Current Research in Agricultural Sciences
2022 Vol. 9, No. 1, pp. 59-83.
ISSN(e): 2312-6418
ISSN(p): 2313-3716
DOI: 10.18488/cras.v9i1.3048

FARMERS' USE OF INDIGENOUS FRUIT TREES TO COPE WITH CLIMATE VARIABILITY IN THE LAKE VICTORIA BASIN DISTRICTS OF UGANDA

John Bosco Lamoris Okullo[1+]
Francis Omujal[2]
Thomas Enuru[3]
Celestin Bigirimana[4]
Prossy Isubikalu[5]
Jacob Godfrey Agea[6]
Elias Bizuru[7]
Joseph Obua[8]

[1,3,8]*Department of Forestry, Biodiversity& Tourism, College of Agricultural and Environment Sciences. Makerere University, Kampala, Uganda.*
[1]*Email:* jbl.okullo@gmail.com
[3]*Email:* tenuru@gmail.com
[8]*Email:* jobua09@gmail.com
[2]*Natural Chemotherapeutics Research Institute, Ministry of Health, Kampala, Uganda.*
[2]*Email:* fomujal@gmail.com
[4]*Department of Rural Development and Agricultural Economics, College of Agriculture, Animal Sciences and Veterinary Medicine, University of Rwanda, Musanze, Rwanda.*
[4]*Email:* celbigirimana@gmail.com
[5,6]*Department of Extension & Innovation Studies, College of Agricultural and Environment Sciences, Makerere University, Kampala, Uganda.*
[5]*Email:* isubikalu@gmail.com
[6]*Email:* jgagea@gmail.com
[7]*Department of Biology, College of Science and Technology, University of Rwanda, Kigali, Rwanda.*
[7]*Email:* ebizuru@gmail.com

(+ Corresponding author)

Article History
Received: 4 April 2022
Revised: 20 May 2022
Accepted: 8 June 2022
Published: 30 June 2022

Keywords
Adaptation strategies
On-farm trees
Vulnerability
Weather change effects
Wild edible fruits.

ABSTRACT

The escalating extreme weather conditions has forced rural farmers in Africa to rely disproportionately on Indigenous Fruit Trees (IFTs) to sustain their household food/nutrition security, employment and income generation. This paper analysed farmers' use of IFTs to cope with climate variability in selected Lake Victoria Basin Districts of Uganda. Data were collected from farmers using questionnaires, key informant interviews and focus group discussions. From 13 most preferred IFTs, focus was on the most popular and highly ranked five: *Garcinia buchananii*, *Vangueria apiculata*, *Canarium schweinfurthii*, *Tamarindus indica* and *Saba comorensis*. Preferences for these IFTs were influenced by their uses for food, medicine, timber, compound shade provision and marketability. Age, sex, education, occupation, family size, land size, non-farming activities, period of stay on the same piece of land, and income level significantly ($P \le 0.05$) influenced choice of the preferred IFTs. Majority of the respondents had IFTs planted on-farms, along the roads to provide various goods/services and in marginal lands unsuitable for farming to diversify agriculture as a strategy to cope with climate variability. Given that the uses of IFTs in the five LVB districts are associated with farmers' efforts to cope with climate variability, the goal of any climate-adaptive farmer-based project should support sustainable use of IFTs, in the short-term and foster innovations such as on-farm planting of IFTs and other fast-growing tree species to meet household demands.

Contribution/Originality: The paper analysed farmers' use of IFTs to cope with climate variability in selected Lake Victoria Basin Districts of Uganda. Thus, it contributes to an understanding of farmers use of IFTs to cope with the effects of climate change and as a strategy for diversifying and sustainably supporting their livelihoods.

1. INTRODUCTION

Across sub-Saharan Africa, there are many rural households that use natural resources including a wide variety of indigenous plant/wild fruits species and vegetables to meet their daily food and nutrition security as well as generate income [1, 2]. This is because forests can combat climate change, contribute to households' livelihoods and create a base for sustainable economic and social development. Non-Timber Forest Products (NTFPs) from these indigenous plant species have traditionally sustained the African people's lives over centuries [3].

According to Tieminie, et al. [4], rural people in Africa rely on forest resources to cope with climate events and NTFPs play a critical role in this regard. NTFPs are products of biological origin from forests, wooded land and trees outside forests. Among the most widely used NTFPs, wild edible fruits (WEFs) are important sources of nutrition, medicine, and cash income essential for purchasing household goods and services [3].

In addition to their use as food, WEF species also provide fiber, fuel and a range of processed products. The WEF species thrive in diverse environments with agroforestry practices and on urban landscapes, deserts, fallows, natural lands and plantations [5]. One of the key WEFs are Indigenous Fruit Trees (IFTs). IFTs are fruit trees that are native to an area, where they have originated and evolved over centuries [6]. They are different from exotic fruit trees (which have been imported from other continents), although they may be commonly grown [7]. However, IFTs of tropical Africa are not formally traded and are barely acknowledged in research outside Africa [8].

In spite of the above, reliance upon IFTs as a source of household diet especially during drought when there are food shortages is not a new phenomenon in the Lake Victoria Basin (LVB) districts of Uganda [9, 10]. Apart from being a source of income a vital component of the household livelihoods in rural areas, IFTs are also sources of vital nutrients and essential vitamins needed by children below 10 years who are prone to malnutrition [11]. According to CTA [7], IFTs are more resilient to climate change than most exotic crops in Africa. For instance, they can also withstand hot-dry conditions [5] and increase farmers' ability to cope with the negative impacts of climate change [12].

Although Africa is rich in indigenous plant species whose products have traditionally provided employment, income and sustained rural people's lives for centuries [2, 3, 9], climate change and variability present a formidable challenge for rural communities in Africa and other developing countries [13]. The production of IFTs has been ignored by the commercial sectors [2, 5], yet commercialisation of IFTs is central to many livelihood strategies [14] and could be leveraged to improve food and nutrition security, alleviate poverty, reduce inequality and curb environmental degradation in the face of climate variability/change [15].

Climate change results in climate variability, frequency, intensity, spatial extent, duration and timing of extreme weather and climate events [16]. It is a threat to sustainable development due to its grave impact on socio-economic development, particularly in the Global South [17]. The United Nations Framework Convention on Climate Change (UNFCCC) defines climate change as "a an alteration of climate (a long-term shift in temperatures and weather patterns) attributed to human activities that modify the composition of the global atmosphere over comparable time periods" [18]. According to IPCC [19], climate variability is variations in the mean state and other statistics of the climate on all temporal and spatial scales beyond that of individual weather events. It is also the decadal or yearly or seasonal fluctuation of climate elements (e.g., rainfall, temperature, humidity, etc.) above or below a long-term average [16].

Adaptation to climate change and variability is the process of adjustment to actual, experienced or expected climate change /its effects and seeks to moderate harm or exploit beneficial opportunities in human systems. Coping measures, on the other hand, refers to short-term strategies employed by households to lessen the negative repercussions of climate and ecological change on well-being and livelihoods over short period of time normally less than one calendar year [20]. According to Alemayehu and Bewket [21], coping and adaptation to climate change and variability are closely related and interchangeably used in the context of disaster response except that they have different time spans. Coping strategies are autonomous, short-term, location-specific actions and adjustments targeted against a certain hazard and activities that take place within existing structures.

Due to continued decreasing rainfall, higher frequency and severity of droughts [2], mechanisms need to be put in place to enable farmers cope with climate risks such as reduced crop productivity, reduced household livelihoods and food security [20]. This is imperative as IFTs play a crucial role in enhancing societal adaptation to climate variability [3, 22]. Undeniably, the existence of IFTs in the LVB districts - which is now prone to the effects of climate variability [23] is an indication that farmers use IFTs to cope with climate variability.

With a current population of about 45 million people living in the LVB districts of East Africa [24] and the escalating extreme weather conditions (high winds, hailstorms, excessive precipitation, prolonged drought, flooding and wildfires), rural households are being forced to rely disproportionately on IFTs to enhance their coping efforts and adaptation to climate variability [11]. Furthermore, ways in which IFTs help farmers to sustain household food security, nutrition, health and income as a means of coping with and adapting to climate variability have not been investigated in the LVB districts of Uganda. The recurrent crop failures and livestock losses justify the integration of IFTs in the farming systems for food security and income generation. in the LVB districts.

Apart from the above, the continued worsening of the effects of climate change in Uganda [25] and the expansion of agriculture to supply food within the LVB districts is expected to influence the use and conservation of IFTs [26]. This situation is exacerbated by the fact that most research organizations viewed IFTs in the context of multipurpose trees within agroforestry systems [27]. Since climate change is a major environmental and socio-economic challenge in East Africa-the LVB study site inclusive [26], understanding how farmers use IFTs to adapt and cope with the effects of climate variability is crucial to developing and implementing adaptation strategies that can alleviate the adverse effects of climate change in the area .

Bearing in mind that use of particular IFT is influenced by factors such as its abundance, scarcity, ownership and availability, assessing how farmers' socio-economic factors determine availability of IFTs and household decision in using the trees to cope with climate variability becomes paramount. To date, ways in which socio-economic factors shape farmers' use of IFTs to cope with the effects of climate variability in the LVB districts is unknown. More importantly, the need to assess how socio-economic factors shape farmers' use of IFTs to cope with climate variability is based on the fact that many traditional mechanisms to cope with drought have been diminished in Africa where social and economic change: knowledge of famine foods, as well as of food conservation techniques, is progressively disappearing [28]. Since understanding local community perceptions of the impacts, causes and responses to climate change is vital for promotion of community resilience towards climate change [29], it was imperative to analyse farmers' use of IFTs to cope with climate variability. Specifically, the study documented perceived niches/availability of IFTs, assessed farmers' perception of the use and contribution of IFTs to their livelihoods and the socio-economic factors that influence the preferred uses of IFTs among farmers in the LVB Districts of Uganda. The following questions guided the study:

What local knowledge do farming communities have on availability status and preference of IFTs in the LVB? What are the local uses of IFTs, particularly for enhancing communities' adaptation to weather variability? How do IFTs contribute to the enhancing climate change adaptation strategies of rural community in the LVB? How do LVB communities perceive the use of IFTs in enhancing their adaptation to climate change effects? What factors influence community knowledge on the local uses and the contribution of IFTs to climate change adaptation.

