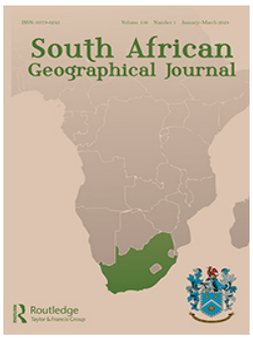

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Enhancing household food security through flood disaster risk reduction in little Ruaha River Basin, Iringa district, Tanzania

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ABSTRACT

The study presents strategies adopted by households in the Little Ruaha River Basin in Iringa district to reduce flood disaster risk thereby enhancing household food security. A mixed research design was employed. Primary data were collected through semi-structured interviews, in-depth interviews, direct field observation and Focus Group Discussions; secondary data were collected through documentary review. The study found that the Little Ruaha river floodplain is very fertile and conducive for crop and livestock rearing. However, the area is frequently affected by flood disasters, thus, making livelihoods at risk. It was also noted that floods in the area affected food production and intensified the households' food insecurity. It shows that to enhance food security in the household, people moved to safe places during floods, planted trees, dredged the river, practised social cohesion, built flood-resistant houses and used early warning systems. It was also revealed that most flood disaster risk reduction strategies were not effective in enhancing household food security. The study, thus, recommends that the government and other stakehodgders need to organize communities to actively participate in flood disaster risk reduction to reduce their vulnerability to floods and enhance household food security.

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Flood plain; Food security; flood; disaster risk reduction; Tanzania

1 Introduction

Floods are among the hazards that affect households' food security worldwide (FAO, 2018: McGlade et al., 2019; IFAD et al., 2019). The United Nations (UN, 2020) reports that food insecurity caused by floods reduced the efforts to achieve the second Sustainable Development Goal (SDG 2) which aims to achieve zero hunger by 2030. The World Food Programme (WFP, 2020) shows that in the past 20 years, more than 2.3 billion people were food insecure globally due to floods, whereby 64% were from the developing countries. For instance, Pakistan was highly vulnerable to flood-induced food insecurity, with more than 50% food insecure households (Chapagain & Raizada, 2017).

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Dewan (2015) and FAO (2015) also reported that 50% of the food insecure households in Nepal and Myanmar were caused by floods, respectively.

Food and Agricultural Organisation (FAO) defines food security as a situation in which all household members always have ability to secure adequate, safe, and nutritious food that meets their dietary requirements (FAO, 1996). Food security comprises four pillars: food availability, accessibility, utilization and stability (FAO, 2014). Equally, FAO (2018) also observed that in most cases floods affected all the four pillars and, in view of that, defined 'food insecurity' as a disruption of food intake patterns because of lack of food. Therefore, flood disaster risk reduction is important to enhance household resilience to flood-induced food insecurity (FAO, 1996, 2014, 2018).

Sub-Saharan Africa (SSA) is the most food insecure region (Gellert, 2020; IFAD et al., 2021; Suhr & Steinert, 2022). For instance, FAO (2018) noted that in the past 20 years, more than 57% of households in SSA suffered from food shortage due to floods. Prosekov and Ivanova (2018) report that 18 out of 20 countries that are the most food insecure globally are found in SSA. Ecker and Keneddy (2019) found that 60% of food insecure communities in Nigeria were caused by floods. Floods affected households' food security in SSA because of farming in floodplains (Akukwe et al., 2018). For instance, Sidibé et al. (2016) revealed that most (83%) of smallholder farmers in Ghana established farming in floodplains. Similarly, Dube (2017) reports that more than 55% of food insecurity communities in Zimbabwe were found in floodplains. Correspondingly, Chawawa (2018) reported that floods in Lilongwe district in Malawi contributed to 12% of maize loss, thus, exacerbating food shortage to floodplain occupants. These studies, however, did not examine how and to what extent the smallholders in floodplains adopted the flood disaster risk reduction strategies to enhance their resilience to the effects of flood disasters, thereby improving the household food security.

Studies have also shown that Tanzania is food secure; however, there are geographical disparities in the food security (URT, 2017). For example, over the past 7 years, Tanzania recorded high number of devastating effects of floods on households' food security (Ires, 2021). Equally, Tanzania Food and Nutrition Centre (TFNC, 2015) reported that food shortage caused by floods has resulted in the growing number of stunted children aged below 5 years. In relation, the United Republic of Tanzania (URT) (2021) revealed that over the past 20 years, the government budget on food importation has risen from 40% to 46% to cover food shortage occurred due to the impact of floods. Likewise, URT (2008) ranked flood in Tanzania as the highest disaster incident due to its effects on household food security. Furthermore, URT (2021) further noted that floods impacted the country's economy by reducing the actual Gross Domestic Product (GDP) growth rate as estimated from 6.6% to 5.5% loss for the year 2020/2021. Also, in 2015, El-Niño event resulted in floods which brought massive damage to agricultural production whereby more than 25,000 households became food insecure in six assessed regions: Arusha, Dodoma, Mara, Morogoro, Mwanza and Shinyanga (Mollet and Barelli, 2016).

