Landslide-effects on food security, the nutritional status of children under five years and the human right to adequate food in Uganda

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List of Papers

The papers in this thesis will be referred to by their Roman numerals.

Paper I

Nahalomo A, Iversen PO, Andreassen BA, Kaaya AN, Rukooko AB, Tushabe G, Nateme NC, Rukundo PM.

Malnutrition and Associated Risk Factors among Children 6-59 Months Old in the Landslide-Prone Bududa District, Eastern Uganda: A Cohort Study.

Current Developments in Nutrition (2022); 6(2):nzac005. doi: 10.1093/cdn/nzac005

Paper II

Nahalomo A, Iversen PO, Andreassen BA, Kaaya AN, Rukooko AB, Rukundo PM.

Food insecurity, diet diversity and the right to adequate food among households in landslide-prone communities in Eastern Uganda: a cohort study.

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Paper III

Nahalomo A, Iversen PO, Andreassen BA, Kaaya AN, Rukooko AB, Rukundo PM.

Seasonality- and disaster effects on food variety and food insecurity coping strategies among a landslide-prone cohort.

Clinical Nutrition ESPEN 2022; 52: 229-239. doi:10.1016/j.clnesp.2022.11.05

Abbreviations

ANCOVA	Analysis of Covariance
aOR	Adjusted odds ratio
CCHIP	Community Childhood Hunger Identification Project
CESCR	Committee on Economic Social and Cultural Rights
CI	Confidence interval
CRC	Convention on the Rights of the Child
cOR	Crude odds ratio
CSI	Coping Strategy Index
ICESCR	International Covenant on Economic Social and Cultural Rights
FAO	Food and Agriculture Organization of the United Nations
FGDs	Focus Group Discussions
FFQ	Food frequency questionnaire
FVS	Food variety score(s)
GC	General Comment
GOU	Government of Uganda
HAZ	Height-for-age z-score
HCZ	Head circumference-for-age z-score
HDDS	Household Dietary Diversity Score
HFIAS	Household Food Insecurity Access Scale
KIIs	Key informant interviews
LMICs	Low-and middle-income countries
MANCOVA	Multivariate analysis of covariance
MUACZ	Mid upper arm circumference-for-age z-score
RtAF	Right to adequate food
SD	Standard deviation
SDGs	Sustainable Development Goals
SE	Standard error
UDHR	Universal Declaration of Human Rights
UDHS	Uganda Demographic Health Survey
UN	United Nations
WHO	World Health Organization
WHZ	Weight-for-height z-score

Summary

Background: Landslides predispose Ugandans to risk factors that may lead to poor nutritional health. However, longitudinal cohort data on landslides and seasonality effects on food security, diet, child nutritional status and the realization of the right to adequate food among landslide-prone communities are scarce.

Aims: We investigated landslides and seasonality effects on food security, diet, the nutritional status of children 6-59 months, and the right to adequate food among households affected by the major 2010 and 2018 landslides in rural Eastern Uganda.

Methods: In this mixed methods cohort study, we used a 3-stage simple random technique to select 422 households including 392 children in May-August (food-plenty season) 2019. After 6 months, in January-March (food-poor season) 2020, 388 households and 366 children were re-assessed. Food insecurity and child anthropometry were measured by standardized scoring questionnaires and WHO-standards, respectively. Four focus group discussions with affected rights-holders and key informant interviews with 10 purposively sampled duty-bearers, such as the Chairperson Disaster Management Committee, Bududa hospital nutritionist, Sub-county Chiefs and Local Council Leaders, among others, explored issues of food insecurity, diet and the right to adequate food.

Results: The landslide-affected households had a higher prevalence of child stunting in the food-poor season (42.6%) than in the food-plenty season (37.7%). Both levels were higher than the national and Bududa sub-region prevalence of 29% and 35.9%, respectively. Residing in the landslide-affected sub-county increased the odds for stunting (aOR = 1.68, 95% CI: 1.08, 2.59; p = 0.025) and underweight (aOR = 4.25, 95% CI: 1.10, 15.36; p = 0.032) for children in food-plenty season. Affected households compared to the controls had significantly higher mean (SE) food insecurity scores: 15.3 (0.5) vs. 10.8 (0.5) and 15.9 (0.4) vs. 12.5 (0.0) ($p < 0.001$), and significantly lower mean dietary diversity scores: 5.4 (0.2) vs. 7.5 (0.2) and 5.2 (0.2) vs. 7.3 (0.1) ($p < 0.001$) during both food-seasons. Affected households compared to the controls had significantly lower mean food variety scores: 9.3 (0.5) vs. 11.4 (0.3) and 7.6 (0.5) vs 10.1 (0.1) ($p < 0.001$), and significantly higher mean food insecurity coping strategies: 35.2 (2.1) vs. 27.1 (1.8) and 42.1 (2.1) vs. 28.2 (2.1) ($p < 0.001$) during both food-seasons. Disaster exposure was significantly associated with all the food insecurity outcomes during both food-seasons ($p < 0.001$). Awareness of human rights principles and state obligations was low among both rights-holders and duty-bearers.

Conclusion: Landslides and seasonality, without efficient risk preparedness and management systems, contribute to food insecurity, child malnutrition and non-realization of the right to adequate food in rural Uganda.

Norsk oppsummering

Bakgrunn: I Uganda øker jordskred i jordbruksområder faren for underernæring. Samtidig er det gjort lite forskning om hvordan jordskred påvirker matsikkerhet og særlig barns ernæringsstatus over tid. Vi vet også lite om hvordan sesongvariasjoner kan påvirke ernæringsstatus i jordskredberørte samfunn i landet. Det er behov for mer kunnskap om hvordan innbyggerne i jordskredberørte områder kan få realisert deres rett til mat, slik dette omtales i FNs menneskerettighetskonvensjoner.

Formål: Vi undersøkte hvordan ulike matsesonger påvirket matsikkerhet, kosthold og ernæringsstatus blant barn i alderen 6-59 måneder samt retten til mat blant familiene/husholdningene til de som ble berørt av de store jordskredene i 2010 og 2018 i det østlige Uganda.

Metode: I denne kohorte-studien inkluderte vi 422 husstander med til sammen 392 barn i perioden mai-august (i mat-rik sesong) 2019. Seks måneder senere (januar-mars 2020, i mat-fattig sesong) ble 388 av disse husstandene med 366 barn undersøkt på nytt. Matsikkerhet og barnas kroppsmål ble undersøkt med henholdsvis standardiserte spørreskjemaer og WHO-verktøy. Fire fokusgruppediskusjoner med berørte rettighetshavere og intervjuer med 10 utvalgte, lokale, sentrale nøkkelinformanter («pliktbærere» i menneskerettslig terminologi) ble også gjennomført. De utvalgte informantene besto av komiteen for jordskredkatastrofer, ernæringsfysiolog, fylkessjefer og rådsledere. Disse fikk spørsmål om matsikkerhet, kosthold og om ivaretakelse av retten til mat slik dette defineres av FN og FAO.

Resultater: Barna hadde høyere forekomst av kortvoksthet (markør på kronisk underernæring) i den mat-fattige sesongen (42,6%) sammenliknet med den mat-rike sesongen (37,7%). Til sammenlikning er den nasjonale forekomsten 29%. Det å være bosatt i jordskredområdet i den mat-rike sesongen økte sjansen for kortvoksthet (justert odds ratio-aOR: 1,68, 95% KI 1,08-2,59, p=0,025) og undervektige barn (aOR: 4,25, 95% KI 1,10-15,36, p=0,032). De jordskredberørte husholdningene hadde signifikant høyere gjennomsnittlig skår på mat-usikkerhet sammenliknet med uberørte husholdninger (kontrollgruppen) i begge matsesongene. De førstnevnte hadde også signifikant lavere gjennomsnittlig skår på kostholdsmangfold (markør på grad av tilfredsstillende matinntak) sammenliknet med kontrollgruppen. I begge sesongene hadde de jordskredberørte husholdningene også signifikant lavere gjennomsnittlig skår på matvarevariasjon samt høyere skår på strategier for mestring av lav mat-sikkerhet sammenliknet med kontrollgruppen. Det å bli utsatt for jordskred var signifikant assosiert med alle indikatorer for mat-usikkerhet i begge sesongene. Både rettighetshavere og pliktbærere hadde lav bevissthet om retten til mat og statlige forpliktelser i henhold til internasjonale menneskerettighetstraktater.

Konklusjon: Jordskred og sesongvariasjoner i mattilgang uten effektive beredskap- og styringssystemer, bidrar til mat-usikkerhet, underernæring blant barn og mangel på realisering av retten til mat på landsbygda i Uganda.

1. Introduction

Ending hunger, food insecurity and all forms of malnutrition in low-and middle-income countries (LMICs) is still a major challenge due to a nexus of factors such as climate change, disasters, seasonality, conflicts, diseases, inadequate education and poverty, among others.

This thesis examines landslide disasters and seasonality, and the extent to which they posed a serious risk to the nutritional health of children, food security, and the human right to adequate food for communities of the Eastern parts of the Mount Elgon Volcano in Eastern Uganda. Landslides and seasonality may increase and/or predispose individuals, households, communities and societies to risk-factors that hinder optimal foetal and child growth and development. Such factors include increased food insecurity, limited intake of a diversified diet and a variety of foods, recurrent illnesses/infections, reduced childcare, reduced accessibility to land for food production, and limited access to safe water sources, health facilities, transport and emergency assistance and reliance on negative food insecurity coping strategies.

1.1 Landslide disasters

Landslides are geologic, natural disasters that occur when large masses of soil, rocks, debris, or earth move down the slope under the action of gravity due to a natural occurrence or human activity [1]. The frequency and intensity of landslides, usually triggered by heavy rainstorms, heavy rains, volcanic eruptions or earthquakes, are increasing due to modern land-use practices, climate change, population growth, rapid urbanization, deforestation and unplanned development of mountainous terrain [2-5]. Unfortunately, this increment in landslides comes with devastating effects on humans, animals and the environment, particularly in LMIICs [2]. Worldwide, many countries have suffered deaths and economic

losses due to landslides and the impact is on the rise, threatening global sustainable development goals and targets [4, 6-9].

Reportedly, from 1980-2003, the total area of the world exposed to landslides was estimated at 3.7 million square kilometres, placing about 300 million people at risk of landslide effects [10, 11]. During the period between 1995 and 2014, a total of 3,876 landslide events worldwide killed 163,658 people and left 11,689 injured, homeless, displaced or in need of emergency assistance including food [5]. Between 1998 and 2017, a total of 4,862 distinct landslide events resulted in the death of 55,997 people and an estimated 4.8 million people were affected [7, 12].

An estimated annual average of economic losses of 20 billion US dollars (USD), which is 17% of the total (121 billion USD) yearly mean global disaster losses from 1980 and 2013, was reported [8, 13]. Between 1998 and 2017, landslides, volcanic activity and dry mass movement resulted in 8 billion USD in economic losses [12], and in 2020, a total of 19 (6.1%) landslide disasters occurred worldwide with a death toll of 514 people, affecting 179,800 people and resulted in 1.3 billion USD direct economic losses [14]. Notably, 40% of the world's poor are living in sub-Saharan Africa where natural disasters including landslides have a profound socio-economic impact, by increasing food insecurity, poverty and inequality [15]. Similarly, in Africa, the frequency and intensity of landslides have been increasing in the past two decades with catastrophic effects on the lives, property, and livelihoods of people. The effects are more devastating to LMICs because of the lack of resources, fragile infrastructure, unsustainable production systems, disaster preparedness systems and the presence of weak policies that would otherwise promote resilience mechanisms to the landslides risks and the ability of communities to anticipate, cope with, resist and recover from shocks [15-18].

According to Broeckx *et al* [19], by the end of 2018, about 10% of the African continent had a moderate to very high landslide susceptibility with approximately 18,050 landslide inventories covering 51 out of 55 African countries. In Eastern Africa, landslides are among the most frequent natural disasters [20, 21] with effects reaching 1% of the gross domestic products in the individual countries [22]. Uganda has over the past years experienced frequent natural disasters including landslides [23]. During 2019-2020, excluding Covid-19 impacts, disaster events in 70 districts affected 800,000 people, displaced 21,000 families, and resulted in 152.2 million USD economic losses [24]. Moreover, between 1900-2020, landslides were the second biggest killer among natural disasters in Uganda, causing an estimated death of 2,718 people [23, 25, 26]. Mount Elgon volcano in Eastern Uganda is one of the most landslide-prone regions in Africa with records dating to 1933 [6, 27] (Table 1).

Table 1: Key landslide occurrences since 1933 in Bududa District, Eastern Uganda.

Year	Number of people affected	Estimated number of deaths	Number of families or people displaced	Reference
2021	214	None	33	[28]
2019	669	06	480	[29]
2018	12,000	60	858	[30]
2012	300	16	15	[31, 32]
2010	10,000	365	8,000	[6, 33, 34]
2007	Not known	17	Not known	[6]
1997-1999	10,000	48	> 500	[31, 35]
1970	Not known	60	Not known	[31]
1964	Not known	18	Not known	[6]
1933	Not known	25	Not known	[6]

Unfortunately, the economic damage from these landslides is not well documented [31]. Reportedly, this region has experienced about 650 landslides from 2002-2016 with catastrophic effects to life, property, crops, livestock and the environment [27]. One of the major landslides in the region (on March 1, 2010 in Nametsi, Bukalasi sub-county) left over 350 people dead, thousands displaced and infrastructures, food crops and livestock destroyed

[6, 33, 34, 36]. In October 2018, another major incident occurred in the same sub-county and left 60 dead, 858 people displaced and 144 houses destroyed [30].

1.2 Seasonality in food production

Seasonality in relation to food refers to the food grown or produced in the natural production season and consumed either within the same climatic location or anywhere in the world [37]. In this thesis, seasonality refers to the food grown in the natural production season and consumed within the same climatic location. Seasonality coupled with variations in temperature and rainfall affects food production, availability, access and utilization among rural households in LMICs. This is due to their dependency on food from own agricultural production activities, poor storage and preservation facilities and limited purchasing power of food during seasons of food scarcity [38-42]. In LMICS, food seasons are mainly of two categories i.e. the food-plenty (surplus, post-harvest or dry) season and the food-poor (pre-harvest, lean or wet) season occurring at different periods during the year [43].

Unlike the food-plenty season, the food-poor season is characterized by food scarcity due to the depletion of food stocks from the previous year's harvest. This period usually coincides with the rainy season, a time of labour-intensive land preparation and planting and food prices reach their maximum [43-45]. The temperature and rainfall determine the survival and breeding patterns of mosquitoes, thus increasing the incidence of e.g. malaria [46]. Similarly, the rainy season sees a greater incidence of diarrheal diseases while the markets and other social services become inaccessible due to the impassable roads [43, 47]. It is a period when time and physical energy are needed for agricultural work [43, 48]. Family hygiene, childcare, and food preparation including cooking are sometimes neglected or not effectively performed by women overstrained with work; and late pregnancy is common, with births peaking near harvest. Loss of body weight, low birth weights, high neonatal mortality and malnutrition are highly prevalent in this season [43]. The heightened food insecurity

experienced in the lean season, forces the affected households to adopt coping mechanisms including dietary changes such as reduction in the quantity and nutritional quality of food consumed; borrowing food, or seeking food assistance from neighbours, friends or relatives; and seasonal migration among others. Some of the coping strategies are detrimental and when continuously used may further hamper the life, well-being and health of the people. The rains in this period may cause water contamination, yet usage of unsafe water is among the determinants of child undernutrition by increasing the risk of e.g. diarrhoea [49, 50].

Over the years, Uganda, especially the rural mountainous areas of Bududa District in Eastern Uganda, has been experiencing erratic alternate dry and shorter or longer rainfall seasons, due to climate change effects [51]. This has resulted in changes in the periods for the food seasons in Uganda [52-54]. More often some months of the rainy seasons overlap with some months of the dry seasons and vice visa, hence affecting the growing and harvesting food seasons. As noted by Ocen *et al* [52], climate variability in Uganda exacerbates challenges of seasonal variability by causing failure to distinguish between the true and false start of the growing season among the rain-fed subsistence-dependent agricultural households. This results in delays or haste in the start of planting crops thereby affecting seed germination and normal growth after emergence, hence leading to some overlaps between the food seasons. However, in general, the food-poor season in rural mountainous areas of Bududa District, in the years 2019 to 2020 coincided with the rainy seasons and periods of intensive agricultural production activities in October-April while the food-plenty season (the period right after harvest), occurred from May to September [55].

1.3 Food security

Based on the 1996 World Food Summit, food security exists when "*all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life*" [56]. Ensuring food

security for all is not only among the core aspect of the right to adequate food (RtAF), but also a priority goal under the United Nations (UN) *Transforming our World: the 2030 Agenda for Sustainable Development* [57, 58]. Attainment of food security necessitates fulfilment of the six dimensions of: (1) availability-food of sufficient nutritional quality that can be grown, purchased or bartered; (2) accessibility-economic, social and physical access to food; (3) utilization-food that can be used physiologically and availability of resources to transform food into meals; (4) stability-that all these elements are stable irrespective of household, civil unrest, or weather conditions; (5) agency-people can choose what they eat and how it is produced with freedom and dignity; and (6) sustainability-indicating long-term measures that protect human and environmental health [59]. Thus, food insecurity occurs when one or more of these dimensions are compromised.

Unfortunately, eliminating food insecurity is still a global problem due to several factors including climate change, conflict, disasters, seasonality, rising food prices, and poverty among others. As many as 828 million people were affected by hunger in 2021: inclusive of 46 million people more from 2020 and 150 million more than in 2019 [60]. Similarly, more than 3 billion cannot afford a healthy diet mainly in the rural areas of LMICs [61]. A healthy diet quality is greatly associated with food and nutrition security. Poor diet quality is linked to different forms of malnutrition, including undernutrition, micronutrient deficiencies, overweight and obesity [61]. Most food-insecure and undernourished people live in Asia and Africa. In sub-Saharan Africa, the number of undernourished people has increased from 174.3 million people in 2005 to 260.6 million people in 2021. Moreover, Eastern Africa bears the greatest number (136.4 million) of undernourished people in Sub-Saharan Africa as of 2021. Meanwhile, the prevalence of moderate or severe food insecurity in Eastern Africa is still unacceptably high at 66.9% as of 2021 [60].

Food insecurity is still a development concern in Uganda. By the end of 2020, 69.2% (30.6 million) Ugandans were food insecure, of which 21.7% (9.6 million) were severely food insecure [61]. Moreover, 26% and 5% were already stressed and in a crisis of food insecurity, [62] respectively, even before the effects of Covid-19 and the Russia-Ukraine war had led to the globally declined food supply and increase in the prices of some food items. The national average energy intake of adult Ugandans is 8,715 kJ (2,083 kcal) per day per adult, thus below the recommended 9,210 kJ (2,200 kcal) [63]. Moreover, about 40% of Ugandans are estimated not to meet their energy requirements and the quality of Ugandan households' diets is lacking with 40-60% of the energy intake derived from starchy staples [64]. The above problems are more pronounced in rural areas like Bududa District which are often devastated by recurring landslide disasters. Moreover, food insecurity causes in Uganda are multifaceted, often as a result of poverty, natural disasters, landlessness, high food prices, high fertility, lack of education, seasonality and dependency on rain-fed subsistence agriculture as a main livelihood activity by the majority of Ugandans [65].

1.4 The right to adequate food

The right to adequate food (RtAF) is realized "when every man, woman and child, alone or in the community with others, have physical and economic access at all times to adequate food or means for its procurement" [66]. Thus, all citizens are rights-holders whereas the State and other actors with State obligations and responsibilities are duty-bearers under international human rights law to which Uganda is a party. Adequate food entails the availability and accessibility of food in quantities and quality sufficient to satisfy the dietary needs of an individual, free from adverse substances, culturally acceptable, and the accessibility of food in ways that are sustainable and do not interfere with the enjoyment of other human rights [66].

Many international documents recognize the RtAF, specifically in articles 11(1) and 11(2) of the International Covenant on Economic, Social and Cultural Rights (ICESCR) [67],

article 25 of the Universal Declaration of Human Rights (UDHR) [68] and article 27 of the Convention on the Rights of Children (CRC) [69]. Article 25 of the UDHR states that:

"*Everyone has the right to a standard of living adequate for the health and well-being of himself and his family, including food, clothing, housing and medical care and necessary social services, and the right to security in the event of unemployment, sickness, disability, widowhood, old age or other lack of livelihood in circumstances beyond his control*" [68]. The RtAF not only complements the food security components of availability, accessibility, utilization, stability, agency and sustainability with the State obligations to respect, protect and fulfil the right [66], but also ensures that all humans to live in dignity, free from hunger, food insecurity and malnutrition [67, 68].

State parties to the ICESCR have the principal obligation to take steps to achieve progressively the full realization of the RtAF. The State is obliged to ensure for everyone under its authority has access to the minimum essential food, which is sufficient, nutritionally adequate and safe, to ensure their freedom from hunger [66, 70]. The obligation to respect means that the State should not arbitrarily take away people's RtAF or make it difficult for people to gain access to food while the obligation to protect means that the State should create conditions for-example passing and enforce laws to prevent third parties from violating this right. The obligation to fulfil (facilitate) means the State must proactively involve in activities intended to reinforce people's access to and utilization of resources and means to ensure their livelihood, including food security [66]. Lastly, the obligation to fulfil (provide) means that, whenever an individual or group is unable, for reasons beyond their control, to enjoy the RtAF by the means at their disposal, e.g., in the presence of landslides coupled with seasonality, the State has the obligation to fulfil (provide) that right directly [66].

In line with state obligations, the Voluntary Guidelines (VG), developed by an Inter-Governmental Working Group (IGWG) recommended by the World Food Summit: Five

Years Later, to support the progressive realization of the RtAF in the context of national food security, urges State parties as primary duty-bearers to provide legal remedies to individuals whose RtAF has been violated [71]. Moreover, the 2022 revised VG on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security, exhorts States to ensure tenure security when preventing, preparing and responding to natural disasters. In particular, States are encouraged to design regulatory frameworks for tenure security, including spatial planning to minimize or avoid the potential effects of natural disasters [72].

The realization of the RtAF, therefore, entails the recognition of the interdependency, indivisibility and interrelatedness of human rights [66, 71]. The inability to achieve one human right, e.g., the right to adequate food, may affect the realization of another, e.g., the right to health [73-75]. Moreover, the States have a core obligation to take the necessary action to mitigate and alleviate hunger, even in times when humans are faced with circumstances beyond their control such as landslide disasters [66].

In low-income countries like Uganda, where 39% of the population depends mainly on rain-fed agriculture for their livelihood and income [76], access to land is vital for households to feed themselves directly through production or means for its procurement, and the realization of the RtAF. In addition, the majority (73.4%) of Ugandans reside in rural areas where poverty, food insecurity and malnutrition levels are highest [46, 47]. Uganda is a State party to many international human rights instruments recognizing the RtAF[1]. The 1995 Constitution of the Republic of Uganda recognized the right to adequate food and other economic, social and cultural rights. It has committed to ensuring food security and good

[1] The 1948 Universal Declaration of Human Rights, the 1966 International Covenant on Civil and Political Rights ratified in 1995, the International Covenant on Economic, Social and Cultural Rights ratified in 1987, the 1986 African Charter on Human and Peoples' Rights ratified in 1986 (though silent on the right to adequate food, article 18 mentions protection of family and vulnerable groups) and the 1989 Convention On the Rights of the Child ratified in 1989.

nutrition for all as a matter of national objectives and directive principles of state policy (NODPSP), specifically under provisions of objectives XIV and XXII [77]. A Food and Nutrition Policy that recognizes the RtAF was also adopted in 2003, stipulating the adoption of a rights-based approach in the implementation of food and nutrition programs. The Uganda Nutrition Action Plans (UNAP II and I) have also been developed with a focus on multi-sectoral nutrition interventions while a Nutrition Policy and Zero Hunger Strategy are awaiting approval. Uganda also participated in the Food Systems Summit of September 2021 and committed to transforming its food systems to achieve the SDGs [78].

1.5 The nutritional health of children

Optimal nutrition provides a strong foundation for achieving good health and well-being for children. However many countries still suffer unacceptable levels of malnutrition and related consequences. Globally, an unacceptably large number of children under 5 years are affected by malnutrition [79]. Notably, one in five children under 5 years are stunted (149.2 million), 45.4 million (6.7%) are wasted-the fatal form of malnutrition, which increases children's risk of death by up to 12 times [80], and 38.9 million (5.7%) are overweight [79, 81]. Child stunting (linear growth failure), defined as height-for-age more than two standard deviations below the WHO child growth standard's median [82], is the most recognizable and quantifiable physical indicator of chronic child malnutrition. Stunting is associated with increased morbidity and mortality, reduced immune system, loss of physical growth potential, reduced neurodevelopmental and cognitive function and an elevated risk of chronic disease in adulthood. Thus, the severe irreversible physical and neurocognitive damage that accompanies stunted growth poses a major threat to human development [83-86].

Around 45% of deaths among children under 5 years are linked to undernutrition particularly in LMICs [87]. Moreover, later in future, stunted children experience economic losses as adults through decreased physical productivity, decreased cognitive abilities, and

increased health care costs associated with weak immune systems [85, 87, 88]. Worldwide, malnutrition costs 3.5 trillion USD to the economy annually, or 500 USD per individual resulting from economic growth foregone and lost investments in human capital associated with preventable child deaths [89]. Due to poor nutrition during pregnancy, an estimated 20% of child stunting begins *in utero* and continues for at least the first two years of post-natal life [83, 90, 91]. Intrauterine growth restriction, a condition where the foetus is not growing at a normal rate inside the womb, affects many children in LMICs [92]. However, stunting also continues to accumulate beyond the first 1000 days in many children in LMICs [93]. As a global effort to reduce the high prevalence of child stunting, the "1000-days window of opportunity" (the period from conception to the child's second birthday), with more resources required for interventions targeting women of reproductive age and children up to two years was identified [94]. Thus, this period is critical in the growth and development of the foetus and child and its long-term health outcomes [84, 95-97]. Many factors such as maternal health, breast- and complementary feeding, childcare, socioeconomic and environmental factors, among others directly or indirectly influence this period [97, 98].

During the last two decades (2000-2020), the number of stunted children in Africa increased from 54.4 million in 2000 to 61.4 million in 2020. Moreover, Eastern Africa bears the majority (22.1 million) of stunted children in Africa [81]. These high levels of malnutrition among children under 5 years are due to several factors including poverty, food insecurity, seasonal variations, maternal depression, landslides and related external shocks. Such effects occurring during critical periods in a child's development can be detrimental to mental and physical health, and hence, a negative impact on the human capital of a country [50].

1.5.1 Conceptual framework on the malnutrition-landslide and seasonality linkage.

This thesis adopted UNICEF's conceptual framework for the causes of child malnutrition (Figure 1).

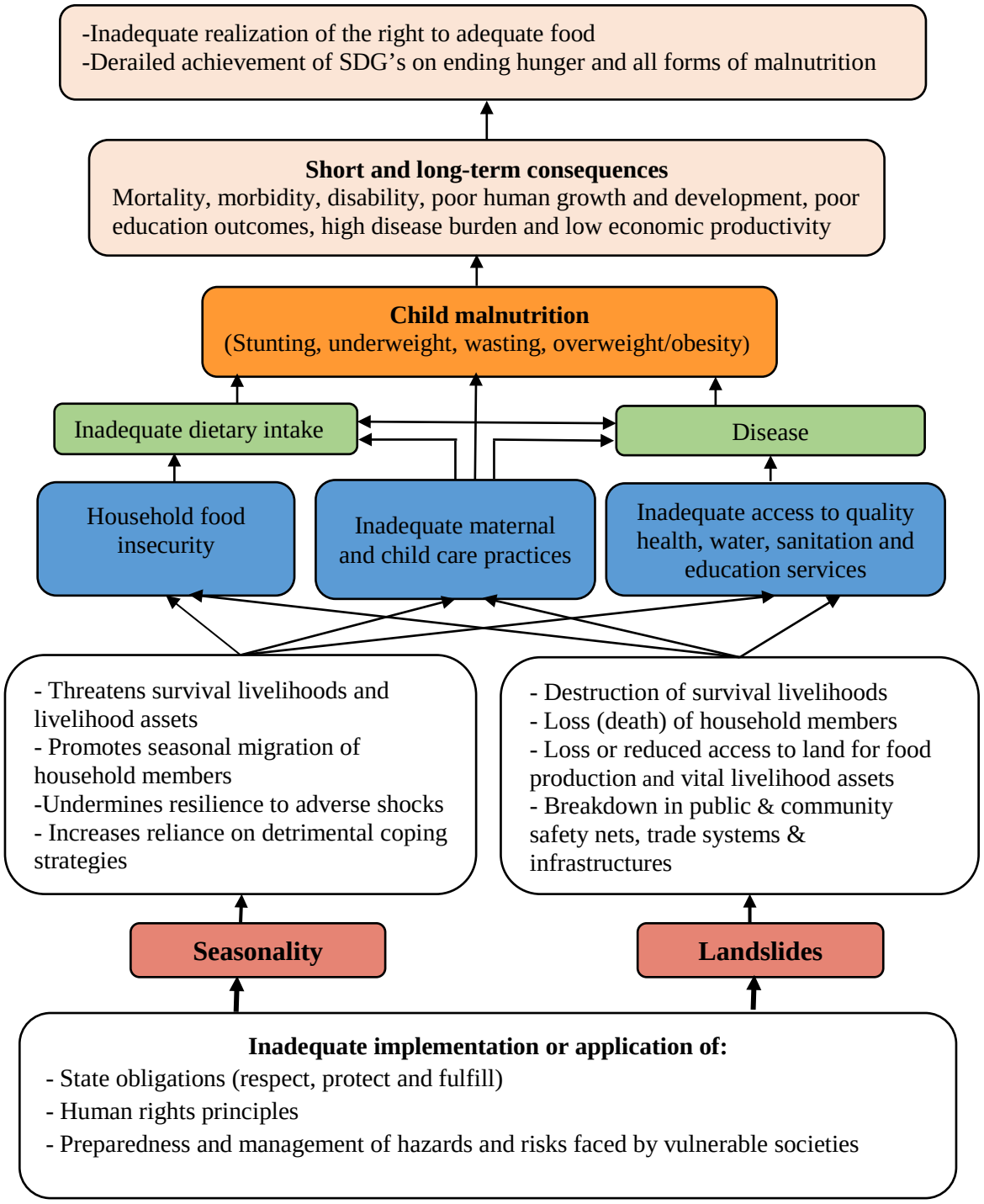

Figure 1: A conceptual framework on the malnutrition-landslides and seasonality linkage. Modified from UNICEF's conceptual framework [99].

According to this framework, malnutrition is a multifaceted problem caused by basic, underlying, and immediate causes in the sectors of environment, agriculture, nutrition, health, water and sanitation, infrastructure, gender and education, which often overlap. Equally, malnutrition consequences are multidimensional, and can be both short-term and long-term. At the bottom level of the framework are the basic causes of malnutrition, which include social, economic, environmental, and political issues that lead to lack of or unequal distribution of financial, human, physical, social, and natural resources. In this case, in the advent of landslides and seasonality amidst inadequate preparedness and management and inadequate application of state obligations and human rights principles, household food security, maternal and childcare and access to quality health, water, sanitation and education services are disrupted. In particular, landslides lead to loss of life; usually of household members, loss or damage to land and destruction of survival livelihood assets such as houses, livestock, and water systems that support households' access to food [7-9]. Landslides may prevent households' access to land for years, destroy seed and food stocks and result in the loss of livestock and standing crops [9]. In addition, landslides cause the destruction of public and community safety nets, trade systems and infrastructure [9, 100] that support households' achievement of food and nutrition security.

On the other hand, seasonality threatens the survival livelihood activities and livelihood assets of rural households [101]; undermines households' resilience to adverse shocks like illness, loss of property, and increased households' reliance on detrimental coping strategies [102], consequently resulting in child malnutrition. Once the landslide and seasonality effects are not well managed or well planned for, food intake and diet quality are compromised and the risk and burden of disease increase, leading to malnutrition. This exhibits in form of undesirable outcomes and impacts in form of child stunting, underweight, wasting and immunity-compromising conditions especially anaemia and micronutrient

deficiencies. In the long term, the affected population is highly likely to experience poor human growth and development, poor education outcomes, high burden of preventable deaths and diseases as well as low economic productivity. Equally, the realization of the RtAF and achievement of SDG's on ending hunger and all forms of malnutrition will be negatively affected.

In the middle of the framework are the underlying causes of malnutrition (inadequate household food security, inadequate care practices and inadequate services and the presence of an unhealthy environment). These affect the household's and individual's ability to obtain proper nutrition. Inadequate household food security, relates to the household economy and contextual determinants (maternal knowledge of care and feeding practices, maternal chores or livelihoods, and family eating behaviours). Inadequate care practices include lack of exclusive breastfeeding and poor infant and young child feeding practices while inadequate services and the presence of an unhealthy environment includes poor access to and quality of health services, water, and sanitation facilities, substandard hygiene practices, and inadequate food preparation, which contribute to the disease environment. Inadequate dietary intake and disease are the most significant immediate causes of malnutrition. Inadequate food intake refers to both the quantity of food and dietary quality. The nutritional quality of food intake regulates the biological processes that govern the growth and development of the musculoskeletal and nervous system [86]. Dietary quality is reflected by the dietary diversity and the micronutrient content of the diet. The presence of disease is the second immediate cause of malnutrition, which affects dietary intake and nutrient utilization. Reportedly, an increase in the incidence of diarrhoea increases the risk of child stunting at two years of age [103].

In 2008, the *Lancet* published a series of five papers [97, 104-107], on maternal and child malnutrition, which identified a high prevalence of maternal and child undernutrition in

LMICs leading to under-5 child mortality [97], and consequences for adult health and human capital later in life [104]. Interventions for maternal and child undernutrition and survival were reviewed [105] and recommendations to address malnutrition at the national [106] and international levels [107] were given. The necessity to focus on the first 1000 days, in which good nutrition and healthy growth would have benefits that would last for a lifetime, was recognized. Similarly, the prevention of maternal and child undernutrition was identified as a long-term investment that would benefit the present generation and their children [104].

Five years after the *Lancet* 2008 series [97, 104-107], the *Lancet* launched the 2013 [84], series reassessing the situation of maternal and child undernutrition and identified the growing problem and consequences of over-nutrition (overweight/obesity) in women and children. Reportedly, in several LMICs, there was the occurrence of a double burden of malnutrition (the presence of chronic malnutrition and deficiency of essential nutrients coexisting with obesity). The consequences of maternal malnutrition and their association with child malnutrition were emphasized [84]. Undernutrition before conception and during pregnancy, affecting foetal growth, and the first two years of life was cited as a major determinant of both stunting and subsequent obesity and non-communicable diseases in adulthood [84].

Additionally, the 2013 *Lancet* series featured a novel conceptual framework that depicts the means to attain optimal foetal and child growth and development. This new framework, reinforced the importance of proper development of the foetus and child, associated with good nutrition, which would bring benefits throughout the life cycle of the human being [95]. Tackling the immediate, underlying and basic factors to mitigate the negative effects of global changes (climate change, growing population, and urbanization) and environmental shocks, in supporting livelihoods, food security, diet quality, and women's

empowerment, and in achieving scale and high coverage of nutritionally at-risk households and individuals were recognized [108].

1.5.2 Situation of child nutritional health in Uganda

Uganda has over the past years increasingly recognized nutrition as a key pillar for human, social and economic development. Currently, Uganda is part of the Scale Up Nutrition movement launched in 2010 to work toward improving global nutrition [94]. In 2013, the Uganda Vision 2040 was launched with one of its vision targets to reduce the prevalence of under 5 child stunting from 33% in 2011 to 0% by 2040 [109]. Equally, Uganda has implemented the UN SDG of 2015, participated in the Food Systems Summit of September 2021 and committed to transform its food systems to achieve the SDGs, including that on ending all forms of malnutrition [78].

Despite efforts made by Uganda to eliminate child malnutrition, the prevalence of child malnutrition remains unacceptably high (Figure 2).

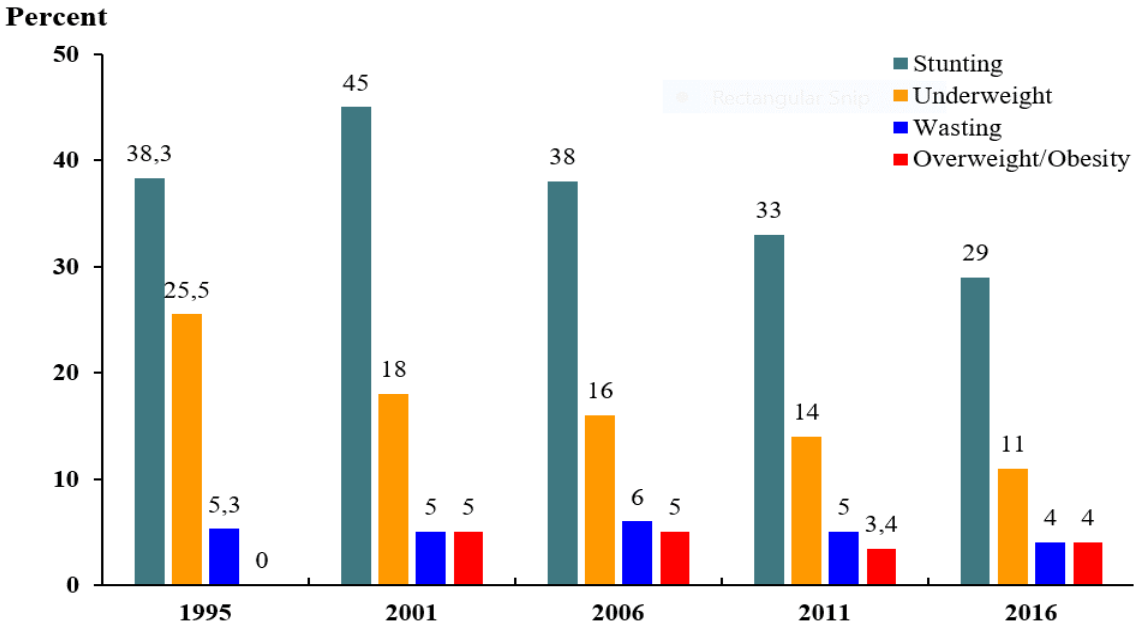

Figure 2: Nutritional status, trends in Uganda among 6-59 months children.

Source: Data extracted from the Uganda Demographic and Health Surveys of 1995, 2001, 2006, 2011 and 2016 [110-114].

Stunting in children 6-59 months old, was reduced minimally from 33% in 2011 to 29% (equivalent to nearly 2 million) in 2016. The UDHS of 2016 further noted that stunting increases with age, peaking at 37% among children 18-35 months and is greater among children in rural areas (30%) than urban areas (24%) [110]. Stunting prevalence decreases with increasing levels of mother's education and about four in ten (37%) children born to mothers with no education are stunted compared with one in ten (10%) of children born to mothers with more than a secondary education. Moreover, the prevalence of wasting was 4% in 2016. Child overweight/obesity in Uganda has remained relatively stable i.e. 3.7% in 2016 and 4% in 2011. Nevertheless, there is a need to stop child overweight/obesity from increasing as it can lead to early onset of type-2 diabetes, stigmatization and depression, and is a strong predictor of adult obesity, with serious health and economic consequences [115].

Anaemia, among children 6-59 months old increased from 49% to 53%, which is more than the WHO cut-off (40%). Anaemia reflects micronutrient deficiencies, infections, and even genetic traits in malaria-endemic areas [64, 110, 116], and leads to a significant slowdown in cognitive development, decreased physical activity, and reduced resistance to disease especially in the first two years of life in children [117-119]. Although the proportion of children who were exclusively breastfed for the first six months increased from 63% in 2011 to 66% in 2016 [110], it is still below the 90% global target coverage recommended by WHO [120]. The percentage of children aged 6-23 months in Uganda who received a minimum acceptable diet, received meals the minimum number of times and had an adequately diverse diet were low at 15%, 42% and 30%, respectively in 2016 [110].

1.6 Landslide effects on food security and children's nutritional health

Landslide disasters have profound impacts on food security dimensions of availability, accessibility, utilization, stability, agency and sustainability particularly in LMIC [9, 121-124], which consequently directly or indirectly affect the children's nutritional health.

Landslides are detrimental to crop growth, livestock health, fisheries and aquaculture production, and can seriously compromise forests and other ecosystems [58, 125]. When directly affecting a household's house or plots, landslides often destroy crops and productive assets like land and livestock and thereby cause a shock [126]. Soil erosion, destruction of soil structure and leaching of nutrients which in turn affect crop production are some of the after-effects of landslides. Moreover, mineral leaching affects nutrient quality in foods grown and in water [23, 36]. Crop and animal destruction limits the quantity, quality and variety of foods accessible by households. Landslides often involve destruction of gardens and transport systems [9, 23], hence limiting households' accessibility to the food on farms. Due to food destruction, this not only results in a limited variety of food on the market for sale but is also expensive for households to afford. Landslides result in casualties to both humans and animals, and also disrupt the water quality of streams and rivers as well as destruction of structural and infrastructural development [8, 9, 23].

According to Kousky [50], natural disasters including landslides are often followed by epidemics like cholera, and diarrhoea, especially among children. This forces families to divert financial resources that would have otherwise been used for meeting basic needs like water, clothing and education. Besides, a diseased and ill body is weak and never productive thus affecting the overall economic productivity of the country. Water contamination is also usually a consequence of landslide disasters, hence increasing the possibility of using contaminated water by households [125, 127]. Usage of contaminated water is a potential source of waterborne diseases and infections such as diarrhoea and cholera, which not only affect the person's dietary intake and nutrient utilization but also lead to dehydration [49, 50], thus resulting in malnutrition such as wasting and stunting. A malnourished body is prone to disease infections, and illnesses and is not productive enough to engage in activities that promote food and nutrition security [95, 128]. Similarly, movement of long distances

involved in looking for safe water, especially among the rural poor populations decreases the time needed for childcare including food preparation [129, 130].

