Journal of Agriculture and Food Research 14 (2023) 100895

Contents lists available at ScienceDirect

Journal of Agriculture and Food Research

journal homepage: www.sciencedirect.com/journal/journal-of-agriculture-and-food-research

The influence of sugarcane growing by smallholder farmers on household livelihood, food security, and nutrition status of children below five years in mid-western Uganda

Robert Mbabazi Kaahwa, Sunday Mark Oyet, Christopher Muggaga *, Ipolto Okello-Uma

Gulu University, Faculty of Agriculture and Environment, Department of Food Science and Postharvest Technology, P.O. Box 166, Gulu, Uganda

ARTICLE INFO

Keywords:
Livelihood
Food security
Nutrition security
Nutritional status
Bunyoro subregion
Uganda

ABSTRACT

The current study aimed at determining the influence of sugarcane production on livelihoods, food security and nutrition status. A cross-sectional study was carried out among 350 smallholder farmers in mid-western Uganda. Food security was assessed by Household Food Insecurity Access Scale (HFIAS) while household livelihood and nutrition status of children below five (5) years were assessed by a semi-structured questionnaire and anthropometry respectively. Results showed that sugarcane growing households (SCG) cultivated more acreage of food, owned more assets, earned more income than the non-sugarcane growing households (NSCG). Ownership of motorcycles was higher ($p < 0.05$) among SCG than NSCG. Households reported anxiety and uncertainty of having food in the previous four weeks (SCG 38%; NSCG 55.2%); had insufficient food quality (SCG 56.8%; NSCG 70.7%); and had insufficient food quantity (SCG 41.7%; NSCG 49.2%). SCG were more food secure (32.3%) than the NSCG (20.8%) ($p < 0.05$) with a corresponding mean HFIAS of 6.56 ± 6.69 and 8.41 ± 6.41, respectively. Stunting among children below five years among NSCG was higher (34.6%) than in SCG (21.3%). Among SCG, 7.3% and 5.2% of children were underweight and wasted while 6.06% and 2.7% were underweight and wasted from NSCG. This demonstrated that sugarcane growing had better livelihood outcomes, positively impacted on asset ownership and food security but mixed effect on nutrition indicators among children in sugarcane growing and non-sugarcane growing households. It is recommended that government and development agencies diversify livelihoods among the NSCG and reinforce the existing livelihoods among SCG; provide nutrition education to both SCG and NSCG for improved food security and nutrition outcomes. Authors suggest further studies using a mixed approach to assess the levels of household nutrient intake in sugarcane growing areas.

1. Introduction

Globally, agriculture is a source of livelihood, employment, income, and is vital for improving food and nutrition security, socio-economic development and environmental sustainability in developing countries [1]. Sugarcane production is regarded as an essential component of agricultural intervention due to its extensive benefits to the day-to-day lives of people, and industrial use intended for dietary and economic sustenance [2]. About 80% of sugar is produced from tropics and sub-tropics while 20% is from sugar beets grown in temperate regions [3–5]. Sub-Saharan Africa (SSA) represents only 4% of current global sugarcane production and is considered a critical region for continued expansion due to its high production potential, low cost and proximity to European markets [6].

In Uganda, some farmers perceive sugarcane production a more profitable and economically viable enterprise than other traditional cash crops such as coffee, tobacco and cotton [7]. Previously, sugarcane growing and processing in the country was confined to the fertile soils on the Northern shores of Lake Victoria in Busoga and Buganda regions, except in the mid-western part of Uganda [8]. Consequently, the production of sugarcane in Uganda increased from 1,476,215 tons in 2000 to 4,892,047 tons in 2019 [9] concurrent with upsurge of sugarcane processing industries in many parts of the country contributing to sugarcane value chain [7]. As such, sugar industry accounts for 6.5% of the

* Corresponding author.
E-mail addresses: kaahwaagric@gmail.com (R.M. Kaahwa), sundaymarkoyet@gmail.com (S.M. Oyet), c.muggaga@gu.ac.ug (C. Muggaga), okellouma@gmail.com (I. Okello-Uma).

https://doi.org/10.1016/j.jafr.2023.100895
Received 5 September 2023; Received in revised form 24 November 2023; Accepted 26 November 2023
Available online 2 December 2023

industrial growth of the country, providing twenty thousand (20,000) direct and fifty thousand (50,0000) indirect employments [8]. However, a study conducted in Kamuli district in Eastern Uganda indicated that there was less production of food crops and hence increasing famine and poverty due to commercialization of sugarcane and other non-food crop cultivation gaining greater attention in rural households [10]. This implies that the effect of sugarcane on food security as well as nutrition outcomes should not be taken for granted, hence, our motivation to undertake the current study in mid-western Uganda.

The concept of food security is best understood from its four domains: availability, access, utilization and stability [11], hence, agricultural production is inextricably linked to it. Food security has complex dimensions and it exists when all people at all times have physical or economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life [12,13]. This definition incorporates nutrition as an integral component of food security, implying that good nutrition is important for achieving better nutrition outcomes. Additionally, good nutrition status of children is critical because of the positive effects on growth, labor productivity, cognitive achievement, schooling, and preschool ability [14]. Therefore, this study also sought to provide an understanding of nutrition status among children 6–59 months. Food security can be achieved through crops, livestock, skilled and unskilled labor, trade or gifts and loan [15]. On the other hand, diverse income generating activities reduce food insecurity [16]. Hence, the current study is anchored on the following questions: 1) How do livelihoods and food security status vary between sugarcane and non-sugarcane growers in the study area? 2) What is the nutrition status of children between 6 and 59 months in the sugarcane growing and non-sugarcane growing households?

Despite the enormous potential of sugarcane sub-sector for economic development, food security and well-being, empirical findings and reviews provide a mixed effect on smallholder farmers engaged in sugarcane cultivation. This is consistent with previous authors [6,17], who reported that sugarcane production had significant positive and negative environmental and socio-economic impacts. For instance, some authors argued that sugarcane production was crucial in stimulating socio-economic development processes to overcome barriers that prevent the eradication of hunger [18]. On the contrary, other studies [19] reported that sugarcane farming was popular but does not sustain smallholder farmers' livelihoods and food security. Mwavu et al. [7] also affirmed that commercialization of sugarcane had negative impacts on the farm land for other food crops and natural vegetation trend and hence comprising on the household food and nutrition security. This suggests differential effects of sugarcane production by smallholder famers depend on geographical location.

Added to the aforementioned, Uganda still experiences high levels of malnutrition. For instance, the Uganda Demographic Health Survey report of 2021 [20] indicated that 26, 2.9 and 10.2% of children 6–59 months were stunted, wasted and underweight, respectively. Among the adult women 15–49 years, 9% were categorized as thin, 18% and 6.4 categorized as overweight and obese, respectively which is worse than their adult male counterparts 15–54 years. The poor nutrition status can have a worrying effect on maternal and child health. Located in mid-western Uganda, Bunyoro sub-region also has high levels of malnutrition [21]. For instance, a study in Masindi by Isingoma, Mbugua and Karuri [22] showed that 30.5%, 11.6% and 7.4% of children 7–36 months were stunted, underweight and wasted, respectively. While 7.4%. and 1.4% of them were wasted and had Mid-Upper Arm Circumference (MUAC) of less than 11.5 cm. From the finding of these authors [22] it is evident that child undernutrition is largely chronic rather than acute in nature. However, their study fell short of comparing nutrition status among children in sugarcane and non-sugarcane growing households.