A household survey conducted in Iringa region revealed that more than 60% of households said that they have never been satisfied with food security condition (URT, 2013). Moreover, it was revealed that nearly 50% of the smallholder farmers in Iringa district were reported to experience the food shortage (2013). Haule (2019, 2022) found that 76% of households in Iringa district were food insecure. The Little Ruaha River floodplain in Iringa district is potential for food production; however, it is highly

vulnerable to recurrent floods (URT, 2019; Ndimbo, 2021). Thus, many households in the area were affected by flood-induced food shortages (Kangalawe, 2012). Little was known on how and to what extent local communities in the Little Ruaha River Basin (LRRB) reduced flood disaster risk, thereby alleviating, among others, flood-induced food insecurity.

Flood disaster risk reduction refers to the ongoing activity of reducing flood risk through preventing the new and existing risks to rebuild communities' resilience to floods (Zubir and Amirrol, 2011; Kundzewicz et al., 2018). Communities adopt flood disaster risk reduction strategies that suit their context (Bankoff el al., 2004; Phiri et al., 2016). A paradigm-shift from rescue and relief operations to flood disaster risk reduction and flood preparedness is advocated in order to reduce the severity of flood effects on agriculture to enhance household food security (FAO et al., 2021). Local communities' participation in disaster risk reduction is among the five priorities set out by the United Nations World Conference for Disaster Risk Reduction (UNWCDRR) and the Sendai Framework for Disaster Risk Reduction (SFDR) that aim at ensuring a meaningful paradigm shift from a reactive to proactive approach (UNWCDRR, 2005; ISDR, 2015). According to FAO et al. (2021), due to the global relations between communities, there is a need to develop strategies that enhance food security at all groups to achieve sustainable development. Thus, flood disaster risk reduction for food security can be more meaningful if local communities become active participants with the use of local resources (Haulle, 2007; Zubir and Amirrol, 2011).

Disaster Management in Tanzania is placed in the Prime minister's Office where there is Disaster Management Department (URT, 2003). The government formed disaster management policy which, among others, seeks to reduce disaster risk to rebuild livelihoods' resilience; thus, enhancing households' food security. Besides, the policy stipulates that local communities in specific areas should manage disaster risk using local resources (URT, 2003). Katunzi (2013) found that smallholder farmers in Magu district in Mwanza region adapt to the adverse impacts of floods on food security by practising agroforestry. Study by Andrea and Kangalawe (2016) report that communities living in Lower Rufiji floodplain planted trees reduce floods while offering food. Ringo et al. (2016) also added that communities living in Kilombero floodplain planted trees to farm demarcations to protect crops from being swept away by floods.

Studies have also reported on flood disaster risk reduction strategies that communities in Tanzania use to enhance food security (Kangalawe, 2012; Katunzi, 2013). However, little was reported along the LRRB. Absence of the adequate knowledge on the effects of flood along the LRRB motivated the development of the present study which was mainly guided by two specific objectives. First, to examine how floods intensify household food insecurity; and second, to assess the strategies employed by the local communities in reducing the flood disaster risks, thereby enhancing food security. The findings of the present study would contribute to the existing knowledge on the vulnerability of households to flood-induced food insecurity and how flood disaster risk reduction strategies contribute to improve the household food security. Similarly, the findings can contribute to the realization of the second Sustainable Development Goal (SDG) that aims to attain zero hunger by 2030.

This study modified and adopted the Disaster Risk Reduction (DRR) for Food and Nutrition Security (FNS) framework developed by the FAO in 2011. According to

Borychowski et al. (2022) and Yadav et al. (2022), the DRR for FNS framework advocates the need to safeguard livelihoods from disaster risks to make food production sector more resilient. It is built with four important pillars, which are: first, 'enabling environment' which seeks to have an effective institutional framework responsible for DRR for FNS at all levels. Second, 'watch to safeguard' which aims at improving information and Early Warning Systems on food security to build better preparedness and responses to monitor and control different threats to food security (Lam et al., 2012). Third, 'prepare to respond' that seeks at building capacities in preparedness and being able to respond to, and monitor the future threats to food security by reducing their livelihoods' vulnerability to different shocks. Fourth, 'building resilience' that focuses on understanding the underlying threats to food security and builds the resilience of livelihoods through the application of technologies across all food production sectors (Wordofa et al., 2020). Although the framework is responsible for food and nutrition, it was useful in examining how local communities along the LRRB used flood DRR strategies to enhance food security.

