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How Rural Communities Relate to Nature in Sub-Saharan Regions: Perception of Ecosystem Services Provided by Wetlands in South-Kivu

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Abstract: Research on ecosystem services (ES) has become central to landscape planning, framing the relationship between people and nature. In Sub-Saharan regions, local communities rely heavily on wetlands for various ES. For the first time, we assessed perceptions of ES provided by these wetlands, focusing on marshes, peatlands, swamps, and inland valleys/floodplains in eastern DR Congo. Fieldwork combined with a survey of 510 households, using both open-ended and 35 direct questions, evaluated perceptions of wetland ecosystem services (WESs). The most frequently reported WES were provisioning (38%) and regulating (24%), while supporting (22%) and cultural (16%) were less mentioned. These perceptions varied across wetland types and among communities based on gender, religion, seniority in wetland use, land tenure, and educational level. Rural communities had a deep relationship with nature, shaped by cultural, economic, and geographical factors. Wetlands are viewed positively as sources of goods but also negatively as sources of diseases. A structural equation model (SEM) helped in identifying four latent variables—livelihood, knowledge, personal, and geographical factors—driving WES perceptions. These findings are relevant for developing wetland management policies and suggest including community engagement and collaboration in wetland restoration and regulatory frameworks.

Keywords: wetland ecosystem services (WES); community perception; wetland types; household survey; structural equation model (SEM); sustainable development; D.R. Congo

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1. Introduction

Wetlands are among the most critical and productive ecosystems, providing a wide range of ecosystem services (ESs) supporting both ecological stability, human well-being and livelihood [1,2]. Their destruction, management and protection significantly impact on sustainable development goals. These ESs include water purification, flood regulation, carbon sequestration, and the provision of food and raw materials. They also support biodiversity, offering habitats for a wide range of plants and animal species, including many that are endangered or endemic [1–7]. Wetlands are considered as an area of land, usually flat, where the soil is saturated or flooded with water either permanently or seasonally. They include different types according to the region, climate, topography, and terrain, going from bogs, to mangroves, deltas, marshes, swamps, peatlands, floodplains and inland valleys, etc. [1,3].

In Sub-Saharan regions and eastern Democratic Republic of Congo (DRC) in particular, wetland ecosystems play a vital role in supporting the socio-economic and environmental needs to local communities [4–6]. Their role in climate mitigation through carbon sequestration and contaminant and pollutants reduction are also well demonstrated in

such a way that community assessments of ES by different wetland habitats have become common in recent years [2,7]. Despite their importance, however, wetlands still face numerous threats, including degradation, pollution, and encroachment, which jeopardize their ability to continue providing essential services to the people who depend on them. These increasing threats are both anthropogenic and natural pressures. This is particularly high the last century in all the regions from the equator to the polar climate [8–12]. Based on their diversity and the role they play, special attention should be given to these areas.

Recognized as the contribution of wetland ecosystems to human well-being and classically comprise provisioning, regulating, supporting, and cultural services, wetland ecosystem services (WESs) constitute and are considered as an abstract tool that integrates community–nature relationships and contribute to policy implementations and reinforcing practices for the wetland sustainable use [13,14]. In fact, WESs are referred to as the benefits that ecosystems provide to human well-being [1]. They combine the benefits people obtain from wetlands or the direct and indirect contributions of ecosystems to human well-being, derived from acknowledgement that humans fundamentally rely on the range of benefits provided by healthy ecosystems [15,16]. These WESs are generally grouped in four classes (provision, support, cultural, and regulation) that provide a conceptual framework for understanding the interactions between humans and the natural environment, aiding in the development of effective policies and strategies for sustainable ecosystem management [17]. Furthermore, as suggested by Lhoest et al. [18], to understand the complex social-ecological systems, social approaches are needed to ensure optimal provision of ESs on which community rely. Therefore, integrating community perceptions is essential for management, decisions, and strategical sustainability.

South-Kivu province, located in eastern Democratic Republic of Congo (DRC), is home to diverse types of wetlands. Estimated at ~13.5% (898,690 ha), these areas are rich and diverse and include marshes, swamps, peatlands, floodplains, bogs, lakes, rivers, floodplains/inland valleys, etc. Wetlands serve as critical habitats for numerous plant and animal species, while also offering a range of ES to local communities. From providing clean water for drinking and irrigation to supporting fisheries, agriculture, and cultural practices, the services rendered by these wetlands are indispensable for the socio-economic development and resilience of communities in the region. They are found across all territories, climates, topographies, and the overall landscape of the region [19]. The province is a region marked by its post-conflict status and presents a unique landscape where the interaction between humans and nature is both intricate and vital. However, they continue to face various forms of anthropogenic pressures leading to their degradation and loss [20,21]. Although these areas provide these ecosystem services, they also have negative aspects, particularly related to the resurgence of diseases such as malaria, tsetse fly, typhoid fever, etc.; livelihood and water-related diseases are strongly linked to wetland management. In fact, the degradation and contamination of water from wetland use has the potential to spread disease coming from microorganisms and increase breeding habitats for disease vectors [22–25].