Nutrition status is a manifestation of food security [4]. However, a review by Carletto et al. [23] indicated that few studies demonstrated the link between agricultural commercialization and food and nutrition security because they largely focused on commercialization of staple food crops. Another study in Eastern Uganda [24] that investigated how and whether commercial farming was an appropriate intervention and remedy to youth socio-economic vulnerabilities focused on areas such as jobs and incomes *vis-à-vis* youth experiences of sugarcane farming as a solution to livelihood vulnerabilities. A similar study [7] on expansion of commercial sugarcane cultivation among smallholder farmers in Busoga sub-region in Eastern Uganda reported the implications for household food security but lacked information on the effect on nutrition status, and also covered a limited scope on food security and livelihoods. Therefore, objective of the current study was to investigate the influence of sugarcane cultivation by smallholder farmers on the status of food security and nutrition status of children 6–59 months of age using Masindi district in mid-western Uganda as a case study area. The current study adds to the scanty body of knowledge in a different methodological and content perspective of the extent to which sugarcane production by smallholder farmers affect household livelihoods, food security and nutrition status of children 6–59 months. Hence, current research provides the basis for strategic policies for improving food security, nutrition status and livelihoods among sugarcane and non-sugarcane cultivating households inhabiting the same geographical area.

2. Methodology

2.1. Study design

A descriptive cross-sectional survey was carried out. This design was considered particularly appropriate for assessing the effect of sugarcane growing on livelihoods, food security in sugarcane growing households (SCG). Quantitative approach was used to obtain information on livelihoods, food security status and nutrition status. The study was conducted in Masindi district in mid-western Uganda. According to local government development plan of 2020/2021-2024-2025 [25]. Masindi district lies between 1°22′ and 2°20′North of the Equator; longitudes 31°22′, 32 and 32° 23′ East of Greenwich [25]. The district's headquarters is approximately 216 km (km) away from Kampala, the capital city of Uganda. Masindi district is bordered by Nwoya district in the North, Kiryandongo in the East, Nakasongola and Nakaseke in the South-east, Kyankwanzi in the South, Hoima in the South-west and Buliisa district in the West. It has total area of 3607 km^2 and consists of 2 counties, 1 municipality, 5 sub-counties, 4 divisions, 21 parishes, 11 wards 237 villages and 83 cells. Masindi district has an estimated population of 291,113 people with an annual growth rate of 2.8%. The total number of households is 281,753 and an average household size of 4.3 [25,26]. By the year 2025 the Population projection is estimated to be 384,200, of which 197,900 are males and 186,300 are females. The population density is 74 people per square kilometer [25]. The relief is dominantly plateau with an altitude of 900 m–2500 m above sea level. The district is at an average altitude of 1295 m above sea level and the temperatures ranges from 17 to 29 °C. It is also blessed with a favorable climate with an average annual rain fall of about 1300 mm with a bimodal pattern. The rains are from March to May and August to October. The natural vegetation of Masindi is made up of forest and dry and humid savannah land with prolific elephant grass. It is mainly covered by sandy and clay loam soils. The major crops grown in the district are maize, sweet potatoes, cassava, beans, banana, groundnuts, rice and sugarcane. In addition, other livelihood activities include charcoal burning, sand mining and brick making [25]. Therefore, the current study was conducted in two sub-counties of Masindi district, Bwijanga and Budongo sub-counties (Fig. 1).

Households having women aged 19–49 years and children aged 6–59 months were enrolled into the study. A standard formula (Equation (1)) was used to calculate the sample size (n) [27].

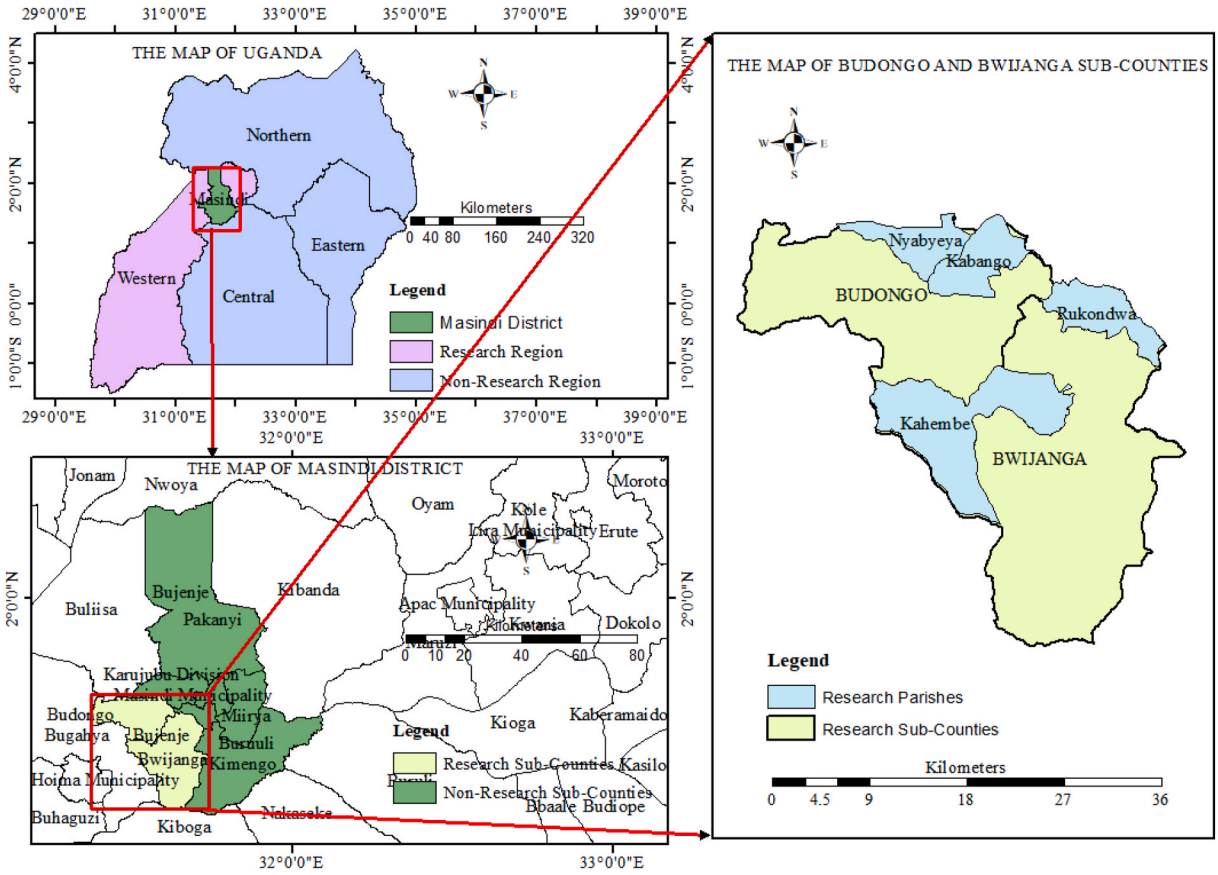


Fig. 1. Location of Masindi District in Uganda, study sub-counties and Parishes.

$$\text{Hence, } n = \frac{z^2 p(1-p)}{r^2} \quad (1)$$

Where; z is the confidence level at 95% (Standard value 1.96), p is the prevalence of malnutrition in Bunyoro estimated at 34.5% [21], r is the margin error at 5% (standard value of 0.05). Substituting the values in the equation, a total of 349 households was calculated and distributed between the sugarcane and non-sugarcane growers. The number of households was adjusted upwards by 10%–384 to cater for attrition. After cleaning the data, 350 participants were considered for this study, out of 350 which 192 were non-sugarcane growers and 158 were sugarcane growers.