2 Material and methods

The study was conducted along the LRRB in Iringa district, the LRRB lies within longitudes 35° 2'E and 35° 36' E and latitudes 7°11'S and 8° 36' S. The study area is found in Iringa region, in the southern highlands of Tanzania. The LRRB is very potential for food production that feeds many people within and outside Tanzania. It is found in the floodplain with alluvial fertile soil that is potential for agriculture. It is among the catchments of the Ihemi Cluster in the Southern Agricultural Growth Corridor of Tanzania (SAGCOT). More than 70% of the people in the study area were employed in agriculture mostly producing food crops and cattle (URT, 2013). The LRRB drains parts of Iringa Municipal, Iringa district, Kilolo and Mufindi district (URT, 2013). Figure 1 presents the study area.

The choice of this study area was based on the recurrent floods that affect food security (Kangalawe, 2012; URT, 2019). Its location in low-lying plain was surrounded by highlands that increase vulnerability to recurrent floods (Ndimbo, 2021; URT, 2019). Again, little was known for its extent to which floods affected the household food security and how local communities reduced flood disaster risk to, among others, enhance the household food security.

Mixed research method was employed whereby the purposive sampling technique was used to sample 16 participants for Focused Group Discussions (FGDs), 8 from each village. This selection was based on their experiences on floods, food security, gender, and age. The study used 11 key informants for in-depth interviews. These were two Village Disaster Management Committee chairpersons (VIDMACs), two Village Executive Officers (VEOs), two Village Agricultural Extension Officers (VAEOs), two Ward Executive Officers (WEOs), the District Disaster Management Committee Chairperson (DIDMAC), the District Environmental Officer (DEO) and the District Coordinator of Red Cross Society of Tanzania (TRCS).

Mbuyuni village in Itunundu ward and Magozi village in Ilolo Mpya ward were purposively sampled due to their vulnerability to recurrent floods because they are located near the Little Ruaha River. The sampling unit was household heads aged 30

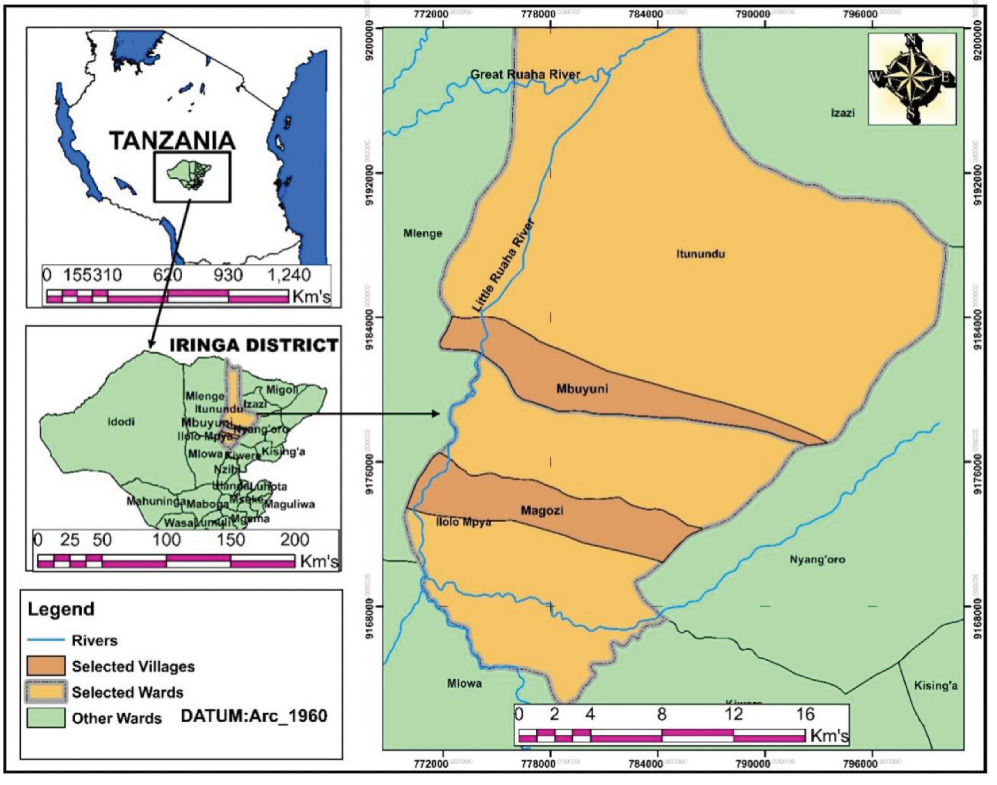

Figure 1. Location of the study area. **Source**: Modified from URT (2021)

and above years. This age was chosen because the study needed individuals' experiences on flood disasters and food security over the past 20 years. Sampling frame was 1290 households, whereas 900 and 390 households were from Mbuyuni and Magozi villages, respectively. This study used a sample size of 10% as recommended by Kothari (2004) that at least 10% of the total population is representative. Thus, 90 and 39 household heads were sampled from Mbuyuni and Magozi villages, respectively, summing up to a total of 129 respondents.

