Research article

Women's contribution to household improvement through Neglected and Underutilized Crops (NUCs) cultivation: Evidence from the Highland Kivu Region

René M. Civava [a, b, f, **], Géant B. Chuma [a, b, c, *], Adrien B. Ndeko [a], Joelle M. Nzigi [a], Prince L. Baraka [d], Blandine Sanginga [e], Raphaël Mufumbo [e], Léonard M. Kazamwali [a], Alphonse Z. Balezi [f]

[a] Faculty of Agriculture and Environmental Sciences, Université Evangélique en Afrique (UEA), PO. Box: 3323, Bukavu, Democratic Republic of the Congo
[b] INERA-Mulungu Station, South-Kivu, Democratic Republic of the Congo
[c] Laplec-UR SPHERES, Department of Geography, University of Liège, Liège, Belgium
[d] Department of Natural Resources Management, Faculty of Agricultural Sciences and Environment, University of Kinshasa, Kinshasa, Democratic Republic of the Congo
[e] African Agricultural Leadership Institute, AALI HQ, President Olusegun Obasanjo Campus, Kalambo, South-Kivu, DR Congo
[f] Faculty of Sciences, Université Officielle de Bukavu, UOB, Bukavu, South-Kivu, Democratic Republic of the Congo
[g] Uganda National Gene Bank, Biodiversity and Biotechnology Program, National Agricultural Research Laboratories- Kawanda, P.O. Box 7065, Kampala; Uganda

ARTICLE INFO

ABSTRACT

Research on the extent to which women in post-conflict and low-income regions contribute to improving household income through the cultivation of neglected and underutilized crops (NUCs) is limited or sometimes entirely lacking. This study examines how NUC cultivation empowers women by enabling them to increase household income and food security. The factors influencing this process, as well as specific interventions to reduce gender disparities while improving household livelihoods in eastern DRC, are also documented. The territories of Walungu and Kabare in the highlands of Kivu, eastern Democratic Republic of Congo (DRC), were selected as case studies. Data were collected through surveys and focus group discussions (FGDs) involving households engaged in NUC cultivation. Household survey data were analyzed using multiple correspondence analysis (MCA), with χ^2, Cronbach's alpha, and Cramer's V tests employed to uncover hidden structures and relationships between different categories and to visualize patterns within the data. The results highlight the critical role of women in shaping NUC farming practices and underscore the potential of NUCs to contribute to sustainable livelihoods. Our findings revealed that NUCs contribute up to 78 % (USD 100–200) of household income when managed by women, compared to only 22 % when managed by men. However, a significant gap remains between men's and women's contributions to total household income. NUC cultivation remains predominantly practiced by women (75 %), with six main factors influencing NUC-derived income: the source of seeds used, level of education, marital status, age, cropping systems, and type of inputs used. Despite women's contributions to NUC production, numerous constraints hinder its development. This study suggests empowering women by encouraging organizations supporting the NUC sector by providing seeds and essential inputs and improving other socio-economic conditions related to NUC production. This research is vital for

*
** rene.civava@outlook.com
  E-mail addresses: rene.civava@outlook.com (R.M. Civava), geant.ch@gmail.com (G.B. Chuma).

Note: Low-resolution images were used to create this PDF. The original images will be used in the final composition.

economic growth, poverty reduction, and food security, as women play a crucial role in agriculture and their empowerment is essential for achieving sustainable development goals.

1. Introduction

Agriculture is the backbone of African economies, particularly in rural areas where most households rely on smallholder farming for sustenance and livelihoods [1–3]. The intricate relationship between agriculture and household income in these settings is undeniably vital, shaping economic well-being and socio-cultural dynamics within communities [1]. However, within this context, the role of gender assumes paramount importance. African agriculture is inherently gendered, with women contributing significantly to all stages of the agricultural value chain, from planting and nurturing crops to post-harvest processing and marketing [4]. Despite these substantial contributions, women face persistent disparities in access to resources, extension services, and decision-making power, often constraining their full potential as agricultural agents [4–6]. The implications of these gender imbalances reverberate through the broader economic landscape. Rural households, mainly those reliant on subsistence farming, are highly susceptible to external shocks, including erratic weather patterns and market fluctuations. As such, the equitable distribution of agricultural resources and benefits is not merely an issue of social justice but also a practical necessity for building resilient and sustainable rural economies [7].

In this context, the cultivation of neglected and underutilized crops (NUCs) [8] emerges as a promising avenue for bolstering household income and food security [9]. Neglected crops, often regionally adapted and resilient to local conditions, have the potential to diversify income streams and enhance nutritional diversity. However, various socio-economic factors, including gender-related constraints [9–11], have hampered their integration into mainstream agricultural practices.

Neglected and underutilized crops (NUCs) refer to plant species that have not received significant attention or investment in research, development, and promotion despite their potential contributions to food security, nutrition, and livelihoods [12–14]. These crops often possess valuable traits such as adaptability to local environments, resistance to pests and diseases, and interesting nutritional qualities [15]. In the context of the Republic Democratic of Congo (DRC), several NUCs are notable in South Kivu [12]. Efforts to promote these NUCs can lead to improved food security through increased income, enhanced nutrition, and increased resilience in the face of environmental challenges [16–18]. This can be achieved through research and development programs, policy support, farmer training, and promoting markets for these crops. Additionally, raising awareness about the nutritional benefits and adaptability of NUCs is crucial for their wider adoption and utilization in the region.

The role of rural women in improving the standard of living in rural households is acknowledged. However, despite their substantial contributions to agriculture, women have been disproportionately excluded from decision-making processes related to crop selection, resource allocation, and market access [4,19]. These barriers hinder the adoption of neglected crops and perpetuate household income disparities. In DRC, neglected and underutilized crops (NUCs) have received limited attention in agricultural research and development despite their potential to contribute significantly to rural economies. At the regional scale, studies are available on gender in agriculture and NUC diversity, but few are focused on their place in household income contribution and its drivers.

A vast body of literature exists on the role of women in agricultural production within rural households in Sub-Saharan Africa and throughout the tropical regions [20,21,22]. However, there is a scarcity of studies focusing specifically on their role in regions like the eastern Democratic Republic of Congo, where women have suffered from the effects of armed conflict and where their place and role within the community remain largely unknown and undocumented. This is compounded by this region's socio-economic and demographic context, located in the Great Lakes of Africa, an area renowned for its high birth rate and demographic growth.

The gender contribution to household income from NUCs in regions such as eastern DRC provides novel insights by quantifying women's economic impact, revealing how women's involvement increases HH income. The gender-specific challenges are highlighted while showing how NUC production empowers women socially and economically in rural areas. Such research explores crop-specific gender dynamics while proposing policy solutions to improve market access for female farmers in rural areas. This study also tried to link women's participation in NUC farming to resilience to climate change and advises sustainable efforts by offering perspectives on both economic and environmental benefits.

This study aimed to elucidate the role of rural women in improving the food security and economic situation of rural households mainly engaged in the NUC's production. It examines the multifaceted relationship between gender dynamics, neglected crop cultivation, and household income in the post-conflict region of Kivu Highland. Specifically, this study aimed to (i) conduct a socio-economic characterization of rural households producing NUCs in South Kivu; (ii) assess the economic contribution of Neglected and Underutilized Crops (NUCs) to household income; (iii) investigate if, among the socio-economic characteristics, the female category of the gender variable stands out; and if so, (iv) identify the determinants of this income contribution by women.

By exploring the interplay of gender roles within the agricultural landscape, we aim to provide insights that contribute to a more inclusive and equitable agricultural sector and foster sustainable rural livelihoods in Africa. Through this lens, we delve into households' specific challenges and opportunities in the Highland of Kivu region, offering evidence-based pathways towards enhanced economic well-being and gender equality.

1.1. Gender and agriculture

1.1.1. Gender roles in agriculture

Gender dynamics in agriculture have been the subject of extensive research [3,23–25]. Women constitute a significant portion of the agricultural labor force in many developing countries, particularly in Sub-Saharan Africa. Studies highlight that women play crucial roles in various stages of the agricultural process, from land preparation and planting to weeding, harvesting, and post-harvest activities [26,27]. Owoicho et al. [28] investigated the gender issues in access to land among farmers in Karu local government in Nigeria, while Croppenstedt et al. [29] analyzed gender and agriculture in highlighting the inefficiencies, segregation, and low productivity traps. However, despite their pivotal contributions, women face persistent barriers, such as unequal access to land, credit, inputs, and extension services, that limit their productivity and income-generating potential [30,31]. Moreover, entrenched social norms and discriminatory legal frameworks further exacerbate these disparities, constraining women's agency and decision-making power in agricultural contexts [32,33]. Most sub-saharan governments' constitutions grant equal rights to women and men in all spheres of public life, and laws are enacted and amended to protect women's rights. The governments and decision-makers have also committed to recognizing the Millennium Development Goals (MDG), even if they have not been pursued most of the time with support for women's issues. In most of the cases, women's rights continue to be violated, especially of rural and poor women. In general, there is still room for discussion on the elimination of all kinds of discrimination against women in the region, economy, and family [23,34].

According to the discussion on women, gender relations, and development, literature shows that several social and economic shifts have played a pivotal role in influencing policies, programs, and research related to gender and development. During the 1970s, coinciding with the rise of the international women's movement and heightened interest from donors in framing development initiatives, the Women in Development (WID) approach emerged within the research community [35–38]. This approach operated under the mistaken assumption that since women were largely excluded from the development process, concerted efforts were needed to incorporate them. Within this framework, research and intervention strategies tended to view women as recipients of welfare policies, often perceived as lacking agency, and whose societal standing was predominantly shaped by patriarchal norms and relationships [38,39]. Consequently, early WID research in Africa, while recognizing women's pivotal role in household activities, primarily focused on their marginalized position, which hindered their full participation in economic advancement [40].

In analyzing all the references on women and NUC production, we can conclude that women play a pivotal role in producing NUCs, which are critical for household food security and income generation in many low-income and marginalized regions such as sub-Saharan regions [9,13]. As primary cultivators, women manage nearly all stages of NUC production, utilizing indigenous knowledge to ensure crop productivity. These crops, often grown in marginal environments, provide essential nutrients and resilience against food insecurity [82]. Studies have shown that NUCs can significantly enhance household income, with women often retaining control over the proceeds. For instance, they leverage niche markets for organic and traditional foods, while cooperatives focus on value in addition to further boosting income [83]. However, women face persistent challenges, including limited access to quality inputs, secure land tenure, profitable markets, and cultural norms that restrict their decision-making and opportunities [26,32,41,47].

Addressing these challenges is crucial for unlocking the full potential of NUCs. Empowering women through training, resource access, and creating women-friendly market linkages can significantly improve their livelihoods [32,38,39,41]. Additionally, policy interventions that integrate NUCs into agricultural frameworks and prioritize gender equity are vital. Research highlights the transformative impact of such initiatives, showing that women's empowerment in NUC production enhances household income and food security and contributes to poverty reduction and sustainable development. Governments and development organizations can drive progress toward equitable and sustainable agricultural systems by overcoming structural barriers and investing in women as key agricultural stakeholders.

1.2. Neglected crops and sustainable agriculture

Neglected crops, often underutilized or orphan crops, have garnered increasing attention recently. These crops, which may be indigenous or adapted to local environments, demonstrate resilience to pests, diseases, and adverse climatic conditions [41,42]. Neglected crops encompass various species, including grains, tubers, and fruits [8,18].