Multistage sampling technique was used to enroll participants. Briefly, two sub-counties Bwijanga and Budongo were purposively selected because they are prominent sugarcane growing sub-counties in Masindi district. In each sub-county, two parishes were selected randomly by ballot. The selected parishes were Kahembe and Rukondwa in Bwijanga sub-county, and Nyabyeya and Kabango in Budongo sub-county. From each of these parishes, three villages were randomly selected by ballot. With the help of Local Council one (LC I) officials, participants were purposively selected on the basis of households with women aged 19–49 years having children 6–59 months of age. The authors acknowledge the limitation to purposive sampling as it is often associated with limited external validity [28]. The focus on households with children 6–59 years was driven by the wide body of knowledge that such children are vulnerable [29–31]) and probably, the households they belong to are vulnerable but also, they share similar characteristics, being homogenous.

2.2. Data collection

Data were collected through face-to-face interview using semi-structured questionnaire. Accordingly, we gathered information on livelihood activities, household assets, and income. A standard Household Food Insecurity Access Scale (HFIAS) questionnaire [32] was used to obtain information on food security status. These questionnaires were administered to either the household heads or their spouses. Nutritional status of the children aged 6–59 months was assessed using anthropometry [33]. Briefly, the weights of the children measured to the nearest 0.1 kg, Mid-Upper Arm Circumference (MUAC) and height to the nearest 0.1 cm. The age and sex of the children were also noted from the child health card. Three trained research assistants were used to conduct the interviews in both the local language (*Runyoro/Rutooro*) spoken in these areas and English.

2.3. Data analysis

Socioeconomic and demographic data, livelihood and food security data were organized in Statistical Package for Social Scientists (SPSS) version 20. Data on livelihood activities and food security status of households were analyzed using descriptive statistics followed by Pearson Chi-square to determine the association of household livestock and assets ownership to sugarcane and non-sugarcane growers.

In the case of food security status of households, the responses (i.e. no, rarely, sometimes, and often) to the nine questions were coded as 0, 1, 2, and 3, respectively. This was followed by summing up the HFIAS scores for the nine questions for each household. The minimum is 0 and maximum 27. The higher the HFIAS score, the more food insecure (in terms of access) a household is. Households were also classified into four levels of food insecurity: food secure, mildly food insecure, moderately food insecure, and severely food insecure basing on the cumulative HFIAS score. This study adopted the HFIAS classification by Ref. [34]: HFIAS = 0–1 was classified as food secure; HFIAS = 2–7, mildly food insecure, HFIAS = 8–11, moderately food insecure and HFIAS > 11,

severely food insecure. Finally, independent *t*-test was performed to compare the mean HFIAS between the sugarcane growing and non-sugarcane growing households.

Nutrition indices for children between the age of 6–59 months analyzed using WHO Anthro version 3.2. The proportion of children who were malnourished was interpreted in terms of height for age, weight for age and weight for height. Graphical presentations were used to visualize nutrition status between the children from sugarcane growing and non-sugarcane growing households with WHO standard reference curve. Descriptive statistics was used to compare the nutrition status of children 0–59 months of age between sugarcane and non-sugarcane growing households based on the age categories and z-score cut-off of less than −2.

3. Results

3.1. Demographic characteristics of respondents

The findings (Table 1) reveal that majority of respondents were females (SCG: 96.8%; NSCG: 90.1%) while 79.7% and 70.8% of SCG and NSCG, respectively were in the age bracket of 21–40 years. Majority of respondents were married (SCG: 82.3%; NSCG: 79.2%). A higher proportion of mothers/caregivers and household heads from sugarcane growing households (60.8–72.9%) completed primary level education than the corresponding non-sugarcane growing households 48.7–59.4%). A large proportion of respondents from monogamous families (SCG: 75.3%; NSCG: 76.6%). In addition, 75.9–89.9% and 70.8–85.4% of SCG and NSCG, respectively were self-employed household heads and mothers.

3.2. Household livelihood activities, assets, income and household food security status

The mean acreage of food crops ranged from 0.27 to 0.95 among sugarcane growers and 0.2 to 0.83 among non-sugarcane growers. While the mean yield of food crops ranged from 87.56 to 544.05 kg for sugarcane growers and 43.2–447.14 kg for non-sugarcane growers. There was no significant difference in acreage ($p > 0.05$) between the sugarcane growers and the non-sugarcane growers but the yields for groundnuts were significantly higher ($p < 0.05$) among sugarcane growers than non-sugarcane growers (Table 2). Regarding livestock production, chicken and in particular the local breed was mostly reared by 19.3–30.2% of non-sugarcane growing households compared to 19–29.1% of sugarcane growing households. In contrast, sugarcane

Table 2
Mean yields and acreages of major crops grown by respondents segregated by sugarcane and non-sugarcane growers.

Crops	Area planted/ Yield	Sugarcane growers	Non-sugarcane growers	p-value
		Mean ± SD	Mean ± SD	
Beans	Area planted	0.92 ± 2.19	0.61 ± 0.59	0.062
	Yield	258.56 ± 826.09	178.47 ± 303.51	0.215
Ground nuts	Area planted	0.27 ± 0.56	0.2 ± 0.31	0.118
	Yield	87.56 ± 230.99	43.2 ± 85.22	0.014
Maize	Area planted	0.95 ± 1.12	0.83 ± 1.06	0.336
	Yield	544.05 ± 1214.12	447.14 ± 709.12	0.353
Cassava	Area planted	0.63 ± 4.78	0.19 ± 0.27	0.201
Potatoes	Area planted	0.40 ± 2.53	0.09 ± 0.17	0.092

SD: Standard deviation, p-value significant at 0.05 level; Yield were measured in Kgs, and area planted in acres.

Table 1
Demographic characteristics of respondents.