Consequently, the impact of landslides threatens to reverse development gains and slow down poverty reduction and hunger alleviation. The menace of their increased frequency poses a fundamental threat to achieving international commitments such as SDGs, in particular, Goal 2 on "ending hunger, food security, improved nutrition and promotion of sustainable agriculture" (7) and global initiatives of ending all forms of malnutrition. The costs in human and financial effects are enormous at the household and community levels, especially when damaged or destroyed property is uninsured. Lost crops and damaged agricultural land also affect hardest on the poorest, with chronic long-term consequences. For instance, malnutrition and stunted growth are both high in areas of repeated flooding in India [131].

Landslides limit peoples' access to adequate food through interference with the food security components via the destruction of the food systems and livelihood-related infrastructure [15]. The aftermath effects of landslides include the destruction of homes, damaged infrastructure, and severe crop damage, with little or no harvest available for own consumption and sale. Moreover, landslides also involve the death and injury of household members [6, 9, 132]. When the lost or injured household members were key in securing the household's food security, this may result in undernourishment and hunger mainly in areas where chronic food insecurity was already a major problem and thus create vicious cycles of poverty, disease and hunger [58]. Disasters including landslides are stressful and frightening, thus children usually suffer psychological harm from the damage to their homes and possessions; from the grief of losing loved ones; seeing parents or caregivers undergo stress; migration; neglect and abuse; and breakdowns in social networks, neighbourhoods, and local economies [50].

In Uganda, landslides have similarly had profound effects such as destruction of lives, loss of property including damages to houses, and destruction of crop, livestock, land, drinking water, health facilities, markets and roads [6, 9, 33, 34, 36]. A case study in Uganda reported landslides to have reduced the total household income by 15% on average during the first years after a landslide has occurred [126]. A reduction in income may reduce the economic accessibility to food by the household. All these factors consequently result in food insecurity and poor nutritional health of children.

1.7 Seasonality effects on food security and children's nutritional health

Effects of seasonality on food security and children's nutritional health are widely accepted [39, 48, 128, 133-135]. Seasonality affects rural livelihoods [101], mostly in LMICs, where the majority of the world's poor, food insecure, and malnourished people live and depend mainly on rain-fed subsistence agriculture, and with a limited income to purchase food [61]. Food security dimensions are affected differently by seasonality usually with the food-plenty season characterised by increased availability, accessibility and utilisation of food while the food-poor season is characterised by the limited availability of the food security dimensions which affects the nutritional health of children.

Fluctuations in food availability are one of the effects of seasonality. Generally, during the food-plenty season, there is increased availability of food varieties ranging from fresh fruits, vegetables, legumes and pulses, and cereals on the farms/ gardens or in the households and on the market in form of food stocks from the harvests as compared to the food-poor season [48]. These seasonal fluctuations in food availability force households to adapt food consumption patterns by modifying not only the number of meals and quantities of foods they consume, but also the types and quality of foods they consume [48, 136].

Due to the reduced availability of various food items on farms, gardens or markets, households tend not to access a variety of these foods during the food-poor season as compared to the food-plenty season. Also, households have reduced purchasing power for animal-source food groups like eggs, milk, meat, fish, and chicken during the food-poor season as compared to the food-plenty season. This is depicted by decreased dietary diversity and food variety and the deteriorating nutritional status of women of child bearing age and children under-5 years [38, 41, 133, 137, 138]. Moreover, studies from rural Southwest Uganda [39] and South Ethiopia [42] reported increased food insecurity during the lean season compared to the food-plenty season.

Seasonal changes in food availability and accessibility grossly affect dietary diversity and subsequently, nutrient adequacy of diets consumed by women of child-bearing age from rural subsistence households in Sub-Saharan Africa [137, 139, 140]. This insufficient nutrient intake among women of reproductive age results in increased micronutrient deficiencies, increased incidences and severity of infections, poor pregnancy outcomes and even mortality which consequently affects the nutritional health of their children. Ravaoarisoa *et al* [48] reported an increase in the prevalence of undernutrition among women of child-bearing age during the lean food season as compared to the post-harvest food season in Madagascar. Similarly, a study in rural India where babies were exposed to the season with greatest food availability in late gestation, found that the babies were heavier than those exposed to food during the lean season in late gestation [141].

Seasonality affects nutrient intake as depicted by lower nutrient intakes during the food-poor season compared to the food-plenty season, which consequently affects children's nutritional health [142]. A study in Ethiopia using nationally representative data showed that households experienced food shortage and a decline in calorie consumption during the lean season [143] whereas a study in Kenya found significant improvements in intakes of calcium,

iron and vitamin E during the post-harvest season compared to the harvest season among women and their children 6-23 months [137].

During the food-poor/lean/hunger season period, which often corresponds with the rainy season in many LMICs, household food stocks from the previous harvest are depleted, markets become inaccessible, food prices reach their maximum, wages drop, and income-generating avenues become limited [44, 45]. This results in the consumption of highly monotonous and less nutritious diets dominated by starchy staples and sugary foods which quickly fill up the stomach and dispel hunger pangs, with little or no animal-source foods and fewer fruits and vegetables. Such dietary patterns compromise dietary quality and increase the risk of micronutrient deficiencies [144, 145]. Such short-term food deprivations may have long-term consequences for women of child-bearing age and children under-5 years. In particular, micronutrient deficiency in children, even at modest levels, has been reported to harm cognitive development and reduce disease resistance [146]. Similarly, children that repetitively experience seasonal hunger are at high risk of undernutrition, including insufficient micronutrient intake [147].

The birth of low birth-weight babies particularly in LMICs [135, 148], is another effect of seasonality. This is attributed to seasonal energy stress, an increase in food insecurity, agricultural activity, and seasonal epidemics of infectious and parasitic diseases, which affects maternal dietary intakes, nutritional status, gestational weight gain, and eventually birth weight [43]. Seasonal morbidity due to malaria and diarrhoea epidemics during the rainy season that coincides with the food-poor season can also deteriorate the children's nutritional status by decreasing appetite and increasing nutrient needs [149]. The effect of seasonality on child height-for-age scores has been shown in Tanzania [238], Gambia [237] and Malawi [239], where child stunting was associated with the rainy seasons commonly related to household food insecurity.

2. Rationale for the current study

Given the findings from our previous cross-sectional study conducted in 2012-2013, we established that in the Bududa district where the landslide occurred, affected households had lower food insecurity than controls, but higher diet diversity scores (DDS), a proxy for nutritional intake [121]. Whereas household size increased the likelihood of food insecurity and reduced DDS, the Food Variety Score (FVS), an indication of the number of total food varieties eaten, were higher among those affected by landslides, mostly farmers and relief food recipients. Affected households had a higher likelihood of skipping meals for a whole day [150]. However, the situation could have changed over the years that have passed. Moreover, the 2012 study did not include nutritional status of children 6-59 months of age yet they are key outcomes of the health status of the population.

Similarly, between 2018 and 2019, when we initiated this study, the Elgon region in Eastern Uganda was still at risk of persistent recurring devastating landslides [27, 29, 30]. Landslides have continued to occur with distressing effects on the lives and livelihoods of the rural poor vulnerable households including their children under 5 years. Similarly, under 5 child malnutrition in Eastern Uganda was higher than the Uganda national average as per the 2016 UDHS [110]. Food insecurity was still a challenge linked to poverty, landlessness, high fertility, natural disasters, seasonality, high food prices, and a lack of education [65]. According to the 2014 National Housing and Population Census [151], the majority (51.4%) of Ugandans were consuming fewer meals with fewer calories than recommended. This problem was more pronounced in rural areas [151], which are also worst affected by landslides [152] and seasonality effects [39].

The effects of seasonality on food insecurity, food varieties, food insecurity coping strategies and child malnutrition in this region were not known. Also, there was limited longitudinal cohort information about the extent to which food security, diet adequacy, the

nutritional health of children 6-59 months and the realization of the right to adequate of rural Ugandans were affected by landslides. Therefore, this thesis set out to provide a further step towards bridging persistent knowledge gaps and fostering a better understanding of how landslides coupled with seasonality affected the nutritional health of children under 5 years. Hence, we decided to perform a cohort study among landslide-affected households, to unveil the landslides and seasonality effects on household food security, diet adequacy, the nutritional status of young children (6-59 months) and the right to adequate food among these vulnerable groups.

3. Aim, objectives and research questions

The main aim was to investigate landslides and seasonality effects on household food security, diet adequacy, the nutritional status of children 6-59 months and the right to adequate food among households affected by the major 2010 and 2018 landslide disasters in rural Uganda.

3.1 Research objectives.

The specific objectives of the study were to:

(i) Assess the nutritional status and effect of seasonal variations and associated factors among children 6-59 months in the landslide-affected households in Bududa District, Eastern Uganda.

(ii) Describe the seasonal variations in food insecurity, diet diversity and the right to adequate food among households that were affected by the major 2010 and 2018 landslides in Eastern Uganda.

(iii) Identify the extent to which seasonality changes and disaster effects affected food varieties consumed and food insecurity coping strategies among the 2010 and 2018 landslide-affected households in Eastern Uganda.

3.2 Research questions and indicators

The link between the study objectives, research questions and indicators for the current thesis is given in Table 2.

Table 2: Linking the objectives to research questions and indicators

Research questions	**Indicators**
Objective 1: Asses the nutritional status and effect of seasonal variations and associated factors among children 6-59 months in the landslide-affected households in Bududa District, Eastern Uganda.	
(i). What is the nutritional status of children 6-59 months?	- Proportion of stunting, underweight, acute undernutrition, overweight and obesity
(ii). What is the impact of seasonal variations on the nutritional status of children aged 6-59 months in the landslide-affected households in Bududa District, Eastern Uganda?	- Differences in the proportions of nutritional status parameters of children according to seasonal variations
(iii). What factors are associated with child malnutrition and seasonal variations among landslide-affected households?	-Socio-economic factors associated with child malnutrition -Demographic factors associated with child malnutrition
Objective 2: Describe the seasonal variations in food insecurity, diet diversity and the right to adequate food among households that were affected by the major 2010 and 2018 landslides in Eastern Uganda	
(i). Taking into account seasonal variations, what is the situation of food insecurity and diet adequacy?	- Proportion of households affected by food insecurity - Mean differences in food insecurity scores between affected and control households - Mean differences in food insecurity scores according to seasonal variations
(ii). Which socio-economic and demographic factors predict household food insecurity and diet adequacy?	- Socio-economic characteristics associated with food insecurity and diet - Demographic factors associated with food insecurity and diet adequacy
(iii). To what extent does household food insecurity	- Variations in household food insecurity that influence diet adequacy among affected and control households

Research questions	Indicators
influence the adequacy of the diet?	- Correlation between household food insecurity and diet adequacy
(iv). Is the right to adequate food sufficiently realized among households in landslide-prone communities?	- The proportion of households who reported consumption of unsafe, poor quality and less nutritious food - The proportion of households who reported that landslides affected their food and nutrition security - The proportion of households aware of the principles of human rights of participation, accountability, non-discrimination and transparency - The proportion of households aware about the State's obligations to respect, protect and fulfil - The proportion of households reported that the provision of food for their households limited their ability to provide other amenities like health, water, housing, clothing and education. - **Perceptions on**: (a) Food and nutrition situation in the study area (b) Who are the most affected, where, when and why (c) whether landslides affected the food and nutrition security and the RtAF of landslides affected households (d) whether the disaster response in the study area is satisfactory; (e) whether the human rights principles of participation, accountability, non-discrimination and transparency are taken into consideration during the response of public authorities to disasters; (f) on the obligation of the State to ensure that no Ugandan suffers from hunger and malnutrition even in times of disaster; (g) how the State should ensure the realization of the RtAF of landslide-prone communities; and (h) The preferred means to ensure the RtAF of landslide-affected households.
Objective 3: Identify the extent to which seasonality changes and disaster effects affected food varieties consumed and food insecurity coping strategies among the 2010 and 2018 landslide-affected households in Eastern Uganda	
i). How does seasonality influence the food varieties consumed by	- Food variety scores in the affected and control households

Research questions	Indicators
2010 and 2018 landslide-affected households?	- Mean differences in food variety scores between affected and control households - Mean differences in food variety scores according to seasonal variations
(ii). Which socio-economic and demographic factors predict food varieties consumed and diet food insecurity coping strategies?	- Socio-economic characteristics associated with food varieties and food insecurity coping strategies - Demographic factors associated with food varieties and food insecurity coping strategies
iii). Are there seasonal variations in the food insecurity coping strategies relied on by the households affected by the 2010 and 2018 landslide disasters in Bududa District?	- Mean differences in Coping Strategy Index (CSI) scores between the affected and controls - Seasonal variations in in Coping Strategy Index (CSI) scores between the affected and controls - Socio-demographic characteristics associated with coping strategies

4. Methodology

4.1 Study area

The study site was the Bududa District (Figure 3), located at the foot of Mount Elgon in rural Eastern Uganda. Specifically, the study was performed in the Bukalasi sub-county, which was affected by the 2010 and 2018 landslides whereas the Bubiita sub-county acted as the control since it is the neighbouring sub-county to the affected sub-county.

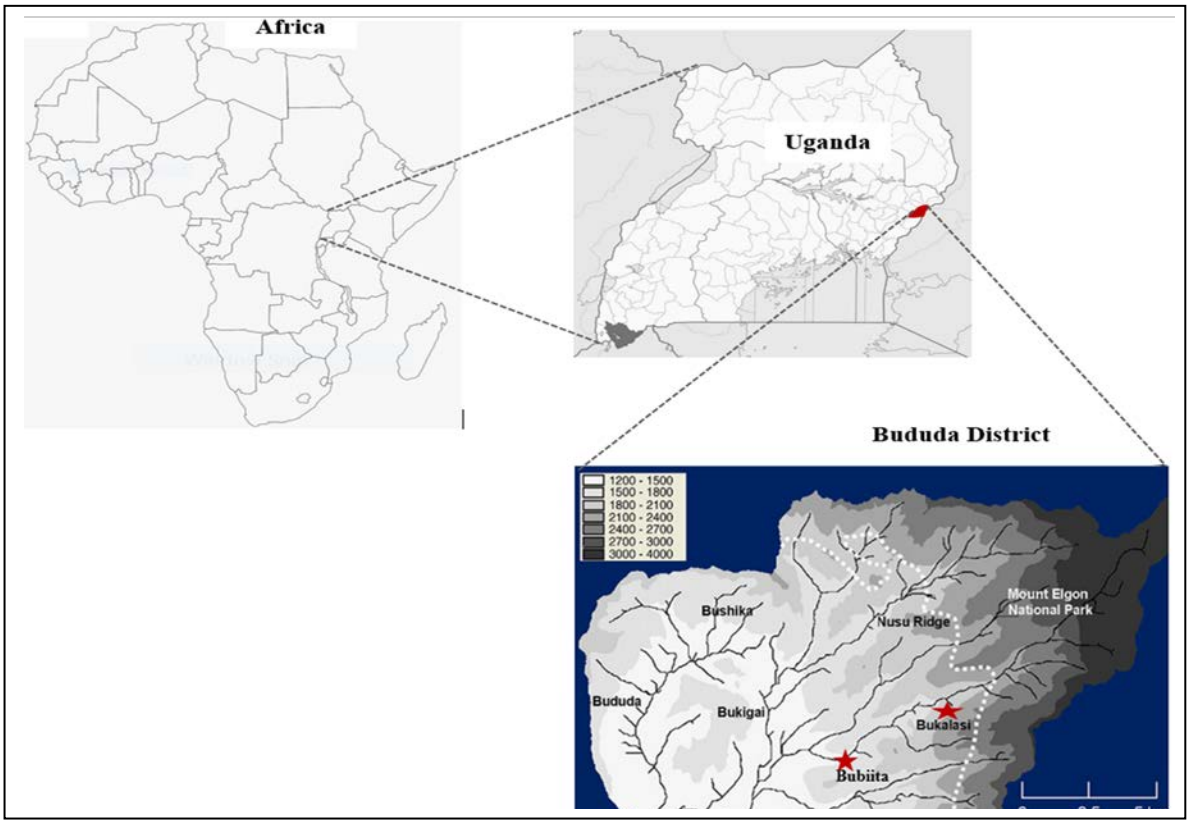

Figure 3: Map of Uganda showing the location of Bududa district and study sites in asterisks. Source: Modified from Kitutu [153].

The District is located on the foot of the South-Western slopes of Mount Elgon Volcano, about 250 km North-East of Kampala [6]. The District has an elevated topography; subjecting the entire Mount Elgon region to regular devastating landslides and floods [153]. The area has an average precipitation of above 1500 mm of rainfall per year and this is dependent on the

area's high altitude, between 1250 to 2850 meters above sea level [6]. The District receives heavy rainfall almost throughout the whole year and has fertile lands supporting a high population of 210,173. Similarly, the District has a high population density of 952 persons per km^2 [151], and is at a high risk for landslides [6, 154, 155] due to the he continued agricultural activities on the steep slopes of Mount Elgon, with V-shaped valleys and river incisions (Figure 4). The population consists of mainly rural, poor, peasant communities that rely majorly on subsistence agriculture of food crops (bananas, cabbage, beans, onions, tomatoes, other green vegetables) and cash crops (coffee) [6, 151].The people are mainly of the Bamasaba (Bagisu) tribe [156].

Figure 4: Continued agricultural activities on the steep slopes of Mount Elgon and a landslide that ravaged through a plantation of trees and banana plantains.

Source: Bård Anders Andreassen and International Organization for Migration (IOM)/ Emmanuel Kironde.

4.2 Study design

We performed a prospective cohort survey among landslide-affected households during May-August (food-plenty season) of 2019 and January-March (food-poor season) of 2020. A

mixed methods approach involving both quantitative and qualitative methods was used. The assessments of households and eligible children were performed twice to account for seasonal variations between the post-harvest (food-plenty) and the lean food-poor seasons and to minimize confounding bias due to seasonality and related factors.

Qualitative data from key informants and focus group discussions (FGDs) were collected once during the food-poor season (January-March of 2020). The aim was to get a broader understanding of the extent to which the commonly re-occurring landslides were affecting food security, diet and the right to adequate food in this landslide-prone study area.

4.3 Study participants

We had two categories of study participants; rights-holders and duty-bearers.

Rights-holders were household heads in the two sub-counties, their respective eligible and index children aged 6-59 months and focus group discussants that constituted adult women and men (18-55 years) who were members of the local council (LC) at village and parish level in the study area.

Duty-bearers, who served as key informants, were purposively sampled individuals among representatives of institutions considered being conversant with the subject matter being studied or were or had been in positions of authority in their respective institutions in areas related to landslides, food security, diet and the right to adequate food.

4.4 Sampling technique and sample size determination

4.4.1 Selection of landslide-affected households (rights-holders)

Households for structured interviews were selected using a 3-stage simple random sampling procedure. Using a simple ballot, the control sub-county was selected from a list of sub-counties neighbouring the sub-county with the affected households. In each of the parishes that constitute a sub-county (affected and control), all the villages were listed and eligible

households with children under five years of age were mapped and assigned in the 20 villages per sub-county hence 40 villages in both sub-counties. This was followed by randomly selecting at least 11 representative households in each village from the household lists that were generated using probability proportion to size techniques; more households were sampled in villages with a relatively high number of households. This stage was undertaken with the assistance of the area local councils and research assistants who were familiar with the areas since they were recruited from the study district.

Computer generated randomization was used to obtain random numbers from a range of an ascending numbered list of village households. The households whose position on the numbered list matched with the random numbers were identified as index households whose head was consulted for interviews. Since the households were considered as the measurement unit, one household member (the household head) acted as a respondent for the selected household. Where both genders were available, the study preferred interviewing the women, with permission of the partners, given the crucial role played by women in the food security and nutrition well-being of children in most parts of Africa.

Due to the absence of reliable effect measures of landslides on food insecurity and diet diversity in Uganda, we targeted a sample size of 418 households with eligible children. This was based on the reported 35.9% stunting level among children (6-59 months) in the Bugisu sub-region, where Bududa District is located [110]. A 10% higher (44.9 %) hypothetical projection of the prevalence of child stunting in the landslide-exposed communities was assumed on the basis that the landslides disrupted food security, nutrition well-being, the human right to adequate and the other determinants of health. The precision values included a power of 80% at a 95% confidence interval ($p < 0.05$) and a margin of 3% was provided to cater for non-response. Therefore, 215 households were targeted per sub-county with the overall sample size as 430 households in the two sub-counties. The nutritional

status for one index child from each sampled household was assessed. Moreover, in case a household had more than one eligible child, the youngest child among those aged 6-59 months was selected. This is because the youngest is the most vulnerable in case nutritional needs are not met. In households whose eligible children were twins, both children were assessed.

As illustrated in Figure 5, a total of 424 households and 395 children were assessed out of the 430 eligible participants, indicating a baseline response rate of 98.6% and 91.8% for households and children, respectively. At follow-up, 388 households and 366 children were re-assessed out of the 430 eligible participants, thus a response rate of 90.2% and 85.1% for households and children, respectively was achieved.

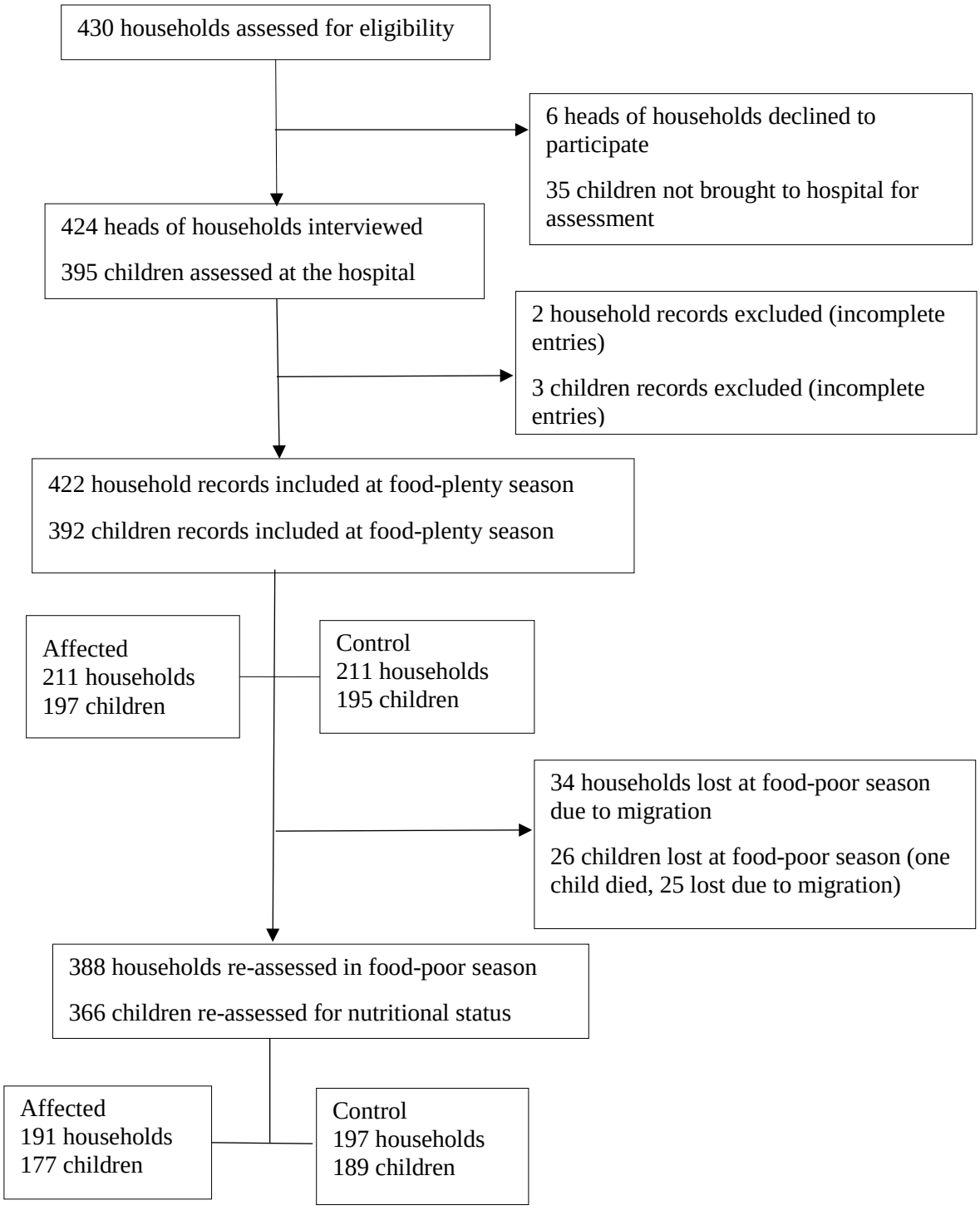

Figure 5: Inclusion process of the study participants.

4.4.2 Selection of relevant duty-bearers (key-informants)

A non-probability purposive sampling technique was used to select 10 duty-bearers. This was based on the reasoning that they were conversant with the subject matter being studied or were or had been in positions of authority in their respective institutions or ministries in areas related to landslides, food security, diet and the right to adequate food. Snowball techniques were also applied when selected key informants referred the study to other core respondents not previously included in the sampling frame.

The duty-bearers involved in this study included individuals or representatives from the Bududa district and relevant government departments. Specifically, those from Bududa were: the Chairperson of the Disaster Management Committee; Nutritionist; Senior Environmental Officer: Health Inspector: Community Development Officer; Production Officer; Sub-county Chiefs from Bukalasi and Bubiita sub-counties and Local Council Leaders. A response rate of 100% (10 duty-bearers out of the targeted 10) was achieved.

4.4.3 Constitution of focus group participants from affected and control groups

Participants for FGDs in each sub-county were sampled independently and excluded from households who were sampled for survey interviews. They constituted adult women and men (18-55 years) who were members of the local council at the village and parish level in the study area. We held separate discussions with two groups of people (adult women and adult men, of 18-55 years) in each of the affected and control sub-counties. A total of four separate FGDs, two from the affected and two from the control sub-county were held. Six to ten participants for each FGD were targeted. Thirty-six participants in four focus groups participated in the study. The leadership in each sub-county assisted to mobilize the FGD participants.

4.5 Research approvals

This study was approved by the Uganda National Council of Science and Technology; reference number SS 4967, Makerere School of Health Sciences Research Ethics Committee; reference number 2018-082 and the Office of the President of the Republic of Uganda also provided a letter for security clearance; reference ADM 194/212/01. We also received clearance from the Norwegian Regional Committee for Medical and Health Research Ethics; reference number 2019/917.

Ethical principles of confidentiality, respect for different opinions and cultures, and all the other standards set by the World Medical Association Declaration of Helsinki were upheld. Participation in the study was by informed written or thumbprint consent (Annex 1). Assent for child participation in the study were thought from the child's parent or caretaker on behalf of the child (Annex 2). The child's parent or caretaker were given 20,000 Ugandan shillings (about 5.4 US dollars) after the child anthropometrical assessments and interview to cover transport costs to the hospital.

4.6 Assessment tools and data collection

4.6.1 Structured questionnaires

The questionnaires were the main data collection tool for quantitative data. Trained and skilled research assistants with at least a College or University level of education collected the quantitative data. Using pretested and structured questionnaires that were translated from English to the local language (Lumasaba) and back-translated into English, quantitative data from household heads was collected through face-to-face interviews. In this study, we had two categories of questionnaires: the household questionnaire and the child questionnaire. The household questionnaire incorporated questions on demographic and socio-economic characteristics of the household; experiences on access to food; the type and frequency of

food consumed by the household; food insecurity coping strategies; and the right to adequate food (Annex 3). The child questionnaire incorporated questions on: the child's demographic and socio-economic information; child feeding practices; anthropometry; dietary assessment; and common malnutrition-related signs and symptoms experienced by the child in the last 30 days preceding the survey (Annex 4).

The head of each selected household was the index member interviewed on behalf of the household. Where both genders were available, preference was given to women, with permission of the partners, given the crucial role played by women in the food security and nutrition well-being of children in most parts of Africa. However, in the absence of the women, the head of the household who was available and willing to participate at the time when the households were visited, were the ones consistently interviewed. Similarly, the child's parent or guardian who brought the child to the hospital for anthropometric assessments was the one interviewed on behalf of the child.

4.6.2 Household food insecurity assessment

Household food insecurity was measured based on the frequency of occurrence of specific experiences within the households regarding access to food and the situation of hunger in the 30 days preceding the interview. Questions were adapted from the combination of the Household Food Insecurity Access Scale (HFIAS) index [157] and the Community Childhood Hunger Identification Project (CCHIP) scale index [158, 159]. This is because the two tools provide a measure to understand the food insecurity problem in resource-constrained settings, especially among rural populations that rely largely on rain-fed subsistence farming [160]. Similarly, CCHIP provides a more understanding of the food insecurity effects on household members by accounting for child hunger [158, 159].

The combined HFIAS and CCHIP scale consists of eleven food-insecurity experience-based indicators linked to worry about lack of food, insufficient quality and quantity of meals,

and going to sleep hungry, both in adults and children of the household in the last 30-days preceding the survey. The indicators included: (1) having skipped a day without a household meal of breakfast, lunch or supper; (2) children had ever gone to bed hungry due to lack of food; (3) children were allowed to roam and eat elsewhere because of lack of food; (4) sought financial support to buy food; (5) children having eaten less food due to there not being enough food; (6) sought food assistance from neighbours, relatives and friends; (7) limited portion sizes at meals due to there not being enough food; (8) reduced food for adults because of there not being enough food; (9) parents/caretakers eating less because of there not being enough food; (10) purchased food on credit; and (11) relied on less-preferred, less-expensive food.

For each indicator, the respondent replied to a frequency of the experience as: never, rarely, sometimes, or always. The frequency scores ranged from 0 to 3. Non-occurrence (never) was scored as 0; rarely, a frequency of once or twice scored 1 point; sometimes, a frequency of three to ten times scored 2 points; and often, a frequency of more than ten times scored 3 points [157, 158]. A maximum score of 33 points was given if the household's response to all the eleven questions was 'often' and a minimum score of 0 was given if the respondent answered 'never' to all the questions. The generated score from 0-33 represented a single statistical measurement of food insecurity. A score of 0 indicated the household is food secure while a score from 1-33 indicated the household was food insecure. The higher the score, the more the households experienced food insecurity.

4.6.3 Household dietary diversity assessment

Using the Household Dietary Diversity Score (HDDS), the household's dietary diversity was measured to establish each household's access to different types of food. This was based on a retrospective recall by the household's head about the frequency of the household's consumption of all food items and beverages listed in a food frequency questionnaire (FFQ)

within the previous twenty four hours prior to the interview. The FFQ was adapted for Uganda and was composed of the commonly eaten foods (n = 86) grouped into 12 groups: (1) cereals and grains, (2) legumes, (3) starchy roots, tubers and plantain, (4) vegetables, (5) fruits and fruit juice, (6) meat and meat products, (7) poultry and eggs, (8) milk and milk products, (9) fish (10) fats and oils (11) sugars and confectionaries, and (12) condiments, spices and beverages [161]. A single point was given to each of the food groups consumed over the given reference period.

The HDDS was computed by summing the number of food groups consumed by each household over the previous twenty-four hour period. The maximum score was 12 if the household consumed all the food groups and the minimum score was 0 if the household did not consume any of the food groups. This score was used as a proxy to estimate the diet quality given their suitability in resource constrained settings. The higher the score, was the higher the nutrient adequacy of the diets consumed while the lower the score, the lower the diet nutrient adequacy.

4.6.4 Assessment of food varieties consumed

Food varieties consumed by a household were measured using the food variety score (FVS), the count of different food items consumed by a household as a proxy estimate of dietary quality and nutritional adequacy [162]. The FVS was computed based on a list of food items and a set of frequency-of-use response categories from the Food Frequency Questionnaire (FFQ) over a 7-day recall period. As has been earlier used in Uganda [163, 164], frequently consumed varieties totalling 86 food items were listed into 12 groups to facilitate a retrospective 7-day recall by the household head. The 12 food groups included: (1) cereals; (2) legumes; (3) starchy roots, tubers and plantain; (4) vegetables; (5) fruits and fruit juice; (6) meat and meat products; (7) poultry and eggs; (8) milk and milk products; (9) fish; (10) fats and oils; (11) sugars and confectionaries, and (12) condiments, spices and beverages.

Household heads were asked whether their household members had consumed each of the listed food items in the previous 7 days preceding the survey. The approximate frequency of use of each of the consumed food items (responses ranging from never, once, 2-3 times, 3-4 times and more than 4 times) was then recorded. A score of 1, was given if the food item was consumed at least once over the 7-days and a score of 0 was given if the food item was never consumed. The FVS for each assigned food group (sub-group FVS) was equal to the summation of the points for each food item within the assigned food group. For example, a cereal food group with 5 individual food items would have a maximum score of 5 while a vegetable food group with 19 individual food items would have a maximum score of 19. The overall FVS was equal to the sum of the points for all 12 assigned food groups. The maximum score was 86 if all the listed food items were consumed. The minimum score was 0 if none of the food item was consumed. Higher scores indicated higher food varieties consumed. The analysed overall and sub-group FVS were computed into means and SD or SE. The sub-group and the overall FVS were used to determine household food consumption within each assigned food groups and among the 12 food groups respectively.

4.6.5 Assessment of food insecurity coping strategies

Food insecurity coping strategies were measured using a coping strategy index score, generated based on the eleven strategies that were frequently used by households facing food insecurity threats in resource-constrained settings [160]. Questions about the household's experiences to food access, child hunger and food insecurity coping practices were adapted from the Household Food Insecurity Access Scale (HFIAS) [157], the Community Childhood Hunger Identification Project (CCHIP) index [158, 159] and the Coping Strategy Index (CSI) [160], respectively. In particular, four strategies were adapted from the HFIAS: (i) reducing portion sizes; (ii) reducing food for adults; (iii) children going to bed hungry because there was not enough food to eat; and (iv) skipping a day without a household meal. Five strategies

were adapted from the CSI: (i) relying on less preferred and less expensive food; (ii) purchasing food on credit; (iii) borrowing food, or seeking food assistance from neighbours, friends or relatives; (iv) seeking financial support for food; and (v) children eating elsewhere due to no food. In addition, two strategies were integrated from the CCHIP: (i) parents eating less food so children can eat; and, (ii) children eating less due to inadequate food or means for its procurement.

Each coping strategy commonly used by households when faced with food insecurity challenges was ranked for severity using a severity scale ranging from 1 to 4 points [160]. The frequency of each coping strategy over a 7-day recall period was scored. The severity of coping with food insecurity was computed as an overall of weighted scores. A severity score of 1 denoted the least severe coping strategy; indicating a coping practice likely to be adopted first in times of crises, and 4 denoted the most severe coping strategy, a practice that would be adopted as a last resort. The least weight of 1 point was assigned to relying on less expensive and less preferred foods. A weight of 2 points was allocated to reducing food for adults; eating less as a parent; limiting portion sizes at meals; and purchasing food on credit.
A weight of 3 points was assigned to children eating less food; seeking financial credit to buy food and borrowing food, or seeking food assistance from neighbours, friends or relatives. A weight of 4 points was assigned to skipping a day without eating a household meal (three main household meals of breakfast, lunch and supper, while excluding snacks or other food eaten outside the household were considered); children going to bed hungry; and allowing children to roam and eat elsewhere due to inadequate food in the household. A severity score for each coping strategy was calculated by multiplying its weighted value by the frequency of times a household reported as having experienced it over the last 7-day period [160]. For example, a single category 1 strategy experienced every day would have a minimum score of 7 points ($1 \times 7 \times 1$), while a category 4 strategy experienced every day for the recall period of

7 days would have a maximum score of 28 points (4 × 7 × 1). The total severity of coping score for each household was a total of the weighted scores for the eleven coping strategies. The maximum severity of coping score for a household that experienced all eleven strategies daily was 210 points [(1× 7× 1) + (2×7×4) + (3×7×3) + (4×7×3)]. The analysed scores were computed into means and SD or SE. The higher the CSI score was the higher the level of food insecurity in the household.

4.6.6 Child nutritional status assessment

Child nutritional status assessments were performed in the Nutrition Unit of Bududa District Hospital by trained and skilled field workers with college level qualifications in nutrition. Anthropometry measurements (length/height, weight, mid-upper arm circumference and head circumference), of children 6-59 months were performed following standard WHO guidelines [82, 165]. The WHO Child Growth Reference standards was used as the reference for growth. We computed z-scores as (observed value - median value of the reference population)/SD value of the reference population [82]. Stunting, wasting and underweight were defined as z-scores of < -2SD from the median of the reference population [166].

4.6.7 The right to adequate food assessment

The right to adequate food was measured based on questions adopted and modified from FAO's "Guide to conducting right to adequate food assessment" [167]. The RtAF data was collected from household heads, focus group discussants and key informants.

A pre-coded and structured questionnaire (as part of the household questionnaire (Annex 3)), with mainly closed-ended questions regarding perceptions of the RtAF during the disaster in Bududa District was used for data collection from the household heads. Questions comprised: (1) whether in the past 30 days there were instances when: (a) a household did not have sufficient food for more than 2 days, (b) a household head felt the household was not eating safe food, (c) a household head felt the household was eating less nutritious food and

could not do much about it; (2) whether providing food for the household limited the household's ability to provide other amenities like health, water, housing, clothing and education; (3) whether the landslides had affected the household's food and nutrition security and the RtAF; (4) awareness about the principles of human rights of participation, accountability, non-discrimination and transparency; (5) awareness about the State obligations of respect, protect and fulfil; and (6) the preferred means to ensure the right to adequate food of landslide-affected individuals.

Using FGD and key informant interview guides (Annex 5 and 6 respectively), FGDs and key informant interviews (KII) were held to get an extensive perspective on food security, diet and the RtAF. Guiding questions included: What is the situation of food and nutrition security in the study area; where, when and who are the most affected and why; whether landslides affected the food and nutrition security and the RtAF of landslides affected individuals; whether the disaster response in the study area is satisfactory; whether the human rights principles of participation, accountability, non-discrimination and transparency were taken into consideration during the response of public authorities to the disasters; the perception of the fact that the State should ensure that no Ugandans suffers from hunger and malnutrition even in times of disaster; how the State should ensure the realization of the RtAF of landslide-prone communities; and the preferred means to ensure the RtAF of landslide-affected individuals.

The FGDs took place at the respective sub-county headquarters. An experienced facilitator fluent in both English and the local language led the FGDs. The FGD participants were told beforehand to be at liberty to discuss in English or their native languages, and that all answers were equally important. The FGDs ranged from 60 to 90 minutes. Interviews with key informants were conducted on appointment by the first author and took place in the participant's office. The interviews ranged from 45-90 minutes. Both audio-recorded and

written data were collected during the FGDs and KIIs. Written informed consent to participate and record the interview/discussion was sought from each participant before the start of each session.

4.7 Data analysis

4.7.1 Categorisation of nutritional status of children

WHO Anthro version 3.2.2 [168] and WHO AnthroPlus version 1.0.4 [169], were used for processing anthropometric data to generate height-for-age (HAZ), weight-for-age (WAZ), weight-for-height (WHZ), mid-upper arm circumference-for-age (MUACZ) and head circumference-for-age (HCZ) z scores. Z-scores of < -2 SD from the median of the WHO reference population indicated child stunting, underweight and wasting [82]. Weight-for-height z score (WHZ) > +2 SD implied overweight/ obesity among the assessed children [82]. Presence of microcephaly, a condition where a child's head circumference is significantly smaller than expected for the child's age was defined as head-circumference-for-age z scores (HCZ) < -2 SD from the median of the reference population [170].

4.7.2 Statistical analysis

Analyses for quantitative data were conducted using Stata version 16.1 statistical software [171].

Paper I: Normally distributed data were presented using proportions, means and SD. Bivariate associations between the outcome variables (stunting, underweight, wasting and overweight) and the independent variables were examined using Pearson's chi-square tests and unadjusted logistic regression models. The effect of each explanatory variable on the outcome was determined using multivariate binary logistic regressions while controlling for selected covariates. The obtained crude odds ratio (cOR) and adjusted odds ratio (aOR) with the corresponding 95% confidence interval (CI) showed the strength of the association between the outcome and the independent variable(s). The statistical association was assumed

significant at $p < 0.05$. The model fit in the multivariate binary logistic regression was assessed by the Hosmer-Lemeshow Goodness-of-fit test and was considered a good fit when the computed chi-square p value of the model was > 0.05. Variance inflation factor (VIF) was used to identify presence of multicollinearity (high correlation) between covariates. Covariates with VIF > 10 indicated high multicollinearity effect between the covariates and hence not included in the multivariate analyses. Sensitivity analysis was performed to assess any possible effect of missing data due to loss-to-follow up on the overall fitted model. This was done by comparing the results of model performance from an analysis of the fitted model with complete data with an analysis of the fitted model with missing data [172]. Sensitivity analysis results of the fitted model with complete data that are consistent with results from analysis of the fitted model with missing data indicated no possible effect of missing data on the overall fitted model, thus the obtained results were taken to be robust.

Papers II and III: Given that our data had some extreme values that affected the normality of the data, crude mean differences in scores were tested using Levene's independent-samples *t*-test due to its appropriateness for application to both normally and non-normally distributed data. The dependent outcomes (food insecurity scores and DDS) and (FVS and food insecurity coping strategy scores), were first tested for linearity with each other using Pearson's correlation (r). Given a small positive and small negative correlation between household food insecurity and DDS in the food-plenty and food-poor seasons respectively and a moderate positive correlation between FVS and household food insecurity scores in the food-plenty and food-poor seasons respectively, a one-way multivariate analysis of covariance (MANCOVA) model was used to test for univariate and multivariate effects while adjusting for the disaster effect and socio-demographic covariates.

The socio-demographic covariates considered were: interviewed head of the household; the household head's age; education level; the main source of livelihood; household size,

household ownership of assets or entitlements and migration of a household member in the past 12 months preceding the interview). Multivariate binary logistic regression was used to analyse the likelihood to adopt versus the likelihood not to adopt each of the food insecurity coping strategies while adjusting for the disaster effect, interviewed household head, household head's age, household head's education level, the main source of food, main livelihood source, household size, asset ownership, migration and loss of any household member in the past 12 months prior to the survey. The crude and adjusted odds ratio with their corresponding 95% confidence interval were attained to show the strength of association at a statistical significance of $p < 0.05$. The Hosmer-Lemeshow goodness-of-fit test was used to assess the model fit in the multivariate binary logistic regression. Household heads' responses regarding the RtAF were treated as categorical variables in the analysis. Pearson chi-square test was used to examine associations between these categorical variables, using a $p < 0.05$ as a level of significance.