2. STUDY AREA AND METHODS

2.1. Study Area

The study was carried out in LVB districts of Uganda covering Buikwe, Busia, Kamuli, Masaka and Namutumba districts Figure 1. Uganda (1° 00' N and 32° 00' E); is one of the LVB landlocked country lying astride the equator. It lies on the north-western shores of Lake Victoria, extending from 1° South to 4° North latitude and 30° to 35° East longitude. Uganda is bordered by Tanzania and Rwanda to the South, Democratic Republic of Congo (DRC) to the West, South Sudan to the North, and Kenya to the East.

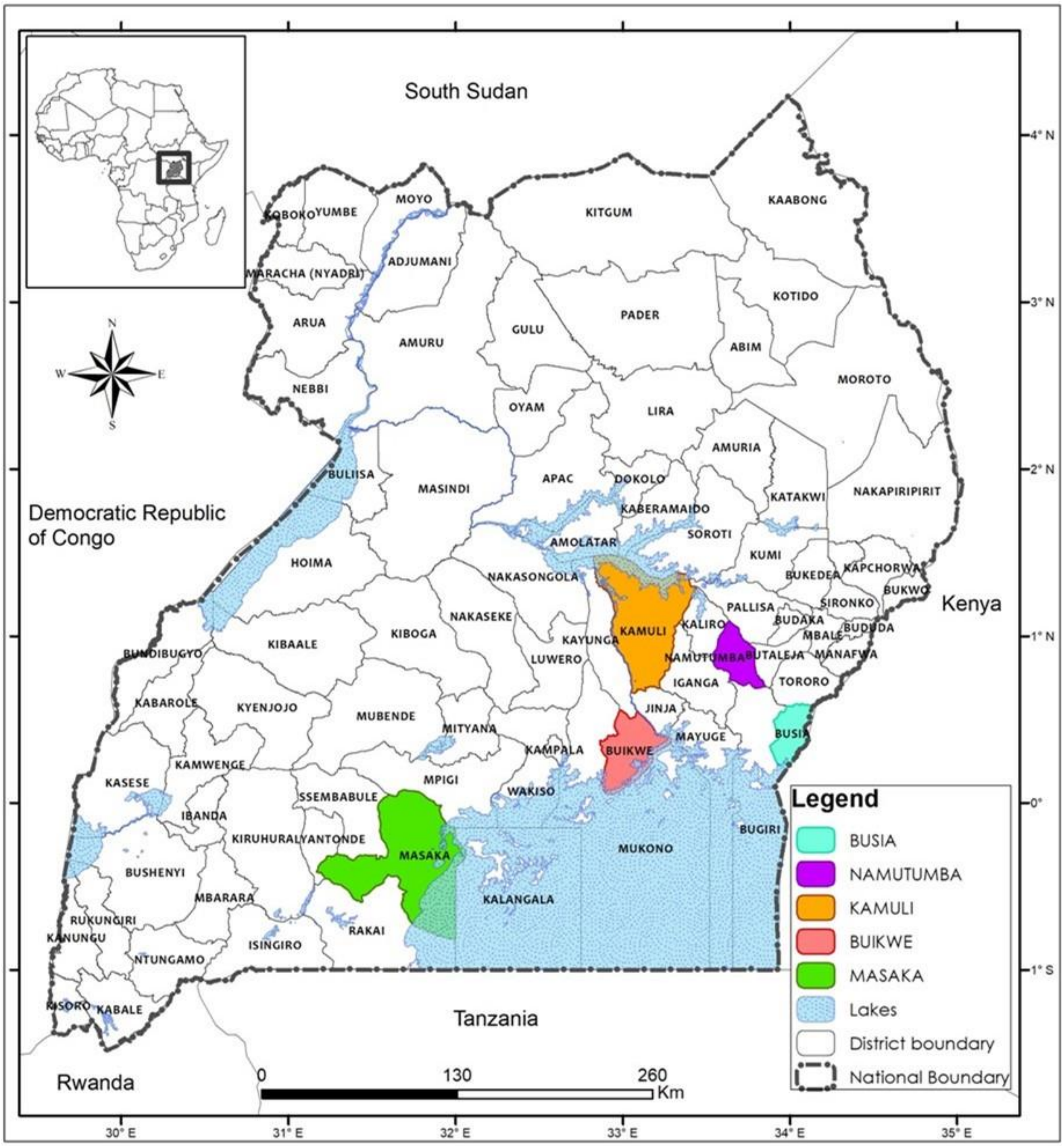

Figure 1. Location of study sites in the Lake Victoria Basin Districts, Uganda.

LVB was chosen because (a) of rapid population growth, urbanization, and industrialization which have stepped up deforestation and (b) it is experiencing a higher magnitude of climate variability effects [24]. The five districts were selected due the high concentration of the most popular IFTs, and high dependence of the population on natural resources for their livelihoods [11].

LVB (68,000 square kilometers) is home to around 40 million people distributed as follows: 51% Kenya, 6% Tanzania and 43% Uganda [30]. With the LVB population growing rate of 3.5 percent each year (which is among the highest in the world), the LVB's population has grown from 35 million in 2006 to about 45 million in 2017. The population density is among the highest in the world averaging more than 500 persons/km^2 and exceeding 1,200 person/km^2 in some parts [26].

LVB has a diverse and dynamic environment. The vegetation consists of variations in a savanna ecosystem dominated by forest-thicket and forest-savanna mosaic, with smaller areas of grassland and tree savanna. The exploitation of natural resource in the LVB is closely defined by the livelihood system, cultural practices and property rights [24], agricultural expansion into forests, unsustainable extraction of forest products and clearing of forests for non-agricultural uses [23].

There is high dependence of the poor on natural resources for livelihoods and the dense population increase pressure on land, forests, catchments and the lake itself. The dense population and low levels of development also drive unsustainable use of natural resources and negatively impact on the basin [23, 24]. LVB was formed by the geological shifts that created the rift valley, thus, its climate is naturally variable and susceptible to flood and drought. agriculture is the most important sector of the economy, employing over 80% of the workforce in the LVB areas of East Africa (Mwaura and Okoboi [27]).

2.2. Research Design

This study employed a mixed-methods approach to gather data in two phases, each phase was a triangulation of quantitative and qualitative methods meant to understand how the socio-economic characteristics influenced the use of specific IFTs. To get a diverse community with high interest in IFTs to work with, the districts were first stratified according to availability of common IFTs and the National Agricultural Zonation in the country [31].

2.3. Data Collection Methods/Procedure

Key Informant Interview (KII), Focus Group Discussion (FGD) and Interviewer-administered questionnaire were used to collect data in the local language [32]. To ensure data validity and reliability, research assistants with tertiary education were recruited and trained in data collection techniques. To identify districts with diversity of IFTs, diagnostic studies and Participatory Rural Appraisal (PRA) were carried out in Masaka, Buikwe, Kamuli, Namutumba, Kaliro, Iganga, Mpigi, Rakai, Sembabule, Busia and Kayunga districts. Based on prior information collected on available IFTs from the key informants, Buikwe, Busia, Kamuli, Masaka and Namutumba districts were purposively selected. A total of 400 households (80 households per district) were interviewed using a semi-structured questionnaire to document local knowledge and perceptions about IFTs. The questionnaire was pre-tested to refine the questions and clarity before final administration [29]. To ensure triangulation of findings, focus group discussions (FGDs) were held to share, validate and explore the findings of the household survey [10]. Key informant interviews and informal discussions were held with farmers to refine the questions [29].

After the IFTs were listed, each respondent was asked to rank and prioritise them as first, second and third based on attributes such as food, taste, medicine, juice, sauce, food preservative, food additive and timber [33, 34]. A species was prioritized by a total number of people raising the hands. The two best IFTs were further discussed for preferences as food, medicine, income generation and adaptation to climate variability. Other information collected included availability, propagation techniques and local growing niches of IFTs. Ecosystem services provided by the fruit trees reflect how trees in agricultural landscapes can empower societies to cope with the effects of climate variability.

The challenges and opportunities for sustainable use and management of IFTs were discussed [29]. The scientific names of the IFTs were confirmed by a taxonomist while pressed samples were taken to Makerere University Herbarium for further identification [33]. Availability of IFTs were categorised as abundant, few and scarce/rare following a modification from [35].

2.4. Statistical Data Analysis

Household survey data were coded, entered in SPSS software and analysed in STATA to generate descriptive statistics (percentages and frequencies) on abundance, reasons for farmers' preferences and use of IFTs to enhance farmers' coping strategies to climate change effects [36]. The percentage of respondents' preference for an IFT was calculated as follows [9].

$$X_i (\%) = \frac{ni}{N} x \ 100$$

Where:

X_i: The percentage of groups having ranked the species i as priority IFT.

Ni: The total number of groups having selected the species i as priority IFT.

N: The total number of groups surveyed.

For each IFT, X_i was calculated for the overall value, food, medicinal and commercial values. Only the overall value was considered in the selection of priority IFT, as it integrated food, medicine and economic/commercial values. IFTs with the highest percentage of respondents' preference were selected as a priority. For each district, a short list of three priority IFTs was generated [12].

Both qualitative and quantitative techniques were used to analyse data. Before processing the responses, the completed copes of the questionnaire were edited for completeness and consistency in responses. Qualitative data were summarized using text analyses [37] while information obtained from the PRA group interviews was analysed on the spot by recording consensus conclusions from the participants [10]. Data from the FGD, KIIs and informal discussions were subjected to content analysis to generate emerging themes [38].

Quantitative data were tabulated and analysed using descriptive statistics and OLS regression analysis in Microsoft Excel and STATA version-13 [39]. Data were summarized into frequencies, percentages, mean and standard deviation and quantitative variables were presented in tables and graphs [40]. Descriptive statistics were used because they enabled the research to meaningfully describe the distribution of scores using a few indices. Growing niches for each IFT were determined and data subjected to logistic regression analysis to examine factors influencing farmers' knowledge of abundance, availability, propagation techniques and use of IFTs for climate change adaptation [1, 29].

3. RESULTS

3.1. Socio-Economic and Demographic Characteristics of the Respondents

Buikwe and Masaka districts had more females while Masaka district had the highest number of widowed respondents Table 1. Namutumba and Busia districts had the youngest respondents. All respondents in Kamuli and Namutumba districts owned land and carried out farming as an economic activity whereas respondents in Buikwe and Masaka districts had the smallest family size and high monthly incomes Table 1. In general, 60% of the respondents were males and 77% were married. Seventy one percent did not have formal education or stopped in primary school, 90% were peasant farmers and 99% owned farm land. The average land holding was six acres while the household size was eight members Table 1.