Characteristics	Sugarcane growers		Non-sugarcane growers		Characteristics	Sugarcane growers		Non-sugarcane growers	
	n	%	n	%		n	%	n	%
Gender of household head					**Physiological status of respondent**				
Male	5	3.2	19	9.9	Pregnant woman	7	4.4	8	4.2
Female	153	96.8	173	90.1	Lactating mother	60	38.0	69	35.9
					Non pregnant	77	48.7	90	46.9
					Other caregivers	14	8.9	25	13.0
Age of respondent					**Family type**				
≤20 years	13	8.2	24	12.5	Monogamous	9	8.1	4	3.6
21–40 years	126	79.7	136	70.8	Polygamous	19	17.1	20	18.2
41–60 years	17	10.8	30	15.6	Monogamous and extended	36	32.4	32	29.1
61 and above	2	1.3	2	1.0	Polygamous and extended	27	24.3	28	25.5
Marital Status of the respondent					**Occupation of household head**				
Married	130	82.3	152	79.2	Civil servant	8	5.1	13	6.8
Single	12	7.6	12	6.3	Self employed	120	75.9	136	70.8
Widow	9	5.7	4	2.1	Casual labourer	29	18.4	43	22.4
Widower	1	0.6	1	0.5	Others	1	0.6	0	0.0
Divorced/Separated	6	3.8	23	12.0					
Education level of the mother/caregiver					**Occupation of the mother (if different from the household head)**				
No formal education	8	5.1	10	5.2	Civil servant	5	3.2	6	3.1
Primary	96	60.8	140	72.9	Self employed	142	89.9	164	85.4
Secondary	53	33.5	35	18.2	Casual labourer	8	5.1	17	8.9
Tertiary/University	1	0.6	7	3.6	Others	3	1.9	5	2.6
Education level of household head (if different from mother/caregiver)									
No formal education	8	5.1	12	6.3					
Primary	77	48.7	114	59.4					
Secondary	67	42.4	55	28.6					
Tertiary/University	6	3.8	11	5.7					

n: number of households, %: percentage.

growing households reared slightly more pigs (34.7%) than the non-sugar cane growing households (28.1%). The average proportion of households that reared goats were approximately equal between the sugarcane growing households (27.9%) and non-sugarcane growing households (27%). The least reared livestock by sugar cane growing and non-sugarcane growing households was turkeys accounting for 0.6% and 1.5%, respectively. There were no significant differences in the type of livestock reared by both the sugarcane growers and non-sugarcane growers. Furthermore, only 3.8% and 1.6% of the households of sugarcane growers and non-sugarcane growers respectively practiced bee farming as a source of livelihood (Table 3).

Regarding assets sugarcane growers (1.9–65.8%) owned more household assets than non-sugarcane growers (0.5–60.9%). However, with the exception of motorcycles ($p < 0.05$), there was no significant difference in household ownership of assets between the sugarcane and non-sugarcane growers ($p > 0.05$) (Table 4). From (Table 5), along income and expenditure gradient in an increasing order, the proportion of sugarcane growing households earning and spending was generally higher than those from non-sugarcane growing households. The daily income and expenditure of most non-sugarcane growing households was 5000 Ugandan shillings or below which was higher than those from sugarcane growing households (Table 5). Regarding food access (Table 6), 38% and 55.2% of the respondents from sugarcane growing and non-sugarcane growing households, respectively had anxiety and uncertainty of having food in the previous four weeks. In addition, the average proportion of respondents that reported affirmatively to having consumed insufficient quality foods was higher among non-sugarcane growing households (70.7%) compared to the sugarcane growing households (56.8%). Meanwhile, the respondents who reported affirmatively to have had insufficient quantity of food from sugarcane growing and non-sugarcane growing households accounted for 41.7% and 49.2% respectively. According to the results (Table 7), the prevalence of food insecurity was statistically different (p>0.05) between sugarcane growing and non-sugarcane growing households. Sugarcane growing households were more food secure (32.3%) than the non-sugarcane growing households (20.8%) with a corresponding mean HFIAS of 6.56 ± 6.69 and 8.41 ± 6.41 ($p < 0.05$). Similarly, the proportion of food insecure households was higher among non-sugarcane growers (79.2%) compared sugarcane growing households (67.7%).

The results for nutrition status (Table 8) show that overall, the proportion of children from sugarcane growing households who were underweight, stunted and wasted were 7.2%, 21.26% and 5.8% respectively, while 6.06%, 34.62% and 2.68% of the children from non-sugarcane growing households were underweight, stunted and wasted respectively.

The weight for height for children belonging to sugarcane growing and non-sugarcane growing households were skewed to the right of the WHO reference curve (Fig. 2a and b). For weight for age, children from both sugarcane growing and non-sugarcane growing households, the curve was skewed to the left of the WHO reference curve (Fig. 2c and d). Similarly, for height for age, the curve was skewed to the left of the WHO reference graph for children from both sugarcane growing and non-sugarcane growing households (Fig. 2e and f). In light of the aforementioned, future studies should focus on using a mixed approach, to assess the level of household nutrient intake in the current study are or similar areas.

Table 3
Percent of animals reared by the respondents segregated between sugarcane and non-sugarcane growers.

Livestock type	Sugarcane growers		Non sugarcane growers		*P*-value
	n	%	n	%	
Goat					0.333
None	114	72.2	140	72.9	
1–3	33	20.9	33	17.2	
4–6	9	5.8	14	7.3	
≥7	2	1.2	5	2.5	
Cattle					0.391
None	152	96.2	187	97.4	
1–3	6	3.8	5	2.6	
4–6	0	0.0	0	0.0	
≥7	0	0.0	0	0.0	
Pig					0.181
None	103	65.2	138	71.9	
1–3	49	31	53	27.6	
4–6	6	3.7	1	0.5	
≥7	0	0.0	0	0.0	
Sheep					0.571
None	152	96.2	184	95.8	
1–3	5	3.2	5	2.6	
4–6	1	0.6	2	1.0	
≥7	0	0.0	1	0.5	
Chicken					0.086
None	42	26.6	58	30.2	
1–3	30	19.0	37	19.3	
4–6	40	25.3	39	20.3	
≥7	46	29.1	58	30.2	
Ducks					0.584
None	150	94.9	182	94.8	
1–3	4	2.5	8	4.2	
4–6	3	1.9	2	1.0	
≥7	1	0.6	0	0.0	
Turkey					0.297
None	157	99.4	189	98.4	
1–3	0	0.0	3	1.5	
4–6	0	0.0	0	0.0	
≥7	1	0.6	0	0.0	
Bee keeping/Apiary					
Yes	6	3.8	3	1.6	
No	152	96.2	189	98.4	

P-value significant at ≤ 0.05 level, n: number of households, %: percentage.

Table 4
Proportion of household assets owned by sugarcane and non-sugarcane growers.

Household assets	Sugarcane growers		Non-sugarcane growers		*P*-value
	n	%	n	%	
Bicycle	92	58.2	93	48.4	0.068
Motorcycle	57	36.1	37	19.3	0.000
Motor Vehicle	5	3.2	5	2.6	0.754
Permanent building	66	41.8	67	34.9	0.187
Land	44	27.8	65	33.9	0.227
Sewing Machine	3	1.9	1	0.5	0.227
Solar	104	65.8	117	60.9	0.346
Radio	95	60.1	106	53.2	0.354

P-value significant at ≤ 0.05 level, n: number of households, %: percentage.

Table 5
Distribution of household income and expenditure segregated by sugarcane and non-sugarcane growers.

Category	Classification	Sugarcane growers		Non-sugarcane growers	
		n	%	n	%
Daily household income	5000 and below	70	44.3	114	59.4
	5000–10,000	32	20.3	38	19.8
	10,000–15,000	22	13.9	15	7.8
	15,000–20,000	15	9.5	15	7.8
	20,000 and above	19	12.0	10	5.2
Daily household expenditure	5000 and below	95	60.1	147	76.6
	5000–10,000	43	27.2	36	18.8
	10,000–15,000	10	6.3	5	2.6
	15,000–20,000	7	4.4	2	1.0
	20,000 and above	3	1.9	2	1.0

n: number of households, %: percentage.

