al. (2013), Sicat et al. (2004), Sojayya (2005) and FitzSimons et al. (2013). This knowledge is crucial in the sustenance of production of both food and fiber for the communities. The failure of most rural development programmes in developing countries due to their highly technical level (Buthelezi et al., 2013) has highlighted the role of traditional knowledge in the development process, and therefore, the need to investigate and document it for future knowledge synthesis and integration. Indigenous agricultural and environmental knowledge gained global recognition through the United Nations Conference on

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Environment and Development (UNCED) in 1992, and in strategy papers such as the *World Conservation Strategy* (International Union for the Conservation of Nature and Natural Resources (IUCN) 1980) and Brundtland Commission's *Our Common Future* (WCED, 1987). In short, indigenous knowledge is an immensely valuable resource that provides humankind with insights on how communities interact with their environment. Such kind of interaction is through evaluation of the suitability of land for agriculture.

Rossiter (1994) defines land evaluation as the process of prediction of land performance when the land is used for specified purposes. An expanded definition is given by Liu et al. (2006) as cited in Gong et al. (2012) that land suitability evaluation means the process of appraisal and grouping of specific areas of land in terms of their suitability for defined uses. A case is made for indigenous knowledge in land suitability evaluation because most rural communities in developing countries are characterized by low levels of literacy and therefore high reliance on traditional agricultural practices. Although modern land suitability evaluations may exist, they largely remain unused due to, firstly, the highly technical nature, rendering them unusable to the illiterate farmers. According to Scherr and Yadav (1996), western scientific planning models often ignore local interests (leading to noncompliance or resource expropriation), overlook possibilities for technical or organizational innovations to resolve conflicts between environment and production objectives, and lead to plans that remain static in the face of economic and environmental change.

Secondly, most land suitability mapping units are prepared at scales that ignore local variations in the land, yet significant in influencing decisions pertaining to crop production. In Uganda, most existing soil and land use maps are prepared at very small scales like 1:250,000 for the soils of Uganda (NEMA, 2010), and 1: 1,000,000 for the Agro-Ecological Zonation of Uganda, which is currently used as a proxy for suitability of various areas for particular crops. This is largely based on physical environmental factors like rainfall regime, temperature and soils. Because culture and customs play a significant role in influencing choice of land use types, given the localized nature of culture and therefore indigenous knowledge, local land suitability evaluations may be rendered more usable than modern scientific ones since the indigenous knowledge has been developed and tested for generations in the particular environment. Therefore, the objective of this paper was to establish and document farmers' indigenous knowledge used in land suitability evaluation by the Acholi ethnic group in Amuru district of northern Uganda.

Indigenous knowledge

According to Akullo et al. (2007), Indigenous knowledge (IK) is ideas, beliefs, values, norms and rituals, which are native and embedded in the minds of people. It is local knowledge which is unique to a given culture or society. Different terminologies to mean the same phenomenon have been developed, for example indigenous knowledge systems, indigenous technical knowledge, ethno science, local science, traditional science, people's science and village science (Atte 1989 cited in Williams and Muchena, 1991).

Indigenous knowledge is handed down orally from generation to generation. This makes it susceptible to disappearance because of not being captured and stored in a systematic way if/when certain situation like disruption of social life by war or promotion of modern technological innovations, especially among the younger generation. Some indigenous knowledge may be specific to a particular cohort in society, for example held by elders only, men/women, or a specialized group like medicine-men and artisans. Therefore, when looking to document indigenous knowledge, identification of a target resource cohort is very important.

Another characteristic of this knowledge is that it is area-specific, developed and used by and in a particular geographical space. The varied nature of physical and social environments means that indigenous knowledge differs from community to community because different communities use the environment for different survival strategies. For example pastoral communities may develop different sets of indigenous knowledge in the same community, different from cultivators. Because of its localized nature, indigenous knowledge has been used to solve relevant social and economic problems. Indigenous knowledge can enhance resilience of social-ecological systems because this knowledge, accumulated through experience, learning, and intergenerational transmission, has demonstrated the ability to deal with complexity and uncertainty (Berkes et al., 2000).

Many studies about best practices in indigenous knowledge have been undertaken (Kuldip et al., 2011; Akullo et al., 2007; MOST, 2003; Kaniki and Mphahlele, 2002; Haugerud and Collinson, 1991; Kumar 2010) in areas of human and animal health, crop science, soil fertility management and energy. In land suitability evaluation, reviewed literature reveals that more studies have been conducted in Asia than in Africa, particularly not in Uganda. Various methods are used by farmers to assess the suitability of land for crops.

Indigenous knowledge uses various criteria to evaluate the suitability of land for different crops. Sicat et al. (2004) notes that soil colour, texture, depth, cropping season and slope were used by local farmers in Nizamabad district of Andhra Paradesh State in India as parameter to evaluate the suitability of land for different crops. Sojayya (2005) noted that farmers in Thailand use indigenous knowledge on soil, terrain, weather and vegetation to infer on the suitability of their land for various crops. In