3.2. IFTs Commonly Found in the LVB Districts

A total of 13 IFTs belonging to 10 families were recorded in the five LVB districts. Two indigenous fruit species belonged the family apocynaceae and anacardiaceae while Burseraceae, Sapotaceae, Flacourtiaceae, Moraceae, Clusiaceae, Fabaceae, Rubiaceae and Arecaceae had one species each.

Table 1. Socio-economic and demographic characteristics of the respondents (N=400).

Variables	**Districts (Uganda)**						
Variables & their Descriptions	**Buikwe (N=80)**	**Busia (N=80)**	**Masaka (N=80)**	**Kamuli (N=80)**	**Namutumba (N=80)**	**P≤0.05**	**Total (N=400)**
Age (Years)							
Mean	54(16)	47(15)	50(15)	52(15)	46(9)	0.008	50(16)
Min	20-102	23-85	23-92	24-90	20-88		20-102
Max	102	85	92	90	88		102
Median	52	49	50	52	43		50
Sex (%)							
Male	41.3	78.9	41.7	76.2	60.5		59.72
Female	58.7	21.1	58.3	23.8	39.5		40.28
Marital status (%)							
Single	06.2	05.1	07.5	02.5	05.1		05.30
Married	67.5	76.2	72.5	84.3	83.5		76.76
Divorced	03.8	02.5	08.8	05.5	03.8		04.88
Widowed	22.5	16.2	11.2	07.7	07.6		13.06
Level of Education (%)							
None	27.4	17.7	15.0	17.5	32.2		22.2
Primary	51.3	59.5	56.2	35.0	41.8		48.8
Secondary	20.0	17.7	17.5	42.5	17.7		23.2
College	01.3	05.1	11.3	05.0	08.3		05.8
Main occupation (%)							
Farming	90	97.5	94.5	100	98.7		96.00
Civil service	04.5	01.3	03.8	0.00	01.3		02.00
Others (Petty business, etc)	05.5	01.2	01.3	0.00	00.0		02.00
Family size							
Mean (SD)	07(4)	10(6)	06(2)	10(8)	09(5)	0.000	08(06)
Range	01-120	03-35	01-12	01-65	01-25		01
Min	01	03	01	01	01		01
Max	20	35	12	67	25		67
Median	06	09	05	08	08		07
Household land ownership							
Owned land	96.3	98.8	98.8	100.0	100.0		98.8
Type of land ownership							
Freehold	13.8	60.3	00.0	08.3	30.0		22.5
Customary/inherited	52.5	22.6	17.5	88.9	70.0		50.3
Hired/rented	03.7	17.1	05.0	00.0	00.0-		05.2
Mailo	00.0	00.0-	05.0	00.0	00.0		01.0
Tenancy	30.0	00.0	72.5	00.0	00.0-		20.5
Given	00.0	00.0	00.0	02.8	00.0		00.6
Period spent in the area (years)							
Mean (SD)	32(19)	38(17)	33(18)	43(20)	34(22)	0.003	36(19)
Min	02	06	02	09	01		01
Max	70	85	90	88	88		90
Median	30	36	30	41	30		35
Approximate monthly income ('000) UGX							
Mean (SD)	211(652)	60(101)	223.0(274)	191(194)	123(243)	0.012	159(331)
Min	03	05	05	25	05		03
Max	5,000	700	2,000	1,000	1,700		5,000
Median	90	30	150	100	50		80

Among the fruit tree species, *Rhus vulgaris* (anacardiaceae) was recorded in all the districts while *C. schweinfurthii (*Burseraceae) and *T. indica* (Fabaceae) were reported in four districts except Busia and Masaka districts, respectively. With the exception of *T. indica*, Buikwe and Masaka district had the same IFTs Table 2. The five most common IFT species were *T. indica*, *C. schweinfurthii*, *Garcinia buchananii*, *Saba comorensis* and *Carisa edulis* reported by 52.25%, 35.75%, 26%, 25% and 20.75% of the respondents respectively Table 2.

Table 2. IFTs found in the five LVB districts.

Common and Available IFTs		N= 400	Districts				
Scientific name and (Family)	**Local name (dialect)**	**%**	**Buikwe**	**Busia**	**Masaka**	**Kamuli**	**Namutumba**
Tamarindus indica (Fabaceae)	Enkoge (LUG)/ Nkoge (LUS) Omuhuwa (SAM)	52.25	*	*	-	*	*
Canarium schweinfurthii Burseraceae	Embafu /mbafu (LUG)/Mpafu (LUS)	35.75	*	-	*	*	*
Garcinia buchannanii (Clusiaceae)	Ensaali (LUG)/ nsaali (LUS)	26.00	*	-	*	*	-
Saba comorensis (Apocynaceae)	Amachawungo (SAM)	25.00	-	*	-	-	*
Carisa edulis (Apocynaceae)	Enyonza (LUG)/ Ntooga (LUS)	20.75	*	-	*	-	*
Rhus vulgaris (Anacardiaceae)	Akonsonkonso (LUG)/ Owayo (SAM)/Busogyole (LUS)	18.00	*	*	*	*	*
Vangueria apiculata (Rubiaceae)	Matungunda (LUG)	17.75	*	-	*	*	-
Dovyalis macrocalyx (Flacourtiaceae)	Osongola (SAM)	16.00	-	*	-	-	-
Chrysophyllum albidum (Sapotaceae)	Amahuu (SAM), Malulu (LUS)	14.50	-	*	-	-	*
Pseudospondias microcarpa (Anacardiaceae)	Ensiru (LUG)	13.75	*		*	-	-
Ficus sur (Moraceae)	Amahuyu (SAM)/Omukunyu (LUG)	03.75	-	*	-	-	-
Phoenix reclinata (Arecaceae)	Empiruvuma (LUG)	00.75	*	-	*	*	-
Vitex doniana (Verbenacea)	Amafudu (SAM)	00.50	-	*	-	-	-

Note: LUG = Luganda, LUS = Lusoga, SAM = Samia.
* = Fruit Tree Present.
- = Fruit Tree Absent.

3.3. Perceived Availability of IFTS in the LVB Districts

The perceived availability status of IFTs in the five LVB districts of Uganda is presented in Table 3. In Busia district, *T. indica* was reported by 59.5% and *S. comorensis* by 56.1% of the respondents as the most abundant and occasionally abundant, respectively. *Rhus vulgaris, D. macrocalyx, F. sur, C. albidum* and *V. doniana* were reported by 60.0%, 45.5%, 87.5%, 66.7% *and* 100.0% of the respondents respectively as rare in Busia district. In Buikwe district, C. *schweinfurthii, G. buchananii, T. Indica,, C. edulis and V. apiculata* were reported by 43.8%, 36.6%, 44.1%, 40.0% and 47.4% of the respondents respectively as occasionally occurring while *Rhus vulgaris* and *Phoenix reclinata* were reported by 37.5% and 100% of the respondents respectively as rare.

In Masaka district, *C. schweinfurthii, G. buchananii, C. edulis, V. apiculata, R. vulgaris and P.reclinata* were reported by 72.0%, 73.3%, 54.5%, 51.6%, 55.6% and 100% of the respondents respectively as scarce. Although in Namutumba district *T. indica* was reported by 44.8% of the farmers as abundant, C. *schweinfurthii and C. edulis* were reported by 50% and 48.9% of the farmers respectively as occasionally available while *R. vulgaris* and *S. comorensis* were reported by 42.9% and 38.1% of the farmers respectively as scarce Table 3

Table 3. Perceived availability of IFTs.

District	IFT species	Respondents (%)	Availability Status (%)		
			Abundant	Few (less abundant)	Scarce/Rare
Busia	*R.vulgaris*	15.0	00.0	00.0	100.0
	S. comorensis	51.0	02.4	56.1	41.5
	T.indica	53.0	59.5	28.6	11.9
	D.macrocalyx	33.0	03.0	12.1	84.9
	Ficus sur	08.0	00.0	12.8	87.5
	C.albidum	27.0	03.7	14.8	81.5
	V.doniana	01.0	00.0	00.0	100.0
Buikwe	*R.vulgaris*	14.0	00.0	28.6	71.4
	C. schweinfurthii	32.0	31.3	43.8	25.0
	P. reclinata	02.0	00.0	00.0	100.0
	T.indica	34.0	29.4	44.1	26.5
	G. buchananii.	51.0	14.6	36.6	48.7
	C.edulis	05.0	00.0	40.0	60.0
	V.apiculata	38.0	23.7	47.4	29.0
Kamuli	*R.vulgaris*	02.0	00.0	50.0	50.0-
	C.schweinfurthii	75.0	10.7	52.0	37.4
	T.indica	95.0	34.2	56.6	09.2
	G.buchananii	13.0	00.0	15.4	84.6
	C. edulis	02.0	00.0	00.0	100.0
	C.albidum	13.0	07.7	07.7	84.6
Masaka	*R.vulgaris*	18.0	00.0	27.8	72.3
	C. schweinfurthii	25.0	00.0	8.0	92.0
	P.reclinata	03.0	00.0	00.0	100.0
	G.buchananii.	45.0	02.2	11.1	86.6
	C.edulis	11.0	09.1	00.0	90.9
	V.apiculata	31.0	12.9	29.0	52.1
Namutumba	*R. vulgaris*	28.0	17.9	21.4	60.8
	C. schweinfurthii	10.0	30.0	50.0	20.0
	T.indica	29.0	44.8	41.4	13.8
	G.buchananii.	05.0	20.0	00.0	80.0
	C.edulis	47.0	23.4	48.9	27.7
	S.comorensis	21.0	00.0	09.5	90.5

3.4. Perceived niches of IFTs in the Five LVB District s

Respondents knew of the IFTs growing niches such as wilderness, crop fields and agricultural land. In Busia district, *T. indica* was mentioned by 54.3% of the respondents as growing on home compounds while S. *comorensis*, *R. vulgaris*, *D. macrocalyx*, *F. sur*, *C. albidum* and *V. doniana* were reported respectively by 74.3%, 88.9%, 80.9%, 60%, 80.9% and 50% of the respondents as most available in crop fields and boundaries Table 4.