4.7.3 Triangulation

Using thematic analysis, data from FGDs and key informants were triangulated to augment the quantitative data outcomes. The translated information was first transcribed, followed by the identification and coding of key words and phrases with similar impressions. The coded information was assigned into groups and categorized into themes. The generated themes were reviewed to ensure that the themes were accurate representations of the data. Defining and renaming the generated themes was then performed to establish a sequence of patterns and associations related to study themes and included in the results and discussion of results accordingly.

5. Main results

5.1 Child nutritional status and effect of seasonal variations and associated factors (Paper I)

In Paper I, we assessed the nutritional status and effect of seasonal variations and associated factors among children 6-59 months in the landslide-affected households. As reported [173], the levels of child stunting were higher in the food-poor season (42.6%) than in the food-plenty season (37.7%). Both levels recorded were higher than the national and Bududa sub-region prevalence of 29% and 35.9% respectively.

There were significantly more stunted children among the affected group than in the controls in the food-plenty season, but not in the food-poor season. On the contrary, underweight prevalence among children was significantly higher among the affected group compared with the controls in both food seasons. We did not observe any significant differences between the two study groups at either time point regarding wasting, overweight, or the combined anthropometrical deficiencies (stunting + wasting and stunting + overweight). Over 50% of the stunted, underweight, and wasted children were males in the food-plenty season, whereas over 50% of the stunted, underweight, and wasted children were females in the food-poor season.

Residing in the landslide-affected sub-county, child age, child sex, breastfeeding status, parents' education, usage of a non-improved drinking water source and migration of any household member in the past 12 months prior to the survey were significant risk factors for child malnutrition in the food-plenty season. In the food-poor season, child age, child sex, parents' education and loss of any household member in the past 12 months prior to the survey were significant risk factors for child malnutrition.

The conclusions on this study component point to child stunting being more prevalent in the food-poor season while child wasting and being overweight were more prevalent in the food-plenty season. With exception of child age, child sex, and parents' education, child malnutrition risk factors differed between the food-plenty and food-poor seasons.

5.2 Seasonal variations in food insecurity, diet diversity and the right to adequate food among households affected by the major 2010 and 2018 landslides (Paper II)

This study component dealt with seasonal variations in food security and diet diversity among households of the major 2010 and 2018 landslide disasters to provide a proxy estimate to which nutritional health was affected. We also analysed the extent to which the right to adequate food among households of the major 2010 and 2018 landslide disasters was being realized [174].

The main findings showed that household food insecurity levels were higher among the affected households compared to the controls during the food-plenty season and the severity increased in the food-poor season. Similarly, the average diet diversity was lower adjusted mean score of diet diversity among the affected households compared to the controls during the food-plenty season and the severity increased in the food-poor season. After controlling for the socio-demographic covariates, the disaster and parents' education were associated with both household food security and diet diversity during both food seasons. The main source of livelihood was associated with both household food security and diet diversity during the food-plenty season only.

Household heads reported to have consumed less nutritious and unsafe food and agreed that the provision of food for their households limited their ability to provide other amenities like health, water, housing, clothing and education. Focus group discussion participants and key informants emphasized that cash-handouts, sensitization of both duty-

bearers and rights-holders about the right to food, and creation and enforcement of policies were essential for the realization of the right to adequate food of landslide-affected households. Comprehension and awareness of human rights principles and state obligations were low among the study participants.

Based on the findings, we concluded that, the severity of food-insecurity and diet diversity differed significantly between the affected and control households during both food seasons. Moreover, the right to adequate food for landslide-affected individuals was not sufficiently realized.

5.3 Seasonality changes and disaster effects on food varieties consumed and food insecurity coping strategies among the 2010 and 2018 landslide-affected households (Paper III)

This component of the study described the extent to which seasonal variations and disaster effect on food varieties consumed and on how households cope during situations of food shortages [175].

On average, the affected households had consumed less than 10 while the controls had consumed less than 12 food items out of the 86 common food items over the seven days recall period in both food seasons. High biological value protein sources such as milk and milk products and poultry and eggs scored poorly in both food seasons and were significantly lower among the affected compared to the controls in both seasons.

After adjusting for covariates, significantly lower mean food variety cores were found among the affected than controls during the food-plenty season and the food-poor season. The affected households were more likely to use food insecurity coping strategies compared to the controls in both seasons. The magnitude of using the food insecurity coping strategies among the affected compared to the controls increased during the food-poor season. The disaster was associated with both household food varieties and food insecurity coping strategies during

both food seasons. The main source of livelihood was associated with both household food varieties and food insecurity coping strategies during the food-plenty season only.

The adjusted models, showed that, the affected compared to the controls had a significantly higher likelihood to rely on 5 of the 11 coping strategies during food-plenty season and 9 of the 11 coping strategies during the food-poor season.

In conclusion, the severity of food varieties consumed and food insecurity coping strategies used differed significantly between the affected and control households during both food seasons, and increased during the food-poor season. Reliance on food insecurity coping strategies was higher among the affected than the controls during the food-plenty season and it increased during the food-poor season.

6. Discussion

6.1 Summary of main findings

Our results revealed that the levels of child stunting were higher in the food-poor season (42.6%) than in the food-plenty season (37.7%). Both levels recorded were higher than the national and Bududa sub-region prevalence of 29% and 35.9%, respectively. The landslide-affected households had significantly higher prevalence of child stunting in both food seasons than the controls. Residing in the landslide-affected sub-county significantly increased the odds for stunting for children in the food-plenty season. With exception of child age, child sex, and parents' education, child malnutrition risk factors differed between the food-plenty and food-poor seasons.

The affected households compared to the controls had significantly higher mean food insecurity scores, higher mean food insecurity coping strategies, lower mean dietary diversity scores and lower mean food variety scores during both food-seasons and the severity increased during the food-poor season. Disaster exposure and education were significantly associated with all the food insecurity outcomes (food insecurity scores, DDS, FVS and food insecurity coping strategies scores) during both food-seasons. The right to adequate food is not sufficiently realised among the landslide-affected individuals.

6.2 Child nutritional status and effect of seasonal variations and associated factors

Our results build on existing evidence of the shared risk/causal factors for child malnutrition as identified in the UNICEF 1990 [99] and in the proposed 2013 *Lancet* frameworks [84]. Child malnutrition is a multifaceted problem stemming from basic, underlying and immediate causes. Presence of unfavourable ecological conditions in the society is among the basic causes of child malnutrition [99]. In this case, the persistent landslides, which have continuously disrupted the social determinants of health for people in rural Uganda. This may

have led to intergenerational malnutrition that in the long run manifested as the higher prevalence of child stunting in the food-poor season (42.6%) and in the food-plenty season (37.7%). Moreover, these figures were higher than the national and Bududa sub-region prevalence of 29% and 35.9%, respectively. [110]. The possible explanation for the higher prevalence of child stunting in both food seasons is that, probably there has been an increased prevalence of child undernutrition in the landslide-prone community from 2010 to 2020, probably attributed to several factors, including the persistent landslides in the district, and there were deprivation effects on the well-being and livelihoods and the right to adequate food. Arguably, natural disasters often unmask pre-existing poor nutritional status in children, particularly in low-income settings, that could be well above the emergency threshold [176].

Stunting is a marker of chronic undernutrition. Thus, the observed high prevalence of stunting in this study is possibly a manifestation of the effects of food deprivation before conception, *in utero*, after birth and beyond the first 1000 days, which the households and the parents of the children had been exposed to in the recent or distant past due to the persistent and recurring landslide disaster exposures. As noted by Caruso [177] children in utero and young children are the most vulnerable to natural disasters and suffer the most long-lasting negative effects. In addition, presence of child malnutrition is one of the most recognizable outcome indicators for the non-realization of the RtAF among the population [178]. Hence, possibly the observed stunting prevalence which was higher than the Bugisu sub-region, signifies that the presence of persistent landsides without provision and access to appropriate forms of disaster preparedness and management systems further interferes with the ability of landslide-affected individuals to enjoy the RtAF.

Our study findings identified effect of seasonal variations and the factors associated with child malnutrition among the vulnerable landslide-prone communities. The identification of risk factors is important for informing strategies and programs to improve, buffer against

risk and guide formulation of targeted policies to combat child malnutrition in Uganda. The identified risk factor for child malnutrition in the food-plenty season were: residing in the landslide-affected sub-county, child age, child sex, breastfeeding status, parents' education, usage of a non-improved drinking water source and migration of any household member in the past 12 months prior to the survey. In the food-poor season, child age, child sex, parents' education and loss of any household member in the past 12 months prior to the survey were significant risk factors for child malnutrition.

Residing in the landslide-affected area appears to increase the odds for child stunting and underweight. This is consistent with findings from India [179], Nepal [180] and the Philippines [181], showing that exposure to natural disasters increased the likelihood of child malnutrition. One explanation may be that persistent exposure to landslides disrupted the community livelihoods and exposed the community to continuous reduced food supply, restricted access to safe and nutritious food, reduced quantity and quality of food consumed, disrupted access to health, safe water and sanitation facilities, thus increase in child malnutrition [50, 58]. Similarly, the disaster effect might have affected the parents and influenced their food and nutrition decisions specifically before conception, during and after pregnancy, thus resulting in stunted children. Furthermore, the landslide-affected community is located on steep mountainous terrain, with poor road infrastructure, poor transportation facilities, and limited supply of adequate health facilities. Such factors restrict accessibility to maternal and child health care services such as health facility delivery, and antenatal and post-natal care visits that could otherwise raise community awareness to provide quality complementary feeding and access to child immunization and growth monitoring services. Therefore, efforts to mitigate disaster effects and related shocks would help to reduce child malnutrition among the disaster-prone communities, hence improving human development of future generations.

Child age, was a risk factor for child stunting. In particular, the younger children aged 12-23 months had higher odds of stunting than those in the older age group 24-59 months in the food-plenty season. This is contrary to findings from Zambia [182] where children aged 12-23 months had lower odds of stunting than those aged 24-59 months. This discrepancy is probably due to the rapid growth and development of children who are below 24 months (in the first 1000 days), thus demanding relatively high nutritional needs and any disruption along the food system due to landslides and related shocks increased the younger children's vulnerability to malnutrition.

Child sex was a risk factor for child malnutrition. In particular, male children had higher odds of stunting and underweight compared to the female children. Similar findings have been reported in sub-Saharan Africa [183-186], in a systematic review of 74 studies [187] and in a meta-analysis of 16 Demographic and Health Surveys in 10 sub-Saharan African countries [188]. These findings highlight the association of being male with higher odds of child stunting and underweight. Several reasons could explain this association. The preferences in feeding practices such as early weaning of boys [187] and children's behaviours whereby girls might stay closer to the home and have more access to the prepared food , while boys play outside and in turn eat less while expending more energy [187]. This is also due to the fact that, the growth of boys is slightly more rapid in the first months of life and thus affected by any nutritional deficiencies [189] than girls. Similarly, this could have been partially attributed to the exposure effects of the 2018 landslide that occurred 6-7 months before data collection in the food-plenty season, possibly affecting the household's food and nutrition security and other social determinants of health and thus the manifestation of malnutrition among the children in the food-plenty season.

Child breastfeeding status was found to increase the odds for child stunting during the food plenty-season. This means that children who were not breastfeeding had higher odds of

being stunted than the children who were breastfeeding during the food-plenty season. This may be attributed to the breastmilk's immune protective factors reducing the risk of infections such as diarrheal and acute respiratory diseases [49]. Findings from Mexico [190], Zimbabwe [191] and Mozambique [184] reported similar results of child breastfeeding as a protective factor for stunting. It is plausible to argue that, in the absence of breast-feeding, children were depending on inadequate complementary feeding involving intake of low-nutrient-density foods not sufficient to support their optimal growth and development and thus manifesting as stunting. Nevertheless, it is worth noting that breastfeeding decisions and behaviours are determined by multiple factors. Factors, such as maternal depression, lower education levels and inadequate feeding resulting into inadequate breastmilk production could have contributed to the mother's inability to breastfeed their children.

Further, our study found usage of a non-improved drinking water source as a risk factor for child underweight. Usage of non-improved water is among the determinants of childhood undernutrition in LMICs [49, 99, 129]. Non-improved water sources may be contaminated and thus increase the risk of waterborne diseases and infections e.g. diarrhoea and cholera, [49, 129, 130]. This not only affects the children's dietary intake and nutrient utilization but also may lead to dehydration, thus resulting in child undernutrition.

Our findings revealed that migration of any household member in the past 12 months is a risk factor for child wasting. Children from households where there had been migration of any household member had higher odds of wasting compared to those from households where there was no migration of any household member. This is in agreement with findings from a systematic review by Fellmeth et al., [192] that reported an increased risk of wasting among children left behind by their parents, in LMICs. Migration is an indicator of extreme food insecurity coping strategy in the household [193] and possibly the individuals that had migrated were important in ensuring the household's food and nutrition security. Reportedly,

migration is often the last option left to household members in LMICs at risk of starvation [193]. Migration not only increases psychological stress for the children left behind but also reduces the time allocated to childcare including sub-optimal and changed feeding practices [192].

6.3 Seasonal variations in food insecurity, diet diversity and the right to adequate food

Our study found higher food insecurity and lower diet diversity among the affected households compared to their counterparts, in both seasons and the magnitude increased during the food-poor season. This contradicts the findings in our previous study [121], which found lower food insecurity and higher diet diversity among the landslide-affected communities in Bududa District. This disparity is possibly due to the massive and disastrous nature of the 2010 landslide disaster that gathered both national and international disaster response in terms of emergency interventions in areas of water, relief food assistance sanitation, hygiene and health promotion among the landslide-affected households [33, 121, 154], hence the reduced food insecurity and higher diet diversity.

Consistent with our current findings, a study in Haiti found more food insecurity and poorer dietary diversity among participants who were severely impacted by the hurricane compared to the less severely impacted participants [194]. Similarly, a longitudinal cohort study in the Philippines [181] found increased food insecurity among households that had been exposed to greater numbers of natural disasters. In our setting, the high food insecurity and low levels of dietary diversity might be attributed to the long-term effects of landslide disasters and related shocks that led to prolonged deprivation of livelihoods and the means to secure an adequate and diverse diet among the affected households. Most affected areas rely on subsistence farming for survival, so the loss of crops and animals in a disaster has a disproportionate effect on food security and income generation.

As would be expected, the severity of food insecurity and lower diet diversity among the affected households increased during the food-poor season. This concurs with a study in rural Southwest Uganda [39] and in South Ethiopia [42] that reported increased food insecurity during the dry season compared to the food-plenty season. The food-poor season is characterized by lower food availability both on the farms and on the market, thus the affected probably faced both limited physical access to food on the farm and limited economic accessibility to food on the market due to low purchasing power. Household diet diversity is a proxy indicator of a household's economic access to a variety of foods during a determined period [195]. This may imply that landslide-affected households' financial costs associated with the acquisition of food for an adequate diet were threatened by a lack of resources during the food-poor season. Equally, consumption of a lower diversified diet may indicate that the affected households' diets were nutritionally inadequate. Prolonged intake of a nutritionally inadequate diet is linked to multiple micronutrient deficiencies that lead to impaired physical and cognitive development, poor physical growth and reduced work productivity which have a negative macro-economic impact [145]. Moreover, poor diets contribute to one in five adult deaths, through both insufficient intake of healthy foods and excess intake of unhealthy items [196].

Our findings indicate that regardless of the food season, disaster exposure was associated with both food-insecurity and diet diversity, however, the severity was more in the food-poor season and more among the affected households than the controls. Arguably, natural disasters are a leading cause of food insecurity as they affect all components of food security thus, reducing the economic and physical access to food, utilization, and stability [197]. Persistent exposure to landslides probably exposed the community to reduced food supply, restricted access to safe and nutritious food, and reduced quantity and quality of food consumed [58]. Moreover, the landslide-affected community is located on steep mountainous

terrain, restricting accessibility to market places for households to purchase a variety of food to complement their household diets. Greater market access has been shown to increase household reliability on market purchases to improve the diversity of household consumption [198].

Primary education level was associated with both household food insecurity and low diet diversity in terms of scores in both seasons. Education is one of the determinants of household food security because of its association with the economic status of a household [195, 199]. Wealthier households have the resources to purchase more diverse food than poor households [195]. On the other hand, less educated parents tend to have lower household income and higher poverty levels and hence have a low purchasing power for more nutritious and highly diversified foods. Similarly, it could be due to the limited nutritional knowledge on how to meet the health and nutritional needs for the household members.

Livelihood source was not a significant factor linked to food security during the food-poor season. This is probably because the majority of the population in the study area is rural and depends mainly on rain-fed subsistence agriculture as a major source of livelihood [6, 156]. In rural subsistence agricultural settings, the food-poor season is characterized by intensive preparation of farmlands, depleted food stocks from the previous harvest and limited income-generating avenues [44, 45]. This leads to decreased availability and accessibility to food, both on the farms and on the markets due to lower crop production and higher food costs respectively. It is also argued that where people depend on land for their food security, access to land is essential for the progressive realization of the RtAF [200]. However, in this context, the analysis seems to reinforce seasonality as a factor that impacts food insecurity beyond access to land. This calls for consideration of seasonality beyond access to land, in interventions for combating food insecurity in Uganda.

The majority of both the affected and the control answered affirmatively to the question of the household eating unsafe food and on the question of a household eating less nutritious food and could not do much about it. This indicates that a bigger proportion of the affected and control households were consuming nutritionally inadequate and unsafe food. Reportedly, unsafe food contains microbiological, chemical, or physical hazards that affect the health of people, causing acute or chronic illness that in extreme cases lead to death or permanent disability [201]. In our setting, prolonged consumption of less nutritious and unsafe food may compromise the overall health and the nutritional status of landslide-affected individuals and thus further increase their vulnerability to food insecurity and poverty-related shocks and effects. Furthermore, this contradicts paragraphs 10 and 11 of United Nations GC 12 which emphasizes the importance of assuring food safety and the perceived non-nutrient-based values attached to food and food consumption as crucial for the realization of the RtAF [66]. In addition, this may further delay the progress towards achieving SDG Target 2.1 of ensuring access to safe, nutritious and sufficient food for all people all year among the vulnerable landslide-affected households.

A considerable proportion of households agreed that the provision of food for their households limited their ability to provide other amenities like health, water, housing, clothing and education. Similarly, FGD and key informants cited landslides to affect sectors of food, health, water, education and transport among others. This reaffirms the interdependency, indivisibility and interrelatedness of human rights [66]. The inability to achieve one human right, e.g., the right to adequate food, may affect the realization of another, e.g., the right to health [73-75]. It is plausible to argue that households in Bududa District were probably accessing food in unsustainable ways and thus interfering with the enjoyment of other human rights. This is inconsistent with paragraph 8 and 13 of the United Nations GC 12 which stresses that food should be accessible in ways that are sustainable such that the attainment of

other basic needs is not threatened or compromised as a crucial condition for the realization of the RtAF [66]. It may also be plausible to argue that as the households were struggling to put food on the table, so were they compromising the attainment of other basic needs like safe water, health and housing.

Cash handout stood out as the most preferred aspect for ensuring the RtAF among the households in the affected and control areas in both seasons. This contradicts our previous findings from these study groups [202] where both the affected and control households preferred the provision of land for food production as the outstanding choice to ensure the RtAF of landslide-affected individuals. This is possibly related to previous findings in the same area which indicated that the relief food in the area was of limited variety mostly dominated by dry rations of beans and maize flour, often less preferred and less desirable [202]. Moreover, food preparation of the dry rations of beans requires a lot of fuel, water and cooking time, which perhaps were not readily available and accessible to the landslide-affected households. Another possible reason might be because the landslide-affected households were previously resettled in a different district on land with lack of a land ownership and not sensitive to the *"Bamasaba"* culture and food security needs [202].

It is plausible to argue that, cash provision presents the landslide-affected households with the opportunity to be resettled to safer locations of their choice and on land with full land ownership rights, favourable and familiar factors. Such factors include high soil fertility, geographical location similar to Bududa district and sensitivity to the *"Bamasaba"* culture, and proximity to the original ancestral land and land that promotes the production of culturally safe, familiar and acceptable foods. Similarly, cash provision is thought to be a faster process compared to construction of houses for the landslide-affected households as noted by the State Minister for Disaster Preparedness in Uganda [203].

Our findings also found low awareness about the RtAF, State obligations and principles of human rights among the study participants. This corroborates findings in Uganda that found low knowledge and low awareness of the RtAF and related State obligations among duty-bearers [204, 205] and rights-holders [202]. Knowledge and awareness about the RtAF by duty-bearers and rights-holders is an essential pre-condition for the realization of the RtAF. This situation of limited awareness of human rights and the right to adequate food in particular by the key State actors narrows the possibilities of pursuing remedies and recourse mechanisms in the case of violations. Whereas rights-holders may be deprived of this human right without knowing it [167], they need to know whom to hold accountable and to whom they should direct complaints in case of violations of their RtAF.

6.4 Seasonality- and disaster effects on food variety and food insecurity coping strategies

Our study findings are in agreement with the hypothesis that seasonal variations and disaster effects influenced the food varieties and food insecurity coping strategies among the affected and control households among landslide-prone communities in Uganda.

The study findings showed that the affected households had consumed food of lower variety (less than 10 food items) as compared to the controls, who had consumed less than 12 food items out of the 86 common food items over the seven-day recall period in both food seasons. High biological value protein sources such as fish, eggs, poultry, milk and milk products and meat and meat products scored poorly in both food seasons and were significantly lower among the affected compared to the controls in both seasons. This implies that affected households faced difficulty in ensuring availability and accessibility to the animal food sources. Animal food sources are expensive and thus accessibility is low in many rural parts in LMICs where income levels are low [206]. In some cases, low education levels and low awareness on the optimal nutrition practices have also contributed to low intake of such food in Africa [207]. High consumption of animal food sources is observed to be

significantly associated with pregnancy outcomes and birth outcomes such as improved growth, cognitive function, physical activity levels, school performance, and morbidity in young children [208, 209]. Low animal source food consumption has been reported to increase the risks of being undernourished [210, 211].

After adjusting for covariates, we found significantly lower mean household FVS among the affected households compared to their counterparts during both seasons and a reduction in the mean of the household FVS further decreased during the food-poor season. This result contrasts findings from our previous cross-sectional study [150], which found higher food variety scores among the affected than the controls in Bududa District. This discrepancy is likely attributable to the disastrous nature of the 2010 landslide disaster that gathered both international and national disaster emergency response in areas of relief food assistance, water, sanitation, hygiene and health promotion among the landslide-affected households [33, 121, 154]. Such immediate and large-scale response probably limited the nutritional stress caused by the landslides, hence the higher food variety scores. The lower food variety scores among the landslide-affected households could be attributed to declining resilience following an additional landslide in 2018, possibly leading to multiple and longer-term effects of landslide disasters and related shocks that aggravated the deprivation of livelihoods and the means to a variety of foods in the diets.

The increased reduction in household food variety scores during the food-poor season probably reflects seasonal hunger that constrained food accessibility and consumption of a variety of foods among the landslide-affected households during the food-poor season. In rural subsistence agricultural settings, the food-poor season is characterised by decreased availability and accessibility to food, both on the farms due to lower crop production and higher food costs on the market. This further compromises the food quality and varieties,

consequently resulting in substantial changes in the consumed diets [212], and possibly increasing the risk for severe acute malnutrition in children [147].

Like for most food insecure populations, several strategies were being employed to address food insecurity among the affected households. In particular, our results showed that the affected households exhibited significantly higher mean scores of the food insecurity coping strategies than the controls during both food seasons. In addition, the severity of household coping strategies for the affected households increased during the food-poor season. This implies that the affected households compared to the controls experienced heightened food insecurity during both food seasons. Food insecurity is associated with the consumption of low-quality food [213] and unsafe food [214]. Experiencing food insecurity in both food seasons possibly further compelled the affected households to rely on more severe food insecurity coping strategies as a means of survival. Prolonged dependence on more and more severe food consumption coping strategies has been shown to reduce the quality and quantity of consumed foods [215], thus undermining the nutrient intakes of household members including children. This consequently undermines the child's optimal growth and development in the due course of time.

Our findings further showed that during both food seasons, the likelihood to adopt each of the food insecurity coping strategies differed significantly between the affected households and the controls. The likelihood to depend on less expensive and less preferred food and skipping meals stood out as major issues among the affected during both food seasons. Skipping meals and eating less expensive and less preferred foods are negative coping mechanisms which do not relieve food insecurity, but secure the continued existence of people under compromised living conditions [216]. Similarly, prolonged consumption of less preferred foods which are cheap and of low quality for-example mouldy and insect-infested beans and maize flour due to the inability to purchase better quality beans, poses a

risk of intake of food of lower nutritional value [217] and chronic diseases such as cancer and infections [218]. This may further compromise the health and nutritional status of the landslide-affected households. In addition, this practice is contrary to paragraphs 10 and 11 of the Committee on Economic Social and Cultural Rights General Comments 12: The Right to Adequate Food, which accentuate the importance of assuring food safety and the perceived non-nutrient-based values attached to food and food consumption as crucial for the realization of the right to adequate food [66].

Skipping a whole day or days without a household meal in both food seasons stood out as a key issue among the landslide-affected households. Skipping a whole day or days without a household meal is an indicator of severely inadequate access to food (severe food insecurity), which is associated with being undernourished or experiencing hunger [219]. Hunger, an uncomfortable or painful sensation caused by insufficient consumption of dietary energy [219], affects children's physical and cognitive development prenatally, perinatally, and during early years, and some of the effects continue through adolescents and adulthood [220]. This lowers the general productivity of individuals in developmental sectors of education, agriculture and health hence further reducing the landslide-affected households' ability to be free from hunger and malnutrition. As argued by Kent [221], hunger is best solved through creating conditions in which all humans can live a decent life to provide for themselves in dignity. Additionally, United Nations GC 12 (par.14) also asserts that:

> "*Every State is obliged to ensure for everyone under its jurisdiction access to the minimum essential food which is sufficient, nutritionally adequate and safe, to ensure their freedom from hunger*".

Uganda ratified the ICESCR and also recognizes the fundamental human right to food and nutrition in Objectives XIV and XXII of the *1995 Constitution of the Republic of Uganda* [77]. The presence of hunger among landslide-affected households in both food seasons may

imply the inability of duty-bearers to fulfil the RtAF by all Ugandans as obliged by United Nations GC 12 [66]. As asserted in article 2 of the ICESCR, this calls for the Government to '*take steps either individually or through international assistance and co-operation (especially economic and technical assistance), to the maximum of its available resources'* [66] to ensure that all Ugandans including the landslide-affected households to achieve the RtAF.

Our study further revealed that landslide-affected households relied on borrowing food or help from neighbours, relatives and friends to cope with food shortages. This may be explained by the absence of community safety nets, public social safety nets and a shortage of social support administrative structures of the Government [222]. Much as the family and neighbourhood safety nets seem to have been the alternative in this case, the capital base of supportive families is often limited and may not provide long-term solutions and guarantees for sustaining an adequate food supply to the landslide-affected households. It is necessary to have Government-instituted structures to provide social protection measures to alleviate severe food insecurity coping strategies such as skipping meals and checking the poor food variety scores at the household level.

6.5 Methodological strengths and weaknesses

6.5.1 The overall study design

This thesis mainly employed the observational prospective cohort design for quantitative data. However, qualitative data was collected once to get a deeper understanding of issues related to landslides, seasonality, food security, diet and the right to adequate food among households in the study area.

6.5.2 The observational prospective cohort design for quantitative data

The intent of observational studies is to investigate the 'natural' state of risk factors, diseases or outcomes [223], while prospective cohort studies assess of an exposure at baseline and the participants are followed in time to evaluate the development of the outcome of interest [224]. Prospective cohort studies are considered the gold standard among observational studies and being accurate in regards to the information collected about exposures, endpoints, and confounders [225]. In this longitudinal prospective cohort study, we investigated the natural state of child malnutrition, food insecurity, DDS, FVS and food insecurity coping strategies between the two sub-counties at baseline (food-plenty). The six months follow-up time (pre-harvest and post-harvest) of participants at different food seasons offered a snap shot of the changes in child malnutrition, food insecurity, DDS, FVS and food insecurity coping strategies between the two sub-counties at different food seasons. However, due to climate change that is grossly changing the times of the food-seasons, it is possible for the situation of time for the food-seasons to be different and present more varying results. This study also allowed for drawing inferences of associations between landslides and the study outcomes (child malnutrition, food insecurity, DDS, FVS and food insecurity coping strategies) including other socio-demographic factors. Issues that arise when conducting observational prospective cohort studies include choosing the correct sample, the control group and selecting appropriate methods for measurement, and confounding and mediation in the observed associations. These are discussed below:

6.5.2.1 Multi-stage sampling of affected and control households

We used a three-stage sampling to select household heads for household interviews from the two sub-counties. The commonality of the two sub-counties was that one was affected by the landslide while the other acted as the control neighbouring the affected sub- county. The two sub-counties also both receive bi-modal rainfall patterns, have a high population growth rate

of 4.2% and the natives are mainly subsistence farmers [226]. This comparability between the two sub-counties allowed us to establish internal validity between the exposure and study outcomes of interest. However, the landslide-affected sub-county may have differed from the control sub-county in other aspects such as location on the steep slope and less accessibility to markets than just landslide [6, 156]. Moreover, floods were also experienced during the study period [29], and possibly may have affected the food and nutrition outcomes of the study participants.

Our study had a high response rate of 98.6% and 91.8% for households and children, respectively at baseline (food-plenty season). This was due to the multi-stage sampling strategy that also involved identification, locating and contacting the eligible households during the household mapping and listing exercise with the assistance of the area local councils and the research assistants. A high response rate of 80% or higher is considered excellent for generating valid, reliable, and generalizable results for survey and prospective observational studies [227]. Moreover, the proportion of non-participation in cohort studies, if associated with both the exposure and the probability of occurrence of the event, can introduce bias in the estimates of interest [228]. At follow-up, we had a relatively low rate of loss to follow-up of 9.8% and 14.9% for households and children, respectively. Both proportions were below 20%, and thus did not threaten the validity of the findings [229]. This low rate of loss to follow-up was partly because as per approval, we collected baseline information that facilitated tracking the participants, e.g., phone numbers, not only for the subjects, but also for possible contacts such as next of kin, close friends, neighbours, local area leaders or research assistants in order to reach the participants again for follow-up. Similarly, we made regular follow-up phone calls to the area local leaders and the research assistants to keep reminding the participants of the scheduled dates of follow-up. The interval between exposure and development of the outcome was relatively short to minimize loss to

follow-up. However, it should be noted that the loss of follow-up of children could have reduced the effective sample size because of missing the outcome measures on those who are lost. We also used probability sampling that ensured that more households were sampled in villages with a relatively high number of households.

6.5.2.2 Selection bias

Selection bias occurs when the sample population being studied provides data that is not representative of the target population [230, 231]. Thus, the results generated cannot be applied to the general population or are an inaccurate representation of the relationship between the exposure and the outcome [230]. In cohort studies, selection bias can be introduced via the methods used to select the population of interest, the sampling methods, or the recruitment of participants [232]. Thus, a comprehensive approach that includes the selection of appropriate comparison groups, the identification and assessment of the comparability of potential confounders between those comparison groups, and the use of appropriate statistical techniques in the analysis is needed to minimize selection bias [232].

In this study, selection bias was minimized by employing a careful selection criteria and procedure as detailed in Paper I, that involved random selection of a control/comparison sub-county (Bubiita sub-county), neighbouring to the area with the disaster affected households. This control group was identical to the exposure group, apart from the fact that they did not receive the exposure of interest. This ensured comparison between the two groups regarding the study variables of interest. Similarly, identification and assessment of the comparability of potential confounders between those comparison groups, and the use of appropriate statistical techniques in the analysis was applied to minimize selection bias. Details are discussed in section 6.5.2.4 of control for confounding and mediation in the observed associations.

6.5.2.3 Information bias

It occurs when any information or measurements collected and used in a study are either measured or recorded inaccurately, leading to systematic errors in the estimation of association and effect [233]. Information bias is usually influenced by reliability i.e., the ability of instruments to produce the same estimate on two different occasions and the validity of methods and instruments used to collect information; ability of instruments to measure what they are intended to measure [234].

In Paper I, information bias was minimized by developing a well formulated questionnaire that captured all information of interest in relation to the study objectives of Paper I. The questionnaire was further translated from English the local language (Lumasaba) and back-translated into English to ensure measuring concepts that were intended to be measured. The use of trained and skilled field workers with the background of nutrition also ensured minimization of information bias. Moreover, our questionnaires were first pretested before actual data collection to assure that survey questions would collect the information for which they were designed. Pretesting also helps to detect sources of measurement error in the survey instrument which can be rectified before the start of survey data collection, thereby assuring quality [235, 236].

The child assessments were carried out at Bududa Hospital using well calibrated and standardized anthropometric tools/ equipment to ensure validity and reliability of results. Anthropometric measurements were taken twice and recorded precisely to eliminate any errors. We followed the WHO standardized procedures for anthropometric measurements and classifications. However, the 14.5% loss to follow-up of children at the follow-up could have interfered with the internal validity of nutritional status results. Also distance to hospital could have limited the number of children brought to the hospitals for assessments.

In Papers II and III, we minimized information bias by adapting multiple previously validated questionnaires for estimating the proxy indicators related to diet. The questionnaires were first translated from English to the local language (Lumasaba) and back-translated into English. Pretesting was also done as a way of standardization to ensure that the instruments of data collection are adapted and made suitable for the intended use and purpose [235]. The use of trained and skilled field workers with the background of nutrition in household interviews was key. Multiple-week diet records, which require participants to record everything food or drink consumed over the course of several weeks, are the gold standard for ascertaining dietary information because of non-reliance on memory. However, the high participant burden, the skill and cost of keeping diet records has limited their use [237]. Hence, usage of multiple validated techniques is a more desirable approach to improve precision in diet related studies [238]. In this study, we adapted multiple previously validated questionnaires for estimating the proxy indicators related to diet. The structured questionnaire that included the socio-demographic questions, a food frequency questionnaire and questions on household food insecurity adapted from the previously validated tools: the Household Food Insecurity Access Scale (HFIAS) [157]; the Childhood Community Hunger Identification Project (CCHIP) index [158, 159, 164], and the Copping strategies Index [160] were used. These tools have already been used in resource limited settings in several African countries [239-242], including Uganda [163, 243]. The reliability of the HFIAS was found to be high in vulnerable settings in the context of HIV/AIDS in Uganda [244]. The CHIPP had also been applied in Southern Africa as an important complementary tool to the HFIAS given its focus to identifying food-access related child hunger [158]. The FFQ that was designed and adapted used the same food groups that had been applied to estimate diet diversity and food variety in the context of HIV/AIDS at the household level and in resource limiting settings in Uganda

[158, 159]. The food items were arranged in 12 food groups identifiable to the Ugandan context.

6.5.2.4 Control for confounding and mediation in the observed associations

A confounder is a variable that affects or is associated with both the independent and dependent variable and contributes to the observed association between exposure and outcome [245-247]. A mediator is a variable that is affected by the exposure of interest, proceeding to affect the outcome [248, 249].

Quantitative data in Papers I-III, permitted statistical tests for confounding. Disaster and seasonality exposures were treated as independent variables that had potential associations with the dependent variables of: child malnutrition (Paper I); household food insecurity and diet diversity (Paper II); and food variety and food insecurity coping strategies (Paper III). The socio-demographic variables were treated as potential confounders or mediators, accordingly. However, qualitative data from key informants and focus group discussions (part of Paper III) did not permit statistical tests for confounding.

In Paper I, we used multivariate binary logistic regression models to test for multivariate effects while controlling for the disaster and seasonality effects and socio-demographic covariates. Study variables of interest were first tested for any correlation between affected and control groups using Pearson's chi-square tests and unadjusted logistic regression models to expose any possible confounders or mediators. Similarly, potential confounders or mediators which have been shown to cause or increase the risk for child malnutrition in LMICS [185, 250-252], were also considered in the multivariate binary logistic regression models. The confounders /mediators considered included: (1) child-level factors of sex, parity, history of illness in the past 30 days before the survey, child breastfeeding status and age of introduction of semi-solid food; (2) household head-related factors of marital status, sex, education status and household source of livelihood; and (3)

household factors of household size, number of under-5 children, ownership of assets, availability and access to improved toilet facility, access to improved water sources, reported migration and death of any member in the past 12 months prior the survey. Finally, sensitivity analyses were also performed to compare results of model performance from an analysis of the fitted model with complete data with an analysis of the fitted model with missing data to confirm the robustness of the results obtained [172].

In Papers II and III, study variables of interest were first tested for any correlation between affected and control groups using either Pearson's chi-square tests, t-tests or levene's tests accordingly, to expose any possible confounders or mediators between the affected and control groups. Given a small positive and small negative correlation between household food insecurity and DDS in the food-plenty and food-poor season respectively and a moderate positive correlation between FVS and household food insecurity scores in the food plenty and food-poor seasons respectively, a one-way multivariate analysis of covariance (MANCOVA) model was used to test for univariate and multivariate effects while adjusting for the disaster and seasonality effect and socio-demographic covariates. The socio-demographic covariates considered were: interviewed head of the household; household head's age; education level; main source of livelihood; household size, household ownership of assets or entitlements and migration of a household member in the past 12 months preceding the interview). Presence of repeated measures (at food-plenty and food-poor seasons) was a strength that allowed the extent to which mediation could be reported.

6.5.3 The qualitative part of the study

Qualitative component of this study dealt with data from key informants and focus group discussants. Arguably, qualitative approaches are more spontaneous, easier to respond to changes in questions and offer more interaction between the researcher and the subject than quantitative approaches [253]. Moreover, results of qualitative data allowed for a better

understanding of issues landslides, seasonality, food security, diet and the right to adequate food among households in the study area. Methodological concerns about qualitative approaches include selection of participants, sample size determination, and data collection. These are discussed below:

6.5.3.1 Purposive sampling of key informants (duty-bearers)

Part of Paper III, explored issues related to landslides, seasonality, food security, diet and the right to adequate food among households in the study area. We used a non-probability purposive sampling technique for selecting duty-bearers. This was based on the reasoning that they were conversant with the subject matter being studied or were or had been in positions of authority in their respective institutions or ministries in areas related to landslides, food security, diet and the right to adequate food. Purposive sampling and a semi-structured tool were suitable for this group given the need for specific information on activities that happened [253], in this case landslides and seasonality. This method permitted in-depth exploration of issues about landslides, seasonality, food security, diet and the right to adequate food among participants in the study area. It added credibility and depth to the quantitate findings as recommended in the human rights research approach [254]. As argued by Kumar [255], the number of key informants interviewed largely depends on the researcher's data needs, available time, and resources. Typically, 10-35 interviews are the most that are needed. In this study, a response rate of 100% was achieved as 10 out of the targeted 10 duty bearers were interviewed.

Purposive sampling is less expensive and relatively convenient. However quantifying phenomenon and drawing statistical inferences from the obtained responses is challenging [256]. Distributions are often not homogeneous and results are usually limited to descriptive output with more emphasis on facts. Purposive samples are usually not exhaustive, hardly report associations and interactions, have weak generalizability, as they contribute to internal

validity and are specific to the population that was studied [257, 258]. This technique emphasizes the need for the most relevant key informants to be consulted, however, the sampling reality can be complex for the cross-cutting topics like the right to adequate food, landslides and seasonality, given the multiple sectors, agencies and actors that are involved. Moreover, this nexus gets more intricate when targeted key informants are not willing to participate or delegate authority to subordinate authorities, which though legitimate, may not offer the same equal and similar response expected of the targeted informant.

6.5.3.2 Focus group discussions with adult men and adult women

Part of Paper III, explored issues related to landslides, seasonality, food security, diet and the right to adequate food among households in the study area. We used data from FGDs held with participants from the affected and control areas, from households who were not selected for interviews. The selection was random, however individuals easily known to the sub-county mobilisers and those with leadership positions in the community were easy to identify and mobilized. As argued by Mishra [259], focus group participants need to be experienced or knowledgeable about the topic under discussion so as to provide information required to achieve the intended study objective. In this case, we considered adult women and men (18-55 years) who were thought to be knowledgeable in issues related to the study topic. The diversity in the group composition also enhanced discussion.

The venue for the focus group session should be accessible, spacious, and convenient to all participants to reach it on time without much difficulty in finding it [260]. The FGDs were conducted at the respective sub-county headquarters with the intention of having an environment in which all the participants felt comfortable and free to talk without any possible distraction. There are different opinions regarding the required number and size of the focus groups. However, a focus group of six- twelve participants is thought to be ideal [261, 262], whereas two- three focus groups are sufficient to reach data or thematic saturation;

the point in data collection when issues begin to be repeated and further data collection becomes redundant [263, 264]. In this study, we had four FGDs, two from the affected and two from the control area. Six to ten participants for each FGD were targeted. Overall, thirty-six participants in the four focus groups participated in the study.

Focus groups promote interaction among participants and this generates deeper and richer data than those obtained from one-to-one interviews [260, 262]. Moreover, they can encourage participation from people reluctant to be interviewed on their own or who feel they have nothing to say [259, 260]. This method also examines in detail how the group members think and feel about the topic of interest, show a high possibility to explore topics widely in order to generate more information related to selective objectives and hypotheses. The costs are relatively low compared to other forms of data collection [260, 262].

Poorly facilitated discussions may draw upon spontaneous rather than cautiously considered responses, thereby restricting the level to which phenomena is explored [259, 260, 262]. Poor choice of recruitment may result in acquaintances who can be counterfactual by generating common responses, scenario boundaries, and deliberate limitations in their responses whereas poor translation techniques may also introduce errors [259, 262]. FGDs are also susceptible to bias, because group and individual opinions can be swayed by dominant participants [260, 262]. Generalizability of results from the focus group to the larger population is poor, as it is difficult to have a really representative sample [262].