Table 6
Proportion of participants with affirmative responses on household Food Insecurity Access Scale (HFIAS) between sugarcane growers and non-sugarcane growers.

Category of assessment and questions	% of the affirmative responses							
	Sugarcane growers				Non-sugarcane growers			
	Yes	Rarely	Sometimes	Often	Yes	Rarely	Sometimes	Often
Domain: Anxiety and Uncertainty								
In the past four weeks, did you worry that your household would not have enough food?	38.0	17.7	13.9	6.3	55.2	27.1	20.3	7.8
Domain: Insufficient Quality								
In the past four weeks, were you or any household member not able to eat the kinds of foods you preferred because of lack of resources?	55.7	26.6	16.5	12.7	70.3	32.8	28.1	9.4
In the past four weeks, were you or any household member not able to eat the kinds of foods you preferred because of lack of resources?	57.0	27.2	20.9	8.2	71.9	32.3	31.8	7.8
In the past four weeks, did you or any household member have to eat some foods that you really did not want to eat because of a lack of resources to obtain other types of food?	57.6	23.4	25.9	8.2	69.8	27.1	32.8	9.9
Average for insufficient quality	**56.8**	**25.7**	**21.1**	**9.7**	**70.7**	**30.7**	**30.9**	**9.0**
Domain: Insufficient Quantity								
In the past four weeks, did you or any household member have to eat a smaller meal than you felt you needed because there was not enough food?	48.1	15.8	26.6	5.7	67.2	28.6	34.4	4.2
In the past four weeks, did you or any household member have to eat fewer meals in a day because there was not enough food?	44.9	18.4	22.4	3.8	63.0	29.7	28.1	5.2
In the past four weeks, was there ever no food to eat of any kind in your household because of lack of resources to get food?	24.7	10.1	12.7	1.9	42.2	27.1	10.4	4.7
In the past four weeks, did you or any household member go to sleep at night hungry because there was not enough food?	25.9	16.5	8.9	6.0	32.8	20.3	8.3	4.2
In the past four weeks, did you or any household member go a whole day and night without eating anything because there was not enough food?	38.0	18.4	15.2	4.4	40.6	20.8	13.0	6.8
Average for insufficient quantity	**41.7**	**15.8**	**17.2**	**4.4**	**49.2**	**25.3**	**18.8**	**5.0**

%: percentage of households.

Table 7
Prevalence of food insecurity and mean HFIAS of households segregated by sugarcane and non-sugarcane growers.

HFIAS Cut-offs	HFIAS Categories	Sugarcane growers		Non-sugarcane growers		p-value
		n	%	n	%	
0–1	Food secure	51	32.3	40	20.8	0.023
2–7	Mildly food insecure	50	31.6	53	27.6	
8–11	Moderately food insecure	21	13.3	37	19.3	
12–27	Severely food insecure	36	22.8	62	32.3	
2–27	Food insecure combined	107	67.7	152	79.2	
Mean HFIAS score (SD)		6.56 ± 6.69		8.41 ± 6.41		

n: number of households, %: percentage of households, p-value significant at 0.05 level.

4. Discussion

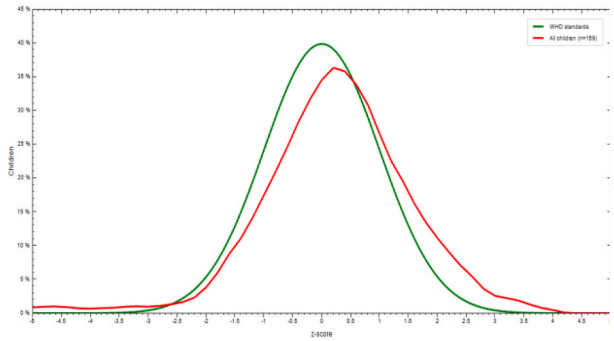
This study estimated the influence of sugarcane growing on the livelihoods, household food security, and nutrition status of children aged 6–59 months in mid-western Uganda. According to the results of this study, sugarcane growing households possessed larger acreage of food crops planted and yields (Table 2), more animals (Table 3) and owned more assets (Table 4) than non-sugarcane growing households. Previous studies [35] revealed that households that possess large pieces of land for cultivating crops were at an advantage of being food secure due to increased crop production as compared to those with smaller land sizes. In the current study, although there is no significant difference between sugarcane and non-sugarcane producing households regarding the area cultivated with food crops, there is additional benefit through sugarcane production. This can be translated into increased food availability and higher purchasing power. Indeed, it is demonstrated in the current study (Table 5) that sugarcane growing households generally had higher daily income and expenditures than the non-sugarcane growing households. This is in agreement with a study [7] which reported better household income among smallholder farmers engaged in sugarcane production compared to the non-sugarcane growing. It is also indicated in previous studies [36] that households with higher income may be in position to purchase more and diverse food items for household members as compared to those with less income. Therefore, this can increase the likelihood of being food secure because such households can purchase variety of nutritious foods [37].

It is widely known that diversity of assets enables smallholder farmers to become more resilient to shocks and raise their incomes, create stable and productive livelihoods for enhanced food security [19]. The results of the current study indicate that sugarcane growing households possessed more assets on average than non-sugarcane growers (Table 4). However, with exception of motorcycles ($p <$

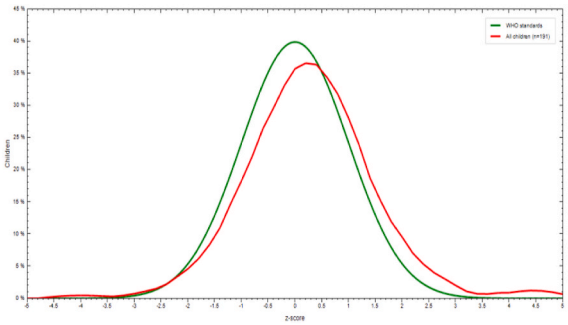
Table 8
Nutritional status of children from sugarcane and none-sugarcane growing households segregated by age groups and nutrition indices.

Age groups (months)	n		Weight-for-age (%<-2SD)		Height-for-age (%<-2SD)		Weight-for-height (%<-2SD)	
	SCG	NSCG	SCG	NSCG	SCG	NSCG	SCG	NSCG
(6–11)	23	32	0	6.2	8.7	28.2	0	9.4
(12–23)	50	60	12	5	35.4	31.7	12	1.7
(24–35)	39	44	20.6	0	28.6	22.8	10.2	2.3
(36–47)	27	33	3.7	6.1	23.1	30.3	3.7	0
(48–60)	19	23	0	13	10.5	60.1	0	0
Total	**158**	**192**	**7.26**	**6.06**	**21.26**	**34.62**	**5.18**	**2.68**

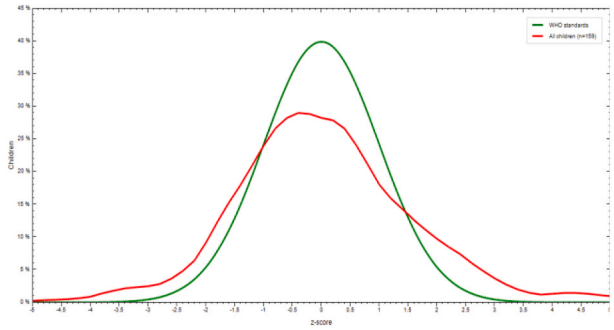
n: number of children, SCG: Sugarcane growing households, NSCG: Non-sugarcane growing households, <-2SD: standard deviation of the Z-score cut-off for s healthy child of the same age.