In Buikwe district, *R. vulgaris*, *T. indica*, *C. schweinfurthii* and *V. apiculata* were reported by 50%, 62.5%, 46.4% and 66.7% of the respondents respectively as mostly found on home compounds while *C. edulis* were reported by 66.7% of the respondents as growing in the crop fields and boundaries. In Masaka district, *R. vulgaris*, *G. buchananii*, *C. schweinfurthii*, *P. reclinata* and C. *edulis* were reported respectively by 100%, 61.1%, 80% and 100% of the respondents to be present in the crop fields and boundaries except *V. apiculata* that was reported by 53.8% to be present in the home compounds Table 4.

3.5. Preferences and Use of IFTS to Enhance Respondents' Coping Strategies against Climate Variability

Preferences for and use of IFTs to enhance respondents' coping strategies against climate variability differed in the districts. The IFTs were preferred and eaten as snacks in all the districts Table 5.

Table 4. Growing niches of the IFTs.

District	IFT species	Respondents (N)	Location niches (%)			
			Homestead compounds	Wilderness	Garden boundaries	Others niches*
Busia	*R.vulgaris*	18	05.6	05.6	88.9	00.0
	S.comorensis	69	07.1	15.7	74.3	00.0
	T.indica	80	54.3	22.9	21.0	01.8
	D.macrocalyx	31	06.5	12.9	80.6	00.0
	F.sur	05	40.0	00.0	60.0	00.0
	C. albidum	20	00.0	09.5	80.9	00.0
	V.doniana	02	50.0	00.0	50.0	00.0
Buikwe	*R.vulgaris*	10	50.0	10.0	40.0	00.0
	C.schweinfurthii	29	46.4	46.4	07.2	00.0
	P. reclinata	00	00.0	00.0	00.0	00.0
	T.indica	32	62.5	28.1	09.4	00.0
	G.buchananii.	00	00.0	00.0	00.0	00.0
	C. edulis	03	33.3	00.0	66.7	00.0
	V.apiculata	30	66.7	20.0	06.7	06.7
Kamuli	*R.vulgaris*	00	00.0	00.0	00.0	00.0
	C.schweinfurthii	69	13.7	44.2	42.1	00.0
	T. indica	00	37.3	34.3	28.5	00.0
	G. buchananii.	07	00.0	00.0	100.0	00.0
	C.edulis	00	00.0	00.0	00.0	00.0
	C.albidum	03	33.3	66.7	00.0	00.0
Masaka	*R.vulgaris*	14	00.0	00.0	100.0	00.0
	C.schweinfurthii	21	09.5	23.8	66.7	00.0
	P.reclinata	05	00.0	20.0	80.0	00.0
	G.buchananii.	36	25.0	13.9	61.1	00.0
	C.edulis	15	00.0	00.0	100.0	00.0
	V.apiculata	26	53.8	07.7	38.5	00.0
Namutumba	*R.vulgaris*	14	00.0	00.0	100.0	00.0
	C.schweinfurthii	07	85.7	00.0	14.3	00.0
	T.indica	23	47.8	17.4	34.8	00.0
	G.buchananii.	11	63.6	00.0	36.4	00.0
	C.edulis	37	00.0	16.4	83.8	00.0
	S.comorensis	07	00.0	14.3	57.1	28.6

Note: * Others include Swamps, Road sides and Orchards.

The preference for and use of IFTs as snacks was exceptionally high for *T. indica* in Busia, Namutumba and Kamuli districts. The preference for and use of *C. schweinfurthii* as a snack was higher in Kamuli than in Masaka, Buikwe and Namutumba districts.

Although *G. buchananii* was the most preferred and ranked first in Buikwe and third in Masaka districts respectively, its preference and use as snack was higher in Masaka than Buikwe district. There were similar preferences for *T. indica* as a snack in Namumba and Busia districts respectively. The preference for *G. buchananii* and *C. schweinfurthii*; as snack or medicine were the same in Buikwe and Masaka districts respectively. *C. edulis* was the most preferred as a source of herbal medicine in Namutumba district Table 5.

In Buikwe district, *G. buchananii*, *V. apiculata* and *C. schweinfurthii* were the most preferred and reported by 52%, 48.8% and 45% of the respective respondents while in Busia district; *T. indica*, *S. comorensis* and *C. albidum* were the most preferred and reported by 95%, 87.5% and 82.5% of the respondents respectively. In Masaka district, *V. apiculata*, *C. schweinfurthii* and *G. buchananii* were reported by 76.2%, 57.5% and 41.2% as the most preferred for enhancing farmers coping strategies against climate variability as they were eaten as snacks, used as medicine and sold. *Tamarindus indica*, *S. comorensis* and *C. schweinfurthii* were the most preferred because of their market values and shielded respondents against the effects of climate variability Table 5.

In Busia district, *T. indica* was the most preferred IFT species followed by *S. comorensis* and *C. albidum* as a food additive while in Namutumba district, the most preferred IFT species was *C. schweinfurthii* followed by *T. indica*. In Kamuli district, *C. schweinfurthii* was ranked higher than other IFTs while *G. buchananii* and *V. apiculata* were the most preferred in Buikwe district. *V. apiculata* and *C. schweinfurthii* were the most preferred species in Masaka district Table 5.

Logit and probit analyses showed that age, sex, education, occupation, income and period of stay on the land influenced the respondents' preference for IFTs and were ranked first, second or third Table 6.

Age with a negative coefficient and marital status plus period stayed on same piece of land significantly influenced ($P \leq 0.05$) the preference and ranking of *S. comorensis* as third most important in Busia district. Number of members in a household and education positively and significantly influenced ($P \leq 0.05$) the preference for and ranking of *C. albidum* as the third most important IFT in Busia district. Although the type of non-farming activity had a significant negative coefficient effect ($P \leq 0.05$) on the ranking of *T. indica* as the most preferred in Busia district; sex, occupation, land size and income positively influenced its ranking as the most preferred in Kamuli district.

The younger respondents were 0.938 times and 0.881 times more likely to prefer *T. indica* and *S. comorensis* as second and third most preferred IFTs in Busia district. The older respondent were 1.178 times more likely to prefer C. *albidum* as third most important in Busia district, 1.051 times more likely to prefer *T. indica* as third most important in Kamuli and 1.091 times more likely to prefer *C. edulis* as third most important in Masaka district.

The study also revealed that low level of education was 0.210 times more likely to influence choice of *C. albidum* as the third most important IFT whereas those with higher level of education were 7.520 times more likely to prefer *V. apiculata* as the fourth most important and those with tertiary education were 6.80 times more likely to rank *V. apiculata* as second most important IFT. At te same time, respondents who were involved in crop farming were 0.302 times, 1.701 times and 38.424 times more likely to rank *C. schweinfurthii*, *G. buchananii* and *C. albidum* as first, second and third most important IFTs respectively Table 6.

In terms of marriage, the results show that single respondents were 0.129 times more likely to rank *T. indica* as most important IFT in Namutumba district while married respondents were 8.116 times more likely to rank *S. comorensis* as the third most important in Busia district. In regard to gender, female respondents were 0.145 times more likely to rank *T. indica* as second choice in Kamuli district while male respondents were 416.923 times and 11.152 times more likely to rank it as first and third most important in Kamuli and Buikwe districts respectively

The respondents with high incomes (UGX ≥ 385,000/=) were 1.000 times more likely to rank *C. schweinfurthii* and *T. indica* as most important in Kamuli district while those with low incomes (UGX ≤ 123,000/=.) were 1.000 times more likely to rank *C. edulis* as the third most important IFT in Namutumba district. Respondents who had stayed longer on the same piece of land were 1.120 times more likely to rank S. *comorensis* as third most important in Busia district while those who had stayed for a short period on the same piece of land were 0.957 times and 0.937 times more likely to rank *C. schweinfurthii* as third and fourth most important IFTs in Kamuli and Buikwe districts respectively Table 6.

With regard to marital status, single respondents were 0.129 times more likely to prefer *T. indica* as the most important in Namutumba district while married respondents were 8.116 times more likely to rank *S. comorensis* as third most important choice in Busia district. On the other hand, female respondents were 0.145 times more likely to rank *T. indica* as the second choice in Kamuli district while male respondents were 416.923 times and 11.152 times more likely to rank *T. indica* as first and third most important IFTs in Kamuli and Buikwe districts respectively Table 6.

Table 5. Preferences and use of IFTs to enhance coping strategies.

District	Scientific name	% Response (N=80)	Preference (Ranking)	Reason for use Preferences (%)							
				As snacks	As medicine	Market potential	As food additive	Its taste	As timber	More fruit yield	Shade provision
Buikwe	*G. buchananii*	52.5	1st	39.1	30.4	00.0	00.0	39.0	00.0	00.0	00.0
	V. apiculata	48.8	2nd	45.0	05.0	00.0	00.0	25.0	00.0	00.0	00.0
	C. schweinfurthii	45.0	3rd	40.0	15.5	12.5	00.0	03.8	00.0	00.0	00.0
Busia	*T. indica*	95.0	1st	81.1	18.9	05.4	37.8	02.8	04.1	00.0	00.0
	S. comorensis	87.5	2nd	63.4	30.0	05.1	11.6	15.0	00.0	00.0	00.0
	C. albidum	82.5	3rd	57.9	15.8	00.0	10.6	00.0	05.3	05.3	00.0
Masaka	*V. apiculata*	76.2	1st	82.4	11.8	00.0	00.0	23.5	00.0	00.0	00.0
	C. schweinfurthii	57.5	2nd	44.4	38.9	05.6	00.0	22.3	00.0	00.0	00.0
	G. buchananii	41.2	3rd	55.9	23.5	00.0	00.0	02.9	00.0	02.9	02.9
Namutumba	*C. edulis*	80.2	1st	89.1	56.5	00.0	00.0	06.5	00.0	00.0	00.0
	T. indica	76.3	2nd	89.5	26.3	05.3	00.0	05.3	00.0	00.0	00.0
	C. schweinfurthii	57.1	3rd	57.1	28.6	28.6	00.0	00.0	00.0	00.0	00.0
Kamuli	*C. schweinfurthii*	78.8	1st	69.1	07.4	27.9	00.0	11.8	00.0	00.0	00.0
	T. indica	57.5	2nd	87.4	45.5	01.5	00.0	01.5	00.0	00.0	00.0
	C. albidum	53.6	3rd	100	00.0	00.0	00.0	00.0	00.0	00.0	00.0

Table 6. Socio-demographic variables that influenced choice, preferences and use of IFTS to enhance coping with climate variability.

