Journal of Socioeconomics and Development

https://publishing-widyagama.ac.id/ejournal-v2/index.php/jsed

Determinants of crop diversification among smallholder farmers within marshes around Bukavu, Eastern DR Congo

Mushagalusa Balasha Arsene[1]*, Adrien Lugendo Rodrigue[2], Aloise Bitagirwa[2], John Tshomba Kulumbu[1], and Jules Nkulu Mwine Fyama[1]

[1]University of Lubumbashi, Democratic Republic of the Congo
[2]Institut Supérieur Pédagogique de Bukavu, Democratic Republic of the Congo

*Correspondence email: MushagalusaBalasha@unilu.ac.cd

ARTICLE INFO

►**Research Article**

Article History
Received 4 June 2022
Accepted 28 June 2022
Published 10 July 2023

Keywords
adaptation strategies, smallholder farmer, food security, marshy landscape, COVID-19

JEL Classification
Q01; Q10; R14

ABSTRACT

In the South Kivu province of the democratic republic of Congo, smallholder farmers have been draining marshlands for years to grow a variety of crops into a mixed cropping system. This study based on interviews with smallholder farmers examines the drivers of crop diversification and the challenges these farmers face in marshes where various crops are grown for food and income security. Results showed that in these marshy landscapes, crop diversification system is traditionally rooted in local farming practices (84%), and this is designed to meet farmers' self-consumption and market objectives (72%), and also withstand risks associated with the changing climate and pest outbreaks (91%). Further, results from the logistic regression showed that farming experience, farm size, and livestock ownership influence significantly farmers 'decisions to diversify crops. However, farmers claimed to face increasing prices of agricultural inputs (73%) and unusual crop theft (32%) during this ongoing COVID-19 pandemic whereas floods and pest attack as well as plant diseases are raising more concerns among farmers. Although farmers acknowledged the significant roles of livestock in easily acquiring manure and mulch to improve croplands, they still requested specific interventions in terms of priorities (*e.g* drainage equipment, pest management information) to strengthen the resilience and sustainability of agriculture within marshes.

To cite this article: Arsene, M. B., Rodrigue, A. L., Bitagirwa, A., Kulumbu, J. T., & Fyama, J. N. M. (2023). Determinants of crop diversification among smallholder farmers within marshes around Bukavu, Eastern DR Congo. Journal of Socioeconomics and Development, 6(1), 74-85. https://doi.org/10.31328/jsed.v6i1.3750

ISSN 2615-6075 online; ISSN 2615-6946 print

INTRODUCTION

In the South Kivu province of the Democratic Republic of Congo (DRC), agriculture is practiced in high and low lands into a traditional intercropped system, often mixed with livestock (Heri-Kazi & Bielders, 2020a; Civava et al., 2013; Cox, 2011). Farming in the South Kivu rural and periurban areas is meaningful for local communities because it helps farmers 'households produce self-food, generate income, and support children's education (Klapwijk et al., 2020; Maass et al., 2012; Cox, 2011).

In the territory of Kabare, we observe significant changes in crop production within marshlands. While before the 2000s, most of the wetlands in Kabare were still used for the production of beans, corn, sorghum into a mixed cropping system; many farmers have been changing their crop speculations over time. To date, many farmers are more inclined towards vegetable farming for its short production cycle, to

access permanent diversified food, and incomes (Balasha & Nkulu, 2021; Munyahali et al., 2020). Most of the crops observed in Kabare marshlands included head cabbage, tomato, beans, amaranth, eggplants, squash, and taro as well as sugarcane. However, farmers are facing many challenges that include climatic and socioecomic stressors. For example, while most of farmers are already portrayed as poor, the coronavirus-19 pandemic (COVID-19) has complicated their situation and limited their capacity to buying inputs and accessing needed information due to mobility and import restrictions.

A recent survey conducted in different marshlands around the town of Bukavu indicated that climate change is also a potential threat to agricultural food production (Balasha & Nkulu, 2021). The perceived climate change impacts include floods, increasing temperature, and pest infestation that have led to crop failure and harvest loss (Balasha & Nkulu, 2021; Mushagalusa et al., 2021). Also, heavy rains reported in Kabare are accompanied by intense erosion and this leads to cropland degradation and a decrease in soil fertility, thus compromising the sustainability of agriculture in high and low lands, such as marshes in this case (Heri-Kazi & Bielders, 2020a; 2020b). To adapt to these changes, farmers use, often in combination several strategies. Some of these are environment-friendly practices such as crop diversification. Dessie et al. (2019); Makate *et al.* (2016) and Krista et al. (2016) present crop diversification as a climate-smart technique, and one of the rational ways of reducing uncertainties in agriculture due to the fluctuation in the market and agro-climatic conditions.

Crop diversification is the practice of cultivating more than one variety of crops belonging to the same or different species in a given area in the form of rotations and or intercropping (Makate et al., 2016). This farming technique is easy to implement and acknowledged to have multiple benefits for most smallholder farmers because it is a sustainable approach for pest management, it improves soil fertility and reduces the need for fertilizers, especially if crop mix include leguminous crops that fix nitrogen (Mahmud et al., 2020; Jensen et al., 2020; Munyahali et al., 2020). It also provides the basis for food security and diverse diets and secure farmers 'incomes (Dessie et al., 2019; Krista et al., 2016).

However, despite these benefits, Balasha & Nkulu (2020) and Burchfield & de la Poterie (2018) identified limits (example: insecure land tenure, the high price of agricultural inputs such as seeds) that prevent farmers to implement long lasting crop diversification in the sites. In South Kivu, although crop diversification is recognized as the widespread farming system (Heri-Kazi & Bielders, 2020a; Civava et al., 2013; Cox, 2011), there is still limited knowledge of the drivers of and interests in crop diversification among farmers. We hypothesized that crop diversification depends on socioeconomic factors and farmers' perception of climate risks, and this farming system helps farmers to meet their food needs and market objectives in the context of changing climate and COVID-19 pandemic crisis. The objective of this study was to identify the drivers of crop diversification and challenges that farmers face in marshlands at this era of climate change and COVID-19. In this study, we combined field observations and farmers' interviews to address these 3 research questions: (i) Why are farmers interested in crop diversification in Kabare marshlands?, (ii) What factors do influence farmers' decisions to diversify crops?, (iii) How do climate change and COVID-19 affect marshland farmers?