In Africa and mainly in Sub-Saharan Africa, women represent the crucial target group from a nutritional perspective, primarily in nutrition transition. They face significant disparities in food production. Therefore, food-based, women-centered strategies are recommended to bridge nutrient gaps and provide education and empowerment for women [16]. In these developing country regions, women play a crucial role in food systems, and empowering them is fundamental to achieving positive nutrition outcomes. Their active involvement and influence can significantly improve nutrition for communities and households.

Furthermore, as primary caregivers in sub-Saharan Africa, women influence their children's nutrition through their nutritional status and childcare practices. Most available literature primarily focuses on the nutritional composition and usage of Neglected and Underutilized Crops (NUCs). Few studies delve into women's role in producing these crops and their contribution to household income improvement. The research in DRC, specifically in the eastern provinces, underscores their potential to enhance food security, improve nutrition, and contribute to sustainable agricultural practices. However, NUCs often require fewer inputs and are well-suited to smallholder farming systems in most areas. At the same time, their genetic diversity also serves as a critical resource for breeding programs, contributing to agricultural biodiversity and resilience [9]. It is essential to note that NUCs exhibit resilience to extreme environmental conditions. Due to their adaptability to marginal and low-input environments, these crops offer opportunities for reducing greenhouse gas emissions [43].

1.3. Impact on household income

Gender plays a crucial role in Africa's agricultural income. Women constitute a significant portion of the agricultural labor force, yet they often face systemic barriers that limit their access to productive resources and opportunities. This includes limited access to land, credit, and modern agricultural technologies [44,45]. Studies have shown that agricultural productivity can significantly increase when women have equal access to these resources. This benefits individual women farmers and has positive effects on food security and economic development at the community and national levels. In Africa, efforts to promote gender equality in agriculture often focus on policies and programs that aim to increase access to resources, enhance technological adoption, improve market access, promote education and training, and address cultural and social norms. Other factors, such as supporting women's participation in agricultural cooperatives and associations, must be empowered; this includes improving food security, poverty reduction, and overall sustainable crop practices [6,32].

Studies examining the impact of neglected crop cultivation on household income reveal promising findings [8,46]. Adopting neglected crops has been associated with diversified income sources for rural households [44,47]. Their market potential, particularly in niche and value-added markets, offers opportunities for income generation and livelihood improvement [48,49]. Moreover, neglected crops contribute to increased dietary diversity and nutritional security, potentially reducing household expenditures on purchased foods [50]. However, the extent of these benefits varies depending on crop choice, market access, and socio-economic context [49,51].

2. Methodology

2.1. Study area and context

The study was conducted in the South-Kivu province, eastern DRC. Considering the extensive area covered, we focused on two of the eight territories within the province (Fig. 1), namely Walungu and Kabare. These territories are among the highland Kivu region located between 2°30′ S and 2°50′ S, 28°40′ E and 28°55′ E, and between 900 and 3200 m above sea level. They were selected based
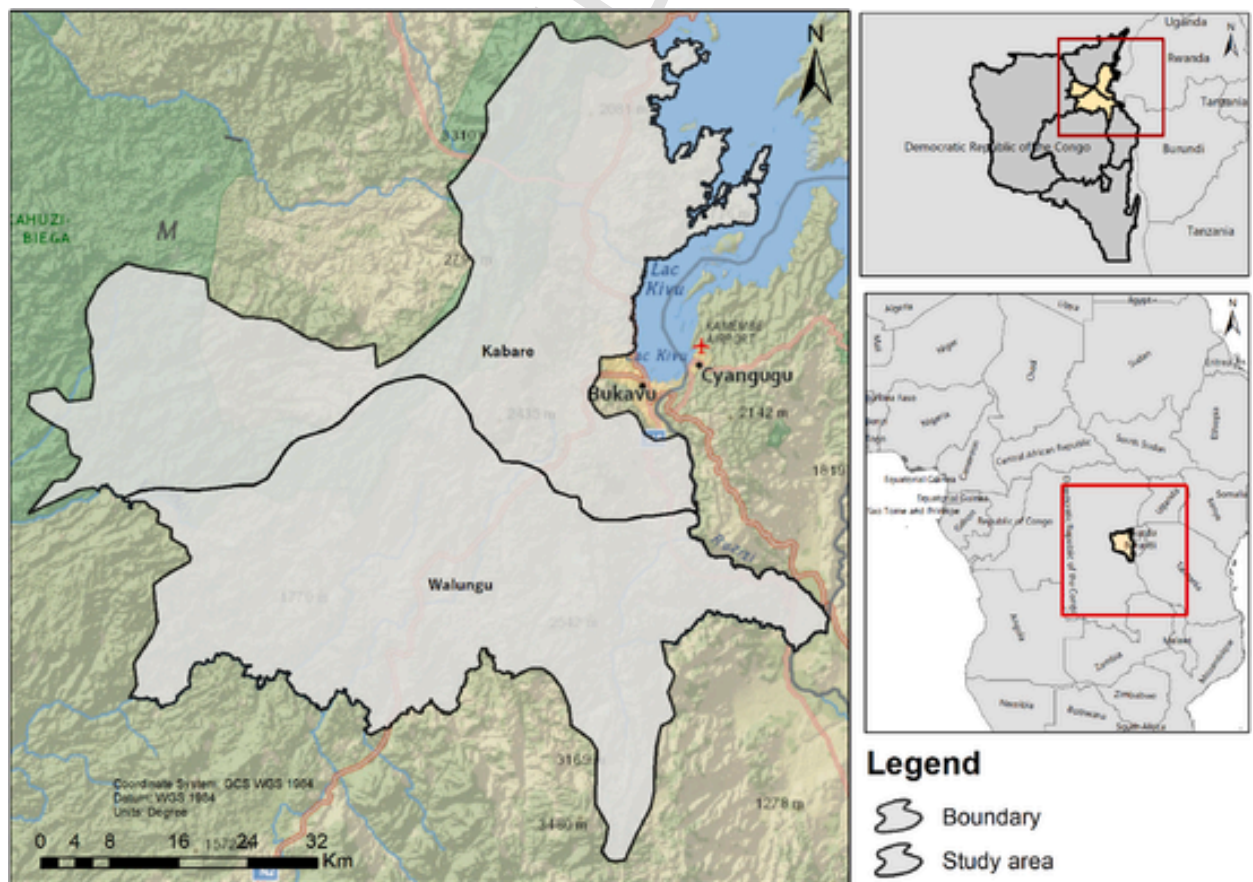

Fig. 1. Study area, Walungu and Kabare territories in South-Kivu, eastern DR Congo (county and country limits were obtained from RGC: www.rgc.com, the map was created by the first author using ArcMap 10.7.1 Esri-TM).

on the prominence of agriculture in the area, particularly on NUCs' significance to the local community in the region [12]. The Highland Kivu region is located in the eastern part of the DRC, near the border between Rwanda and Uganda. It is characterized by its high-altitude terrain, which includes a series of mountain ranges, hills, and plateaus [52]. The region is known for its lush landscapes, including dense forests and fertile inland valleys, making it suitable for agriculture.

Socio-economically, the region faces a range of challenges. Access to essential services such as healthcare and education can be limited, and there may be economic disparities among different communities. Additionally, the region's economy is often driven by artisanal mining, trading, and agriculture, with crops such as coffee, tea, etc. [45]. Other agricultural products are important contributors to the local economy. However, the region also faces infrastructure, market access, and economic development challenges due to political crises and armed conflicts. Additionally, the area has historical significance and has been influenced by various colonial powers over the years [53,54].

2.2. Study design

This research adopts a mixed-methods approach, combining quantitative and qualitative techniques to comprehensively understand the relationship between gender, neglected crop cultivation, and household income improvement. This was thematically analyzed to identify key themes and patterns related to gender roles in agriculture and NUCs. Initially, we conducted a literature review focusing on neglected crops and gender studies in the South-Kivu province and the Democratic Republic of Congo (DRC). This step allowed us to refine the research questions and formulate hypotheses.

This comprehensive approach enables us to triangulate findings and provide a nuanced understanding of the complex interplay between gender, neglected crop cultivation, and household income improvement in the highland Kivu region. Subsequently, we adopted a quantitative approach involving a structured survey implemented through a questionnaire developed and deployed using Kobo Collect [55]. In a structured survey, the initial step is determining the sample size. In this case, we utilized a complete random sampling method to ascertain the number of rural households to be included in the study.

According to Sharma et al. [56], the survey is a set of questions aimed at extracting a desired set of data or opinions from a specific group of individuals. Since surveys can be conducted more quickly than other data collection methods and facilitate gathering data from many participants, this approach was selected to get data. A survey can include many questions, allowing for increased flexibility in assessing multiple research areas. This was combined with observation, as suggested by Zossou et al. [57] and Dancer and Tsikata [58]. Systematically observing and recording behavior, interactions, and phenomena in natural settings to gain insights into social processes, cultural norms, and everyday life.

Considering the findings presented by Mondo et al. [17], which indicate that ∼28 % of households are primarily involved in selling NUCs, this proportion was then applied to the total number of households in the area [59] to identify the households to be included. After calculation, 150 households were selected for the field surveys.

2.2.1. Sampling and data collection

The province of South Kivu, rich in biodiversity and forests, led us to focus solely on the communities found along the Kahuzi-Biéga National Park (KBNP), which supplies NTFPs to the city of Bukavu and other towns in the province. This study thus focused only on the NTFPs derived from the KNBP and, therefore, on the producers and traders surrounding this protected area [17]. Information regarding the selected site is available in Supplementary Table 1. To determine the sample size needed for household surveys, we used a margin of error of 5 % and 95 % confidence level, the above-mentioned values, following the formula available online at https://fr.surveymonkey.com/mp/sample-size-calculator/and considering the Cochran [60] formula:

$$n = \frac{\frac{Z^2 \times P(1-P)}{e^2}}{1 + \left(\frac{Z^2 \times P(1-P)}{e^2 \times N}\right)}$$

Where: n: The sample size (initial estimate), Z: Z-value corresponding to the desired confidence level (e.g., 1.96 for a 95 % confidence level), p = The estimated proportion of the population with the desired characteristic (if unknown, use p = 0.5 to maximize the sample size), e: The desired margin of error (e.g., 0.05 for ±5 % precision).

Based on national agricultural statistics and using the abovementioned formula, 150 farmers were surveyed, corresponding to 78 and 72 for Kabare and Walungu, which led to 150 households. It is worth noting that RTB crops are practiced at a very low scale within the community in eastern DRC. Only a few farms are engaged in cultivating these crops. A stratified random sampling method was employed to select the 150 households from various communities within the Kabare and Walungu of the Kivu highland region. Data was collected through a structured survey questionnaire (see Supplementary material) administered to heads of households (HH) from December 2021 to March 2022 and repeated in 2023. Household surveys and focus group discussions (FGD) involved both men and women farmers. One FGD was done in each territory. The mixed approach combining household surveys and focus group discussions (FGDs) helped gather qualitative and quantitative data. To collect standardized data from many individuals or households for statistical analysis. The questionnaire was designed to capture sociodemographic information on households, NUC practices, access to resources, and income sources. Triangulation was employed to ensure comprehensive data collection and verify that no information was overlooked [61]. This involved conducting HH surveys and focus group discussions with farming families and agricultural associations working in rural settings, mainly on Neglected and Underutilized Crops (NUCs). The household surveys primarily

helped with statistical analysis, identifying trends and patterns in NUC producers, while FGDs helped explore social norms, group perspectives, and the range of opinions within a community [62,63].