IFTs	Variables	District	N	Preference Ranks	Logit			Probit	
					Coefficient	p-Value	Odd ratio	dF/dx	Coefficient
S.comorensis	Age	Busia	80	3rd choice	-0.1267	0.030	0.8809	-0.0084	0.033
	Marital status	Busia	80	3rd choice	2.0937	0.012	8.1156	0.1438	0.013
	Period stayed on land	Busia	80	3rd choice	0.1131	0.060	1.1197	0.0086	0.044
C. albidum	Age	Busia	80	3rd choice	0.1637	0.011	1.1777	0.0039	0.007
	No. of members in a household	Busia	80	3rd choice	-0.3171	0.017	0.7283	-0.0076	0.013
	Education	Busia	80	3rd choice	-1.5587	0.039	0.2104	0.0358	0.042
	Occupation	Busia	80	3rd choice	3.6487	0.010	38.4243	0.1319	0.013
T.indica	Non farming activity	Busia	80	1st choice	-0.1480	0.020	0.8624	-0.0335	0.020
	Age	Busia	80	2nd choice	-0.0633	0.039	0.9387	-0.0140	0.037
	Sex	Buikwe	80	3rd choice	2.4112	0.039	11.1522	0.1983	0.038
	Sex	Kamuli	80	1st choice	6.0329	0.047	416.9229	0.0004	0.044
	Occupation	Kamuli	80	1st choice	5.8958	0.048	363.5148	0.0004	0.048
	Land size	Kamuli	80	1st choice	1.1984	0.039	3.3148	0.0001	0.037
	Income	Kamuli	80	1st choice	0.0000	0.050	1.0000	-0.0000	0.045
	Sex	Kamuli	80	2nd choice	-1.9319	0.011	0.1449	-0.3187	0.007

	Occupation	Kamuli	80	2nd choice	-1.4896	0.019	0.2255	-0.2405	0.015
	Age	Kamuli	80	3rd choice	0.0497	0.027	1.0509	0.0108	0.023
G.buchannanii	Occupation	Buikwe	80	2nd choice	0.5311	0.038	1.7001	0.0325	0.035
C.schweinfurthii	Income	Kamuli	80	1st Choice	0.0000	0.028	1.0000	0.0000	0.024
	Period of stay on the land	Buikwe	80	4th Choice	-0.0652	0.050	0.9368	-0.0011	0.036
	Period of stay on the land	Kamuli	80	3rd choice	-0.0437	0.040	0.9572	-0.0051	0.039
	Occupation	Kamuli	80	1st Choice	-1.1980	0.042	0.3017	-0.2467	0.034
C.edulis	Age	Masaka	79	3rd choice	0.0875	0.028	1.0914	0.0043	0.033
	Marital status	Namutumba	80	1st Choice	-2.0471	0.032	0.1291	-0.0500	0.031
	Income	Namutumba	80	3rd Choice	-0.0000	0.047	1.0000	-0.0000	0.054
V. apiculata	Education	Masaka	80	4th Choice	2.0175	0.040	7.5197	0.1081	0.040
	Qualification	Masaka	80	2nd choice	1.9161	0.035	6.7999	0.2099	0.027

3.6. Effects of climate variability in the five LVB Districts

All respondents reported that climate variability and climate change had affected their livelihoods in one way or another and the indicators are presented in Table 7.

Table 7. Effects of climate variability in the five LVB districts (N=400).

Effects of climate variability	% Response
Pre-mature drying of crops	55.5
Poor crop harvest yields	53.5
Increased drought months	46.5
Increased pest/disease incidences	43.8
Frequent climate related hazards	43.5
Increased occurrences of wind and soil erosion	30.0
Increased famine	29.5
Increased soil compaction	27.8

Table 7 shows that 55.5% of the respondents mentioned pre-mature drying of crop/crop failure as the primary indicator of the effects of climate change/variability, followed by poor yields and increase in the number of dry months reported by 53.5% and 46.5% of the respondents respectively. Increased pests and diseases incidences, frequent climate related hazards, increased occurrences of wind and soil erosion, increased famine and soil compaction were linked to climate change by 43.8%, 43.5%, 30%, 29.5% and 27.8% .4 of the respondents respectively Table 7.

3.7. Strategies to cope with climate variability

To minimize the effects of climate variability, farmers reported that they practiced water harvesting, diversification of agriculture through incorporation of IFs, practicing conservation agriculture/conservation tillage; on-farm soil-water management; and engagement in off-farm activities reported by more than 50% of the respondents Table 8.

Table 8. Strategies to cope with climate variability.

Coping strategies against climate variability	% Response
Water Harvesting/management	60.0
Diversification of agricultural crops	56.3
Practicing conservation agriculture	52.5
Engagement in off-farm activities as income source diversification	50.6
Use of IFTs for fruits/firewood etc.	31.8
Using IFTs as medicine	31.3
Distribution of seedlings to the communities	30.5
Proper timing/adjustment of planting season	29.8
Selling of some household items	27.3
Wetlands farming	26.5
Buying food/borrowing food from others.	19.5
Planting disease resistant crops	12.0
Seeking information on seasonal climate forecasts	10.8
Minimize cutting of trees	07.5
Applying Pesticides/fertilizers	05.8

More than 30% of the respondents reported use of branches of trees (IFTs inclusive) for firewood/construction materials for granaries and engagement in off-farm activities as their major coping strategies with climate variability and over 20% reported proper timing of planting season, using IFTs as medicinal plants to manage pests and diseases incidences, selling of some household items, borrowing food from others and farming in wetlands and at valley bottom/flood recession cultivation (e.g. land drainage interventions) respectively as their major strategies for coping with climate variability Table 8.

Other practices included used of mixed farming, early and late planting (changing sowing periods), application of pesticides, construction of trenches, establishment of tree nursery for distribution of seeds to the community, using IFTs to manage prevalent diseases such as malaria, diarrhoea, cough and skin disease infections that are associated with effects of changes in climate. Further measures included use of plant phenology such as shading of leaves by *Ficus sur* to predict on-set of dry spell and leaf flush to predict the on-set of rains.

4. DISCUSSION

4.1. Niches and availability of IFTs

The 13 IFTs documented in the five LVB districts of Uganda is a rather low number given that Uganda and other African countries have rich diversity of IFTs [33, 41]. Although a total of 105, 700 and 400 wild fruit plants were inventoried in Uganda, Tanzania and Kenya respectively [9], the few reported IFTs in this study could be due to few study districts covered or mixing up of naturalized with indigenous fruit trees [10]. To most respondents, naturalised fruit trees like mangoes, oranges and jack fruit are regarded as truly indigenous. A similar study in Malawi and Zimbabwe also revealed that most farmers could not differentiate some exotic from indigenous fruit trees [42]. This implies that future studies on IFTs could borrow and incorporate community perceived definitions of IFTs, especially when conducting on-farm trials of the prioritized IFTs.

Availability of IFTs differed greatly by districts. *T. indica*, for instance, was reported to be abundant in Busia district and few in Kamuli district. This implies that more abundant species are either more likely to be prioritized [42] or are chosen based on their multiple-use values [9].Variations in abundance of IFTs in the LVB districts could also be attributed to increased clearance of natural vegetation for settlement/crop farming and increased human population in some districts compared to others [43] because communal areas with forests are viewed as common property with free access that results in over exploitation. Over exploitation of IFTs adversely affects the livelihoods of the rural poor who depend on them [4, 44].

The high abundance of some IFTs (e.g., *T. indica* and *C. schweinfurthii*) reported in certain districts could be as a result of increased retention and demand for their uses as food, medicine and income [45]. Apart from on-farm maintenance of landraces and integration of IFTs in agricultural production systems [29], *in situ* conservation ought to be promoted to reduce the risks inherent to monocultures of staple food crops [36].

Having *C. schweinfurthii*, *T. indica* and *G. buchananii* in farmers' crop gardens indicates that farmers are making extra efforts to grow IFTs in a bid to enhance their adaptation strategies to climate variability [1]. Since the IFTs mostly grow in the wild [18]; extension workers need to sensitize farmers in the LVB districts to domesticate them. This effort should be preceded by training on propagation and management techniques of the preferred IFTs [19] including provision of proper planting materials [42]. Farmers in the LVB districts of Uganda also protect IFTs on their home compounds Figure 2 to cope with climate variability.

Unlike domesticated fruit trees, well protected IFTs have become scarcer due to unsustainable harvesting for various products/purposes [29]. Reduction of IFTs has led to negative effects on the farmers who benefit from such IFT products [3]. The disappearance of IFTs can lead to loss of indigenous technical knowledge of preferred IFTs and their roles in enabling communities to cope with the effects of climate variability. Continued destruction of natural resources have similarly led to reduced dietary use of IFTs among LVB communities [43]. This has resulted in incidences of nutrition-related disorders; and disrupted coexistence of people and IFTs [44]. Such disruptions cuase loss of traditional knowledge desired for sustainable use/management of IFTs [45].

Figure 2. *T. indica* growing on a home compound.

4.2. Preferences and use of IFTs to cope with climate variability

Preferences for and use of IFTs such as *T. indica* and *C. albidum* to enhance farmers' coping strategies against climate variability varied in the LVB districts perhaps due to differences in socio-cultural backgrounds of the local communities [11]. Much as farmers are able to prioritize IFTs, such ranking would vary with ethnic groups and availability of IFTs [10]. Consequently, species that are not locally available would get low ranking even though the same could be highly ranked in the areas where they are abundant [46].

IFTs occurring across East and Central Africa [9, 47] can be promoted through on-far growing, processing and marketing to increase income for improved livelihoods [3]. Prioritization of IFTs with potential to contribute to food security can expedite their domestication [8], thereby halting their overexploitation. To enhance on-farm domestication of IFTs [11], the preferred IFTs should be tried on-farm together with naturalized species [45].

Some similarities in preferences for IFTs among respondents could be due to their socio-cultural backgrounds. For example, in Buikwe and Masaka districts (inhabited mostly by the Baganda ethnic group), the respondents preferred *G. buchananii* and *V. apiculata* while in Namutumba and Kamuli districts (inhabited mostly by the Basoga ethnic group), the respondents preferred *T. indica.* As reported by Kugedera [47], the IFTs are preferred by the ethnic groups for spiritual inspiration, cultural identity and recreation.