The answers to these questions will help actors involved in agriculture development understand the factors that promote the use of sustainable practices among marshland farmers and formulate appropriate strategies based on farmers' needs and priorities.

RESEARCH METHOD

Description of the Study Area

The study was conducted from April to June 2020 in 4 marshy sites: Kabirundu, Kanosha, Kavule, Nakishangizi Kiko. These marshes are located between the villages of Buhozi, Nyantende, Chirhinja, Ihemba, Ihasi, Kabanda, and Mandwe in the territory of Kabare, around the town of Bukavu, in the province of South Kivu eastern DR Congo (Figure 1). The Provincial Inspectorate of Agriculture of the South Kivu province has identified 78 marshes in Kabare yet, no study, at the time of writing this article, has attempted to assess the farmers' motivations and challenges in these landscapes.

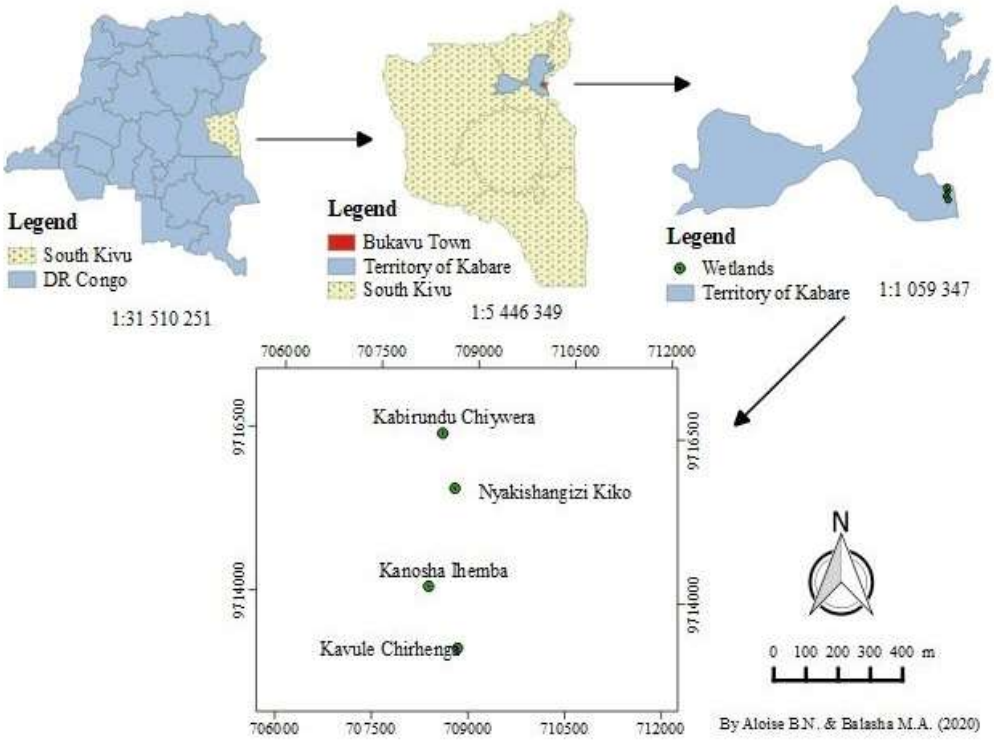

Figure 1. Map of South Kivu (eastern DR Congo) showing the marshes investigated in Kabare