The above mentioned challenges were minimized by employing a trained and skilled translation assistant with a college level of education, who was fluent in both English and the local language. Participants were notified, using prior written consent forms and verbally before the discussion, that all of their opinions would be considered without bias so that they could discuss freely and without fear. Moreover, we used a trained and skilled moderator who not only guided the participants through the discussion, but also for looked after the group

dynamics to ensure all participants join in the discussion [262]. The audio recordings and the field notes were stored safely for cross referencing. A key-code connected the participants with the audio recordings, the field notes and the anonymous transcripts. The transcription was done on a password protected laptop, and the audio files were deleted from the laptop afterwards. We also tried to connect the reader to the transcripts through well-chosen quotations of the participants' statements, thereby improving reliability [261].

6.5.4 External validity

External validity refers to the generalizability of the study results outside the study sample and seeks to provide an understanding on the extent to which findings can be applied to the general population [265]. Observational cohort studies have high external validity given their reliance on two or more measurement observations that consider time, location, seasonality conditions and scope. In this study we had quantitative assessments at both food-seasons, hence results may be generalised to the food seasons in the study areas.

The choice of the sample population for key informants was purposive and therefore suitable given the nature of their obligations related to the right to adequate food. However, generalization would be limited to the Ugandan Context. Although the provision of control households to provide relative comparison to the affected group may have been a desirable choice, the population validity is specific to landslide disaster-affected populations, while ecological validity is also limited to post-landslide disaster settings.

7. Conclusions

This study aimed to investigate landslides and seasonality effects on household food security, diet adequacy, the nutritional status of children 6-59 months and the right to adequate food among households affected by the major 2010 and 2018 landslide disasters in rural Uganda. The landslide-affected households compared to the controls experienced more food insecurity

at both food-seasons as evident by the significantly higher mean food insecurity scores, higher mean food insecurity coping strategies, lower mean DDS and lower mean FVS.

The severity of food insecurity among the landslide-affected increased during the food-poor season as evident by the significantly higher mean food insecurity scores, higher mean food insecurity coping strategies, lower mean DDS and lower mean FVS.

Disaster exposure was significantly associated with all the food insecurity outcomes (food insecurity scores, DDS, FVS and food insecurity coping strategies scores) during both food-seasons.

Results further conclude that the exception of overweight/obesity, various forms of child malnutrition were observed in the study area. The affected children were more at risk for malnutrition than the controls and the risk factors for child malnutrition differed between the food-plenty and food-poor seasons. Moreover, the human right to adequate food in the disaster-prone Bududa district seems not to be realized as indicated by the low comprehension and awareness of human rights principles and state obligations among the study participants.

Therefore, the determinants and exposures to malnutrition in children, food insecurity, diet and the right to adequate food among poor rural landslide-prone households should be addressed integrally. The Ugandan Government has continuously recognized the multi-sectoral approach to preventing malnutrition centred on the development of policies to incorporate the best evidence and practices for improving human nutrition in all sectors of health, agriculture, food security, social protection, gender, climate change, water, sanitation and education. However, there is a gap between policy and practice demonstrated by the adoption of relevant policy designs that are not harmonised with actual resource access and institutional budget capacity, leading to slow and inadequate implementation. This may explain the continued existence of food insecurity, child malnutrition and the non-realisation

of the right to adequate food observed among the landslide-affected communities despite the existence of the many food and nutrition policies in Uganda.

Going forward, it is essential for the Ugandan Government to secure and allocate adequate resources for effective implementation of the existing food and nutrition multi-sectoral policies, strategies, guidelines, and action plans by actors at different levels of government. In addition, strengthening and expanding the social protection programs to alleviate landslide-victim's vulnerability to food insecurity in the face of landslides is key if we are to achieve "zero hunger" by 2030 and the right to adequate food for all. Policy actions which promote landslide-affected households' accessibility to and ownership of land that is not prone to landslides are vital. Education and income diversification are key factors in enhancing the resilience of rural livelihoods in the face of landslides and seasonality. The continuous use, development and improvement of the existing early warning systems in the landslide-affected areas for real-time monitoring of landslide occurrences and to alert people are needed. This, in turn, shall help to save people's lives, property and prevent the after-effects of landslides. There is a necessity for human rights training in Uganda for both duty-bearers and rights-holders to know about their rights, including the RtAF.

8. Implications for future research

This observational prospective cohort study described the current situation of landslides and seasonality effects on household food security, diet adequacy, the nutritional status of children 6-59 months and the right to adequate food among households affected by the major 2010 and 2018 landslide disasters in rural Uganda. Information from such studies are important to develop and implement effective interventions, aiming at addressing the challenges of food insecurity, child malnutrition and the non-realization of the right to adequate food among disaster-prone vulnerable communities.

Disaster exposure was significantly associated with all the food insecurity outcomes (food insecurity scores, DDS, FVS and food insecurity coping strategies scores) during both food-seasons. This shows that effects of disaster exposure are cutting across both food-seasons among the landslide-prone communities. This calls for targeted interventions e.g. increased food production, diet and income diversification and timely and reliable disaster-specific public social safety nets such as unconditional cash transfers, irrespective of season.

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10. Annexes

Annex 1: Information sheet and informed consent for participation in the study

Dear Participant,

Re: Information for informed consent

Title of the study: Household food security and nutritional status of children 6 to 59 months old in landslide-prone Bududa district of Eastern Uganda.

Investigators:
The principal investigator is Peter Milton Rukundo, a lecturer at Kyambogo University, Kampala, Uganda. Telephone: +256782425076.

The following are co-investigators:

(i) Archileo Kaaya, Makerere University School of Food Technology, Nutrition and Bio-Engineering, Kampala, Uganda.

(ii) Byaruhanga Rukooko, Makerere University School of Liberal and Performing Arts, Kampala.

(iii) Gerald Tushabe, Makerere University School of Liberal and Performing Arts, Kampala.

(iv) Aziiza Nahalomo, Mildmay Institute of Health Sciences, Kampala, Uganda.

(v) Bård Anders Andreassen, Norwegian Centre for Human Rights, Faculty of Law, University of Oslo, Norway.

(vi) Per Ole Iversen, Faculty of Medicine, University of Oslo, Norway.

Study sponsor
The study is funded by Henning og Johan Throne Holst Foundation, Stockholm Sweden.

Background
This information is to seek your consent to participate in this study. The study is part of ongoing collaboration between Kyambogo and Makerere Universities in Uganda and the University of Oslo in Norway. The study is planned to obtain more reliable estimates on household food insecurity and child nutritional status parameters in Bududa district.

Purpose of the study
The study aims to assess the household food insecurity and nutritional status of children 6-59 months old in landslide-prone Bududa district in Eastern Uganda.

Participation in the study
Participation in the study is voluntary. We shall have three categories of participants: (i) Heads' of households' in the survey area of Bududa (ii) One child from each sampled household be assessed to for nutritional status; and (iii) Persons in authority relevant to the study and drawn from Bududa district, Government of Uganda Ministries, Departments and Agencies (MDAs).

Procedures involved in data collection that will involve the child

(a) The head of the household will be interviewed on issues regarding household food security and the nutrition practices of members. The focus shall be on household socio-economic and demographic characteristics, access to food and experiences with hunger and food insecurity. The interview will last 45-60 minutes.

(b) One child from each sampled household will be identified and assessed for nutritional status at Bududa. This will involve measurements of weight, height, waist and hip circumference and mid-upper arm circumference. The process will last a maximum of 30 minutes per child.

Collection, storage and management of information and food samples

(a) Information shall be collected through face-to-face interviews at the location of the household and subsequently stored in original and duplicate at Kyambogo University in Kampala. It will be entered into a computer database for analysis.

(b) Commonly used food and recipes for complementary feeding shall be identified, optimised and analysed for nutritional properties. The samples will be analysed at Makerere University and other recognized laboratories in Uganda.

Risk

We do not envisage any major risk effects related to this study. Working with Bududa hospital on all nutritional status assessment procedures will ensure the professionalism of the process.

Benefits

Parents and the community will get to know about the nutritional status of their children and how it can be further improved. Information, education and communication materials shall be developed to sensitize the community on nutrition practices, including harnessing the nutritional value of commonly used complementary feeds.

Alternatives

Participation in this study is not mandatory. You can also opt out of the study at any time of your choice.

Compensation and reimbursement

(a) Depending on the distance to be travelled to the Bududa hospital, caretakers and children will be facilitated with the monetary equivalent of transport and lunch. Depending on the cost incurred by the caretaker and child, a total compensation of up to 25 000 Uganda shillings (about 7 United States dollars) shall be provided for two visits.

(b) Health workers of Bududa hospital who will participate in the study activities will be engaged minimally every weekend and compensated with a monetary equivalent of a subsistence allowance.

Questions on the study

Participants with any questions regarding the study can reach the principal investigator, Peter Milton Rukundo on mobile telephone: +256782425076.

Questions about participants' rights

Participants who have questions about their rights as research participants can have their queries addressed by the Makerere University School of Health Sciences IRB chairperson by Telephone: +256 772404970 or +256 0200903786.

Feedback and dissemination of information
The study report will be shared with the sub-county and district authorities in Bududa district, while publications and conference presentations shall also be shared for others to learn and benefit.

Voluntarism and withdrew from the study
Participation in the study is voluntary. One has a right to withdraw from the study before the commencement of data analysis in November 2019.

Approval of the research study
In accordance with existing legal requirements in Uganda, the study has sought ethical approval and research clearance from the Uganda National Council of Science and Technology (UNCST). Independent review has been sought from the Makerere University School of Health Sciences Research Ethics Committee/IRB.

Confidentiality
The results of this study will be kept strictly confidential and used only for research purposes. My identity will be concealed as far as the law allows. My name will not appear anywhere on the coded forms with the information. Paper and computer records will be kept under lock and key and with password protection respectively.

The interviewer has discussed this information with me and offered to answer my questions. For any further questions, contact the Chairperson of the School of Health Sciences Research and Ethics Committee, Dr. Paul Kutyabami: on (+256) 772-404970 / (+256) 0200903786 / or Uganda National Council of Sciences and Technology. Tel: (+256)-041-4705500).

STATEMENT OF CONSENT/ASSENT
..... has described to me what is going to be done, the risks, the benefits involved and my rights regarding this study. I understand that my decision to participate in this study will not alter my usual medical care. In the use of this information, my identity will be concealed. I am aware that I may withdraw at any time. I understand that by signing this form, I do not waive any of my legal rights but merely indicate that I have been informed about the research study in which I am voluntarily agreeing to participate. A copy of this form will be provided to me.

Name…….Signature/thumbprint of participant ……..Age ..……
Date (DD/MM/YY)……

Witness (Applicable to illiterate, mentally incapacitated or physically handicapped).
Name of Witness …….. Signature of Witness……
Date (DD/MM/YY)…….
Name……Signature: …… Date(DD/MM/YY……...

Name……Signature of Interviewer ……. Date (DD/MM/YY)……..

Annex 2: Parental consent for a child to participate in the research study

Dear Parent/Guardian,

Re: Information for parental informed consent for the child to participate in the study

Title of the study: Household food security and nutritional status of children 6 to 59 months old in landslide-prone Bududa district of Eastern Uganda.

Investigators
The principal investigator is Peter Milton Rukundo, a lecturer at Kyambogo University, Kampala, Uganda. Telephone: +256782425076.

The following are co-investigators:

(i) Archileo Kaaya, Makerere University School of Food Technology, Nutrition and Bio-Engineering, Kampala, Uganda.

(ii) Byaruhanga Rukooko, Makerere University School of Liberal and Performing Arts, Kampala.

(iii) Gerald Tushabe, Makerere University School of Liberal and Performing Arts, Kampala.

(iv) Aziiza Nahalomo, Mildmay Institute of Health Sciences, Kampala, Uganda.

(v) Bård Anders Andreassen, Norwegian Centre for Human Rights, Faculty of Law, University of Oslo, Norway.

(vi) Per Ole Iversen, Faculty of Medicine, University of Oslo, Norway.

Study sponsor
The study is funded by Henning og Johan Throne Holst Foundation, Stockholm Sweden.

Background
This information is to seek your parental consent for your child to participate in this study. It involves assessing the nutritional status of children in selected households and your parental consent is a key requirement.

Purpose of the study
The study aims to assess the household food insecurity and nutritional status of children 6-59 months old in landslide-prone Bududa district in Eastern Uganda.

Participation of the child
Participation in the study will be voluntary. One index child from each household will be assessed for nutritional status. The child of interest will be the age bracket of 6-59 months. The assessment will include measurements of weight, height, waist and hip circumference and mid-upper arm circumference. The process will last a maximum of 30 minutes.

Collection, storage and management of information

(a) Questionnaire-based information shall be collected through face-to-face interviews at the location of the household and subsequently stored in original and duplicate at Kyambogo University in Kampala. It will be entered into a computer data-base and analysed.

(b) Commonly used food and recipes for complementary feeding shall be identified, procured, prepared and analysed for nutritional properties. The samples will be collected and analysed at Makerere University and other recognised laboratories in Uganda.

Risk
We do not envisage any major risk effects related to this study. Working with Bududa hospital on all nutritional status assessment procedures will ensure the professionalism of the process.

Benefits
Parents and the community get to know about the nutritional status of their children and how it can be further improved. Information, education and communication materials shall be developed to sensitize the community on nutrition practices, including harnessing the nutritional value of commonly used complementary feeds.

Alternatives
Participation in this study is not mandatory. You can opt out of the study at any time of your choice.

Compensation and reimbursement
(c) Depending on the distance to be travelled to the Bududa hospital, caretakers and children will be facilitated with the monetary equivalent of transport and lunch. Depending on the cost incurred by the caretaker and child, a total compensation of up to 25 000 Uganda shillings (about 7 United States dollars) shall be provided for two visits.

(a) Health workers of Bududa hospital who will participate in the study activities will be engaged minimally every weekend and compensated with a monetary equivalent of a subsistence allowance.

Questions on the study
Participants with any questions regarding the study can reach the principal investigator, Peter Milton Rukundo on mobile telephone: +256782425076.

Questions about participants' rights
Participants who have questions about their rights as research participants can have their queries addressed by the Makerere University School of Health Sciences IRB chairperson by Telephone: +256 772404970 or +256 0200903786.

Feedback and dissemination of information
The study report will be shared with the sub-county and district authorities in Bududa district, while publications and conference presentations shall also be shared for others to learn and benefit from.

Voluntarism and withdrew from the study
Participation in the study is voluntary. One has a right to withdraw from the study before the commencement of data analysis in November 2019.

Approval of the research study
In accordance with existing legal requirements in Uganda, the study has sought ethical approval and research clearance from the Uganda National Council of Science and Technology (UNCST). Independent review has been sought from the Makerere University School of Health Sciences Research Ethics Committee/IRB.

Confidentiality
The results of this study will be kept strictly confidential and used only for research purposes. My identity will be concealed as far as the law allows. My name will not appear anywhere on the coded forms with the information. Paper and computer records will be kept under lock and key and with password protection respectively.

The interviewer discussed this information with me and offered to answer my questions. For any further questions, contact the Chairperson of the School of Health Sciences Research and Ethics Committee, Dr. Paul Kutyabami: at (+256) 772-404970 / (+256) 0200903786 / or Uganda National Council of Sciences and Technology. Tel: (+256)-041-4705500).

STATEMENT OF CONSENT/ASSENT

..... has described to me what is going to be done, the risks, the benefits involved and my rights regarding this study. I understand that my decision to participate in this study will not alter my usual medical care. In the use of this information, my identity will be concealed. I am aware that I may withdraw at any time. I understand that by signing this form, I do not waive any of my legal rights but merely indicate that I have been informed about the research study in which I am voluntarily agreeing to participate. A copy of this form will be provided to me.

Name…….Signature/thumbprint of participant ……..Age ..……
Date (DD/MM/YY)……

Witness (Applicable to illiterate, mentally incapacitated or physically handicapped).
Name of Witness …….. Signature of Witness……
Date (DD/MM/YY)…….
Name……Signature/thumbprint of parent or guardian for minors ……
Date (DD/MM/YY)……

Name……Signature of Interviewer ……. Date (DD/MM/YY)……...

Annex 3: Questionnaire on household characteristics

Date: _____ Village: _____ Cluster No.☐☐ Household ID: ☐☐☐

Sub county: _____Parish:_____

Section A: Socio-economic and demographic characteristics

1. Interviewed head of household: Father☐ Mother ☐ Both ☐Other☐ _____
2. Age of respondent: ☐☐ years
3. How many are you in the household? ☐☐ people
4. Among the household members, how many are children 6-59 months? ☐☐
5. What is your main source of income?
   Wage employee ☐ Trading ☐ Farming ☐ Fishing ☐
   Casual labourer ☐ others☐ specify_____
6. What is the household's main source of food?
   Own production ☐Purchased ☐ Own labour ☐ others ☐_____
7. What is you marital status?
   Married ☐Single ☐ Separated ☐Divorced☐Widow/widower ☐
   Cohabiting ☐
8. What is your level of education?
   No formal education ☐ Primary level ☐ Ordinary level Secondary ☐
   Advanced level Secondary ☐ Tertiary/college/University level ☐
9. Are there culture-related restrictions and beliefs on food (Food taboos, myths etc.)?
   Yes ☐ No ☐

9a. If yes, specify which ones?_____

10. Have you lost (died) any family members in the past 12 months?
    Yes ☐ _____ (specify if child, relative, mother, father, grandparent etc.)
    No ☐

10a. If yes, were they playing a role in securing food for the household?

Yes ☐ Specify: _____ No ☐

11. Is this place your ancestral home? Yes ☐ No ☐ specify when and where you moved from: _____

12. In the past 12 months, is there any members of your family who have migrated to other areas due to difficulty in livelihood and survival

Yes ☐ _____ specify how many ☐☐ members

No ☐

13. Do you own assets/entitlement (e.g. farm, livestock, motorcycle, bicycles, etc.) that you rely on sometimes to get food?

Yes_____ Specify _____

No _____

Household food security and coping strategies

14. In the **last month**, how frequently did your household resort to using one or more of the following to meet your household food security? (**complete each strategy if the response is yes)**

	Coping strategy	No	Yes	How many times/month	How many times/week	How many times/daily
14.1	Limit portion size at meal times					
14.2	Reduce adult consumption so children can eat					
14.3	Children go to bed hungry due to not being enough food to eat					
14.4	Skip an entire day without eating a household meal (breakfast, lunch, supper)					
14.5	Rely on less expensive and less preferred food					
14.6	Purchasing food on credit					
14.7	Borrow food or seek food assistance from neighbours, friends and relatives					
14.8	Children/household members are allowed to roam and eat elsewhere due to there not being enough food					
14.9	Accept help from friends/relatives that have collected					
14.10	Parents eat less food/meal portions so that children can eat more					
14.11	Children eat less food/meal portions because there is not enough to eat					
14.12	Other coping strategies, mention_____					

The right to adequate food

15. On average, how many meals does your household have per day? ☐☐ Meals.

16. In the past 30 days, are there been instances when the household did not have sufficient food for more than two days?

Yes ☐ Specify _____

No ☐ Specify _____

17. In the past 30 days, are there instances when you felt the households were eating unsafe food?

Yes ☐ Specify _____ No ☐

18. In the past 30 days, are there instances when you felt the households were eating less nutritious food and you could not do much about it?

Yes ☐ Specify _____ No ☐

19. In your opinion:

19a. Do you think the provision/sourcing of food for your household limits your ability to provide other amenities like health, water, housing, clothing and education

19b. Do you think landslides have affected your household's food and nutrition security?

Yes ☐ Specify _____

No ☐ Specify _____

19c. Are you aware of the principles of human rights of participation, accountability, non-discrimination and transparency?

Yes ☐ Specify _____

No ☐ Specify _____

19d. Are you aware of the State obligations of respect, protect and fulfil?

Yes ☐ Specify _____

No ☐ Specify _____

20. In your opinion, what would be most important for ensuring the human right to food in landslide-prone communities in Eastern Uganda?

Relief food _____ Resettlement land for agriculture____

Cash hand-out _____ Others_____ Specify _____

21. **Frequency and diversity of food intake**

In the last seven days, did the household eat any of the following foods listed in the Table below? ***If yes,***

21a. How frequent per day and week?

21b. What was the main reason for choice?

21c. What was the main source?

21d. What was the main method of preparation?

No.	Food groups	Eaten yesterday (Yes/No)	No. of times consumed		Reason for choice	Main source	Preparation method
			Per day	Per week			
1	**Cereals and grains**						
1.1	Maize (Posho, maize kob, seeds, porridge)						
1.2	Wheat (bread, samosas, mandazi, chapatti, buns, doughnuts, cakes)						
1.3	Rice (Cooked rice or rice porridge)						
1.4	Sorghum (sorghum bread or porridge)						
1.5	Millet (Millet bread or porridge)						
2	**Legumes**						
2.1	Beans						
2.2	Pigeon peas						
2.3	Cow peas						
2.4	Nuts (Ground nuts and ground nut paste)						
2.5	Soybean						
2.6	Simsim						
2.7	Green grams						
3	**Starchy roots, tubers and plantain**						
3.1	Sweet potatoes						
3.2	Solanum (Irish) potatoes						
3.3	Cassava (Includes whole cassava, cassava flour, fried cassava)						
3.4	Coco yam						
3.5	Yam						
3.6	Creeping yam						
3.7	Roasted plantain (gonja)						
3.8	Banana plantains (*matooke)*						
4	**Vegetables**						
4.1	Bamboo shoots						
4.2	Cabbage						
4.3	Edible vegetable leaves (Bean leaves, cow-peas leaves, coco yam leaves)						
4.4	Bell pepper (Includes red, yellow and green peppers)						
4.5	Tomatoes						
4.6	Onions						
4.7	Carrots						
4.8	Amaranthus (Doodo)(Includes, green doodo or red dodo(bugga)						
4.9	Night-shade (Nakati)						
4.10	Spinach						
4.11	Mushrooms						
4.12	Garden eggs (Biringanya)						
4.13	Egg-plants (Entula)						
4.14	Okra						

No.	Food groups	Eaten yesterday (Yes/No)	No. of times consumed		Reason for choice	Main source	Preparation method
			Per day	Per week			
4.15	Garlic						
4.16	Collard greens (Sukuma wiki) or (*B. oleracea*)						
4.17	Cucumber						
4.18	Pumpkin (Includes whole pumpkin, pumpkin flour, porridge, pumpkin seeds and pumpkin leaves)						
4.19	African spider plant or spider wisp (Jobyo) (Cleome gynandra)						
5	**Fruits and juice**						
5.1	Bananas (Big banana, baby banana, banana juice)						
5.2	Mangoes						
5.3	Passion fruits						
5.4	Guavas						
5.5	Pawpaw						
5.6	Goose berries, indian black berries (jambula), tamarind fruit (enkogge)						
5.7	Melon						
5.8	Apple						
5.9	Citrus (oranges/tangerine)						
5.10	Pineapples						
5.11	Avocado						
5.12	Jack fruit (Ffeene)						
5.13	Sugar cane or sugar cane juice						
6	**Meat and meat products**						
6.1	Beef (cow meat, cow hooves, cow head, kidneys, sausages)						
6.2	Goat						
6.3	Pork (pig)						
6.4	Ham/mutton (sheep)						
6.5	Rabbit						
6.6	Edible rats						
6.7	Offals						
6.8	Liver						
7	**Poultry and eggs**						
7.1	Chicken						
7.2	Duck						
7.3	Turkey						
7.4	Eggs (Eggs from all birds)						
7.5	Pigeon						
8	**Milk and milk products**						
8.1	Cow's milk						
8.2	Goats milk						
8.3	Fermented milk/yoghurt						
8.4	Ghee/Butter						
8.5	Cheese						
8.6	Chocolate						

No.	Food groups	Eaten yesterday (Yes/No)	No. of times consumed		Reason for choice	Main source	Preparation method
			Per day	Per week			
9	**Fish**						
9.1	Fresh fish						
9.2	Dry fish						
9.3	Fish oils						
9.4	Silver-fish (mukeene)						
10	**Fats and oils**						
10.1	Cooking fat (solid)						
10.2	Cooking oil (liquid)						
10.3	Margarine						
11	**Sugars and confectionaries**						
11.1	Sugar						
11.2	Sweets (Includes honey, biscuits and cakes)						
11.3	Banana fritters (Kabalagala)						
12	**Condiments, spices and beverages**						
12.1	Tea						
12.2	Coffee						
12.3	Spices						
12.4	Salt						
12.5	Non-alcoholic beverage (e.g. soda, safi, splash)						

Thank you.

Nutritional Status Assessment of the Index Child

(Tear off and hand it to the caretaker. Caretaker should come with slip and index child to Health Centre)

Sex of the Child: _____

Date of Birth: _____

Age: _____ Months _____

Village: _____

Cluster No: _____

Household ID: _____ Enumerator ID: _____

Annex 4: Questionnaire for assessing the nutritional status of children 6-59 months old

Date: _____ Village: _____ Cluster No.☐☐ Household ID: ☐☐☐

Section A: General characteristics of the child

1. Sex of the child: Male ☐ Female ☐
2. Parity (child spacing) of the child ☐☐
3. Age of the child (from child health card) in months ☐☐ .☐ Months

NOTE: *If the child is 6-23 months old, proceed with questions in Section B and all other sections. If child is above 23 months old, skip section B and go to the other sections.*

Section B: Infant and Young Child Feeding (For Children 6-23 Months Old)

4. Is the child still breastfeeding? Yes ☐ No ☐

4a. If no, why? _____

4b. At what age did the child stop breast feeding ☐☐ months

4c. If yes, was the child breastfed in the last 24 hours?

Yes ☐ How many times ☐☐ No ☐

4d. If no, why? _____

5. Is the child already eating other foods? Yes ☐ No ☐

5a. If No, why?_____

5a. If Yes, what food did you first introduce to the child? _____

5b If Yes, at what age did you start giving the child other foods? ☐☐ Months

5c. What was the main reason to introduce food at that particular age?

_____

6. Do you know the recommendation of how long a child should breastfeed on breast milk only before introducing other foods?

Yes ☐ No ☐

6a. If yes, for how long? ☐☐ months

7. Did the child eat any solid, semi-solid, or soft foods other than breastmilk in the last 24 hours?

Yes ☐ No ☐ Why? _____

8. What challenges do/did you face when breastfeeding the child?

_____

Section C: Anthropometric Assessment

(NB: At Bududa Hospital upon presenting the assessment slip issued to the household)

9. Weight of the Child ☐☐ . ☐☐ kg

10. Height of the Child ☐☐ . ☐ cm

11. Mid-upper arm circumference ☐☐ . ☐ mm

12. Waist circumference ☐☐ . ☐ mm

13. Hip Circumference ☐☐ . ☐ mm

Section C: malnutrition and disease history and prevention

14. Any visible signs of malnutrition and disease: Yes ☐ No ☐

If yes, specify: _____

15. Has your child ever suffered from a condition related to poor nutrition? Yes ☐ No ☐

15a. If Yes, what was the condition: _____ I do not know it name ☐

15b. If Yes, where was it managed?

Home ☐ Health facility ☐ Other ☐ Specify: _____

16. Did your child suffer any illness in the past 30 days?

16a. If yes, what was the condition: ____I do not know ☐ signs & symptoms: _____

16b. If yes, where was it treated?

Home ☐ Health facility ☐ Other ☐ Specify: _____

16c. If yes, what was the most common sign and symptoms of the disease the child suffered from? _____

17. When was the child last immunised? Month: ____ Year: ___Do not know/remember_

18. When was the child given vitamin A supplement (oil from the capsule through the mouth) Month:_____ year:_____ Do not know/remember_____

19. Has your child been ever dewormed? Yes____When: Month___ Year_____

No_____ Why? _____ Do not know:_____

Annex: 5 Focus group discussion guide and registration form

Date: _____ Sub-county: _____

Parish: _____ Venue: _____

Guiding questions:

Guiding questions:

(i) What is the situation of food and nutrition security in your areas?

Probe: Where, when and who are most affected by food insecurity and malnutrition and why.

(ii) Whether landslides affected the food and nutrition security and the RtAF of landslides affected individuals;

(iii) Whether the disaster response in the study area is satisfactory;

(iv) Whether the human rights principles of participation, accountability, non-discrimination and transparency are taken into consideration during the response of public authorities to disasters;

(v) The perception on the fact that the State should ensure that no Ugandans suffer from hunger and malnutrition even in times of disaster;

(vi) How the State should ensure the realization of the RtAF of landslide disaster-prone communities; and

(vii) What are the preferred means to ensure the RtAF of landslide disaster-affected individuals?

(viii) How are mothers addressing the issue of children feeding and nutrition in this area?
Probe: Do mothers know and practice early initiation, exclusive breastfeeding for 6 months, and optimal complementary feeding practices like hygiene and diet diversity?
Probe: Do mothers know and practice early initiation, exclusive breastfeeding for 6 months, and optimal complementary feeding practices like hygiene and diet diversity?
Probe: Commonly used complementary food, how they are prepared and perceptions on quality, frequency, and portion size to be used.

(ix) What are the challenges affecting the food security of households and the nutrition of children 6-59 months old in this area?

(x) What measures are required to improve food and nutrition security in this area?

Registration of Participants

No.	Respondent ID	Designation	Signature
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			

Observer/Assistant: _____ Signature _____

Researcher: _____ Signature _____

Annex 6: Key informant interview guide for duty-bearers

Ministry/institution: _____ Respondent ID: _____
Position held by respondent: _____ Sex_____ Date: _____

1. What is the situation of food and nutrition security in your areas? Probe: Where, when and who are most affected by food insecurity and malnutrition and why.
2. Do you think landslides have affected the food and nutrition security and the right to adequate food of landslides affected individuals? If yes, explain how
3. Do you think the disaster response in the study area is satisfactory?
4. In your opinion, to what extent have the human rights principles of participation, accountability, non-discrimination, human dignity and transparency been taken into consideration during the response of public authorities to the disasters?
5. What is your perception on the fact that it is the obligation of the State to ensure that no Ugandans suffer from hunger and malnutrition even in times of disaster?
6. How should the State ensure the realization of the right to adequate food of landslide disaster-prone communities?
7. What is the preferred means to ensure the right to adequate food of landslide disaster affected individuals?
8. How do you rate Uganda's disaster preparedness and emergency response system and why?
9. Given the problem of landslides in Eastern Uganda, has the Government provided the desired attention to landslide disaster preparedness and management? How/Why?
10. Do you think Uganda's policy on disaster preparedness and emergency response is robust to address the food and nutrition security concerns associated with landslide disaster? If yes, specify?
11. In your view, is the institutional framework for disaster preparedness and management in Uganda adequate to assure food and nutrition security of those affected? Specify?
12. In your opinion, are districts sufficiently empowered to deal with the landslide disaster preparedness, mitigation and response under the current decentralized system of governance? How/Why?
13. Who should be blamed when disaster affected communities suffer from hunger in inadequate access to sufficient, safe and nutritious food. Specify why?
14. In your opinion, to what extent has action been taken to improve the nutritional status of children in landslide-prone communities of Ugandan?
15. What is your overall impression of the state of the right to adequate food in Uganda?

Thank you for the interview.

11. Papers I, II, and III

I

ORIGINAL RESEARCH

CURRENT DEVELOPMENTS IN NUTRITION

Community and Global Nutrition

Malnutrition and Associated Risk Factors among Children 6–59 Months Old in the Landslide-Prone Bududa District, Eastern Uganda: A Cohort Study

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ABSTRACT

Background: The United Nations Sustainable Development Goal 2.2 calls for an end to all forms of malnutrition. This might be derailed due to persistent landslide disasters in low-income countries like Uganda.

Objectives: The prevalence of malnutrition and the impact of seasonal variations and associated factors were assessed among children aged 6–59 mo in the landslide-affected households in Bududa District, eastern Uganda.

Methods: A prospective cohort study using a 2-stage simple random technique was applied to select 422 households including 392 children during May–August (food-plenty season) 2019. After 6 mo, in January–March (food-poor season) 2020, 388 households and 366 children were assessed. Socioeconomic and demographic data were collected using structured questionnaires. Child malnutrition outcomes were defined according to WHO criteria. Factors associated with malnutrition outcomes were identified by bivariate and multivariate logistic regression.

Results: Stunting, underweight, wasting, and overweight prevalences were 37.7%, 13.3%, 3.6%, and 4.3%, respectively, in the food-plenty season and 42.6%, 14.2%, 2.1%, and 2.7%, respectively, in the food-poor season. Residing in the landslide-affected sub-county increased the odds for stunting [adjusted OR (aOR): 1.68; 95% CI: 1.08, 2.59; $P = 0.025$] and underweight (aOR = 4.25; 95% CI: 1.10, 15.36; $P = 0.032$) for children in the food-plenty season. Child age, sex, breastfeeding status, a nonimproved drinking water source, migration of any household member, and parents' education were significant risk factors in the food-plenty season. In the food-poor season, parents' education status, loss of any household member, child sex, and child age were significant risk factors.

Conclusions: Stunting and underweight were more prevalent in the food-poor season while wasting and overweight were more prevalent in the food-plenty season. With the exception of child age, child sex, and parents' education, child malnutrition risk factors differed between food-plenty and food-poor seasons. There is a need to address seasonality factors in program interventions targeting children <5 y in landslide-prone areas. *Curr Dev Nutr* 2022;6:nzac005.

Keywords: children, malnutrition, landslides, overweight, stunting, Uganda, wasting

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Abbreviations used: aOR, adjusted OR; MUAC, midupper arm circumference; USD, US dollars; VIF, variance inflation factor.

Introduction

Malnutrition risk due to natural disasters among children is rarely quantified despite the fundamental rights of the child to adequate food, nutrition, care, and an adequate standard of living, recognized under the Convention on the Rights of the Child (1) and other international human rights instruments (2). Natural disasters are detrimental events that occur beyond the control of humans (3). Globally, natural disasters are increasing (4, 5) with devastating effects, particularly among low- and middle-income countries (6, 7). Between 2000 and 2019, disaster events worldwide killed 1.23 million people, resulted in 2.97 trillion US dollars (USD) in economic losses and left 4.03 billion people injured, homeless, displaced, or in need of emergency assistance, including food (4). Similarly, in 2020, climate-related disasters resulted in 171.3 billion USD in

economic losses and 98.4 million deaths and 15,080 people were affected (5).

Notably, 40% of the world's poor are living in sub-Saharan Africa where natural disasters have a profound socioeconomic impact, by increasing food insecurity, poverty, and inequality (8). The effects are more devastating to the poor rural populations and households (8). Uganda has, over the past years, experienced frequent disasters (landslides, floods, droughts, locusts, and hailstorms, among others) (9). During 2019–2020, excluding coronavirus disease 2019 (COVID-19) impacts, disaster events in 70 districts affected 800,000 people, displaced 21,000 families, and resulted in 152.2 million USD in economic losses (10).

Globally, malnutrition is still high among children under 5 y (11). By 2020, approximately 149 million (22.0%) were stunted, 45.4 million (6.7%) had wasting, and 38.9 million (5.7%) were overweight (11). In Africa, the majority of stunted children (21.2 million) live in eastern Africa (11). These high levels of under-5 malnutrition are intensified by frequent natural disasters and related shocks. Such effects occurring during critical periods in a child's development can be detrimental to human capital development and future generations (12). Consequently, the progress towards the achievement of the United Nations Sustainable Development Goal number 2 of zero hunger and ending all forms of malnutrition (13–15) is being hindered. Similarly, global nutrition initiatives emphasizing the "1000-days window of opportunity" from conception to the child's second birthday (16) and the global 2025 nutrition targets of reducing under-5 child malnutrition (17) might be derailed. Equally, the realization of the right to adequate food (2, 18) and the right of the child to the highest attainable standard of health care, including combating disease and malnutrition (1), is disrupted by persistent disasters.

Uganda is burdened by hunger (19, 20) and malnutrition (11, 21, 22). By 2017, most Ugandans (51.5%) were consuming fewer number of meals with fewer calories per day than recommended (23). Similarly, approximately 29% of children under 5 y in Uganda are stunted, 10.5% are underweight, 3.6% are wasted, and 3.7% are overweight (21). This problem was more pronounced in rural than in urban areas, like Bugisu subregion in eastern Uganda (24), often worse affected by landslides (25). The Bududa District in the Bugisu subregion is particularly prone to recurrent landslides (26). In this subregion, under-5 malnutrition is still a challenge, with stunting, underweight, wasting, and overweight levels at 35.9%, 14.8%, 5.0%, and 3.8%, respectively (21).

Bududa District has experienced devastating landslides since 1933 (27). The most serious landslide occurred in 2010 at Nametsi Parish in Bukalasi sub-county. It killed 350 people and caused the displacement of people and the destruction of infrastructure, food crops, and livestock (25, 27). Another major incident that occurred in the same sub-county in 2018 killed 60 people, displaced 858 people, and washed away 144 houses (28).

Although landslides are frequent in Uganda, there are limited linkages and considerations in targeted nutrition interventions (18, 29). Studies on landslides in eastern Uganda have mostly examined farmers' perceptions and mortality risk (30), food security and diet diversity (31), and perceptions on the right to adequate food (32). However, there is limited information on how landslides affect the nutritional status of children under 5 y in the country, also in relation to seasonal variations in food supply. Hence, this study aimed to assess the prevalence and factors associated with possible seasonal variations in malnutrition among children 6–59 mo in the landslide-prone communities 8 y after the major 2010 landslide disaster and after the occurrence of another 2018 landslide in Bududa District.

The age group was chosen to take into account the introduction of complementary feeding at 6 mo, a fragile period when children are at high risk of malnutrition (33). Moreover, household food shortages that are common in the aftermath of disasters are likely to have more adverse effects on the nutritional status of children under 5 y (12) because young children are a vulnerable group undergoing rapid growth and development that demand higher nutritional needs (33). Also, young children depend on adults or caretakers for all decisions or actions pertaining to their food and nutrition security (12). Natural disasters cause disruptions in the availability, accessibility, stability, and utilization of food for the household (6), which consequently affects the children's nutritional health. In addition, natural disasters, especially landslides, increase exposure and susceptibility to infections such as diarrhea and acute respiratory diseases, which may further compromise the nutritional status of young children (12).

Methods

Study design, setting, and participants

This prospective cohort survey was performed during May–August (food-plenty season) 2019 and January–March (food-poor season) 2020. The study participants were the heads of households in the survey area, usually women. One index child from each sampled household was assessed for nutritional status. In households with more than 1 eligible child, the youngest in the category of those aged 6–59 mo was selected because the youngest is the most vulnerable in case nutritional needs are not met. In the case of a household whose eligible children were twins, both were assessed. The assessments of children were performed in the Nutrition Unit of Bududa District Hospital. All assessments were performed to account for variations between food-plenty and food-poor seasons.

The study site was the Bududa District in the Bukalasi sub-county, whereas the Bubiita sub-county acted as the control since it is the neighboring sub-county to Bukalasi sub-county. Bududa District is located on the foot of the southwestern slopes of Mount Elgon, approximately 250 km from Kampala. The district's elevated topography subjects the Mount Elgon region to regular disastrous floods and landslides (34). The average precipitation of the area is above 1500 mm of rainfall per year (27). The district's population is 210,173 (24), with a high population density of approximately 952 persons per square kilometer. The continued agricultural activities on the steep slopes of Mount Elgon, with V-shaped valleys and river incisions, pose a high risk for landslides in the area (27). The majority of the population is rural and relies mainly on subsistence agriculture (24, 27).

The sample-size estimator for households and children was the prevalence of stunting. A sample size of 418 households with eligible children was targeted based on the 35.9% stunting level among children aged 6–59 mo in the Bugisu subregion (21). We assumed a 10% higher (44.9%) prevalence in the landslide-exposed communities. The precision values included a power of 80% and a P value of 0.05, plus a margin of 3% to cater for nonresponse. Hence, an extra 12 households

were added to each group in each sub-county to cater for the possible nonresponse. Therefore, 215 households were targeted per sub-county.

In each of the parishes that constitute a sub-county, a 3-stage simple random sampling technique was adopted to select villages and eligible households using probability proportion to size techniques—that is, more households were sampled in villages with a relatively high number of households. In the first stage, from the affected and control sub-counties, all of the villages in each of the designated affected and control areas were listed and households were assigned to 20 villages using probability proportion size—hence, a total of 40 villages per sub-county. This was followed by randomly selecting 11 representative households in each village from the household lists that were generated with the assistance of the area local councils and the research assistants during the household mapping and listing exercise.

The study was approved by the Uganda National Council for Science and Technology (UNCST) (no. SS 4967), Makerere School of Health Sciences Research Ethics Committee (no. 2018–082), and the Norwegian Regional Committee for Medical and Health Research Ethics (no. 2019/917). Participation in the study was by voluntary written or thumb-print consent.

Data collection and measurements

Socioeconomic and demographic characteristics of the household and child were collected by trained research assistants through face-to-face interviews with the heads of the households using pretested and structured questionnaires that were translated from English to the local language (Lumasaba) and back-translated into English.

Anthropometry measurements were performed following standard WHO guidelines (35, 36). Weight was measured to the nearest 0.1 kg with an electronic scale (Seca 876). Standing height for children older than 2 y was measured with a portable stadiometer (Seca 213), whereas recumbent length for children younger than 2 years was measured with a measuring board to the nearest 0.1 cm. Head circumference was measured with a non-stretchable measuring tape while midupper arm circumference (MUAC) was measured with a nonstretchable MUAC tape at the midpoint between the acromion and the olecranon to the nearest 0.1 cm. The child's date of birth was obtained from child immunization cards. In children without the cards, a record of events was used to determine the approximate date of birth.

Outcomes and risk factors

The outcome variables for childhood malnutrition were stunting, underweight, wasting, and overweight/obesity treated as dichotomous variables (yes/no) in the analysis. The main independent variable of interest was exposure to landslides (affected sub-county vs. control sub-county).

The risk-covariate factors included child-level, household head–related, and household factors selected based on previous literature that examined risk factors of under-5 malnutrition in low- and middle-income countries (37–40). Child-level factors comprised sex, parity, history of illness in the past 30 d before the survey, child breastfeeding status, and age of introduction of semi-solid food, which were treated as dichotomous variables in the analysis. Child age was categorized as 6–11, 12–23, 24–35, 36–47, or 48–59 mo.