Apart from *T. indica* and *C. schweinfurthii*, preferred for learning and support experiences that uphold moral, religious and aesthetic values by many communities in the LVB districts, the trees also provide shade and shelter. The ecosystem services provided by the IFTs reflect how trees in agricultural landscapes can enable societies realize cultural needs [29] while at the same time empowering them to cope with the effects of climate variability [3].

IFTs can also enhance household income [14, 46] for instance, in Buikwe district, *C. schweinfurthii* fruits are sold n the local markets and also eaten as snacks Figure 3.

Figure 3. Fruits of *C. schweinfurthii* eaten as sauce and sold for cash income.

To reinforce the marketability of *C. schweinfurthii*, middle sales men usually book the fruits when still on the tree before ripening. Apart from income being used by households to pay for school fees, buy scholastic materials for children and agricultural crop planting materials, retention of *C. schweinfurthii* and other IFTs can also improve biodiversity, reduce soil erosion, and enhance the capacity of soil to hold water [33]. This means that integrating IFTs on-farms can be beneficial for farmers, especially those struggling to cope with the impacts of climate change [3].

While preferences and uses of IFTs for medicines can have beneficial effects, it can also result into negative effects especially when the method of extraction is destructive. In this study, destructive extraction of various parts of *G. buchananii*, *T. indica*, *Saba comorensis* and *C. schweinfurthii* to treat many illnesses make them face the risk of disappearance. For instance, harvesting the bark of *C. schweinfurthii* for incense (***Kibani*** in Luganda dialect) and the bark of *G. buchananii* for cough and stomach ache medication can lead to their mortality Figure 4.

Figure 4. *G. buchananii* debarked for medicine.

Garcina buchananii trees are often debarked and pounded into powder before administering to pregnant women, using as a remedy for stomach disorder, asthma, intestinal worms and measles as well as for casting out evil spirits. Since such IFTs with multiple uses will face the risk of rapid destruction and loss, they should be targeted for on-farm domestication [3, 47]. Such incorporation of IFTs in an agroforestry system also increases carbon storage and improves agricultural productivity [8]

Given the future prospect of carbon trading and payments through the implementation of payment for environmental services (PES) and REDD+ programs [29], local communities may be incentivized to maintain IFTs in indigenous agroforestry systems as large carbon sinks for mitigating climate change effects [33]. Such adaptation strategies are centred on the needs of peasant farmers who are encouraged to diversify to other economic activities inclusive of crop/livelihood diversification as a way of strengthening household's adaptive capacity [48].

4.3. Socio-Demographic Influence on Choice, Preferences and Use of IFTS to Enhance Coping Strategies against Climate Variability in the Five LVB Districts, Uganda

Since majority of the respondents had attained only primary level of education, it is probable that the knowledge on use of most IFTs could have been passed from generation to generation through verbal communication. This confirmation of farmers' use of both indigenous knowledge (IK) and scientific knowledge suggests that neither is currently accurate and sufficiently reliable in informing farmers' decision making on the preference for and use of IFTs. It also suggests that total reliance on only IK to promote use of IFTs to enable farmers cope with climate variability may not be effective as access to IK is now a problem for younger people [29]. Accordingly, development and incorporation of any climate change policy on the use of IFTs to enable farmers cope with effects of climate variability in the LVB districts should also recognize the applicability of IK and its values in crafting of adaptive frameworks related to climate change [18].

Preference for and use of IFTs is also influenced by gender. While men dominated decision making on the use of IFTs for timber and fuelwood and could plant or retain them in and around homes [14], women had a strong attachment to use of IFTs for food and medicine (Table 6). Women in the study area are culturally bound, and as such are responsible for fire wood collection and harvesting of fruits such as that of *T. indica* for household consumption and sale in local markets. In terms of coping with climate variability, this confirms the roles of women in Sub-Saharan countries as key food and health care providers [2].

Tamarindus indica is also reported to be among the marketable IFTs in LVB districts and the best choice for male respondents who are the major providers of household income. The above scenario illustrates that both men and women may have separate rights to different parts of the tree and any benefits from their harvesting, sale or use [49]. This is an issue which should always be taken into account when targeting or promoting IFTs with ability to enable farmers cope with effects of climate variability.

In this study, respondents with high household income tend to prefer those IFTs presumably with high economic potential such as *T. indica*, C. *schweinfurthii* and *C. edulis*. The implication is that such IFTs could be easily promoted and accepted for commercialization in the LVB districts [3]. As some of these preferred IFTs have become one of the reliable sources of income for most of the poor households within the LVB districts, promoting sustainable use/management of IFTs is one way of ensuring eradication of extreme poverty and hunger in addition to ensuring healthy lives and promoting well-being for all ages [11] as is stipulated in the Sustainable Development Goals (SDGs) 1 and 3 respectively

The contribution of IFTs towards meeting the basic needs and incomes of households has also been reported by Baana, et al. [36] in Uganda and Leakey, et al. [3] in parts of East and Central Africa and in Indonesia by Suwardi, et al.[14]. Since IFTs such as *T. indica* potentially augment household income with good management and marketing, farmers would aim for income generation early enough to implement practices that give marketable products such as fruits, firewood, construction materials [45] and on-farm carbon accumulation [44].

Commercialization of IFTs should, thus, be considered a priority when promoting on-farm planting and management of IFTs in the LVB districts of Uganda, in particular and of East Africa in general. This would also enable farming households to benefit from a wide range of opportunities related to use of on-farm IFTs to cope with climate variability [29].

Deliberate retention of IFTs on-farms would also help a lot in soil and water conservation while reducing the risk of soil exhaustion to which annually cropped and harvested systems are prone. A case in point is *C. schweinfurthii* whose fallen leaves (during the dry spells) is reported to enrich soil nutrients. Shaded leaves from such trees retained on-farms have also been reported to help in trapping moisture from the soil and retarding evaporation during dry seasons. In addition to improving cropping practices with greater numbers of trees on-farms, cultivated lands significantly contribute to farmers' efforts in coping with climate variability [50]. Such diversification of adaptive strategies is also vital for sustaining livelihoods in a changing climate [4].

Period of stay on land, likewise, had influence on respondents' choices of and preferences for IFTs (Table 7). It was clear that, the longer the period stayed by households on same piece of land, the more likely they were to rank certain IFTs such as *S. comorensis* among their preferred choices. According to Leakey, et al. [3], as respondents stay longer on the land, they usually get a better understanding of the abundance status and economic importance of IFTs therein. Again, scarcity and rarity of IFTs (such as *C. schweinfurthii*) which most people are always on the lookout for its fruits in some districts could have been the reason it was reported as being highly preferred by those who had stayed on same piece of land for a short time.

Even if IFTs such as *T. indica*, *G. buchananii* and *V. apiculata* are now retained to diversify total farm output as a climate change risk management strategy Kugedera [47], women may not have control over tree planting and management. This could be due to differential access to and control of land/IFTs and its influences on preferences and retention of IFTs in the LVB districts. According to Leakey and Akinnifesi [46], farmers who always retain such IFTs have a belief that a mixture of IFTs maturing at different times, demanding different growing conditions and producing a variety of products with different market niches are a blessing in boosting farmers' struggle to cope with climate variability. Such mixtures of trees also often supplement each other in case of seasonal climatic/market failures while also reducing on the spread of pests and diseases. Ideally, such benefits from IFTs can make the system less susceptible to drastic productivity fluctuations and also make farmers less dependent on commercial agro-chemicals [50].

4.4. Use of IFTS to Enhance Farmers' Coping Strategies against Climate Variability in the Five LVB Districts, Uganda

Majority of the respondents in the five LVB districts also had IFTs planted on-farms and along roads to provide various good/services Table 8. While *S. comorensis* is planted to provide fruit and worthy construction materials for granaries, *T. indica*, *C. albidum* and *C. schweinfurthii* are highly valued and planted/retained for the provision of fruits and as alternative source of fuelwood to communities for domestic use and sale. There are also assertions that IFTs such as *T. indica.* C. *albidum* and *C. schweinfurthii* could moderate microclimate within their vicinity and also protect crops as windbreaks. Such positive ability of IFTs that include maintaining/regulating relative humidity have also been reported elsewhere [51]. Just like in other areas, some of these IFTs are now planted in marginal lands where arable farming is not a stable enterprise to diversify agriculture as a strategy to cope with effects of climate change [44].

The use of parts of some IFTs to manage certain ailments and diseases such as malaria, diarrhoea, cough and skin infection are also prevalent among families within LVB districts [52]. An example is the use of parts of *T. indica*, *C. albidum*, and *S. comorensis* to treat malaria, *C. schweinfurthii* to treat cough and *R. vulgaris* to treat diarrhoea. The fact that some of these IFTs have already been tested for bioactive phytochemical properties and evaluated pharmacologically for their effectiveness is a proof of the significant role IFTs can play in enhancing primary health care [5, 11, 38]; which are either directly or indirectly associated with their abilities to enable farmers cope with climate variability.

Since managing IFTs on-farms has been reported by majority of the respondents in this study, it could be promoted widely as an effective cheap system for carbon sequestration [53]. While trees on-farms will rarely be planted for their carbon value alone, up-front financial provisions could reduce some of the barriers to introducing IFT and other trees into agricultural systems [54]. Payments would cover labour, costs of planting and nurturing trees to help smallholder farmers adapt to the multiple threats epitomised by a changing climate [10].

Although expansion of fruit crop gardens can lead to high carbon sequestration thereby contributing to mitigation of climate change effects, the establishment of a fruit tree cropping system is not an easy task [53], [55]. Besides requiring a substantial investment of resources, carbon sequestration potential in a fruit tree cropping system might also depend on the soil where the crop is grown. Thus, to both manage impacts and mitigate climate change effects, adequate fruit crops have to be grown in the areas where each of them will have high yield and carbon sequestration potential [5]. Consequently, integrating trees in agroforestry have benefits from both the climate and farmers' point of view of simultaneously mitigating climate change effects and improving livelihoods [21].

As has also been reported by Leakey, et al. [3], part of the efforts to promote cultivation of IFTs among farming households would be to engage model farmers, Community-Based organizations (CBOs) and NGOs whose work relate to agriculture. Apart from creating awareness on fruit growing, the CBOs and NGOs would also serve as frontline extension agents who can advise farmers to include IFTs along the entire agricultural production value chain in their areas [56].