Quantitative data were collected using semi-structured interviews, key themes included; what were the effects of floods on households' food security and what strategies people in the study area used to reduce flood disaster risk to enhance households' food security. Qualitative data were collected using in-depth interviews, FGDs and field observation. In-depth interviews and FGD data collected included; to what extent floods affected food security at the household level and beyond, and what were the most affected food crops. Interviewees and FGD participants were also asked on how each flood disaster risk reduction strategy enhanced food security. Observation method helped to collect evidence of flood effects on food security and the communities' strategies adopted to reduce flood disaster risk while enhancing food security. Secondary data were obtained through documentary reviews in order to triangulate the primary data.

2.1 Data analysis

Quantitative data collected through questionnaires were edited and coded and then were entered into Statistical Product and Service Solutions (SPSS) software version 27. The SPSS software and Microsoft Excel 2010 enabled the determination of descriptive statistics (frequencies and percentages) which made easily the description and presentation of the findings. Qualitative data collected through in-depth interviews, FGDs and observation methods were organized into themes and sub-themes. Photographs were also examined, and captions were used to present key themes. The content analysis was used to analyse secondary data that were obtained from different reviewed documents related to the study objectives.

2.2 Ethical consideration

This study abided to the people's rights and national regulations in research works. The researcher sought clearance from the University of Dar es Salaam and submitted it to Iringa Regional Administrative Secretary (RAS) who directed the researcher to Iringa District Executive Director (DED) who later submitted it to WEOs, then directed to VEOs in the respective villages for data collection. The participants were assured of their anonymity and that participation in this study was voluntary. Besides, the participants were informed that the data collected were confidential and were for the purpose of this study only.

3 Findings and discussion

3.1 Effects of floods on household food security

The study examined how floods contributed to the household food insecurity. The findings show that floods in the study area affected households' food security. Table 1 presents the findings on the diverse impacts of floods on households' food security.

Findings in Table 1 show that most of the respondents (81%) said floods damaged crops before they matured. In-depth interviews with VAEOs affirmed that paddy was the most affected food crop because it was planted near the river through irrigation schemes. During the FGDs, it was revealed that when floods destroyed crops, farmers replanted new seeds; however, not all could afford it as reported by one female in the FGDs in Mbuyuni village:

Table 1. Effects of floods on household food security ($N = 129$).

	Mbuyuni		Magozi		Total	
Perceived Effects	Frequency	%	Frequency	%	Frequency	%
Damage of crops before maturity	79	88	26	67	105	81
Farm damage	79	88	25	64	104	81
Effects on soil quality	64	71	30	77	94	73
Loss of income	63	70	29	74	92	71
Death of livestock	40	44	17	44	57	54
Loss of harvests	49	54	17	44	66	51
Effects on transport networks	28	31	16	41	44	34
Damage of irrigation infrastructure	12	13	9	23	21	16

Source: Filed Data (2021).

> . . . there was water all over my rice farm of one hectare area in 2020, and crop was waterlogged. Finally, my whole crop was damaged, I was supposed to replant new seeds, but I failed because there was no money to buy new seeds . . . .

The findings show that floods affected crops that were not yet matured, and not all farmers afforded to replant new seeds after destruction. In-depth interviews with VAEO in Mbuyuni village revealed that one Kilogram (kg) of the improved rice seeds was sold at the price of 8,500 Tanzanian Shillings (Tshs.), and a one acre of farm needed at least 6 kg which was equivalent to 51,000 Tshs. Further, it was revealed that farmers preferred the improved seeds of rice because they at least tolerated flood conditions. Thus, the findings imply that poor households faced food shortage. Although, it is well understood that floodplains increased livelihood opportunities for poor households, yet, the findings showed that floods caused food insecurity to households in floodplain. Similarly, FAO (2015) reported that most smallholder farmers in Myanmar were food insecure because floods destroyed crops in farms. However, Chawawa (2018) had shown that, although floods swept away crops in Nsanje District in Malawi, the government subsidized the maize seeds to help smallholder farmers to solve the problem of food insecurity.

Findings in Table 1 show that 81% of the respondents admitted that floods destroyed farms. In-depth interviews with VAEOs revealed that about one to three hectares of farms were affected by floods in each flood's year. In-depth interviews with the VEOs indicated that floods swept away farms that were close to the riverbanks. Field observation revealed that floods affected farms which were close either to the riverbanks or near the locally constructed irrigation canals. Plate 1 shows a damaged farm due to floods of 2020. A farm was located near the locally constructed irrigation canal, thus, floods damaged the canal and the nearby farms.

Plate 1. A farm affected by floods at Magozi village.

Plate 1 shows how a farm that was close to the irrigation canal being damaged by floods at Magozi village in 2020. Focus Group Discussions in Mbuyuni village revealed that one acre area of farm cost about Tanzanian Shillings (Tshs.) 400,000 (1$ was equivalent to 2,350 Tshs), from preparations, seeds, weeding and using agrochemicals, and then they harvest about 16 bags of rice, which were to be sold at 50,000 Tshs. per each bag equivalent to a sum of 800,000 Tshs. Therefore, farms' damage affected crop production and income of farmers, thus, created food shortage not only in the respective season but also to the upcoming seasons. Studies by Parvin et al. (2016) and Sarkar et al. (2021) in Bangladesh and India, respectively, found similar findings.

