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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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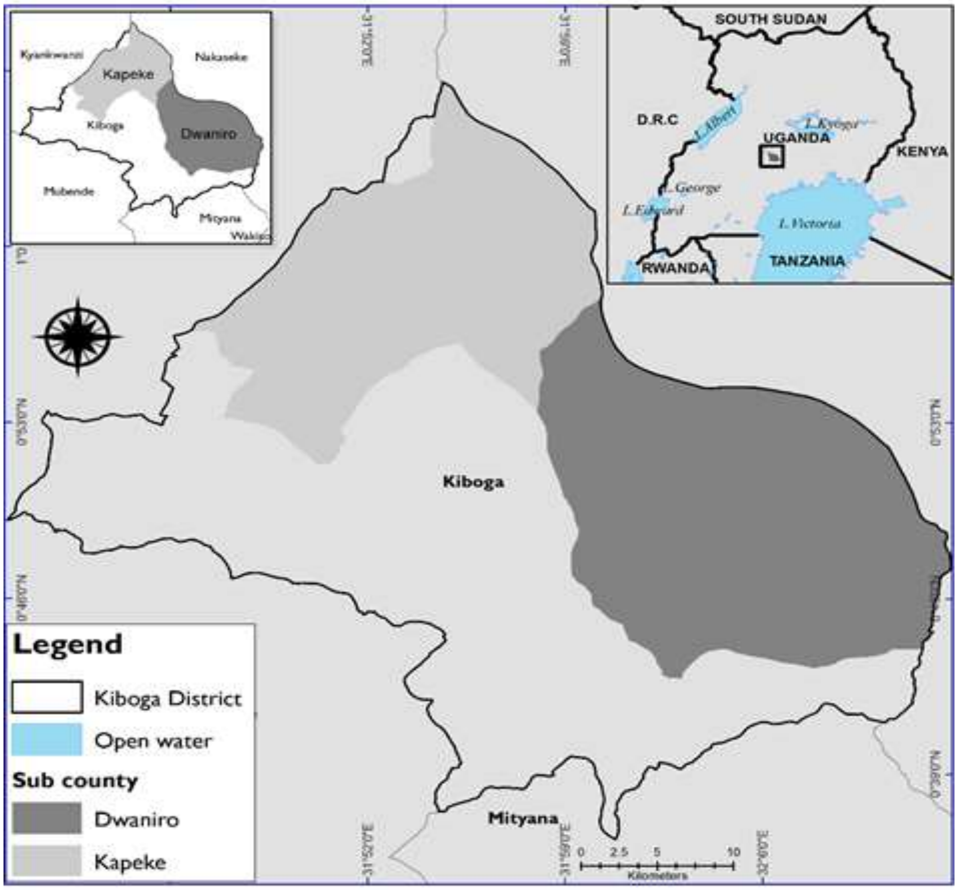

Figure 1. Location of study area.

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.

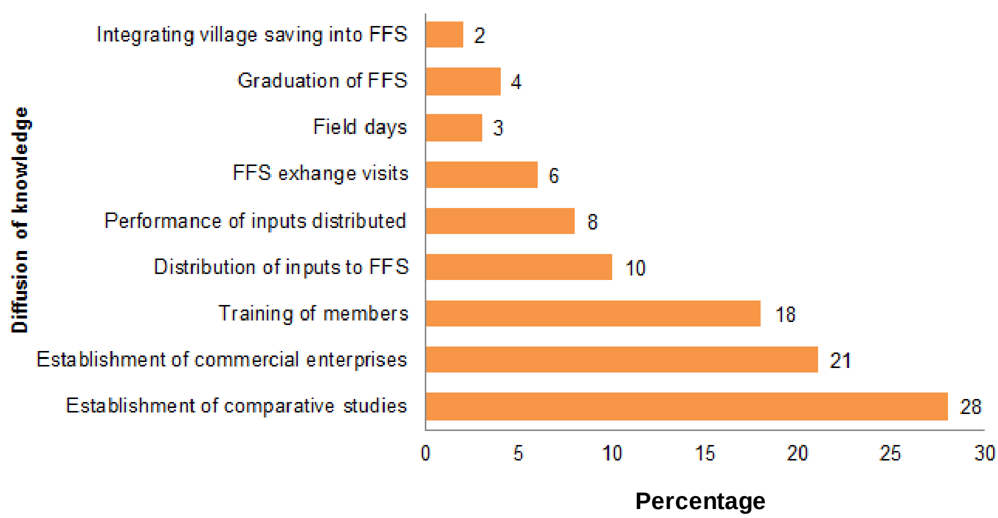

Figure 2. FFS's diffusion knowledge and skills.