2.2.2. Data treatment and analysis

Once the database was finalized, the work involved correcting errors in the dataset, re-encoding variables, etc. The initial analyses consisted of descriptive statistics of all the variables. Table 1 provides a summary of the 14 variables considered for gender analysis. After executing the collinearity analysis and descriptive statistics, we selected variables used in the Multiple Component Analysis (MCA) analysis. Since qualitative analyses such as MCA and χ^2 are sensible to low frequencies, in the end, only 10 variables were utilized for this analysis. In a Chi-square test, as in MCA, low-frequency categories result in smaller expected values, which can violate the test's assumptions. The Chi-square test assumes that expected frequencies in each contingency table cell are sufficiently large (typically ≥5). The test becomes less reliable when this assumption is violated and might yield inaccurate p-values. When some categories have very few observations (low frequencies), the algorithm gives them disproportionate weight, which can lead to distorted factor scores or dimensions that do not reflect the fundamental patterns in the data [64,65]. All these tests were executed at 5 % probability thresholds.

The analyses aimed to assess the correlation between monthly income and gender. The income was divided into two categories: (i) income derived from NUCs and (ii) income from other activities of the household head. Additionally, constraints in NUC production, support observed by NUC farmers, and gender were evaluated.

Quantitative data such as number of people per household (HH), the number of exploited farms, the farm area, the monthly income, and the age were finally converted into qualitative (nominal and categorical). To identify the variables that contribute to the income derived from NUCs and characterize the households where this contribution was observed, we conducted a Multiple Component Analysis: MCA [66]. In total, all ten variables were included in the analysis. To avoid confusion, we use only two modalities for gender: "male" and "female". MCA is well-suited for the type of data collected, which consists primarily of qualitative variables. Using variables such as age, marital status, education level, and household composition, MCA helped uncover patterns and relationships among these characteristics to identify the socioeconomic profiles of RTB producers [84]. It also enabled the inclusion of variables and their often complex interactions while reducing dimensionality, making visualization possible. This allowed us to observe how variables like seed origin, cropping system, and income relate to specific demographic groups, such as gender. In our case, MCA also grouped households or farms with similar characteristics in terms of income and gender. Performing MCA on these variables helps reveal the underlying patterns in farming and socioeconomic data, offering valuable insights into household behaviors, resource allocation, and the socioeconomic dynamics shaping agricultural systems. These findings can enhance understanding and support targeted strategies for development [84,85].

The χ^2 test assessed the dependence between the variable' monthly income,' main constraints, 'types of support', and 'gender' variables.

Three tests were used to validate and evaluate the MCA results. First, we used the Kaiser-Meyer-Olkin (KMO), which measures data adequacy for factorial analysis. The value obtained of 0.72 for the KMO test was considered acceptable (>0.5) and a good value for adequacy. Secondly, Bartlett's sphericity test evaluated the correlation matrix between variables. A value obtained of 0.038 indicated that the correlation matrix was not an identity matrix, as suggested for an MCA analysis. The Cattell slope test (Raîche et al., 2013) was used to identify the number of factors to retain in the analysis. The test consisted of determining the slope value of the contribution value. A contribution value higher than 1 and more significant than the mean was retained. Tables and figures were generated using MS Excel 2018, RStudio, and R 4.2.1. Packages such as *ggplot2, tidyverse, explor,* and *ade4* were employed for the analyses and figure production. Fig. 2 displays the percentage of variances explained by the ten dimensions.

Table 1
Summary of variables analyzed and integrated in the MCA analysis.

Variable	Type	Modalities/Code
Age	Ordinal	*1:<30years, 2:30-40 years, 3: 40–60 years, 4:>60 years*
Marital status	Nominal	*Married, Single, Widow(er)*
Educational level	Nominal	*Illiterate, Primary, Secondary, University*
Number of people per HH	Quantitative	*1 to 15*
Number of exploited farms	Quantitative	*1 to 5*
Farm status	Categorical	*1: Owner, 2: Annual renter, 3: Perennial renter*
Farm size	Ordinal	*1:<0.5 ha, 2: 0.5-1 ha, 3: 1–2 ha, 4: >2 ha*
Seed origin	Quantitative	*1: Market, 2: Previous crop, 3: NGOs, NGOs and Neighbor*
Type of settlement	Nominal	*Straw and Mud, Board and sheets, Semi-Durable, Durable*
Cropping system	Binary	*Monoculture and Polyculture*
Input used	Qualitative	*Organic fertilizer, Pesticides,*
[a]Monthly income from NUCs	Qualitative	*Valur*
Income from other sources	Quantitative	*Idem*
Gender	Binary	*Male and Female*

[a] the monthly income was obtained in Congolese Francs (CFr) but converted after calculation in USD dollar ($). During the survey, 1$ = 2000 CFr.
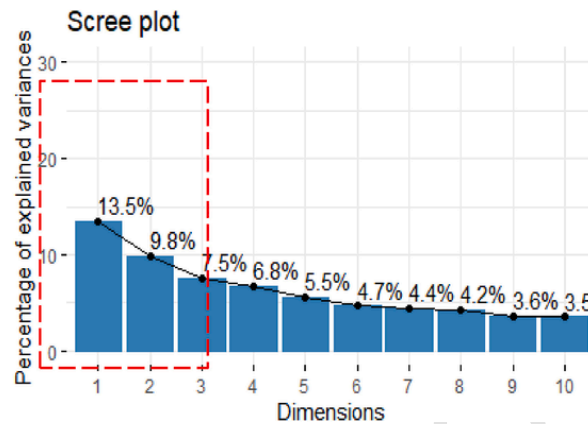
Fig. 2. Explained variances of all the ten dimensions during the MCA.

Overall, the analysis considered the first three dimensions. The first dimension accounts for 13.5 % of the variance, while the second and third dimensions account for 9.8 % and 7.5 %, respectively. Therefore, when all three components are considered, they collectively explain 30.8 % of the variance.

3. Results

3.1. Socioeconomic characteristics

The results regarding the socio-demographic characteristics of the households surveyed are presented in Table 2. It emerges that the majority are women (75 %), married (80.7 %), with secondary (38 %) to primary (24 %) education levels, and a significant presence of illiteracy (28 %). More than half (59 %) are aged between 30 and 40 years, with fewer being older (< 5 %). These households have fewer than three individuals (48 %) and between 3 and 7 (44 %). Their houses are primarily constructed from wood (30 %), and they mainly operate in two fields, primarily (66 %) seasonally rented and less than 0.5 ha in size. Regarding the use of Neglected and Underutilized Crops (NUCs), the majority source their seeds from local markets (44 %) and previous crops (35 %). Generally, polyculture is predominant (73 %) in household fields, with a notable utilization of organic fertilizers (79 %) comprising crop residues and animal manure (from cattle, goats, sheep, guinea pigs, pigs, chickens, etc.). On average, households generate less than 100$ in monthly income (46 %) from NUCs, while 24 % earn between 150$ and 200$, and 100$ to 150$ (45 %) from other income-generating activities. No difference was observed between NUC producers in Kabare and Walungu ($p > 0.05$). However, the number of crops, farm size and status, cropping system, and seed origin varied significantly from one territory to another ($p < 0.05$).

Based on the synthesis of the FGD results, labor in these NUC-based agricultural operations remains predominantly family-driven, with a notable contribution from youth in product collection. The discussion highlighted that these operations generally focus on local production or harvesting certain products from the forest. Some species grow naturally in the forest and lack cultivated products such as cuttings or seeds. Given the proximity to the altitude forest, particularly around Kahuzi-Biega National Park (PNKB), many of these farmers gather fruits and other valuable plants for sale or domestic use.

3.2. Neglected crops and other crops utilized by households

Regarding agriculture, households cultivate several crops, with cassava, beans, and maize being the most dominant. The number of produced crops varied significantly from one territory to another ($\chi^2 = 121.5$, df $= 8$, $p < 0.01$), varied by the gender of the farm head, depending on whether it is male- or female-led ($\chi^2 = 58.7$, df $= 4$, $p < 0.001$). Unfortunately, bananas suffer from pest attacks, similar to cassava, leading the farmers to shift to NUC production primarily. The results also indicated that 72 % of households cultivate one or two (NUCs) ($\chi^2 = 7.4$, df $= 1$, $p = 0.01$). While these crops may not be households' main activity, they play a significant role (at the primary level) in generating income and, consequently, in household survival. The monthly income was correlated to the number of crops produced ($\chi^2 = 3.98$, df $= 4$, $p = 0.023$). The main NUCs cultivated include papaya and avocado, sunflower, yam, physalis, taro, blackberry, Passion fruit, amaranth, cabbage, African nightshade, garlic, sugar cane, sorghum, etc. as highlights in the Fig. 3 from **a** to **s**.

Fig. 4 below encompasses the diversity of some NUCs found in the field. These include squash and zucchini (Fig. 3a and b); yam plants in the field without staking (Fig. 3b) and with stakes (Fig. 3f); a few taro plants (Fig. 3d–m) and their tuber (Fig. 3k); ginger roots being sold in the local market in the open air (Fig. 3g); amaranth leaves piled up for sale (Fig. 3h–n); sorghum in the field (Fig. 3r) and during the harvesting of ears (Fig. 3i). Other items include fruits, notably passion fruit (Fig. 3g–o,q).

NUCs are primarily used for three purposes: food, medicine, and for sale. These uses vary from one crop to another (Supplementary data). For instance, crops such as taro, sunflower, amaranth, etc., are used for food, while crops like yam, sorghum, and papaya are used for both food and medicinal purposes, with a strong emphasis on medicinal use. Others, like gooseberry, avocado, passion

Table 2

Socioeconomic characteristics of households surveyed in Kivu highland in South-Kivu for NUC production.

Variable	Modality	Frequency (%)
Gender	*Female*	75.3
	Male	24.7
Marital status	*Married*	80.7
	Single	7.3
	Widow(er)	12.0
Educational level	*Primary*	24.7
	Secondary	38.0
	University	9.30
	Illiterate	28.0
Age	*<30 years*	22.7
	30-40 years	59.3
	40-60 years	13.3
	>60 years	4.7
Households size (HHS)	*<3*	48.7
	3–7	44.0
	>7	7.30
Type of settlement	*Straw and Mud*	24.0
	Board and sheets	30.7
	Semi-Durable	31.3
	Durable	14.0
Number of exploited farms	*One*	8.70
	Two	69.3
	More than two	22.0
Farm status	*Owner*	22.0
	Seasonal rent	66.0
	Perennial rent	12.0
Farm size (ha)	*<0.5 ha*	41.3
	0.5-1 ha	26.0
	1-2 ha	18.7
	>2 ha	14.0
Origin of the seed used	*Market*	44.7
	NGOs	14.0
	NGOs and Neighbor	6.00
	Previous crop	35.3
Cropping system	*Monoculture*	26.7
	Polyculture	73.3
Input used	*Organic fertilizer*	79.3
	Pesticide	20.7
Income from NUCs	*<100$*	46.0
	101-150$	24.0
	151-200$	12.7
	251-300$	10.0
	>301$	7.30
Other income	*<100$*	24.7
	101-150$	45.3
	151-200$	21.3
	251-300$	4.70
	>301$	4.00

fruit, etc., are primarily NUCs for commercial purposes. There is also a distinction in usage based on gender (χ^2: 12.72, p < 0.001). For instance, crops such as yam, papaya, and ginger are more commonly used for medicinal purposes among men than women.