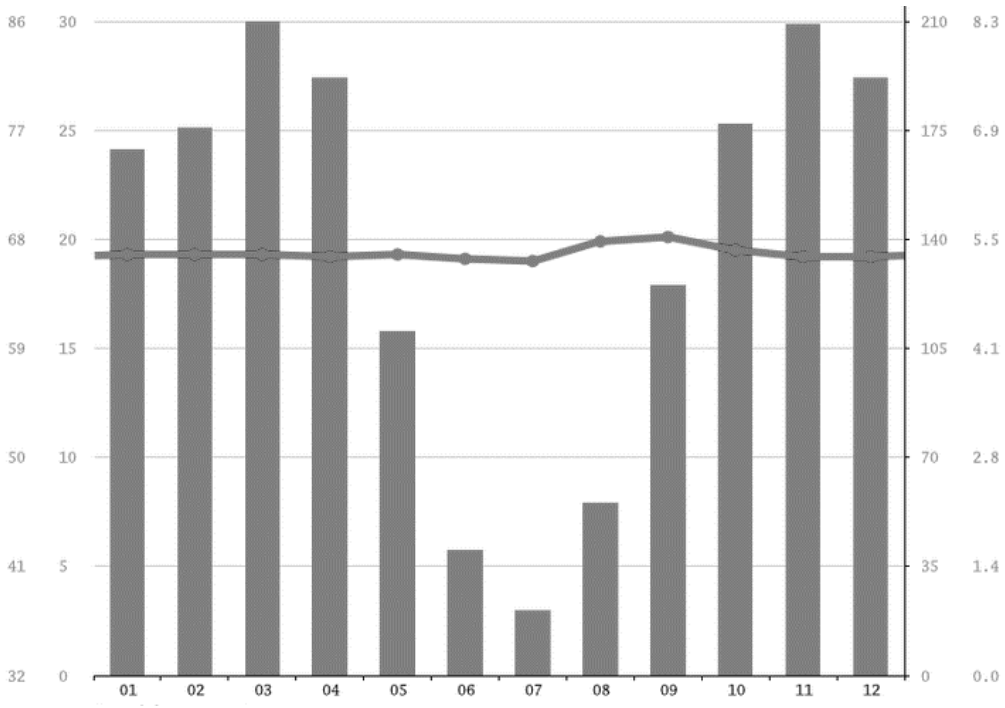

Figure 2. Ombrothermic diagram of the study area

Table 1. Description of The Variables Used in The Binary Logistic Regression

Variables	Description
Dependent variable	
Cropdiv	Crop diversification is specified by 1 if the farmer intercrops two or more crops in the same field, 0 otherwise
Explanatory variables	
Gender (x_1)	Gender (1 = male, 0 = female)
Household size(x_2)	1=Medium if household contains l-6 individuals, 0=large if ≥7
Experience (x_3)	Farming experience(1= short if ≤5 years, 0= long if ≥6 years
Land holding(x_4)	Way farmer holds land(1=owner, 0=tenants)
Farm size(x_5)	Size of arable land in m^2(1=≤ 299 m^2, 0= ≥300m^2
Labor (x_6)	Available labor during farming works (1 = yes, 0 = no)
Time (x_7)	Time spent in farm/ day (1 = if ≤ 4h, 0 if = ≥ 5h)
Objectives (x_8)	Farming objectives (1 =both food and income, 0= otherwise)
Livestock (x_9)	Farmer owns a livestock (1 = yes, 0 = no)
Climat -pest (x_{10})	Farmers perceived climate change and pest risks (1 = yes, 0= no)
Input price (x_{11})	Farmer noticed an increasing price of inputs (1 = yes, 0 = no)
Drainage (x_{12})	Drainage (1 = if done on time, 0 = otherwise)

The choice of these marshy sites was motivated by 3 reasons. First, the sites are large (± 10 hectares each) and exposed to climatic hazards such as floods. Second, many women and young people, including school dropouts work there for their financial autonomy. Finally, we conducted previously there a study on the perception of these farmers of climate change (Mushagalusa et al., 2021). The study area has a humid tropical climate characterized by a rainy season from September to May and a dry season from June to August. The variability of temperature and rainfall quantities for the last decades is presented in Figure 2. In that region, land degradation and landslides are a phenomenon execrated by the combination of intense rainfall, demographic pressure, and bad agricultural practices (Heri-Kazi & Bielders, 2020b; Nobile et al., 2018). Leeuwen et al. (2020); Mathys & Vlassenroot (2016) and Ansoms et al. (2012) have reported several cases of land disputes and land grabbing which increase violence among farming communities. In marshes, various vegetables (cabbage, amaranth, tomatoes; squash, eggplant, beans) and sugarcane, taro as well as potatoes are cultivated for cash and subsistence but farmers claimed to observe significant post-harvest losses (Mushagalusa et al., 2021; Chuma et al., 2022).

Data Collection and Analysis

A semi-structured questionnaire was used to collect information during field visits and interviews among 148 farmers chosen randomly within the four marshy sites (see Figure 1). These farmers were met on their fields during farming works from April to June 2020. A questionnaire was prepared in French and translated into *mashi*, a local language, and included this information: (i) farmers 'socio-economic characteristics (gender, age, access to land, owning livestock, contact with extension agents, sharing information among farmers, farm and households' size, time worked in the farm, farming objectives); (ii) farming system and practices (intercropping or pure cropping system), and (iii) perception of threats to agricultural production in this time of COVID-19 and climatic change. In addition, field observations helped understand the level of the damage associated with floods and pests whereas farmers' stories related to interests in crop diversification and perceived threats increased an understanding of farmers' motivations and challenges.

Data were encoded into Microsoft Excel and crosschecked to clean errors and analyzed using IBM SPSS Statistical Package Version 21.0. Data analysis was performed using descriptive statistics. A chi-square test (χ^2) was used to investigate if significant differences existed between socioeconomic variables and the farming objectives, as well the differences between marshes and perceived threats to crops. The binary logit model was performed to identify the drivers of crop diversification among farmers. The specification of the empirical model or reduced form that was estimated is as follows (see Table 1):

$$Y_i = \beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3+\beta_4X_4+\beta_5X_5+ \beta_6X6+\beta_7X_7+\ldots\beta nX_n$$

Where Y_i is the dependent variable (crop diversification). It takes the value 1 if the farmer diversifies crops, 0 otherwise. X is the matrix of the variables likely to explain the variation of Y. β0 is the

Y intercept; whereas β_1- β_9 is a set of coefficients to be estimated and X_1-X_n are the explanatory variables hypothesized. This study considered α <0.05 as a criterion for statistical significance.

RESULT AND DISCUSSION

Socioeconomic Characteristics

Table 2 presents the relationship between the socioeconomic characteristics of farmers, their perception of climate risk, and crop diversification within marshlands. The total sample size of farmers surveyed was 148. We found that overall more than four-fifth (82%) of marshland farmers were crop diversifiers while 12% practiced pure cropping. There were statistically significant differences between the cropping system and the farming objectives among farmers (χ^2 = 4.474, p=0.034). Crop diversification was more observed among females (66%) and farmers living within large households (more than 7 individuals), having a farming experience of more than five years. Moreover, farmers who owned land (53%) and livestock (88%), and worked more than 5 hours per day in farms diversified their productions to meet household self-consumption as well as market objectives and also withstand risks associated with pests and climate change.

However, there were no statistically significant differences between males and females regarding the farming objectives (χ2 =0.712, p>0.05). These results are consistent with surveys conducted in Ethiopia and Zimbabwe where more than 80% of smallholder farmers diversified their agricultural productions and this depended on various demographic, land and livestock ownership, and environmental factors (Dessie et al., 2019; Makate et al., 2016). In this study, if the proportion of females was high among crop diversification farmers, it is because women tended to invest much of their resources in various mixed vegetable productions to expect collecting income in a short time. Also, in DR Congo, women are considered as a keystone of the agriculture sector and play a vital role in food production, food distribution, and food utilization – the three components of food security (African Development Bank, 2020; Habtezion, 2012; FAO, 2010).

