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Full Length Research Paper

Assessing the farmer field school's diffusion of knowledge and adaptation to climate change by smallholder farmers in Kiboga District, Uganda

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Farmer Field Schools (FFS) can empower farmers through meetings at demonstration sites to promote agricultural production because of discovery learning. This study empirically investigated the FFS's diffusion of knowledge and its impact on the smallholder farmer's adaptation to climate change in Kiboga district characterised by low rainfall pattern. A cross-sectional research design was adopted where a total of 120 FFS-members and 60 non-FFS-members were randomly selected and interview using a validated household survey questionnaire. Data was analysed through descriptive statistics and Chi-test (χ^2) to the relationship between the FFS and the member's adaptation to climate change. The findings revealed that drought, hailstorms, changes in onset and cessation of seasons were the main seasonal manifestations of climate change experienced in the district. The FFS majorly diffused adaptation knowledge and skills through establishment of comparative studies (28%); establishment of commercial enterprises (21%) and training of the members (18%); distribution of inputs to the FFS (10), examination of performances of distributed inputs (8%), FFS exchange-visits (6%), graduation of FFS members (4%), field days (3%) and integration of village savings into FFS (2%) throughout the seasonal calendar.The FFS-members aggressively adapted to the manifestations of climate change through the application of micro-irrigation, early planting, mulching, seed multiplication, the sale of livestock, construction of barns and planting of drought-tolerant crop and pasture varieties during the eventualities on their farmlands. The FFS significantly contributed to the adaptation to climate change (drought and shifts in seasons) by the smallholder farmers ($p<0.05$) throughout the season in the study area.The FFS enabled the farmers to validate and adopt new technologies in their fields that were a success. The FFS-members increased their innovations and use of local resources in adaptation to climate change. The FFS's promotion of adaptation options to climate change improves the farmer's seasonal food security status.

Key words: Climate change, farmer field schools, smallholder farmers, diffusion.

INTRODUCTION

Climate change is a major issue in agricultural production that has destabilised rural smallholder farmers because of their dependence on nature for survival (Reidsma et al., 2010; Mubaya et al., 2012). Climate is here referred to as the average of the weather over a 30-year period (Beswick, 2007). Worldwide, among the climate change hotspots, is the Eastern North America on the continent of US, while the Southern Equatorial Africa and the Sahara are the most protruding hotspots in Africa (Giorgi, 2006; Hepworth et al., 2008; Šmilauer et al., 2015). In East Africa, the drylands are the most impacted areas with severe manifestations of climate change from season to season (Egeru et al., 2014). In Uganda, the drylands cover 44% and support up to 90% of the country's livestock herd because of available patches of grasslands and scattered bushes (Kugonza et al., 2012; Mugerwa et al., 2014; Nimusiima et al., 2014).

Recently, the Farmer Field Schools (FFS) have been promoted by development agencies such as the World Bank, Food and Agriculture Organization and Non-governmental Organisations as a more effective approach to extend agricultural knowledge and practices to the farmers more impacted with numerous farm and off-farm challenges (Garreaud et al., 2003; Godtland et al., 2004; Barr et al., 2005). FFS are participatory initiatives where farmers gather together for instance on a weekly basis to learn more about agricultural production and related activities at any selected site of their choice (Feder et al., 2004; Godtland et al., 2004; Anandajayasekeram et al., 2007). This study also recognised FFS as a cost effective approach that improved the smallholder farmer's adaptation responses to the seasonal manifestations of climate change under crop and livestock production. This is because the approach emphasises learning by practice and sharing of farm experiences. In addition, the FFS use discovery-based learning methods to improve the farmer's agricultural knowledge and their capacity to make on-farm and off-farm decisions (Thiele et al., 2001; Quizon et al., 2001) believed to improve productivity (Palis, 2006; Mancini and Jiggins, 2008).

Africa is thought to be the most vulnerable continent to the seasonal impacts of climate change and more especially the dryland areas (O'Reilly et al., 2003; Patz et al., 2005; Challinor et al., 2007; Thornton et al., 2009; Patricola and Cook, 2010). The seasonal occurrences of extreme climatic events such as drought, floods, hailstorms and bushfires among others have jeopardised agricultural production of smallholder farmer (Rahmstorf and Coumou, 2011). The unpredictable conditions have caused massive shortages in water and pasture availability reduced crop and milk yields, loss of animals, famine and loss of income (Apuuli et al., 2000; Christiaensen et al., 2003; Sivakumar, 2005). This is because the rural smallholder farmers are largely poverty stricken and characterized with low education levels (Ebwongu et al., 2001; Burton et al., 2002; Hisali et al., 2011), low investment capital, unreliable weather forecasts, limited knowledge on cost-effective adaptation responses and inadequate extension programmes which have thus affected their production potential resulting into food insecurity (Abele and Pillay, 2007; Hepworth et al., 2008; Thornton et al., 2010).

The smallholder farmers have tried to adapt to the seasonal manifestations of climate change by using a cocktail of responses such as storing food, digging drainage channels, planting trees, early maturing and high yielding varieties, planting drought-tolerant and disease and/or pest-resistant varieties; planting at onset of rains; increased pesticide/fungicide application among others to enhance agricultural production (Simpson and Owens, 2002; Okonya et al., 2013; Antwi-Agyei et al., 2014). With these applications, however, climate change continues to ravage the smallholder farmer's agricultural efforts to adapt because of limited awareness on a number of cost effective applicable measures (Van Asten et al., 2011). This study shows how the FFS can facilitate smallholder farmers to validate and adopt new adaptation technologies in their farm fields that are a success to enhance both crop and livestock production. It also adds to an understanding of FFS's methodologies of empowering farmers and their successes which are important if these are to be replicated in other regions with similar climatic conditions.

This study differs from other studies that have aimed at examining FFS in helping smallholder farmers to improve crop agronomic practices (Guo et al., 2015), poverty eradication (Davis et al., 2012), integrated pest management (Erbaugh et al., 2010), animal husbandry and social wellbeing (Vaarst et al., 2007), impacts of FFS on gender (Friis-Hansen et al., 2012) among others. In addition, there is limited literature available that shows comparisons between FFS members and non-FFS-members adaptation options and constraints faced by both groups in the adaptation to climate change by the smallholder farmers in East Africa's drylands. The study also contributes to the debate of understanding the FFS's diffusion of knowledge and skills in facilitating farmers adapt to climate change in areas characterised by low rainfall distribution. Therefore, this study bridges this information gap by examining the FFS's diffusion of knowledge and their impacts on the adaptation to climate change by the smallholder farmers. This importance of this study is to contribute to the debate that FFS can be used to capitalise new technologies geared towards the adaptation to climate change by the smallholder farmers in both crop and livestock production.

This study investigated the FFS's diffusion of

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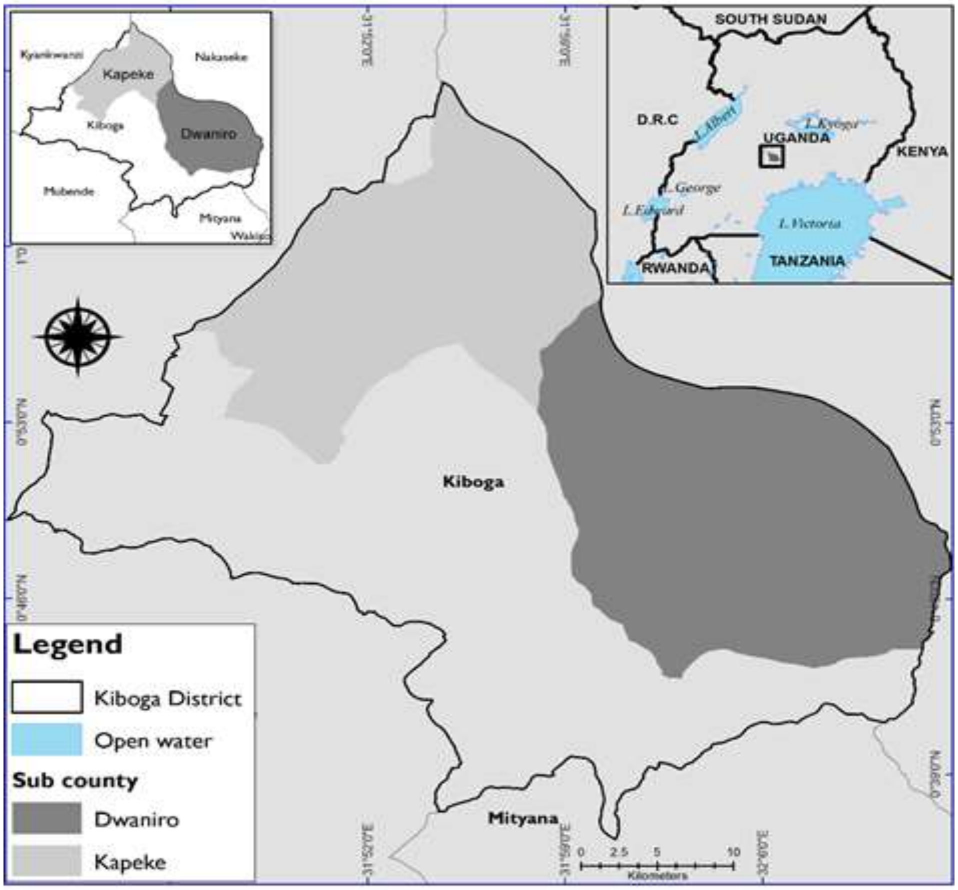

Figure 1. Location of study area.

knowledge and their impacts on the adaptation to climate change by the smallholder farmers in Kiboga district, Uganda. The specific objectives were to examine the smallholder farmer's perceptions of seasonal manifestations of climate change and ascertain the FFS's diffusion of knowledge and their impacts on the member's adaptation to climate change in Kiboga district located in Central Uganda.