3.3. Economical contribution of neglected crops and other activities

The economic contribution of NUCs and other income-generating activities and their improvement are presented in Fig. 4(a and b). The Chi-square results indicate a correlation between income from NUCs and gender (χ^2: 5.78, p < 0.001). This contribution significantly varies based on whether one is male or female. It is noteworthy that high income (>300$) primarily comes from men (6 %), while a small percentage (8 %) of rural women have high incomes. Nearly 83 % of women have an income of 100$ derived from agricultural earnings related to NUC cultivation. On the other hand, for other sources of income, the trend shows an equal distribution between men and women, with a strong dominance for men. For high-income (>300$), the proportion is 33 % and 67 %, respectively, for women and men.

In general, cultivating NUCs yields an income of approximately $100 per month, contributing up to 26 % for men and 64 % for women engaged in their cultivation. However, there is a disparity in the monthly income of households involved in NUC cultivation.
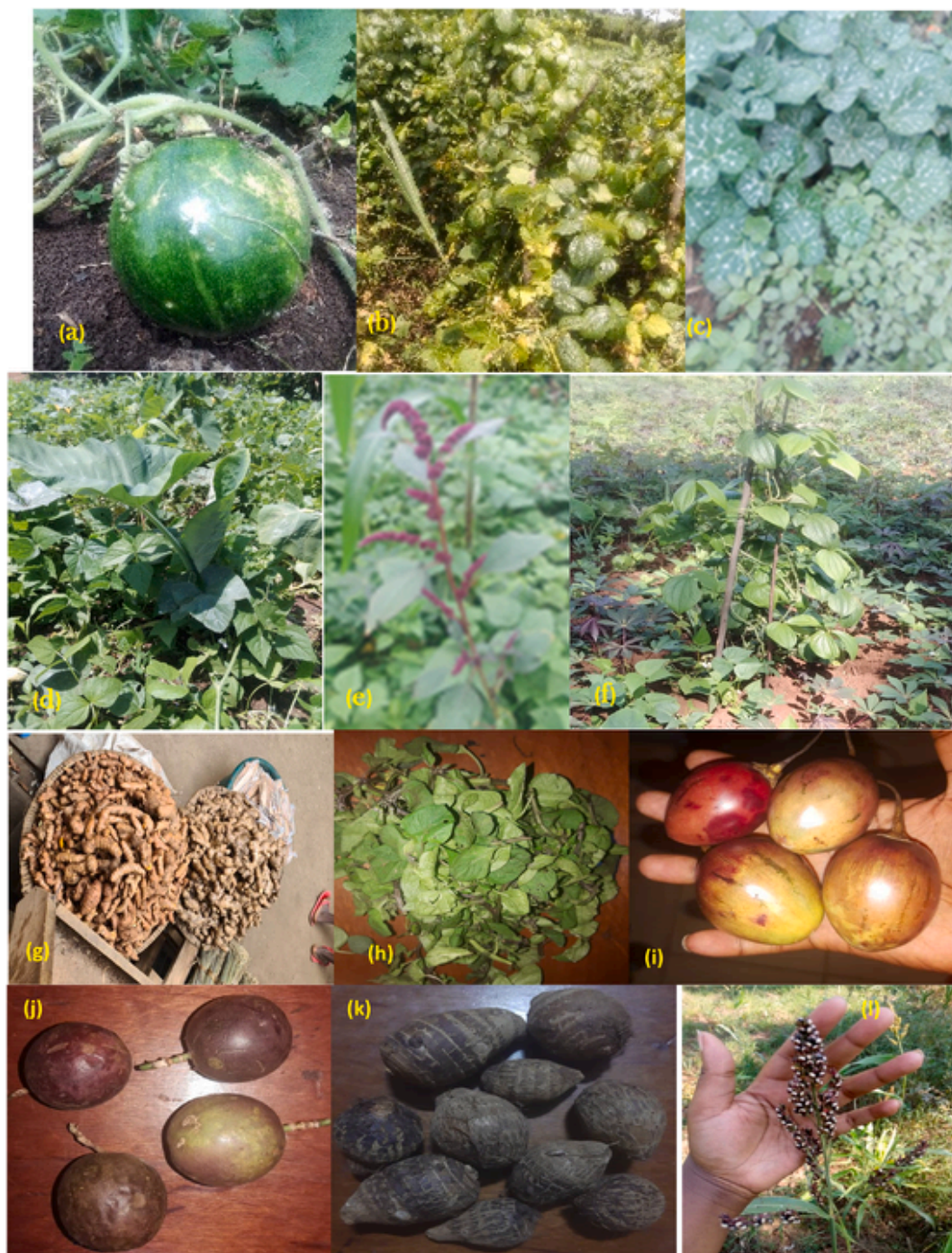
Fig. 3. Pictures of some NUCs taken during field visit (***a***: Gourd, ***b***:wild yam, **c**:squash, ***d***:taro leaves, **e**:amaranth, ***f***: local yam**, *g*:**ginger root, ***h*:** black nightshade, ***i*:**plum, ***j*:** Passion fruit, ***k*:** taro, ***l*:** improved sorghum, ***m*:** leaves of taro, ***n*:**amaranth, ***o*:** Guava tree, passion fruit, ***p*:**wild eggplant, ***q*:** wild plum tree, ***r*:** local sorghum variety, ***s*:** indian borage, french thyme**)**.

Fig. 3. (*continued*)

Despite the substantial contribution from NUCs to household income, it is still heavily influenced by the male gender. Men continue to contribute significantly to overall household income.

3.4. Analysis of the gender on improvement of crop trading

To analyze the influence of gender, a Multiple Correspondence Analysis (MCA) was conducted, explaining 30.8 % of the variance. The results of the different dimensions considered are presented in Fig. 2, and the figures in the supplementary data. The representation of individuals and variables in the three dimensions considered is displayed in Fig. 5. Here, dimensions 1 and 2 are depicted. These graphs show the contribution (in %) and cos^2 of each variable and individual, allowing us to identify any individuals that stand out from the rest. The biplot of the different modalities in the first two dimensions was also considered. In terms of the contribution of variable modalities, it was evident that for the first dimension, the seed source from NGOs, field size (0.5–1 ha), household head age (<30 years), monoculture farming system, and income level >300$ have significantly contributed to the formation of dimension 1. For dimension 2: the modalities, including Chirunga location, field size of <0.5 ha, earthen housing type, seed source from previous crops, and NUC production intended for the market, have contributed significantly. The last dimension considered is dimension 3. This includes marital status, secondary education level, and Mudaka and Bugorhe locations. These also have an income of 150–200$.

As for the individuals, specific individuals were found to be significantly correlated and contributed to the formation of the axes. Specifically, individuals 131, 113, 125, 24, 19, 132, 126, 147, and 23 positively influenced dimension 1, while 45, 35, 45, 39, and 57 had a negative impact. In dimension 2, individuals 116, 149, 115, 88, and 87 had a positive influence, while 8, 2, 30, 136, and 74 had a negative influence. Regarding the contribution to dimension 3, individuals 40, 49, 143, 91, 44, 27, and 74 significantly contributed to its formation.

On the one hand, regarding variable contributions, the first dimension is correlated with farm size, the origin of the seed used, the age of the farmer, and the HH income. It also correlated to educational level, cropping system, marital status, HH income, gender, and
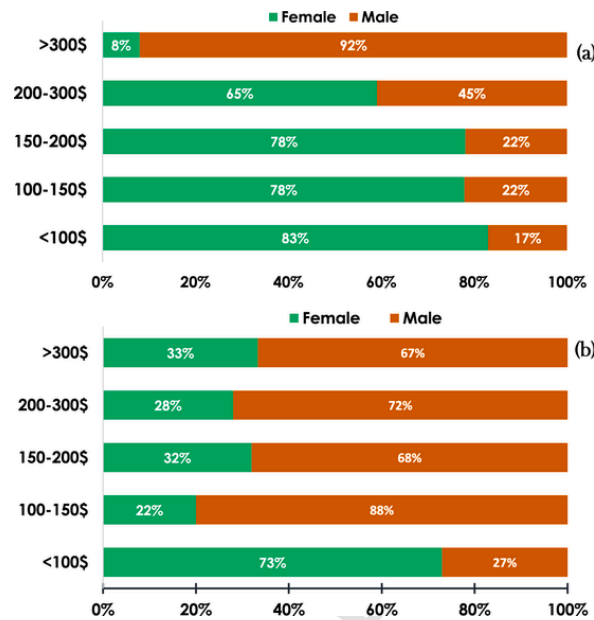
Fig. 4. *Contribution of activities related to the sale of NUCs (a) and other sources (b) in improving household income based on gender. The estimates were made for a duration of one month* (χ^2: 8.92, p < 0001 for monthly income from NUCs, and χ^2: 7.8, p < 0.001 for other source of income out of NUCs; the household income was obtained in Congolese francs "CFr" and converted in US Dollar "$", during the survey 1$ = 2000 FRw).
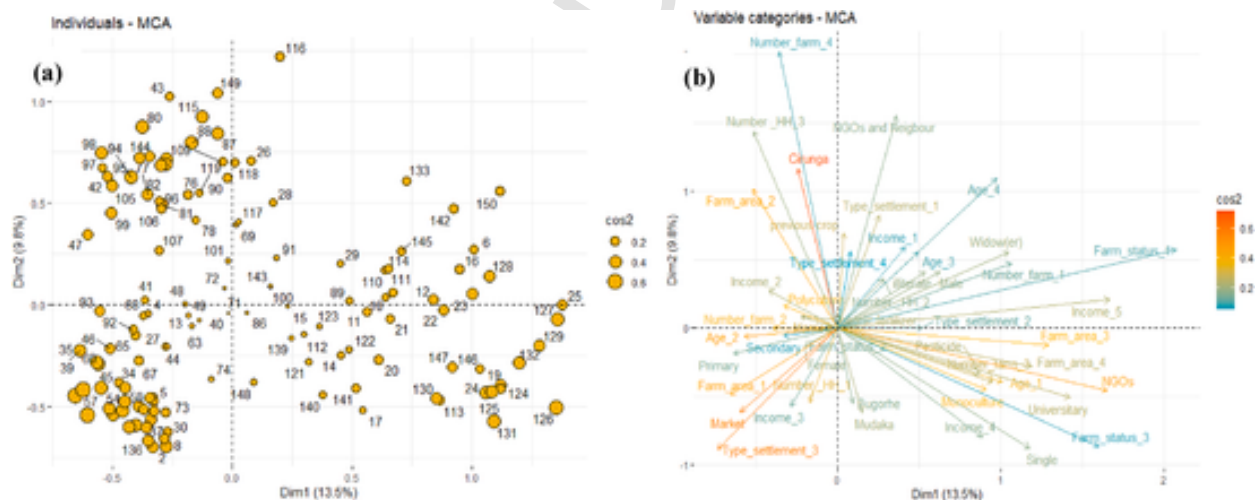

Fig. 5. **MCA results presenting (a) the biplot of individuals (b) and modalities of variables** (value of modalities are presented in the Table 1, the point size and color represent the $\cos^2$ of individuals and variables**).**

field status (Fig. 9). On the other hand, the second dimension is correlated with the origin or location of households, the number of people per household, type of housing, and seed origin. The third dimension correlated with gender, field status, and monthly income of the household head.