Moreover, women know better than men what types of crops to grow according to the market demand trends since many of these women are involved in crop commercialization. For instance, Balasha & Nkulu (2020) found in Lubumbashi that female vegetable farmers were simultaneously vendors of harvests in order to reduce actors in the distribution chain. Discussing and exchanging information among fellow farmers were found to be significantly associated with crop diversification. This is because farmers learn in groups and imitate among themselves successful practices. This is confirmed by Balasha & Nkulu (2020) in a study conducted on the adoption of integrated production practices for sustainable urban agriculture in Lubumbashi. Also, in Nepal, Anjani et al. (2020) noticed that receiving seed information from fellow farmers helped to increase 12% the adoption of technologies or improved practices for most crops. The drainage of flooded lands was also significantly associated with crop diversification in the sites investigated. This is because drainage is the first operation farmers do to make marshes usable for agriculture. Verhoeven & Setter (2010) showed that marshes worldwide have been drained for long years to convert them into agricultural lands because they have fertile soils as a result of regular sediment deposition during flood events.

As the chi-square test did not highlight more significant differences to tell us enough about the factors associated with crop diversification, we were interested in performing a logistic regression to learn more about additional drivers of crop diversification among marshland farmers as shown in Table 3.

Drivers of Crop Diversification within Marshlands

In marshlands investigated, farmers grow various crops that meet their food needs and these crops generate income in a short time. Like this Farmer No11, many vegetable growers explained: `*'Before, when I used to grow cassava, I had to wait 12 or 15 months to harvest. With amaranth or squash, it is about 30 or 45 days. I can rotate these crops 3 times a year and mix them with other long-lasting crops such as taro".* Crops grown included in large part vegetables (95%), sugar cane (8%), taro (83%), corns and beans as well as cassava (Figure 3).

We observed that almost (4/5) of farmers maintained high levels of crop diversity: three up to five crops in the same field. Crops intercropped in most of the fields can be grouped as follows: (i) cabbage, amaranths, corn, eggplants and taro (ii) squash, eggplants and taro, sweet potato (iii) beans, corn, taro, and cassava, (iv) squash and sugarcane

and taro. Our results are in line with Bellon et al. (2020) who found high-level crop diversity in Ghana, ranging from two up to eight crops, with an average of 3crops per farmer. A recent study conducted in South Kivu by Ndjadi et al. (2020) shows that these crops, especially vegetables play an important role in rural and urban communities as both food and a business opportunity because they are fast-growing species, with high nutritional values and able to generate income in a relatively short period compared to other crops, example corn.

Table 2. Socioeconomic Characteristics of Diversifier Farmers within Marshlands

Variables	Category	Diversifiers	No diversifiers	Differences χ^2 sig.
		%	%	
Crop diversification	Overall	122(82)	26(18)	148***
Gender	Men	41(34)	11(42)	0.712ns
	Women	81(66)	15(58)	
Age (mean=43)	15-39	45(37)	9(35	0.048ns
	≥ 40	77(63)	12(65)	
Farmer 'household size	l-6(small)	43(35)	11(42)	0.461ns
Mean =8	≥7(large)	79(65)	15(58)	
Farming experience (years); Mean =11	≤ 5(short)	53(43)	14(54)	0.936ns
	≥6 (long)	69((57)	12(46)	
Land holding	Land owners	65(53)	15(58)	0.168ns
	Land tenants	57(47)	11(42)	
Farm size (m²); Mean =289	≤ 299(small)	76(62)	14(54)	0.0642
	≥ 300(large)	46(38)	12(46)	
Drainage	Yes	85(70)	24(92)	5.658*
	No	37(30)	2(8)	
Contact with NGO or agronomist	Yes	17(14)	4(15)	0.037ns
	No	105(86)	22(85)	
Worked time (hours); Mean = 6.25	≤ 4h	8(7)	1(4)	0.729ns
	≥5h	114(93)	25(98)	
Own a livestock	Yes	88(88)	16(89	0.012ns
	No	12(12)	2(11)	
Hired casual labor; Mean =2 persons	Yes	93(76)	21(81)	0.250ns
	No	29(24)	5(19)	
Perception of climatic and pest threats	Yes	108(88)	20(77)	2.468ns
	No	14(12)	6(23)	
Farming objectives	Food and income	91(75)	14(57)	4.474*
Sharing info with fellow	Yes	70(57)	9(35)	4 .462*
Farmers	No	52(43)	17(65)	
Increasing price of	Yes	88(72)	20(77)	0.250ns
agricultural inputs	No	34(28)	6(23)	

χ^2=Chi square test, sig = significance, *= significant at 10%, ns= no significant

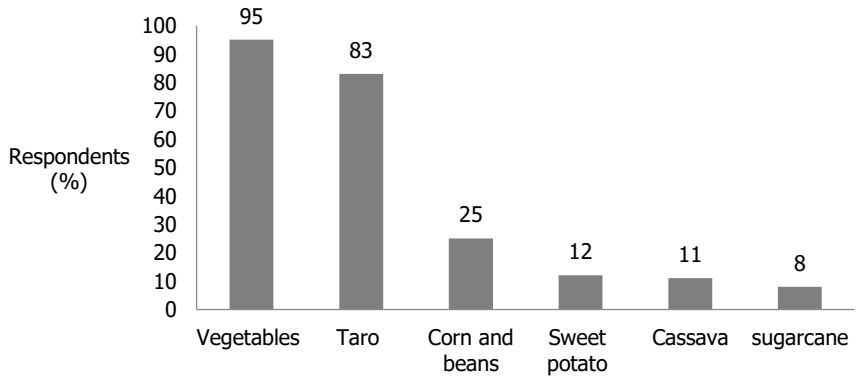

Figure 3. Crops produced by marshland farmers within investigated marshlands

Table 3. Factors Influencing Farmers' Decisions to Diversify Crops within Marshlands

Variables	Coefficient	Std. Error	Exp(B)
Gender	0.355	0.632	1.426
Household size	-0.304	0.570	0.738
Farming experience	-1.437*	0.636	0.238
Land holding	0.712	0.589	2.038
Farm 'size	1.104*	0.650	3.017
Permanant Labor	0.984	0.708	2.676
Time spent in farm	2.474	2.184	11.871
Farming objectives	0.514	0.720	1.672
Livestock ownship	1.942*	0.765	6.970
Perception of climatic and pest risks	1.143	0.814	3.136
Increasing price of agricultural inputs	-1.219	0.787	0.295
Drainage of water canals	0.153	0.658	1.165
Constant	-11.400	5.757	0.000