Household head–related factors included marital status, sex, education status, and household source of livelihood. Marital status and sex were treated as dichotomous variables. Educational status was defined as primary level and less and secondary level and more of education. Household source of livelihood was classified as a farmer or nonfarmer.

The household factors included household size, number of under-5 children, ownership of assets, season of survey, availability and access to an improved toilet facility, access to improved water sources, reported migration, and death of any member in the past 12 mo preceding the survey. These were treated as dichotomous variables. Source of drinking water was categorized as improved or nonimproved.

Statistical analysis

Anthropometric data were processed using WHO Anthro version 3.2.2 (41) and WHO AnthroPlus version 1.0.4 (42), respectively, to generate height-for-age, weight-for-age, weight-for-height, MUAC-for-age, and head circumference-for-age z scores. Stunting, underweight, and wasting were defined as a z score less than −2 SDs of the median of the WHO reference population (35). Values less than −3 were categorized as severe, −3 to −2 as moderate, and −2 or more as normal nutritional status. Overweight/obesity was defined as weight-for-height z score greater than +2 SDs (35). Head-circumference-for-age z scores less than −2 SDs of the median of the reference population indicated the presence of microcephaly (43).

Descriptive statistics are presented as proportions, means, and SDs. Pearson's chi-square tests and unadjusted logistic regression models were used to examine bivariate associations between the outcome variables (stunting, underweight, wasting, and overweight) and independent variables. The independent variables with a significant P value in the bivariate analysis were entered into the multivariate analysis for effect determination of each explanatory variable on outcome variable and to control for covariates. Similarly, relevant variables that have been shown to cause or increase the risk for child malnutrition (44) were considered for multivariate analysis even if the P value was not significant in the bivariate analysis. Multivariate binary logistic regressions were fitted by using the backward-elimination technique. Both crude OR and adjusted OR (aOR) with the corresponding 95% CI were obtained to show the strength of association. The statistical association was assumed significant at $P < 0.05$. The model fit in the multivariate binary logistic regression was assessed using the Hosmer-Lemeshow goodness-of-fit test. When the computed chi-square probability value of the model was not significant ($P > 0.05$), the model was considered a good fit.

Multicollinearity between covariates were checked by the variance inflation factor (VIF). Covariates with VIF greater than 10 were considered having multicollinearity effect and hence not included in the multivariate analyses. Sensitivity analysis compared results of model performance from an analysis of the fitted model with complete data with an analysis of the fitted model with missing data (45). Analyses were conducted using Stata version 16.1 statistical software (StataCorp) (46).

Results

Among the targeted 430 households, 424 were interviewed, whereas 6 households declined to participate. Complete response was obtained for 422 households and 392 children in the food-plenty season and 388 households including 366 children in the food-poor season (**Figure 1**).

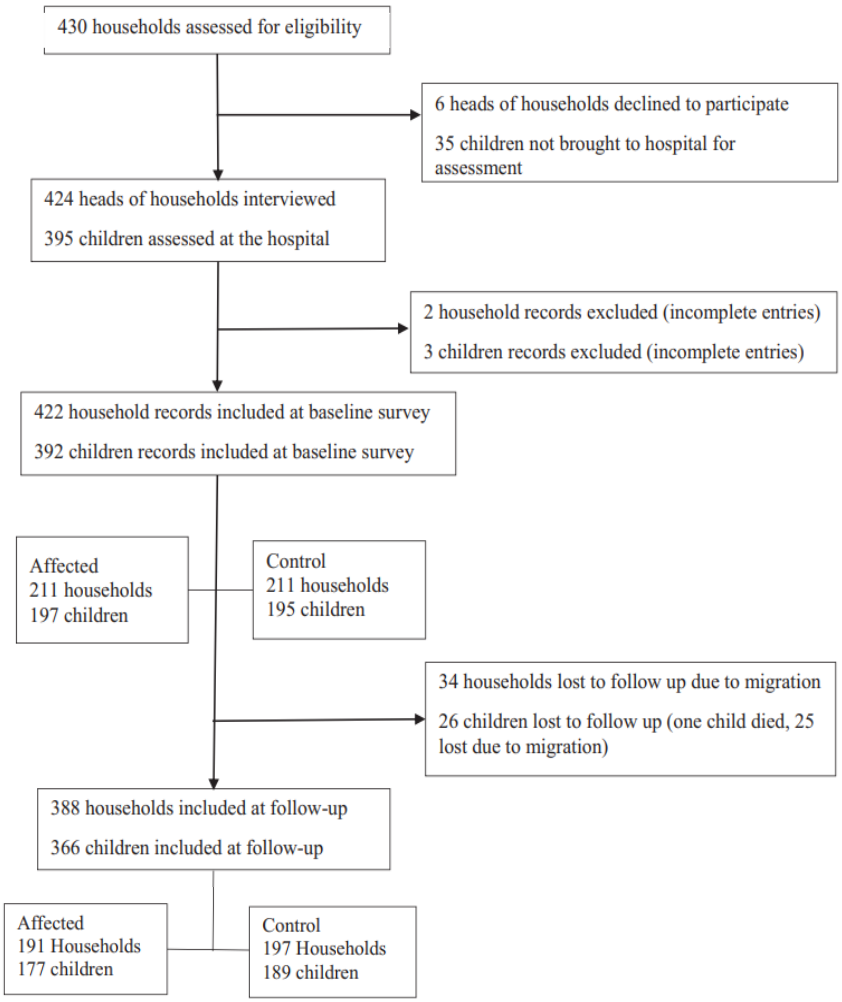

FIGURE 1 Flowchart showing the enrollment of study participants into the study.

Most interviewed heads of households were mothers in the food-plenty season and fathers in the food-poor season. The majority of the participants were married and relied on farming as the main income source. Participants' ages ranged from 15 to 84 y in the food-plenty season and from 16 to 77 y in the food-poor season. The educational level of most participants was primary school education. Household ownership of assets was relatively higher in the food-plenty season and decreased by more than half in the food-poor season among the affected sub-county (**Table 1**).

Sex distribution was statistically significant between affected and control groups with more females (55.3%) than males (48.7%) in the food-plenty season and more males (52.9%) than females (47.1%) in the food-poor season (**Table 2**). A majority of the children were still breastfeeding in the food-plenty season.

Prevalence of malnutrition

There were significantly more stunted children among the affected group than in the controls in the food-plenty season, but not in the food-poor season (**Table 3**). In contrast, the prevalence of underweight was significantly higher among the affected group compared with the controls in both food seasons, whereas there were no significant differences between the 2 study groups at either time point regarding wasting, overweight, or the combined anthropometrical deficiencies (stunting + wasting and stunting + overweight) (Table 3). Over half of the stunted (51.4%), underweight (55.8%), and wasted (71.4%) children were males in the food-plenty season, whereas over half of the stunted (58.3%), underweight (69.2%), and wasted (57.1%) children were females in the food-poor season (**Supplemental Table 1**).

Risk factors associated with child malnutrition

Residing in the landslide-affected area, parents' education status, child sex, child age, and breastfeeding status of the child were significantly associated with stunting in the food-plenty season (**Table 4**). Children residing in the landslide-affected sub-county were 1.68 times more likely to be stunted than children residing in the control sub-county. Similarly, boys were 1.19 times more likely to be stunted than girls. Also, children aged 12–23 mo were 3.41 times more likely to be stunted than children aged 48–59 mo in the food-plenty season. On the contrary, age of the

TABLE 1 Characteristics of the participating households[1]

	Food-plenty season ($n = 422$)				Food-poor season ($n = 388$)				
Variables	Affected ($n = 211$)	Control ($n = 211$)	Total ($n = 422$)	P[2]	Affected ($n = 191$)	Control ($n = 197$)	Total ($n = 388$)	P[3]	P[4]
Interviewed household head									
Father	40 (18.9)	17 (8.1)	57 (13.5)	0.003*	134 (70.2)	157 (79.7)	291 (75.0)	0.11	0.000*
Mother	161(76.3)	174 (82.5)	335(79.4)		40 (20.9)	25 (12.7)	65 (16.8)		
Others[5]	10 (4.8)	20 (9.5)	30 (7.1)		17 (8.9)	15 (7.6)	32 (8.2)		
Age, y	32.1 ± 11.7	32.3 ± 11.5	32.2 ± 11.6	0.71	33.2 ± 11.9	33.9 ± 11.8	33.6 ± 11.9	0.56	0.095
Marital status									
Married	187 (88.6)	162 (76.8)	349 (82.7)	0.002*	166 (86.9)	176 (89.3)	342 (88.1)	0.12	0.000*
Not married	24 (11.4)	49 (23.2)	73 (17.3)		25 (13.1)	21 (10.7)	46 (11.9)		
Household size	6.5 ± 2.5	6.3 ± 2.3	6.2 ± 2.5	0.014*	6.6 ± 2.6	6.32 ± .3	6.5 ± 2.5	0.16	0.22
Main source of livelihood									
Farming	174 (82.5)	125 (59.2)	299 (70.9)	0.000*	178 (93.2)	173 (87.8)	351 (90.5)	0.04*	0.000*
Trading	17 (8.1)	18 (8.5)	35 (8.3)		4 (2.1)	13 (6.6)	17 (4.4)		
Casual laborer	16 (7.6)	44 (20.9)	60 (14.2)		9 (4.7)	7 (3.6)	16 (4.1)		
Others[6]	4 (1.8)	24 (11.4)	28 (6.6)		0 (0.0)	4 (2.0)	4 (1.0)		
Main source of food									
Own production	150 (71.1)	80 (37.9)	230 (54.5)	0.000*	100 (52.4)	61 (30.9)	161 (41.5)	0.000*	0.000*
Purchase	33 (15.6)	121(57.3)	154 (36.5)		90 (47.1)	133 (67.6)	223 (57.5)		
Own labor	28 (13.3)	10 (4.7)	38 (9.0)		1 (0.5)	3 (1.5)	4 (1.0)		
Education status of head of household									
None	14 (6.7)	13 (6.2)	27 (6.4)	0.18	6 (3.1)	18 (9.1)	24 (6.2)	0.21	0.660
Primary	156 (73.9)	145 (68.7)	301 (71.3)		150 (78.6)	142 (72.1)	292 (75.3)		
Secondary	39 (18.5)	47 (22.3)	86 (20.4)		33 (17.3)	32 (16.2)	65 (16.7)		
≥College	2 (0.9)	6 (2.8)	8 (1.9)		2 (1.0)	5 (2.5)	7 (1.8)		
Lost any household members in the past 12 mo preceding the survey									
Yes	32 (15.2)	38 (18.0)	70 (16.6)	0.56	8 (4.2)	17 (8.6)	25 (6.4)	0.07	0.000*
No	179 (84.8)	173 (81.9)	352 (83.4)		183 (95.8)	180 (91.4)	363 (93.6)		
The lost household member was playing a key role in securing food for the household									
Yes	22 (68.7)	24 (63.2)	46 (65.7)	0.001*	6 (75.0)	11(64.7)	17 (68.0)	0.61	0.001*
No	10 (31.3)	14 (36.8)	24 (34.3)		2 (25.0)	6 (35.3)	8 (32.0)		
Migration of any member of the household in the past 12 mo preceding the survey									
Yes	19 (9.0)	54 (25.6)	73 (17.3)	0.000*	38 (19.9)	16 (8.1)	54 (13.9)	0.001*	0.32
No	193 (91.0)	157 (74.4)	350 (82.7)		153 (80.1)	181 (91.9)	334 (86.1)		
Household ownership of assets or entitlements[7]									
Yes	137 (64.9)	143 (67.8)	280 (66.4)	0.21	57 (29.8)	121 (61.4)	178 (45.9)	0.000*	0.000*
No	74 (35.1)	68 (32.2)	142 (33.6)		134 (70.2)	76 (38.6)	210 (54.1)		
Main source of drinking water for the household									
Improved[8]	112 (53.1)	95 (45.0)	207 (49.1)	0.000*	103 (53.9)	189 (95.9)	292 (75.3)	0.000*	0.000*
Nonimproved[9]	99 (46.9)	117 (55.0)	215 (50.9)		88 (46.1)	8 (4.1)	96 (24.7)		
Type of toilet facility used by the household									
Improved pit[10]	3 (1.4)	7 (3.3)	10 (2.4)	0.22	0 (0.0)	5 (2.5)	5 (1.3)	0.08	0.25
Open pit	208 (98.6)	204 (96.7)	412 (97.6)		191 (100.0)	192 (97.5)	383 (98.7)		

[1]Values are n (%) or means ± SDs. *$P < 0.05$.
[2]P value is for chi-square or t test between affected and control groups in the food-plenty season.
[3]P value is for chi-square or t test between affected and control groups in the food-poor season.
[4]P value is for chi-square or t test between the food-plenty and food-poor seasons.
[5]Refers to grandparents or elderly siblings.
[6]Refers to fishing or wage employee.
[7]Such as farm, livestock, poultry, motorcycle, bicycle.
[8]Defined as piped/tap, protected well/spring, and borehole water.
[9]Defined as surface water, river, stream, gravity flow water, rainwater, and water from open well or spring.
[10]Defined as flush toilet, ventilated improved pit latrine, or pit latrine with slab and cover.

TABLE 2 Socioeconomic demographics of the participating children[1]

Variables	Food-plenty season ($n = 392$)				Food-poor season ($n = 366$)				
	Affected ($n = 197$)	Control ($n = 195$)	Total ($n = 392$)	P[2]	Affected ($n = 175$)	Control ($n = 191$)	Total ($n = 366$)	P[3]	P[4]
Sex									
Male	88 (44.7)	108 (55.4)	196 (50.0)	0.034*	73 (41.7)	101 (52.9)	174 (47.5)	0.042*	0.48
Female	109 (55.3)	87 (44.6)	196 (50.0)		102 (58.3)	91 (47.6)	192 (52.5)		
Age (mo)									
6–11	48 (24.4)	28 (14.4)	76 (19.4)	0.003*				0.008*	0.003*
12–23	63 (31.9)	53 (27.2)	116 (29.6)		67 (38.3)	51 (26.7)	118 (32.2)		
24–35	37 (18.8)	45 (23.1)	82 (20.9)		53 (30.3)	45 (23.6)	100 (27.3)		
36–47	26 (13.2)	45 (23.1)	71 (18.1)		29 (16.6)	52 (27.2)	81 (22.1)		
48–59	22 (11.2)	27 (13.8)	47(11.9)		16 (9.1)	32 (16.7)	50 (13.7)		
>60					8 (4.6)	9 (4.7)	17 (4.6)		
Child parity	4.0 ± 2.8	3.5 ± 2.3	3.8 ± 2.6	0.059	4.0 ± 2.8	3.6 ± 2.3	3.8 ± 2.6	0.11	0.95
Child still breastfeeding, *n*	111	78			61	48	109		
Yes	88 (79.3)	61 (78.2)		0.32	42 (68.85)	25 (58.08)	67 (64.4)	0.14	0.000*
No	23 (20.72	17 (21.79)			19 (31.14)	23 (47.91)	42 (38.5)		
Age of introduction of solid and semi-solid food									
Below 6 mo	53 (49.5)	36 (44.4)	89 (47.1)	0.41	42 (47.2)	27 (54.0)	69 (49.6)	0.52	0.000*
Above 6 mo	55 (51.4)	45 (55.5)	100 (52.9)		47 (52.8)	23 (46.0)	70 (50.3)		
Child suffered any illness in the last 30 d preceding the survey									
Yes[5]	132 (67.0)	114 (58.5)	246 (62.8)	0.11	66 (37.1)	82 (42.9)	148 (40.4)	0.31	0.000*
No	65 (33.5)	81 (41.54)	146 (37.2)		109 (62.28)	109 (57.06)	218 (59.6)		

[1]Values are *n* (%) or means ± SDs. *$P < 0.05$.
[2]*P* value is for chi-square or *t* test between affected and control groups in the food-plenty season.
[3]*P* value is for chi-square or *t* test between affected and control groups in the food-poor season.
[4]*P* value is for chi-square or *t* test between the food-plenty and food-poor seasons.
[5]Illness conditions included malaria, upper respiratory infection, diarrhea, measles, and fever.

TABLE 3 Child malnutrition indicators[1]

Variables	Food-plenty season ($n = 392$)				Food-poor season ($n = 366$)[2]				
	Affected ($n = 197$)	Control ($n = 195$)	Total ($n = 392$)	P^3	Affected ($n = 177$)	Control ($n = 189$)	Total ($n = 366$)	P^4	P^5
Stunted (HAZ < −2)	84 (42.6)	64 (32.8)	148 (37.7)	0.045*	87 (49.1)	78 (41.2)	156 (42.6)	0.11	0.11
HAZ	−1.6 ± 1.6	−1.4 ± 1.3	−1.5 ± 1.5		−1.8 ± 1.3	−1.6 ± 1.4	−1.7 ± 1.4		
Underweight (WAZ < −2)	36 (18.3)	16 (8.2)	52 (13.3)	0.003*	32 (18.1)	20 (10.5)	52 (14.2)	0.032*	0.62
WAZ	−0.8 ± 1.3	−0.6 ± 1.1	−0.7 ± 1.2		−0.9 ± 1.1	−0.8 ± 1.0	−0.8 ± 1.1		
Wasted (WHZ < −2)	9 (4.5)	5 (2.5)	14 (3.6)	0.29	4 (2.3)	3 (1.6)	7 (2.0)	0.62	0.18
WHZ	0.4 ± 1.1	0.3 ± 1.5	0.2 ± 1.1		0.1 ± 0.9	0.2 ± 1.0	0.2 ± 1.0		
Overweight (WHZ > +2)	7 (3.5)	10 (5.1)	17 (4.3)	0.44	5 (2.9)	6 (3.2)	10 (2.7)	0.89	0.23
Concurrent stunting and wasting	5 (2.5)	2 (1.0)	7 (1.8)	0.25	3 (1.7)	0 (0.0)	3 (1.7)		0.25
Concurrent stunting and overweight	3 (1.5)	2 (1.0)	5 (1.3)	0.66	4 (2.3)	7 (3.9)	11(3.2)	0.42	0.08
Low MUAC[6]	13 (6.6)	5 (2.5)	18 (4.6)	0.056	5 (2.6)	3 (1.6)	8 (2.3)	0.48	0.07
MUACZ	−0.5 ± 1.1	−0.3 ± 1.0	−0.4 ± 1.0		−0.5 ± 1.0	−0.4 ± 0.9	−0.9 ± 0.9		
Low HC (HCZ < −2)	12 (6.1)	1 (0.5)	13 (3.3)	0.002*	11 (5.6)	1 (0.5)	12 (3.4)	0.002*	0.76
HCZ	−0.0 ± 1.3	0.2 ± 1.1	0.1 ± 1.2		−0.4 ± 1.4	0.0 ± 0.9	0.0 ± 1.2		

[1]Values are *n* (%) or mean ± SDs. *$P < 0.05$. HAZ, height-for-age *z* score; HC, head circumference; HCZ, HC- for-age *z* score; MUAC, midupper arm circumference; MUACZ, MUAC-for-age *z* score; WAZ, weight-for-age *z* score; WHZ, weight-for-height *z* score.
[2]Percentages differed according to the age of the children included in the study in the food-poor season.
[3]*P* value is for chi-square or *t* test between affected and control in the food-plenty season.
[4]*P* value is for chi-square or *t* test between affected and control in the food-poor season.
[5]*P* value is for chi-square or *t* test between the food-plenty and food-poor seasons.
[6]Low MUAC is defined as MUAC <125 mm, an indicator of wasting/acute malnutrition.

child, particularly 36–47 mo, came with minimum odds for stunting (aOR = 0.34), whereas parents' education status came with higher odds for stunting (aOR = 2.32) at follow-up (Table 4).

Children residing in the landslide-affected sub-county were 4.25 times more likely to be underweight than children residing in the control sub-county (**Table 5**). Similarly, male children were 1.48 times more likely to be underweight than female children in the food-plenty season, while children from households with a nonimproved drinking water source were 2.74 times more likely to be underweight compared with children from households with an improved drinking water source in the food-plenty season. On the other hand, being male came with a minimum risk (aOR = 0.42) for being underweight, whereas children whose parents had attained primary-level education or less were 4.74 times more likely to be underweight in the food-poor season (Table 5).

Children from households that had reported migration of any household member in the past 12 mo preceding the survey were 7.78 times more likely to be wasted in the food-plenty season than children from households that had not reported such migration (**Table 6**). Children from households that had reported loss of any household member in the past 12 mo preceding the survey were 8.08 times more likely to be wasted in the food-poor season than children from households that had not reported loss of any household member in the past 12 mo preceding the survey.

Results further showed that parents' education status of secondary level and above (aOR = 2.97) and parents' marital status of not being married (aOR = 3.46) were significantly associated with child overweight in the food-plenty season (**Table 7**). There were no significantly associated risk factors of overweight observed in the food-poor season. The results of the sensitivity analyses on model performance were similar to those of the primary analyses (**Supplemental Tables 2** and **3**).

Discussion

Our current study demonstrates seasonal variations in the prevalence and associated risk factors of under-5 child malnutrition in the landslide-prone Bududa District, eastern Uganda. Specifically, we found a high prevalence of stunting and underweight in both food seasons based on the WHO classification (47). Moreover, this high stunting prevalence was higher compared with that of *1)* the Bugisu subregion, *2)* the national average based on the 2016 Uganda Demographic Health Survey (21), and *3)* a pooled prevalence of 33.3% in the recent multi-level analysis in 12 East African countries (38). This implies that there has probably been an increased prevalence of the 2 forms of child undernutrition in the landslide-prone community from 2010 to 2020, possibly attributed to many factors, including the persistent landslides in the district, and there were deprivation effects on livelihoods and the right to adequate food. Arguably, natural disasters often unmask pre-existing poor nutritional status in children, particularly in low-income settings, that could be well above the emergency threshold (48).

The most interviewed heads of households were mothers in the food-plenty season and fathers in the food-poor season. Perhaps the one-on-one nutrition-sensitization and nutrition-education sessions that took place at the Nutrition Unit in Bududa Hospital during data collection in the food-plenty season with the household heads could

TABLE 4 Factors associated with child stunting[1]

	Food-plenty season (n = 392)						Food-poor season (n = 366)					
	Stunting						Stunting					
Variable	Yes	No	cOR (95% CI)	*P*	aOR (95% CI)[2]	*P*	Yes	No	cOR (95% CI)	*P*	aOR (95% CI)[2]	*P*
Sub-county												
Affected	84	113	1.52 (1.01, 2.29)	0.045*	1.68 (1.08, 2.59)	0.019*	87	89	1.40 (0.92, 2.12)	0.11	1.10 (0.68, 1.17)	0.69
Control	64	131	1		1		78	112	1		1	
Child's sex												
Male	76	120	1.09 (0.72, 1.64)	0.67	1.19 (1.02, 2.83)	0.040*	69	104	0.66 (0.44, 1.01)	0.053*	0.68 (0.43, 1.07)	0.09
Female	72	124	1		1		96	96	1		1	
Age of the child (mo)												
6–11	17	59	1		1							
12–23	52	64	2.82 (1.46, 5.41)	0.002*	3.41 (1.67, 6.94)	0.001*	61	57	1			
24–35	34	48	2.45 (1.22, 4.92)	0.011*	2.87 (1.33, 6.19)	0.007*	45	55	0.75 (0.43, 1.28)	0.29	0.74 (0.42, 1.31)	0.31
36–47	26	45	2.13 (1.03, 4.38)	0.040*	2.57 (1.17, 5.66)	0.018*	21	60	0.32 (0.17, 0.59)	0.000*	0.34 (0.18, 0.66)	0.008*
48–59	18	29	2.15 (0.96, 4.78)	0.059	2.40 (1.01, 5.69)	0.046*	21	29	0.66 (0.34, 1.29)	0.23	0.64 (0.32, 1.29)	0.22
≥60							16	01				
	Child still breastfeeding (n = 198)						Child breastfeeding (n = 125)					
Yes	46	103	1		1		40	25	1		1	
No	26	23	2.53 (1.31, 4.84)	0.006*	2.16 (1.01, 4.60)	0.042*	36	24	0.91 (0.44, 1.87)	0.80	0.90 (0.45, 1.81)	0.78
Age of introduction of solid and semi-solid food												
Below 6 mo	37	52	1		1		30	38	1		1	
Above 6 mo	33	67	0.69 (0.39, 1.25)	0.22	0.60 (0.31, 1.15)	0.13	19	38	0.64 (0.42, 1.34)	0.52	0.93 (0.59, 1.47)	0.77
Number of under-5 children in the household												
≤3	133	230	1		1		156	196	1		1	
≥4	15	14	1.85 (0.86, 3.95)	0.11	2.04 (0.89, 4.68)	0.09	09	06	1.87 (0.65, 5.38)	0.24	1.63 (0.52, 5.07)	0.39
Parents' education status												
≤Primary	123	182	1.67 (1.00, 2.81)	0.050*	1.73 (1.01, 2.97)	0.044*	135	153	2.26 (1.32, 3.89)	0.003*	2.28 (1.26, 4.12)	0.006*
≥Secondary	25	62	1		1		21	57	1		1	
Household size												
≤5 members	62	117	1		1		92	115	1		1	
≥6 members	86	127	1.03 (0.66, 1.62)	0.26	1.13 (0.73, 1.75)	0.86	73	86	1.06 (0.70, 1.61)	0.78	1.04 (0.63, 1.63)	0.95

[1]* $P < 0.05$. aOR, adjusted OR; cOR, crude OR.
[2]Adjusted for child sex, age, breastfeeding, age of introduction of solid and semi-solid food, parents' educ:ation status, and household size.

TABLE 5 Factors associated with child underweight[1]

	Food-plenty season (n = 392)						Food-poor season (n = 366)					
	Underweight						Underweight					
Variables	Yes	No	cOR (95% CI)	*P*	aOR (95% CI)[2]	*P*	Yes	No	cOR (95% CI)	*P*	aOR (95% CI)[2]	*P*
Subcounty												
Affected	36	161	2.50 (1.34, 4.67)	0.004*	4.25 (1.10–15.36)	0.032*	32	143	1.91 (1.04, 3.49)	0.034*	1.18 (0.53–2.63)	0.67
Control	16	179	1		1		20	171	1		1	
Child's sex												
Male	29	167	1.31 (0.73, 2.33)	0.37	1.48 (1.12–4.47)	0.024*	16	157	0.44 (0.23, 0.83)	0.012*	0.42 (0.21, 0.81)	0.010*
Female	23	173	1		1		36	157	1		1	
Age of the child (mo)												
6–11	11	65	1		1							
12–23	17	99	1.01 (0.44, 2.30)	0.97			18	100	1		1	
24–35	07	75	0.55 (0.20, 1.50)	0.24	1.66 (0.60, 4.63)	0.33	16	84	1.05 (0.51, 2.20)	0.88	1.12 (0.52, 2.44)	0.76
36–47	07	64	0.64 (0.23, 1.77)	0.39	4.06 (0.29, 56.21)	0.29	08	73	0.61 (0.25, 1.47)	0.27	0.74 (0.29, 1.89)	0.53
48–59	10	37	1.59 (0.62, 4.11)	0.33			05	45	0.61 (0.22, 1.76)	0.36	0.62 (0.2, 1.92)	0.41
≥60							05	12	2.31(0.72, 7.36	0.15	2.79 (2.77, 10.10)	0.11
Age of introduction of solid and semi-solid food												
Below 6 mo	19	70	1		1		24	169	1		1	
Below 6 mo	10	90	0.41 (0.81, 0.92)	0.031*	0.44 (0.18, 1.06)	0.06	28	145	1.35 (0.75, 2.44)	0.31	1.55 (0.82, 2.93)	0.17
Number of under-5 children in the household												
≤3	43	320	1		1		49	302	1		1	
≥4	09	20	3.35 (1.43, 7.82)	0.005*	2.67 (0.80, 8.84)	0.11	03	12	1.54 (0.42, 5.65)	0.52	1.12 (0.28, 4.35)	0.86
Parents' education status												
≤Primary	44	261	1.61 (0.76, 3.62)	0.20	1.42 (0.43, 2.49)	0.28	49	239	5.12 (1.64, 15.92)	0.003*	4.74 (1.40, 16.03)	0.012*
≥Secondary	08	79	1		1		03	75	1		1	
Main source of drinking water												
Improved	28	253	1		1		32	243	1		1	
Nonimproved	23	84	2.47 (1.35, 4.52)	0.003*	2.74 (1.04, 7.18)	0.041*	20	71	2.14 (1.15, 3.96)	0.016*	1.87 (0.86, 4.09)	0.11
Main source of food												
Purchasing	24	152	1		1		28	182	1		1	
Own production	28	188	0.94 (0.53, 1.69)	0.85	0.53 (0.19, 1.46)	0.22	24	132	1.18 (0.65, 2.13)	0.57	1.23 (0.63, 2.41)	0.53

[1]* $P < 0.05$. aOR, adjusted OR; cOR, crude OR.
[2]Adjusted for child sex, age, age of introduction of solid and semi-solid food, number of under-5 children in the household, parents' education status, source of drinking water, and source of food.

TABLE 6 Factors associated with child wasting[1]

	Food-plenty season ($n = 392$)						Food-poor season ($n = 366$)					
	Wasting						Wasting					
Variables	Yes	No	cOR (95% CI)	*P*	aOR (95% CI)[2]	*P*	Yes	No	cOR (95% CI)	*P*	aOR (95% CI)[3]	*P*
Subcounty												
Affected	09	188	1.82 (0.62, 5.27)	0.28	2.70 (0.51, 14.32)	0.24	04	163	1.12 (0.36, 5.93)	0.90	1.37 (0.17, 7.15)	0.71
Control	05	190	1		1		03	179	1		1	
Sex of the child												
Male	10	186 1	2.58 (0.83, 7.91)	0.10	2.06 (0.53, 9.94)	0.29	03	163	0.82 (0.18, 3.73)	0.80	0.78 (0.16, 3.76)	0.76
Female	04	192	1		1		04	179	1		1	
Age of introduction of semi-solid food												
Below 6 mo	07	82	1		1		03	163	1		1	
Above 6 mo	04	96	0.48 (0.14, 1.73)	0.26	0.44 (0.10, 1.81)	0.25	04	179	1.46 (0.32, 6.64)	0.62	1.62 (0.34, 7.66)	0.54
Suffered any illness in the past 30 d preceding the survey												
Yes	12	233	3.71 (0.81, 16.80)	0.089	6.16 (0.70, 53.72)	0.10						
No	02	144	1		1							
Parents' education status												
≤Primary	13	292	3.82 (0.63, 0.01)	0.16	3.05 (0.35, 26.29)	0.31	06	268	1.65 (0.25, 0.01)	0.63	1.82 (0.20, 16.26)	0.58
≥Secondary	01	86	1		1		01	74	1		1	
Reported migration of any household member in the past 12 mo												
Yes	06	57	3.82 (1.28, 11.4)	0.016*	7.78 (1.16, 37.59)	0.011*	01	47	1.05 (0.12, 8.88)	0.96	0.73 (0.07, 7.01)	0.79
No	08	317	1		1		06	295	1		1	
Reported to have lost any household member in the past 12 mo												
Yes	01	62	0.39 (0.01, 2.39)	0.35			02	323	6.8 (1.23, 37.36)	0.027*	8.08 (1.37, 27.71)	0.021*
No	13	316	1	0.35			05	19	1		1	
Main source of drinking water												
Improved	08	273	1		1		04	258	1		1	
Nonimproved	06	101	2.03 (0.68, 5.98)	0.20	1.68 (0.36, 7.75)	0.25	03	84	2.30 (0.50, 10.50)	0.28	2.58 (0.41, 16.18)	0.31

[1]*$P < 0.05$. aOR, adjusted OR; cOR, crude OR.
[2]Adjusted for child sex, age of introduction of solid and semi-solid food, child suffered any illness, parents' education status, migration of any household member, and main source of drinking water.
[3]Adjusted for child sex, age of introduction of solid and semi-solid food, parents' education status, migration of any household member, and main source of drinking water.

TABLE 7 Factors associated with child overweight[1]

	Food-plenty season (n = 392)						Food-poor season (n = 366)					
	Overweight						Overweight					
Variables	Yes	No	cOR (95% CI)	*P*	aOR (95% CI)[2]	*P*	Yes	No	cOR (95% CI)	*P*	aOR (95% CI)[3]	*P*
Subcounty												
Affected	07	190	0.68 (0.26, 1.77)	0.44	0.91 (0.30, 2.73)	0.81	05	162	1.09 (0.33, 3.59)	0.89	0.95 (0.25, 3.59)	0.94
Control	10	185	1		1		05	177	1		1	
Sex of the child												
Male	09	187	1.13 (0.44, 2.90)	0.80	1.08 (0.39, 3.01)	0.87	05	161	1.1 (0.33, 3.63)	0.87	1.22 (0.34, 4.42)	0.75
Female	08	188	1		1		05	178	1		1	
Child parity												
1	03	89	0.68 (0.19, 2.45)	0.56	0.54 (0.14, 2.06)	0.37	01	73	0.41 (0.05, 3.24)	0.39	0.41 (0.05, 3.39)	0.41
≥2	14	286	1		1		09	266	1		1	
Parents' education status												
≤Primary	10	295	1		1		06	268	1		1	
≥Secondary	07	80	2.58 (0.98, 6.78)	0.054*	2.97 (1.02, 8.58)	0.041*	04	71	2.51 (0.74, 8.55)	0.15	2.61 (0.69, 9.88)	0.16
Pa rents' marital status												
Married	11	315	1		1							
Not married	06	60	2.86 (1.02, 8.03)	0.046*	3.46 (1.12,10.73)	0.031*						
Household main source of livelihood												
Farming	10	265	0.59 (0.22, 1.54)	0.29	0.53 (0.17, 1.63)	0.23	04	150	0.84 (0.23, 3.03)	0.79	0.65 (0.17, 2.51)	0.54
Other	07	110	1		1		06	189	1		1	

[1]* $P < 0.05$. aOR, adjusted OR; cOR, crude OR.
[2]Adjusted for child sex, child parity, parents' education status, parents' marital status and household source of livelihood.
[3]Adjusted for child sex, child parity, parents' education status and household source of livelihood.

have created awareness among the mothers who managed to convince the fathers to participate in the follow-up survey of data collection. Also, probably, the ethically approved transport reimbursement that was issued to each household head at baseline for bringing the eligible child to the hospital for standard anthropometric assessment could have motivated more fathers to participate in the follow-up survey of data collection.

Although those affected by landslides seem to be more at risk, stunting and underweight prevalence was higher in the food-poor season while wasting and overweight prevalence was higher in the food-plenty season. The prevalence of wasting (3.6%) in the food-plenty season was in the same range as the national prevalence (21). This shows that, even amidst the food-plenty season, some households in the study area were consuming a less diversified diet, a proxy measure of nutrient adequacy, as shown by the prevalence of wasting among the children.

Children residing in the landslide-affected area had higher odds of stunting and underweight than children in the control area. These results are consistent with findings in India (49) and Nepal (50), which showed that exposure to floods increased the likelihood of child malnutrition. This probably indicates that exposure to the persistent landslides in the landslide-prone community contributed to the malnutrition prevalence levels among children in the landslide-affected community. Persistent exposure to natural disasters such as landslides exposes the community to reduced food supply; restricted access to safe and nutritious food; reduced quantity and quality of food consumed; and disrupted access to health, safe water, and sanitation facilities, thus increasing child malnutrition (6, 12, 51). Furthermore, the landslide-affected community is located on steep mountainous terrain, restricting accessibility to maternal and child health care services, such as health facility delivery, antenatal, and postnatal care visits that could otherwise raise community awareness to provide quality complementary feeding and access to child immunization and growth-monitoring services.

Children aged 12–23 mo had higher odds of stunting than those in the older age group of 24–59 mo in the food-plenty season. This contradicts findings in Zambia (51) in which children aged 12–23 mo had lower odds of stunting than those aged 24–59 mo. Moreover, the stunting peak in the 2016 Uganda Demographic and Health Survey was 37% in the age category of 18–35 mo (20). This mismatch is probably because growth and development of children are most rapid when children are younger than 24 mo, with relatively high nutritional needs, and any food shortage due to disasters and related shocks makes the younger age group of children more vulnerable to malnutrition.

Being male was associated with higher odds of stunting and underweight in the food-plenty season, which is in agreement with similar trends from sub-Saharan Africa (38, 52). This might be due to preferences in feeding practices such as early weaning of boys (53) and children's behaviors, whereby girls might stay closer to the home and have more access to food being cooked, while boys play outside and, in turn, eat less while expending more energy (53). This is also because in the first months of life, the growth of boys is slightly more rapid and affected by nutritional deficiencies (54) or other exposures like lower respiratory infections and malaria (55) than girls. Likewise, this could be partially attributed to the exposure effects of the 2018 landslide that occurred 6–7 mo before data collection in the food-plenty season, possibly affecting the food and nutrition security of households and thus the manifestation of malnutrition among the children in the food-plenty season.

Our analysis further showed that parental education was associated with stunting, underweight, and overweight. Children of parents who had attained primary-level education or less were more likely to be stunted and underweight compared with children of parents who had attained secondary-level education and above. This is supported by findings of an association of lower parental education with poor growth outcomes of children in low- and middle-income countries (39, 40, 56). Parents' education status is one of the most important determinants of under-5 malnutrition (57). Parental education not only influences health-seeking behaviors (39, 58), such as timely and full childhood vaccinations and use of health facility services (39), but also affects household income and resource allocation towards children's health (58). Less educated parents tend to have lower household income and a higher poverty level and thus spend less on proper nutrition, and their children are more susceptible to growth failure due to insufficient access to adequate food and basic health care services and greater exposure to poor living conditions and diseases (39, 58).

Children who were not breastfeeding had higher odds of being stunted than the children who were breastfeeding at baseline. Findings from Mexico (59) reported similar trends of child breastfeeding as a protective factor for stunting. This is, at least in part, due to the breast-milk's immune-protective factors reducing the risk of infections such as diarrhea and acute respiratory diseases (60). Moreover, delayed early introduction to complementary feeding is linked to intake of low-nutrient-density foods and recurrent infections resulting in child malnutrition (60).

Children whose drinking water sources were nonimproved were more likely to be underweight than those with an improved drinking water source. Arguably, unsafe water has been reported to be among the determinants of childhood undernutrition (60, 61). Nonimproved water sources may be contaminated and thus increase the risk of waterborne diseases and infections (e.g., diarrhea and cholera) (60–62), which not only affect the children's dietary intake and nutrient utilization but also lead to dehydration, thus resulting in child undernutrition such as wasting and stunting.

Migration of any household member in the past month preceding the survey was a risk factor for child wasting. This corroborates with findings (63) that reported increased risk of wasting among children left behind by their parents in low- and middle-income countries. Migration is an indicator of an extreme-food-insecurity coping strategy in the household (64) and possibly the persons who had migrated were vital in ensuring the household's food security. Reportedly, migration is often the last option left to household members at a risk of starvation (64). Notably, migration not only increases psychological stress to the children left behind but also reduces the time allocated to child care, including changed feeding practices (63).

The main strength of our current study is the cohort design that allowed for variations in the prevalence and risk factors of child malnutrition during both food seasons. Additionally, the study had a fairly large and representative sample size; thus, these findings might be generalizable to the current context of landslide disasters in Uganda and probably elsewhere in different disaster, geographical, and cultural contexts. The major limitation was loss to follow-up and the possibility of recall and reporting bias in socioeconomic and demographic

variables of the household and the child, although we used a short recall period to reduce such bias. The different caretakers who brought the children for assessment, especially the phenomenon of more male caretakers on follow-up, could also have introduced information bias about factors relating to the child. Moreover, we do not have actual data on actual food intake, detailed body composition, or biomarkers of nutrient intake among the study participants. Also, the sample size was estimated to detect expected prevalence of anthropometric outcomes, and not based on associations tested in the study.

In conclusion, with the exception of overweight/obesity, various forms of child malnutrition were observed in the study area. The affected children were more at risk for malnutrition than the controls and the risk factors differed between the food-plenty and food-poor seasons. Therefore, underlying determinants and exposures to malnutrition in children should be concurrently addressed in an integral manner during disaster management. Moreover, our study outcomes imply that there is a gap in the availability, access, and/or delivery of postnatal nutrition support and growth-monitoring and promotion services in the study areas.

National development plans especially the current Uganda National Development III 2020/2021–2024/2025, the overarching macroeconomic development policy framework, as well as multisectoral policies, especially the Uganda Disaster Preparedness and Management Policy 2010 and the Uganda Nutrition Action II 2020/2021–2024/2025, should give greater attention to the serious and growing problem of landslides, a problem linked to climate change, which is affecting the safety, livelihood, and survival of the poor rural communities including vulnerable children aged 6–59 mo. Policy actions that promote landslide victims' accessibility to and ownership of land that is not prone to landslides are crucial. Similarly, policies that promote food production, diet diversification, empowerment of households with income-generating activities, and concrete, legally appropriated, disaster-specific public social safety nets such as unconditional cash transfers are of essence.

Equally, elimination of poverty and improving parental education, access to improved water sources, health care services, and early child care and development programs and policies are key in the improvement in the nutritional status of children in the disaster-prone areas if we are to combat hunger and end all forms of malnutrition as stated by Sustainable Development Goal 2.2. Policies and programs should align with the Uganda National Development III 2020/2021–2024/2025, the Uganda Nutrition Action Plan II (2020–2025), the Maternal Infant and Young Child and Adolescent Nutrition Strategy and Guidelines 2021, and the international nutrition commitments from the UN Food Systems Summit, the Conference of the Parties 26 (COP 26) and the Nutrition For Growth Summit 2021. It is also important that there is political support in relevant Ugandan ministries, directorates, and at the local/regional level for such policies and programs. Finally, our study findings illustrate how crucial food and nutrition security are for human and planetary health in the context of climate change and vice versa.

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Data Availability

Data described in the manuscript, code book, and analytic code will be made available upon request pending application and approval.