3.5. Socioeconomic factors of improvement of income of NUCs

The analysis of the results in Fig. 6 (a,b,c) and the Supplementary materials 1 to 3 in the appendix revealed a distinct group among the surveyed individuals when gender is considered (Fig. 6a). Some women stand out from the rest. Specifically, women with primary and secondary education levels (Fig. 5b), aged between 30 and 40 years, and whose Neglected and Underutilized Crops (NUCs) are intended for commercialization with a monthly income of 150–200$ are notable (Fig. 6b). These women also highlighted insecurity (64 %) and the absence of quality seeds (55 %) as primary constraints in production (Figs. 7 and 6c). On the other hand, some women mentioned financial constraints (82 %), technical support (57 %), and the distance to the market (74 %) as their main challenges. Regarding the source of seeds, most women obtain them from previous crops (75 %), while men typically go directly to the market to
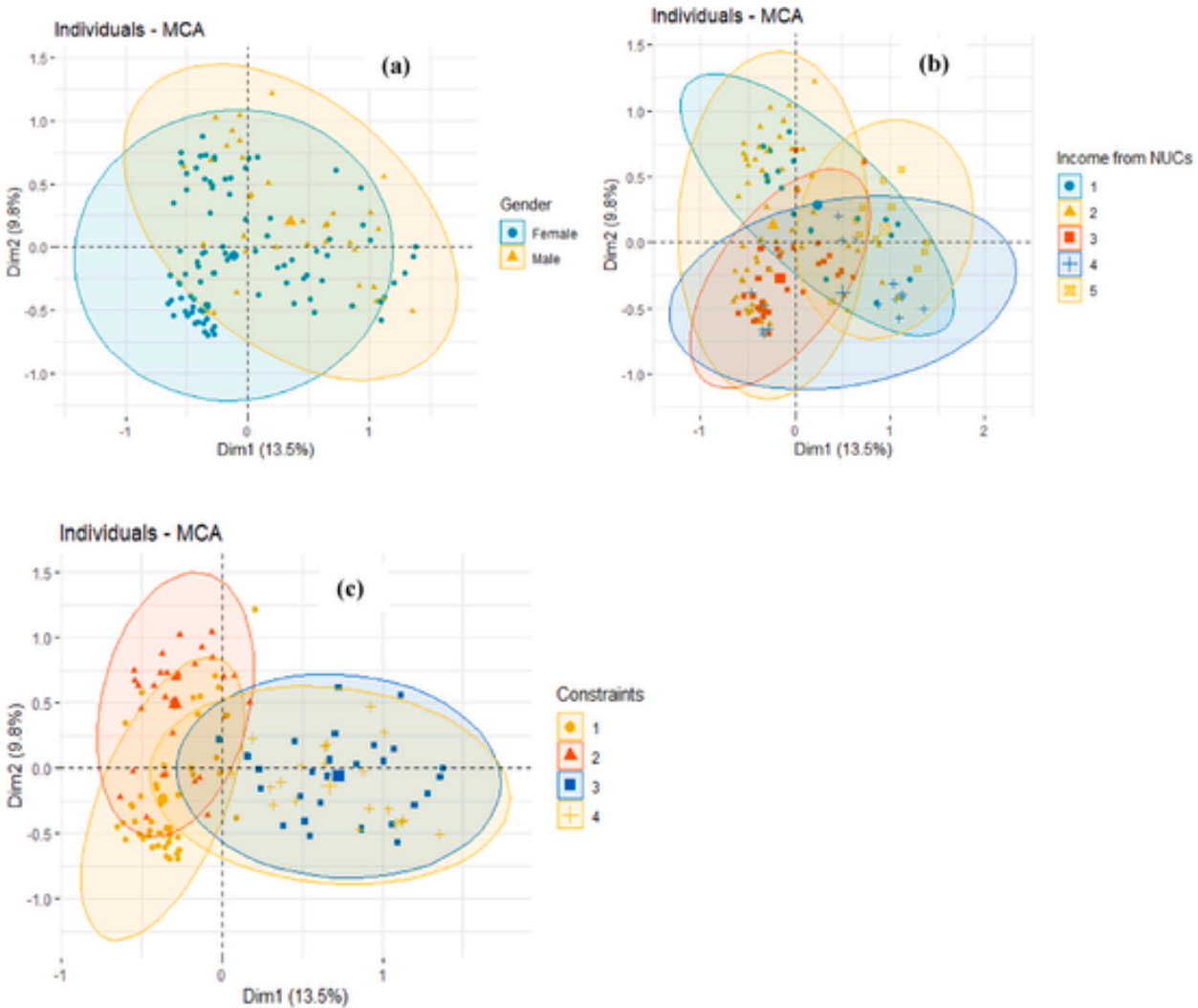
Fig. 6. Distribution of individuals in the first two dimensions by gender *(a)*, by level of income from NUCs *(b)*, and various observed constraints *(c)* (legend: for income from NUCs: 1: <100$, 2:100–150$, 3: 150–200$, 4: 250–300$, 5: >300$; and constraints: 1: insecurity, 2: Lack of seeds, 3: Distance to market, 4: Supports, 5: Financial).
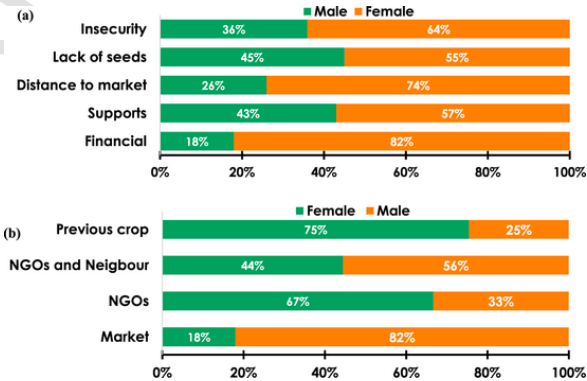

Fig. 7. Main constraints in NUCs production (a) and source of seed used for production (b) in Kivu highland, eastern DR Congo.

purchase seeds (82 %). These results also indicate that very few organizations actively provide seeds to women in rural areas. Only (33 %) of women source their seeds from NGOs. Fig. 7 presents the main constraints in NUC production and the source of seed used for production, which vary by gender. It comes from the Fig. 7a that significant dependence was observed between the constraints ($\chi^2 = 14.34$, df = 4, p < 0.001), the source of seed used (Fig. 7b) for NUCs production ($\chi^2 = 11.92$, df:3, p < 0.001).

Crops (NUCs) in the study region. Six additional variables were analyzed: seed origin, level of education, age group, marital status, types of inputs used, and farming system. Although 38 % have a secondary level of education, 24 % and 28 % have primary and no formal education, respectively. These proportions vary based on gender.

Among those with no formal education, 86 % are women, while for those with a primary education, 69 % are women (Fig. 8d). On the other hand, the frequencies for secondary (58 %) and university education (50 %) are evenly distributed. Generally, women tend to have lower educational attainment (75 %) than men (24 %). In terms of marital status, 75 % of these women are married, while others are widowed. Approximately half of these women (59 %) primarily fall within the age range of 30–40 years. Older women (> 60 years) are rare in general agricultural activities, particularly those related to NUCs (Figure. Regarding the farming system, women engage more in polyculture (72 %) than men (χ^2: 11.32, p < 0.001). Polyculture allows for production diversification and, consequently, dietary diversification within households. In contrast, men prefer cash crops like sugarcane, maize, and coffee. Variables such as cultivated area, field status, number of fields in operation, and number of people per household did not vary based on gender. They were not significantly correlated with income from NUCs (χ^2: 2.08, p > 0.05).

Another factor is related to the use of inputs. Two main types of inputs are utilized: organic fertilizers and pesticides. No operator producing and selling Neglected and Underutilized Crops (NUCs) and using mineral fertilizers was found (Fig. 8e and f), indicating that this is not a common practice among these farmers. Significant differences were observed based on gender (χ^2: 9.82, p < 0.001). Women use fewer inputs than men. This is partly due to their generally lower level of education, which affects their understanding of usage methods compared to men.

Additionally, in the region, the livestock that produce the organic matter used (such as cows, goats, sheep, etc.) usually belong to men. As a result, the only organic materials readily available to women are guinea pig and pig droppings, chicken waste, and crop residues. Gender was significantly and positively correlated to HH income and farming system, while type of house, marital status, and educational level were negatively correlated to gender, as presented in Fig. 9(a and b).

The obtained results allowed the conclusion that the determining factors for the profitability of NUC crops in the region included the origin of the seeds used (whether they come from NGOs, are purchased from the market, or come from previous crops), as well as the level of education of the farmers (with higher levels observed in high-yield cultivators). The cultivation system and the fertilizers type also significantly contribute to this income improvement. Other factors, such as age and marital status, have contributed only marginally. By incorporating gender through MCA analysis, it is evident that gender plays a significant role in enhancing the income of households whose primary activity revolves around NUCs.

4. Discussion

Much research confirms that small-scale farms predominantly produce Neglected and Underutilized Crops (NUCs) within communities where gender plays a significant role [16,17]. On the one hand, many NUCs are associated with female-centric activities (often considered women's crops), although some crops, such as ginger, yam, and papaya, are consumed more by men. In Africa and the DRC in particular, women are more involved in subsistence farming than men are [67–69]; this type of agriculture tends to be more diverse, with a broader range of crops cultivated. On the other hand, men typically grow cash crops with higher economic returns (Maass et al., 2012; Mugumaarhahama et al., 2021). This study showed that a small proportion of men (~23 %) are engaged in NUC production, especially when there is an easily accessible market, as was the case in Mudaka and Bugorhe, where products like passion fruit, yam, and plums are sold to travelers on the Bukavu-Kavumu road. It was also noted that men continue to be interested in these crops if they find them economically viable compared to the region's more typical crops [17]. These results also demonstrate that neglected crops can be a promising avenue for empowering and economically uplifting women in rural areas, particularly in the eastern DRC, where constraints and armed conflicts have significantly restricted women's societal roles [70,71]. By enhancing production and consequently the income of these women, Neglected and Underutilized Crops (NUCs) also improve their overall quality of life [17,71]. Therefore, reframing the narratives surrounding NUCs to better support women in this environment is crucial. Support should also be considered at various levels, including addressing security concerns, implementing NUC-focused projects, and facilitating access to education and resources in rural settings.