* denotes significant level at 10%, Overall percentage of correctly predicted model = 83.9%, Exp(B): exponentiation of the B coefficient, -2 Log likelihood = 86.926

Table 3 shows results from the binary logit model for the entire sample of farmers surveyed. Among the 12 variables examined, farming experience, farm size, and livestock ownership influenced significantly farmers 'decision to diversify crops. This implies that farmers' experience helps to manage diverse crops on a given piece of land and livestock provides manure to the system. Also, experienced farmers are assumed to have better knowledge of farming practices and agricultural challenges (Belay et al., 2017). Makate & Mango (2017) argued that farmers 'socioeconomic characteristics and practices are important factors in agricultural food production. In Zimbabwe, farming experience, household wealth, and land size holding were found to be the key determinants of crop diversification among farmers (Makate *et al.,* 2016). In South Kivu's rural areas, livestock influences positively agricultural production since soil fertility of most fields is maintained by available livestock manure, especially from cattle, guinea pigs, and rabbits (Klapwijk et al., 2020; Maass et al., 2012; Cox, 2011).

Results showed that livestock ownership increased 7 times farmers' chances to diversify crops compared to those who did not own livestock. Two reasons can explain this. First, livestock generates money, produces manure and trash for organic fertilization of crops and mulching, and in return, animals are fed with crop residues (Klapwijk et al., 2020; Zamukulu et al., 2019; Cox, 2011). Secondly, livestock (if some animals are sold) helps farmers acquire or adopt new agricultural technologies such as improved seeds which are expected to have a positive effect on agricultural productivity (Dontsop-Nguezet et al., 2016). In some cases, farmers trade their animals to access land, as said farmer No 24. *I cultivate this piece of land but does not belong to me. I give every year to the landowner a goat to use the land*. Farmers are encouraged to diversify crops to enhance crop productivity and resilience in rural smallholder farming systems threatened by changing climate (Hufnagel et al., 2020; Makate et al., 2016). Time worked on farms (6 hours /day on average) illustrates in large part that farming is an important activity for respondents. Time spent daily on farm increased by was positively correlated to farmers' decision to diversify crops. Our results are consistent with Balasha & Kesonga (2019) who found that vegetable growers in Lubumbashi worked daily about 5 hours and considered vegetable production as their main income-generating activity.

Farmers' Motivations for and Interests in Crop Diversification

Farmers 'interests and motivations for crop diversification in marshes are shown in figure 4. Farmers claimed to diversify crops because this practice is rooted in their farming traditions (84%) and helped to minimize climatic and pest risks (91%), meeting their farming objectives e.g. self-consumption and income-generating (72%), preventing food shortage (57%), stabilizing yield (65%) and maintaining soil fertility (54%). Like these respondents No 12 and 63, many farmers explained "*we intercrop amaranth, cabbage and eggplants, and taro because they grow fast. We start selling amaranth from the 30th day after sowing, and this first harvest helps to purchase inputs (example pesticide, manure) for the remaining crops. The diversification farming system is mainly designed to meet our food needs (diverse diets) and allows collecting progressively incomes from sequenced harvests. The most benefit of this system is that if one crop fails due to any hazard, at least one crop can survive and help us".*

Farmers 'motivations and interests in the intercropping system are in agreement with many studies on crop diversification. For example, Bellon et al. (2020) found that crop diversity is positively associated with self-consumption of food crops, and cash income from crops sold. Makate et al. (2016) and

Thimmegowda et al. (2016) stated that diversified cropping systems tend to be more agronomically stable and resilient to climate change. This resilience is explained by different advantages such as reduced weed and pest pressures, reduced need for chemical inputs like fertilizers, especially if the crop mix includes leguminous crops that fix nitrogen (Mahmud et al., 2020; Jensen et al., 2020; Munyahali et al., 2020). Also, FAO has been encouraging vegetable farmers to diversify crops to reduce pest incidence and excessive pesticide sprays in urban and periurban agriculture (Mushagalusa, 2019; Mutshail, 2008). Farmers 'interests in and motivations for diversified vegetable productions such as amaranth, squash, cabbage have been increasing because of the short cycle of growth of these crops and the income they provide (Ndjadi et al., 2020; Balasha & Kesonga, 2019). Additionally, the production of these vegetables is stimulated by the increase in demand for food in Bukavu town where the growing urban population has led to new food habits. In the context of the COVID-19 pandemic characterized by the disruption of food supply chains, lockdowns measures, and limited food imports (Clapp & Moseley, 2020; Workie et al., 2020; Béné, 2020), local smallholder farming systems based on crop diversification are resilient and accepted to adapt better to both climate change and ongoing pandemic because food is produced locally and disturbed straight among communities (Adhikari et al., 2021; Rattan, 2020).

Perceived Impacts of Climate Change and C0VID-19 among Marshland Farmers

Farmers reported various impacts linked to climate change and the COVID-19 pandemic (Table 4). The impacts related to COVID-19 were the increase in agricultural input prices (e.g pesticides, seeds) and crop theft cases whereas the propagation of pest and plant diseases, as well as floods, were due to climate change. There were significant differences between marshes and increases in the price of agricultural inputs as well as crop theft ($p< 0.05$). Overall, 32% of farmers were victims of crop theft, and this issue was more reported by 51% in Kabirundu. Moreover, more than 89% of farmers of the entire sample mentioned pest attacks and floods as potentials threats to agricultural production within marshes.

These threats jeopardize farmers' livelihoods on which farmers base their financial and food sources. Such a situation might be critical in the DRC, especially in the South Kivu province where agriculture is still a strategic livelihood and often the main source of income for about 70 and 80% of households (Dontsop-Nguezet et al., 2016). If the increases in agricultural input or food commodities prices are attributed to mobility restrictions, reduced good imports, and lockdowns due to COVID-19, the situation has been worsening with the volatility of the exchange rate that affects farming production cost (Murhula et al., 2020; Balasha et al., 2020; Balasha & Kesonga, 2019).