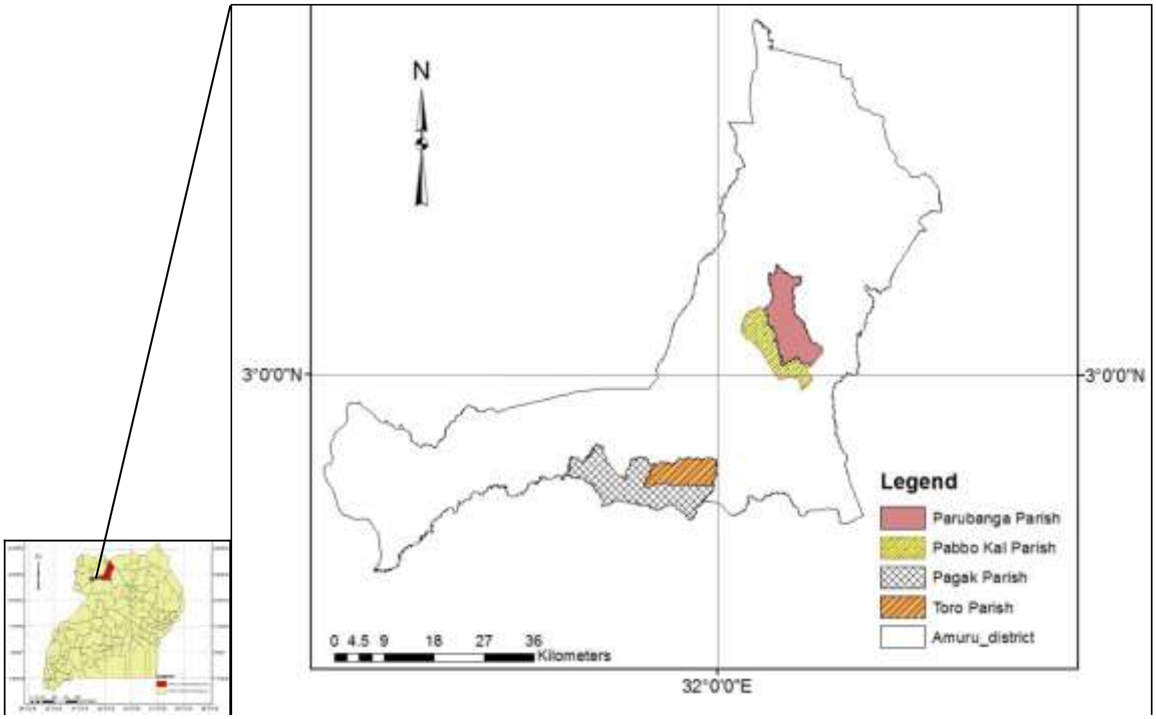

Figure 1. Location of Study parishes in Amuru district.

the two cases, it was realized that indigenous land suitability knowledge was crucial in sustaining agricultural productivity in rural areas.

Some indigenous people can infer suitability of the land by identifying soil macro organisms. Earth worms, insect larvae and some types of insects present in a soil are used in land suitability evaluation (Sicat et al., 2004). Documenting farmers' indigenous knowledge in land suitability evaluation was done in Southern Africa by Buthelezi et al. (2013), where farmer vernacular evaluation was compared to the scientifically surveyed evaluation maps. It was found out that farmers' evaluation mainly was based on top soil colour and texture. Slope position was the main factor influencing suitability. Crop yield, crop appearance, natural vegetation, soil colour and texture and mesofauna were used to estimate soil fertility. In the study, farmers' indigenous knowledge was found to be more holistic than that of scientific researchers.

MATERIALS AND METHODS

Study area

Amuru district is located in the northern-most region in Uganda neighbouring South Sudan. It is bounded by longitudes 31°4'3"E and 32°3'4"E and latitudes 2°7'8"N and 3°6'3"N. The district is bordered by Lamwo district in the north, Gulu district in the east, Adjumani district in the west and Nwoya district in the south. Grassland savanna is the dominant vegetation, with annual rainfall of about 900 to 1000 mm. The average temperature is 22°C, with an average maximum of 34°C and average minimum of 16°C (Seebauer, 2011). The area is covered with a variety of soil types weathered from basement complex gneisses and granites. Figure 1 presents the map of the study area. The district is mostly inhabited by the Acholi of the greater Luo ethnic group, mainly practicing small scale rain-fed subsistence arable farming. Some households rear livestock like goats and poultry. Purely traditional agricultural methods are practiced, without the use of fertilizers or pesticides. Data was collected from PabboKal, Parubanga, (Amuru Sub County) Toro and Pagak (Pabbo sub-county) parishes (Figure 1).

The four parishes were chosen because of their relative ethnic homogeneity in the district compared to parishes that are neighbouring Adjumani district in the west (inhabited by the Madi tribe) and in the north of the district (inhabited by the South Sudanese tribes). Because of the history of civil unrest in the area, migration of neighbouring tribes into Acholi land has affected the ethnic composition of border parishes. Indigenous knowledge is specific to a particular culture, so the parishes away from other cultural influences were selected.

Sample selection

According to UBOS (2012), Amuru district is estimated to have a total of 37,340 households. Using the Krejcie and Morgan (1970) table for sample determination, a total of 380 respondents (local farmers) were initially selected, but 306 (80%) were interviewed (38% male and 62% female), because some people were never found at home, others were too busy to be interviewed. A questionnaire was used to interview farmers to identify indigenous knowledge used in land suitability evaluation in 2013. A follow-up study was conducted in 2014 where 52 farmers were selected based on the Israel (2012) sample determination tables, and asked to rate the suitability of the land for maize, rice and beans using the parameters identified in the previous survey. The three crops were chosen because they are the most important in the region in terms of food and income security. The suitability rating was on a scale of 1 to 4, with 1 for '*highly suitable*', 2 for '*moderately suitable*', 3, '*marginally suitable*' and 4, '*not suitable*'. The rating was adopted from the FAO (2007) rating for land suitability evaluation. Primary data from the questionnaires was analyzed by grouping and coding the questionnaires and responses, then entered into a computer software SPSS (16.0), that is, Statistical Package for Social Scientists. The 'Descriptive Statistics' tool of the software was used to generate frequencies, cross-tabulations and chi-square values from the data.

Focus group discussions were also conducted to collect information about the indigenous knowledge and practices of land suitability evaluation. Recorded interviews were transcribed and presented in text form. Transect walks with farmers to identify the observable physical parameters used in indigenous suitability evaluation like plants and soil organisms were carried out. A mini soil survey was conducted to test the soils to establish the relationship between indigenous and scientific knowledge. Sampling of top soil was done at a depth of 20 cm because this is the layer that farmers use in their assessment. Field tests were carried out for pH using the pH meter, colour, using the Munsell soil colour chart whereas percentage organic matter and texture were tested at a soil laboratory at Makerere University.

RESULTS

Local farmers' soil taxonomy

In land suitability evaluation, one of the most important aspects is the identification of the soil types and properties. The ability to differentiate various soil types forms the basis for assessing the relative suitability for the various land use types. Farmers in Amuru district identified and classified four major soil types. The classification in Acholi, was majorly based on physical properties of texture and colour. In the Acholi classification system, soil colour and texture are used in combination. Dark soil with granular structure is classified as *opwuyu/ngom macol*. *Ngom macol* is loosely translated as "black soil". This soil type has relatively higher humus content. Soil samples of this type contained 4% organic matter, the colour was described as dark brown, and the structure as silt clay loams. Because of its distinct dark colour, it is also used in decorating the exterior of huts, and it is the most favourable for the cultivation of a wide variety of crops. Farmers rated it highly suitable for all the crops.