Notwithstanding the above, farmers' interest and willingness to participate in sustainable use/management of IFTs can only be successful if the selected species are fast growing with the ability to yield large quantities of fruits while also improving soil fertility. Since by their nature IFTs take long to mature/yield fruits [7], there is need to step up breeding programme that can reduce their time to maturity and fruit yields. In addition, knowledge that farmers have about uses of IFTs to enhance their coping strategies to climate variability can be strengthened by having in place appropriate bye-laws on fruit growing. Such bye-laws should also incorporate ways of improving networks among farmers and CBOs as a strategy for boosting sustainable use/management of IFTs in the face of worsening effects of climate variability; thereby ensuring environmental sustainability [29].

Aside from these coping strategies that involve use of IFTs, other coping strategies such as distress selling of assets, borrowing from others, cutting expenditures on non-essential items that are also being practiced by some households should be promoted to minimize livelihood adverse effects of climatic shocks and variability [15].

5. CONCLUSIONS

Consumption of indigenous fruits as a coping strategy was ranked highest and the most frequently used strategy in coping with food shortage. The contribution of IFTs was significant in assisting households to cope with food insecurity/shortage thereby providing safety or emergency net when food availability is threatened in the households.

Since all LVB districts frequently experience climate variability and food shortage, wild harvesting of IFT products can contribute to food security, poverty reduction and enhance coping strategies against climate variability. Much as the value of IFTs in the livelihoods of communities living in LVB districts is critical, IFTs have become scarce due to unsustainable harvesting thus negatively affecting adaptation to the effects of climate variability. Continued destructions of IFTs have reduced collection and dietary use of IFTs among LVB communities, increased incidences of nutrition-related disorders; and disruptive coexistence of people and IFTs.

Farmers' interest and willingness to participate in sustainable use/management of IFTs can only be successful if the selected species are fast growing with the ability to yield large quantities of fruits while also improving soil fertility.

As some coping strategies (such as diversification into off-farm activities), are applicable to most smallholder farmers, new options and innovations that integrate production of IFTs on-farms are needed to enhance the resilience of agricultural production and reduced vulnerability of communities in the LVB districts to climate variability.

6. RECOMMENDATIONS

Given that the uses of IFTs in the five LVB districts are associated with farmers' efforts to cope with climate variability, the goal of any climate-adaptive farmer-based project should support sustainable use of IFTs, in the short-term and foster innovations such as on-farm planting of IFTs and other fast-growing tree species to meet household demands.

The challenges to conserving IFTs and their ecosystem services can be met at a local/community-based level in a variety of creative ways (like promoting on-farm tree planting, beekeeping) where people depend directly on these services to meet their daily needs.

Policies that will increase volumes of indigenous fruit trees such as promoting on-farm domestication and stepping-up appropriate tree breeding and improvement programs of IFTs are required in the area since by their nature IFTs take long to mature/yield fruits. Such policies and legislations should be developed by involving all stakeholders in order to encourage economic growth of the rural communities in the LVB districts.

In order to improve management of natural resources and ensure sustainable extraction of not only IFTs but other Non-Timber Forest Products for improved community livelihoods, appropriate agricultural/forestry extension services ought to be redesigned in the LVB districts.

The uptake of IFTs and in country businesses for processing and value-addition in the IFTs value chain would also give a much-needed boost to the local economy in ways not achieved by dependence on international commodity crops for export.

Development and incorporation of any climate change policy on the use of IFTs to enable farmers cope with effects of climate variability in the LVB districts should also recognize the applicability of Indigenous Knowledge (IK) and its values in crafting of adaptive frameworks related to climate change.

Commercialization of IFTs should be considered a priority when promoting on-farm planting and management of IFTs in the LVB districts of Uganda, in particular and of East Africa in general. This is expected to enable farming households' benefit from a wide range of opportunities related to use of on-farm IFTs to cope with climate variability.

Funding: This research is supported by SIDA through the Inter University Council of East Africa–Lake Victoria Research Initiative (Grant number: NR06-2010).
Competing Interests: The authors declare that they have no competing interests.
Authors' Contributions: All authors contributed equally to the conception and design of the study.

REFERENCES

[1] G. O. Ibe and J. Amikuzuno, "Effect of climate variability on the contribution of non-timber forest products to the livelihood of rural dwellers In Ohafia Abia State Nigeria: The Peoples' Perception," *Ethiopian Journal of Environmental Studies & Management*, vol. 11, pp. 587 – 607, 2018.

[2] C. Bvenura and D. Sivakumar, "The role of wild fruits and vegetables in delivering a balanced and healthy diet," *Food Research International*, vol. 99, pp. 15-30, 2017.Available at: https://doi.org/10.1016/j.foodres.2017.06.046.

[3] R. R. Leakey, T. Mabhaudhi, and A. Gurib-Fakim, "African Lives Matter: Wild food plants matter for livelihoods, justice, and the environment—a policy brief for agricultural reform and new crops," *Sustainability*, vol. 13, p. 7252, 2021.Available at: https://doi.org/10.3390/su13137252.

[4] R. N. Tieminie, C. E. Loh, J. C. Tieguhong, M. F. Nghobuoche, P. S. Mandiefe, and M. R. Tieguhong, "Non-timber forest products and climate change adaptation among forest dependent communities in Bamboko forest reserve, Southwest region of Cameroon," *Environmental Systems Research*, vol. 10, pp. 1-13, 2021.Available at: https://doi.org/10.1186/s40068-020-00215-z.

[5] M. Sardeshpande and C. Shackleton, "Wild edible fruits: A systematic review of an under-researched multifunctional NTFP (non-timber forest product)," *Forests*, vol. 10, pp. 1-24, 2019.Available at: https://doi.org/doi:10.3390/f10060467.

[6] D. Mithöfer and H. Waibel, "Income and labour productivity of collection and use of indigenous fruit tree products in Zimbabwe," *Agroforestry Systems*, vol. 59, pp. 295–305, 2003.Available at: https://doi.org/10.1023/B:AGFO.0000005230.09714.b4.

[7] CTA, "“Indigenous fruits”, The technical centre for agricultural and rural cooperation, (CTA)," Rural Radio Resource Pack (RRRP 2007/5. No 07/52007.

[8] A. M. E. Sulieman and A. A. Mariod, *Domestication of indigenous fruit trees. In: Mariod A. (eds) wild fruits: Composition, nutritional value and products*. Cham: Springer, 2019.

[9] B. O. Muok, "Potentials and utilization of indigenous fruit trees for food and nutrition security in East Africa," *Global Advanced Research Journal of Agricultural Science*, vol. 8, pp. 40-49, 2019.

[10] C. Bigirimana, F. Omujal, P. Isubikalu, E. Bizuru, B. Obaa, M. Malinga, J. G. Agea, and J. B. Lamoris, "Utilisation of indigenous fruit tree species within the Lake Victoria Basin, Rwanda," *Agricultural Science International Journal*, vol. 1, pp. 1-3, 2016.

[11] A. O. Omotayo and A. O. Aremu, "Underutilized African indigenous fruit trees and food–nutrition security: Opportunities, challenges, and prospects," *Food and Energy Security*, vol. 9, p. e220, 2020.Available at: https://doi.org/10.1002/fes3.220.

[12] E. Assan, M. Suvedi, L. Schmitt Olabisi, and A. Allen, "Coping with and adapting to climate change: A gender perspective from smallholder farming in Ghana," *Environments*, vol. 5, p. 86, 2018.Available at: https://doi.org/10.3390/environments5080086.

[13] P. Dorward, H. Osbahr, C. Sutcliffe, and R. Mbeche, "Supporting climate change adaptation using historical climate analysis," *Climate and Development*, vol. 12, pp. 469-480, 2020.Available at: https://doi.org/10.1080/17565529.2019.1642177.

[14] A. B. Suwardi, Z. I. Navia, T. Harmawan, S. Syamsuardi, and E. Mukhtar, "Wild edible fruits generate substantial income for local people of the Gunung Leuser National Park, Aceh Tamiang Region," *Ethnobotany Research and Applications*, vol. 20, pp. 1-13, 2020.Available at: https://doi.org/10.32859/era.20.11.1-13.

[15] W. Berhanu and F. Beyene, "Climate variability and household adaptation strategies in Southern Ethiopia," *Sustainability*, vol. 7, pp. 6353-6375, 2015.Available at: https://doi.org/10.3390/su7066353.

[16] IPCC, *Managing the risks of extreme events and disasters to advance climate change adaptation. In: A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change". (Eds. CB Field, V Barros, TF Stocker et al.)*. Cambridge, NY, USA: Cambridge University Press, 2012.

[17] IPCC, *Summary for policymakers. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]*. Geneva, Switzerland: World Meteorological Organization, 2018.

[18] UNFCC, "Fact sheet: Climate change science—the status of climate change science today. In United Nations Framework Convention on Climate Change; Bonn, Germany. Retrieved: https://unfccc.int/files/press/backgrounders/application/pdf/press_factsh_science.pdf. [Accessed 2March 2022]," 2011.

[19] IPCC, *Summary for policymakers. In: Climate Change 2014: Impacts,Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L.White (eds.)]*. Cambridge, United Kingdom and New York, USA: Cambridge University Press, 2014.

[20] IPCC, *Annex II: Glossary [Mach, K.J., S. Planton and C. von Stechow (eds.)]. In: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth. Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC*. Geneva, Switzerland,: Cambridge University Press, 2014.

[21] A. Alemayehu and W. Bewket, "Smallholder farmers' coping and adaptation strategies to climate change and variability in the central highlands of Ethiopia," *Local Environment*, vol. 22, pp. 825-839, 2017.Available at: https://doi.org/10.1080/13549839.2017.1290058.

[22] R. D. Lasco, R. J. P. Delfino, D. C. Catacutan, E. S. Simelton, and D. M. Wilson, "Climate risk adaptation by smallholder farmers: The roles of trees and agroforestry," *Current Opinion in Environmental Sustainability*, vol. 6, pp. 83-88, 2014.Available at: https://doi.org/10.1016/j.cosust.2013.11.013.