Findings in Table 1 indicate that 73% of the respondents had perceptions that floods affected soil quality. The FGDs in Magozi village revealed that floods caused soil erosion which swept away top fertile soil; thus, farmers were required to use inorganic fertilizers to increase crop yields. But, due to low income, most farmers did not afford as reported by a male FGD participant:

> ' . . . most of us can't afford the cost of using inorganic fertilizers that increase crop yields. For example, in one acre area of farm you need to have one bag of Diammonium Phosphate (DAP) for sowing, which is sold at 68,000 Tshs. Besides, still you need to use one bag for Calcium Ammonium Nitrate (CAN) (58,000 Tshs.) to enhance crops growth; thus, due to low capital we don't use them thus we normally harvest low yields'.

The findings indicate that floods caused soil erosion which removed soil nutrients as they not only affected the food production but also intensified the food shortage. Haule (2019) reports that soil erosion caused by floods in Iringa district reduced crop yields. Equally, Iringa district household survey revealed that soil infertility was a big challenge; however, only 34% of smallholder famers used inorganic fertilizers to increase harvests (URT, 2013). Similarly, Sarkar et al. (2021) found that a few smallholder farmers in rural India afforded to apply artificial soil nutrients in farms after floods had swept away top-soil fertility. By contrast, Akukwe et al. (2018) noted that floods increased soil nutrients that supported the crops to grow healthily. Although it is widely known that floods increased the soil fertility for agricultural production in floodplains that enhance households' food security, evidence from the present study indicates that floods affected the soil quality, hence, reduced food production.

Findings in Table 1 also show that 71% of the respondents expressed that floods affected their income. Focus Group Discussions revealed that due to the floods, people lost crops, livestock and fishing nets as reported by a male participant in Mbuyuni village:

> ' . . . .due to floods of 2020, I lost four bags of maize and two goats, while more than 10 bags of rice were soaked. . .'.

In-depth interviews with VAEOs revealed that one bag of maize was sold at 50,000 Tshs. one bag of rice 80,000 Tshs. and one goat was sold at an approximate price of 60,000 Tshs. Thus, based on the findings on the loss encountered at a household due to floods in 2020, it was evident that a household had to lose more than 1,000,000 Tshs. According to FAO (2018), most households dwelling in floodplains are economically poor. Thus, income loss exacerbated by floods made the situation even worse thus, affected the food security condition. In northern Ghana, more than 25% households become food insecure each year because of floods (Atanga & Tankpa, 2021). Likewise, in Nigeria, floods

were ranked as the first disaster that affects food security by disrupting livelihoods of many people (Echendu, 2022).

Findings in Table 1 show that 54% of the respondents affirm that floods affected livestock. Correspondingly, the FGDs in both two villages showed that floods caused deaths and injuries of goats, cows, sheep, pigs and chickens. Further, it was noted that the most affected livestock were chickens and goats whereby in each flood incident chickens and goats lost were more than 30 and 20, respectively. Indeed, the cows lost over the past 10 years were about 20 as reported by a male participant in Mbuyuni village during FGDs:

> . . . I was asleep when my three cows and two sheep were all taken by floods in 2014.

In-depth interviews with the VAEOs' revealed that a cow was sold at the estimated price from 200,000 Tshs to 1,000,000 Tshs and goat from 40,000 to 100,000 Tshs, while a sheep was sold from 50,000 to 100,000 Tshs. Based on the number of livestock lost by a household, the findings show that floods in 2014 caused loss of income to a household about 600,000 Tshs. Since the livestock were also source of food, it was necessary that the food shortage would occur. During the FGDs in Magozi village, it was revealed that pastoralists normally sold livestock to buy other food items. Thus, loss of livestock that was a flood-induced promoted the food shortage. The findings on the loss of livestock due to floods were also affirmed by Likuwa (2016) in eastern Namibia, where the loss was approximately 15% at each flood's season. Similarly, FAO (2015) reported that the government of Myanmar incurred the cost of assisting pastoralists in floodplains to establish infrastructure that enabled them to reduce flood disaster risk on livestock by improving livestock barns; thus, livestock loss was reduced. The findings suggest the importance of investing in flood disaster risk reduction to reduce livestock loss and to enhance food security.

Household survey indicated that 51% of respondents (Table 1) expressed that floods affected the already harvested and stored grains. Interviews with VEOs also revealed that in each flood's season, households lost more than 10 bags of the harvested grains of rice and maize. Similarly, in-depth interviews with VAEOs showed that most households put the harvested grains on the floor of their houses. Thus, by so doing, they were easily swept or soaked by floods. The findings also show that floods affected the already harvested and stored grains and this resulted in food shortage. Similar findings were reported by Echendu (2022) in Nigeria and Kangalawe (2012) in Tanzania. Findings suggest that to ensure food security, priority should not be on production only but also on storage facilities.