MATERIALS AND METHODS

Study area

This study was conducted during the first rainy season of 2016 in Dwaniro and Kapeeke sub counties located in Kiboga district. The sub-counties are located between coordinates 385242.8 (Longitude) and 294728.3 (Latitude) found in the northern part of Kiboga district (Figure 1). Kiboga is among the districts that are severely affected by the seasonal manifestation of climate change. Dwaniro and Kapeeke sub-counties are the most affected with the manifestations that undermined crop and livestock production. The district lies in Uganda's dry land corridor, characterised by unreliable rainfall patterns and drought. In terms of climate, the dry season is usually experienced in the months of June to July and December to February of each year, though the patterns of occurrence have changed over time. Despite, the variability in climate, 65% of the households depend on subsistence agriculture as the main source of income which involves both the growing of crops and rearing of livestock. The major types of crops grown include beans, cassava, sweet potatoes, maize, bananas, vegetation, citrus and coffee. Whilst, cows, goats, sheep, pigs and poultry are the main livestock types reared.

A total of 52 farmer field schools were established and had a membership of 1196 (676 female and 520 male) farmer. The farmer field schools were implemented by the Hunger Project, Uganda under the global climate change alliance project. The duration of the project was 18 months in the district. During this period, a lot of learning activities were employed during the rainy seasons. The rainy periods were the busiest time in farmer field schools learning calendar where validations, multiplications and commercial enterprises were grown at study sites and individual farms.

Socio-economic data collection

A cross-sectional design was used by the study. The design involved collecting data at the same time from groups of individuals at different stages of development (Lindell and Whitney, 2001). The design was also the only practicable method of studying various problems (Mann, 2003). In this case, the studied groups were the farmer field school members and non-members situated in the selected sub-counties. In addition, the farmer field schools were also investigated to understand their approaches to fostering

Table 1. Perceived seasonal manifestations of climate change.

Seasonal manifestations of climate change	Percentage
Hailstorms	14
Flash floods	10
Bushfires	11
Drought	39
Changes in onset and cessation of seasons	26

learning activities. Out of 52 schools, 30 FFS were purposively selected and studied to understand the FFS diffusion of knowledge and their impacts in facilitating farmers adapt to climate change. In each sub-county, two parishes were selected in the sampling of both FFS farmers, non-FFS-members. A total of 120 FFS-members were randomly selected and studied with the guidance of FFS group leaders. From each FFS, four members were randomly selected using the membership list. While sixty non-FFS members were also randomly selected in the studied sub-counties (30 from each sub-county).

A household questionnaire was designed and pretested on 20 farmers and later modified to ensure appropriateness prior to field work. The selected respondents were subjected to household questionnaires through interviews. The respondents were interviewed from their respective homesteads minimise loss of production time. In addition, the study also carried out key informant interviews among the FFS leaders, district agricultural, environmental, production, planning and educational officers for expert opinions on the impacts of climate change and FFS. Furthermore, one focus group discussion was conducted in each sub-county comprising 10 to 12 members as selected by the FFS leaders to confirm some of the responses recorded during the administration of questionnaires. The composition of respondents included both women and men (young and old).

The smallholder farmer's perceptions on the seasonal manifestations of climate changes were captured using the questionnaire through what the farmers experienced in both crop and livestock production. Data on the FFS's diffusion of knowledge was captured through interviewing farmers, FFS leaders and the Hunger Project, Uganda staff on the learning activities employed to disseminate knowledge and skills on climate change adaptation. Information on the adaptation to climate change and constraints faced by the smallholder farmers was also collected to understand how the FFS helped their members to adapt to climate change. The collected socio-economic responses were captured and analysed using SPSS (version 16) statistical software for descriptive and quantitative analysis. The Chi-square test was performed to examine if the FFS significantly contributed to the adaptation to climate change (drought and shifts in seasons) by the smallholder farmers.

RESULTS

Farmer's perceptions on the seasonal manifestations of climate change

Table 1 show that the majority of the interviewed farmers (FFS members and non-members) perceived drought to be the main seasonal manifestation climate change given their experiences in crop and livestock production from season to season. This was followed by changes in the onset and cessation of seasons, hailstorms, bushfire and flash floods. The catastrophic manifestations of climate change underhanded the production potential of farmers resulting into household food insecurity.

The Chi-square test results showed that the FFS significantly contributed to the adaptation to climate change (drought and shifts in seasons) by the smallholder farmers ($p<0.05$) in crop production. In livestock production, the FFS only significantly contributed to the farmer's adaptation to drought. However, the FFS did not significantly influence the adaptation responses towards coping with bush fires, floods and hailstorms from the interviewed farmers. Thus, the crop production related adaptation responses were given the highest priority than those under livestock production (Table 2).

FFS diffusion of knowledge on the adaptation to climate change

Figure 2 indicates that the establishment of comparative studies (28%,; commercial enterprises (21%) and training of the members (18%) were the major means of information delivery undertaken to train the FFS-members on the adaptation to climate change by the FFS. The dissemination was also carried out during the distribution of inputs to the FFS (10), performances of inputs distributed (8%), FFS exchange visits (6%), graduation of FFS members (4%), field days (3%) and integration of village savings into FFS (2%).

Impacts of FFS on the member's adaptation to climate change

FFS strongly contributed to the adaptation to climate change by the smallholder farmers unlike the non-members in both crop and livestock production. Table 3 shows that seed multiplication (74%) and the establishment of kitchen gardens (70%) were the most adapted responses to climate change by the farmers in crop production. Secondly, the farmer field schools helped their members to adapt through undertaking sustainable agricultural practices such as mulching, planting of drought tolerant crop varieties, application of

Table 2. Comparison of FFS members with the adaptation to climate change (drought, bushfires, hailstorms, floods, and shifts in seasons) in crop and livestock production.

Crop adaptation responses	P-value (Pearson chi-square)
Drought	0.001**
Bushfires	0.281*
Hailstorms	0.507*
Floods	0.505*
Shifts in seasons	0.019**
Livestock adaptation responses	
Drought	0.029**
Bushfires	0.361*
Hailstorms	0.172*
Floods	0.157*
Shifts in seasons	0.287*

**Significant at 5% level of significance. *Not significant at 5% level of significance.

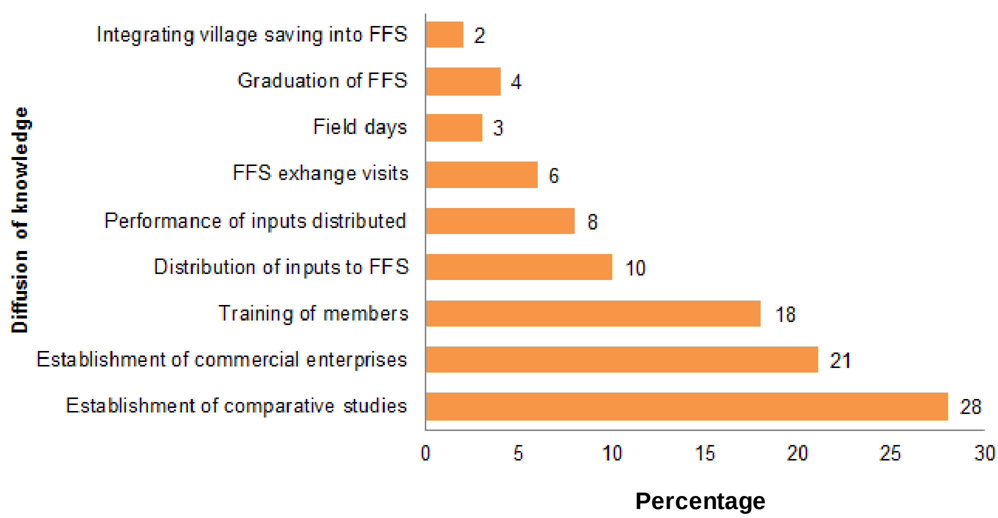

Figure 2. FFS's diffusion knowledge and skills.

organic manure and agroforestry (Figure 3). The impacts of climate change were also anonymously minimised by carrying out micro-irrigation (41%) to support the growth of cultivated crops. Still, under crop production, the non-FFS-members acquired most of their adaptation knowledge and skills from the elders (traditional knowledge), Non-governmental Organisations (NGOs), National Agricultural Advisory Services (NAADS), fellow farmers and radio stations to cope with the impacts of climate change. The Non-FFS-members secured their agricultural production potential mainly through applying organic manures, planting trees in farmlands, early planting and irrigating the crops.

Planting drought tolerant crop varieties (35%) and seed multiplication (26%) were the least adopted adaptation options to climate change by the non-FFS-members. While under livestock production, a vast number (100%) of the FFS-members adapted to climate change by making silage and growing of hay (84%). The ruthless impacts of climate change were also adapted to through sale of livestock, multiplication of improved pasture varieties, construction of barns to store hay and collection of pasture feeds for the animals. Because of limited knowledge on adaptation by the non-FFS-members, the collection of pasture feeds, construction of barns to store hay, growing drought tolerant pastures and sale of livestock were the most adaptation responses undertaken in livestock production.

Table 3. Farmer's adaptation to climate change in crop and livestock production.

Climate change adaptation responses	FFS members (%)	Non-FFS members (%)				
Crop production	**FFS**	**NGOs**	**Farmer to farmer**	**Traditional knowledge**	**NAADS**	**Radios**
Early planting	58	0	0	42	0	0
Irrigation	41	8	17	34	0	0
Mulching	69	0	6	21	2	2
Agroforestry	56	0	0	44	0	0
Application of organic manure	56	0	0	44	0	0
Planting drought tolerant crop varieties	65	0	0	35	0	0
Establish kitchen gardens	70	26	4	0	0	0
Seed multiplication	74	0	0	0	26	0
Livestock production						
Sale of livestock	68	3	13	3	2	11
Growing drought tolerant pastures	58	0	42	0	0	0
Construction of barns to store hay	32	0	56	12	0	0
Collection of pasture/feeds	24	0	63	0	4	9
Making of silage	100	0	0	0	0	0
Growing of hay	83	9	0	8	0	0
Multiplication of improved pasture varieties	64	36	0	0	0	0

Figure 3. Kitchen garden (a), silage making (b), and mulching (c).