[23] D. Waiswa, M. J. Stern, and S. P. Prisley, "Drivers of deforestation in the Lake Victoria crescent, Uganda," *Journal of Sustainable Forestry*, vol. 34, pp. 259-275, 2015.Available at: https://doi.org/10.1080/10549811.2014.1003565.

[24] World Bank, *The world bank lake victoria environmental management project III (P165352), Project Information Document/Integrated Safeguards Data Sheet (PID/ISDS). Concept Stage | Date Prepared/Updated: 05-Oct-2018|Report No: PIDISDSC23414*. Washing ton DC: World Bank, 2018.

[25] F. W. Nsubuga and H. Rautenbach, "Climate change and variability: A review of what is known and ought to be known for Uganda," *International Journal of Climate Change Strategies and Management*, vol. 10, pp. 752-771, 2018.Available at: https://doi.org/10.1108/IJCCSM-04-2017-0090.

[26] L. A. Olaka, J. O. Ogutu, M. Y. Said, and C. Oludhe, "Projected climatic and hydrologic changes to Lake Victoria Basin Rivers under three RCP emission scenarios for 2015–2100 and impacts on the water sector," *Water*, vol. 11, pp. 1-27, 2019.Available at: https://doi.org/10.3390/w11071449.

[27] F. M. Mwaura and G. Okoboi, "Climate variability and crop production in Uganda," *Journal of Sustainable Development*, vol. 7, pp. 1-14, 2014.Available at: https://doi.org/10.5539/jsd.v7n2p159.

[28] M. Endris Ahmed and M. Ahmed Bihi, "Indigenous knowledge for resilience and adaptation in pastoral production system of Somali Regional State in Ethiopia," *Interdisciplinary Description of Complex Systems: INDECS*, vol. 17, pp. 723-737, 2019.Available at: https://doi.org/10.7906/indecs.17.4.4.

[29] O. L. Kupika, E. Gandiwa, G. Nhamo, and S. Kativu, "Local ecological knowledge on climate change and ecosystem-based adaptation strategies promote resilience in the Middle Zambezi Biosphere Reserve, Zimbabwe," *Scientifica*, vol. 2019, p. 15, 2019.Available at: https://doi.org/10.1155/2019/3069254.

[30] D. Agol, H. Reid, F. Crick, and H. Wendo, "Ecosystem-based adaptation in Lake Victoria Basin; Synergies and trade-offs," *Royal Society Open Science*, vol. 8, p. 201847, 2021.Available at: https://doi.org/10.1098/rsos.201847.

[31] J. W. Mulumba, "A risk-minimizing argument for traditional crop varietal diversity use to reduce pest and disease damage in agricultural ecosystems of Uganda," *Agriculture, Ecosystems & Environment*, vol. 157, pp. 70-86, 2012.Available at: https://doi.org/10.1016/j.agee.2012.02.012.

[32] B. F. Nero, N. A. Kwapong, R. Jatta, and O. Fatunbi, "Tree species diversity and socioeconomic perspectives of the urban (food) forest of Accra, Ghana," *Sustainability*, vol. 10, pp. 1-19, 2018.Available at: https://doi.org/10.3390/su10103417.

[33] M. Ashagre, Z. Asfaw, and E. Kelbessa, "Ethnobotanical study of wild edible plants in Burji District, Segan area zone of southern nations, nationalities and peoples region (SNNPR), Ethiopia," *Journal of Ethnobiology and Ethnomedicine*, vol. 12, pp. 1-15, 2016.Available at: https://doi.org/10.1186/s13002-016-0103-1.

[34] P. Tugume, "Ethnobotanical survey of medicinal plant species used by communities around Mabira Central Forest Reserve, Uganda," *Journal of Ethnobiology and Ethnomedicine*, vol. 12, pp. 1-28, 2016.Available at: https://doi.org/10.1186/s13002-015-0077-4.

[35] J. C. Ordonez, "Constraints and opportunities for tree diversity management along the forest transition curve to achieve multifunctional agriculture," *Current Opinion in Environmental Sustainability*, vol. 6, pp. 54–60, 2014.

[36] K. Baana, H. Angwech, and G. M. Malinga, "Ethnobotanical survey of plants used as repellents against housefly, Musca domestica L.(Diptera: Muscidae) in Budondo Subcounty, Jinja District, Uganda," *Journal of Ethnobiology and Ethnomedicine*, vol. 14, pp. 1-8, 2018.Available at: https://doi.org/10.1186/s13002-018-0235-6.

[37] W. N. Aye, Y. Wen, K. Marin, S. Thapa, and A. W. Tun, "Contribution of mangrove forest to the livelihood of local communities in Ayeyarwaddy region, Myanmar," *Forests*, vol. 10, pp. 1-13, 2019.Available at: https://doi.org/10.3390/f10050414.

[38] M. Bengtsson, "How to plan and perform a qualitative study using content analysis," *Nursing Plus Open*, vol. 2, pp. 8–14, 2016.

[39] C. Bigirimana, F. Omujal, P. Isubikalu, E. Bizuru, B. B. Obaa, M. Malinga, J. G. Agea, and J. B. Okullo, "Perceived availability and management of Garcinia buchananii Fruit tree species in the Lake Victoria Basin Districts of Rwanda and Uganda," *Journal of Agricultural Research 2016*, vol. 4, pp. 230-238, 2016.Available at: https://doi.org/10.13189/ujar.2016.040602.

[40] J. B. L. Okullo, "Ethno-medicinal uses of selected indigenous fruit trees from the Lake Victoria Basin Districts in Uganda," *Journal of Medicinal Plants Studies*, vol. 2, pp. 78-88, 2014.

[41] K. Kehlenbeck, M. Wiehle, and A. Sennhenn, "Exotic and indigenous fruit tree diversity on farm and the conservation of tree genetic resources: case studies from Sub-Saharan Africa. InTropical Fruit Tree Diversity." vol. 12, 1st ed London: Routledge, 2016, pp. 140-149.

[42] R. O. Awodoyin, O. S. Olubode, J. U. Ogbu, R. B. Balogun, J. U. Nwawuisi, and K. O. Orji, "Indigenous fruit trees of tropical Africa: Status, opportunity for development and biodiversity management," *Agricultural Sciences*, vol. 6, pp. 31-41, 2015.Available at: http://dx.doi.org/10.4236/as.2015.61004.

[43] S. P. Bos, T. Pagella, R. Kindt, A. J. Russell, and E. Luedeling, "Climate analogs for agricultural impact projection and adaptation—a reliability test," *Frontiers in Environmental Science*, vol. 3, p. 65, 2015.Available at: https://doi.org/10.3389/fenvs.2015.00065.

[44] H. T. Duguma, "Wild edible plant nutritional contribution and consumer perception in Ethiopia," *International Journal of Food Science*, pp. 1-16, 2020.Available at: https://doi.org/10.1155/2020/2958623.

[45] E. Chivandi, N. Mukonowenzou, T. Nyakudya, and K. H. Erlwanger, "Potential of indigenous fruit-bearing trees to curb malnutrition, improve household food security, income and community health in Sub-Saharan Africa: A review," *Food Research International*, vol. 76, pp. 980-985, 2015.Available at: https://doi.org/10.1016/j.foodres.2015.06.015.

[46] R. R. B. Leakey and F. K. Akinnifesi, "Towards a domestication strategy for indigenous fruit trees in the tropics. In Leaky, R.R.B (Editor): Multifunctional Agriculture: Achieving Sustainable Development Goals in Africa". Chapter." vol. 16, ed: Academic Press, 2017, pp. 165-176.

[47] A. T. Kugedera, "Domestication of indigenous trees as a sustainable way of improving rural livelihoods," *International Journal of Agriculture & Agribusiness*, vol. 2, pp. 72 – 77, 2019.

[48] D. O. Appiah and S. E. Gbeddy, "A synthesis of the implementation ambivalence of REDD+ in Sub-Saharan Africa and Southeast Asia," *Forest and Society*, vol. 2, pp. 92-111, 2018.Available at: https://doi.org/10.24259/fs.v2i1.2918.

[49] T. Abebe and D. Mulu, "The role of women in the management and utilization of home garden: The case of Dale District, in southern Ethiopia," *Asian Journal of Plant Science and Research*, vol. 7, pp. 41-54, 2017.

[50] S. Kuyah, I. Öborn, M. Jonsson, A. S. Dahlin, E. Barrios, C. Muthuri, A. Malmer, J. Nyaga, C. Magaju, and S. Namirembe, "Trees in agricultural landscapes enhance provision of ecosystem services in Sub-Saharan Africa," *International Journal of Biodiversity Science, Ecosystem Services & Management*, vol. 12, pp. 255-273, 2016.

[51] S. Reppin, S. Kuyah, A. de Neergaard, M. Oelofse, and T. S. Rosenstock, "Contribution of agroforestry to climate change mitigation and livelihoods in Western Kenya," *Agroforestry Systems*, vol. 94, pp. 203-220, 2020.Available at: https://doi.org/10.1007/s10457-019-00383-7.

[52] R. Nieminen, M. Sørensen, and I. Theilade, "Identification of indigenous fruits with export potential from Mukono district, Uganda: An assessment of two methods," *Agroforestry Systems*, vol. 91, pp. 967-979, 2017.Available at: https://doi.org/10.1007/s10457-016-9971-6.

[53] H. Tschora and F. Cherubini, "Co-benefits and trade-offs of agroforestry for climate change mitigation and other sustainability goals in West Africa," *Global Ecology and Conservation*, vol. 22, p. e00919, 2020.Available at: https://doi.org/10.1016/j.gecco.2020.e00919.

[54] T. A. Melketo, E. Geta, and S. Sieber, "Understanding livelihood diversification patterns among smallholder farm households in Southern Ethiopia," *Sustainable Agriculture Research*, vol. 9, pp. 26-41, 2020.Available at: https://doi.org/10.5539/sar.v9n1p26.

[55] R. Reid, "Developing farmer and community capacity in Agroforestry: Is the Australian Master TreeGrower program transferable to other countries?," *Agroforestry Systems*, vol. 91, pp. 847-865, 2017.Available at: https://doi.org/10.1007/s10457-016-0039-4.

[56] H. Bang, L. Miles, and R. Gordon, "Enhancing local livelihoods resilience and food security in the face of frequent flooding in Africa: A disaster management perspective," *Journal of African Studies and Development*, vol. 10, pp. 85-100, 2018.Available at: https://doi.org/10.5897/jasd2018.0510.