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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REFERENCES

Abele S, Pillay M (2007). Bacterial wilt and drought stresses in banana production and their impact on economic welfare in Uganda: Implications for banana research in East African highlands. J. Crop Improv. 19(1-2):173-91.

Anandajayasekeram P, Davis KE, Workneh S (2007). Farmer field schools: an alternative to existing extension systems? Experience from Eastern and Southern Africa. J. Int. Agric. Ext. Educ. 14(1):81-93.

Antwi-Agyei P, Stringer LC, Dougill AJ (2014). Livelihood adaptations to climate variability: insights from farming households in Ghana. Reg. Environ. Change 14(4):1615-1626.

Apuuli B, Wright J, Elias C, Burton I (2000). Reconciling national and global priorities in adaptation to climate change: with an illustration from Uganda. Environ. Monit. Assess. 61(1):145-59.

Barr A, Fafchamps M, Owens T (2005). The governance of non-governmental organizations in Uganda. World Dev. 33(4):657-79.

Beswick A (2007). What Is Climate Change?. Prim. Sci. Rev. 96:11-14.

Burton I, Huq S, Lim B, Pilifosova O, Schipper EL (2002). From impacts assessment to adaptation priorities: the shaping of adaptation policy. Clim. Policy 2(2-3):145-59.

Challinor A, Wheeler T, Garforth C, Craufurd P, Kassam A (2007). Assessing the vulnerability of food crop systems in Africa to climate change. Clim. Change 83(3):381-399.

Christiaensen L, Demery L, Paternostro S (2003). Macro and micro perspectives of growth and poverty in Africa. World Bank Econ. Rev. 17(3):317-347.

Davis K, Nkonya E, Kato E, Ayalew D, Odendo M, Miiro R, Nkuba J (2012). Impact of farmer field schools on agricultural productivity and poverty in East Africa. World Dev. 40(2):402-413.

Ebwongu M, Adipala E, Ssekabembe CK, Kyamanywa S, Bhagsari AS (2001). Effect of intercropping maize and Solanum potato on yield of the component crops in central Uganda. Afr. Crop Sci. J. 9(1):83-96.

Egeru A, Wasonga O, Kyagulanyi J, Majaliwa GM, MacOpiyo L, Mburu J (2014). Spatio-temporal dynamics of forage and land cover changes in Karamoja sub-region, Uganda. Pastoralism 4(1):6.

Erbaugh JM, Donnermeyer J, Amujal M, Kidoido M (2010). Assessing the impact of farmer field school participation on IPM adoption in Uganda. J. Int. Agric. Ext. Educ. 17(3):5-17.

Feder G, Murgai R, Quizon JB (2004). Sending farmers back to school: The impact of farmer field schools in Indonesia. Appl. Econ.