Constraints faced by FFS, FFS-members and non-members in adaptation to climate change

The FFS-members faced more adaptation constraints than the non-FFS-members towards crop and livestock production (Table 4). The FFS-members were majorly constrained by inadequate funding (20%), longer distances to water sources (14%), and limited time to make field preparations (13%) in their adaptation to climate change. The FFS-members were also constrained by the inadequate shelter for animals, scarce poles for staking bananas, differences in farmer interests, in-adequate land to grow hay among others. The FFS were mainly constrained by inadequate funding (43%), unreliable weather information (15%), a limited number of facilitators (13%) and inaccessibility (9%) in disseminating adaptation knowledge and skills to the FFS-members. These schools were also challenged with resource use conflicts, differences in farmer interests, political interference, the introduction of new diseases and invasive species and conflict over sharing benefits. The non-FFS-members were primarily constrained by inadequate funding (23%), shortage of building materials (22%) and distant water sources (20%) in their means to adapt to the impacts of climate change in the studied area. The non-FFS-members were also faced with inadequate shelter for animals, congestion at water points and limited and expensive labour.

Table 4. Constraints faced by the FFS, FFS members and Non-FFS members in adaptation to climate change.

Constraints	FFS-members (%)	Non-FFS members (%)
Distant water sources	14	20
Inadequate watering equipment	4	-
Substandard pesticides	9	-
Limited and expensive labour	4	9
Water resource conflicts	3	-
Paying fees to access water from dams	1	-
Inadequate land to grow hay	4	-
Inadequate water for irrigation	6	-
Congestion at water points	3	11
Limited time to make field preparations	13	-
Inadequate shelter for animals	8	15
Inadequate funding	20	23
Shortage of building materials	6	22
Scarce poles for staking bananas	5	-
FFS		
Inadequate funding	43	-
Unreliable weather information	15	-
Limited number of facilitators	13	-
Inaccessibility	9	-
Conflict over sharing benefits	2	-
Differences in farmer interests	5	-
Political interference	4	-
Introduction of new diseases and invasive species	3	-
Resource use conflicts	6	-

DISCUSSION

The majority of FFS-members and non-members revealed that drought was the main seasonal manifestation of climate change that hampered their crop and livestock productivity through reduced yields and water quality/quantity resulting into food insecurity. Drought as a paradigm is triggered by the changes in the global weather patterns attributed to the movement of warm dry air masses in the Atlantic and Indian water bodies towards the drylands causing disastrous events especially those that occur in the months of December to February. The catastrophic drought episodes are also as a result of rampant defiant local deforestation activities that have made the region arid because of the search for cultivatable land, indiscriminate cutting of trees for charcoal production and bush burning. This observation also relates to studies conducted in Uganda’s dry lands (Vermeulen et al., 2012; Šmilauer et al., 2015) that recognised that anthropogenic factors were significant inducers of climate change. Despite the fact that the study area is characterised by low rainfall, it experiences erratic amounts of rainfall that has devastated infrastructure and settlements, hence, cutting off food supplies and destruction of crops in the farmlands.

In response to the widespread seasonal manifestation of climate change in the study area, the FFS were introduced to facilitate the smallholder farmers adapt to the delimiting conditions. After their formation, the FFS used a variety of mechanisms to diffuse knowledge and skills to the farmers such as the establishment of comparative studies, establishment of commercial enterprises, training of the members, distribution of inputs to the FFS, assessing the performances of inputs distributed, FFS exchange visits, graduation of FFS members, field days and integration of village savings into FFS. Using these communication tools was welcome because of relatively low educational levels of the farmers and the member’s willingness to share their knowledge and farming experiences. This finding was not expected because of the low education levels of the farmers; we thought they could not compare the performances of inputs, plants and run the cost-benefit analysis for the proposed ventures. This finding also relates to Godtland et al. (2004) who also observed that farmers learn better when the learning strategy is based on the principle of learning by discovery.

In particular, the comparative studies were a collective and investigative process carried out the farmers to solve prioritised local problems by designing simple and practical experiments to test and selected the best solution to their problem. These were conducted with the aim of enhancing farmer's observational and analytical skills to investigate the cause and effect of major production problems identified in the problem identification phase. During the studies, the farmers were guided to set up field study plots with the aim to facilitate hands-on learning studies and skills such as in the planning, implementation, and monitoring the implemented adaptation options. The studies enabled the farmers to validate and adopt new technologies that were a success. One of the key findings from the validation plots was that groundnuts planted using the recommended spacing were not affected by rosette and had an average yield that was 50% higher than for the plots that were broadcasted.

The FFS established enterprises mainly for commercial purposes to improve on their household levels of income. The FFS members were aided in the cost-benefit computation of their intended enterprises and thus invested in the best choices among land, seeds, crops and market accessibility. The beneficiaries were trained and equipped with skills and knowledge on climate change adaptation for improved agricultural production. These were delivered to the farmers through hands-on and field practical sessions where all the farmers participated. The covered subjects included improved crop and livestock production, soil and water conservation, dry season farming, seed selection and setting up of bio-intensive gardens. However, the FFS members preferred to be trained on adaptations aimed at improving both crop and livestock production because of immediate benefits that accrued from these systems. The outcomes of the training were the widespread replication of the taught practices/technologies by the FFS members in their own fields such as the adoption of intensive gardens, energy saving stoves and soil and water conservation techniques.

The FFS members also received inputs such as planting materials from the Food and Agriculture Organization, The Hunger Project Uganda and government for commercial/ multiplication purposes. Among the reported inputs included fungicides, maize, beans, groundnuts, carrots, onions, bananas, cassava and tomatoes among others. With the comparisons made by the FFS farmers with the distributed farm inputs, these yield better than the tradition seedlings when the best agronomic practices were implemented such as agroforestry, bio-intensive gardening and water harvesting. Learning of adaptation options to climate change were also conducted during field farmer exchange visits with the successful farmers from the neighbouring districts such as Mubende. The FFS groups also visited each other to learn more about technologies and also be able to strengthen with farming next works. The farmer studied improved commercial kitchen gardens, water harvesting techniques, mushroom growing, compost making, dry season farming, sac mounds, formulation of organic pesticides, agroforestry practices, biogas among others. Field days were also organised with the aim of attracting non-FFS members and development partners from the neighbouring districts to display their produce, political populism and also be advised on the prevalent markets. Some of the showcased technologies included bio-intensive gardening, compost making, mulching, fodder multiplication, water harvesting techniques among others

The recognition of the best performing farmer field schools with certificates and gifts such as wheelbarrows, spray pumps among others on the organised graduation days increased the adoption and learning to the other FFS members. The best performing FFS had farmer's adoption level of 90% of the taught adaptation options to climate change. The most adopted techniques included establishment of commercial kitchen garden, dry season farming, digging contour trenches, mulching, bottle irrigation, agroforestry and construction of energy-saving stoves. The farmers also learnt about better-improved practices during village saving meetings where those who had higher savings/deposits confessed to having adopted a variety of taught practices and harvested good yields that earned them income

After the learning activities, the FFS members adapted to climate change by undertaking micro-irrigation on their farmlands especially during drought and changes in the onset and cessation of planting seasons to help the planted crops mature/yield. The members also adapted by employing a number of responses that included early planting, and mulching of gardens using local materials with the aim to increase water infiltration rates important in the germination of crops, growing of *Lablab legume* which adds nitrogen to the soil and it's also used to feed livestock, application of compost and backyard manures, growing of droughts tolerant crop varieties such as cassava and mushrooms, establishment of bio-intensive gardens like kitchen, sac mounds and backyard gardens to grow vegetables, multiplication of clean seeds and planting of shade trees. The adoption rate of crop-based adaptation responses was 90% out of the sampled FFS members.

In livestock production, a large number of FFS members adapted to the impacts of climate change by growing of drought tolerant pastures and fodder varieties such as *Lablab purpureus, Bracharia, Calliandra Calothyrsus* and *Chloris Gayana,* the sale of livestock to meet home necessities and construction of barns to store hay. Notably, the study results showed that the adapted responses by the FFS members in this sub-sector generally did not vary much in disparity because of the limited resource envelope to widen the implementation of diverse responses. This also explained why the adoption rate of the adaptation responses to climate change was

60% in livestock production. Elsewhere, Feder et al. (2004) also observed that the FFS program in Indonesia contributed significant impacts on the performance of fellow farmers in the promotion of livestock productivity.

The FFS members were more knowledgeable on a variety of adaptation options which they transferred onto their farmlands, thus, explains why they faced a number of constraints, unlike the non-members who applied fewer options. The FFS members were largely constrained by the distant water sources which reduced their production time, inadequate shelter facilities for animals, limited funding, shortage of building materials, a limited number of training facilitators, unreliable weather information, inaccessibility and limited and expensive labour among others. By the same token, the non-FFS members experienced lesser adaptation constraints because of the limited responses implemented to minimise the impacts of climate changes in both crop and livestock production. The major constraints also faced by the non-FFS members included distant water sources, shortage of building materials and inadequate shelter for animals which hampered the survival of both crops and livestock. Most of the reported constraints by the non-FFS members accrued from livestock production than crop growing. This was because of a sizeable high number of respondents engaged in livestock production because of their higher resistance to the impacts of climate change than the planted crops as was also observed by Hakiza et al. (2004).

Conclusion

FFS can contribute to the adaptation responses to climate change by the smallholder farmers in both crop and livestock production. Both the FFS members and non-members perceived drought to be the main seasonal manifestation climate change that hampered their crop and livestock production resulting into food insecurity. In helping the FFS-members adapt to drought, the FFS used a variety of mechanisms to diffuse knowledge and skills to the farmers such as the establishment of comparative studies, establishment of commercial enterprises, training of the members, distribution of inputs to the FFS, assessing the performances of inputs distributed, FFS exchange visits, graduation of FFS members, field days and integration of village savings into FFS were fruitful. The FFS members adapted to seasonal climate change manifestations through seed multiplication, the establishment of kitchen gardens, mulching, planting of drought tolerant crop varieties, application of organic manure and agroforestry because of their higher cost effectiveness and improved productivity. Thus, the FFS can significantly contribute to the adaptation to climate change by the smallholder farmers. The constraints that hindered FFS, members and non-members included inadequate funding, longer distances to water sources, unreliable weather information, inaccessibility by facilitators, political interference, differences in farmers interests, limited time to make field preparations in their adaptation to climate change in both crop and livestock production. Thus, the FFS studies enabled the farmers to validate and adopt new technologies that were a success.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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Factors influencing agritourism adoption by small farmers in North Carolina

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The study estimates a logit model to identify factors influencing adoption of agritourism by small farmers in North Carolina using a survey. All variables included in the model were dummies and of these having at least a college education has the greatest impact on participating in agritourism, followed by race, public access to the farm for recreation, farms with more than 50 acres of land deemed unsuitable for crop production, and the total amount of land owned. Other factors such as farms near cities, willingness to pay for farm management advice, and before-tax household income also significantly influenced the adoption of this enterprise.