Household survey found that 34% of the respondents (Table 1) agreed that floods affected transport networks. Both FGDs and in-depth interviews with VEO in Mbuyuni village also revealed that the 2020 floods affected the road connecting the study villages with Iringa urban (Pawaga-Iringa Road) by destroying the bridge at Godikafu hamlet; as a result, there was no crossable route from Iringa urban to Pawaga (including the study villages). The findings imply that floods affected roads that were linked with food production and market service. This made a timely transportation means difficult; as such, people failed to access food and farm inputs. Haule (2022) reported that floods broke communication between villages and Iringa urban by destroying road networks in Iringa district. This, again, made it difficult for the households to access the market

services. In the South Sudan, frequent floods of 2019, 2020 and 2021 created food shortage that needed humanitarian supports but the support was constrained by the lack of the effective transport system which was badly destroyed by floods (FAO et al., 2019; Wilkinson et al., 2022). This indicates that effective transport network system is vital to the sustainable food security strategy in any community.

Findings in Table 1 show that 16% of the respondents uphold that floods damaged irrigation infrastructure. During FGDs, two types of irrigation infrastructure were revealed; first was that under Tanzania National Irrigation Scheme; second was that under local communities. The VEOs reported that floods damaged irrigation infrastructure; thus, affected rice production that depended on irrigation. Field observation showed flood deposited materials in the locally constructed irrigation infrastructure and blocked the distribution of water to farms; consequently, it decreased the rice production. Similar findings were reported by Atanga and Tankpa (2021) who revealed that food shortage in northern Ghana was a result of the floods' impacts on the irrigation schemes. Likewise, FAO (2015) found that the government of Myanmar focused on rehabilitating irrigation structures to support rural communities to produce food after floods. For the purpose of ensuring food security in floodplains, investing in effective irrigation infrastructure was paramount.

3.2 Flood disaster risk reduction strategies for enhancing household food security

The study examined the strategies used by the local communities to reduce flood disaster risk to enhance households' food security. The findings in Table 2 show different strategies adopted by the local communities in the study area to reduce flood disaster risk to enhance households' food security.

Flood disaster risk reduction practitioners assert that strategies should base on reducing people's exposure and vulnerability to floods (ISDR, 2015; Wisner et al., 2004). Communities employ a diverse means of flood disaster risk reduction strategies that suit their context. The strategies enhancing the household resilience to the effects of floods include stabilizing the household food security (FAO, 2018). Based on the findings in Table 2, it is evident that 61% of respondents moved to safe places during floods. At village level, findings show that Mbuyuni village had many respondents (84%) who moved to safe places than Magozi village (5%). It was revealed during FGDs in Magozi village that most houses were built in a raised land unlikely in Mbuyuni village where larger numbers of houses were found near the river. Equally, the FGDs in Mbuyuni village revealed that more than 200 households moved during floods of 2020. It was

Table 2. Flood disaster risk reduction strategies ($N = 129$).

	Mbuyuni		Magozi		Total	
Strategy	Frequency	%	Frequency	%	Frequency	%
Moving to safe places	76	84	2	5	78	61
Planting trees	59	66	11	28	70	54
Dredging the river	51	57	11	28	62	48
Social cohesion	47	53	11	23	58	45
Building flood-resistant houses	48	52	9	28	57	44
Early warning system	44	49	10	26	54	42

Source: Field Data (2021).

noted that there were evacuation sites that were at VEO's office, Pawaga secondary school, and Mbuyuni primary school. These places were less affected by floods because of the raised land. In-depth interviews with the VIDMACs revealed that there were task forces in each village that organized evacuation processes. The task forces were supported by Iringa district council, TRCS and ASAS Group of Companies.

The study further revealed that people moved to safe places with only a few movable properties as expressed by a female FGD participant in Mbuyuni village:

> . . . .when there was water in my house, I moved to Pawaga secondary school (safe place) but, I left my 3 bags of maize, 2 bags of rice, after floods I found them soaked.

The findings show that the strategy was effective in saving life of the people but not on enhancing household food security. The Disaster Risk Reduction for Food Nutrition Security framework (DRR for FNS) advocates the need to have strong institutional frameworks and build capacities at all levels to prepare and respond to different threats for food and nutrition security. Mbura (2014) and Dube (2018) noted that flood victims in Dar es Salaam, Eastern Tanzania, and in Tsholotsho district in Zimbabwe were frequently moving to safer places during floods and after floods they could go back to flood prone areas, while the resources they left had already been destroyed. The findings suggest the need to invest in the long-term flood disaster risk reduction strategies that enhance food security in floodplains.