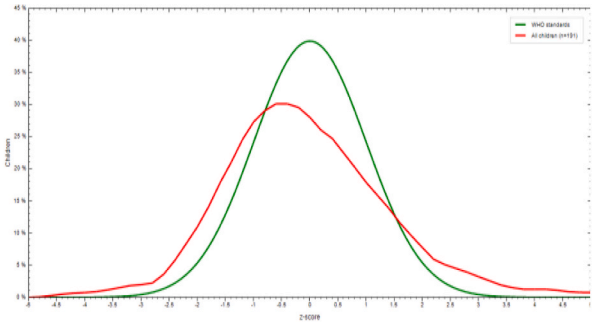
a: Weight for Height Z-score curve for sugar cane growers compared with WHO reference curve



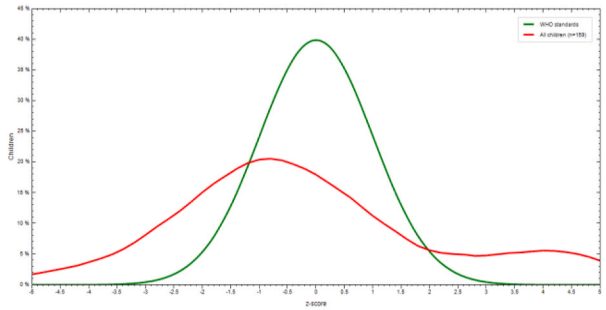
b: Weight for Height Z-score curve for non sugar cane growers compared with WHO reference curve



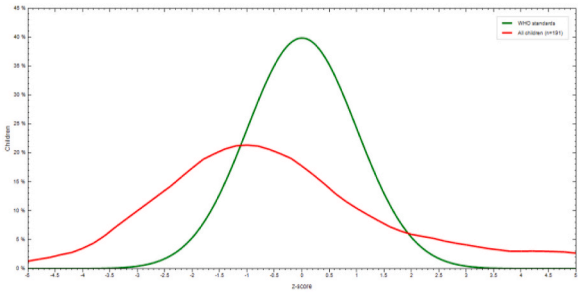
c: Weight for Age Z-score curve for sugar cane growers compared with WHO reference curve



d: Weight for Age Z-score curve for non sugar cane growers compared with WHO reference curve



e: Height for Age Z-score curve for sugar cane growers compared with WHO reference curve



f: Height for Age Z-score curve for non sugar cane growers compared with WHO reference curve

Fig. 2. Comparison of nutrition anthropometric indicators with WHO reference curves.

0.05), there was no significant difference in household ownership of assets between the sugarcane and non-sugarcane growers ($p > 0.05$). This can partly be attributed to the fact that sugar cane growing households are in position to earn and spend more income (Table 5) from the sale of sugarcane which can be transformed into assets.

Disparities in crop production, ownership of domestic animals, income levels, and assets between sugarcane growing and non-sugarcane growing households should not be underestimated by policy makers and local authorities because of their influence on food security and quality of life. Therefore, interventions to address specific barriers to increasing crop production levels and diversity, coupled with rearing of poultry and small ruminants targeting non-sugarcane growing households can be important consideration alongside empowering the households to own assets.

Our finding (Table 6) suggest that non-sugarcane growing households were more susceptible to food insecurity than the sugarcane growing households. This is consistent with the result in Table 7 where the prevalence of food insecurity in non-sugarcane growing households was high compared to sugarcane growing households. The disparities in the food security status between sugarcane growing and non-sugarcane growing households can be attributed to the disparities in the level of food availability and economic access. For instance, sugarcane growers reared more animals, earned and spent more money, cultivated more food crops compared to the non-sugarcane growing households. The

assets and food surplus can be converted to income coupled with the sale of sugarcane and hence increased purchasing power. This consequently leads to improved food security status of households [38–42]. The finding of the current study suggests that non-sugarcane growing households are less resilient and susceptible to food insecurity and its dire consequences. This is because food insecurity is associated with inadequate macro and micronutrient intake [43] and depletes household resources through increased hospital bills to treat malnutrition related diseases [44,45]. This eventually translates into nutritional deficiency conditions such as stunting, underweight and wasting, micronutrient deficiencies [46–48].

In line with the aforementioned, our assessment of nutrition status (Table 8 and Fig. 2) indicate mixed results depending on the nutrition indicators. According to our result (Table 8), children from non-sugarcane growing households experienced high prevalence of stunting, while those from sugarcane growing households had high prevalence of underweight and wasting. However, in both scenarios for sugarcane growing households and non-sugarcane growing households, the proportion of undernourishment (underweight and stunted) among the children in the current study was lower than that reported by Lwanga et al. [49] and UBOS and ICF [20]. On the other hand, the proportion of wasted children (only sugarcane growers) in this study was higher than that reported for Bunyoro sub-region and nationally [20]. Underweight combines information about linear growth obstruction and weight for length/height [50] and measures both acute undernutrition (wasting) and chronic undernutrition (stunting) [51]. Irrespective of the nutrition indicators, these forms of undernutrition have been implicated for their effect on health [52,53], growth [54] and economic development [55,56]. For instance, stunting results from long-term insufficient nutrient intake and repeated infections and leads to delayed motor development, and impaired cognitive development, which are largely irreversible, while wasting, which is a result of acute food shortage and illness is a strong predictor of mortality requiring urgent response [50]. The mixed effect of sugarcane growing on nutrition indicators suggest that factors other than food security exist and influence the nutrition situation. According to the United Nations International Children's Emergency Fund (UNICEF) conceptual framework, food insecurity is one of the underlying causes of malnutrition affecting dietary intake and health of an individual [57]. Coupled with this framework, other factors influencing nutrition status include poverty, low parental education, poor feeding practices, economic status, residence, family size, living in developing countries, number of children under five years in one family, as well as urban and rural differences [52]. Therefore, despite the disparities in the socio-economic and demographic characteristics, agricultural production levels, asset ownership, income and expenditure, food security status between sugarcane and non-sugarcane growing households, nutrition status is generally poor. To improve food security and nutrition status, promotion of agricultural diversification and non-agricultural livelihood strategies among non-sugarcane growing households by government and non-governmental organizations can strengthen availability and access to diverse foods. Nutrition and health education should be integrated in agricultural interventions and promoted among both sugarcane and non-sugarcane growers to address all forms of malnutrition among children below five years of age while emphasizing good maternal nutrition practices within the first 1000 days from conception [58,59].

5. Conclusions

This study aimed at investigating the extent to which sugarcane growing influences livelihoods, food security and nutrition status. Overall, the study has demonstrated that households engaged in sugarcane growing had better livelihood activities, owned more assets, earned more income, and spent more on a daily basis than those not growing sugarcane. Further, we found that households that participated in sugarcane growing were more food secure than the non-sugarcane growing households. This was demonstrated by the fact that, non-sugarcane growing households expressed more anxiety and uncertainty of having food in the previous four weeks; had insufficient food quality; and had insufficient food quantity than sugarcane growing households. On the other hand, this study showed that sugarcane growing had a mixed effect on nutrition indicators of children below five years. For instance, stunting was higher among children from non-sugarcane growing households while wasting and underweight was high among children from sugarcane growing households. Therefore, we recommend a comprehensive package of interventions for both sugarcane growing and non-sugarcane growing households that include agricultural diversification, non-agricultural livelihoods concurrent with health and nutrition education.