Key words: Agritourism, public access for recreation, farm location, logit model, odds ratios, operator characteristics.

INTRODUCTION

Agritourism has received a lot of attention in recent years both among researchers and also state policy makers. According to the U.S. Travel Association, travel and tourism is a $947 billion industry in the United States that has directly generated more than 8.1 million jobs. Travel and tourism generates $147.9 billion in tax revenue for federal, state, and local governments, with the restaurant industry accounting for the majority of economic activity. An increasing popular and growing opportunity for agricultural producers is agritourism (Agricultural Marketing Resource Center, 2016). Research has been conducted to identify farm and farm operator characteristics that are associated with the adoption of agritourism, a term which has been used to describe activities ranging from U-pick activities, field rides, cultural or historic exhibits, festivals, paid or customized hunting tours to wildlife observations and holiday-related activities. Bagi and Reeder (2012) hypothesized that if successful, such activities might be beneficial to the agricultural economy and have positive environmental and health-related objectives. They further observed and noted that among those who might benefit, most are low-income, undereducated, and older farmers, as well as small family farms. The purpose of this paper is to determine the extent to which some of these findings

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are applicable to small farmers in North Carolina.

Although many do not realize it, agritourism has a long history in the United States. Holland and Wolfe (2000) provide a historical narrative of agritourism in the United States. Agritainment (agritourism and entertainment farming enterprises) dates back to the 1800s, when families would visit their relatives in the country to escape from the city's summer heat. The advent of the automobile in the 1920s and the stresses of the Great Depression of the 1930s and 40’s generated renewed interest in rural/farm recreation. These demands for rural recreation continued through the 1970s into the 1990s as manifest by the popularity of horseback riding, farm petting zoos, farm vacations, bed and breakfasts, and commercial farm tours during those decades (Holland and Wolfe, 2000).

Agritourism has been defined and labeled in various ways in the literature. Philips et al. (2010) provide a typology of definitions of Agritourism. The term *agritourism* has often been used interchangeably with *agrotourism*, *farm tourism*, *farm-based tourism*, *and rural tourism* (McGehee and Kim, 2004; Clarke, 1999; Ilbery and Bowler, 1998; Roberts and Hall, 2001; Barbieri and Mshenga, 2008). Agritourism may be defined as "rural enterprises which incorporate both a working farm environment and a commercial tourism component" (Weaver and Fennel, 1997; McGehee et al., 2007). Barbieri and Mshenga (2008) referred to agritourism as "any practice developed on a working farm with the purpose of attracting visitors."

Examples of agritourism may include farm stays, bed and breakfasts, pick-your-own produce, agricultural festivals, and farm tours for children, or hay rides (Clarke, 1999; McGehee et al., 2007). Farm/ranch recreation refers to activities conducted on private agricultural lands, which might include fee-hunting and fishing, overnight stays, educational activities, etc. This category of tourism is a subset of a larger industry known as agritourism. Agritourism in turn is a subset of a larger industry called rural tourism that includes resorts, off-site farmers' markets, non-profit agricultural tours, and other leisure and hospitality businesses that attract visitors to the countryside. Rural Tourism differs from agritourism in two ways. First, rural tourism enterprises do not necessarily occur on a farm or ranch, or at an agricultural plant, and secondly, they do not generate supplemental income for the agricultural enterprise. Agritourism and nature-tourism enterprises might include outdoor recreation (fishing, hunting, wildlife study, horseback riding), educational experiences (cannery tours, cooking classes, or wine tasting), entertainment (harvest festivals or barn dances), hospitality services (farm stays, guided tours or outfitter services) and on-farm direct sales (u-pick operations or roadside stands).

Farm enterprise diversification has become a strategy for small farms to remain viable especially in the face of high risks facing modern day farming. McGehee et al. (2007) have identified agritourism as a form of enterprise diversification. Ilbery and Bowler (1998) describe seven pathways to agricultural diversification, of which on-farm recreational activities are one survival strategy for farm businesses. Incorporating agritourism as an alternative enterprise has the potential to contribute to agricultural sustainability, broaden farmers' economic base, provide educational opportunities to tourists, and engender a strong communal cohesion (Ilbery and Bowler, 1998). Beus (2008) describes agritourism as a possible strategy for many U.S. farmers to expand their incomes and stay in business. This practice, referred to as the "cultivation of tourists on the farm in addition to crops" is already well established in countries like Switzerland, Italy, New Zealand and other European countries.

As pressure increases on farmers to diversify their enterprises in order to remain competitive, agritourism has emerged as one viable alternative. In an exploratory study of agritourism development in Nova Scotia, Colton and Bissix (2005) identified a number of issues and challenges. Chief among the issues and challenges identified by stakeholders as critical to the development of successful agritourism include marketing, product development, government support, education and training, and partnership and communication. There was consensus among stakeholders that farmers going into agritourism need to be able to define the product that they are offering consumers and be able to communicate this to the potential visitors. Also, fostering linkages with other farmers, business community, educational and governmental agencies, as well as, researchers can significantly impact the success of agritourism ventures.

However, successful operation of agritourism depends on certain factors both within and beyond the control of the farmer. Industrialization and globalization provide opportunities as well as challenges and threats to the survival of small farms in this ever-changing agricultural landscape. While agritourism may provide a way to diversify small farms, there are challenges to successful operation of an agritourism farm. Barbieri and Mshenga (2008) investigated the role of owner and firm characteristics on the performance of agritourism farms. They found out that the length of time in operation, number of employees, and farm acreage tended to have a positive impact on agritourism performance as measured by annual gross sales. In other words, larger farms tend to be more successful as agritourism sites. Their hypothesis is that larger farms, as measured by larger acreages and large number of employees, are able to offer a great variety of tourism products and services that ultimately attract more tourists. Other characteristics such as location of the farm, whether it is a working farm, whether the operator has a business or marketing plan, source of start-up capital and the farmer's educational level did not appear to have a significant relationship with the success of agritourism.

In a more recent study, Bagi and Reeder (2012) conducted a national survey to investigate the factors affecting U.S. farmers' participation in agritourism. Their results revealed a slew of factors that either promote or hinder the successful operation of an agritourism business. Among the factors that have positive impact are: public access to the farm; proximity to central cities; farms in Rocky Mountains and southern plains, and farms enrolled in conservation programs. Other characteristics that impinge upon farmers' decision to participate in agritourism include age, educational level of the farmer, number of acres of farm, whether the farmer pays for advice, and whether the farm is organized as a partnership or corporation. The data showed that nationally over 84 million acres (representing 10% of farm land) is engaged in agritourism, employing 17 million full-time-equivalent days of family labor. Figures from the Agricultural Resource Management Survey (USDA-ERS, 2007) showed that the gross income from agritourism operations was in excess of $16,000 per annum, while national total income from agritourism activities was $554 million in 2007. An additional $258 million was generated from direct sale of farm produce to tourists.

Most of the above cited studies focused on established large farms that are already practicing agritourism. Those that dealt with issues and challenges focused exclusively on existing agritourism operations as opposed to new entrants. There are no studies identifying the challenges that prevent farmers, especially small and socially-disadvantaged ones from adopting or incorporating agritourism into their farms. A number of relevant questions remain unanswered: For example, what factors constrain the likelihood that small farmers will adopt agritourism on their farms? Are those practicing agritourism doing better economically than those that do not? The present research seeks to provide answers to some of these and other questions that have not been tackled in the literature, particularly as they relate to agritourism development among small and socially-disadvantaged farmers in North Carolina. However, the question of whether agritourism does enhance farm profitability is not addressed. As noted by Schilling et al. (2014) “parsing out the effects of agritourism on farm income is challenging for several reasons.” Reasons cited included the lack of consistent definition for “agritourism”; variation in reasons for farmers to develop agritourism enterprises and the strong likelihood of self-selection. While these studies provided a broad overview of the current state of agritourism in North Carolina and elsewhere, they do not provide any demographic information about the farm operators that may be useful for other operators, specifically Small and Socially Disadvantaged Farmers (SSDFs), to use in planning their own agritourism operation. In addition to other objectives, this research helps bridge this gap by analyzing the opportunities for agritourism enhancement among SSDFs and the factors that may influence the decision to add this enterprise to their farm operations. It is hoped that the findings of this research will help provide the foundation for proposing recommendations for addressing the needs of small and socially-disadvantaged farmers in North Carolina who are either involved with agritourism or have interest in adding this enterprise to their farm operations.

Research among small farmers in North Carolina indicates that profit maximization was not a priority reason for farming and farmers cite a "love of farming" and "desire to keep the family farm in the family" as the primary reason for farming (Yeboah et al., 2009). Given recent economic conditions, small farms that do not operate efficiently can exacerbate loss of farm ownership especially for socially disadvantaged farmers. The concept of “family farm” is changing dramatically and small farmers increasingly see themselves as entrepreneurs. Many farms, especially those in eastern North Carolina, will have to continue to change in size and structure to remain viable in the 21st Century agricultural environment. Farmers must focus much of their energies on diversification as a means to stay competitive and agritourism can provide the diversification and additional income to make the small farm profitable.

Empirical analysis

Data

The data for the analysis were obtained as part of a study sponsored by the Evans-Allen Research Program at North Carolina A&T State University. The overall goal of the project was to study small farm agritourism as a tool for community development in North Carolina. The data were collected using a survey administered in the fall of 2014. A total of 895 questionnaires providing detailed information on farm businesses and their operators were sent out yielding a valid response rate of 23.92%. The questionnaire solicited responses to categorical questions resulting in qualitative responses. These were then converted to quantitative factors through the creation of dummy variables.