Lwala is mainly silt loam with relatively low organic matter content (3% according to the tested samples) and has a light brown colour according to the Munsell colour chart. It is described as being "dust-like" by the farmers because of absence of high amounts of humus to enhance its structure. In areas which have not been under cultivation, it forms a blocky structure, whereas in areas of permanent cultivation it has no structure. *Lwala* was rated moderately suitable for crops, especially cereals, during the growing season when rainfall is available. During the dry season, this soil type does not support any crops apart from cassava. Cassava survives during the dry season because the tubers store nutrients for a long time to supply the plant. Cassava, according to the farmers can remain growing in the garden for as long as three years or more. It is a climax crop after exhausting the crop rotation cycle. It is believed that land can fallow under the cassava crop, and after harvesting, it will have regained its fertility.

Anywang is another soil type which was identified. It has very fine particles, sticky and very hard to till, with a reddish gray colour. This is clay soil. In terms of suitability for crops, this soil type was rated marginally suitable as compared to the four soil types, and is the only one of the four soil types which is cultivated outside of the rainy season for vegetables and sugar cane. It is generally located at the bottom of the valley, and characteristically overlaid by a thin layer of opwuyu of about 10 cm depth or less, which makes it favourable for dry season agriculture. Figure 2 shows dry season farming in the valley.

The last major soil type is *kweyo* (sandy soil). It is described as whitish, by the farmers and according to the Munsell colour chart, it is pinkish white. Its distinguishing characteristic is non-stickiness and rough texture. This soil type is not suitable for any crops because apart from not holding any moisture, it is devoid of organic matter (0.5% according to the tested samples), therefore with poor nutrient supply. Areas covered by this soil type are used for grazing or sand mining.

Topography highly influences the distribution of the soil types, with clay and sandy soils found at the bottom of the valley. The dark brown loamy soil (*opwuyu*) is generally found around the concave slope facet next to the valley floor and is deeper because of deposition from upslope whereas the silt loam is located at the convex and mid slope facets of the slope and are relatively shallow due to transportation. Figure 3 shows the distribution of the soil types across the slope.

Some valleys may contain either clay or sand, or both. The suitability mean rankings of the different soil types for maize, rice and beans are presented in Table 1.

When each soil type, excluding *ngom macol* is analyzed independently, *lwala* was rated to be highly suitable for beans than rice and maize while *anywang* is highly suitable for rice than maize and beans. On the other hand, *kweyo* is relatively highly suitable for beans than maize and rice. A soil sub-type locally called *bye* was identified. However, it was not classified for agriculture. It is red and fine soil from an anthill, used for construction of traditional energy saving firewood stoves. Figure 4 shows the four soil types.

Farmers' land suitability assessment and soil fertility indicators

Farmers use indicator plants to assess suitability of land

Figure 2. Dry season cultivation in the valley.

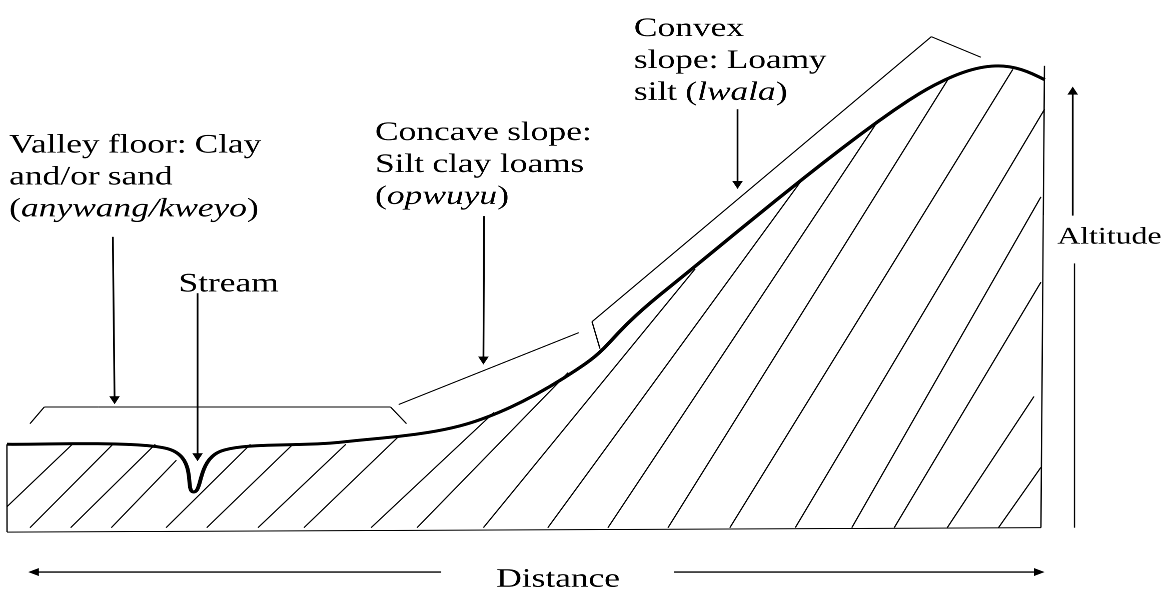

Figure 3. Topography and the distribution of soil types**.**

for crops. The presence of certain types of plants in a plot (listed in Table 2) shows that the land is suitable whereas the presence of indicator plants in Table 4 implies unsuitable land. There are indicator plants which are particular to some crops as shown in Table 2. However, this does not mean they are not suitable for others. For example, whereas farmers acknowledge that *Hyparrhenia rufa* is best suited for maize, rice and beans too may be cultivated in areas where it is found.

Yields figures for maize, rice and beans from the

Table 1. Suitability mean rankings of different soil types for maize rice and beans.

Crop	Soil type			
	Silt clay loams (*opwuyu)*	Loamy sand *(kweyo)*	Clay *(anywang)*	Silt loam *(lwala)*
Maize	1.19	3.01	2.0	1.50
Rice	1.15	3.07	1.76	1.51
Beans	1.46	2.96	2.28	1.44
Mean total average	1.26	3.01	2.01	1.48

Scale based on the FAO (1976) suitability classes *(from which the mean total average is calculated).*

Figure 4. Photo showing different soil types.

previous harvest were collected from the respondents and correlated with indicator plant *Neonotonia wightii* (suitable for all the three crops). Chi square test results revealed that there was a statistically significant relationship between maize, rice and beans yields and awareness of *Neonotonia wightii* as an indicator plant for suitable land. Table 3 summarizes the finding on this comparison.