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Supplemental Tables 1-3

Supplemental Table 1 Prevalence of child malnutrition by sex

	Food-plenty season				**Food-poor season**				
Variable[1]	Affected (n = 197)	Control (n = 195)	Total (n = 392)	*P* value[2]	Affected (n = 177)	Control (n = 189)	Total (n = 366)	*P* value[3]	*P* value[4]
Stunted									
Male	49 (58.3)	27 (42.2)	76 (51.4)	0.05	30 (36.6)	35(47.3)	65 (41.7)	0.175	0.091
Female	35 (41.7)	37 (57.8)	72 (48.6)		52 (63.4)	39 (52.7)	91 (58.3)		
Underweight									
Male	19 (52.8)	10 (62.5)	29 (55.8)	0.52	10 (31.2)	06 (30.0)	16 (28.8)	0.924	0.008
Female	17 (47.2)	06 (37.5)	23 (44.2)		22 (68.8)	14 (70.0)	36 (69.2)		
Wasted									
Male	05 (55.6)	05 (100.0)	10 (71.4)	0.078	02 (50.0)	01 (33.3)	03 (42.8)	0.659	0.204
Female	04 (44.4)	00 (00.0)	04 (28.6)		02 (50.0)	02 (66.7)	04 (57.1)		
Overweight/obesity									
Male	04 (57.1)	04 (44.4)	09 (52.9)	0.614	03 (60.0)	02 (40.0)	05 (50.0)	0.527	0.883
Female	03 (42.9)	05 (55.6)	08 (47.1)		02 (40.0)	03 (60.0)	05 (50.0)		
Concurrent stunted and wasted									
Male	02 (40.0)	02(100.0)	04 (57.1)	0.147	02 (66.7)	00 (00.0)	02 (66.7)	-	0.778
Female	03 (60.0)	00 (00.0)	03 (42.8)		01 (33.3)	00 (00.0)	01 (33.3)		
Concurrent stunted and overweight									
Male	02 (66.7)	01 (50.0)	03 (60.0)	0.71	02 (50.0)	02 (28.6)	04 (36.4)	0.477	0.377
Female	01 (33.3)	01 (50.0)	02 (40.0)		02 (50.0)	05 (71.4)	07 (63.6)		
Low mid upper arm circumference (MUAC)[5]									
Male	04 (30.8)	05 (100.0)	09 (50.0)	0.009	05 (71.4)	01 (100.0)	06 (75.0)	0.537	0.234
Female	09 (69.2)	00 (00.0)	09 (50.0)		02 (28.6)	00 (00.0)	02 (25.0)		
MUAC-for-age-z scores									
Male	09 (45.0)	07 (70.0)	16 (53.3)	0.196	05 (45.6)	01 (16.7)	06 (35.3)	0.235	0.234
Female	11 (55.0)	03 (30.0)	14 (46.7)		06 (54.5)	05 (83.3)	11 (64.3)		
Low head circumference[6]									
Male	04 (33.3)	00 (00.0)	04 (30.8)	0.48	04 (36.4)	00 (0.00)	04 (33.3)	0.46	0.891
Female	08 (66.7)	01 (100.0)	09 (69.2)		07 (63.6)	01 (100.0)	08 (66.7)		

[1] Values are numbers (%)
[2] *P* value is for chi square test between affected and control in food-plenty season
[3] *P* value is for chi square test between affected and control in food-poor season
[4] *P* value is for chi square test between the food plenty and food poor seasons
[5] Low MUAC is defined as MUAC < 125 mm, an indicator of wasting/acute malnutrition
[6] Low head circumference is defined as head circumference z-score < -2.

Supplemental Table 2 Sensitivity analysis results of model performance from an analysis of the fitted model with complete data cases and the fitted model with missing data cases at food-plenty season

	Food-plenty season				
Variable	N	Model	Sensitivity	Specificity	Correctly classified
Stunting[a]	392	1	80.1	79.5	79.3
	395	2	80.6	80.1	80.3
Underweight[b]	392	1	98.0	84.7	83.4
	395	2	98.1	85.0	82.6
Wasting[c]	392	1	89.1	80.6	94.1
	395	2	89.2	80.2	93.1
Overweight[d]	392	1	79.6	80.2	95.6
	395	2	80.3	80.5	94.2

N is the number of data cases

Model 1: Fitted model analyzed with only complete data cases of the outcome and independent variables

Model 2: Fitted model analyzed including missing data cases of the outcome and independent variables

[a]Adjusting for child sex, -age, -breastfeeding, age of introduction of solid and semi-solid food, parents' education level and household size.

[b]Adjusting for child sex, age, age of introduction of solid and semi-solid food, number of under-5 children in the household, parents' education status, source of drinking water and source of food

[c] Adjusting for child sex, age of introduction of solid and semi-solid food, child suffered any illness, parents' education status, migration of any household member and main source of drinking water.

[d] Adjusting for child sex, child parity, parents' education status, parents' marital status and household source of livelihood.

Supplemental Table 3 Sensitivity analysis results of model performance from an analysis of the fitted model with complete data cases and the fitted model with missing data cases at food-poor season

	Food-poor season				
Variable	N	Model	Sensitivity	Specificity	Correctly classified
Stunting[a]	366	1	89.1	79.5	78.3
	395	2	80.6	80.1	80.3
Underweight[b]	366	1	85.5	99.3	86.6
	395	2	85.2	85.0	85.7
Wasting[c]	366	1	96.9	100	97.1
	395	2	96.2	97.9	96.2
Overweight[d]	366	1	82.6	80.2	90.2
	395	2	82.3	81.5	89.1

N is the number of data cases

Model 1: Fitted model analyzed with only complete data cases of the outcome and independent variables

Model 2: Fitted model analyzed including missing data cases of the outcome and independent variables

[a]Adjusting for child sex, -age, -breastfeeding, age of introduction of solid and semi-solid food, parents' education level and household size.

[b]Adjusting for child sex, age, age of introduction of solid and semi-solid food, number of under-5 children in the household, parents' education status, source of drinking water and source of food

[c] Adjusting for child sex, age of introduction of solid and semi-solid food, parents' education status, migration of any household member and main source of drinking water.

[d] Adjusting for child sex, child parity, parents' education status and household source of livelihood

II

PLOS ONE

RESEARCH ARTICLE

Food insecurity, dietary diversity and the right to adequate food among households in landslide-prone communities in Eastern Uganda: A cohort study

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Abstract

We assessed food insecurity, dietary diversity and the right to adequate food among households in communities in Eastern Uganda that were affected by major landslides in 2010 and 2018. A prospective cohort study was applied to select 422 households during May-August (the food-plenty season) of 2019. In January-March (the food-poor season) of 2020, 388 households were re-assessed. Socio-demographic, food security, dietary diversity and right to adequate food data were collected using structured questionnaires. Four focus groups discussions and key informant interviews with 10 purposively sampled duty-bearers explored issues of food insecurity, dietary and the right to adequate food. The affected households had significantly higher mean (SE) food insecurity scores than controls, both during the food plenty season: 15.3 (0.5) vs. 10.8 (0.5), and during food-poor season: 15.9 (0.4) vs. 12.5 (0.0). The affected households had significantly lower mean (SE) dietary diversity scores than controls during the food plenty season: 5.4 (0.2) vs. 7.5 (0.2) and during the food poor season: 5.2 (0.2) vs. 7.3 (0.1). Multivariate analyses showed that the disaster event, education and main source of livelihood, were significantly associated with household food security and dietary diversity during the food-plenty season whereas during the food-poor season, the disaster event and education were associated with household food security and dietary diversity. During both food seasons, the majority of affected and control households reported to have consumed unsafe food. Cash-handout was the most preferred for ensuring the right to adequate food. Comprehension and awareness of human rights principles and state obligations were low. The severity of food-insecurity and dietary diversity differed significantly between the affected and control households during both food seasons. Moreover, the right to adequate food of landslide victims faced challenges to its realization. There is need for policy and planning frameworks that cater for seasonal variations, disaster effects and right to adequate food in order to reduce landslide victims'

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vulnerability to food insecurity and poor dietary diversity. In the long-term, education and income diversification program interventions need to be integrated into disaster recovery programs since they are central in enhancing the resilience of rural livelihoods to shocks and stressors on the food system.

Introduction

Ensuring food security for all is not only among the core aspect of the right to adequate food (RtAF), but also a priority goal under the United Nations (UN) Transforming our World: The 2030 Agenda for Sustainable Development [1, 2]. The UN Committee on Economic, Social and Cultural Rights clarified through its General Comment 12 (GC12) that the right to adequate food (RtAF) is realized *"when every man, woman and child, alone or in the community with others, have physical and economic access at all times to adequate food or means for its procurement"* [3]. All citizens are rights-holders whereas the State and other actors with State obligations and responsibilities are duty-bearers under international human rights law to which Uganda is a party. The RtAF not only compliments food security components with the State obligations of respect, protect and fulfil the right [3, 4], but also protects all humans to live in dignity, free from hunger, food insecurity and malnutrition [5, 6]. Moreover, the realization of the RtAF requires the recognition of the interdependency and progressive realization of all human rights. Also, the States have a core obligation to take the necessary action to mitigate and alleviate hunger, even in times of natural disasters [3].

The achievement of UN's Sustainable Development Goal (SDG) number 2 on ending hunger and achieving food security by 2030, may be derailed. This is due to food insecurity and inequalities in access to food, unaffordability of healthy diets, climate change and natural disasters [7, 8]. Globally, in 2020, 811 million people were suffering from hunger and the number of moderate or severely food insecure people had risen from about 1.64 billion (22.6%) in 2014 to nearly 2.37 billion (30.4%) in 2020. Equally, more than 3 billion people could not afford a healthy diet in 2020. Notably, 290.9 million of the moderate or severely food insecure people live in Eastern Africa [7].

The RtAF and ensuring food security and nutrition for all, are recognized in the 1995 Uganda Constitution [9]. However, food insecurity has persisted in Uganda. By the end of 2020, 69.2% (30.6 million) Ugandans were food insecure among which 21.7% (9.6 million) were severely food insecure [7]. Similarly, 26% and 5% of households were already stressed and in a crisis of food insecurity, respectively [10], even before the Covid-19 effects had become apparent. The national average energy intake is at 8,715 kJ (2,083 kcal) per day per adult, below the recommended 9,210 kJ (2,200 kcal) [11]. Moreover, about 40% of Ugandans are estimated not to meet their energy requirements and the quality of Ugandan household's diets is lacking with 40–60% of the energy intake derived from starchy staples [12]. Ugandans are also still grappling with malnutrition [13–15] and high poverty levels [16].

Over the past years, Uganda has experienced frequent disasters such as landslides, floods and droughts, usually escalated by climate change [17, 18] (Table 1). The National Policy for Disaster Preparedness and Management acknowledges that on average, 200,000 Ugandans are affected annually by disasters [19]. During 2019–2020, excluding Covid-19 impacts, disaster events in Uganda affected nearly 800,000 people, displaced 21,000 families, and resulted in 152.2 million US dollars (USD) economic losses [20]. Morever, between 1900–2020, landslides were the second biggest killer among natural disasters in Uganda, causing an estimated death of 2,718 people [17] (Table 1). Among these, about 610 deaths occurred in Bududa District (Fig 1).

Table 1. Occurrence of key natural disasters in Uganda, 1900–2020.

Natural disaster	Total deaths	Total number of people affected	Total damage ('000 USD)	References
Drought	194	4,975,000	1,800	[18, 26]
Floods	343	1,060,559	6,871	[18, 26]
Epidemics	3,670	345,701	Not known	[18, 26]
Landslides	2,718	151,546	Not known	[17, 18, 26, 27, 28]
Storm	23	47	Not known	[18, 26]
Earthquake	115	58,100	71,500	[18, 26]

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Natural disasters limit peoples' access to adequate food through interference with the food security components via destruction of the food systems and livelihood-related infrastructure [21]. This may result in malnutrition and hunger predominantly in areas where chronic food insecurity is already a significant problem and thus create vicious cycles of poverty, disease and hunger [2]. Consequently, the achievement of the right to adequate food [5, 22] and SDG targets 2.1 and 2.2 related to food security and nutrition [1], are disrupted.

Bududa District in Eastern Uganda has experienced several devastating landslides with the earliest records dating to as early as 1933 (Fig 1), with catastrophic effects to life, property, crops, livestock, infrastructures and the environment [23]. Unfortunately, the economic damage from these landslides is not well documented [24]. In March 2010, a major landslide in Bukalasi sub-county in Bududa District left over 360 dead, thousands displaced and infrastructures, food crops and livestock destroyed [23]. In October 2018, another major incident occurred in the same sub-county and left 60 dead, 858 people displaced and 144 houses destroyed [25].

As a result of the major 2010 landslide, we performed a cross-sectional study and identified lower food insecurity, higher dietary diversity and food variety scores among the affected communities compared to the unaffected (control) communities in Bududa District [29]. Food varieties were also higher among farmers and relief food recipients compared to the non-farmers and non-relief food recipients. Still, the affected households had a higher likelihood to skip a day without eating a household meal compared to the control households [30]. However, there is limited longitudinal cohort data on how landslide disaster affect household food

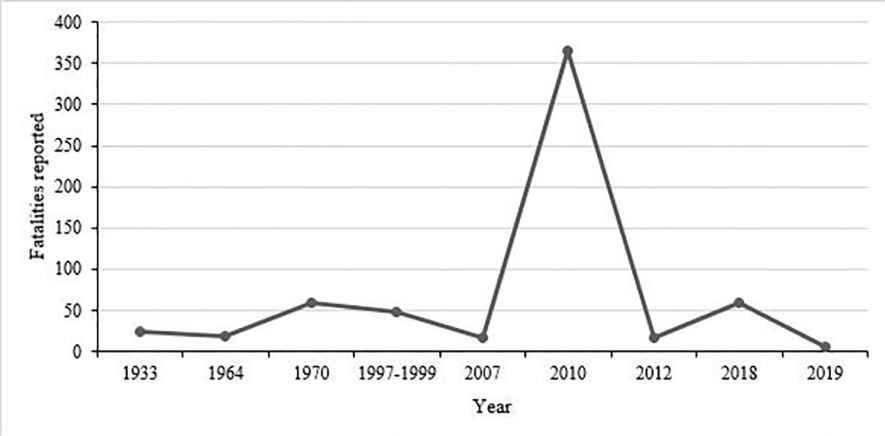

Fig 1. People killed by landslides in Bududa district of Eastern Uganda, 1900–2020. Data sources: [23–25, 27, 28].

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security, dietary and the RtAF among victims of landslides in the country. Yet, such data are very important in the country's efforts to plan for these vulnerable categories of people. Hence, in this follow-up study we aimed to assess food insecurity, dietary diversity and the RtAF among households in the landslide-prone communities of the 2010 and 2018 landslide disasters in the Bududa District.

Materials and methods

Study design and setting

A prospective cohort study was performed in the periods May-August 2019 and January-March 2020 and we report the results according to the STROBE guidelines [31]. The study site was the Bududa District in the Bukalasi sub-county, which was devastated by the landslides of 2010 and 2018. The neighboring sub-county Bubiita acted as the control. Bududa District is located on the foot of the South-Western slopes of Mount Elgon, about 250 km from Kampala, Uganda's capital city. The district's elevated topography subjects Mount Elgon region to regular disastrous floods and landslides [32]. The average precipitation of the area is above 1500 mm of rainfall per year [23]. The district's population is 210,173 people [33], with a high population density of about 952 persons per km^2. The continued agricultural activities on the steep slopes of Mount Elgon with V-shaped valleys and river incisions precipitate a high risk for landslides [23]. The majority of the population is rural and relies mainly on subsistence agriculture [23, 33].

Bukalasi sub-county is located on the steep slopes of Mt. Elgon with loose soil types, bi-modal rainfall patterns, high population growth rate and increased land cultivation making it more vulnerable to landslides and related consequences [34]. The natives are mainly rural subsistence farmers and the steep terrain limits their accessibility to the markets [23].

Bubiita sub-county is situated on the low terrain at the foot of Mt. Elgon with fertile soils and bi-modal rainfall patterns. It has a high population growth rate, however it less vulnerable to landslides and their consequences due to its location on the low terrain [34]. The natives are mainly subsistence farmers and a small portion of traders with adequate access to the market. The population is rural with a small semi-urban segment [35].

Study participants

Study participants were household heads in the study area, focus group discussants (FGD) and key informants (KIs).

The FGDs constituted adult women and men who were members of the local council at village and parish level in the study area whereas KIs constituted individuals or representatives from the Bududa District and relevant government departments. Specifically, they were: the Chairperson Disaster Management Committee, Bududa hospital nutritionist, Senior Environmental Officer, Health Inspector, Community Development Officer, Production Officer, Sub-county Chiefs and Local Council Leaders.

Sample size

This study is part of a research project that involved a cohort and descriptive survey among the 2010 and 2018 victims of landslide disasters in Eastern Uganda. A computed sample size of 418 households was targeted based on the 35.9% stunting level reported in children 6–59 months old in the Bugisu sub-region [36], due to the absence of reliable effect measures of landslides on food insecurity and dietary diversity. Details for sample size and sampling procedure of households are reported in our previous study [13].

Participants for FGDs in each sub-county were sampled independently from households which were not selected for quantitative interviews. Four FGDs were targeted, two from the affected and two from the control sub-county. Six to ten participants for each FGD were targeted. The leadership in each sub-county assisted to mobilize the FGD participants.

Ten key informants were purposively selected on the basis that they were conversant with the subject matter being studied or were in positions of authority in their respective institutions or ministries in areas related to landslides, food security, diet and the right to adequate food.

Study approvals

The Uganda National Council for Science and Technology (UNCST) (no: SS 4967), Makerere School of Health Sciences Research Ethics Committee (no: 2018–082) and the Norwegian Regional Committee for Medical and Health Research Ethics (no: 2019/917) approved this study. Participation into the study was by informed and voluntary written or thumb printed consent.

Data collection and measurements

The research applied mixed methods, with a combination of quantitative and qualitative research activities suited to an interdisciplinary exploration of food security, dietary and the RtAF [37]. Quantitative data from household heads were collected twice: (i) in the food-plenty season (May-August 2019), and (ii) after six months at food-poor season (January-March 2020) to account for variations in food-plenty and food-poor seasons. Trained research assistants with at least a College or University level of education collected the quantitative data from the household heads. This was through face-to-face interviews using pretested and structured questionnaires that were translated from English to the local language (Lumasaba) and back-translated into English. The questionnaire included mainly close-ended questions related to demographic and socio-economic information, experiences on access to food, the frequency and diversity of food groups consumed and the RtAF.

Qualitative data from KIs and FGDs were collected once during the food-poor season (January-March of 2020) using semi-structured interviews and discussion guides, respectively, in a face-to-face set up. The aim was to get a broader understanding of the food security, dietary and the RtAF in the study area. Both written and audio records were collected with permission of the participants.

Household food insecurity

Household food insecurity was assessed using standardized food access and hunger scales adapted from a combination of the Household Food Insecurity Access Scale (HFIAS) index [38] and the Community Childhood Hunger Identification Project (CCHIP) scale index [39, 40]. Importantly, CCHIP provides a more understanding of the effects of food insecurity on household members by accounting for child hunger [39, 40]. Additionally, the scoring of CCHIP is similar to HFIAS, and the two tools provide a measure to understand the food insecurity problem in resource-limited settings, especially among rural populations that rely mainly on subsistence farming [41].

The combined HFIAS and CCHIP scale has eleven food-insecurity experience-based indicators related to worry about lack of food, insufficient quality and quantity of meals, and going to sleep hungry, both in adults and children of the household in the last 30-days preceding the survey. The indicators included: (1) having skipped a day without a general household meal of breakfast, lunch or supper; (2) children ever went to bed hungry because of lack of food; (3)

children were allowed to roam and eat elsewhere because of lack of food; (4) sought financial support to buy food; (5) children having eaten less food because of there not being enough food; (6) sought food assistance from neighbors, relatives and friends; (7) limited portion sizes at meals because of there not being enough food; (8) reduced food for adults because of there not being enough food; (9) parents eating less because of there not being enough food; (10) purchased food on credit; and (11) relied on less-preferred, less-expensive food.

For each item, the respondent selected a frequency of the experience as: never, rarely, sometimes, or always. Never was scored as 0; a frequency of one to two times was considered as 'rare' and scored 1 point; three to ten times was considered as 'sometimes' and scored 2 points; and more than ten times was considered as 'often' and scored 3 points [38, 39]. If the household's response to all the eleven questions was often reported 'yes', a maximum score of 33 points was given and a minimum score of 0 if the respondent answered 'never' to all the questions. The generated score from 0 to 33 reflected a single statistical dimension of food insecurity. A score of 0 indicated food secure while a score between 1–33 indicated food insecure, i.e. the higher the score, the more the households experienced food insecurity.

Household dietary diversity

Household dietary diversity was assessed using the Household Dietary Diversity Score (HDDS) to establish each household's access to different types of food. This was based on a retrospective recall by the household's head about the frequency of the household eating food items listed in a food frequency questionnaire (FFQ). This FFQ was adapted for Uganda and contained commonly eaten foods (n = 86) grouped into 12 groups: (1) cereals (2) legumes, (3) starchy roots, tubers and plantain, (4) vegetables, (5) fruits and fruit juice, (6) meat and meat products, (7) poultry and eggs, (8) milk and milk products, (9) fish, (10) fats and oils, (11) sugars and confectionaries, and (12) condiments, spices and beverages [42]. The HDDS is a continuous score which measures the consumption of these 12 food groups within the past 24 hours. Household heads were asked whether the household had eaten each of the listed food items in the previous 24 hours and the approximate frequency of use of each of the eaten items. The information regarding food items consumed in the household over the 24 hours preceding the interview was used to compute the HDDS.

The HDDS was calculated by summing the number of food groups consumed by each respondent over the previous 24-hour period. Minimum score was 0 if the household did not consume any food group and the maximum score was 12 if the household consumed all the food groups. This score was used as a proxy to estimate the dietary quality given their suitability in resource limited settings. The higher the score was, the higher was the nutrient adequacy of the diets consumed while the lower the score, was the lower the dietary nutrient adequacy.

Perceptions on the right to adequate food, food and nutrition security and diet diversity

Perceptions about the right to adequate food, food and nutrition security and diet diversity were assessed based on questions adapted and modified from the "Guide to conducting right to food assessment" by FAO [43], because the right to food encompasses food security attributes including nutrition security and diet [3]. A pre-coded and structured questionnaire with mainly closed-ended questions regarding perceptions on the right to adequate food, food and nutrition security and diet diversity during disaster in Bududa District, was used for data collection from household heads. Questions included: (1) whether in the past 30 days there were instances when: (a) a household did not have sufficient food for more than 2 days, (b) a household head felt the household was not eating food that was safe, (c) a household head felt the

household was eating less nutritious food and could not do much about it; (2) whether providing food for the household limited the household's ability to provide other amenities like health, water, housing, clothing and education; (3) whether the landslides had affected the household's food and nutrition security and the RtAF; (4) awareness about the principles of human rights of participation, accountability, non-discrimination and transparency; (5) awareness about the State obligations of respect, protect and fulfill; and (6) the preferred means to ensure the right to adequate food of landslide disaster victims.

Using discussion and interview guides, FGDs and KIIs were held to get the broader perspective on food security, diet and the RtAF. Guiding questions included: What is the situation of food and nutrition security in the study area; where, when and who are the most affected and why; whether landslides affected the food and nutrition security and the RtAF of landslides victims; whether the disaster response in the study area is satisfactory; whether the human rights principles of participation, accountability, non-discrimination and transparency are taken into consideration during the response of public authorities to the disasters; the perception on the obligation of the State to ensure that no Ugandan suffers from hunger and malnutrition even in times of disaster; how the State should ensure the realization of the RtAF of landslide disaster prone communities; and the preferred means to ensure the RtAF of disaster victims.

The FGDs were conducted at the respective sub-county headquarters. A facilitator fluent in both English and the local language led the FGDs and the FGD participants were told beforehand to be at liberty to discuss in English or their native languages, and that all answers were equally important. The discussions ranged from 60–90 minutes. Interviews with KIs were conducted in English on appointment by the first author (A.N) and took place in the participant's office. The interviews ranged from 45–90 minutes. Both audio- and written data were collected during the FGDs and KIIs. Written informed consent to participate and record the interview/discussion was sought from each participant prior to the start of each session.

Statistical analyses

Analyses for quantitative data were conducted using Stata version 16.1 statistical software [44]. The Levene's independent samples t-test tested the unadjusted mean differences in the household and dietary diversity scores because of its appropriateness for application to both normally and non-normally distributed data. The two dependent outcomes of food insecurity and dietary diversity scores were first tested for linearity with each other using Pearson's correlation (r). Given that the two dependent variables showed a small positive correlation ($r = 0.08$) in the food-plenty season and a small negative correlation ($r = -0.27$) in the food-poor season, a one-way analysis of covariance (ANCOVA) and multivariate analysis of covariance (MANCOVA) models were used to test for univariate and multivariate effects while adjusting for the disaster effect and socio-demographic covariates. The covariates included were: interviewed household head, age of the household head, education level of household head, family size, main source of livelihood, household ownership of assets or entitlements and migration of a household member in the past 12 months preceding the survey.

Responses from household heads regarding perceptions on food and nutrition security, diet and the RtAF were treated as categorical variables in the analysis. Pearson chi-square test was used to examine associations between these categorical variables, using a $p < 0.05$ as a level of significance.

Data from KIs and FDGs were triangulated to augment the quantitative data outcomes using thematic analysis. The process involved transcription of translated information which was also cross-checked to ensure quality, followed by identification and coding of key words

and phrases with similar impressions. The coded information was assigned into groups and categorized into themes. The generated themes were reviewed to ensure that the themes were accurate representations of the data. Defining and renaming of the generated themes was then done to establish a sequence of patterns and associations related to study themes and included in the results and discussion of results accordingly.

Inclusivity in global research

Additional information regarding the ethical, cultural, and scientific considerations specific to inclusivity in global research is included in the S1 Checklist.

Results

Characteristics of the study population

A total of 422 households participated in the study during the food-plenty season while 388 households were followed-up during the food-poor season (Fig 2). Thirty-six participants in four focus groups and 10 key informants participated in the study.

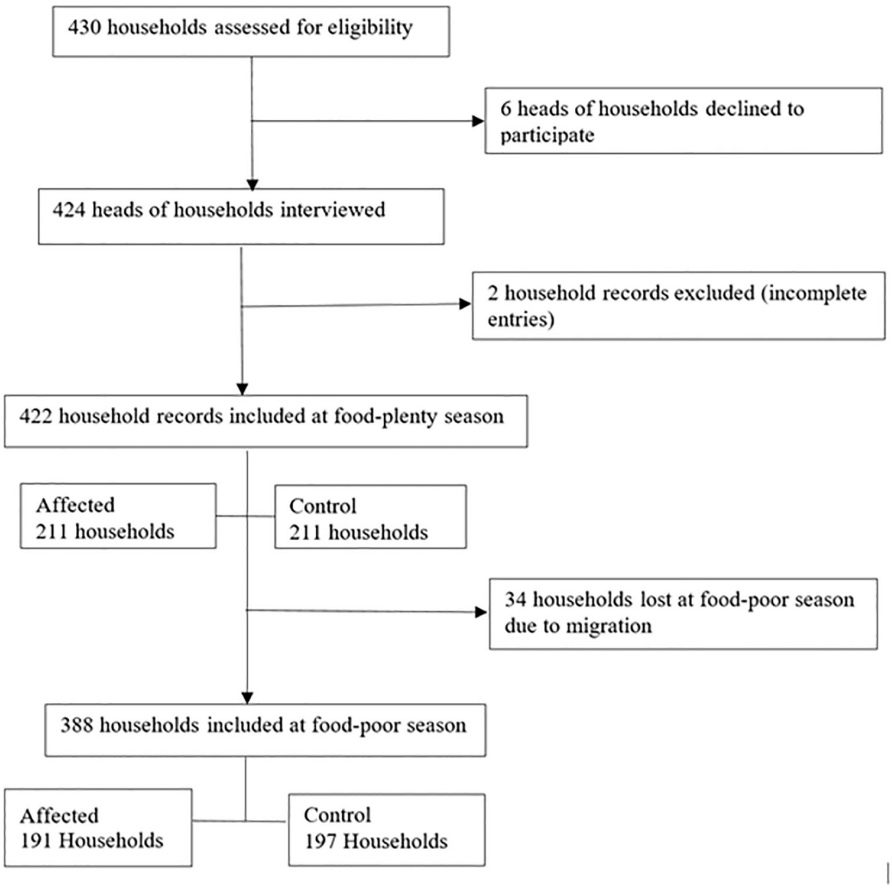

Fig 2. Flow chart showing enrollment of study participants into the study.

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Table 2. Characteristics of the participating households[a].

	Food-plenty season (n = 422)			Food-poor season (n = 388)		
Variables	**Affected (n = 211)**	**Control (n = 211)**	**P-value[b]**	**Affected (n = 191)**	**Control (n = 197)**	**P-value[c]**
Interviewed household head						
Father	40 (18.9)	17 (8.1)	0.003*	134 (70.2)	157 (79.7)	0.11
Mother	161 (76.3)	174 (82.5)		40 (20.9)	25 (12.7)	
Grandparents or elderly siblings	10 (4.8)	20 (9.5)		17 (8.9)	15 (7.6)	
Age of the household head (years)	32.1 ± 11.7	32.3 ± 11.5	0.71	33.2 ± 11.9	33.9 ± 11.8	0.56
Education level of household head						
None	14 (6.7)	13 (6.2)	0.18	6 (3.1)	18 (9.1)	0.21
Primary	156 (73.9)	145 (68.7)		150 (78.6)	142 (72.1)	
Secondary	39 (18.5)	47 (22.3)		33 (17.3)	32 (16.2)	
≥ College	2 (0.9)	6 (2.8)		2 (1.0)	5 (2.5)	
Household size	6.5 ± 2.6	5.9 ± 2.3	0.014*	6.6 ± 2.6	6.3 ± 2.3	0.16
Main source of livelihood						
Farming	174 (82.5)	125 (59.2)	0.000*	178 (93.2)	173 (87.8)	0.004*
Trading	17 (8.1)	18 (8.5)		4 (2.1)	13 (6.6)	
Casual laborer	16 (7.6)	44 (20.9)		9 (4.7)	7 (3.6)	
Fishing or wage employee	4 (1.8)	24 (11.4)		0 (0.0)	4 (2.0)	
Main source of food						
Own production	150 (71.1)	80 (37.9)	0.000*	100 (52.4)	61 (30.9)	0.000*
Purchase	33 (15.6)	121 (57.3)		90 (47.1)	133 (67.6)	
Own labor	28 (13.3)	10 (4.7)		1 (0.5)	3 (1.5)	
Lost any household members in the past 12 months preceding the survey						
Yes	32 (15.2)	38 (18.0)	0.56	8 (4.2)	17 (8.6)	0.07
No	179 (84.8)	173 (81.9)		183 (95.8)	180 (91.4)	
Migration of any member of the household in the past 12 months preceding the survey						
Yes	19 (9.0)	54 (25.6)	0.000*	38 (19.9)	16 (8.1)	0.001*
No	192 (91.0)	157 (74.4)		153 (80.1)	181 (91.9)	
Household ownership of assets or entitlements[d]						
Yes	137 (64.9)	143 (67.8)	0.21	57 (29.8)	121 (61.4)	0.000*
No	74 (35.1)	68 (32.2)		134 (70.2)	76 (38.6)	
Number of meals consumed/day	2.2 ± 0.6	2.2 ± 0.7	0.07	2.3 ± 0.6	2.3 ± 0.6	0.07
Food insecurity scores (FIS)	15.3 ± 6.8	10.8 ± 5.1	0.000*	15.9 ± 7.0	12.5 ± 6.5	0.000*
Dietary diversity scores (DDS)	5.4 ± 2.6	7.5 ± 2.2	0.000*	5.2 ± 2.5	7.3 ± 2.6	0.000*

[a]Values are numbers (%) or means ± standard deviation.

[b]P-value is for chi square or t test between affected and controls during food-plenty season.

[c]P-value is for chi square or t test between affected and controls during food-poor season.

[d]Such as farm, livestock, poultry, motorcycle, bicycle.

*Denotes statistical significance when $p < 0.05$.

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There were more maternal household heads from the affected than the control group being interviewed during the food-plenty season (p = 0.003), but not during the food-poor season (Table 2).

Primary level was the most attained education level among both the affected and the control households during both food seasons. Moreover, farming was the main source of livelihood, but was different between the affected and the control during both the food-plenty ($p < 0.001$) and the food-poor season (p = 0.04). Additionally, migration of any household member in the

past 12 months preceding the study was significantly lower in the affected compared with the control households during the food-plenty season. However, it increased significantly among the affected compared to the controls during the food-poor season. Household ownership of assets was higher during the food-plenty compared to the food-poor season in both the affected and the control households. Conversely, it decreased during the food-poor season among the affected compared to the control households ($p < 0.001$) (Table 2).

Household food insecurity

Overall, the mean household food insecurity scores were significantly higher among the affected compared to the controls during both food seasons (Table 3). Moreover, FGD participants and KIs further cited that the affected communities faced more food insecurity compared to their counterparts and the situation was worse during the food-poor season. Lack of enough to eat and to feed the young children stood out as a major issue (S1 Table).

Household dietary diversity

The affected households exhibited significantly lower household dietary diversity scores during both the food-plenty and the food-poor seasons compared with the controls (Table 3). Moreover, cereal-based foods, legumes, starchy roots, tubers and plantain and sugars and confectionaries were the most consumed food groups during both food seasons by both the affected and control households (Fig 3). Consumption of animal-source foods was very low among the affected compared to the controls and significantly decreased during the food-poor season. Intake of food of lower dietary diversity among the affected communities was also noted by majority of the KIs and FGDs (S1 Table).

Multivariate effects on food security and dietary diversity

After controlling for potential covariates, ANCOVA results indicated that the disaster event, education level and main source of livelihood were associated with food insecurity at food-plenty season ($p < 0.001$ in all) whereas the disaster event and household ownership of assets or entitlements were associated with food-insecurity ($p < 0.001$ in both) during the food-poor season (Table 3). Furthermore, ANCOVA results indicated that the disaster event and education level were associated with poor dietary diversity during both food-seasons ($p < 0.001$ in both) (Table 3).

The MANCOVA findings showed that the disaster event, education level and main source of livelihood were associated with both household food insecurity and dietary diversity at food-plenty season ($p < 0.001$ in all) whereas during the food-poor season, the disaster event and education level were associated with both outcomes ($p < 0.001$ in both) (Table 3).

Perceptions on the right to adequate food, food and nutrition security and diet diversity

The household's perceptions about food and nutrition security, diet and the right to adequate food differed significantly between the affected households and the controls during both food seasons (Table 4). Regarding the question of a household not consuming safe food, there were significant differences in the responses between the affected and controls during both food seasons. The majority (81.6%) of the affected compared to 68.2% of the control during the food-plenty and 91% of the affected compared to 65% of the controls during the food-poor season, reported that they were consuming food that was not safe, but they could not do much about it (Table 4). This was consistent with information from KIs who linked intake of non-safe food

Table 3. Adjusted differences in household food insecurity and dietary diversity scores.

	Food-plenty season (n = 422)								Food-poor season (n = 388)							
	ANCOVA								ANCOVA							
Variables		Food insecurity[a]			Dietary diversity[b]			MANCOVA[c]		Food insecurity[a]			Dietary diversity[b]			MANCOVA[c]
	n	Mean	SE	P	Mean	SE	P	P	n	Mean	SE	P	Mean	SE	P	P
Disaster																
Affected	211	15.3	0.5	<0.001*	5.4	0.2	<0.001*	<0.001*	191	15.9	0.4	<0.001*	5.2	0.2	<0.001*	<0.001*
Control	211	10.8	0.5		7.5	0.2			197	12.5	0.4		7.3	0.2		
Interviewed household head																
Fathers	57	12.9	1.0	0.59	6.6	0.3	0.48	0.06	291	14.2	0.3	0.38	7.8	0.1	0.25	0.25
Mothers	335	13.3	0.4		6.9	0.1			65	13.6	0.8		8.0	0.2		
Others[d]	30	10.4	1.4		7.5	0.4			32	14.8	1.1		7.3	0.3		
Education level of the household head																
≤ primary	327	15.5	0.4	<0.001*	5.7	0.1	<0.001	<0.001*	305	13.6	0.7	0.19	5.5	0.1	<0.001*	<0.001*
≥ secondary	95	13.3	0.8		7.7	0.2			83	14.3	0.3		8.8	0.2		
Household size																
≤ 5 members	195	12.9	0.6	0.253	7.1	0.2	0.87	0.52	159	13.2	0.5	0.044	7.6	0.2	0.23	0.42
≥ 6 members	227	13.1	0.5		6.9	0.2			229	14.9	0.4		7.8	0.1		
Main source of livelihood																
Farming	299	11.9	0.4	<0.001*	6.5	0.1	0.015	<0.001*	351	14.1	0.3	0.08	7.7	0.1	0.93	0.98
Others[e]	123	15.8	0.6		7.1	0.2			37	15.8	1.1		8.1	0.3		
Household ownership of assets or entitlements[f]																
Yes	282	12.6	0.4	0.07	7.0	0.1	0.56	0.17	178	12.3	0.4	<0.001*	8.0	0.2	0.63	0.69
No	140	13.8	0.6		8.6	0.2			210	16.5	0.4		7.6	0.1		

[a]Adjusting for disaster effect, interviewed household head, household head's education level, family size, main source of livelihood, household ownership of assets or entitlements, migration of any household member in the past 12 months preceding the survey and household dietary diversity score.

[b]Adjusting for disaster effect, interviewed household head, household head's education level, family size, main source of livelihood, household ownership of assets or entitlements, migration of any household member in the past 12 months preceding the survey and household food insecurity score.

[c]Test for multivariate effect of each variable on both outcomes after adjusting for covariates. Given two dependent variables in the model, Hotelling's Trace value is reported.

[d]Refers to grandparents or elderly siblings,

[e]such as trading, wages, carpentry,

[f] such as farm, livestock, poultry, motorcycle, bicycle.

*Denotes statistical significance when $p < 0.05$.

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e.g. maize flour and beans which were insect-infested and with a bad smell and taste, due to lack of enough food and money throughout the food seasons (S1 Table).

Additionally, there were significant differences in responses between the affected and control households during both food seasons on the question regarding if a household head felt the household was eating less nutritious food and could not do much about it ($p < 0.001$ in both). A total of 72.5% of the affected compared to 53.6% of the control during the food-plenty and 74.3% of the affected compared to 64.9% of the control during the food-poor, reported that their households were eating less nutritious food, but could not do much about it (Table 4). Similarly, KIs expressed intake of less nutritious food among the affected

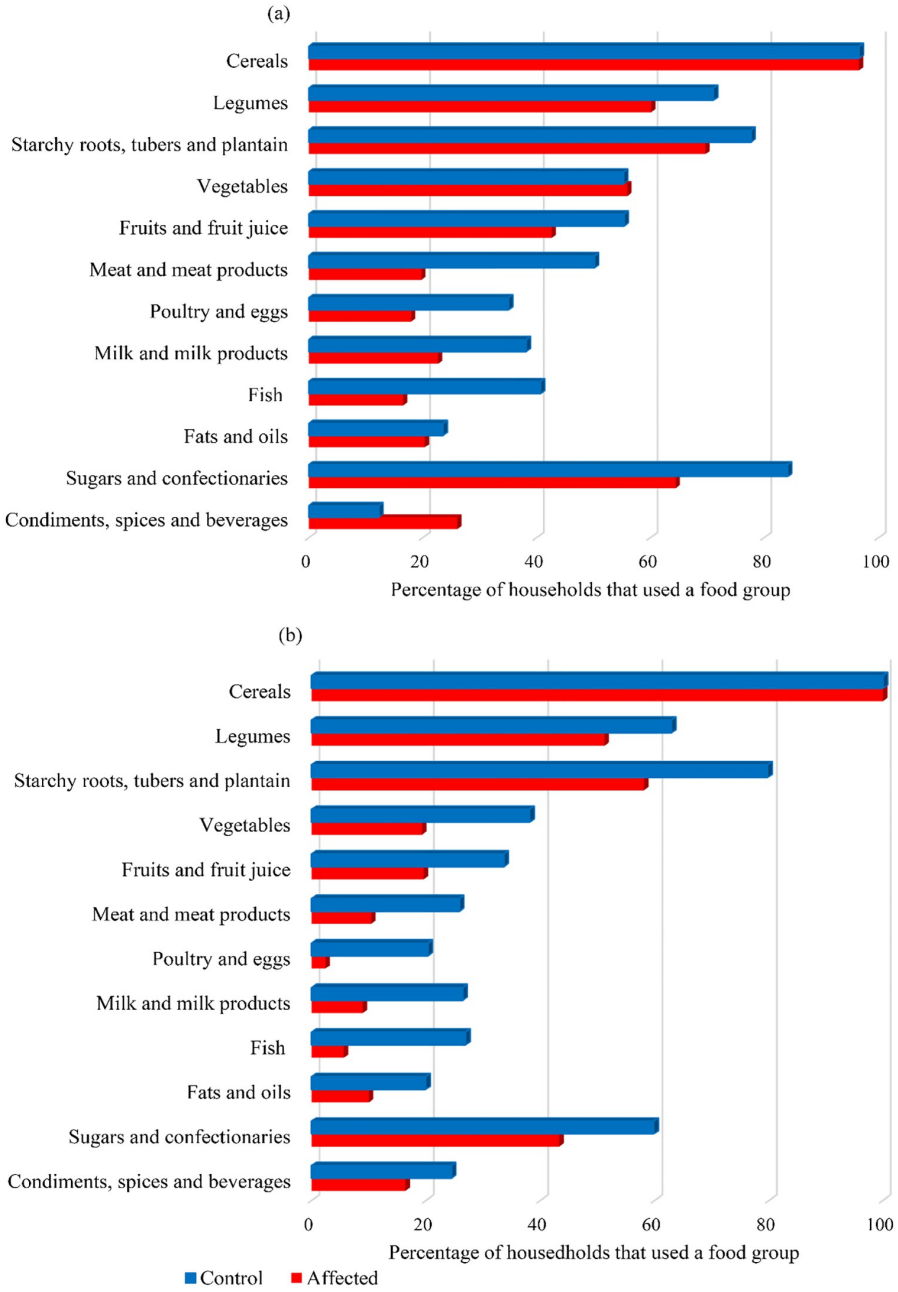

Fig 3. Food groups consumed over the 24 hours period by households in the landslide-prone communities during: (a) food-plenty season (May-August) and (b) food-poor season (January-March).