Theoretical model

According to Bagi and Reeder (2012), a farmer’s decision to participate in agritourism can be compared to the choice between new and traditional technology (activity) and that choice models in consumer theory provide guidance for such decision models (Fernandez-Comejo, 1996). As in previous studies of this kind, the maximum utility a farmer expects to derive from net income from agritourism operation forms the basis in his decision to engage in this enterprise. Following Goodwin et al. (2003) as well as Bagi and Reeder (2012), the utility maximization equation is provided as

Max $\{E(U(\pi_i)) = f(X_i) + \varepsilon_i\}, i = 1,.....,n$ (1)

where $U(\pi_i)$ is the i^{th} farmer's expected or perceived utility from adoption or non-adoption and $f(.)$ is a function of $X_i = x_{i1},.......x_{ik}$ which is a (1 × *k*) vector of observable characteristics or factors specific to the i^{th} farmer, his farm, and his farm business. The random term ε_i represents errors in farmers' perceptions and measurement of expected utility; unobserved characteristics attributes, and preferences; and instrumental variables (Ben-Akiva and Lerman, 1985; Fernandez-Cornejo, 1996).

Let $y_i = 1$ if the i^{th} farmer engages in agritourism and $y_i = 0$ if the i^{th} farmer does not. The probability of a given farmer participating or not participating in any new activity or technology is bounded by zero and one. As such a limited dependent variable model such as logit or probit can be used as the framework for the model. Again according to Bagi and Reeder (2012), if the random error variable ε_i is independently and identically distributed with a Weibull density function, (similar to the normal density function but with greater kurtosis - thicker tails), then a logit structure is an appropriate choice model (McFadden, 1974, 1981; Maddala, 1983). Following Amemiya (1981), the probability of the i^{th} farmer adopting a new activity or enterprise is given by

$$P_i = P(y_i = 1 given X_i) = 1/[1 + \exp - f(X_i)] \quad (2)$$

where P_i is the probability of adoption given the explanatory variable X_i

In the absence of knowledge about the exact functional form of X_i beforehand, we assume a linear form $(f(X_i) = X_i\beta)$ where β is a vector of (1 × *k*) coefficients. For ease of estimation and interpretation of these coefficients, the logarithm of the ratio of probability of adoption to non-adoption is obtained.

$$\ln(P_i/(1 - P_i)) = X_i\beta \quad (3)$$

where $X_i\beta$ (the stochastic part of the model) is given by

$$\ln(P_i/(1 - P_i)) = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + ... + \beta_k x_{ki} \quad (4)$$

This transformation is necessitated by the nonlinear relationship between β and P_i

Equation 4 forms the basis for the empirical model used in estimating the effects of the various factors on the probability of adoption of agritourism by small farmers in North Carolina. The data on farm, farm operators, farm products and services, farmer's agritourism operation, and farmer's perspective of agritourism industry as a whole were all obtained through the administering of a survey questionnaire in 2014.

EMPIRICAL MODEL

The factors that influence farmer's adoption of agritourism have been well studied and according to Bagi and Reeder (2012) are very often grouped into four broad categories: (i) characteristics of the farm's land and operation; (ii) the farm household's wealth or net worth; (iii) characteristics of the farm operator and (iv) location of the farm.

The specific characteristics of these broad categories do vary in their importance in terms of how they influence agritourism. As outlined by Bagi and Reeder (2012), important farm characteristics include farm size (Evans and Ilbery, 1992; Bernardo et al., 2004; Sonnino, 2004), number of acres owned (McGehee and Kim, 2004), a farm's aesthetics (Hilchey, 1993) a farm's attractive characteristics (Rilla, 1999, 2011) and the farm household's wealth or net worth (Sonnino 2004). Specific factors of operator's characteristics include age and education (Barbieri and Mshenga, 2008), degree of social skill (Hilchey, 1993), how outgoing the operator's personality is (Rilla, 1999), and the ability to take advantage of a profitable opportunity (Carter, 1998). Factors related to farm's location include the distance of farm from urban centers (Hilchey, 1993; Che, 2007; Che et al., 2005; Veeck et al., 2006; Bernardo et al., 2004), the farm's distance from urban agritourists (OECD, 2009), and regional geographic characteristics such as a region's particular form of natural and farm assets, climate, infrastructure, tastes and preferences, cultural values, socioeconomic conditions, and policy considerations (Che, 2007; Sonnino, 2004). Carter (1998), Nickerson et al. (2001) and Mace (2005) cite a variety of operator and farm characteristics that influence a decision to adopt innovative activity such as agritourism.

The characteristics in the present study are in line with those used in similar studies and are grouped into two broad classes: farm and land characteristics and farm operator characteristics and all the variables used to measure the different characteristics are expressed in categories. Previous studies have established the effects of these factors on the adoption of agritourism (Bagi and Reeder, 2012). However, in the present study, most of the variables are categorized, and the coefficients are obtained by placing restrictions on the model for the corresponding explanatory variables. Consequently, each coefficient measures the effect of a category on agritourism adoption relative to a referenced category of the variable. This approach is expected to capture variation in these variables.

The included farm characteristics are (i) farm organization or ownership and the corresponding categories are individual ownership X_1 non-incorporated family farm X_2 partnership, incorporated family farm and other forms of ownership X_3; (ii) total acreage owned with four categories: less than 10 acres X_4, 10 to 49 acres X_5, 50 to 499 acres X_6 and >499 acres X_7; (iii) total acreage deemed unsuitable for cropping also with three categories: less than 10 acres X_8, 10 to 49 acres X_9, 50 or more acres X_{10}; (iv) whether or not the farm raises forest products for commercial sale: Yes = 1, No = 0, X_{11}; (v) whether or not the farm provides public access for recreational use: Yes = 1, No = 0, X_{12}; (vi) distance of farm from a central city in the county: <5 miles X_{13}, 5 to 29 miles X_{14}, >29 miles X_{15} and (vii) distance of farm from a city of at least 10,000 people: <5miles X_{16}, 5 to 29 miles X_{17}, >29 miles X_{18}.

The farm operator's characteristics included in the model are: (i) the gender of farm's principal operator: Male = 1, Female = 0 X_{19}; (ii) age of farm's principal operator: 24 years or less X_{20}, 25 to 54 years X_{21}, >54 years X_{22}; (iii) educational background of farm operator: < high school X_{23}, high school X_{24}, some college X_{25}, college and above X_{26}; (iv) whether or not the operator will pay for advice concerning farm operation: Yes = 1, No = 0 X_{27}; (v) whether or not the farm operator has access to the internet: Yes = 1, No = 0 X_{28}; (vi) Household income before taxes: <\$10,000 X_{29}, \$10,000 – \$99,000 X_{30}, >\$99,000 X_{31}; and (vii) the race of farm's principal operator: White = 1, else = 0 X_{32}

As with the adoption of other forms of innovative activity, the ownership structure is expected to influence the decision-making process. Farms that are individually owned and those that are non-incorporated family farms are expected to adopt new innovations such as agritourism much easier than farms under other forms of ownership structures especially incorporated and partnerships. This hypothesis is contrary to what other studies found. For example, Carter (1998) found that diversified farms were more likely to be organized as partnerships and to have more complex forms of ownership than undiversified farms. Thus, a corporate or partnership farm organization could have a positive relationship with participation in agritourism. However, given that the study group is comprised of small and socially disadvantaged farmers, individual ownership and non-incorporated family farms are expected to have a more positive impact on agritourism participation than corporate or partnership farm organization. Adoption decision is expected to be far less complicated than otherwise. The likelihood of agritourism adoption, just like any innovative activity, should increase with land ownership. As the amount of land owned increases as opposed to being leased the farmer's ability to bear risk, make decisions and undertake long-term investments should also increase. Farms with high proportion of land that is unsuitable for traditional cropping are more likely to engage in agritourism since these marginal lands can be sources of additional income from agritourism activities. In addition, public access including walking and biking trails, access for hunting, fishing and other forms of recreational activities provide the opportunity to expose these people to agritourism activities hence should increase their adoption. Bagi and Reeder (2012) have indicated that the presence and sale of forest products such as woodland, which in turns supports wildlife, tends to increase a farmer's participation in agritourism activity. This hypothesis is maintained in the present study. The wealth of a household has been used as a measure of its ability to take risk and hence borrow money for innovative activities. This variable is included in the model as household income before taxes and is expected to have a positive effect on farmer's participation in agritourism activity.

Variables included in the model that are related to the farm operator's characteristics include age, education, access to the internet, gender, race and use of paid farm management advice. Access to internet enhances the farmer's ability to receive and manage a variety of information related to the agricultural enterprise such as prices and weather. It also serves as a viable source of marketing a potential agritourism activity. The *a priori* effect of age on agritourism adoption has been hypothesized to be ambiguous. Older farmers are perceived to have the needed experience and knowledge to handle such a change while younger farmers may have the advantage of health, optimism and openness to new ideas in addition to a longer planning horizon. Education, specifically formal education, training and experience has been hypothesized to increase a person's ability to search for relevant information and to interpret, comprehend, critically analyze, modify, and adapt that information for practical economic decision-making (Schultz, 1975; Becker, 1993). It is therefore theorized that these qualities will enhance a farmer's ability to adopt new technology or activity such as agritourism. Additionally, the availability and a farmer's willingness to use professional advice is also expected to enhance farmers' participation in a new activity. It is further argued that greater education, training, and professional advice could also lead some farmers to opt out of agritourism because of unfavorable cost and benefits situations (Bagi and Reeder, 2012). A study by Carter (1998) found that producers who were involved in diversifying their farms (including those who added recreational activities) were more likely to have received some agricultural and managerial training than producers who did not diversify. Also, the OECD study (2009) of farm diversification cited research showing that education increased a farmer's likelihood to engage in value-added production, a similar diversification activity. These arguments point to possible ambiguity in the effect of education on agritourism adoption. This ambiguity is expected to be amplified by the categorized nature of the education variable in the present study.