Ethical consideration

This study sought Ethical clearance from Gulu University Research Ethnics Committee (GUREC) (No. GUREC-026-19) and conducted with permission from Chief Administration Officer (CAO) and lower local government leadership.

Funding

This study did not receive any grants from any source.

Consent for publication

Not applicable.

Availability of data and materials stake

The data that support the findings of this study are available from the authors upon reasonable request.

CRediT authorship contribution statement

Kaahwa Robert Mbabazi: Conceptualization, Data curation, Formal analysis, Investigation, Writing – original draft. **Sunday Mark Oyet:** Conceptualization, Data curation, Formal analysis, Software, Writing – review & editing. **Christopher Muggaga:** Conceptualization, Data curation, Formal analysis, Software, Supervision, Writing – review & editing. **Ipolto Okello-Uma:** Conceptualization, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Acknowledgements

Authors acknowledge Masindi District Local Government for granting permission to conduct this study.

References

[1] S. Zhou, I.J. Minde, B. Mtigwe, Smallholder agricultural commercialization for income growth and poverty alleviation in southern Africa: a review, Afr. J. Agric. Res. 8 (22) (2013) 2599–2608.

[2] N.S. Zulu, M. Sibanda, B.S. Tlali, Factors affecting sugarcane production by small-scale growers in ndwedwe local unicipality, South Africa, Agriculture 9 (8) (2019) 1–14, https://doi.org/10.3390/agriculture9080170.