Meanwhile, the trend of crop theft rising among farming communities could be understood as an expression of severe poverty and increased insecurity as well as an incapacity for many people to afford food prices during this pandemic. Crop theft consists of stealing harvests including vegetables, fruits, or any agricultural produce belonging to another person. It may discourage farmers from investing their resources in agriculture. For example, Dyer (2020) found in Kenya that the risk of theft is perceived to be significantly stronger for farmers who just adopt and cultivate new valuable crops compared to those who grow traditional crops.

Figure 4. Farmers 'interests in and motivations for crop diversification within marshlands (%)

Table 4. Climate Change and COVID-19 Impacts on Agriculture within Marshes

Marshes	Input prices		Crop theft		Crop pest		Flood	
	Yes	No	Yes	No	Yes	No	Yes	No
	..... %							
Kabirundu	16(39)	25(61)	21(51)	20(49)	41(100)	0(0)	36(88)	5(12)
Kavule	29(91)	3(9)	9(28)	23(72)	25(78)	7(22)	25(78)	7(22)
Kanosha	33(92)	3(8)	10(28)	26(72)	32(89)	4(11)	28(77)	8(23)
Kiko	30(77)	9(23)	7(18)	32(82)	34(87)	5(13)	34(87)	5(13)
Overall	108(73)	40(27)	47(32)	101(68)	132(89)	16(11)	123(83)	25(17)
Test (χ^2)	35.702		11.055		11.429		3.860	
p-value	0.000		0.011		0.076		0.425	

Studies conducted in Kenya and South Africa show that crop theft can lead small-scale farmers to alter their production decisions resulting in crop type change or additional expenses for fencing to improve security (Dyer, 2020; Maluleke et al., 2016; Bunei et al., 2014). For instance, many farmers like this respondent N°41 explained, "*Before, we used to grow corn and tomato. Since last year, we have been switching to crops that we did not grow previously such as sweet potatoes and amaranth. We invest time and money in agriculture but thieves harvest for us. We now harvest prematurely to rescue some harvests".*

Research Implication

Smallholder farmers' motivations and interest in crop diversification as shown in Figure 4 illustrates how marshland agriculture plays a significant role in farming communities, and also how this farming system helps to reduce environmental risks in marshland agriculture. Basimine et al. (2022) have recently argued that wetlands are mainly converted into farmlands to ensure food and income security among rural populations. Based on the findings and other research across Africa, crop diversification is one strategy that smallholder farmers may employ to reduce their vulnerability in the face of global environmental change (Dessie et al., 2019; Makate et al., 2016; Krista et al., 2016).

However, being acknowledged as one of the most vulnerable ecosystems, marshlands should be exploited with a focus on sustainable practices. These practices include, for instance an integrated pest and fertility management, a permanent drainage of ditches or water canals to prevent floods that lead to crop failure and harvest loss (Balasha & Nkulu, 2021; Mushagalusa et al., 2021). Moreover, just like climate change whose response interventions need to target both men and women to strengthen their resilience capacities, a study by Basimine et al. (2021) also recommend that both local communities and decision-makers should be involved in designing sustainable utilizations and conservation options to durably improve livelihoods of populations depending of these marshy landscapes.

CONCLUSION AND SUGGESTION

This study examined the determinants of crop diversification and the challenges that farmers face in marshes where various crops are grown for farmers' livelihoods. Results show that farmers cultivate small-sized lands and produce crops that meet their food needs and market demand in Bukavu where food supply chains and imports are disrupted and restricted by the COVID-19 measures. The logistic regression model indicated that crop diversification in the South Kivu marshes was significantly influenced by farmers 'experience, the size of cultivated plot, and livestock ownership. Additionally, the comparison between crop diversifiers and not diversifiers revealed that the drainage of marshes, information exchange among farmers, time worked per day in the field and farming objectives were associated with crop diversification. Despite the perceived risks that threaten smallholder agriculture, marshes are still considered favorable lands where women and young school dropouts seek their financial autonomy and food for their families. In the face of climate change, crop diversification is a resilient approach and a sustainable way to reduce uncertainties in agriculture. Crop diversification also has the potential to improve farming households' livelihoods and contribute to key pillars of food security: food availability, food accessibility, food utilization, and stability. However, smallholder farmers need technical support to prepare for and

adapt to unexpected events such as pest and disease outbreaks, climatic hazards, and exogenous shocks.

REFERENCES

Adhikari, J., Jagadish, T., Sarba, R., Yamuna, G., & Hemant, O. (2021). COVID-19 impacts on agriculture and food systems in Nepal: Implications for SDGs. Agricultural Systems 186, 102990. https://doi.org/10.1016/j.agsy.2020.102990.

Anjani, K., Hiroyuki, T., Ganesh, T., Naveen, A., Saroja, S. Madhab, K., & Joshi, P. (2020). Adoption and diffusion of improved technologies and production practices in agriculture: Insights from a donor-led intervention in Nepal. Land Use Policy, 95,104621. https://doi.org/10.1016/j.landusepol.2020.104621

African Development Bank, 2020. From farm to fork: The women championing an agricultural transformation in Africa. Retrieved from http://www.ipsnews.net/2020/06/farm-fork-women-championing-agricultural-transformationafrica/

Ansoms, A., Claessens, K., & Mudinga, E. (2012). L'accaparement des terres par des élites en territoire de Kalehe, RDC. L'Afrique des Grands Lacs. Annuaire 2011-2012, pp. 206-226.

Balasha, M., Hwali M., Kesonga, N., Murhula, B., & Kitsali, K. (2020). Understanding the Roles of Street Vendors of Agricultural Commodities during the COVID-19 Outbreak in the Informal Economy. Open Journal of Social Sciences. 8, 115-129. https://doi.org/10.4236/jss.2020.89008.

Balasha, M., & Nkulu, J. (2020). Déterminants d'adoption des techniques de production et protection intégrées pour un maraîchage durable à Lubumbashi, République démocratique du Congo. Cahiers agricultures 29: 13. https://doi.org/10.1051/cagri/2020012.