Several studies indicate that males and females adopt new technologies at different rates and that gender has a significant effect on farmers' engagement in new activities. A number of studies that focus on the gender of the head of household suggest that male-headed households are more likely to adopt new technologies compared to female-headed households (Doss and Morris, 2001; Kumar, 1994). Doss (2001) found that women are adopting improved varieties at a lower rate than men in Africa. Other studies (Overfield and Fleming, 2001; Asiedu-Darko, 2014) found no significant relationship between gender and adoption of technologies. Age, on the other hand showed strong negative association with adoption of agricultural technology with older farmers more likely to stick to use of traditional farming methods, whereas younger farmers prefer use of modern methods of farming (Asiedu-Darko, 2014). Age was found to positively influence adoption of sorghum in Burkina Faso (Adesina and Baidu-Forson,

Table 1. *A priori* directional effects of selected factors on agritourism adoption from previous studies.

Factor	Expected directional effect
Farm organization or ownership ((= 1 if partnership or corporation, else = 0)	+
Land (owned land in acres)	+
Percent of farm land unsuitable for crops	+
Forest sales (= 1 if farm sells forest products, else = 0)	+
Public access for recreational uses (= 1 if public has access, else = 0)	+
Central city in the county (= 1 if a central city in the county, else = 0)	+
Distance from a city of at least 10,000 people	-
Age of principal operator (Farm operator's age in years)	+
Educational background of farm operator (= 1 if operator has at least some college education, else = 0)	+
Pay for advice concerning farm operation (= 1 if farmer paid for farm advice, else = 0)	+
Access to the internet (1 = if farmer has access to internet, else =0)	+
Household net worth in $10,000	+
Conservation (1 = if enrolled in conservation program, else = 0	+

1995), IPM in peanuts in Georgia (McNamara et al., 1991), and chemical control of rice stink bug in Texas (Harper et al., 1990). In contrast, age has been found to be either negatively correlated with adoption, or not significant in farmer's adoption decisions. It can be concluded therefore that the relationship between age and adoption of agricultural technology varies with the type of technology being introduced. Furthermore, some studies have shown a significant interaction between gender and age. For example, Sulo et al. (2012) found that the older the women, the lesser the likelihood of adopting the technology. However, since agritourism is a different kind of activity and cannot be defined necessarily as a new technology, it is quite possible that effect of gender, age and education on agritourism adoption will be quite different from that on agricultural technologies.

Wealth and resource base of farmers influence their ability to bear risk and also enhances information flow to assist in decision making. Both of these are crucial ingredients in adopting new activity. It is hypothesized that being Caucasian and being male will each positively influence the participation in agritourism.

Similar to other studies, two factors related to a farm's location are included in the model. The study uses distance of the farm from a central city in the county rather than the presence of such a city used in other studies and also distance of the farm from the nearest city of at least 10,000 residents. Both are expected to have a positive effect in agritourism participation due to larger number of potential visitors nearby. Table 1 summarizes the a priori directional effects of selected factors on the likelihood of a farmer adopting agritourism from these studies.

Specifications of the estimating model and variables

The empirical logit model (Equation 4) and definitions of vector of variables (X_i) for each farm unit can be rewritten as

$$\ln\left(P_i/\left(1-P_i\right)\right)=\beta_0+\sum_{k=1}^{32}\beta_k X_{ik}+u_i \qquad (5)$$

where u_i is a vector of random errors and X_i variables are the explanatory variables. These explanatory variables X_1 through X_{32} are described and their means expressed in percentages terms (since they are dummy variables) and coefficients of variation are presented for both agritourism farms and non-agritourism farms in Table 2. The t-values for testing the significance of difference in means for two types of farms are also presented in Table 2.

Maximum likelihood procedure is used to estimate the logit probability model specified in Equation 5. Included in the output are the coefficients, the likelihood-ratio test statistic (chi-squared) and the measure of the goodness of fit (Cox and Snell R-square, and Nagelkerke R-square).

RESULTS AND DISCUSSION

The maximum-likelihood estimates, associated standard errors, odds ratios, and test statistics for the goodness-of-fit measures generated by the model are presented in Table 3. The chi-squared statistic (for the log-likelihood test) for the estimation that includes all explanatory variables relative to the equation with only the constant term (in which the coefficients of all explanatory variables are restricted to zero) is 91.12 and is significant at a level of less than .01. All coefficients have expected signs relative to the base categories with the exception of "access to the internet". In addition, 19 of the 32 coefficients for the explanatory variables are significant at the 10% level or lower. The model produces a Cox and Snell R-square of 0.538 and Nagelkerke R-square of 0.800 with 92.5% of its predictions being correct (Table 3).

Interpretation of estimated odds ratios

The coefficient estimates $\left(\hat{\beta}_s\right)$ presented in Table 3 are

Table 2. Means, coefficients of variation, and t-statistics for testing differences in a pair of means of farms by agritourism activity, 2014.

Variable	Agritourism farms	Non-agritourism farms	t-value
Farm Organization/Ownership			
Individual Ownership (X_1)	33.9[a] (12.4)	37.3(16.9)	-0.453
Non-incorporated family farm (X_2)	22.8(16.3)	33.9(18.2)	-1.599*
Partnership, incorporated family farm and others (X_3)	43.3(10.2)	28.8(20.5)	1.889**
Total acreage owned			
<10 acres (X_4)	21.8(17.3)	44.7(18.0)	-2.755***
10 to 49 acres (X_5)	46.2(9.9)	28.9(25.4)	1.878**
50 to 499 acres (X_6)	28.6(14.5)	26.3(27.1)	0.270
>499 acres (X_7)	3.4(49.2)	0	1.145
Total acreage deemed unsuitable for cropping			
<10 acres (X_8)	49.6(9.1)	64.3(10.0)	-1.829**
10 to 49 acres (X_9)	28.5(14.3)	26.8(22.1)	0.231
50 or more acres (X_{10})	22.0(17.0)	8.9(42.7)	2.108**
Raise forest products for commercial sale			
Yes = 1, No = 0 (X_{11})	84.6(3.9)	75.6(8.5)	1.348
Provide public access for recreational use Yes =1, No = 0 (X_{12})	68.6(6.2)	20.0(27.0)	5.990***
Distance of farm from a central city in the county			
<5miles (X_{13})	21.4(17.1)	23.7(23.3)	-0.351
5 to 29 miles (X_{14})	74.6(5.2)	69.5(8.6)	0.730
>29 miles (X_{15})	4.0(43.8)	6.8(48.3)	-0.828
Distance of farm from a city of at least 10,000 people			
located <5 miles (X_{16})	23.6(16.2)	36.2(17.4)	-1.773*
5 to 29 miles (X_{17})	35.0(12.3)	29.3(20.4)	0.753
> 29 miles (X_{18})	41.5(10.7)	34.5(18.1)	0.898
Gender of farm's principal operator			
Male = 1, Female = 0 (X_{19})	65.6(6.4)	72.4(8.1)	-0.918
Age of farm's principal operator			
24 years or less (X_{20})	0.8(99.6)	0	0.675
25 to 54 years (X_{21})	31.3(13.1)	32.8(18.8)	-0.205
>54 years (X_{22})	68.0(6.1)	67.2(9.2)	0.098
Educational background of farm operator			
< high school (X_{23})	1.6(70.2)	11.9(35.5)	-3.059***

Table 2. Contd.

High school (X_{24})	10.9(25.2)	23.7(23.3)	-2.278***
Some college (X_{25})	28.1(14.1)	30.5(19.6)	-0.334
College and above (X_{26})	59.4(7.3)	33.9(18.2)	3.239***
Will you pay for advice concerning farm operation			
Yes = 1, No = 0 (X_{27})	49.2(9.1)	50.9(13.2)	-0.212
Has access to the internet			
Yes = 1, No = 0 (X_{28})	97.7(1.4)	91.4(4.0)	1.942**
Household income before taxes			
<$10,000 (X_{29})	5.7(36.7)	28.1(21.2)	-4.160***
$10,000 - $99,000 (X_{30})	57.4(7.8)	56.1(11.7)	0.156
>$99,000 (X_{31})	36.9(11.8)	15.8(30.6)	2.865***
Race of farm operator			
White = 1, else = 0 (X_{32})	89.8(3.0)	33.9(18.1)	7.901***

[a:] The numbers are means expressed as percentages. For example, 33.9% of the agritourism farms were organized as individual ownership as against 37.3% for all other farms. Figures in parentheses are coefficients of variation. Significant column-difference tests are based on two-tailed [Ho: P1=P2] t-statistic. ***, ** and * show that the difference between a pair of means is significantly different from zero at a 1, 5 and 10% level respectively.

Table 3. Logit model estimates of participation in agritourism activities, 2014.

Variable	Coefficient[a] β	Odds Ratio[b] $\left(\varepsilon^{\beta_k}\right)$
Farm Organization/Ownership (reference: X_2: Family farm non-incorporated)		
X_1: Individual Ownership	-8.7276**(4.583)	0.0002**(-1.904)
X_3 Partnership and others	-8.5192**(4.355)	0.0002**(-1.956)
Total acreage owned (reference: X_6: 50 to 499 acres)		
X_4: <10 acres	-3.3753*(2.148)	0.0342*(-1.571)
X_5: 10 to 49 acres	10.6637**(5.336)	42774.8510**(1.998)
X_7: >499 acres	-2.0715(1.636)	0.1260(-1.266)
Total acreage deemed unsuitable for cropping (reference: X_9 10 to 50 acres)		
X_8: <10 acres	9.3820**(4.901)	11872.8800**(1.914)
X_{10}: >50 acres	12.8000**(6.163)	362230.8610**(2.077)
Raise forest products for commercial sale		
X_{11}: Yes = 1, No = 0	-5.4252**(3.056)	0.0044**(-1.775)

Table 3. Contd.