[3] Ceres organization, An Investor Brief on Impacts that Drive Business Risks: engagethechain.Org, Sugarcane Engage the Chain, 2017.
[4] Inernational Plant Biotechnology Outreach (IPBO), Sugarcane in Africa, Sugarcane in Africa 8 (2017) 1–56, 2017.
[5] FAO, PART 3 Feeding the world, Food Outlook 123–199 (2007).
[6] T.M. Hess, J. Sumberg, T. Biggs, M. Georgescu, D. Haro-Monteagudo, G. Jewitt, J. W. Knox, A sweet deal? Sugarcane, water and agricultural transformation in Sub-Saharan Africa, Global Environ. Change 39 (2016) 181–194, https://doi.org/10.1016/j.gloenvcha.2016.05.003.
[7] E.N. Mwavu, V.K. Kalema, F. Bateganya, P. Byakagaba, D. Waiswa, T. Enuru, M. S. Mbogga, Expansion of commercial sugarcane cultivation among smallholder farmers in Uganda: implications for household food security, Land 7 (2) (2018) 1–15, https://doi.org/10.3390/land7020073.
[8] M.W. Nabalegawa, T.R.J. Asaba, M. Waibi, Sugarcane growing and the livelihoods of small-scale farmers in jinja district, Uganda, Forum Geografi 36 (2) (2022), 2022.
[9] G. Martiniello, A. Owor, I. Bahati, A. Branch, The fragmented politics of sugarcane contract farming in Uganda, J. Agrar. Change 22 (1) (2022) 77–96, https://doi.org/10.1111/joac.12455.
[10] Grace Lubaale, Sugarcane growing and effects on farmer's development in Kamuli district of Uganda, Int. J. Social Sci. Res. Rev. 5 (12) (2022) 6–315, https://doi.org/10.47814/ijssrr.v5i12.810, 2022.
[11] I.F.A.D. FAO, W. UNICEF, W, The State of Food Security and Nutrition in the World. Building Resilience for Peace and Food Security, 2017.
[12] W. Peng, E.M. Berry, The concept of food security, Elsevier, in: P. Ferranti, E. M. Berry, J.R. Anderson (Eds.), Encyclopedia of Food Security and Sustainability, vol. 2, 2019, pp. 1–7, 9780128126875.
[13] FAO, Get the best from your food, in: FAO Food, Nutrition and Agriculture. 1996, vol. 16, FAO, Rome, 1996.
[14] J.R. Behrman, The economic rationale for investing in nutrition in developing countries, World Dev. 2 1 (1 1) (1993), 1749-I 771.
[15] H. Young, S. Jaspars, R. Brown, J. Frize, H. Khogali, Food-security Assessments in Emergencies : a Livelihoods Approach, 2001, 2001 (Issue June).
[16] B. Coello, G. Oseni, T. Savrimootoo, E. Weiss, Rural development in Haiti : challenges and opportunities, in: The World Bank, 2014, 2014(Issue September).
[17] M.B. Masuku, M.B. Dlamini, Profitability of smallholder sugarcane farming in Swaziland: the case of komati downstream development programme (KDDP) sugar farmers' associations, 2005–2011, Sustain. Agric. Res. 2 (1) (2012) 8, https://doi.org/10.5539/sar.v2n1p8.
[18] M. Kaini, Role of agriculture in ensuring food security, Int. J. Human. Appl. Social Sci. (2020) 1–5, https://doi.org/10.33642/ijhass.v5n1p1.
[19] L. Kidula, C. Onyango, W. Ochola, 1700(2006), Analysis of Smallholder Sugarcane Farmers ' Livelihood Assets in Relation to Food Security in Mumias Sub- County Kenya, 2016, pp. 40–47.
[20] UBOS and ICF, Uganda Demographic and Health Survey 2016, Kampala Uganda, 2017.
[21] USAID-Community Connector, Phase II Disticts Ssituation Analysis Report, Kampala, Uganda, 2013.
[22] B.E. Isingoma, S.K. Mbugua, E.G. Edward Gichohi Karuri, Nutritional status of children 7–36 months old from millet consuming communities of Masindi District, Western Uganda, BMC Nutr. 5 (2019) 11, https://doi.org/10.1186/s40795-019-0273-z.
[23] C. Carletto, P. Corral, A. Guelfi, Agricultural commercialization and nutrition revisited: empirical evidence from three African countries, Food Pol. 67 (2017) 106–118, https://doi.org/10.1016/j.foodpol.2016.09.020, 2017.
[24] K. Mwanika, A.E. State, P. Atekyereza, T. Osterberg, Commercial sugarcane farming in eastern Uganda: the answer to vulnerable youth? E. Afr. Soc. Sci. Res. Rev. 37 (1) (2021) 1–25, https://doi.org/10.1353/eas.2021.0000.
[25] (MDLG). The third five-year local government development plan 2020/2021-2024/2025, The Republic of Uganda, Masindi District Local Government, 2020. MDLG.
[26] Uganda Bureau of Statistics, Uganda Bureau of Statistics 2016, the National Population and Housing Census 2014- Main Report, 2014. Kampala, Uganda.
[27] V. Kasiulevičius, V. Šapoka, R. Filipavičiūtė, Sample size calculation in epidemiological studies, Gerontol. 7 (4) (2006) 225–231, 013165/AIM.0010.
[28] C. Andrade, The inconvenient truth about convenience and purposive samples, Indian J. Psychol. Med. 43 (1) (2021) 86–88.
[29] V.N. Maniragaba, L.K. Atuhaire, P.C. Rutayisire, Undernutrition among the children below five years of age in Uganda: a spatial analysis approach, BMC Publ. Health 23 (390) (2023), https://doi.org/10.1186/s12889-023-15214-9.
[30] A. Alexander Bagattini, Children's well-being and vulnerability, Ethics Soc. Welfare 13 (3) (2019) 211–215, https://doi.org/10.1080/17496535.2019.1647973, 2019.
[31] M. Sumit, Assessing vulnerability to chronic undernutrition amongUnder-five children in Egypt: contextual determinants of an individual consequence, International Journal of Population Research (2012), https://doi.org/10.1155/2012/939541.
[32] J. Coates, P. Bilinsky, J. Coates, Household Food Insecurity Access Scale (HFIAS) for Measurement of Food Access: Indicator Guide Version 3, 2007.
[33] MOH, Guidelines for Integrated Management of Acute Malnutrition in Uganda, MOH, 2016, 2016; Kampala Uganda.
[34] G. Chakona, C.M. Shackleton, Household food insecurity along an agro-ecological gradient influences Children's nutritional status in South Africa, Front. Nutr. 4 (72) (2018) 1–13.
[35] S. Kuwenyi, F. Kabuya, M.B. Masuku, D eterminants of rural households' food security in shiselweni region , Swaziland : implications for agricultural policy, IOSR J. Agric. Vet. Sci. 7 (11) (2014) 44–50.
[36] A. Sultana, A. Kiani, Determinants of food security at household level in Pakistan, Afr. J. Bus. Manag. 5 (34) (2011) 12972–12979, https://doi.org/10.5897/AJBM11.1441.
[37] Q. Khan, M.U. Farooq, M.R. Yaseen, Socioeconomic determinants of food security : evidence from jhang district of Punjab, Pakistan, Eur. Online J. Nat. Soc. Sci. 7 (3) (2018) 109–116.
[38] F.A.O. Africa, Regional Review of Food Security and Nutrition, FAO, Rome, 2017.
[39] A. Niehof, L.L. Price, Rural Livelihood Systems : A Conceptual Framework, 2001, pp. 1–15, 2001.
[40] L. Krantz, The Sustainable Livelihood Approach to Poverty Reduction, 2001.
[41] C. Huddleston-Casas, R. Charnigo, L.A. Simmons, Food insecurity and maternal depression in rural, low-income families: a longitudinal investigation, Publ. Health Nutr. 12 (8) (2008) 1133–1140, https://doi.org/10.1017/S1368980008003650.
[42] H. Young, S. Jaspars, R. Brown, J. Frize, KH, Food Security Assessments in Emergencies: A Livelihoods Approach, ODI Humanitarian Practice Network (HPN), Paper No. 36, Overseas Development Institute, London, UK, 2001.
[43] A.H. El Bilbeisi, A. Al-Jawaldeh, A. Albelbeisi, S. Abuzerr, I. Elmadfa, L. Nasreddine, Households' food insecurity and their association with dietary intakes, nutrition-related knowledge, attitudes and practices among under-five children in gaza strip, Palestine, Front. Public Health 10 (2022), 808700, https://doi.org/10.3389/fpubh.2022.808700.
[44] R.E. Black, C.G. Victora, S.P. Walker, Z.A. Bhutta, P. Christian, M De Onis, M. Ezzati, Maternal and Child Nutrition 1 Maternal and Child Undernutrition and Overweight in Low-Income and Middle-Income Countries, 2013, https://doi.org/10.1016/S0140-6736(13)60937-X.
[45] H. Ghattas, Food Security and Nutrition in the Context of the Global Nutrition Transition, FAO, Rome, 2014.
[46] C. Gundersen, J.P. Ziliak, Childhood Food Insecurity in the U.S.: Trends, Causes, and Policy Options, 2014.
[47] S.D. Weiser, D.R. Bangsberg, S. Kegeles, K. Ragland, M.B. Kushel, E.A. Frongillo, Food insecurity among homeless and marginally housed individuals living with HIV/AIDS in san francisco, AIDS Behav. 13 (2009) 841–848.
[48] N.P. Rocha, L.C. Milagres, JFDe Novaes, C. Castro, Association between food and nutrition insecurity with cardiometabolic risk factors in childhood and adolescence : a systematic review, Rev. Paul. Pediatr. 34 (2) (2016) 225–233.
[49] F. Lwanga, R.K. Wanyenze, J.K.B. Matovu, C.G. Orach, Food security and nutritional status of children residing in sugarcane growing communities of east-Central Uganda : a cross-sectional study, J. Food Secur. 3 (2) (2015) 34–39.
[50] R.K. Sinha, R. Dua, V. Bijalwan, S. Rohatgi, P. Kumar, Determinants of stunting, wasting, and underweight in five high-burden pockets of four Indian states, Indian J. Community Med. 43 (2018) 279–283.
[51] M. Mgongo, N.A.S. Chotta, T.H. Hashim, J.G. Uriyo, D.J. Damian, B. Stray-Pedersen, S.E. Msuya, M. Wandel, S. Vangen, Underweight, stunting and wasting among children in kilimanjaro region, Tanzania; a population-based cross-sectional study, Int. J. Environ. Res. Publ. Health 14 (2017) 509, https://doi.org/10.3390/ijerph14050509.
[52] A. Kurtz, K. Grant, R. Marano, A. Arrieta, K. Grant Jr., W. Feaster, C. Steele, L. Ehwerhemuepha, Long-term efects of malnutrition on severity of COVID-19, Sci. Rep. 11 (2021), 14974, https://doi.org/10.1038/s41598-021-94138-z.
[53] O. Müller, M. Krawinkel, Malnutrition and health in eveloping countries, Can. Med. Assoc. J. 173 (3) (2005), https://doi.org/10.1503/cmaj.050342.
[54] Oguegbu A Effects of nutrition on the growth and development of children between 0-6 years of age in the covid-19 era, Unizik J. Educ. Res. Policy Stud. (9) (2021). https://unijerps.org.
[55] H. Alderman, H. Hoogeveen, M. Rossi, Reducing child malnutrition in Tanzania: combined effects of income growth and program interventions, Econ. Hum. Biol. 4 (1) (2006) 1–23, https://doi.org/10.1016/j.ehb.2005.07.001.
[56] P. Fatch, C. Masangano, J. irmgard, T. Higler, A. Kalimbira, M.G. Glas, A. Roehlig, G. Chiutsi-Phiri, J.F.M. Kimoto, I. Mambo, E.-A. Nuppenau, Agricultural diversity linkage to income, wealth, diets and nutrition.: case of lilongwe district in Malawi, Sci. Afr. 19 (2023), e01569.
[57] United Nations Children's Fund (UNICEF), Nutrition for Every Child: UNICEF Nutrition Strategy 2020-2030-In Brief. UNICEF Nutrition Section, Programme Division, 3 United Nations Plaza, New York, NY 10017, USA, 2020.
[58] A. Likhar, M.S. Patil, Importance of maternal nutrition in the first 1,000 Days of life and its effects on child development: a narrative review, Cureus 14 (10) (2022).
[59] A. Pietrobelli, M. Agosti, MeNu Group., Nutrition in the first 1000 days: ten practices to minimize obesity emerging from published science, Int. J. Environ. Res. Publ. Health 14 (12) (2017) 1491.