Among all the factors and their modalities, four explain the high income of NUC farmers. First and foremost is their location. Results show that farmers in Chirunga and Mudaka have higher incomes than those in other surveyed areas, both for men and women. While most of these producers are young and single, a significant proportion of women are also observed in this category. These results can be explained on the one hand by the fact that these two areas are close to two major urban areas in the province (Bukavu and Kavumu), and people are often seen sourcing from these sites; on the other hand, by the fact that most of them are young, i.e., most involved in production, harvesting, collecting and selling NUCs, that lead to high incomes. Another important parameter related to income was the type of housing. In fact, income level is strongly correlated with housing type and assets owned in the area. Durable housing (made of bricks and cement) is that of wealthier households in rural areas and is thus associated with higher income [45,72]. However, this type of housing was not correlated with income from the sale of NUCs. Another factor was support, both material and technical, from NGOs. Currently, few (if any) organizations are involved in the valorization or domestication of NUCs, as seen with other crops such as beans, maize, cassava, etc. Therefore, the absence of organizations empowering farmers affects their approach to
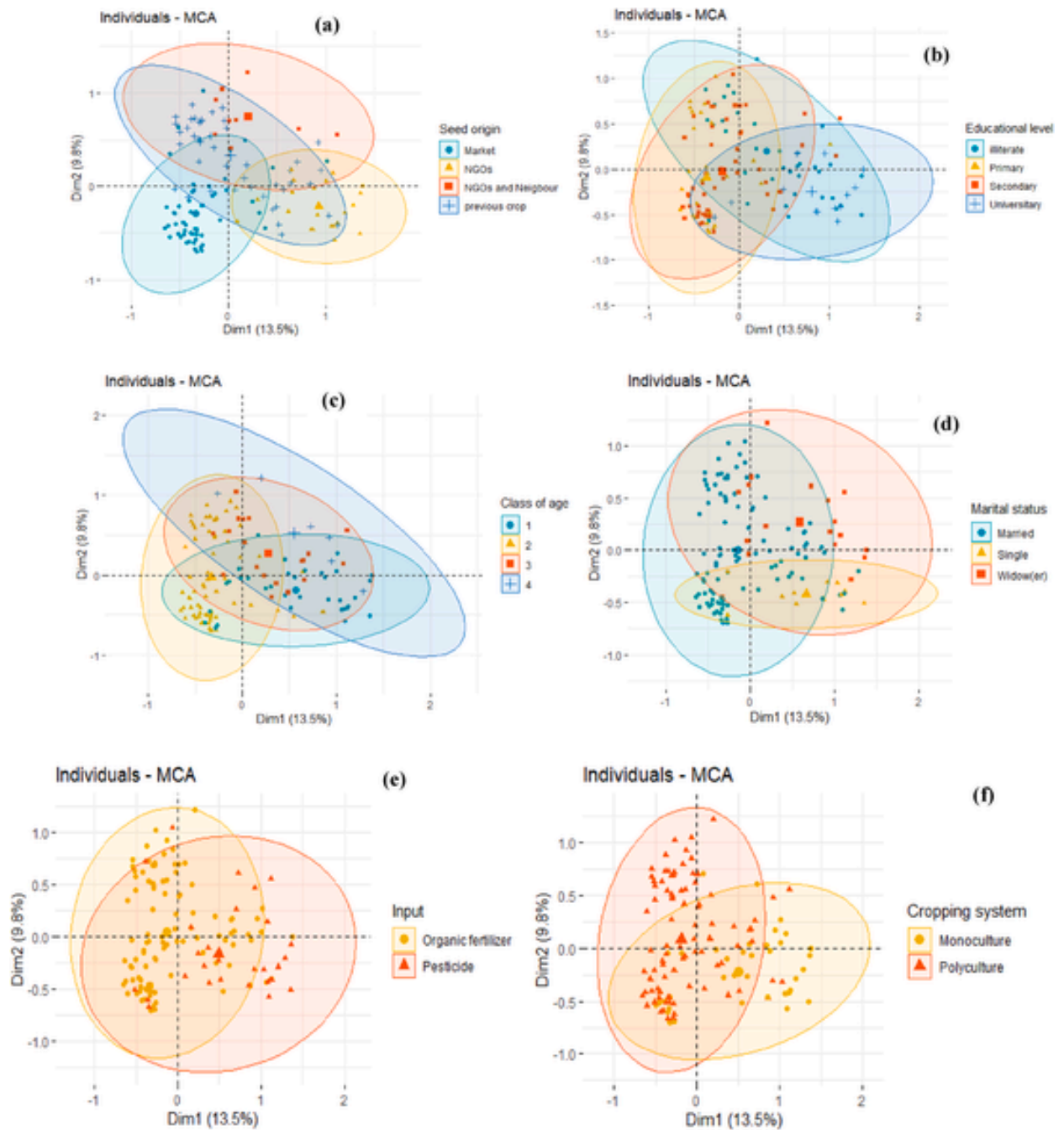
Fig. 8. Factors affecting the monthly household income from NUCs in Kabare and Walungu in the province of South-Kivu (here six variables affected the household's monthly income from NUCs comprising the origin of the seed used (a), the educational level (b), the class of age (c), marital status (d), the input used (e), and the cropping system (f).

producing or valorizing NUCs. It is, therefore, important to develop interventions in this direction by integrating the various aspects presented by this study.

These findings underscore the pivotal role of women in rural agriculture in South Kivu. They contribute to over 28 % of household income through NUCs and play a significant role in household consumption. In contrast, men's income is often allocated to expenses beyond household [45]. Recognizing and supporting this role is crucial. Additionally, rural women, alongside their children, constitute a vital workforce in the fields, further emphasizing their importance in the agricultural landscape. Indeed, this modest financial contribution can be attributed to the prevailing practice in rural areas of South-Kivu and throughout the DRC, where men primarily
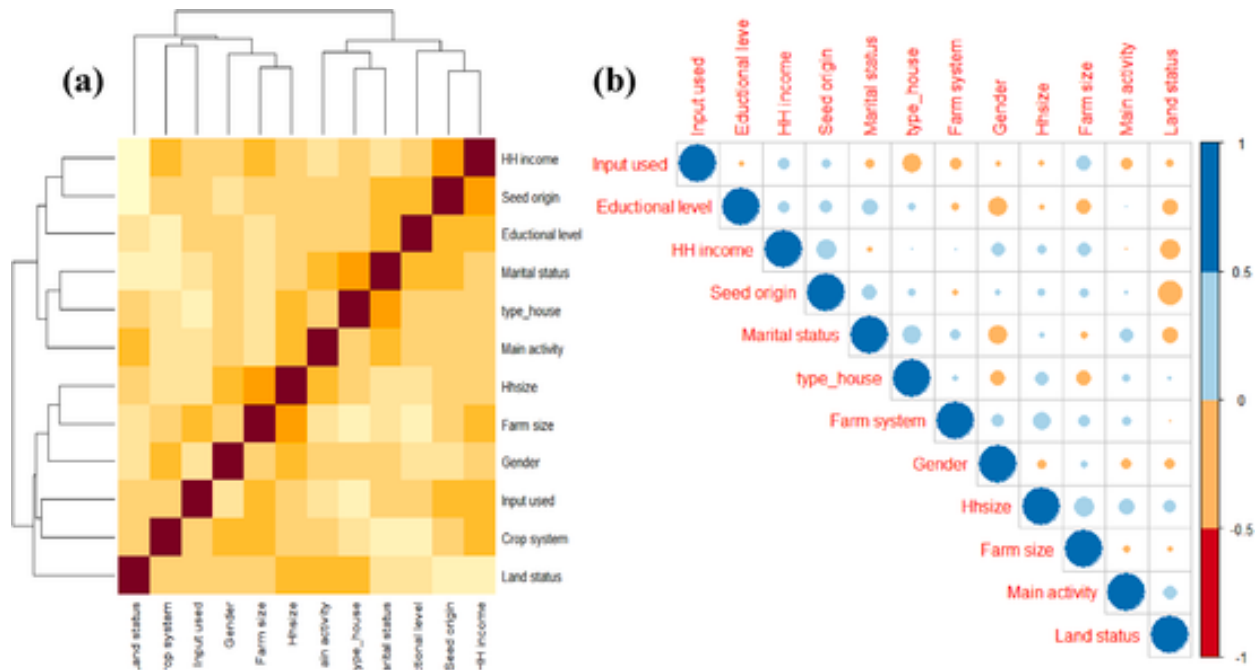
Fig. 9. Heatmap (a) and correlation matrix (b) between parameters used to characterize household intervening in NUC production in the Kivu highland, eastern DR Congo.

cultivate cash crops for commercial purposes. At the same time, women predominantly engage in subsistence farming to provide for their households. Any surplus produce is sold in the local market to secure additional income.

In a post-conflict context, where women have been exploited as tools of war [70,72,73], with all the documented potential consequences, it is evident that recommendations to policymakers should be formulated to alleviate the observed constraints and ensure household food security. Indeed, five primary constraints have been identified. These include insecurity during the collection of Neglected and Underutilized Crops (NUCs) in forests or areas heavily affected by armed groups, as reported by women (64 %). Women highlighted this, in conjunction with limited NGO interventions, the absence of seeds, and the need for technical (57 %) and financial support (82 %). Other constraints are linked to the low level of education among women in rural areas of South Kivu. This is particularly significant considering that most of these women are generally still young (< 30 years old, and predominantly 30–40 years old) and married. Policymakers should consider all these factors in their interventions to empower women in rural areas. This study underscores the urgency of interventions that are not one-dimensional but multi-dimensional, focusing on comprehensive initiatives to empower rural women as pivotal agents of agricultural transformation in the region.

These findings have significant policy implications for interventions that address food insecurity and poverty, especially in the ongoing conflict zones of South-Kivu province, through the promotion of NUCs. Firstly, interventions should prioritize the enhancement of NUCs' yield by developing advanced production techniques and considering the possibility of domesticating favorite wild species within communities. Secondly, there should be a focus on promoting women's participation in household decision-making, along with efforts to address and reduce various forms of gender-based violence. This study emphasizes the importance of considering household gender dynamics when implementing interventions to improve food security. Initiating gender-transformative approaches, such as empowering women to voice their opinions and sensitizing men to reduce gender-based violence, could significantly contribute to ensuring greater food security for many households. Further research on the impacts of such transformative approaches on food security outcomes would aid in developing more context-specific policies at local and regional levels.

As mentioned in many studies [74–77], NUCs also offer significant pest and climate resilience benefits, particularly in challenging agricultural regions such as hot and dry tropical regions. NUCs often have natural resistance to local pests and contribute to agrobiodiversity, reducing the need for chemical pesticides and promoting natural pest control. Their resilience to drought, poor soil fertility, and temperature extremes makes them well-suited to areas affected by climate change, as they require fewer inputs and can thrive in marginal soils. NUCs also offer environmental benefits by improving soil health through nitrogen fixation (for Fabaceae) and reducing soil erosion (the one with good ground cover and deep root systems), as well as demonstrating better water-use efficiency compared to conventional crops [77,78]. This is obvious for eastern DRC and specifically in South-Kivu province, where crop calendar change through climate perturbations [79], water efficiency [80], and soil erosion are among the most common agriculture issues [81]. Furthermore, they help conserve plant biodiversity and enhance overall ecosystem stability, making them a sustainable option for promoting food security, mitigating climate change, and supporting long-term environmental sustainability. Integrating NUCs into local farming systems can strengthen agricultural resilience and environmental conservation.

From a global perspective, NUCs contribute significantly to achieving several Sustainable Development Goals (SDGs) by improving food security, poverty reduction, and gender equality [14]. NUCs, with their climate resilience and natural pest resistance, offer new income opportunities for smallholder farmers, especially women, enhancing economic independence and contributing to poverty alleviation (SDG 1). Their nutritional value and ability to thrive in harsh environments support food security (SDG 2) by providing diverse, nutrient-rich food sources. As shown in this study in South Kivu as in another part of the world [16,41], women play a crucial role in cultivating and processing NUCs, promoting gender equality (SDG 5) by empowering them economically and reducing their labor burden. Additionally, NUCs enhance climate resilience (SDG 13) by thriving in challenging environments and promoting biodiversity conservation and sustainable land management (SDG 15), helping communities adapt to climate change while preserving ecosystems.