At the degree of freedom of 3, the chi square values were 86.533, 57.953 and 67.465 for maize, rice and beans respectively, and p= 0.000 for all the three crops. Whereas 46% of the farmers who mentioned *Neonotonia wightii* realized maize yields of between 5 and 6 bags per acre, only 13% of those who did not mention it managed

Table 2. Indicator plants for suitable land.

Local Acholi name	English	Botanical name	Most suitable crop
Lutoto	Day flower	*Commelina* spp	All crops
Labika	Black jack	*Bidens Pilosa*	All crops
Abi/Lum anyara	Jacaranda grass	*Hyparrhenia rufa*	Maize and rice
Alene	Garden bristle grass	*Setaria pumila*	Beans and rice
Obiya	Spear grass	*Imperata cylindrica*	Maize
Agaba	Glycine	*Neonotonia wightii*	All crops
OywecKatoli	Wild sorghum	*Sorghum Halepense*	Rice
Tilkor/Lajanawara	Itch grass	*Rottboellia cochichinnensis*	All crops
Lukoko	Couch grass	*Agropyron repens*	All crops
Otok	Guinea grass	*Panicum maximum*	Beans and rice

Source: Field survey.

Table 3. Yield comparison between farmers who mentioned *Neonotonia wightii* and those who did not.

Crop	Average yields per acre							
	1-2 bags		3-4 bags		5-6 bags		7+ bags	
	M	DM	M	DM	M	DM	M	DM
Maize	12	54	23	29	46	13	19	4
Rice	15	29	41	30	34	15	10	0.8
Beans	13	57	48	19	35	21	3	3

M = mentioned; DM = Did not mention *(*1 bag is approximately 100 kg).

to realize the same yields. Majority of the farmers (54%) who did not mention *Neonotonia wightii* as a suitability indicator plant got maize yields of between 1-2 bags, and only 4% got yields beyond 7 bags. However, the study did not investigate if *Neonotonia wightii* was present in the plots before cultivation, or if it was the basis for choice of cultivated plots. Additionally, other production parameters could have influenced the yields, like size of the garden, length of the period of cultivation of the plot (old versus new garden), and location of the field. Figure 5 shows pictures of some of the indicator plants for suitable land.

Indicator plants for unsuitable land are presented in Table 4.

All the indicator plants for unsuitable land apply to all the crops. Farmers say that places associated with these plants are barren lands. However, it was found out that farmers still grow crops in places considered barren because of limited land. Case study farmer C, a single mother of four revealed that: '*I have only about two acres of land where I grow maize, peas, ground nuts, millet and sweet potatoes. I wouldn't grow ground nuts and maize here if I had an alternative piece of land somewhere…… I borrowed a plot from my relative two kilometers away, where I grow beans and rice'*. Knowledge of suitability indicators is one thing, and applying it in practical terms of land allocation for crops is dependent their existence on a farmer's plot.

The respondents also use the abundance of meso-fauna to assess the suitability of land for agriculture. Similar to vegetation species, they distinguish between observable soil organisms that are associated with suitable soils from those associated with unsuitable soil. Table 5 presents the distinctive soil organisms.

Unlike indicator plants, there are no indicator soil organisms that are specific to particular crops. The most-referred to among the indicator organisms is earth worms.

Other suitability assessment practices that were identified by Amuru farmers in the general survey with 306 respondents (not specific to maize, rice and beans) include uprooting weeds as a proxy for determining soil structure. Farmers also look out for species diversity of weeds in a prospective agricultural plot. The more diverse the weed species, the higher the suitability of a plot for crop cultivation. Another practice is to assess soil compactness. This is assessed by stamping the ground with ones' foot or sinking a hoe in the ground. If the foot/hoe sinks in easily, the land is considered suitable for crops and vice versa.

The presence of anthills and termite mounds signifies suitability of the land for crops according to the respondents. In Amuru, the practice is that of leveling anthills and termite mounds during the preparation of the

Figure 5. Selected indicator plants.

Table 4. Indicator plants for non-suitable land.

Local Acholi name	English	Botanical name
Mwodo	Star grass	*Heteranthera zosterifolia*
Avaa	Witch weed	*Striga asiatica (*spp.*)*
Belwinyo	Tick berry	*Lantana camara*
Acakacak	Asthma plant	*Euphorbia hirta*
Obuga okutu	Pig weed	*Amaranthus spinosus*

Source: Field survey.

Table 5. Soil organism indicating suitable and non-suitable Land.

Observable soil organisms					
Indicating suitable land			**Indicating non suitable land**		
Acholi name	**English**	**Zoological name**	**Acholi name**	**English**	**Zoological name**
Lanyata	Earthworm	*Lumbricus terrestris*	Odii kot	African field cricket	*Gryllus bimaculatus*
Okok	Soldier termite	*Incisitermes minor*	Ogore	Metal work shaped field crab.	*Insulamon unicorn*
Nginingini	Stink ant	*Tapinoma sessile*	Moro	Red ant	*Solenopsis invicta.*
Kalang	Black ant	*Monomorium minimum*	Odiu	Tree cricket	*Oecanthus fultoni*
Buyu	Mole	*Heterocephalus glaber*			
Okal	Larvae of cricket	*Larvae of Gryllus bimaculatus*			
Obwolmon	Caecilians	*Uraeotyphlus spp*			
Kolok	millipede	*Eurymerodesmus*			

Source: Field survey.

garden and the soil spread out in the new garden. However, the termites and ants have to be killed. If they are not killed, they destroy seeds and plantlets by feeding on them. The most commonly used method of destroying them (ants and termites) is by removing the 'queen'. The rest of the insects scatter in disarray and starve to death. Some farmers however use chemicals purchased from agro-stores, which they pour in the anthill.

Other environmental parameters used to assess the suitability of the land for crops are, firstly, the strength of the green colour of natural vegetation. The greener the vegetation, the more suitable the land is according to the farmers. Secondly, the denser the tree cover, according to the respondents, the more fertile the land and vice versa. Thirdly, test-cropping is practiced in assessing land suitability. The seeds are broadcasted haphazardly on unprepared ground and observed as they germinate and grow. If the seeds grow into healthy crops, the land is dedicated to the crop the next planting season and vice versa. Test-cropping may not be an effective method because the seeds may be eaten/destroyed by wild life. Also, competition with naturally growing weeds may not bring out the required crop vigour even when the soils are suitable.