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communities. Specifically, reliance on low quality food e.g., dry tea and poor quality roasted banana with no sauce was reported to be consumed on several days by the affected communities (S1 Table).

Regarding if landslides affected the households' food- and nutrition security (given a choice of yes or no), there were significant differences in responses between the affected and control

Table 4. Households' perceptions about food and nutrition security, diet diversity and the right to adequate food[a].

	Food-plenty season (n = 422)			Food-poor season (n = 388)		
Question	**Affected (n = 211)**	**Control (n = 211)**	**P value[b]**	**Affected (n = 191)**	**Control (n = 197)**	**P value[c]**
In the past 30 days, instances when:						
(a) A household did not have sufficient food for more than 2 days						
Yes	107 (50.7)	103 (48.8)	0.77	125 (65.4)	89 (45.2)	0.000*
No	104 (49.3)	108 (51.2)		66 (34.6)	108 (54.8)	
(b) A household head felt the household was not eating food that was safe						
Yes	172 (81.5)	145 (68.7)	0.000*	174 (91.1)	130 (65.9)	0.000*
No	39 (18.5)	66 (31.3)		17 (8.9)	67 (34.1)	
(c) A household head felt the household was eating less nutritious food and could not do much about it						
Yes	153 (72.5)	113 (53.6)	0.000*	142 (74.3)	126 (63.9)	0.000*
No	58 (27.5)	98 (46.4)		49 (25.7)	71 (36.1)	
Does providing food for your household limit your ability to provide other amenities like health, water, housing, clothing and education?						
Yes	166 (78.7)	168 (79.6)	0.000*	125 (65.4)	110 (55.8)	0.000*
No	45 (21.3)	43 (20.4)		66 (34.6)	87 (44.2)	
Do you think landslides have affected your household's food and nutrition security?						
Yes	152 (72.0)	133 (63.0)	0.004*	170 (89.0)	155 (78.6)	0.018*
No	59 (27.9)	78 (36.9)		21 (10.1)	42 (21.3)	
Are you aware about the principles of human rights of participation, accountability, non-discrimination and transparency?						
Yes	42 (19.9)	60 (28.4)	0.000*	38 (19.8)	57 (28.9)	0.000*
No	169 (80.1)	151 (71)		153 (80.2)	140 (71.1)	
Are you aware about the State obligations of respect, protect and fulfill						
Yes	18 (8.5)	28 (13.7)	0.000*	17 (8.9)	27 (13.7)	0.000*
No	193 (91.5)	183 (86.7)		174 (91.1)	170 (86.3)	
What would be the most important aspect for ensuring the right to adequate food among victims of landslide disasters?						
Cash hand-out	127 (60.2)	115 (54.5)	0.000*	164 (85.8)	124 (62.9)	0.000*
Resettlement land for agriculture	73 (34.6)	83 (39.3)		22 (11.5)	65 (32.9)	
Relief food	11 (5.2)	13 (6.2)		5 (2.6)	8 (4.1)	

[a] Values are numbers (%).

[b] P-value is for chi square test between affected and control during food-plenty season.

[c] P-value is for chi square test between affected and control during food-poor season.

*Denotes significant association when $P < 0.05$.

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households during both seasons (Table 4). A high proportion of both the affected (72.0%) and the control (63.0%) during the food-plenty season while 89.0% of the affected and 78.6% of the control during the food-poor season, reported that landslides affected the households' food- and nutrition security. Moreover, a significantly higher proportion of the affected households reported that the provision/sourcing of food limited their ability to provide other amenities like health, water, housing, clothing and education during the food poor-poor season compared with the control households (55.8%) (Table 4).

KIs and FGDs further acknowledged that landslides affected the food and nutrition security and the RtAF of landslides victims. Landslide effects were linked to disruption of the social determinants of health (food, nutrition, water, education, sanitation, land and transport). Destruction of crops, water contamination and outbreak of epidemics like cholera immediately after landslides stood out as key issues among the KIs and FDGs (S1 Table).

Awareness about the principles of human rights (participation, accountability, non-discrimination and transparency) and the State obligations of respect, protect and fulfil was significantly lower among both the affected and the control at both seasons ($p < 0.001$ in all) (Table 3). Similarly, the discussions from FGD were shallow in relation to whether the human rights principles of participation, accountability, non-discrimination and transparency were taken into consideration during the response of public authorities to the disasters. This was due to low awareness about human rights including the principles of human rights among the FDG participants and KIs. Human rights were thought to be issues of the developed countries as pointed out by one FDG participant (S1 Table). However, some FDG participants interpreted topics about participation and non-discrimination in relation to decision making and distribution of relief food during disaster management. FDG participants noted that the elected leaders participated in decision making on their behalf and there was no discrimination of any case in relation to food distribution (S1 Table). Low awareness about the principles of accountability and transparency were also a challenge among the key informants who acknowledged not to be fully conversant with all the principles of human rights (S1 Table).

Concerning the obligation of the State to ensure that no Ugandan suffers from hunger and malnutrition even in times of disaster, KIs agreed that it was the government's obligation to ensure that no Ugandan suffers from hunger and malnutrition even in times of disasters (S1 Table). The government's obligations were linked to provision of relief food and creation of an enabling environment that allows non-state actors to participate in the disaster response processes to mitigate food insecurity and malnutrition.

When asked about the preferred means to ensure the RtAF of disaster victims among the three choices of: relief food, cash-hand out, or resettlement land for food production, the most preferred means to ensure the RtAF of disaster victims were cash hand-out followed by resettlement land for agriculture by both the affected and the controls during both seasons (Fig 4).

A difference in responses between the affected and control households was exhibited during both food seasons ($p < 0.001$in both) (Table 4). Equally, FGDs and KIs mentioned that provision of cash hand-outs as the most preferred means for ensuring the RtAF among landslide victims (S1 Table).

Regarding whether the disaster response in the study area was satisfactory; both the FGDs and KIs expressed lack of satisfaction about the disaster response in the study area. Relief food usually beans and posho (maize cornmeal) was cited as the main disaster response received from the government yet the landslide victims usually had other needs like shelter, clothing, safe water, cooking fuel and psycho-social support among others. The lack of variety in the relief food and inability to target the nutritional needs of vulnerable groups specifically the young children below 5 years stood out as a major issue (S1 Table).

On the issue of how the State should ensure the realization of the RtAF of landslide disaster prone communities, varied responses from FGDs and KIs included: sensitization of people about the RtAF, enforcement of existing policies, creation of an enabling environment for people to feed themselves in dignity and provision of adequate food in circumstances beyond peoples' control (S1 Table).

Discussion

The affected households presented relatively higher food insecurity and lower dietary diversity scores during both food seasons compared with the controls and the magnitude increased during the food poor season. This contradicts findings in our previous study [29], that found lower food insecurity and higher dietary diversity among the landslide affected communities in Bududa District. This contrast is possibly due to the massive and disastrous nature of the

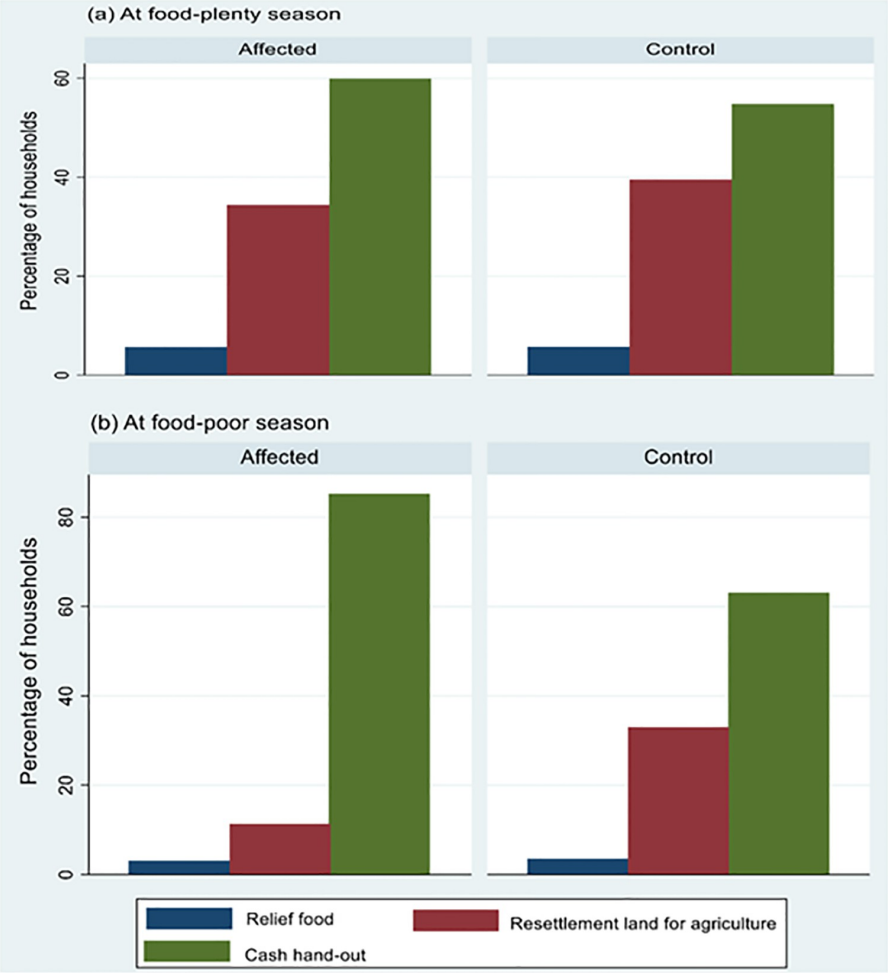

Fig 4. Most important aspect for ensuring the right to adequate food among households in the landslide-prone communities during: (a) food-plenty season (May-August) and (b) food-poor season (January-March).

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2010 landslide disaster that gathered both national and international disaster response in terms of emergency interventions in areas of water, sanitation, hygiene, health promotion and relief food assistance among the landslide victims [29, 45, 46], hence the reduced food insecurity and higher dietary diversity. Consistent with our current findings, a recent study in Haiti found more food insecurity and poor dietary diversity among participants who were severely impacted by a hurricane compared to the less severely impacted participants [47]. In our setting, the relatively higher food insecurity and low levels of dietary diversity might be attributed to the long-term effects of landslide disasters and related shocks that led to prolonged deprivation of livelihoods and the means to secure an adequate and a diverse dietary among the affected households [3, 48].

Our study also found that the severity of food insecurity and lower dietary diversity among the affected households increased during the food-poor season. This is in line with studies from rural Southwest Uganda [49] and South Ethiopia [50] that reported increased food insecurity during the dry lean season compared to the food-plenty season. The food-poor season is

characterized with lower food availability both on the farms and on the market, thus the affected probably faced both limited physical access to food on the farm and limited economic accessibility to food on the market due to low purchasing power. Household dietary diversity is a proxy indicator of a household's economic access to a variety of foods [51]. This may suggest that landslide victims' financial costs associated with acquisition of food for an adequate diet could have been threatened by lack of resources during the food-poor season. Equally, consumption of a lower diversified diet may indicate that the affected households' diets were nutritionally inadequate. Prolonged intake of a nutritionally inadequate diet is linked to multiple micronutrient deficiencies that lead to impaired physical and cognitive development, poor physical growth and reduced work productivity which have negative macro-economic impact [52]. Poor diets also contribute to one in five adult deaths, through both insufficient intake of healthy foods and excess intake of unhealthy ones [48].

After controlling for socio-demographic covariates, our findings indicated that regardless of the food season, the disaster event was associated with both food-insecurity and dietary diversity, however the severity was more during the food-poor season and more among the affected households than the controls. Natural disasters are a leading cause of food insecurity as they affect all components of food security, reducing economic and physical access to food availability, utilization, and stability [53]. As such, persistent exposure to landslide disaster probably exposed the community to reduced food supply, and could have restricted access to safe and nutritious food, reduced quantity and quality of food consumed [2]. Moreover, the landslide affected community is located on steep mountainous terrain, restricting accessibility to market places for households to purchase a variety of food to complement their household diets. Increased availability and accessibility to markets usually conditions households to rely on market purchases to improve the diversity of household consumption [54].

The persistent exposure to disasters creates not only immediate effects, but also long-term effects. Landslides usually involve destruction of survival livelihoods, cause loss of human lives and damages to food crops, animals, houses and infrastructures such as schools, markets, health centers, bridges and roads, which directly or indirectly increase the landslide victims' vulnerability to food insecurity. The widespread losses from landslides, which are beyond the landslide victims' capacity to cope with their own resources, is thus not only short-term, but also long term. Therefore, exposing the victims to future food shortages will be manifested in both food seasons.

Primary education level was associated with both household food insecurity and low dietary diversity in terms of scores during both food seasons. Education is one of the determinants of household food security because of its association with economic status of a household [51, 55]. Wealthier households have the resources to purchase more and diverse food than poor households [51]. Less educated parents tend to have lower household income and higher poverty levels and hence have a low purchasing power for more nutritious and highly diversified foods. They may also have limited nutritional knowledge on how to meet health and nutritional needs for the household members.

Livelihood source was not an important factor associated with food security during the food-poor season. This is probably because the majority of the population in the study area is rural and depends mainly on rain-fed subsistence agriculture as a major source of livelihood [23, 35]. In rural subsistence agricultural settings, the food-poor season is characterized by intensive preparation of farm lands, depleted food stocks from the previous harvest and limited income-generating avenues [56, 57]. This leads to decreased availability and accessibility to food, both on the farms and on the markets due to lower crop production and higher food costs respectively.

The majority of both the affected and the control households answered in the affirmative when asked to the questions on the household not eating food that was safe and on the

question of a household eating less nutritious food and could not do much about it. This indicates that a bigger proportion of the affected and control households' diets were consuming nutritionally inadequate and unsafe food. Consumption of less nutritious and unsafe food may compromise the overall health and the nutritional status of landslide victims and thus further increasing their vulnerability to food insecurity and poverty related shocks and effects. Additionally, this contradicts paragraphs 10 and 11 of GC 12 that emphasizes the importance of assuring food safety and the perceived nonnutrient-based values attached to food and food consumption as crucial for the realization of the RtAF [3]. Also this may further delay the progress towards achieving SDG Target 2.1 of ensuring access to safe, nutritious and sufficient food for all people all year among the vulnerable victims of landslide disasters.

A considerable proportion of the households reported that the high expenses and economic demands on provision of food for their households limited their ability to provide other amenities like health, water, housing, clothing and education. Similarly FGDs and KIs cited landslides to affect sectors of food, health, water, education and transport among others. This reaffirms the interdependency, indivisibility and interrelatedness of humans rights [3]. Inability to achieve one human right, such as the right to adequate food, does affect the realization of other rights like in this case, the right to health [58–60]. This shows that households in Bududa District were accessing food in ways that were not sustainable and thus interfering with the enjoyment of other human rights. This is inconsistent with paragraphs 8 and 13 of the GC 12 that stresses that food should be accessible in ways that are sustainable such that the attainment of other basic needs are not threatened or compromised as a core condition for the realization of the right to adequate food [3]. It may also be plausible to argue that, the households were struggling to put food on the table and in doing so, they compromised or constrained the attainment of other basic needs like safe water, health and housing.

Cash-handout stood out as the most preferred aspect for ensuring the RtAF among the affected and control households during both food seasons. This contradicts our previous findings [61] where both the affected and control households preferred the provision of land for food production as the outstanding choice to ensure the RtAF of disaster victims. This is probably linked to previous findings in the same area which showed that the relief food in the area was of limited variety mostly dominated by dry rations of maize flour and beans, often less preferred and less desirable [61]. Similarly, this is possibly because the landslide victims were previously resettled in a different district on land with lack of land ownership and not sensitive to the *"Bamasaba"* culture and food security needs. It is plausible that the provision of cash presents the landslide victims with the opportunity to be resettled to safer areas of their choice and on land with full land ownership rights and with favorable and familiar factors such as high soil fertility, geographical location similar to Bududa District and sensitive to the *"Bamasaba"* culture including culturally acceptable foods. Similarly, provision of cash is thought to be quicker compared to construction of houses for the landslide victims as noted by the State Minister in charge of disaster preparedness management in Uganda [62].

Our findings also indicated low awareness about the RtAF, State obligations and principles of human rights among the study participants. This corroborates findings in Uganda that found low knowledge and low awareness on the RtAF and related State obligations among duty bearers [63, 64] and rights-holders [61]. Knowledge and awareness about the RtAF by duty-bearers and rights-holders is an essential pre-condition for the realization of the RtAF. This situation of limited awareness of human rights and the right to adequate food in particular by the key State actors narrows the possibilities of pursuing for remedies and recourse mechanisms in the case of violations. Whereas rights-holders may be deprived of this human right without knowing it [43], they need to know whom to hold accountable and to whom they should direct complaints in case of violations of their RtAF.

A major strength of our current study is the longitudinal cohort design that allowed for an account of possible seasonal variations in food insecurity and dietary diversity among victims of landslide disaster. We employed a mixed methods approach to add credibility and depth to the findings as recommended in the human rights research approach [37]. Study limitations included the possibility of bias in socio-economic and demographic variables, and we do not have data on actual food intake, body composition or biomarkers of nutrient intake. Moreover, the landslide affected sub-county may have differed from the control (neighboring) sub-county in other aspects than just landslide. Floods were also experienced during the study period, and possibly they may have affected the food and nutrition outcomes of the study participants.

We conclude by re-echoring that, this study provides evidence of the impact of seasonal variations on food insecurity and dietary diversity among the rural vulnerable populations distressed with landslide disasters in Uganda. Whereas the severity of food insecurity and low dietary diversity were more pronounced among the affected households than the controls during both food-seasons, the right to adequate food of landslide victims was not sufficiently realized. Therefore, underlying determinants of food insecurity, dietary and the RtAF among poor rural landslide prone households should be addressed in an integral manner. The Uganda National Development Plan III 2020/21-2024/25 and its specific programs which are crucial for food and nutrition security, should give greater attention to the serious and growing problem of landslides. Strengthening and expanding the social protection programs to alleviate landslide victim's vulnerability to food insecurity in the face of landslides is key if we are to achieve "zero hunger" by 2030 and the right to adequate food for all. Policy actions that promote landslide victims' accessibility to and ownership of land in risk-free areas are important. Similarly, policies that promote nutrition-sensitive agricultural production, diet diversification and robust legally appropriated and reliable disaster-specific public social safety nets such as unconditional cash transfers are of essence. In the long-term, education and income diversification program interventions need to be integrated into disaster recovery programs since they are central in enhancing the resilience of rural livelihoods to shocks and stressors affecting the food system.

Supporting information

S1 Table. Themes and quotes from focus group discussants and key informants.
(DOCX)

S1 Checklist. STROBE statement—Checklist of items that should be included in reports of *cohort studies*.
(PDF)

S1 Questionnaire. Inclusivity in global research.
(PDF)

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Supplementary table 1

S1 Table. Themes and quotes from Focus Group Discussants and Key Informants

Question	**Themes**	**Quotes**
What is the situation of food and nutrition security in the study area?	Food and nutrition insecurity	*"Generally, the food and nutrition security in Bududa District is bad due to the persistent landslides that affect so many communities…"* (KI-1*)* *"The situation is not good at all; our people here do not have enough food to eat. Sometimes they rely on only a few varieties of foods"* (KI-3) *"Bududa District is a food basket in this region with nutritious foods, however due to the persistent landslides, the food and nutrition security has become poor"* (KI-8) *" …the food and nutrition situation is very bad…especially to us who have suffered from landslides, we hardly have enough food to eat and to feed our children"* (FGD-2 Affected) *" …because of persistent lack of enough food and money, many of our people are consuming maize flour and beans which are insect-infested and with a bad smell and taste throughout the food seasons*" (KI-2)

	Undesirable diet diversity	*"We mainly consume beans and posho almost every day… we do not have money to buy other foods like meat…" and "the situation becomes worse during the dry season where you can hardly get any vegetable in the garden…"* (FGD-4 Affected group) *"Our people rely depend on a monotonous diet all every day and the situation is tougher during the dry season "* (KI-1)
Where?	Landslide affected community	*"Immediately after landslides have occurred, the food security is very bad among the landslide affected communities"* (FGD-1 Control group) *"Our people in the landslide affected communities are more affected than the people in the non-landslide affected communities and the situation is worse during the dry season"* (KI-9)
Who are most affected?	Vulnerable groups	"*The most affected are generally young children below 5 years, pregnant and lactating mothers, the elderly and the sick"* (FGD-2 Affected group) *"The young children are affected especially when the family head who was a bread winner dies due to landslides"* (KI-10) *" The young children are the most affected"* (FGD-8 Control group)

When?	Seasonality	*"The food situation is bad since the area is a hot spot for landslides. However, it is worse immediately after a landslide and during the dry season"* (KI-3) *"It is usually poor during the dry season when there's hardly any food in the gardens and the food in the market is usually very expensive"* (KI-7). *"It is somewhat better during the harvest season as we have food to eat and we can sell some food to the market to buy another food like meat"* (FGD-8 Control group) *"During the dry season, most of the crops dry off including vegetables…there is scarcity of food in the dry season""…and it is even worse when we do not have money for buying food"* (FGD-10 Affected group).
Whether landslides affected the food and nutrition security and RtAF of landslides victims	Right to adequate food dimensions	*"Yes, landslides have a very big impact on the food security of our people"* (KI-2) *"Yes, landslides seriously affect the type of food we eat…; landslides destroy our crops and kill the few livestock we have. This makes us to have no food or limited food for consumption"* (FGD-16 Affected) *"When a landslide occurs, food is destroyed, the animals are killed, roads are cut off and people fail to access their gardens"* (KI-10) *"Landslides destroy the crops, animals, poultry which families depend on"* (KI-9).

		"Animals like cattle are killed, therefore no more milk for the children"(KI-6) *"Water gets contaminated and we have to walk long distances in search of water for drinking and home use"* (FGD-7 Affected group) *"Vegetables are washed away, and we remain with no vegetables to cook"* (FGD-4 Affected group) "*Landslides usually are followed with some epidemics like cholera that mainly affect our young children"* (KI-1) *"Our people consume poor quality and quantity of food since most of the food gets destroyed during landslides"… and many of our people can hardly consume 4 meals per day and the situation is worse during the dry season"* (KI-3) "*When landslides occur, almost all sectors are affected...food is destroyed, water systems and sources get contaminated, transport is cut off, hence no access to health centers by both the service providers and the local natives and there is limited accessibility to land for food production…"* (KI-8)
Whether the disaster response in the study area is satisfactory	Right to adequate food dimensions	*"No, it is not. Satisfactory. Usually the Office of the Prime Minister sends in relief food which is mainly beans and posho"…yet the disaster affected victims usually face many*

		more problems ranging from lack of shelter, clothing, cooking fuel and psycho-social support among others…" (KI-1) *"The relief food does not take into account the nutritional requirements of specific vulnerable age groups like the young children"* (KI-4) *"Disaster response is improving, it is not like before, atleast we now have emergency capacity like tents to handle emergencies due to disasters"* (KI-3) *"We are all given the same type of food irrespective of whether you have a young child or not!"* (FGD-7 Affected group)
Whether the human rights principles of participation, accountability, non-discrimination and transparency are taken into consideration during the response of public authorities to the disasters	Right to adequate food dimensions	*" We are not aware about those things of human rights, the people in the big offices are the ones who know them"* (FGD-13 Control group) *" Our leaders sometimes meet with the government to represent our issues concerning human rights"* (FGD-5 Affected group) *"Accountability and transparency are not well understood, even us the leaders of this area are not fully conversant with all the principles of human rights"* (KI-9) *"Our people partly participate in the decision making through their elected leadership"* (KI-5)

		"Equality and non-discrimination are upheld at all stages during distribution of relief food, … when food is being distributed, no one is discriminated on the basis of race, colour, ethnicity, gender, age, language, religion, political or other opinion, national, social or geographical origin, disability" (KI-2) *"Human dignity is ensured ,government distributes food that is fit for human consumption"* (KI-1) *"Human rights are issues of the developed countries…; they cannot work here in our poor country..."* (FGD- 12 Affected group)
What is your perception on the fact that it is the obligation of the State to ensure that no Ugandan suffer from hunger and malnutrition even in times of disaster?	Right to adequate food dimensions	*"Yes it the government's obligation, to ensure that no Ugandan suffers from hunger and malnutrition even in times of disaster"* (KI-3) *"We are not aware of state obligations; however we know that if we are faced with landslides, the government is supposed to help us with food and shelter…"* (FGD-2 Affected group) *"Our government provides relief food during disasters… and has allowed Civil Society Organisations and Non-Government organisations to participate in the disaster management processes to fight food insecurity and malnutrition"* (KI-10)

		"Government should put up and enforce strong policies that will prevent people from suffering from hunger and malnutrition" (KI-3)
How the State should ensure the realization of the right to adequate food of landslide disaster prone communities	Right to adequate food dimensions	*"Government should sensitize the people about these rights, so that people can demand for them from the people with authority in the respective government institutions"* (KI-6) *"Government should educate us about human rights through our local radio stations and our local leaders"* (FGD-10 Control group) *"Government should create new policies and strictly enforce the existing policies that are linked to food and nutrition security "* (KI-2) *"In times of disasters, government should provide a well-diversified and balanced diet to the disaster victims"* (KI-4) *" Government should create an enabling environment that ensures that every Ugandan feeds himself in dignity"* (KI-3)
The most preferred means to ensure the right to adequate food of disaster victims	Right to adequate food dimensions	*"Cash hand-out is most preferred aspect for ensuring the right to adequate food because it gives the victims liberty to buy land and food of their choice"* (KI-1) *"Relief food is often of limited variety and of poor quality and some landslide victims sell off the given relief food"* (KI-15)

		"Cash handout is the best option since it comes with the freedom for one to buy safe land of his or her choice" (FGD-14 Affected group) *"Cash handout is the best…for people to buy their own food"* (FDG-13 Control group)

Notes: KI- Key informant; FGD- Focus Group Discussion; RtAF- Right to adequate food

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***
Based on clean version of revised manuscript by Nahalomo et al.

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-7, table 1
Objectives	3	State specific objectives, including any prespecified hypotheses	6-7
Methods			
Study design	4	Present key elements of study design early in the paper	7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	8
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	9-14
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	9-14
Bias	9	Describe any efforts to address potential sources of bias	14-15
Study size	10	Explain how the study size was arrived at	8
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	14-15
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	14-15
		(*b*) Describe any methods used to examine subgroups and interactions	
		(*c*) Explain how missing data were addressed	
		(*d*) If applicable, explain how loss to follow-up was addressed	
		(*e*) Describe any sensitivity analyses	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	15, Fig. 1
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Table 2
		(b) Indicate number of participants with missing data for each variable of interest	
		(c) Summarise follow-up time (eg, average and total amount)	

Outcome data	15*	Report numbers of outcome events or summary measures over time	Tables 3-4, fig. 2 and 3
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (*b*) Report category boundaries when continuous variables were categorized (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Tables 3-4, fig 2 and 3
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Tables 3-4, Suppl table 1
Discussion			
Key results	18	Summarise key results with reference to study objectives	27
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	31-32
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	27-31
Generalisability	21	Discuss the generalisability (external validity) of the study results	27-32
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	In web site of PloS One

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.

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The questions have been designed to be applicable to a wide range of study types, and there are subsections for both human subjects research and non-human subjects research. If any of the questions are not relevant to your research please mark them as "N/A" as appropriate.

Ethical considerations, permits and authorship

This section is applicable to all research types.

Provide details as to who granted permissions and/or consent for the study to take place in the Methods section of your manuscript. This should include the names of **all** ethics boards, governmental organizations, community leaders or other bodies that provided approval for the study. If individuals provided approval refer to these people by their role or title but do not list their name(s).

Reported on page number: 10

If there were any deviations from the study protocol after approval was obtained please provide details of these changes in the Methods section of your manuscript.

There were no deviations from the study protocol.

Did this study involve local collaborators that are residents of the country where the research was conducted or members of the community studied? If you do not have any authors from said communities, please provide an explanation for this below.

Yes, the study included Ugandan residents, namely authors: AN, AK, ABR and PMR.

Everyone listed as an author should meet PLOS' criteria for authorship and all individuals who meet these criteria should be included in the author byline, rather than the acknowledgements. Authorship criteria is based on the International Committee of Medical Journal Editors (ICMJE) Uniform Requirements for Manuscripts Submitted to Biomedical Journals - for further information please see here: https://journals.plos.org/plosone/s/authorship.

Human subjects research (e.g. health research, medical research, cross-cultural psychology)

Did you obtain written informed consent from a representative of the local community or region before the research took place? How did you establish who speaks for the community? Details of written informed consent obtained from study participants should be reported separately in the Methods section of your manuscript.

We obtained consent from all study participants, as described on page 10.

How did members of the local community provide input on the aims of the research investigation, its methodology, and its anticipated outcome(s)?

They were actively engaged, e.g. as participants in focus group discussions and with interviews.

When engaging with the local community, how did you ensure that the informed consent documents and other materials could be understood by local stakeholders?

The information was verbally explained to the study participants, and written information was available in the local language.

Will the findings of the research be made available in an understandable format to stakeholders in the community where the study was conducted (e.g. via a presentation, summary report, copies of publications, etc.)? Please provide details of how this will be achieved.

This paper is part of the first author's (AN) PhD thesis. When the thesis is completed we will return to the study areas and give presentation in the form of seminars, meetings etc. We will give out copies of this paper. Note, we did this after the last author (PMR) had finished his PhD in 2016, and with great

Non-human subjects research using specimens/ animals collected as part of the study, or those housed in archival collections. Examples include archaeology, paleontology, botany and zoology.

Did the permission you obtained from a local authority to perform the study include an agreement on access to outputs and benefit sharing? This may include procedures to enable fair distribution of the benefits and resources arising from the research performed. Please include any details of Prior Informed Consent and Benefit Sharing Agreements obtained. These may be required by field-specific regulations, for example the Convention on Biological Diversity (CBD) and the associated Nagoya Protocol.

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How was the potential cultural significance of the materials collected in your study to local communities considered in your research design? Were Indigenous peoples and/or local researchers and institutions involved with archaeological excavations / collection of specimens? If so, please provide a description of their involvement.

N/A

If your manuscript includes photographs of human remains please indicate whether authors obtained permission from descendants or affiliated cultural communities to do so.

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III

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Original article

Seasonality- and disaster effects on food variety and food insecurity coping strategies among a landslide-prone cohort

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SUMMARY

Background & aims: Landslides may impact on nutritional health among vulnerable populations. However, there is limited data on the seasonal effects of landslides on diet and food security. Among the 2010 and 2018 households affected by the landslides in Eastern Uganda, we assessed seasonality and disaster effects on food varieties consumed and food insecurity coping strategies. This study is among the first to report on seasonal- and disaster effects on food varieties and food insecurity coping strategies among vulnerable populations in Uganda.

Methods: We used a three-stage simple random technique to select a total of 422 households during May–August (food-plenty season) in 2019, of whom 211 had been affected by the landslides and 211 had not (controls). Six months later, in January–March (food-poor season) of 2020, 388 households were re-assessed (191 affected and 197 controls). We analyzed data only from the households that participated in both food seasons to compare results between the two food seasons. Food variety scores (FVS) were obtained by summing the frequency of weekly intakes of 86 food items while a coping index was derived based on the severity weighting of household food insecurity coping strategies.

Results: After adjusting for covariates, significantly lower mean (SE) FVS were among the affected than controls during the food-plenty season: 9.3 (0.5) vs 11.4 (0.3), and during the food-poor season: 7.6 (0.5) vs 10.1 (0.1) ($P < 0.001$ for both). The affected households were more likely to use food insecurity coping strategies compared to controls (mean [SE]: 35.2 [2.1] vs. 27.1 [1.8], $P < 0.001$) during the food-plenty season and the severity further increased during the food-poor season: 42.1 (2.1) vs. 28.2 (2.1) ($P < 0.001$). Disaster exposure was associated with both household food varieties and food insecurity coping strategies during both food seasons ($P < 0.001$). The adjusted models, showed that, the affected compared to the controls had a significantly higher likelihood to rely on 5 of the 11 coping strategies during food-plenty season and 9 of the 11 coping strategies during the food-poor season.

Conclusion: Low variety diets and coping strategies among disaster affected individuals cut across seasons and implies needs for strong social protection and targeted safety nets irrespective of season.

1. Introduction

Globally, more than 800 million people are still faced with hunger and about three billion cannot afford a healthy diet, mostly in the rural areas of low-and middle-income countries (LMICs) [1]. This dismal situation is also present in Uganda where 69.2% (30.6

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million) Ugandans are food insecure [1] while 26% and 5% face were already stressed and in a crisis situation of food insecurity, respectively [2] even before the effects of Covid-19 and the Russia–Ukraine war had led to the globally reduced food supply and increase in the prices of some food items.

Consumption of a variety of foods is not only a determinant of nutrient intake, but also improves dietary quality and adequacy [3,4] which are core components of the human right to adequate food, food security and nutrition. Inadequate consumption of a variety of foods in under-privileged rural households is due to many factors, including seasonality [5,6] and natural disasters [7]. Seasonality affects rural livelihoods [8], mostly in LMICs, where the majority of the world's poor, food insecure, and malnourished people live and depend mainly on rain-fed subsistence agriculture [1]. Seasonality effects not only increase the risk for severe acute malnutrition in children [9], but also affects dietary behavior, exacerbate poverty and undermine resilience to adverse shocks [10]. Moreover, effects of seasonality coupled with persistent natural disasters and related shocks are linked to heightened food insecurity [1], often compelling households to adopt coping strategies; actions adopted to situations of food deprivation and risk [11]. However, coping strategies when continuously employed, may negatively affect the quality of life, well-being, diet adequacy, and food security. They also aggravate poor dietary patterns and expose individuals to illness. Consequently, the nutritional health and overall economic productivity may be hampered. Equally, the attainment of the United Nations Sustainable Development Goals, especially number 2 on ending hunger and achieving food security by 2030 [1,12] and the progressive realization of the right to adequate food among vulnerable communities, are negatively affected.

Landslide disasters affect Uganda, mostly around the highland and mountainous areas [13,14]. In March 2010, a major landslide in the Bududa District left over 350 people dead and thousands displaced [13,15]. Inspite of several disaster events having been reported before the major 2010 event [13,15,16], in October 2018, another major incident occurred in the same district and sub-county leaving 60 people dead, 858 people displaced and 144 houses destroyed [17]. Following the major 2010 landslide, we performed a cross-sectional study and identified higher food variety scores among the affected communities compared to the non-affected communities in Bududa District [7]. Also, farmers and relief food recipients had higher food varieties, and the affected households had a higher likelihood to skip a day without eating a meal compared to their counterparts [7]. However, longitudinal cohort data about seasonality effects on food varieties consumed and food insecurity coping strategies among individuals affected landslide by disasters in the country are missing. Hence, we assessed the seasonality effects on food varieties consumed and the food insecurity coping strategies among households in the landslide-prone communities of the 2010 and 2018 landslide disasters in the Bududa District. Information about seasonal effects on food consumption patterns in situations of natural disaster is crucial for formulating and implementing appropriate policies and programmes related to food insecurity for these vulnerable populations under differing seasonal conditions.

2. Materials and methods

2.1. Study design and subjects

We performed a longitudinal survey where the household heads in the survey area, usually women, were the study participants. In order to account for variations in food seasons and minimize seasonality bias, assessments of household were performed twice: during the food-plenty season (May–August 2019), and after six months during the food-poor season (January–March 2020).

2.2. Study location

The Bukalasi sub-county in Bududa District, which was devastated by the landslides of 2010 and 2018, was the affected study site. The Bubiita sub-county acted as the control since it is neighboring Bukalasi sub-county. The Bududa District is located on the foot of the South-Western slopes of Mount Elgon, slightly over 250 km from Kampala, Uganda's capital city. It has an elevated topography that subjects this region to regular disastrous floods and landslides [18]. The average precipitation of the area is above 1500 mm of rainfall per year [13]. The last household survey in 2014 reported that the District had a population of 210,173 people [19], and a high population density of about 952 persons per km^2. The continued agricultural activities on the steep slopes of Mount Elgon with V-shaped valleys and river incisions precipitate a high risk for landslides in the area [13]. The population of Bududa District is mostly rural and depends mainly on subsistence agriculture [13,19].

2.3. Sampling technique and size determination

This study employed a three-stage simple random sampling technique. Using a simple ballot, the control sub-county was selected from a list of sub-counties neighboring the sub-county with the landslide affected households. In each of the parishes that constitute a sub-county, all the villages in the designated affected and control areas were listed and households were assigned into 20 villages using probability proportion to size techniques [20], hence 40 villages in both sub-counties. The third stage involved randomly selecting 11 representative households in each village from the household lists that were generated with the assistance of the area local councils and the research assistants during the pre-survey household mapping and listing exercise. Computer-generated random tables were used to obtain random numbers from a range of an ascending numbered list of village households. Households whose position on the numbered list matched with the random numbers were identified as index households whose head was consulted for interviews.

A computed sample size of 418 households was targeted based on the 35.9% stunting level reported in children 6–59 months old in the Bugisu sub-region [21]. The final sample size was 430 after adding 12 households to cater for non-response. Details of sample size computations have previously been published [22].

2.4. Data collection and measurements

Data from household heads were collected by trained research assistants through face-to-face interviews in the respective homes of each household head. The main data collection tool was pre-tested and structured questionnaires that were translated from English to the local language (Lumasaba) and back-translated into English. The questionnaires comprised mainly close-ended questions related to demographic and socio-economic information, the frequency of food intake and food insecurity coping strategies (Supplementary files 1-3), respectively. The recall period was seven days prior to the interview date.

2.5. Assessment of food variety consumption

Food varieties consumed by a household were assessed using the food variety score (FVS), the count of different food items consumed by a household as a proxy indicator of dietary quality and nutritional adequacy [4]. The FVS was generated based on a list

of food items and a set of frequency-of-use response categories from a food frequency questionnaire (FFQ) over a 7-day recall period (Supplementary file 2). As has been earlier used in Uganda [23,24], frequently consumed varieties totaling 86 food items were listed into 12 groups to facilitate a retrospective 7-days recall by the head of the household: (1) cereals; (2) legumes; (3) starchy roots, tubers and plantain; (4) vegetables; (5) fruits and fruit juice; (6) meat and meat products; (7) poultry and eggs; (8) milk and milk products; (9) fish; (10) fats and oils; (11) sugars and confectionaries, and (12) condiments, spices and beverages.

Household heads were asked whether their household members had eaten each of the listed food items in the previous 7 days preceding the survey and the approximate frequency of use of each of the eaten food items (responses ranging from never, once, 2–3 times, 3–4 times and more than 4 times) was recorded. If the food item was consumed at least once over the 7-day period, a score of 1 was given and if the food item was never consumed, a score of 0 was given.

The FVS for each assigned food group (sub-group FVS) was equal to the summation of the points for each individual food item within the assigned food group. The overall FVS was equal to the sum of the points for all the 12 assigned food groups. Minimum score was 0 if no food item was consumed. Maximum score was 86 if all the listed food items were consumed. Higher scores reflected higher food varieties consumed. We computed the analyzed overall and sub-group FVS into means and standard deviations (SD) or standard error of the mean (SE).

The sub-group and the overall FVS were used to ascertain household food consumption within each assigned food groups and among the 12 food groups, respectively.

2.6. Assessment of food insecurity coping strategies

Food insecurity coping strategies were assessed using a coping strategy index score, generated based on the eleven strategies that were commonly used by households facing food insecurity threats in resource-limited settings [11]. Questions regarding the household's experiences to food access, child hunger and food insecurity coping practices were adapted from the Household Food Insecurity Access Scale (HFIAS) [25], the Community Childhood Hunger Identification Project (CCHIP) index [4,26], and the Coping Strategy Index (CSI) [11], respectively (Supplementary file 3). In particular, four strategies were adapted from the HFIAS: (i) reducing portion sizes, (ii) reducing food for adults, (iii) children going to bed hungry because there was not enough food to eat, and (iv) skipping a day without a household meal; five strategies from the CSI: (i) relying on less preferred and less expensive food, (ii) purchasing food on credit, (iii) borrowing food, or seeking food assistance from neighbors, friends or relatives, (iv) seeking financial support for food, and (v) children eating elsewhere due to no food; and two strategies from the CCHIP: (i) parents eating less food so children can eat and, (ii) children eating less due to inadequate food or means for its procurement.

Data collection assistants with at least a college or university level training were recruited from the study district and trained on the questionnaire content, interviewing, and probing skills before pre-testing the survey tool. Each coping strategy frequently used by households when faced with food insecurity challenges, was ranked for severity using a scale of severity ranging from 1 to 4 points [11]. The frequency of each coping strategy over a 7-day recall period was scored. The severity of coping with food insecurity was computed as a total of weighted scores. A severity score of 1 represented the least severe coping strategy; implying a coping practice likely to be adopted first in times of crises, and 4 represented the most severe coping strategy, a practice that would be adopted as a last resort. The least weight of 1 point was assigned to relying on less expensive and less preferred foods. A weight of 2 points was assigned to: reducing food for adults; eating less as a parent; limiting portion sizes at meals; and purchasing food on credit. A weight of 3 points was assigned to: children eating less food; seeking financial credit to buy food and borrowing food, or seeking food assistance from neighbors, friends or relatives. A weight of 4 points was assigned to: skipping a day without eating a household meal (three main household meals of breakfast, lunch and supper, while excluding snacks or other food eaten outside the household were considered); children going to bed hungry; and allowing children to roam and eat elsewhere due to inadequate food in the household. A severity score for each coping strategy was computed by multiplying its weighted value by the frequency of times a household reported as having experienced it over the last 7 day period [11]. For example, a single category 1 strategy experienced every day would have a minimum score of 7 points ($1 \times 7 \times 1$), while a category 4 strategy experienced every day for the recall period of 7 days would have a maximum score of 28 points ($4 \times 7 \times 1$). The total severity of coping score for each household was a total of the weighted scores for the eleven coping strategies. A maximum severity of coping score for a household that experienced all eleven strategies daily was 210 points [$(1 \times 7 \times 1) + (2 \times 7 \times 4) + (3 \times 7 \times 3) + (4 \times 7 \times 3)$]. We computed the analyzed scores into means and standard deviations (SD) or standard error of the mean (SE).