Provide public access for recreational use		
X_{12}: Yes =1, No = 0	16.0265**(6.985)	9125121.3560**(2.294)
Distance of farm from a central city in the county (X_{14} ***reference: 5 to 29 miles)***		
X_{13}: <5miles	-0.9245(1.688)	0.3970(-0.548)
X_{15}: >29 miles	4.4239*(2.886)	83.4190*(1.533)
Distance of farm from a city of at least 10,000 people (reference: X_{18} ***>29 miles)***		
X_{16}: located <5 miles from a city of 10,000 people	2.5204(2.153)	12.4330(1.171)
X_{17}: 5 to 29 miles	5.2287*(3.276)	186.5470*(1.596)
Gender of farm's principal operator		
X_{19}: Male = 1, Female = 0	-5.6526**(2.996)	0.0040**(-1.887)
Age of farm's principal operator (reference: X_{20} ***24 years or less)***		
X_{21}: 25 to 54 years	-2.449(2.254)	0.0860(-1.082)
X_{22}: >54 years	-2.7824(1.994)	0.0620(-1.395)
Educational background of farm operator (reference: X_{23} ***< high school)***		
X_{24}: High school	17.6311**(9.381)	45402632.6990**(1.879)
X_{25}: Some college	30.8258**(14.040)	24404632789006.4570**(2.195)
X_{26}: College and above	25.1100**(11.730)	80375849074.8750**(2.141)
Will you pay for advice concerning farm operation		
X_{27}: Yes = 1, No = 0	3.3709*(2.037)	29.1060*(1.655)
Have access to the internet		
X_{28}: Yes = 1, No = 0	-9.1813(13.456)	0.0001(-0.682)
Household income before taxes (reference: X_{29} ***<$10,000)***		
X_{30}: $10,000 - $99,000	5.6712**(2.755)	290.3820**(2.059)
X_{31}: >$99,000	4.1945*(2.606)	66.3200*(1.600)
Race of farm operator		
X_{32}: White = 1, else = 0	18.1512**(7.982)	76378448.3600**(2.274)
Intercept	-37.1000(23.722)	0.0000(-1.564)
Sample	118	
LR Chi-square(24)	91.12	
-2 Log Likelihood	40.482	
Cox & Snell R-square	0.538	
Nagelkerke R-square	0.800	
Correct predictions (%)	91.5	

[a] Numbers in parentheses are standard errors. ***, **, and * show that the coefficient is significantly different from zero at the 1, 5 and 10% level, respectively. [b] Numbers in parentheses are t-values. ***, **, and * show that the coefficient is significantly different from zero at the 1, 5 and 10% level, respectively.

Table 4. Logit model estimates of participation in agritourism activities, 2014 (over prediction addressed).

Variable	Coefficient [c] β	Odds Ratio [d] $\left(\varepsilon^{\beta_k}\right)$
Farm Organization/Ownership (reference: X_2 Family farm non-incorporated)		
X_1: Individual Ownership	-1.129(1.183)	0.323(-0.954)
X_3 Partnership and others	-1.172(1.155)	0.310(-1.015)
Total acreage currently being farmed (reference: X_6 50 to 499 acres)		
X_4: <10 acres	-1.913(1.384)	0.148(-1.382)
X_5: 10 to 49 acres	3.218*(1.965)	24.971(1.638)
X_7: >499 acres	-0.335(1.111)	0.715(-0.302)
Total acreage deemed unsuitable for cropping (reference: X_9 :10 to 50 acres)		
X_8: <10 acres	1.792(1.438)	5.999(1.246)
X_{10}: >50 acres	2.614*(1.497)	13.660(1.746)
Raise agricultural products for commercial sale		
X_{11}: Yes = 1, No = 0	-3.440**(1.685)	0.032(-2.042)
Provide public access for recreational use		
X_{12}: Yes =1, No = 0	5.415***(1.492)	224.713(3.629)
Distance of farm from a central city in the county (reference: X_{14} :5 to 29 miles)		
X_{13}: <5 miles	-1.240(1.312)	0.289(-0.945)
X_{15}: >29 miles	0.549(1.354)	1.731(0.406)
Distance of farm from a city of at least 10,000 people (reference: X_{18} >29 miles)		
X_{16}: located <5 miles from a city of 10,000 people	0.629(1.227)	1.875(0.513)
X_{17}: 5 to 29 miles	1.246(1.314)	3.476(0.948)
Gender of farm's principal operator		
X_{19}: Male = 1, Female = 0	-1.443(1.118)	0.236(-1.291)
Age of farm's principal operator (reference: X_{20} : 24 years or less)		
X_{21}: 25 to 54 years	0.031(1.249)	1.032(0.025)
X_{22}: >54 years	0.349(1.062)	1.417(0.329)
Educational background of farm operator		
X_{26}: College and above = 1, else = 0	4.299***(1.598)	73.665(2.690)
Will you pay for advice concerning farm operation		
X_{27}: Yes = 1, No = 0	-0.227(0.903)	0.797(-0.251)
Have access to the internet		
X_{28}: Yes = 1, No = 0	-5.519*(3.298)	0.004(-1.673)
Household income before taxes (reference: X_{29} <$10,000)		
X_{30}: $10,000 - $99,000	2.198*(1.275)	9.007(1.724)

Table 4. Contd.

X_{31}: >$99,000	0.944(1.276)	2.570(0.740)
Race of farm operator		
X_{32}: White = 1, else = 0	4.740***(1.390)	114.413(3.410)
Intercept	-1.298(3.789)	0.273(-0.343)
-2 Log Likelihood	50.171	
Cox & Snell R-square	0.498	
Nagelkerke R-square	0.742	
Correct predictions (%)	90.7	

[c] Numbers in parentheses are standard errors. ***, **, and * show that the coefficient is significantly different from zero at the 1, 5 and 10% level, respectively. [d] Numbers in parentheses are t-values. ***, **, and * show that the coefficient is significantly different from zero at the 1, 5 and 10% level, respectively.

natural logarithms $(\log_e)$ of the odds of the farmer offering an agritourism activity. For ease of interpretation and comparison between variables, we transform the coefficients so that they refer to the effect a variable has on the actual odds of participating rather than on the natural logarithm of the odds. This is obtained by calculating the odds ratio for each explanatory variable as: [the odds ratio for $X_k = e^{\beta_k} =$ the odds after X_k is increased by one unit] divided by [the odds before a unit increase in X_k] (Long and Freese). Odds ratios are also presented in Table 3.

All explanatory variables in the model are dummy variables and the interpretation of the odds ratios provide useful information comparing each categorical variable with the respective base variable. The odds ratio for the categorical variable of farm being between 5 and 29 miles from a city of at least 10,000 people (X_{17}) is 186.547 demonstrating that the odds of a farmer located within this distance range is, ceteris paribus, 187 times more likely to engage in agritourism than the odds of a farmer who is more than 29 miles away. The results show over prediction by several of the variables (very high odd ratios) indicative of perfect separation (Introduction to SAS, 2007) as a result of having few observations in some of the categories of these variables. Results obtained for addressing this problem are summarized in Table 4. Similar to Table 3, the maximum-likelihood estimates, associated standard errors, odds ratios, and test statistics for the goodness-of-fit measures generated by the model are presented in Table 4. Again, all coefficients have expected signs relative to the base categories with the exception of “access to the internet”. However, only 8 of the 32 coefficients for the explanatory variables are significant at the 10% level or lower. The model produces a Cox & Snell R-square of 0.498 and Nagelkerke R-square of 0.742 with 90.7% correct predictions (Table 4).

Among the explanatory variables included in our analysis, education had the greatest effect on odds of a farmer participating in agritourism. Having some college education topped this category followed by college and above and then completing high school compared to farmers with less than high school education. This was followed by the race of the farm operator with white farmers being more likely to engage in agritourism than non-white farmers. Consistent with other studies (Bagi and Reeder, 2012), public access also had great effect on odds of a farmer participating in agritourism followed by farms with acreage between 10 and 49 acres. Farm sizes at both ends of the distribution (less than 10 acres and over 49 acres are likely to reduce farmer’s participation in agritourism. A Small Farm, according to USDA census is a farm that is 179 acres or les, or earns $50,000 or less in gross income per year. Thus by this definition, agritourism adoption might be negatively impacted by the size of the farm. On the other hand farms with less than 10 acres or more than 50 acres of land deemed unsuitable for crop production, may encourage the adoption of agritourism.

Willingness to pay for farm-related advice and a farm organized as a partnership or corporation also increased the odds of agritourism participation, but these effects were not as strong as found by other researchers (Bagi and Reeder, 2012). Total acreage deemed unsuitable for crop production, farm location relative to central city and population centers, raising forest products for commercial sale, male farm operator and households with income of $10,000 and above before taxes all increase the odds of participation in agritourism.

Conclusions

This study has demonstrated that the probability of a farmer’s participation in agritourism in North Carolina is significantly affected by a number of variables related to farm characteristics, the farm operator and the location of the farm vis-à-vis relative distances from urban centers. These variables with significant categories compared to the reference category include amount of land owned, the amount of land deemed unsuitable for crop production and public access for recreational uses to some part of the farm. Similarly, farm operator characteristics with significant odds ratios categories include education, gender, household income before taxes, raising forest products for commercial sales, use of farm management advice and the farm's organization. In terms of farm location, proximity to central city in the county and population centers do not have categories with strong odd ratios compared to the reference categories.