Presence of gravel in the top soil was considered assign of land not suitable for crops. It is believed that gravels signify shallow soil depth. Table 6 summarizes different environmental parameters and their effects on land suitability.

Generally, the farmers who said that they apply indigenous knowledge in their decision-making on the location of gardens got higher yields for all the three crops than those who said they did not use the knowledge. For example, Figure 6 shows the relationship between yields and application of indigenous knowledge in land suitability for beans.

Among the farmers who do not apply indigenous knowledge, there is no one who realized yields of seven bags or more, and the majority of the farmers who harvested between 5 and 6 bags (96%) applied indigenous knowledge. Another observation is that among the farmers who harvested lower yields of between 1 and 2 bags, majority (82%) did not apply indigenous knowledge. It is worth noting that in practice, the various methods and parameters for land evaluation may not be implemented by farmers because of various factors that are presented subsequently. The section first presents how the indigenous knowledge is acquired before explaining the factors that may not permit its application even if farmers possess it.

Table 6. Implications of selected environmental parameters on land suitability.

Parameter/ indicator	Suitability rating
High density of trees	High
Presence of gravel in top soil	Low
Presence of anthills/termite mounds	High
Soft ground	High

Source: Survey.

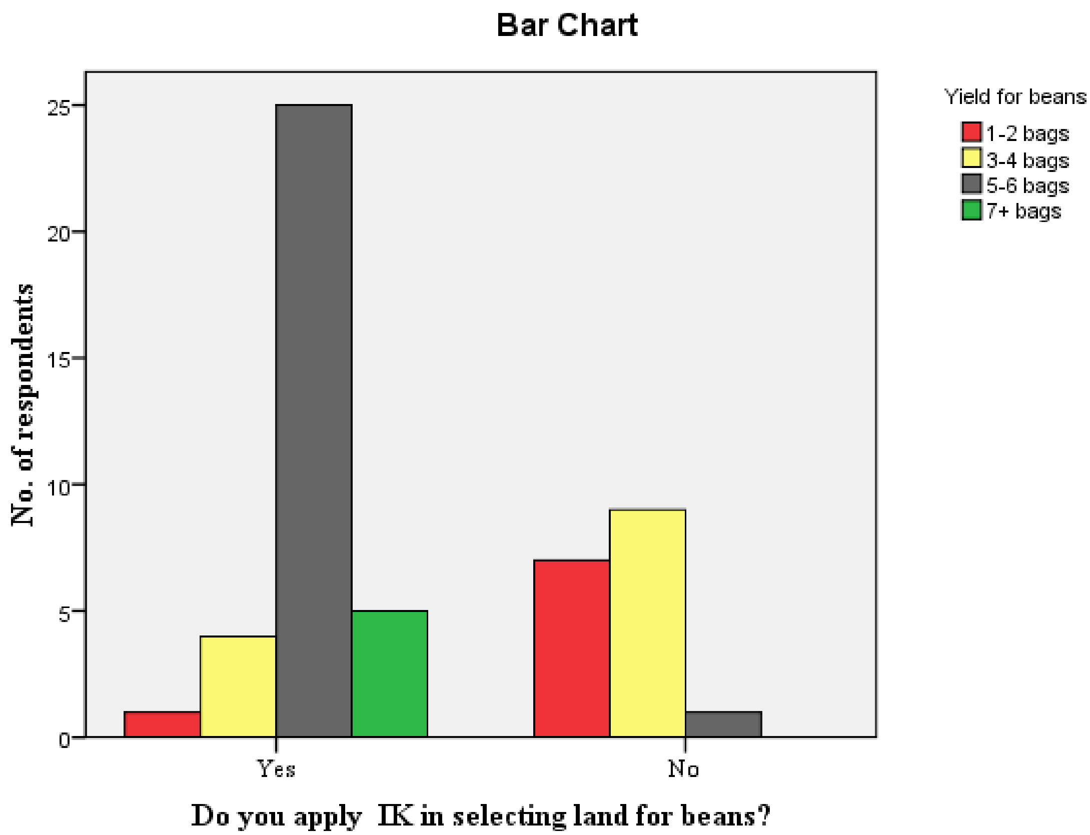

Figure 6. Application of indigenous knowledge and yields for beans.

Dynamics in the application of the indigenous knowledge on land suitability evaluation

The indigenous knowledge is acquired through oral means during digging sessions. The practice is that children of about 12 years or more start accompanying parents/any adults in the home to be taught farming. School-going children cultivate on weekends and during school holidays. During the digging, elders point out characteristics in the environment that show suitable or unsuitable land. The process of acquiring the knowledge is not endless even for adults. They keep acquiring it through informal conversations amongst themselves or older persons in the community. At the same time, modern agricultural knowledge is constantly being acquired by the farmers especially through farmers' seminars organized by the government and Non Governmental Organizations (NGOs). For example, Case study farmer B said that '*I was taught at the seminar that planting maize in lines of equal spacing makes weeding easier, and gives higher yields than the traditional way of broadcasting the seeds haphazardly. So, I have taken to planting maize in lines but I have to rely on local knowledge to determine where and when to plant the maize*'. This is an indication that indigenous knowledge is being applied side by side with best practices of modern farming.