Balasha, A. & Kesonga, N. (2019). Évaluation de la performance économique des exploitations de chou de Chine (Brassica chinensis L.) en maraîchage à Lubumbashi en République Démocratique du Congo. Rev. Afr. d'Envi. et d'Agriculture, 2(1), 11-19.

Balasha, A. & Nkulu, M. (2021). Potential threats to agricultural food production and farmers' coping strategies in the marshlands of Kabare in the Democratic Republic of Congo. Cogent Food & Agriculture 7:1, 1933747, https://doi.org/10.1080/23311932.2021.1933747.

Basimine, C., Mondo, M., Denis, S., Katcho, K. Nachigera, G. & Schmitz, S. (2022). Socio-economic determinants of land use and land cover change in South-Kivu wetlands, eastern D.R. Congo: Case study of Hogola and Chisheke wetlands. Environmental Development. 43, 100711. https://doi.org/10.1016/j.envdev.2022.100711.

Basimine, C., Mondo, M., Katcho, K., Nachigera, G., & Schmitz, S. (2021). Factors driving utilization patterns of marshlands in the vicinity of South-Kivu urban agglomerations based on Rapid Assessment of Wetland Ecosystem Services (RAWES). Environmental Challenges 5, 10029. https://doi.org/10.1016/j.envc.2021.100297

Belay, A., Recha, W., Teshale, W., & Morton, J. (2017). Smallholder farmers' adaptation to climate change and determinants of their adaptation decisions in the Central Rift Valley of Ethiopia. Agric & Food Security. 6:24. https://doi.org/10.1186/s40066-017-0100-1

Bellon, M., Bekele H., Azzarri, C., & Francesco, C. (2020). To diversify or not to diversify, that is the question. Pursuing agricultural development for smallholder farmers in marginal areas of Ghana, World Development. 125, 104682; https://doi.org/10.1016/j.worlddev.2019.104682

Béné, C. (2020). Resilience of local food systems and links to food security – A review of some important concepts in the context of COVID-19 and other shocks. Food Security.12:805–822; https://doi.org/10.1007/s12571-020-01076-1

Bunei, E. K., Rono, J. K., & Chessa, S. R. (2014). Factors influencing farm crime in Kenya: opinions and experiences of farmers. International Journal of Rural Criminology, 2(1), 75–100. https://doi.org/10.18061/1811/58846

Burchfield E. K., & de la Poterie, A. (2018). Determinants of crop diversification in rice dominated Sri Lankan agricultural systems. J Journal of Rural Studies, 61, 206–215. https://doi.org/10.1016/j.jrurstud.2018.05.010

Civava, R., Malice, M. & Baudoin, J. P. (2013). Amélioration des agrosystèmes intégrant le haricot commun (Phaseolus vulgaris L.) au Sud-Kivu montagneux. Ed. Harmattan, pp.69-92.

Clapp, J., & Moseley, G. (2020). This food crisis is different: COVID-19 and the fragility of the neoliberal food security order. The Journal of Peasant Studies. 47(7), 1393-1417, https://doi.org/10.1080/03066150.2020.1823838.

Chuma, B. G., Ndeko, B. A., Mulalisi, B., Safina, B. F., Ndjadi, S. S., & Mushagalusa, N. G. (2022). Post-harvest Constraints of Solanaceae Species Produced in Kabare Wetlands, Eastern Democratic Republic of Congo. Agricultural Research, 11(3), 506–517. https://doi.org/10.1007/s40003-021-00586-4

Cox, T. P. (2011). Farming the battlefield: The meanings of war, cattle and soil in South Kivu, Democratic Republic of the Congo. Disasters, 36(2), 233–248. https://doi.org/10.1111/j.1467-7717.2011.01257.x

Dessie, A. B., Abate, T. M., Mekie, T. M., & Liyew, Y. M. (2019). Crop diversification analysis on red pepper dominated smallholder farming system: evidence from northwest Ethiopia. Ecological Processes, 8(1). https://doi.org/10.1186/s13717-019-0203-7

Dontsop-Nguezet, P. M., Njukwe, E., Amato, M., Nyakuni, A. G., Zozo, R., Okafor, C. & Akem, C. (2016). Non-farm activities and adoption of improved cassava and beans varieties in South-Kivu, DR Congo. Tropicultura. 34(3): 262-275.

FAO (2010). Growing greener cities in Democratic Republic of Congo, 00153 Rome, Italy, 35p.

Habtezion, S. (2012). Gender, agriculture and food security, in Gender and Climate Change Capacity development series, United Nations Development Programme, New York, NY USA, 30P.

Heri-Kazi, B., & Bielders, C. L. (2020a). Dégradation des terres cultivées au Sud-Kivu, R.D. Congo: perceptions paysannes et caractéristiques des exploitations agricoles. Biotechnol. Agron. Soc. Environ. 24(2), 99-116.

Heri-Kazi, B., & Bielders, C. L. (2020b). Erosion and soil and water conservation in South-Kivu (eastern DR Congo): The farmers' view. Land Degrad Dev. 1–15. https://doi.org/10.1002/ldr.3755

Hufnagel, J., Moritz, R., & Ewert, F. (2020). Diverse approaches to crop diversification in agricultural research. A review. Agronomy for Sustainable Development 40: 14. https://doi.org/10.1007/s13593-020-00617-4

Jensen, E., Carlsson G., & Hauggaard-Nielsen, H. (2020). Intercropping of grain legumes and cereals improves the use of soil N resources and reduces the requirement for synthetic fertilizer N: A global-scale analysis. Agronomy for Sustainable Development. 40, Article number: 5. https://doi.org/10.1007/s13593-020-0607-x

Dyer, J. (2020). The Fruits and Vegetables of Crime: Protection from Theft and Agricultural Development, Job Market Paper, University of Toronto, 83p.