5. Conclusion

This paper has delved into the intricate interplay between gender dynamics, neglected crop cultivation, and household income in the context of South-Kivu agriculture, with a specific focus on the post-conflict highland of the Kivu region. The results of this study show that women's activities in the production of NUCs have significantly contributed to improving household income by 65–78 %. This has increased the monthly household income of 100–150$. Most women (75 %) reported facing significant agronomic, technical, and socio-economic challenges, primarily related to insecurity, lack of seeds, insufficient material and financial support, and limited access to urban markets that offer more opportunities. This study also highlights a gap in household income among farming families in the region. While men contribute to income through other activities, women contribute significantly by cultivating RTB crops. By harnessing the potential of NUCs and empowering women as key stakeholders in agricultural systems, we pave the way for more resilient, inclusive, and prosperous rural economies in the region. Overall, understanding the specific challenges women face in neglected crop cultivation, this research provides valuable insights for policymakers, development practitioners, and women farmers themselves, leading to more equitable and sustainable agricultural development in the Highland Kivu Region. We also highlight empowering women farmers through equal access to resources, training, and market opportunities; this research will help to enhance the productivity and increase the income of HH in post-conflict regions such as eastern DRC. This increased income benefits households by improving children's education, healthcare, and nutrition. Moreover, by reducing the gender gap in agricultural income, this research contributes to more significant gender equity and empowers women within their communities. This research is crucial for economic growth, poverty reduction, and food security, as women play a vital role in agriculture, and their empowerment is essential for achieving sustainable development goals. However, this study suggests a broader investigation at the regional level to elucidate better the role of women and NUCs in improving income and food security for populations in conflict-affected or post-conflict areas of eastern DRC.

CRediT authorship contribution statement

Civava M. René: Writing – review & editing, Validation, Supervision, Resources, Project administration, Methodology, Formal analysis, Conceptualization. **Chuma B. Géant:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Ndeko B. Adrien:** Writing – original draft, Supervision, Software, Resources, Data c. **Nzigi M. Joelle:** Methodology, Formal analysis, Data curation, Conceptualization. **Prince Baraka Lucungu:** Writing – original draft, Validation, Supervision, Software, Resources, Methodology. **Blandine Sanginga:** Data curation, Conceptualization. **Raphaël Mufumbo:** Resources, Data curation, Conceptualization. **Kazamwali M. Léonard:** Methodology, Formal analysis, Data curation. **Balezi Alfonse:** Validation, Supervision.

Ethics statement

The Interdisciplinary Center for Ethic Research CIRE of the Université Evangélique en Afrique (UEA) approved the study protocol, Ref: CIRE 008/DPSK/118PP/2022. We obtained consent from all resource persons and households for data collection after ensuring the participants' confidentiality of the data collected. All the national guidelines and legislation from the MULUNGU Station of INERA-DRC were followed, and all experimental protocols were approved. We also certify that the species used (for image capturing) are not on the IUCN red list index of threatened species Convention on the Trade in Endangered Species of Wild Fauna and Flora.

Data availability statement

Data from this paper will be available on reasonable request from the main author.

Funding

Declaration of competing interest

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

Acknowledgments

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2025.e42990.

References

[1] M. Kovaleva, W.L. Filho, C. Borgemeister, Gender issues within climate change research: a bibliometric analysis, Clim. Dev. 14 (8) (2022) 725–740.
[2] O. Matthew, R. Osabohien, K.H. Lakhani, B. Aderounmu, N.E. Osadolor, O. Adediran, A.E. Igharo, Women engagement in agriculture and human capital development in developing countries: an African sub-regional analysis, PLoS One 17 (12) (2022) e0277519.
[3] A.T. Phiri, H.M. Toure, O. Kipkogei, R. Traore, P.M. Afokpe, A.A. Lamore, A review of gender inclusivity in agriculture and natural resources management under the changing climate in sub-Saharan Africa, Cog. Soc. Sci. 8 (1) (2022) 2024674.
[4] T. Kilic, P. Winters, C. Carletto, Gender and agriculture in sub-Saharan Africa: introduction to the special issue, Agric. Econ. 46 (3) (2015) 281–284.
[5] C.R. Farnworth, F. Baudron, J.A. Andersson, M. Misiko, L. Badstue, C.M. Stirling, Gender and conservation agriculture in East and Southern Africa: towards a research agenda, Inter. Jour. Agri Sustain 14 (2) (2016) 142–165.
[6] F.M. Wekesah, E.N. Mutua, C.O. Izugbara, Gender and conservation agriculture in sub-Saharan Africa: a systematic review, Inter. Journ. Agri Sustain 17 (1) (2019) 78–91.
[7] E.L. Ampaire, M. Acosta, S. Huyer, R. Kigonya, P. Muchunguzi, R. Muna, L. Jassogne, Gender in climate change, agriculture, and natural resource policies: insights from East Africa, Clim. Change 158 (1) (2020) 43–60.
[8] J.M. Mondo, G.B. Chuma, P.B. Kwalya, S.A. Balagizi, S.S. Ndjadi, Y. Mugumaarhahama, R.M. Civava, Neglected and underutilized crop species in Kabare and Walungu territories, Eastern DR Congo: identification, uses and socio-economic importance, Journ. Agri. Food Res. 6 (2021) 100234, https://doi.org/10.1016/j.jafr.2021.100234.
[9] S. Padulosi, R. Phrang, F.J. Rosado May, Supporting Nutrition Sensitive Agriculture through Neglected and Underutilized Species, Operational framework, 2019.
[10] R. Per, G. Meldrum, R. Hall, S. Padulosi, E. Hermanowicz, N. Ghezae, Research capacity for neglected and underutilized species: a situation analysis in ten African countries, in: 3rd International Conference on Neglected and Underutilized Species (NUS): for a Food-Secure Africa, Bioversity International, Accra, Ghana, 2016, pp. 255–269 25-27 September 2013.
[11] G. Meldrum, S. Padulosi, Neglected no more: leveraging underutilized crops to address global challenges, in: Routledge Handbook of Agricultural Biodiversity, Routledge, 2017, pp. 298–310.
[12] J.M. Mondo, G.B. Chuma, H.M. Matiti, J.B. Kihye, E.M. Bagula, K. Karume, A. Asfaw, Crop calendar optimization for climate change adaptation in yam farming in South-Kivu, eastern DR Congo, PLoS One 19 (9) (2024) e0309775.
[13] T. Mabhaudhi, V.G. Chimonyo, T.P. Chibarabada, A.T. Modi, Developing a roadmap for improving neglected and underutilized crops: a case study of South Africa, Front. Plant Sci. 8 (2017) 2143.
[14] A. Ali, B. Bhattacharjee, Nutrition security, constraints, and agro-diversification strategies of neglected and underutilized crops to fight global hidden hunger, Front. Nutri. 10 (2023) 1144439.
[15] P. Chivenge, T. Mabhaudhi, A.T. Modi, P. Mafongoya, The potential role of neglected and underutilised crop species as future crops under water scarce conditions in Sub-Saharan Africa. Inter. Journ. Envi resea. Pub. Health 12 (6) (2015) 5685–5711.
[16] M.V. Conti, A. Campanaro, P. Coccetti, R. De Giuseppe, A. Galimberti, M. Labra, H. Cena, Potential role of neglected and underutilized plant species in improving women's empowerment and nutrition in areas of sub-Saharan Africa, Nutr. Rev. 77 (11) (2019) 817–828, https://doi.org/10.1093/nutrit/nuz038.
[17] J.M. Mondo, G.B. Chuma, H.M. Matiti, A.Z. Balezi, J.B. Kihye, R.B. Ayagirwe, A. Asfaw, Farming practices, varietal preferences, and land suitability analyses for yam production in Eastern DR Congo: implications for breeding initiatives and food sovereignty, Front. Sustain. Food Syst. 8 (2024) 1324646.
[18] A. Ali, B. Bhattacharjee, Nutrition security, constraints, and agro-diversification strategies of neglected and underutilized crops to fight global hidden hunger, Front. Nutr. 10 (2023) 1144439.
[19] Catherine Rozel Farnworth, Rebecca Morahan, Anne Rietveld, Gender Norms in Agri-Food Systems: Economic Resilience, 2024.
[20] J.C. Bryson, Women and agriculture in sub-Saharan Africa: implications for development (an exploratory study), J. Dev. Stud. 17 (3) (1981) 29–46.
[21] I. Unay-Gailhard, Š. Bojnec, Gender and the environmental concerns of young farmers: do young women farmers make a difference on family farms? J. Rural Stud. 88 (2021) 71–82, https://doi.org/10.1016/j.jrurstud.2021.09.027.
[22] I. Fertő, Š. Bojnec, Gender and the environmental concerns of young farmers in sustainable agriculture, Sci. Rep. 14 (2024) 7110.
[23] R. Meinzen-Dick, N. Johnson, A.R. Quisumbing, J. Njuki, J.A. Behrman, D. Rubin, E. Waithanji, The gender asset gap and its implications for agricultural and rural development. Gender in Agriculture: Closing the Knowledge Gap, 2014, pp. 91–115.
[24] N.L. Johnson, C. Kovarik, R. Meinzen-Dick, J. Njuki, A. Quisumbing, Gender, assets, and agricultural development: lessons from eight projects, World Dev. 83 (2016) 295–311, https://doi.org/10.1016/j.worlddev.2016.01.009.
[25] M.N. Mokgomo, C. Chagwiza, P.F. Tshilowa, The impact of government agricultural development support on agricultural income, production and food security of beneficiary small-scale farmers in South Africa, Agriculture 12 (11) (2022) 1760.
[26] C. Doss, Data needs for gender analysis in agriculture. Gender in Agriculture: Closing the Knowledge Gap, 2014, pp. 55–68.
[27] A.R. Quisumbing, R. Meinzen-Dick, T.L. Raney, A. Croppenstedt, J.A. Behrman, A. Peterman, Gender in Agriculture, vol. 102072, Springer, 2014, p. 444.
[28] A. Owoicho, S.O. Sennuga, J. Bamidele, B. Osho-Lagunju, F.O. Alabuja, Analysis of gender issues in access to land among farmers in Karu local government area of nassarawa state, Nigeria, Journ. Media & Manage 5 (2) (2023) 2–8.
[29] A. Croppenstedt, M. Goldstein, N. Rosas, Gender and agriculture: inefficiencies, segregation, and low productivity traps, World Bank Res. Obs. 28 (1) (2013) 79–109.
[30] Catherine Weaver, Hypocrite Trap: the World Bank and the Poverty of Reform, Princeton University Press, 2008.
[31] F. A. O., World Health Organization, and WHO Expert Committee on Food Additives, Evaluation of Certain Food Additives and Contaminants: Seventy-Third [73rd] Report of the Joint FAO/WHO Expert Committee on Food Additives, World Health Organization, 2011.
[32] C. Doss, R. Meinzen-Dick, A. Quisumbing, S. Theis, Women in agriculture: four myths, Global Food Secur. 16 (2018) 69–74.
[33] R. Meinzen-Dick, A. Quisumbing, C. Doss, S. Theis, Women's land rights as a pathway to poverty reduction: framework and review of available evidence, Agric. Syst. 172 (2019) 72–82.

[34] R.S. Meinzen-Dick, N.L. Johnson, A.R. Quisumbing, J. Njuki, J. Behrman, D. Rubin, E.M. Waithanji, Gender, Assets, and Agricultural Development Programs: A Conceptual Framework, CAPRi Working Paper, 2011.

[35] G. Chowdry, Women in Development (WID) in international development regimes, Feminism/postmodernism/development 26 (1995) 41.

[36] M. Kevane, Women and Development in Africa: How Gender Works, Lynne Rienner Publishers, 2004.

[37] S. Singh, Deconstructing 'gender and development' for 'identities of women', Int. J. Soc. Welfare 16 (2) (2007) 100–109.

[38] J.S. Jaquette, Women/gender and development: the growing gap between theory and practice, Stud. Comp. Int. Dev. 52 (2017) 242–260.

[39] G. Koczberski, Women in development: a critical analysis, Third World Q. 19 (3) (1998) 395–410.