Although 100% of the respondents possessed the

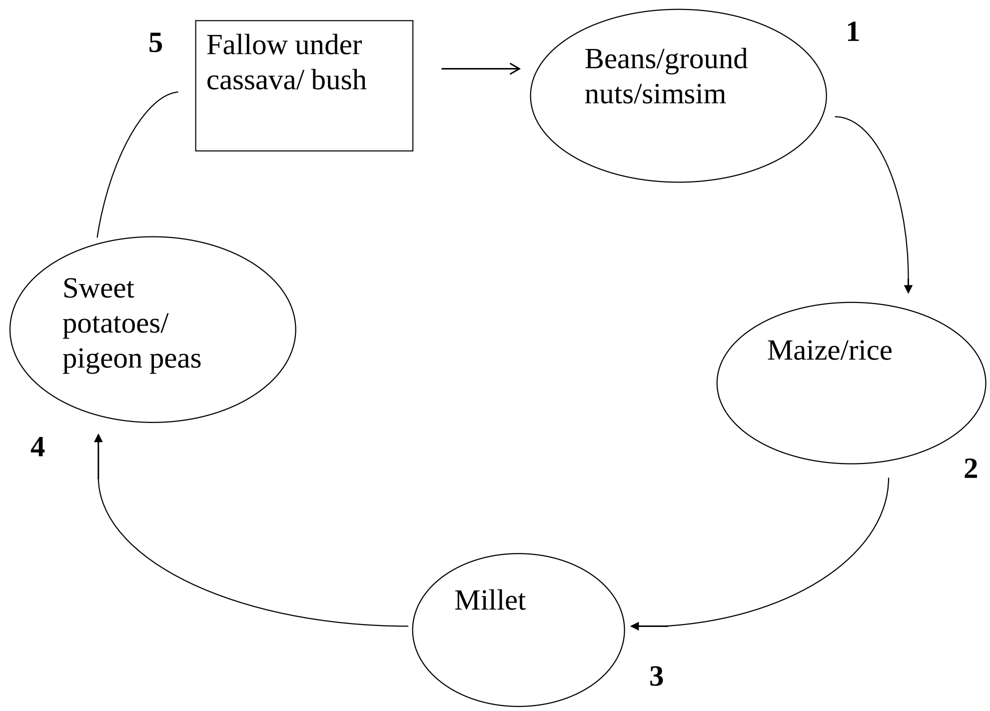

Figure 7. Crop rotation cycle.

indigenous knowledge, about 33% did not apply it because firstly; the power relations based on gender and headship of a household vis a vis the allocation of land uses on the family property. The decision process of where to open a new garden is taken by male heads of households. Traditionally, men are the owners of the land, and therefore they are vested with the power to decide on land use allocation. Even if women and children possessed more and valid knowledge on land suitability evaluation, usually, they do not decide where to allocate which land use. In situations where the household is headed by a woman (usually widowed or unmarried), still she would own the decision process, therefore eliminating other members of the household who may possess more and valid land suitability knowledge.

Secondly, land immediate to the homestead is usually reserved for grazing, especially for goats and ranging for poultry. This is majorly for security against thieves when goats are tethered far away in the bushes away from the homestead. Gardens for that matter are located relatively farther from the homestead, beyond the reach of animals and free-ranging poultry which may destroy the crops. This means even if suitable plots were located next to the homesteads, they may not be cultivated because of this factor.

Thirdly, the practice of crop rotation plays a role in land suitability assessment. In most cases, a new garden may be opened based on suitability parameters for a particular crop, but after the second harvest, new crops are introduced in a cycle that may last between 3 and 4 years before the land is fallowed (for farmers who have enough land). For example respondents said that although there are suitability parameters for maize, it is better cultivated as a second crop in the rotation cycle even if the land is not relatively more suitable for the first crop. This means, following the rotation cycle, some crops which were initially considered not suitable for the garden are introduced later as second or third crops. The crop rotation cycle commonly followed is shown in Figure 7.

Maize and rice are usually the second crops after the first crop, which may be any of beans, ground nuts or simsim. The first crop is normally repeated the next season before dedicating the garden to the second crop. The practice is usually of inter-cropping maize with rice if production is not purely for commercial purposes. No intercropping is done when maize production is solely for commercial purposes. Any crops of millet or sorghum may follow in the rotation. Sweet potatoes are usually the climax crop when yields for other crops have drastically reduced.

Not all the suitability parameters are present in any one location. Although farmers may be aware of the parameters, some may not be found on their plots, so, they only base on the available parameters to make a decision. Sometimes, indicator plants and soil organisms that indicate suitable and non-suitable land may be located in the same plot. In making a decision, the dominant indicators take a precedent if other factors are right.

It was found out that the war in the region which lasted more than twenty years and disrupted normal village life (due to encampment) did not affect indigenous agricultural knowledge. This is because some farmers who were in the vicinity of the Internally Displaced People's (IDP) camps' 4 km radius continued to farm their land during the day, and would go to spend the night in the camp. Some IDPs rented land nearby or were 'gifted' land by their friends/relatives where they would farm.

DISCUSSION

Acholi soil classification is similar to the KwaZulu-Natal system as noted by Buthelezi et.al (2013). In both cases, the physical properties of top soil majorly colour and texture are used. However, in Bellona in Solomon Islands, an indigenous classification also involves sub surface soil layers. In this region (Bellona), the sub soil is mixed with the top soil to enhance crop productivity. This practice produces a different type of soil all together, for example *Hingo hingo* is a name given to any mixed soil, the most common being a mix of *kenge* and *malanga* (Breuning-Madsen et al., 2010). Whereas modern scientific soil classifications are able to combine different textural types to describe a given soil, for example silt clayey soils or loamy silts, local Acholi classifications cannot produce such classifications.

Buthelezi et al. (2013) report that natural vegetation, especially vegetative growth and species diversity were identified as aspects used in land suitability evaluation. The Acholi classification uses the same parameters. However, unlike the KwaZulu-Natal system, the Acholi evaluation method makes a distinction between the vegetation species that indicate suitable land and those that indicate non-suitable land. Mere species diversity is not solely relied upon to make a conclusion regarding land suitability. It matters which species. Moreover Buthelezi et al. (2013) point out that the presence of weeds did not always reflect fertile soil conditions and led to errors by some farmers in their fertility assessment.

Indicator plants are a proxy for environment conditions at a point where they are located. They may reflect the soil moisture conditions, nutrient status, and chemical composition. *Commelina* spp. according to Webster et al. (2006) for example often establishes itself in moist soils with high nutrient status. Additionally, *Bidens Pilosa* grows in areas with a pH range of 4 to 9 and being a tropical weed germinates at an optimum temperature of 25/20 to 35/30°C (Reddy and Singh, 1992). These conditions mirror the requirements for most tropical cereals and legumes like maize and beans, which are widely grown in Amuru district. Some scholars have used indicator plants to map the suitability of land for cultivation.

Gulsoy and Ozkan (2013) determined suitability sites for the cultivation of Crimean juniper *(juniperus excels L* spp.*)* by studying environmental factors and indicator species. A distinction between positive and negative indicator plant species was made, where plants like *Berberiscrataegiana*, *Loniceraetrusca var. etrusca*, *Juniperusfeoettidissima* and *Phlomisarmeniaca* were found to be positively associated with suitable sites. The negative indicator plant species were also identified in the same study. They included Arbutus*andrachne*, *Cercissiliquastrum*, *Cotinuscoggyria*, *Pistaciaterebinthus* and *Styraxofficinalis*. Indicator species therefore play a role in associating given areas to crop suitability.