Klapwijk, J., Schut, M., Piet, J., Vanlauwe, B., Giller, E. & Descheemaeke, K. 2020. Micro-livestock in smallholder farming systems: the role, challenges and opportunities for cavies in South Kivu, eastern DR Congo. Tropical Animal Health and Production, 52(3), 1167–1177. https://doi.org/10.1007/s11250-019-02112-9

Krista, B., Sieglinde, S., Kimberly, C., & Kurt, B. W. (2016). Assessing the value of diverse cropping systems under a new agricultural policy environment in Rwanda. Food Security, 8(3), 491–506. https://doi.org/10.1007/s12571-016-0582-x.

Leeuwen M., Mathys, G., de Vries, L., & Gemma, V. (2020). From resolving land disputes to agrarian justice -dealing with the structural crisis of plantation agriculture in eastern DR Congo. The ournal of Peasant Studies, 49(2), 309–334. https://doi.org/10.1080/03066150.2020.182417

Maass, L., Katunga, M., Wanjiku, L., Anja, G., & Peters, M. (2012). Challenges and opportunities for smallholder livestock production in post-conflict South Kivu, eastern DR Congo. Tropical Animal Health and Production, 44(6), 1221–1232. https://doi.org/10.1007/s11250-011-0061-5.

Mahmud, K., Makaju, S., Ibrahim, R., & Missaoui, A. (2020, January 1). Current progress in nitrogen fixing plants and microbiome research. Plants. 9, 97; https://doi.org/10.3390/plants 9010097.

Makate, C., & Mango, N. (2017). Diversity amongst farm households and achievements from multi stakeholder innovation platform approach: Lessons from Balaka Malawi. griculture and Food Security, 6(1). https://doi.org/10.1186/s40066-017-0115-7.

Makate, C., Wang, R., Makate, M., & Mango, N. (2016). Crop diversification and livelihoods of smallholder farmers in Zimbabwe: Adaptive management for environmental change. SpringerPlus, 5(1). https://doi.org/10.1186/s40064-016-2802-4.

Maluleke, W., Mokwena, R., & Motsepa, L. (2016). Farmers' perspectives on stock theft: police crime statistics. S. Afr. J. Agric. Ext. 44(2) 256-274. http://dx.doi.org/10.17159/2413-3221/2016/v44n2a393.

Mathys, G., & Vlassenroot, K. (2016). It's not all about the land': Land disputes and conflict in the eastern Congo, Rift valley institute PSRP briefing paper. 8p.

Munyahali, W., Kulemba, M., Chakirwa, P., Walangululu, J., Vanlauwe, B., & Nziguheba, G. (2020). Using the Legume CHOICE tool to support legume use on smallholder farms in South Kivu province in the Democratic Republic of Congo. ILRI Project Report. Nairobi, Kenya: International Livestock Research Institute (ILRI).

Murhula, B., Kitsali, K., & Mushagalusa, B. (2020). Pauvreté et Secteur Informel à Bukavu: Profil des détaillants des Produits Agricoles à l'Ere de la Pandémie COVID-19. Journal of Economics, Finance and Accounting Studies. 2(2), 1-10.

Mushagalusa, B. (2019). Drivers of adoption of integrated pest management among small-scale vegetable farmers in Lubumbashi, DR Congo. American Journal of Rural Development 7(2): 53–59. https://doi.org/10.12691/ajrd-7-2-2.

Mushagalusa, B., Kitsali, K., Murhula, B., Hwali, M., Ndele, B., Cirhuza, V., Assumani, B., Akili, I., Nicanor C., & Benoît, B. (2021). Perception et stratégies d'adaptation aux incertitudes climatiques par les exploitants agricoles des zones marécageuses au Sud-Kivu. VertigO - la revue électronique en sciences de l'environnement. 21(1). https://doi.org/10.4000/vertigo.31673

Mutshail, M. (2008). Project for the Development of Urban and Peri-urban Horticulture (UPH) in Lubumbashi (DRC), SENAHUP/FAOUPH, Project, Lubumbashi, online. Retrieved from ftp://ftp.fao.org/docrep/fao/011/ak159f/ak159f20.pdf.

Ndjadi, S. S., Vumilia, R. K., Ahoton, L. E., Saidou, A., Orou, B. D., Mugumaarhahama, Y., … Mushagalusa, G. N (2020). Typology and Prospects for the Improvement of Market Gardening Systems in South-Kivu, Eastern DR Congo. Journal of Agricultural Science, 12(6), 136. https://doi.org/10.5539/jas.v12n6p136.

Nobile, A., Dille A., Monsieurs, E., Basimike, J., Bibentyo, T. M., d'Oreye, N., … Dewitte, O. (2018). Multi-temporal dinsar to characterise landslide ground deformations in a tropical urban environment: Focus on Bukavu (DR Congo). Remote Sensing, 10(4). https://doi.org/10.3390/rs10040626

Rattan, L. (2020). Home gardening and urban agriculture for advancing food and nutritional security in response to the COVID-19 pandemic. Food Security 12:871–876, https://doi.org/10.1007/s12571-020-01058-3.

Thimmegowda, M. N., Ramachandrappa, B. K., Devaraja, K.,… (2016). Climate resilient intercropping systems for rainfed red soils of Karnataka, Indian Journal of Dryland Agricultural Research and Development, 31(2), 39. https://doi.org/10.5958/2231-6701.2016.00023.3.

Verhoeven, J., & Setter, L. (2010). Agricultural use of wetlands: opportunities and limitations, Annals of Botany 105: 155-163. https://doi.org/10.1093/aob/mcp172.

Workie, E., Mackolil, J., Nyika, J., & Sendhil, R. (2020). Deciphering the impact of COVID-19 pandemic on food security, agriculture, and livelihoods: A review of the evidence from developing countries, Current Research in Environmental Sustainability. 2,100014, http://dx.doi.org/10.1016/j.crsust.2020.100014

Zamukulu, P., Ayagirwe, R., Ndeko, A., Bagula, E. ... (2019). Contraintes et opportunités de l'intégration agriculture-élevage à Mushinga dans l'Est de la RD Congo, Journal of Animal & Plant Sciences. 41 (3), 7000-7014. https://doi.org/10.35759/JAnmPlSci.v41-3.4.