Perspect. Policy 26(1):45-62.
Friis-Hansen E, Duveskog D, Taylor EW (2012). Less noise in the household : the impact of Farmer Field Schools on Gender Relations. J. Res. Peace Gend. Dev. 2:44-55.
Garreaud R, Vuille M, Clement AC (2003). The climate of the Altiplano: observed current conditions and mechanisms of past changes. Palaeogeogr. Palaeoclimatol. Palaeoecol. 194(1):5-22.
Giorgi F (2006). Climate change hot-spots. Geophys.Res. Lett. 33(8).
Godtland EM, Sadoulet E, De Janvry A, Murgai R, Ortiz O (2004). The impact of farmer field schools on knowledge and productivity: A study of potato farmers in the Peruvian Andes. Econ. Dev. Cult. Change 53(1):63-92.
Guo M, Jia, Huang J, Kumar KB, Burger NE (2015). Farmer field school and farmer knowledge acquisition in rice production: Experimental evaluation in China. Agric. Ecosyst. Environ. 209:100-107.
Hakiza JJ, Odogola RW, Mugisha J, Semana AR, Nalukwago J, Okoth J, Ekwamu A (2004). Challenges and prospects of disseminating technologies through farmer field schools: Lessons learnt based on experience from Uganda. Uganda J. Agric. Sci. 9:163-175.
Hepworth N, Goulden M, Hammond GP, Jones CI (2008). Climate Change in Uganda: Understanding the implications and appraising the response. Proceedings of the Institution of Civil Engineers - Energy, 161(July), 1–48. https://doi.org/10.1680/ener.2008.161.2.87
Hisali E, Birungi P, Buyinza F (2011). Adaptation to climate change in Uganda: evidence from micro level data. Glob. Environ. Change 21(4):1245-1261.
Kugonza DR, Nabasirye M, Hanotte O, Mpairwe D, Okeyo AM (2012). Pastoralists' indigenous selection criteria and other breeding practices of the long-horned Ankole cattle in Uganda. Trop. Anim. Health Prod. 44(3):557-565.
Lindell MK, Whitney DJ (2001). Accounting for common method variance in cross-sectional research designs. J. Appl. Psychol. 86(1):114.
Mancini F, Jiggins J (2008). Appraisal of methods to evaluate farmer field schools. Dev. Practice 18(4-5):539-550.
Mann CJ (2003). Observational research methods. Research design II: cohort, cross sectional, and case-control studies. Emerg. Med. J. 20(1):54-60.
Mubaya CP, Njuki J, Mutsvangwa EP, Mugabe FT, Nanja D (2012). Climate variability and change or multiple stressors? Farmer perceptions regarding threats to livelihoods in Zimbabwe and Zambia. J. Environ. Manage. 102:9-17.
Mugerwa S, Stephen K, Anthony E (2014). Status of livestock water sources in Karamoja sub-region, Uganda. Resour. Environ. 4(1):58-66.
Nimusiima A, Basalirwa C, Majaliwa J, Mbogga S, Mwavu E, Namaalwa J, Okello-Onen J (2014). Analysis of Future Climate Scenarios over Central Uganda Cattle Corridor. J. Earth Sci. Clim. Change 5(10).
O'Reilly CM, Alin SR, Plisnier PDD, Cohen AS, McKee BA (2003). Climate change decreases aquatic ecosystem productivity of Lake Tanganyika, Africa. Nature 424(6950):766-768.
Okonya JS, Syndikus K, Kroschel J (2013). Farmers' Perception of and Coping Strategies to Climate Change: Evidence From Six Agro-Ecological Zones of Uganda. J. Agric. Sci. 5(8):252-263.
Palis FG (2006). The role of culture in farmer learning and technology adoption: a case study of farmer field schools among rice farmers in central Luzon, Philippines. Agric. Human Values 23(4):491-500.
Patricola CM, Cook KH (2010). Northern African climate at the end of the twenty-first century: an integrated application of regional and global climate models. Clim. Dyn. 35(1):193-212.
Patz JA, Campbell-Lendrum D, Holloway T, Foley JA (2005). Impact of regional climate change on human health. Nature 438(7066):310-317.
Quizon J, Feder G, Murgai R (2001). Fiscal sustainability of agricultural extension: the case of the farmer field school approach. J. Int. Agric. Ext. Educ. 8(1):13-24.
Rahmstorf S, Coumou D (2011). Increase of extreme events in a warming world. Proc. Nat. Acad. Sci. 108(44):17905-17909.
Reidsma P, Ewert F, Lansink AO, Leemans R (2010). Adaptation to climate change and climate variability in European agriculture: the importance of farm level responses. Euro. J. Agron. 32(1):91-102.
Simpson BM, Owens M (2002). Farmer field schools and the future of agricultural extension in Africa. J. Int. Agric. Ext. Educ. 9(2):29-36.
Sivakumar MV (2005). Impacts of natural disasters in agriculture, rangeland and forestry: an overview. InNatural disasters and extreme events in Agriculture 2005 (pp. 1-22). Springer Berlin Heidelberg.
Šmilauer P, Bernard B, Henry M, Paul N (2015). Piosphere syndrome and rangeland degradation in Karamoja sub-region, Uganda. Resour. Environ. 5(3):73-89.
Thiele G, Nelson R, Ortiz O, Sherwood S (2001). Participatory research and training: ten lessons from the Farmer Field Schools (FFS) in the Andes. Currents 27:4-11.
Thornton PK, Jones PG, Alagarswamy G, Andresen J (2009). Spatial variation of crop yield response to climate change in East Africa. Glob. Environ. Change 19(1):54-65.
Thornton PK, Jones PG, Alagarswamy G, Andresen J, Herrero M (2010). Adapting to climate change: agricultural system and household impacts in East Africa. Agric. syst. 103(2):73-82.
Vaarst M, Byarugaba DK, Nakavuma J, Laker C (2007). Participatory livestock farmer training for improvement of animal health in rural and peri-urban smallholder dairy herds in Jinja, Uganda. Trop. Anim. Health Prod. 39(1):1-11.
Van Asten PJ, Fermont AM, Taulya G (2011). Drought is a major yield loss factor for rainfed East African highland banana. Agric. water manag. 98(4):541-552.
Vermeulen SJ, Campbell BM, Ingram JS (2012). Climate change and food systems. Ann. Rev. Environ. Resour. 37(1):195.