Findings in Table 2 reveal that planting trees was used by 54% of the respondents as a strategy for reducing flood disaster risk. In-depth interviews with the VEO in Magozi village revealed different planted tree species such as *Syzygium cordatum* (locally known as *Mivengi*), reeds, mangoes, banana, and baobab trees. Further, it was noted that tree species were from different sources. For example, *Syzygium cordatum* was from the DEO's office. Interviews with WEOs also indicated that there were by-laws that require each household to plant at least 10 trees per year. However, in-depth interviews with the DEO showed that a large number of planted trees' seedlings could not survive because of the prolonged dry season. Field observation found a few trees close to the riverbanks which had survived due to wet soil.

It was found during FGDs in Mbuyuni village that trees reduced soil erosion and absorbed water, and as such, they reduced floods. Trees like banana and mangoes provided food, firewood, and building materials which sometimes were sold, and the money obtained was used to buy food. Thus, trees improved households' livelihoods and offered physical protection against floods, hence, enhanced the food security. This strategy aligned with the DRR for FNS framework pillar number four that puts emphasis on improving livelihoods to enhance food and nutrition. Advantages of trees in managing flood risk while enhancing food security were reported by Ringo et al. (2016) who found that most planted trees along riverbanks in Kilosa district offered households' food security. Asmara and Ludin (2014), Parvin et al. (2016) also found similar results in Malaysia and Bangladesh, respectively.

Dredging the river was another strategy which was revealed by 48% of the respondents for reducing flood disaster risks in order to enhance the food security (Table 2). During FGDs in Mbuyuni village, it was revealed that river siltation was caused by poor farming in the floodplain and in the highlands of Kilolo and Mufindi districts that caused soil erosion. In-depth interviews with the WEO of Itunundu ward showed that river dredging

removed the deposited materials to slow floods. Furthermore, it was noted that the activity was coordinated by the National Irrigation Council of Tanzania in collaboration with Ruaha Pawaga Water Association (RUPAWA). It was expected that dredging the river could be done after every 2 years. However, the WEO expressed that due to lack of funds dredging had not been conducted since 2016. This has increased the propensity for the floods to occur, hence, affecting food security.

Findings on reducing flood disaster risk through increasing river depth have been reported by Lumbroso et al. (2016) in Mozambique under the Ministry of Water Resources Management and were done twice per year. The times were during the start of the rainy season and at the mid of the season. The strategy was effective in reducing flood disasters. Clinton et al. (2021) also found that dredging of rivers in Nigeria was conducted every year and was supervised by the central government. The study shows that dredging of a river was a good strategy of reducing floods and their impacts on food security. However, due to the insufficient funds, it has not been conducted since 2016. Findings suggest that the efficacy of river dredging in reducing flood disaster risk while enhancing household food security in the present study had been constrained by unavailability of funds. According to the framework for DRR for FNS, the achievement of DRR for FNS depends on the presence of strong institutions and legislations responsible for monitoring DRR for FNS. Findings show that there were weak institutional frameworks for DRR for food security. For instance, the river siltation was mainly caused by poor farming methods.

The findings in Table 2 show that 45% of the respondents practised social cohesion as a strategy for reducing flood disaster risk. The study revealed that in Mbuyuni village people had developed friendships and neighbourhoods such that when floods occurred, they assisted each other as reported by a male participant during FGDs:

> . . . although I lost my 6 bags of maize due to floods in 2019, my neighbors gave me 7 bags of maize . . .

The findings show how social cohesion helped a household to recover from floods. The Disaster Risk Reduction for Food and Nutrition Security framework advocates the need to develop effective communities' disasters recovery to reduce long-term suffering of the most vulnerable groups. A study by Parvin et al. (2016) reported that most people living in flood prone areas in rural Bangladesh married in uplands to increase social cohesion that were important at a time of disasters. Chawawa (2018) also found that in Nsanje district in Malawi, communities developed relationship with those in Mozambique through traditional dances. Thus, when floods affected food security in one country, friends from another country could support them by giving food during crisis. The findings justify the importance of collectiveness of individuals and communities for enhancing households' food security.

Findings in Table 2 indicate that 44% of the respondents built houses with materials that withstand floods as a strategy for reducing flood disaster risk on food security. According to Nepal and Neupane (2022), financial capital is vital in mitigating flood risks to enhance food security through building floods resisting houses. It was noted during FGDs in Mbuyuni village that a village had a campaign of building houses that could withstand the floods called '*valisha kaptula*' which means every building should be built with a strong and raised foundation using burnt bricks and concrete cement. Field

observation found that some villagers had started to build houses that withstood floods. Plate 2 shows a house that was built to resist floods to enhance households' food security.

(a) (b)

Plate 2. (A): before floods (b): the same house being flooded.

The findings in Plate 2(a) show a house built using burnt bricks and concrete cement with a raised foundation to prevent floods. Plate 2(b) shows a house which was flooded but because it was built using burnt bricks and concrete cement with the raised foundation it remained stable throughout the floods' period. In-depth interviews with VAEO in Mbuyuni village revealed that houses that resisted floods were important in enhancing household food security because they prevented water from entering the houses where farmers stored grains. It was also noted that if a house was not affected by floods, there was no renovation cost. So, the little family income they had would be spent to buy food as affirmed by the VEO of Magozi village:

> . . .when you build house with materials that withstand floods, it means all your stored grains would be safe. This will reduce the cost of rebuilding and repairing the damaged houses, thus, the money you get will be used to buy other food items.