The diversity of weed species as an indicator of soil suitability is explained by Huston (1997), Spehn et al. (2002), and Tilman et al. *(*1996*)* cited in Dybzinski et al. (2008) that composition and diversity may affect fertility through differential species effects on nutrient inputs. Plants that form associations with N-fixing bacteria may increase soil N availability. Like every functional group, N-fixers are more likely to be present in diverse communities. Also, diverse plots may promote microbial communities that mineralize a large fraction of recalcitrant nitrogen, effectively increasing the input of this growth-limiting nutrient, or they may support or attract greater consumer biomass and thus receive higher levels of labile inputs (Scherer-Lorenzen et al., 2003). Species diversity may also enhance fertility through differential species effects on nutrient retention. The high root biomass of some grasses and the overall greater average root biomass of diverse plots may promote the retention of nitrogen by preventing leaching (Tilman et al., 1996).

Weeds diversity is interpreted by farmers as an indication of a variety of nutrients to support different crops. Most of the farmers practice mixed cropping, mainly for food security (insurance against unreliable weather). This means an agricultural plot is judged based on its capacity to host a variety of crops in the same growing season.

The roles of earthworms in soil health are explained by Elmer (2012) that earthworm castings support a diverse microbial community, including beneficial fungi and bacteria. Also, earthworm activity suppresses some soil borne diseases. This may explain why vermicompost, an end-product of the breakdown of organic matter by earthworms, is also associated with disease suppression in plants.

The practice of uprooting weeds as a form of suitability assessment equates to determination of soil structure. If a lot of soil is held within the roots of the uprooted weed, then the land is deemed suitable for crops (well developed soil structure). On the other hand, when the soil falls off immediately/the uprooted weed is without any soil on the roots, the land is considered less suitable for crops (with a poor structure). Soils with a good structure are held together because of rich humus content and have a well developed crumb structure. Soil structure is important because soil functions related to soil structure according to Brady and Weil (2002) are: Sustaining biological productivity, regulating and partitioning water and solute flow, and cycling and storing nutrients. Soil structure and macro pores are vital to each of these functions based of their influence on water and air exchange, plant root exploration and habitat for soil organisms.

Compacted soils do not support plant growth because, firstly, root penetration and root development is negatively affected. Secondly, water infiltration is not made difficult, thereby leaving the soils with moisture deficiency. This practice also determines soil depth. Available water capacity coupled with soil depth determines the volume of water usable by plants at a particular site FAO (2003). According to the respondents, softer ground is an indication of soil moisture availability. The role of soil moisture in crop growth ranges from photosynthesis to making soil nutrients soluble and therefore ready for uptake for plant nutrition.

Greener vegetation is an indicator of nitrogen availability in the soil according to Hosier and Bradley (1999). One of the symptoms of nitrogen deficiency is the yellowing of plant leaves or existence of lighter green colour of leaves. So, the farmers' practice of observing the strength of the green colour of plant leaves can be equated to nitrogen determination in a soil.

The use of anthill soils for soil fertilization has been reported by Mavedzenge et al. (1999) in Zimbabwe. Termites, in the process of building of anthills break down soil, producing fine clay, which when mixed with other soil types like silts and sand helps improve the structure of the soil. Also, Tunneling by termites improves aeration of the soil, thereby increasing biological activity of soil organisms. Among the indigenous Kayapo of Brazil, termites and ants are killed after razing the anthill, and then buried in the field being prepared for planting. This provides a good supply of organic matter (Posey, 1985).

In the crop rotation cycle, sweet potatoes were identified as the climax crop. Although the farmers did not have an explanation why sweet potatoes were the best climax crop, the interview with the NAADS coordinator for Pabbo Sub County revealed that the process of heaping soil for potato mounds helps to mix the soil, bringing nutrients from the lower soil horizons to be accessed the crop. After harvesting the sweet potatoes, land can be left to fallow, either under bush or cassava crop. The fallow period is shorter amongst farmers with relatively smaller pieces of land (usually between 1 and 2 years) compare to farmers with larger pieces of land (3 and 5 years). For farmers with enough land, a new garden is open after every 4 to 5 years. The indigenous knowledge practices discussed may not be practiced in perpetuity since various factors come into play to influence the knowledge.

According to Grenier (1998), indigenous knowledge systems are dynamic: New knowledge is continuously added. Such systems do innovate from within and also will internalize, use, and adapt external knowledge to suit the local situation. Whereas all members of a community may have traditional ecological knowledge: Elders, women, men, and children, the quantity and quality of the IK that individuals possess vary. Age, education, gender, social and economic status, daily experiences, outside influences, roles and responsibilities in the home and community, profession, available time, aptitude and intellectual capability, level of curiosity and observation skills, ability to travel and degree of autonomy, and control over natural resources are some of the influencing factors.

Conclusion

Farmers use a variety of methods to assess the suitability of land for crops. Notable however is soil colour and texture, which are the main parameters considered. Although indigenous knowledge is not able to answer the 'why' question to explain different suitability assessment parameters, there is a strong connection to modern scientific explanations. Even if indigenous knowledge is widely known by farmers, its application in land suitability assessment is dependent on factors like availability of adequate land on which to survey the required parameters and the power balance among the members of a household on decision pertaining to allocation of land uses on the available family land. The rapid rate of exposure of farmers to modern husbandry practices, coupled with a growing young population is likely to make indigenous knowledge irrelevant in future.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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REFERENCES

Akullo D, Kanzikwera R, Birungi P, Alum W, Aliguma L, Barwogeza M (2007). Indigenous Knowledge in Agriculture: a case study of the challenges in sharing knowledge of past generations in a globalized context in Uganda. Durban, South Africa.

Berkes F, Colding J, Folke C (2000). Rediscovering of Traditional Ecological Knowledge as Adaptive Management. Ecol. Applications 10:1251-1265.

Brady NC, Weil RR (2002). The Nature and Properties of Soils, 13thEdition. Prentice Hall, New Jersey.

Breuning-Madsen H, Bruun TB, Elberling B (2010). An Indigenous Soil Classification System for Bellona Island – A Raised Atoll in Solomon Islands. Sing. J. Trop. Geogr. 31:85-99.

Buthelezi N, Hughes J, Modi A (2013). The Use of Scientific and Indigenous Knowledge in Land Evaluation and Soil Fertility Studies of Two villages in Kwazulu-Natal, South Africa. Afr. J. Agric. Res. 8(6):507-518.