2.7. Approvals

Makerere School of Health Sciences Research Ethics Committee (no: 2018-082), the Uganda National Council for Science and Technology (UNCST) (no: SS 4967), and the Norwegian Regional Committee for Medical and Health Research Ethics (no: 2019/917) approved this study. Participation into the study was by informed voluntary consent in writing or thumb print signature.

2.8. Statistical analyses

All statistical analyses were performed using Stata (StataCorp. 2019, Stata Statistical Software: Release 16. College Station, Texas, USA). Given that our data had some extreme values that affected normality of the data, crude mean differences in household food variety and food insecurity coping strategy scores were tested using Levene's independent-samples t test due to its appropriateness for application to both normally and non-normally distributed data. The two dependent outcomes (household food variety and food insecurity coping strategy scores), were first tested for linearity with each other using Pearson's correlation (r). Given that the two dependent variables showed a moderate positive correlation in the food-plenty season ($r = 0.38$) and in the food-poor season ($r = 0.46$), a one-way multivariate analysis of covariance (MANCOVA) model was used to test for univariate and multivariate effects while adjusting for the disaster effect and socio-demographic covariates: interviewed head of the household; household head's age; education level; main source of livelihood; household size, asset ownership and migration of a household member in the past 12 months preceding the interview.

Similarly, the likelihood to adopt versus the likelihood not to adopt each of the food insecurity coping strategies was analyzed using multivariate binary logistic regression while adjusting for the disaster effect, interviewed household head, age of the household head, household head's education level, main livelihood source, main source of food, household size, asset ownership, migration and loss of any household member in the past 12 months preceding the survey. The crude and adjusted odds ratio (aOR) with their corresponding 95% confidence interval were obtained to show the

strength of association at a statistical significance of $P < 0.05$. The model fit in the multivariate binary logistic regression was assessed using the Hosmer–Lemeshow goodness-of-fit test. The results are reported according to the STROBE guidelines [27].

3. Results

During the food-plenty season, a total of 422 interviewed participants (211 from the affected and 211 from the control households), were included among the 430 household members who were eligible in the study; six households declined to participate while two incomplete entries were excluded from the analysis. During the food-poor season, a total of 388 among the 422 households (191 from the affected and 197 from the control) were re-assessed. In the final analyses, we included only the households that participated in both food-plenty and food-poor seasons (388 households, 191 from affected and 197 from control) to make the results between these two seasons more comparable.

3.1. Study population characteristics

The interviewed household heads changed significantly by season. During the food-plenty season, there were more mothers among the control than the affected, but this was not the case during the food-poor season (Table 1). The most attained education level among the participants for both the affected and the control households during both seasons was primary. The main source of livelihood for households during both seasons was farming and was significantly different between the affected and the control during both the food-plenty and the food-poor season with a higher proportion of the affected households having been involved in farming than the controls.

Migration of any household member in the past 12 months before the survey was significantly lower in the affected compared with the control households during the food-plenty season. However, it increased significantly among the affected compared to the controls during the food-poor season. Household ownership of assets was higher during the food-plenty compared to the food-poor season in both the affected and the control households. Conversely, it decreased significantly during the food-poor season among the affected compared to the control households (Table 1).

3.2. Seasonal variations in household food variety

Generally, there was a low consumption of food varieties from the 86 food items among the affected and the control households during both seasons (Table 2). On average, the affected households had consumed less than 10 while the controls had consumed less than 12 food items out of the 86 common food items over the seven days recall period in both food seasons.

Our results further showed that, the mean household food variety scores were significantly lower among the affected compared to the controls during both seasons and the mean household food variety scores further decreased during the food poor-season (Table 2). During the food-plenty season, there was a significantly lower food variety consumption of cereals and grains; legumes and pulses; vegetables; milk and milk products; poultry and eggs and; sugars and confectionaries, among the affected households compared to the controls. On the other hand, during the food-poor season, there was a significantly lower food variety consumption of cereals and grains; starch roots, tubers and plantain; legumes and pulses; vegetables; milk and milk products; poultry and eggs; fish and; sugars and confectionaries, among the affected households compared to the controls.

Crude FVS by socio-demographic characteristics (Table 3) further showed that the affected had significantly lower FVS than the for controls among: those with both primary and secondary education; those whose main source of livelihood was farming and who reported migration of any household member in the past 12 months preceding the survey.

3.3. Seasonal variations in household food insecurity coping strategies

Table 4 shows the reported number of times the households had adopted each of the eleven food insecurity coping strategies and

Table 1
Characteristics of the study households.

Variables	Food-plenty season (n 388)			Food-poor season (n 388)			
	Affected (n 191)	Control (n 197)	P[1]	Affected (n 191)	Control (n 197)	P[2]	P[3]
Interviewed household head							
Father	37 (19.4)	16 (8.1)	0.001*	134 (70.2)	157 (79.7)	0.11	0.000*
Mother	146 (76.4)	163 (82.7)		40 (20.9)	25 (12.7)		
Others[4]	8 (4.2)	18 (9.1)		17 (8.9)	15 (7.6)		
Mean (SD) age (years)	32.2 ± 11.9	32.5 ± 11.6	0.74	33.2 ± 11.9	33.9 ± 11.8	0.56	0.10
Household head's education level							
None	6 (3.1)	18 (9.1)	0.21	6 (3.1)	18 (9.1)	0.21	0.72
Primary	150 (78.6)	142 (72.1)		150 (78.6)	142 (72.1)		
Secondary and above	35 (18.3)	37 (18.7)		35 (18.3)	37 (18.7)		
Mean (SD) household size	6.5 ± 2.6	5.9 ± 2.4	0.033*	6.6 ± 2.6	6.3 ± 2.3	0.16	0.16
Main source of livelihood							
Farming	157 (82.2)	115 (58.4)	0.000*	178 (93.2)	173 (87.8)	0.04*	0.000*
Others[5]	34 (17.8)	82 (41.6)		13 (6.8)	24 (12.2)		
Lost any household member in the past 12 months preceding the survey							
Yes	29 (15.2)	33 (16.8)	0.37	8 (4.2)	17 (8.6)	0.07	0.000*
No	162 (84.8)	164 (83.2)		183 (95.8)	180 (91.4)		
Migration of any household member in the past 12 months preceding the survey							
Yes	17 (8.9)	49 (24.9)	0.000*	38 (19.9)	16 (8.1)	0.001*	0.38
No	174 (91.1)	148 (75.1)		153 (80.1)	181 (91.9)		
Household ownership of assets or entitlements[6]							
Yes	126 (65.9)	134 (68.1)	0.18	57 (29.8)	121 (61.4)	0.000*	0.000*
No	65 (34.0)	63 (31.9)		134 (70.2)	76 (38.6)		

[1]*P* value is for chi square or student's t-test between affected and controls during food-plenty season. [2]*P* value is for chi square or student's t-test between affected and controls during food-poor season. [3]*P* value is for chi square or student's t-test between the food-plenty and food-poor seasons. [4]Refers to grandparents or elderly siblings. [5]Refers to trading, casual laborer, fishing or wage employee [6] Such as farm, livestock, poultry, motorcycle, bicycle. *Denotes statistical significance when $P < 0.05$.

Table 2
Overall and sub-group food variety scores among the affected and control households.

Food group	Food items (n 86)	Food-plenty season					Food-poor season					
		Affected (n 191)		Control (n 197)		P[1]	Affected (n 191)		Control (n 197)		P[2]	P[3]
		Mean	SD	Mean	SD		Mean	SD	Mean	SD		
Cereals and grains	5	1.2	0.2	1.4	0.4	<0.001	1.0	0.1	1.1	0.4	<0.001	<0.001
Starchy roots, tubers and plantain	8	1.2	0.2	1.4	0.3	0.03	0.2	0.1	1.1	0.2	<0.001	<0.001
Legumes and pulses	7	2.0	0.3	2.7	0.6	<0.001	1.1	0.1	1.4	0.8	<0.001	<0.001
Vegetables	19	4.0	1.3	4.4	1.2	<0.001	3.2	0.4	3.5	1.3	<0.001	<0.001
Fruits and fruit juices	13	3.2	0.2	3.1	0.1	0.05	2.6	0.5	2.8	0.4	0.29	0.45
Meat and meat products	8	0.5	0.3	0.3	0.5	0.38	0.1	0.1	0.2	0.3	0.45	0.23
Milk and milk products	6	0.4	0.2	0.7	0.3	<0.001	0.3	0.2	0.5	0.2	<0.001	<0.001
Poultry and eggs	5	0.3	0.3	0.6	0.2	<0.001	0.1	0.1	0.2	0.2	<0.001	<.0.001
Fish	4	0.3	0.1	0.3	0.2	0.06	0.1	0.1	0.2	0.1	<0.001	0.95
Fats and oils	3	0.1	0.1	0.2	0.2	0.09	0.0	0.1	0.1	0.1	0.23	0.53
Sugars and confectionaries	3	0.4	0.4	0.6	0.5	<0.001	0.3	0.2	0.6	0.2	<0.001	0.23
Condiments, spices and beverages	5	2.1	0.2	2.3	0.3	0.29	1.8	0.7	2.7	1.2	0.43	012
Total food variety score		9.6	3.4	11.2	4.3	<0.001	8.4	3.2	9.7	4.4	<0.001	<0.001

Values are mean scores ± standard deviations (SD) for each food group for both the affected and control households. [1]*P* value is for student's t-test between affected and controls during food-plenty season. [2]*P* value is for student's t-test between affected and controls during food-poor season. [3] *P* value is for student's t-test between the food-plenty and food-poor seasons.

the assigned weights of severity generated from the pre-test. In general, the affected households were more likely to use food insecurity coping strategies compared to the controls in both seasons (Table 4). The magnitude of using the food insecurity coping strategies increased during the food-poor season.

In the food-plenty season, significantly higher coping frequencies among the affected households were observed on six of the eleven coping strategies: relying on less expensive and less preferred food; limiting portion sizes at meal times; reducing food for adults so children can eat; seeking food assistance from neighbors, friends and relatives, children going to bed hungry because there is no enough food and skipping a day without a household meal.

During the food-poor season, higher coping frequencies among the affected were observed on seven of the eleven coping strategies: relying on less expensive and less preferred food; limiting portion sizes at meal times; reducing food for adults so children can eat: seeking food assistance from neighbors, friends and relatives; children going to bed hungry because there is no enough food; children eating less due to there not being enough food; and skipping a day without eating a household meal. In addition, there was a significant statistical difference on six of the eleven food insecurity coping strategies between the two food seasons (Table 4).

Crude food insecurity coping strategy scores by socio-demographic characteristics (Table 5) further showed that the affected significantly relied on higher food insecurity coping strategies than the for controls among: those whose education was less than primary school; households whose main source of livelihood was not farming and those who reported migration of any household member in the past 12 months preceding the survey.

Table 3
Crude differences in food variety scores among the affected and control households.

Variables	Food-plenty season						Food-poor season					
		Affected (n 191)		Control (n 197)				Affected (n 191)		Control (n 197)		
	n	mean	SD	mean	SD	P[1]	n	mean	SD	mean	SD	P[2]	P[3]
Interviewed household head													
Father	53	9.1	3.2	9.3	2.8	0.23	291	8.6	3.4	9.0	3.1	0.85	0.73
Mother	309	10.1	3.5	10.3	3.4	0.46	65	9.6	3.6	9.9	3.6	0.42	0.42
Others[4]	26	8.2	4.1	8.4	3.1	0.56	32	8.3	4.2	8.7	3.3	0.09	0.48
Household head's education level													
≤ primary	303	9.7	5.4	11.3	4.3	<0.001	316	9.2	5.2	10.2	4.7	<0.001	<0.001
≥ Secondary	83	10.5	4.2	11.2	4.6	<0.001	72	10.2	4.0	11.8	4.5	<0.001	<0.001
Household size													
≤5 members	180	9.1	2.9	9.6	3.3	0.21	159	8.6	3.4	8.9	3.2	0.86	0.10
≥6 members	208	8.6	2.5	9.4	2.6	0.08	229	8.4	4.2	9.2	3.4	0.28	0.82
Main source of livelihood													
Farming	273	9.6	3.6	10.2	3.4	<0.001	351	9.2	3.8	10.1	3.9	0.86	<0.001
Others[5]	116	8.2	3.4	9.0	3.1	0.67	37	8.5	3.7	8.7	3.3	0.06	0.91
Household ownership of assets													
Yes	260	10.4	2.7	10.4	3.1	0.99	180	10.1	3.7	10.4	1.88	0.09	1.98
No	128	9.6	3.0	9.7	2.9	0.67	208	9.8	3.2	10.2	2.27	0.21	1.85
Migration of a household member in the past 12 months preceding the survey													
Yes	66	9.1	3.5	9.8	2.8	0.001	54	8.9	2.9	9.5	2.9	0.001	<0.001
No	322	10.2	2.5	10.4	2.6	0.09	334	9.8	3.3	10.2	3.1	0.07	0.06

Values are mean scores ± standard deviations (SD) for each food group for both the affected and control households. [1]*P* value is for levene's test between affected and controls during food-plenty season. [2]*P* value is for levene's test between affected and controls during food-poor season. [3] *P* value is for levene's test between the food-plenty and food-poor seasons. [4]Refers to grandparents or elderly siblings. [5]Refers to trading, casual laborer, fishing or wage employee.

Table 4
The overall and individual household food insecurity coping strategy scores among the affected and control households.

Coping strategy	Severity weight	Food-plenty season					Food-poor season					
		Affected		Control			Affected		Control			
		Mean	SD	Mean	SD	P[1]	Mean	SD	Mean	SD	P[2]	P[3]
Rely on less expensive and less preferred food	1	3.4	2.1	2.4	2.3	<0.001	3.8	2.4	2.4	2.2	<0.001	<0.001
Limit portion sizes at meal times	2	2.6	2.2	2.3	2.4	<0.001	3.9	2.4	1.9	0.8	<0.001	<0.001
Parents eat less because there is no enough food	2	1.6	1.2	1.8	1.3	0.15	2.0	0.7	1.5	0.3	0.45	0.96
Reduce food for adults so children can eat	2	2.9	1.6	2.7	1.2	<0.001	2.8	1.4	2.6	1.1	<0.001	0.05
Purchase food on credit	2	2.2	1.1	2.3	1.1	0.34	1.3	0.3	1.6	0.6	0.08	0.62
Seek financial credit to buy food	3	2.1	0.8	1.1	0.2	0.28	1.9	0.4	2.1	1.2	0.53	0.86
Seek food assistance from neighbors, friends and relatives	3	2.4	1.5	1.8	1.2	<0.001	2.4	2.0	2.0	1.2	<0.001	<0.001
Children eat less due to there not being enough food	3	2.0	0.6	1.6	0.3	0.56	2.3	0.3	1.6	0.5	<0.001	<0.001
Children allowed to roam and eat elsewhere	4	2.6	0.3	2.1	0.5	0.09	2.4	0.3	1.5	0.6	0.05	0.64
Children go to bed hungry due to not being enough food to eat	4	2.3	1.3	0.9	0.2	<0.001	2.8	1.1	1.1	1.2	<0.001	<0.001
Skip a day without eating a household meal	4	2.2	1.0	1.3	0.2	<0.001	2.6	1.6	2.1	0.4	<0.001	<0.001
Total weighted coping strategy score		35.5	26.4	27.4	16.4	<0.001	42.2	21.6	28.3	19.4	<0.01	<0.001

Data are mean scores ± standard deviations (SD) for each food group for both the affected and control households. [1] *P* value is for student's t-test between affected and control during food-plenty season [2] *P* value is for student's t-test between the affected and control during food-poor season.
[3] *P* value is for student's t-test between the food-plenty and food-poor seasons.

3.4. The likelihood to adopt each of the food insecurity coping strategies at each food season

After adjusting for selected covariates, the likelihood to adopt each of the food insecurity coping strategies differed significantly between the affected and the controls during both food seasons. During the food-plenty season, the affected households had a significantly higher likelihood to adopt 5 out of the 11 coping strategies than the controls (Fig. 1). The affected were more than two times more likely to seek food assistance from neighbors, friends and relatives: aOR, 2.75 (95% CI, 1.62–4.32) and parents eat less because there is no enough food to eat: aOR, 2.08 (95% CI, 1.19–362) than the controls (Fig. 1). Similarly, the affected households had about a twice likelihood to limit meal sizes at meals; rely on less preferred and less expensive; and skip a day without eating a household meal compared to the controls. On the contrary, affected households had a less likelihood to reduce food for adults so children could eat: aOR, 0.47 (95% CI, 0.27–0.84).

During the food-poor season, the affected households had a significantly higher likelihood to adopt 9 out of the 11 coping strategies than the controls (Fig. 2). Specifically, the affected households were more than three times more likely to: rely on less expensive and less preferred foods: aOR, 3.44 (95% CI, 2.68–4.12); limit portion sizes at meal times: aOR, 3.31 (95% CI, 2.12–4.21) and parents eat less because there is no enough food to eat: aOR, 3.36 (95% CI, 1.83–4.41).

Equally, the affected households were more than two times more likely to: seek food assistance from neighbors, friends and relatives; children eat less due to no enough food to eat; children go to bed hungry due to there not being enough food, reduce adult food consumption so children can eat and skip a day without eating a household meal than the controls.

Table 5
Crude differences in household food insecurity coping strategies among the affected and control households.

Variable	Food-plenty season					P[1]	n	Food-poor season				P[2]	P[3]
	n	Affected (n 191)		Control (n 197)				Affected (n 191)		Control (n 197)			
		mean	SD	mean	SD			mean	SD	mean	SD		
Interviewed household head													
Father	53	33.4	27.9	28.1	20.0	0.55	291	44.6	21.7	28.7	19.8	0.26	0.52
Mother	309	36.9	26.4	27.6	16.0	0.000	65	39.2	21.5	22.7	17.9	0.54	0.67
Others[4]	26	18.8	7.9	25.4	17.8	0.05	32	31.3	17.9	33.8	16.1	0.75	0.68
Household head's education level													
≤ primary	303	36.0	26.9	28.7	16.3	0.000	316	42.6	21.2	28.6	18.7	<0.01	<0.001
≥ Secondary	83	33.1	23.8	23.3	16.2	0.000	72	40.3	23.5	26.9	22.2	0.82	<0.001
Household size													
≤5 members	180	37.5	26.3	25.3	15.6	0.000	159	37.8	19.3	25.3	20.2	0.25	0.51
≥6 members	208	34.1	26.4	29.7	17.1	0.06	229	45.1	22.6	30.5	18.6	0.03	0.06
Main source of livelihood													
Farming	273	32.6	26.4	28.2	17.4	0.11	351	53.6	21.7	26.3	17.5	0.44	<0.001
Others[5]	116	38.8	22.3	26.3	15.1	0.004	37	41.4	21.4	28.6	19.6	0.41	<0.001
Household ownership of assets													
Yes	260	29.1	21.2	29.9	15.8	0.34	180	42.0	20.3	31.5	19.3	0.62	0.89
No	128	47.9	30.8	22.2	16.6	0.000	208	42.3	22.2	22.9	18.6	0.18	0.07
Migration of a household member in the past 12 months preceding the survey													
Yes	66	62.3	28.9	32.7	17.4	0.001	54	47.6	24.5	28.6	14.1	0.03	0.001
No	322	32.9	24.7	26.6	15.7	0.009	334	40.8	20.7	28.3	19.8	0.81	0.06

Values are mean scores ± standard deviations (SD) for each food group for both the affected and control households. [1]*P* value is for levene's test between affected and controls during food-plenty season. [2]*P* value is for levene's test between affected and controls during food-poor season. [3] *P* value is for levene's test between the food-plenty and food-poor seasons. [4]Refers to grandparents or elderly siblings. [5]Refers to trading, casual laborer, fishing or wage employee.

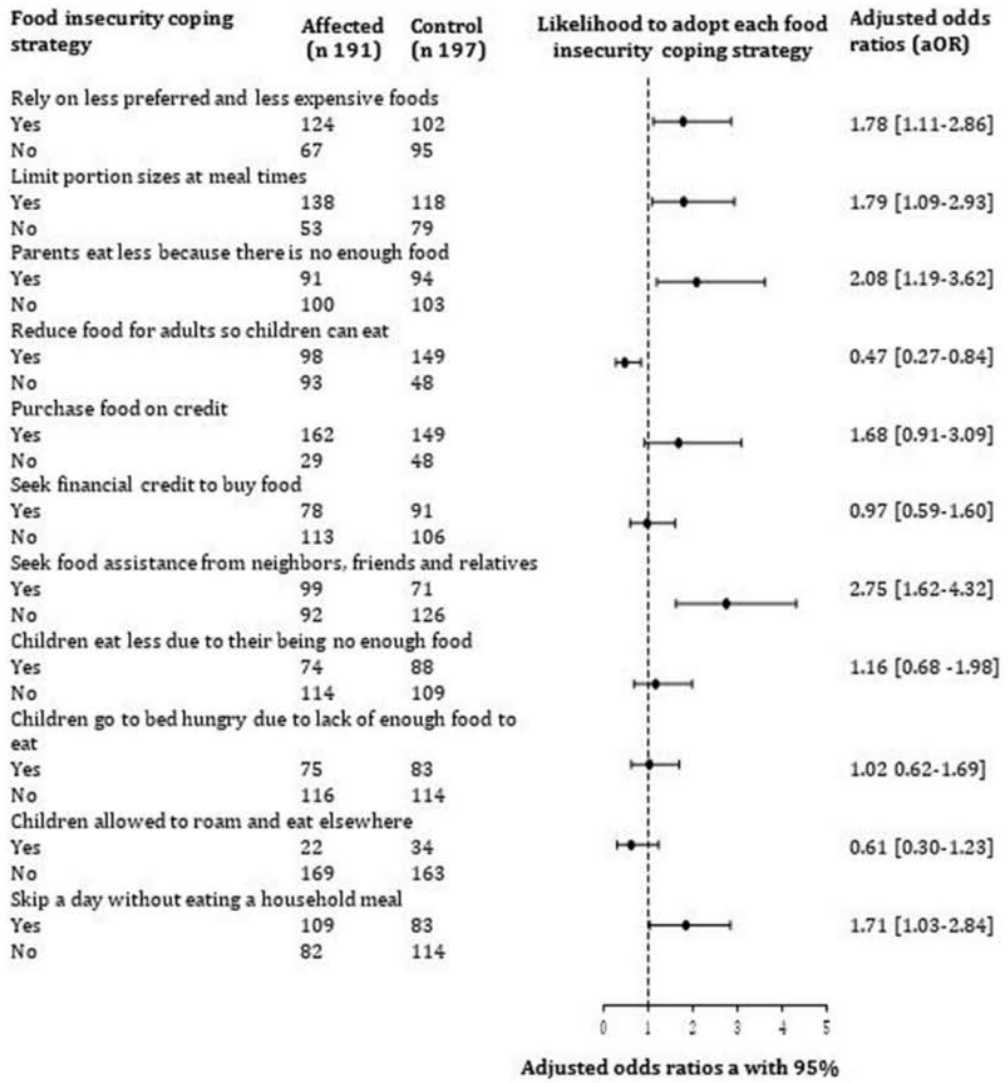

Fig. 1. Likelihood of affected and control households to adopt each food insecurity coping strategy during the food-plenty season.

3.5. Multivariate effects on food variety and household food insecurity scores

In the multivariate model, the MANCOVA test of multivariate effect showed that the disaster effect was associated with both food varieties and food insecurity coping strategies during both food seasons when adjusted for socio-demographic covariates (Table 6). The model further indicated that education level was associated with both outcomes when socio-demographic variables were adjusted for during both food seasons whereas the main source of livelihood was associated with both outcomes during the food-plenty season only.

4. Discussion

The study findings concurred with the hypothesis that seasonal variations and disaster effects influenced the food varieties and food insecurity coping strategies among the affected and control households among landslide-prone communities in Uganda, a LMIC.

Specifically, after adjusting for covariates, we found significantly lower mean household FVS among the affected households compared to their counterparts during both seasons and reduction in the mean of the household food variety scores further decreased during the food-poor season. This result contrasts findings from our previous cross sectional study [7], which reported higher food variety scores among the affected than the controls in Bududa District. This discrepancy is likely attributable to the disastrous nature of the 2010 landslide disaster that gathered both national and international disaster emergency response in areas of water, sanitation, hygiene, health promotion and relief food assistance among the individuals affected by the landslides [28–30]. Such immediate and large-scale response probably limited the nutritional stress caused by the landslide disasters, hence the higher FVS. In our current setting, the lower FVS could be attributed to declining resilience following an additional landslide in 2018, possibly leading to multiple and longer-term effects of landslide disasters and related shocks that exacerbated deprivation of livelihoods and the means to a variety of foods in the diets. This discrepancy might also be due to the permanent migration of some more affluent households (likely with a great food variety) to other places, so the

Food insecurity coping strategy	Affected (n 191)	Control (n 197)	Adjusted odds ratios (aOR)
Rely on less preferred and less expensive foods			
Yes	171	143	3.44 [2.68-4.12]
No	20	54	
Limit portion sizes at meal times			
Yes	147	112	3.31 [2.12-4.24]
No	44	85	
Parents eat less because there is no enough food			
Yes	138	124	3.36 [1.83-4.41]
No	53	73	
Reduce food for adults so children can eat			
Yes	137	118	2.12 [1.43-3.98]
No	54	79	
Purchase food on credit			
Yes	98	144	0.49 [0.30-0.77]
No	93	53	
Seek financial credit to buy food			
Yes	88	85	1.62 [1.00-2.61]
No	103	112	
Seek food assistance from neighbors, friends and relatives			
Yes	136	97	2.94 [1.75-3.73]
No	56	100	
Children eat less due to their being no enough food to eat			
Yes	140	110	2.67 [1.62 -3.38]
No	51	86	
Children go to bed hungry due to lack of enough food			
Yes	106	59	2.92 [1.41-3.72]
No	85	138	
Children allowed to roam and eat elsewhere			
Yes	47	97	0.36 [0.02-0.59]
No	145	99	
Skip a day without eating a household meal			
Yes	128	100	2.22 [1.37-3.57]
No	63	97	

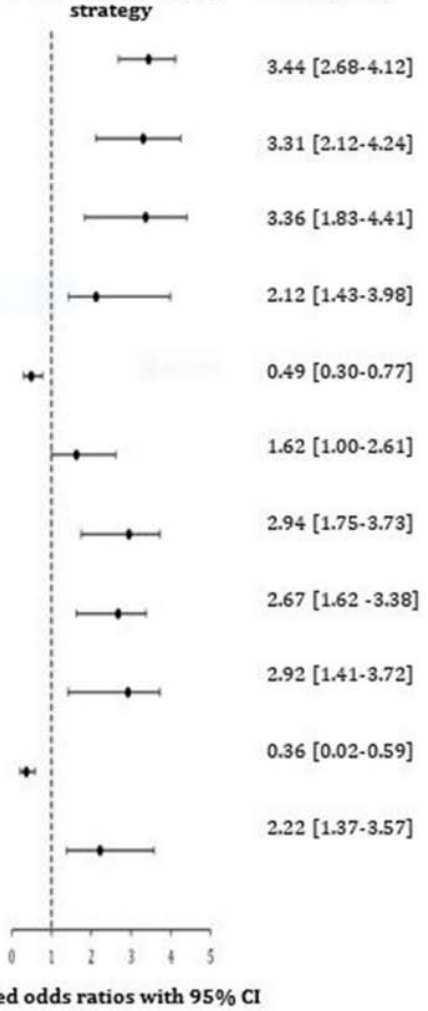

Fig. 2. Likelihood of affected and control households to adopt each food insecurity coping strategy during the food-poor season.

proportion of less affluent people (presumably with less food variety) increased in the affected area. Natural disasters have been showed to be positively associated with migration rates of more educated or skilled people in LMICs [31], presumably with an increased capacity to access food of higher varieties.

The increased reduction in household food variety scores during the food-poor season probably reflects seasonal hunger that constrained food accessibility and consumption of a variety of foods among the landslide affected households during the food-poor season. In rural subsistence agricultural settings, the food-poor season is characterized by decreased availability and accessibility to food, both on the farms due to lower crop production and higher food costs on the market. This further compromises the food quality and varieties, consequently resulting into substantial changes in the consumed diets, and possibly increasing the risk for severe acute malnutrition in children [9].

The affected households were more likely to use food insecurity coping strategies compared to the controls during both food seasons. The magnitude of using food insecurity coping strategies increased during the food-poor season. This shows that the affected households experienced heightened food insecurity during the food-poor season, characterized by limited or uncertain availability and accessibility of nutritionally adequate and safe foods, thus compelling them to rely on more severe food insecurity coping strategies as a means of survival. Prolonged reliance on more and severe food consumption coping strategies has been shown to reduce the quality and quantity of consumed foods [32], thus undermining the nutrient intakes of household members including children. In the due course of time, this consequently undermines the child's optimal growth and development.

The likelihood to adopt each of the food insecurity coping strategies differed significantly between the affected households and the controls during both food seasons. The likelihood to rely on less expensive and less preferred food and skipping meals stood out as major issues among the affected during both food seasons. Coping strategies such as skipping meals and eating less expensive and less preferred foods, can be regarded as negative mechanisms as they do not alleviate food insecurity, but secure the continued existence of people under compromised living conditions [33]. Similarly, prolonged consumption of less preferred foods such as

Table 6
Adjusted differences in household food variety and severity of food insecurity coping strategies among affected and control households.

Variables	Food-plenty season (n 388)								Food-poor season (n 388)							
	ANCOVA[a]								ANCOVA[a]							
		Food variety[b]			Severity of coping[c]			MANCOVA[d]		Food variety[b]			Severity of coping[c]			MANCOVA[d]
	n	Mean	SE	P	Mean	SE	P	P	n	Mean	SE	P	Mean	SE	P	P
Disaster																
Affected	191	9.3	0.5	<0.001	35.2	2.4	<0.001	<0.001	191	7.6	0.5	<0.001	42.1	2.1	<0.001	<0.001
Control	197	11.4	0.3		27.1	1.8			197	10.1	0.1		28.2	2.1		
Interviewed household head																
Fathers	53	9.9	1.0	0.37	30.1	2.2	0.18	0.21	291	9.2	0.1	0.49	43.5	1.8	0.09	0.36
Mothers	309	9.3	0.4		35.2	1.2			65	7.6	0.4		38.2	1.2		
Others[e]	26	10.4	0.3		17.9	0.5			32	10.8	0.2.		29.3	1.3		
Education level of the household head																
≤ primary	303	9.6	0.4	<0.001	36.3	0.2	0.09	<0.001	305	9.7	0.6	<0.001	42.5	0.1	<0.001	<0.001
≥ secondary	83	11.4	0.2		33.1	0.2			83	11.5	0.1		37.6	0.2		
Household size																
≤5 members	180	10.9	1.2	0.87	37.2	1.2	0.76	0.46	159	11.3	0.1	0.89	42.1	0.2	0.69	0.99
≥6 members	208	9.1	0.3		34.1	2.1			229	9.9	1.4		37.2	0.3		
Main source of livelihood																
Farming	273	11.1	0.1	<0.001	32.6	0.1	0.78	<0.001	351	9.1	1.3	0.32	35.2	0.8	0.37	0.18
Others[f]	116	8.8	0.2		38.1	0.2			37	9.3	1.2		38.5	1.6		
Household ownership of assets or entitlements																
Yes	260	9.3	0.1	0.98	29.0	2.1	0.58	0.68	178	10.4	0.4	0.64	42.2	0.2	0.93	0.39
No	128	9.9	0.2		38.4	2.2			210	9.5	0.1		41.3	0.1		

Abbreviations: ANCOVA- Analysis of covariance, MANCOVA – Multivariate Analysis of Covariance, SE - Standard error.
[3] Such as farm, livestock, poultry, motorcycle, bicycle.
[a] Test for univariate effect of each variable on the outcome after adjusting for covariates.
[b] Adjusting for disaster effect, interviewed household head, household head's age, household head's education level, family size, main source of livelihood, household ownership of assets or entitlements and severity of household food insecurity coping strategies.
[c] Adjusting for disaster effect, interviewed household head, household head's age, household head's education level, family size, main source of livelihood, household ownership of assets or entitlements and household food variety scores.
[d] Test for multivariate effect of each variable on both outcomes after adjusting for covariates. Given two dependent variables in the model, Hotelling's Trace value is reported.
[e] Refers to grandparents or elderly siblings.
[f] Such as trading, wages, carpentry.

moldy and insect-infested beans and maize flour due to the inability to purchase better quality beans, poses a risk of intake of food of lower nutritional value [34] and chronic diseases such as cancer and infections [35], which may further compromise the health and nutritional status of the individuals affected by the landslides. In addition, this practice is contradictory to paragraphs 10 and 11 of the Committee on Economic Social and Cultural Rights General Comments 12: The Right to Adequate Food, which stresses the importance of assuring food safety and the perceived non-nutrient-based values attached to food and food consumption as essential for the realization of the right to adequate food [36].

The fact that landslide affected households relied on borrowing food or help from neighbors, relatives and friends to cope with food shortages, may be explained by the lack of community safety nets, public social safety nets and a shortage of social support administrative structures of the Government [37]. Although the family and neighborhood safety nets seem to have been the alternative in this case, the capital base of supportive families is often limited and may not provide long-term prospects and guarantees for sustaining an adequate food supply to the landslide-affected individuals. It is essential to have Government-instituted structures to provide social protection measures to mitigate the severe food insecurity coping strategies such as skipping meals and checking the poor food variety scores at the household level.

Our findings further indicated that regardless of the food season, disaster exposure was associated with both food variety consumption and food insecurity coping strategies, however the severity was more during the food-poor season and more among the affected households than in the controls. Notably, natural disasters are a leading exposure of food insecurity as they affect all core components of food security, reducing economic and physical access to food availability, utilization, and stability [38]. Persistent exposures to landslide disaster probably exposed the community to the reduced food supply, restricted access to safe and nutritious food, and reduced quantity and quality of food consumed [39]. Moreover, the landslide-affected community is situated on steep mountainous terrain, limiting accessibility to market places for households to procure a variety of food to complement their household diets. Greater accessibility to markets has been shown to improve the diversity of household consumption [40].

A major strength of our study is the longitudinal cohort design that allowed for seasonal variations in food varieties consumed and food insecurity coping strategies among households that suffered from two cases of landslides. Our dietary data were derived from a food frequency questionnaire over a 7-day dietary recall, which may have been sufficient to estimate usual dietary intake. Our study had some limitations. There might have been the possibility of recall bias on socio-economic and demographic variables. In addition, this study did not have data on the actual amount of food consumed, body composition or biomarkers of nutrient intake.

5. Conclusion

Our study highlights seasonal- and disaster effects on food varieties and food insecurity coping strategies among landslide-prone communities in Eastern Uganda. The affected households experienced more difficulties in accessing diverse food during both food seasons as depicted by the lower FVS and the increased food insecurity coping strategies.

The likelihood to consume low variety diets and vulnerability of coping among disaster affected individuals cut across seasons and implies the need for strong social protection and targeted safety nets irrespective of season. It is imperative for the Government of Uganda to consider seasonal- and disaster effects which are associated with increasing the severity of food insecurity among households into disaster preparedness and response strategies. This is important in formulating and implementing appropriate policies and programs related to food insecurity in disaster-prone areas in order to ensure the people's right to adequate food.

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Author contributions

P.M.R., P.O.I., B.A.A., A.N.K., and A.B.R contributed to the study design. A.N., and P.M.R., participated in data collection, data analysis, interpreted the results, wrote and edited the manuscript. A.N., P.M.R., P.O.I., B.A.A., A.N.K., and A.B.R contributed to the discussion, reviewed, edited and revised the manuscript.

Declaration of Competing Interest

The authors have nothing to disclose.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.clnesp.2022.11.005.

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Supplementary files 1-3

(Questionnaires on household demographic and socio-economic information, food frequency intake and food insecurity coping strategies).

Supplementary 1: Questionnaire on household demographic and socio-economic information

Date: _____ Village: _____ Cluster No._____ Household ID: _____

Sub county: _____Parish:_____

Section A: Socio-economic and Demographic Characteristics

1. Interviewed head of household: Father_____ Mother ____ Both___ Others_____
2. Age of respondent: _____years
3. How many are you in the household? _____ people
4. Among the household members, how many are children 6-59 months? _____
5. What is your main source of income?
   Wage employee _____ Trading_____ Farming_____ Fishing _____
   Casual laborer_____ Others_____
6. What is the household's main source of food?
   Own production_____ Purchased_____ Own labor_____ others _____
7. What is you marital status?
   Married_____ Single_____ Separated_____ Divorced_____
   Widow/widower_____ Cohabiting_____
8. What is your level of education?
   No formal education_____ Primary level_____ Ordinary level Secondary _____
   Advanced level Secondary _____ Tertiary/college/University level_____
9. Have you lost (died) any family members in the past 12 months?
   Yes _____ (specify if child, relative, mother, father grandparent etc.)
   No_____

9a. If yes, were they playing a role in securing food for the household?

Yes_____ (Specify: _____) No_____

10. In the past 12 months, is there any members of your family who have migrated to other areas due to difficulty in livelihood and survival
    Yes_____ (Specify how many members) _____
    No_____
11. Do you own assets/entitlement (e.g. farm, livestock, motorcycle, bicycles, etc.) that you rely on sometimes to get food?
    Yes_____ Specify _____
    No _____

Supplementary 2: Food frequency questionnaire (FFQ) over a 7-day recall period used to calculate food variety scores (FVS).

In the **last seven days**, did the household eat any of the following foods listed in the Table below?

If yes, how frequent per day and week? (Record the response in the table appropriately).

Food variety groups	Food variety sub-groups	Eaten yesterday (Yes/No)	Number of times consumed	
			Per day	Per week
1. Cereals and grains				
	Maize (Cornmeal, maize kob, roasted maize seeds, porridge)			
	Wheat (bread, samosas, mandazi, chapatti, doughnuts, buns, cakes)			
	Rice (Cooked rice or rice porridge)			
	Sorghum (sorghum bread or porridge)			
	Millet (Millet bread or porridge)			
2. Legumes and pulses				
	Beans			
	Pigeon Peas			
	Cow peas			
	Nuts (Includes ground nuts and ground nut paste)			
	Soybean			
	Simsim			
	Green grams			
3. Starchy roots, tubers and plantain				
	Sweet potatoes			
	Irish potatoes			
	Cassava (Includes whole cassava, cassava flour, fried cassava)			
	Coco yam			
	Yam			
	Creeping yam			
	Roasted plantain (gonja)			
	Banana plantains (*matooke)*			
4. Vegetables				
	Bamboo shoots (malewa)			
	Cruciferous vegetables (cabbage, broccoli, cauliflower)			
	Edible vegetable leaves (Bean leaves, cow peas leaves, coco yam leaves)			
	Bell pepper (Includes red, yellow and green peppers)			
	Tomatoes			
	Onions			
	Carrots			
	Amaranthus (Doodo)(Includes, green doodo or red dodo(bugga)			
	Night shade (Nakati)			
	Spinach			
	Mushrooms			
	Garden eggs (Biringanya)			

	Egg plants (Entula)			
	Okra			
	Garlic			
	Collard greens (Sukuma wiki) or (*B. oleracea*)			
	Cucumber			
	Pumpkin (Includes whole pumpkin, pumpkin flour, porridge, pumpkin seeds and pumpkin leaves)			
	African spider plant or spider wisp (Jobyo) (Cleome gynandra)			
5. Fruits and fruit juices				
	Bananas (Big banana, baby banana, banana juice)			
	Mangoes			
	Passion fruits			
	Guavas			
	Pawpaw			
	Goose berries, indian black berries (jambula), tamarind fruit (enkogge)			
	Melon			
	Apple or pears			
	Citrus fruits (oranges, tangerines)			
	Pineapples			
	Avocado			
	Jack fruit (Ffeene)			
	Sugar cane or sugar cane juice			
6. Meat and meat products				
	Beef (cow meat, cow hooves, cow head, kidneys, sausages)			
	Goat meat			
	Pork (pig)			
	Ham/mutton (sheep)			
	Rabbit			
	Edible rats			
	Offals			
	Liver			
7. Poultry and eggs				
	Chicken			
	Duck			
	Turkey			
	Eggs (All eggs from birds)			
	Pigeon			
8. Milk and milk products				
	Cow’s milk			
	Goats milk			
	Fermented milk/yoghurt			
	Ghee/Butter			
	Cheese			
	Chocolate			
9. Fish				
	Fresh fish			
	Dry fish			
	Fish oils			
	Silver fish (Mukeene)			

10. Fats and oils				
	Cooking fat (solid)			
	Cooking oil (liquid)			
	Margarine			
11. Sugars and confectionaries				
	Sugar			
	Sweets (Includes honey, biscuits, cakes)			
	Banana fritters (Kabalagala)			
12. Condiments, spices and beverages				
	Tea			
	Coffee			
	Spices			
	Salt			
	Non-alcoholic beverage (carbonated soft drinks e.g. soda, fruit flavored drinks e.g. splash)			

Supplementary 3: Household food security coping strategies questionnaire:

In the **last seven days**, how frequently did your household resort to using one or more of the following in order to meet your household food security? (**Complete each coping strategy if the response is yes):**

Coping Strategy		No	Yes	How many times/daily	How many times/week
Four strategies adapted from the Household Food Insecurity Access Scale (HFIAS)					
1	Limit portion size at meal times				
2	Reduce adult consumption so children can eat				
3	Children going to bed hungry due to not being enough food to eat				
4	Skip entire day without eating a household meal (breakfast, lunch, supper)				
Five strategies adapted from the Coping Strategy Index (CSI)					
5	Rely on less expensive and less preferred food				
6	Purchasing food on credit				
7	Seek financial credit to buy food				
8	Borrow food or seek food assistance from neighbors, friends and relatives				
9	Children/household members allowed to roam and eat elsewhere due to there not being enough food				
Two strategies adapted from the Community Childhood Hunger Identification Project (CCHIP) index					
10	Parents eat less food/meal portions so that children can eat more				
11	Children eat less food/meal portions because there is not enough to eat				