The findings show that building houses that withstand floods enabled households to ensure food security. However, in-depth interviews with VEO in Mbuyuni village revealed that building a house that withstands floods needed at least 500,000 Tshs. For that reason, poor households did not afford. The findings are in line with those by URT (2021) which reports that structural strategy for reducing flood disaster risk in Tanzania is difficult because many households living in flood prone areas were economically poor. However, the findings were different from those by Bankoff et al. (2004) who found that in Philippines poor households built traditional houses with raised grain and cereal storage facilities which always kept them safer from floods. This implies that food security enhancement through building houses with secured food storage facilities is not only a matter of income level but also technology. The Disaster Risk Reduction for Food and Nutrition Security framework advocates the use of appropriate technology in food security system. Thus, there is a need to improve education to the communities in the study area to use contextual technologies in building houses and food storage facilities to enhance food security.

Findings in Table 2 show that 42% of the respondents used flood Early Warning System (EWS) to reduce flood disaster risk. Flood EWS represents the established capacities required to generate a warning sound or information for the community at risk to take appropriate measures to reduce damage and loss from the hazards forecasted (ISDR, 2006; IPCC; 2012). It was revealed during FGDs that communities in the study area used both modern and Indigenous Knowledge (IK) flood EWS. Modern EWS included information from the Tanzania Meteorological Agency (TMA) that was provided through television, radio, social networks, village meetings, and seminars. Through IK, communities observed the behaviours of a bird '*Nyakikwangala*', in Hehe language, when the bird flies far away in the sky at the beginning of the rainy season it meant that there would be no floods in that particular season. However, when a bird flies near in the sky it meant that there would be floods; thus, people started to take precautions as reported by a female participant of FGDs in Magozi village:

> . . . .when I see Nyakikwangala flying near in the sky during the starting of rainy season, I understand that there will be floods few days/months to come, thus I start preparing including moving some of my assets to highlands.

The findings show that communities used bird flying to predict flood occurrence and take measures to reduce disasters. However, it was difficult to move all the assets to flood safer places. The Focus Group Discussions in Mbuyuni village revealed that people used whistles and traditional drum '*Balagumu*' to inform each other when floods occurred. In-depth interviews with VIDMACs revealed that although people used flood EWS, yet they were affected by floods. This was because most of them did not take appropriate measures to reduce disasters' occurrence. The findings indicate that having flood EWS was one thing; taking appropriate measures to mitigate the disasters was another. Thus, if people were aware on the occurrence of floods but failed to reduce the disaster risk, then disaster occurrences were inevitable. This might be due to lack of appreciation of the IK or modern flood predicting agency. Also, it might be due to the lack of effective flood disaster risk reduction strategies.

Furthermore, if people were informed through traditional whistles and drums during floods, it would be difficult to enhance food security. The findings show that flood EWS was important in notifying communities about the occurrence of the incident but was not so much effective to enhance the households' food security. It was suggested that there should be strategies put in place to improve EWS in order to enable the communities in preparing better before the occurrence of the floods. This would help in responding effectively to the impacts of the flood while enhancing the food security as promoted in the DRR for FNS framework pillar two and three. These pillars emphasis on improving EWS on FNS as well as building capacities of the practitioners at all levels to enable them to take proper measures against different threats on FNS. Findings from this study correspond with the findings by Ringo et al. (2016) who found that local communities in Kilosa district, Tanzania used traditional trumpets (cow horns) to inform each other about the occurrences of the floods. Thus, people would run from flood prone areas to safer places. Similar results were reported by URT (2021) that flood disasters in Tanzania had doubled over the past 10 years, despite the efforts made by different agencies in providing EWS to vulnerable communities.

4 Conclusions and recommendations

Floodplain along the LRRB is suitable for food production that not only enhances food security but also attracts people to settle in the area. It is also important to note that, the area is vulnerable to the recurrent floods. Local communities in the study area employ different flood disaster risk reduction strategies to enhance food security by creating enabling environment of their survival and the continued food production in the presence of the guiding principles and committees towards DRR. The most strategies used by the people in the study area to reduce flood disaster risk and enhance food security included moving to safe places during floods, planting trees, dredging the river, practising social cohesion, building flood-resistant houses and using EWS. However, most flood disaster risk reduction strategies were not effective to enhance households' food security. Given the floodplain potentials in the LRRB and its fertility in food production that is necessary in enhancing the food security, the study recommends to the government and other stakeholders to formulate policy that would not only promote building capacity of members of the communities along the LRRB but also enhance participation in flood disaster risk reduction for food security.

Disclosure statement

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