[40] N.A. Anyidoho, Women, gender, and development in Africa. In the Palgrave Handbook of African Women's Studies, Springer International Publishing, Cham, 2021, pp. 155–169.

[41] S. Padulosi, J. Thompson, P.G. Rudebjer, Fighting Poverty, Hunger and Malnutrition with Neglected and Underutilized Species: Needs, Challenges and the Way Forward, 2013.

[42] B. Joseph, B. Matilda Ntowa, O. Edmund Osei, T. Rashied, A.A. Richard, K. Yaw, K. Daniel Ashie, Sustainable food system in Ghana: role of neglected and underutilized crop species and diversity, Anthropocene Science 2 (1) (2023) 62–70.

[43] Z. Tadele, D. Bartels, Promoting orphan crops research and development, Planta 250 (2019) 675–676.

[44] H. Harris-Fry, H. Nur, B. Shankar, G. Zanello, C. Srinivasan, S. Kadiyala, The impact of gender equity in agriculture on nutritional status, diets, and household food security: a mixed-methods systematic review, BMJ Glob. Health 5 (3) (2020) e002173.

[45] N.A. Ciza, V. Stany, P. Lebailly, H. Azadi, Agricultural development in the fight against poverty: the case of South Kivu, DR Congo, Land 11 (4) (2022) 472.

[46] A. Bandula, T.K. Nath, Underutilized crops in the agricultural farms of Southeastern Sri-Lanka: farmers' knowledge, preference, and contribution to household economy, Econ. Bot. 74 (2020) 126–139, https://doi.org/10.1007/s12231-020-09492-2.

[47] J. Njuki, S. Eissler, H. Malapit, R. Meinzen-Dick, E. Bryan, A. Quisumbing, A review of evidence on gender equality, women's empowerment, and food systems. Science and Innovations for Food Systems Transformation, 2023, p. 165.

[48] M. Jones, C. Alexander, N.O. Widmar, J. Ricker-Gilbert, J.M. Lowenberg-DeBoer, Do insect and mold damage affect maize prices in Africa? Evidence from Malawi, Mod. Econ. 7 (11) (2016) 1168–1185.

[49] D. Hunter, T. Borelli, D.M. Beltrame, C.N. Oliveira, L. Coradin, V.W. Wasike, F. Tartanac, The potential of neglected and underutilized species for improving diets and nutrition, Planta 250 (2019) 709–729.

[50] N. Lutaladio, B. Burlingame, J. Crews, Horticulture, biodiversity and nutrition, J. Food Compos. Anal. 23 (6) (2010) 481–485.

[51] T. Borelli, D. Beltrame, V.W. Wasike, G. Samarasinghe, A. Tan, D. Hunter, The BFN Mainstreaming Toolkit. A roadmap to using neglected and underutiliZed species for food system change, in: Orphan Crops for Sustainable Food and Nutrition Security, Routledge, 2021, pp. 163–173.

[52] B.G. Chuma, N.G. Mushagalusa, S. Schmitz, Mapping small inland wetlands in the South-Kivu province by integrating optical and SAR data with statistical models for accurate distribution assessment, Sci. Rep. 13 (1) (2023) 17626, https://doi.org/10.1038/s41598-023-43292-7.

[53] B.L. Maass, D. Katunga Musale, W.L. Chiuri, A. Gassner, M. Peters, Challenges and opportunities for smallholder livestock production in post-conflict South Kivu, eastern DR Congo, Trop. Anim. Health Prod. 44 (2012) 1221–1232.

[54] K.B. Eric, B.K. Njehia, J. de Wolf, C. Karani-Gichimu, Competitiveness of smallholder legume production in South Kivu region, democratic republic of Congo, Afr. Journ. Agri Res. 10 (26) (2015) 2562–2567.

[55] M.D. Steinberg, Software solutions for form-based collection of data and the semantic enrichment of form data (2019), 11053 arXiv preprint arXiv:1901.

[56] A. Sharma, N. Minh Duc, T. Luu Lam Thang, et al., A consensus-based checklist for reporting of survey studies (CROSS), J. Gen. Intern. Med. 3 (6) (2021) 3179–3187, https://doi.org/10.1007/s11606-021-06737-1.

[57] E. Zossou, A. Arouna, A. Diagne, R.A. Agboh-Noameshie, Gender gap in acquisition and practice of agricultural knowledge: case study of rice farming in West Africa, Exp. Agric. 53 (4) (2017) 566–577.

[58] H. Dancer, D. Tsikata, Researching Land and Commercial Agriculture in Sub-saharan Africa with a Gender Perspective: Concepts, Issues and Methods, University of Sussex, 2015 (Version 1). https://hdl.handle.net/10779/uos.23452613.v1.

[59] SNSA, Ministère National de l'agriculture 433 (2014).

[60] W.G. Cochran, Sampling Techniques, third ed., John Wiley & Sons, 1977.

[61] H. Noble, R. Heale, Triangulation in research, with examples, Evid. Base Nurs. 22 (3) (2019) 67–68.

[62] N.T. Ochieng, K. Wilson, C.J. Derrick, N. Mukherjee, The use of focus group discussion methodology:Insights from two decades of application in conservation, Methods Ecol. Evol. 9 (2018) 20–32, https://doi.org/10.1111/2041-210X.12860.

[63] V. Aitsidou, E. Michailidou, E. Loizou, G. Tsantopoulos, A. Michailidis, Focus group discussions on food waste: an empirical application providing insights into rural and urban households in Greece, Sustainability 16 (2) (2024) 502.

[64] W. Rojas-Preciado, M. Rojas-Campuzano, P. Galindo-Villardón, O. Ruiz-Barzola, Control chart T2Qv for statistical control of multivariate processes with qualitative variables, Mathematics 11 (12) (2023) 2595.

[65] P. Loslever, Spatiotemporal analysis of traffic data: correspondence analysis with fuzzified variables vs. Principal component analysis using weather and gas price as extra data, Network. Spatial Econ. (2024) 1–33.

[66] H. Abdi, D. Valentin, Multiple correspondence analysis, Encyclopedia of measurement and statistics 2 (4) (2007) 651–657.

[67] M.Y. Bele, D.J. Sonwa, A.M. Tiani, Local communities' vulnerability to climate change and adaptation strategies in Bukavu in DR Congo, J. Environ. Dev. 23 (3) (2014) 331–357.

[68] I. Lambrecht, B. Vanlauwe, M. Maertens, Agricultural extension in eastern DR Congo: does gender matter? in: European Association of Agricultural Economists (EAAE) > 2014 International Congress, August 26-29, 2014 https://doi.org/10.22004/ag.econ.182731, Ljubljana, Slovenia, http://purl.umn.edu/182731.

[69] P.N. Mumbeya, P.K. Matungula, K.K. Masuki, M. Schut, C. Okafor, Can innovation platforms (IPs) improve rural women participation in maize value chain? Evidence from the Eastern DR Congo, Euro Journ Agri & Food Sci. 2 (3) (2020).

[70] C. Altare, E.B. Malembaka, M. Tosha, C. Hook, H. Ba, S.M. Bikoro, & Spiegel, P. Health services for women, children and adolescents in conflict-affected settings: experience from North and South Kivu, Democratic Republic of Congo, Conflict Health 14 (1) (2020) 1–19.

[71] W.A. Bapolisi, G. Ferrari, G. Bisimwa, S. Merten, Gendered determinants of food insecurity in ongoing regional conflicts, North and South Kivu, the Democratic Republic of Congo, Agric. Food Secur. 10 (1) (2021) 1–9.

[72] M. Le Polain, M. Nyssens, An analysis of the socio-economic logics underpinning formal and informal strategies for coping with economic hardships in South Kivu, in: Democratic Republic of Congo, Info Eco Pract& Inst, Securing Livelihoods, 2013, pp. 78–96.

[73] S. Alfaro, K. Myer, I. Ali, L. Roberts, Estimating human rights violations in South Kivu province, democratic republic of Congo: a population-based survey, Vuln. Child. &Youth Stu 7 (3) (2012) 201–210.

[74] P. Chivenge, T. Mabhaudhi, A.T. Modi, P. Mafongoya, The potential role of neglected and underutilised crop species as future crops under water scarce conditions in Sub-Saharan Africa, Intern. Jour. Env Res. Pub Health 12 (6) (2015) 5685–5711.

[75] M. Farooq, A. Rehman, X. Li, K.H. Siddique, Neglected and underutilized crops and global food security, in: In Neglected and Underutilized Crops, Academic Press, 2023, pp. 3–19, https://doi.org/10.1038/s41598-024-57933-y.

[76] C.A. Masao, J. Igoli, E.T. Liwenga, Relevance of neglected and underutilized plants for climate change adaptation & conservation implications in semi-arid regions of Tanzania, Environ. Manag. 71 (1) (2023) 114–130.

[77] M. Singh, S.B. Aglawe, C. Behera, R. Gowthami, J. Purohit, V. Kaur, R. Yadav, Role of neglected potential crops in climate resilient sustainable agriculture, in: In Adapting to Climate Change in Agriculture-Theories and Practices: Approaches for Adapting to Climate Change in Agriculture in India, Springer Nature Switzerland, Cham, 2024, pp. 163–200.

[78] G. Meldrum, S. Padulosi, Neglected no more: leveraging underutilized crops to address global challenges, in: Routledge Handbook of Agricultural Biodiversity, Routledge, 2017, pp. 298–310.

[79] J.M. Mondo, A.B. Ndeko, R.B. Ayagirwe, H.M. Matiti, C. Bahati, R.M. Civava, Seed delivery system in northeastern Democratic Republic of Congo:

characteristics, stakeholders mapping and challenges towards building a well-functioning seed system under humanitarian and security crises, Int. J. Agric. Sustain. 22 (1) (2024) 2335128.

[80] E.M. Bagula, J.G.M. Majaliwa, G.N. Mushagalusa, T.A. Basamba, J.B. Tumuhairwe, J.G.M. Mondo, M.M. Tenywa, Climate change effect on water use efficiency under selected soil and water conservation practices in the Ruzizi catchment, Eastern DR Congo, Land 11 (9) (2022) 1409.

[81] G.B. Chuma, F.S. Bora, A.B. Ndeko, Y. Mugumaarhahama, N.C. Cirezi, J.M. Mondo, S. Schimtz, Estimation of soil erosion using RUSLE modeling and geospatial tools in a tea production watershed (Chisheke in Walungu), eastern Democratic Republic of Congo, MESE (2021) 1–17.

[82] S. Ogutu, J. Mockshell, J. Garrett, T. Ritter, R. Labarta, D. Alvarez, E. Gotor, Women's empowerment, household dietary diversity, and child anthropometry among vulnerable populations in Odisha, India, PLoS One 19 (8) (2024) e0305204.

[83] O.O. Idowu, Contribution of neglected and underutilized crops to household food security and health among rural dwellers in Oyo State, Nigeria, in: International Symposium on Underutilized Plants for Food Security, Nutrition, Income and Sustainable Development 806, 2008, pp. 49–56 March.

[84] R.M. Lana, T.I. Riback, T.F. Lima, M. da Silva-Nunes, O.G. Cruz, F.G. Oliveira, C.T. Codeço, Socioeconomic and demographic characterization of an endemic malaria region in Brazil by multiple correspondence analysis, Malar. J. 16 (2017) 1–16.

[85] A. Barth, The changing nature of attitude constructs: an application of multiple correspondence analysis on gender role attitudes, Qual. Quantity 50 (2016) 1507–1523.