To a large extent these results are consistent with results from other studies and provide useful information for County Extension experts and others at the state and local level in their efforts to promote agritourism. Similar to those of Bagi and Reeder (2012), these findings are particularly useful for individuals who design policies or programs such as education and training, technical assistance, and advertising and promotion and who aim to target minorities and other socially disadvantaged individuals. Findings about farm location, gender, education level and race and income levels can all be useful in assessing the potential for success program design. For example, limited education, a common characteristic of low-income farmers can point to difficulties for such farmers establishing agritourism and staying in business. However, this can be offset, somewhat, by a willingness to solicit management advice from County Extension agents or other experts. Thus, the complementarity between these two factors may make it possible for a limited-resource, undereducated farmer to overcome and succeed in this activity with proper advice.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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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

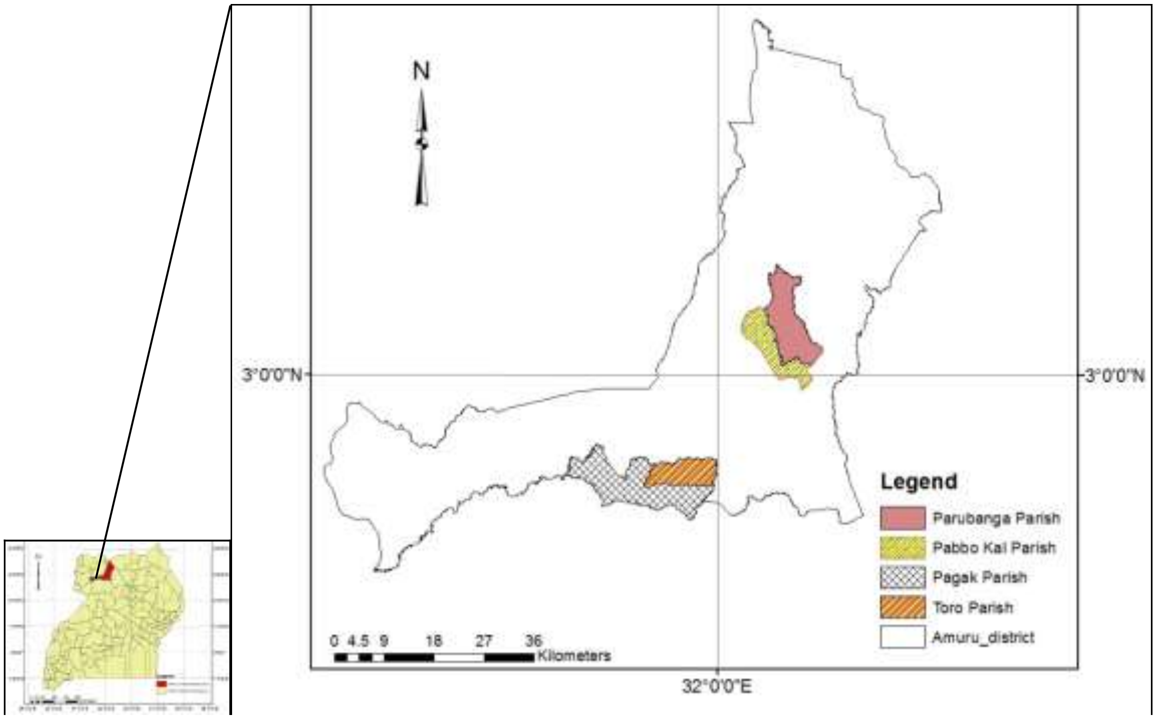

Figure 1. Location of Study parishes in Amuru district.

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.

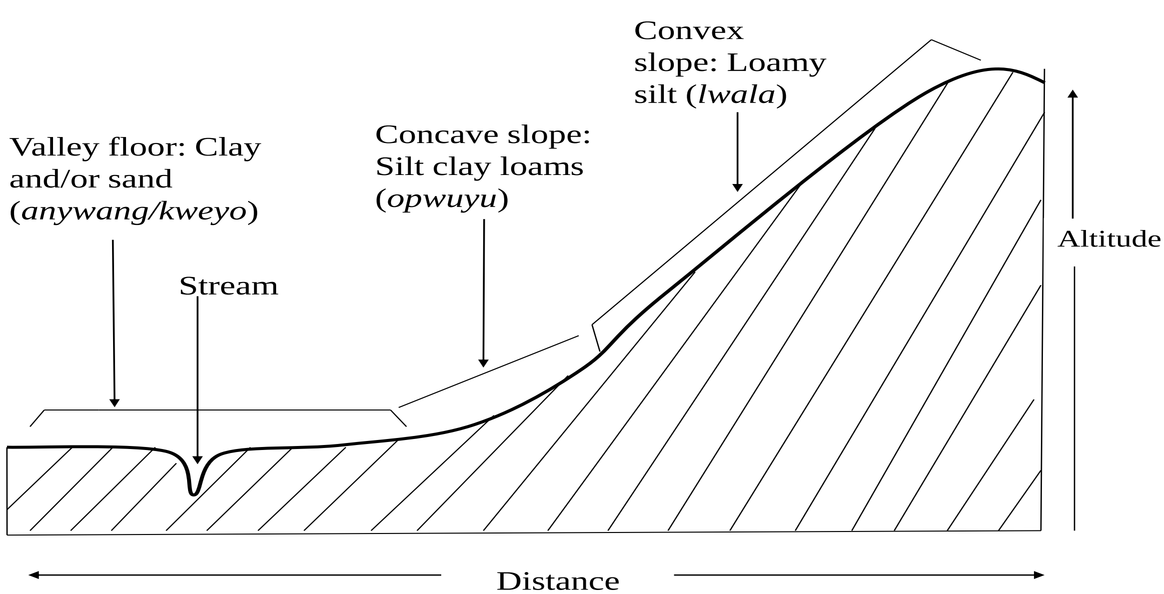

Figure 3. Topography and the distribution of soil types**.**

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*
Ngininigini	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.

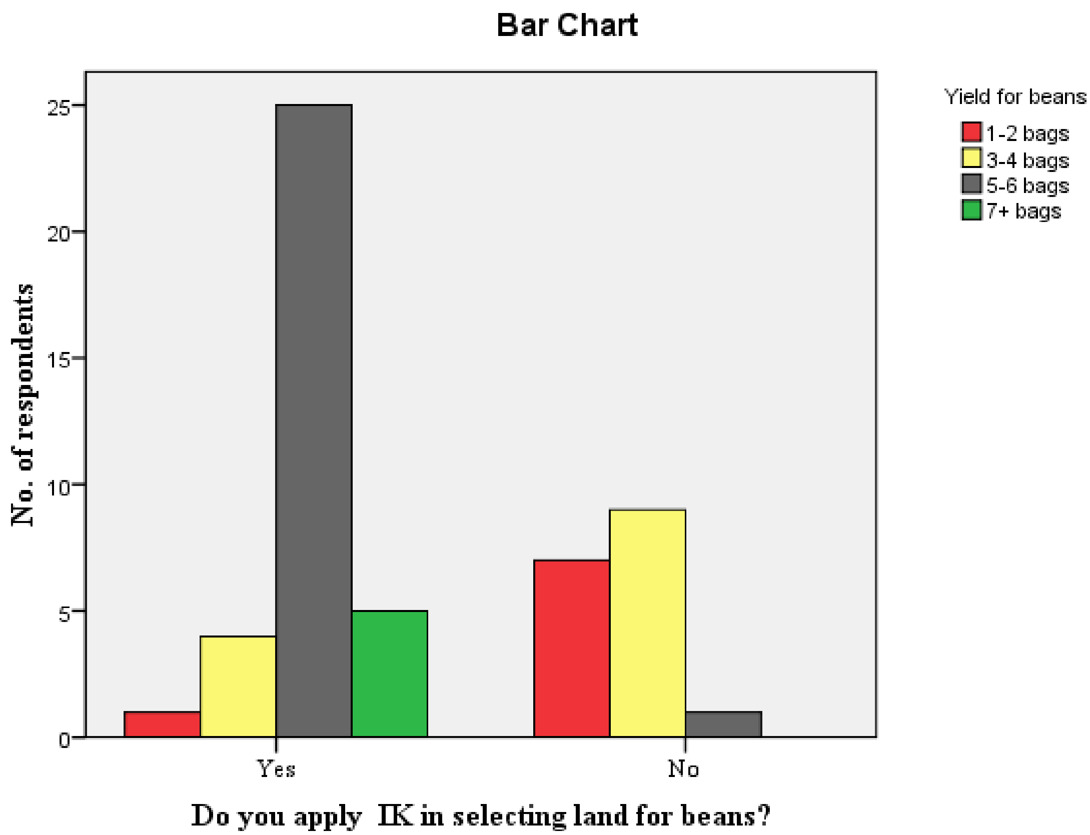

Figure 6. Application of indigenous knowledge and yields for beans.

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

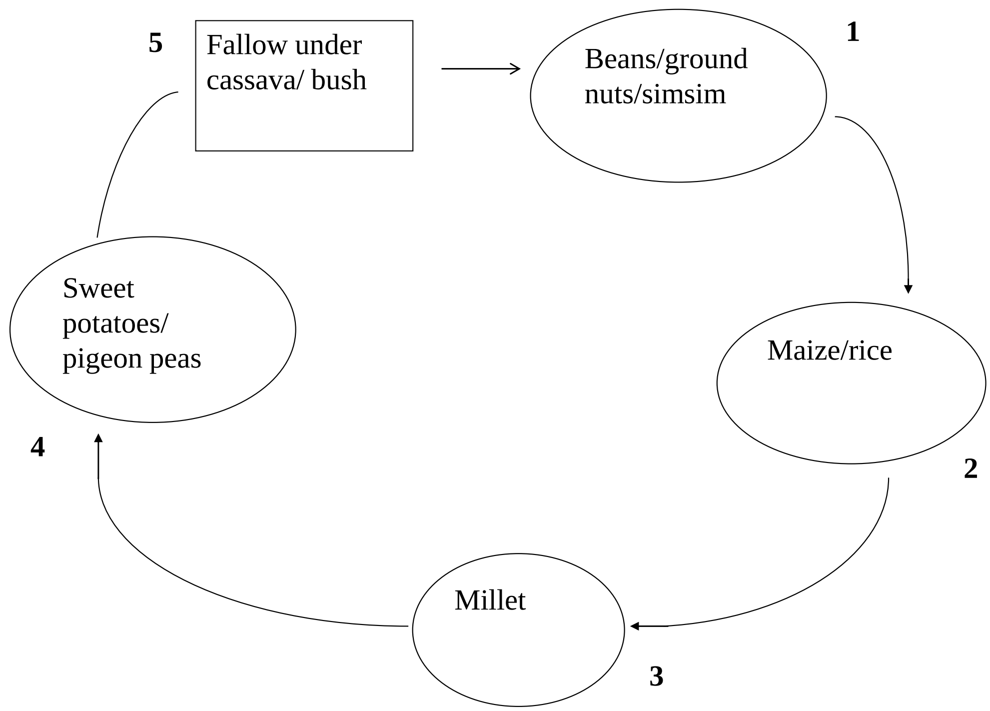

Figure 7. Crop rotation cycle.

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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