Dybzinski R, Fargione JE, Zak DR, Fornara D, Tilman D (2008). Soil Fertility Increase with Plant Species Diversity in A Long-term Biodiversity Experiment. Oecologia 158(1):85-93.

Elmer WH (2012). Using Earthworms to Improve Soil Health and Suppress Diseases. Connecticut Agricultural Experimental Station. Available at: http://www.ct.gov/caes/lib/caes/documents/publications/fact_sheets/plant_pathology_and_ecology/using_earthworms_to_improve_soil_health_and_suppress_diseases_01-27-12.pdf

FAO (1976). A Framework for Land Evaluation. Food and Agricultural Organization of the United Nations. Rome.

FitzSimons J, Abdel-Kader FH, Mustafa A, Bahnassy M (2013). Integrating Indigenous Knowledge and Modeling to Evaluate Options for Agropastoral Systems Development.

FOA (2003). Food and Agricultural Organization of the United Nations. Optimizing Soil Moisture for Plant Production: The significance of Soil Porosity. FAO Soils Bulletin 79, Rome.

FOA (2007). Food and Agricultural Organization of the United Nations. Land Evaluation: Towards A Revised Framework. Land and Water Discussion Paper 6, Rome.

Gong J, Liu Y, Chen W (2012). Land Suitability Evaluation for Development Using A Matter Element Model: A Case Study in Zengcheng, Guangzhou, China. Land Use Policy 29(2):464-472.

Grenier L (1998). Working with Indigenous Knowledge: A Guide for Researchers. International Development Research Centre, Ottawa.

Gulsoy S, Ozkan K (2013). Determination of environmental factors and indicator plant species for site suitability assessment of Crimean Juniper in the Acipayam District, Turkey. Sains Malays. 42(10):1439-1447.

Haugerud A, Collinson MP (1991). Plants, Genes and People: Improving the Relevance of Plant Breeding. Gatekeeper Series No. 30, London: International Institute for Environment and Development.

Hosier S, Bradley L (1999). Guide to Symptoms of Plant Nutrient Deficiencies. University of Arisona, Phoenix.

Huston MA (1997). Hidden Treatments in Ecological Experiments: Re-evaluating the Ecosystem Function of Biodiversity. Oecologia 110:449-460.

Israel DG (2012). Determining Sample Size.University of Florida, Gainesville.

IUCN (1980). International Union for the Conservation of Nature and Natural Resources . World Conservation Strategy: Living Resource Conservation for Sustainable Development. IUCN, Gland, Switzerland.

Kaniki AM, Mphahlele MEK (2002). Indigenous Knowledge for the Benefit of All: Can Knowledge Management Principles be Used Effectively? SCESAL Conference, Carnival City, Kempton Park 20-21 April.

Krejcie RV, Morgan DW (1970). Determining Sample Size for Research Activities. Educ. Psychol. Meas. 30:607-610.

Kuldip G, Arunachalam A, Dutta BK, Kumar PGV (2011). Indigenous Knowledge of Soil Fertility Management in the Humid Tropics of Arunachal Pradesh, India. J. Trad. Knowl. 10(3):508-511.

Kumar KA (2010). Local Knowledge and Agricultural Sustainability: A Case Study of Pradhan Tribe in Adilabad District. Centre for Economic and Social Studies, Working Paper No. 18.

Liu YS, Wang JY, Guo LY (2006). GIS-based Assessment of Land Suitability for Optimal Allocation in the Qinling Mountains, China. Pedosphere 16(5):579-586.

Mavedzenge BZ, Murimbarimba F, Mudzivo C (1999). Experiences of Farmer Participation in Soil Research in Southern Zimbabwe. Manage. Afr. Soils 5:1-20.

MOST (2003). Management of Social Transformation Programme. Best Practices on Indigenous Knowledge, UNESCO, Berlin.

NEMA (2010). State of the Environment Report for Uganda.Ministry of Water and Environment, Kampala.

Posey DA (1985). Indigenous management of tropical forest ecosystems: the case of the Kayapo Indians of the Brazilian Amazon. Agroforestry Syst. 3(2):139-158.

Reddy KN, Singh M (1992). Germination and Emergence of Hairy Beggarticks. Weed Sci. 40:195-199.

Rossiter DG (1994). Lecture Notes:Land Evaluation. Cornell University, College of Agriculture and Life Sciences, Department of Soil, Crop and Atmospheric Sciences. P 29.

Scherer-Lorenzen M, Palmborg C, Prinz A, Schulze ED (2003). The role of plant diversity and composition for nitrate leaching in grasslands. Ecology 84:1539-1552.

Scherr SJ, Yadav S (1996). Land Degradation in the Developing World: Implications for Food, Agriculture and the Environment to 2020. International Food Policy Research Institute, Washington.

Seebauer M (2011). Uganda Research Trial Study: Analysis of the Eucalyptus Trials in Amuru District, Northern Uganda. Unique Forestry Consultants, Freiburg.

Sicat RS, Carranza EJM, Nidomolu UB (2004). Fuzzy Modeling of Farmers' Knowledge for Land Suitability Classification. Agric. Syst. 83:49-75.

Sojayya P (2005). Comparison between Conventional Land Evaluation and A Method Based on Farmers' Indigenous Knowledge. (Unpublished Master of Science Thesis), International Institute of Geo-information Science and Earth Observation, Enschede, The Netherlands.

Spehn EM, Scherer-Lorenz M, Schmid B, Hector A, Caldeira MC, Dimitrakopoulos PG, Finn JA, O'donnovan G, Pereira JS, Schulze ED, Troumbis AY, Korner C (2002). The Role of Legumes as a Component of Biodiversity in A Cross-European Study of Grassland Biomass Nitrogen. Oikos 98(2):205-218.

Tilman D, Wedin D, Knops J (1996). Productivity and Sustainability Influenced by Biodiversity in Grassland Ecosystems. Nature 379:718-720.

WCED (1987). World Commission on Environment and Development. Our Common Future, United Nations Organization, New York.

Webster TM, Burton GM, Culpepper AS, Flanders JT, Grey TL, York AC (2006). Tropical Spiderwort (*Commelinabenghalensis* L.)Control and Emergence Patterns in Pre-emergence Herbicide Systems. J. Cotton Sci. 10:68-75.

Williams DL, Muchena ON (1991). Utilizing Indigenous Knowledge Systems in Agricultural Education to Promote Sustainable Agriculture. J. Agric. Educ. 11:52-58.