The services provided, their perceptions, and drivers have not yet been documented in the area. Nevertheless, these would form the foundational elements for any restoration interventions or the initiation of "wise use" of these areas, within the sustainable development framework. In fact, the Ramsar Convention on wetlands highlighted the "wise use" concept by conserving the ecological character of wetlands while managing the socio-economic value these landscapes hold for different stakeholders. It refers to the sustainable utilization of wetlands for the benefit of humanity in a way that is compatible with maintaining the natural properties of the ecosystem, emphasizing the balance between conservation and sustainable development [26–28]. It is therefore essential to conduct a detailed study on the services these wetlands provide to the local communities, the communities' perceptions of these areas, and the factors influencing these perceptions in the context of a post-conflict region characterized by unique land tenure, diversity in community and beliefs, and generally contrasting sociodemographic situations.

The concept of ecological sustainability of wetlands has been developed in recent decades to guide decision-makers towards ecological sustainability; in DRC, a comprehensive assessment of wetland ecosystem services (WESs)—which is an approach that generally incorporates relevant integrated assessment methodologies with mixed perspectives (ecological, economic, and social) [2]—is required. Ecological methods evaluate the functions and biophysical properties of ecosystems, while economic methods assign monetary values to ES. Many studies, however, propose social approaches that provide more details and attempt to thoroughly detail the elements [13,29]. In South-Kivu, the socio-political context adds layers of complexity to wetland management. The region has been grappling with instability, leading to fragmented governance and competing land use interests. Land tenure issues, lack of effective governance, and poverty drive communities to exploit wetland resources unsustainably.

Despite the essential role that wetlands play in South-Kivu, there is a significant gap in understanding how local communities perceive and value the ESs provided by these wetlands. Most studies on ES tend to focus on ecological and economic assessments, often neglecting the social and cultural dimensions that are crucial for comprehensive management strategies [2,7,30]. In South-Kivu, where traditional knowledge and community engagement are vital for sustainable resource management, this gap in understanding may pose a challenge to effective wetland conservation and use. Furthermore, rural communities have a deeply intertwined relationship with their natural environment. In fact, wetland ecosystems are not only sources of material benefits but also hold cultural and social significance. Wetlands' role in health risk and water-related infections disease according to Anthonj et al. [23] are both sides of the coin. The perceptions of health risk and local knowledge on water-related infectious disease exposure from wetlands in rural communities combined with ongoing generational shift and changing socio-economic dynamics further complicate this relationship, making it essential to capture and understand these perceptions and interactions comprehensively.

In this article, we focused our discussion within a context that concerns how different local communities from South-Kivu interact with the wetland's nature, with a focus on ecosystem services (ESs). We adopted and developed a fieldwork and quantitative approach in accordance with the guidance from Morrison et al. and Moge al. [7,31] to develop an understanding of the functional processes of wetlands that underlie and support all ecosystem services. Given that the functions and processes of wetlands are strongly influenced by variations in edaphic and climatic characteristics specific to different geographic areas, it is important to recognize that there is often significant variation in WESs between different geographic regions and how this is perceived by communities. Even for ES shared across regions, the level and value at which a particular service is expressed and perceived may differ [2,32]. Despite ongoing debates between stakeholders, researchers, etc. around the concepts of ecosystem services (ESs) and nature's contributions to the well-being of users, the adoption of the ES framework while integrating social methodologies into assessments is advisable in regions such as South-Kivu, considering local realities. This integrated approach will highlight the importance of considering ecological, geographical, and social perspectives in the approach to sustainable use. Studies have to highlight the multiple ESs provided by wetlands and how knowledge of ESs can be used to inform land-use decisions affecting sustainability.

As above mentioned, there is a lack of awareness and understanding among policymakers, stakeholders, and local communities about the value of wetlands and the need for their conservation and sustainable management. Local-scale assessments of multiple ES provided by eastern DRC wetlands are urgent and crucial, but none has been made yet. Several communities, users, and stakeholders with contrasting interests influence these complex social-ecological systems and uses of resources, and constitute a high-priority stake considering their contribution to rural life quality in a high-poverty context [20,21]. It is also essential to comprehend how these stakeholders' perceptions of ES are shaped by their wetland environment such as water regime, slope, location (referred to

here as accessibility), and by socio-demographic characteristics to properly align wetland-planning strategies with communities' needs and uses in a sustainable manner. The questions of land tenure, religious belief, and socio-economic situations in a conflict-affected region could also be significant elements shaping the perception that communities have about a space.

This research aims to develop a holistic understanding of the functional processes of wetlands that underlie and support all ecosystem services with social methodologies. This approach underscores the significance of considering social perspectives in the sustainable use and management of wetlands in South-Kivu. The overall objective of this study is to contribute to conservation initiatives and wise use of wetlands through the understanding of services provided. Specifically, this study: (i) assessed the ecosystem services provided by small wetlands to local communities in South-Kivu, eastern DRC, (ii) sought to understand the perception of ESs provided by wetlands, and (iii) examined the factors driving the community perceptions. We hypothesized that the ESs provided varied depending on the local community characteristics and wetland types; that both sociodemographic and geographical factors significantly drive the community perception of WES.

2. Materials and Methods

2.1. Study Area

This study was conducted in the South-Kivu province eastern DRC, known for its diversity in wetland areas. Estimation indicated that nearly ~13.5% (898,690 ha) of the province's surface is covered by wetlands; these wetlands are rich and diverse, located mainly in the southern and western territories rather than the eastern ones [12].

From a biophysical and socio-economic perspective, South-Kivu features a range of climates, including equatorial and humid tropical climates with some areas experiencing a tendency towards dryness, as well as temperate climates influenced by altitude [33,34]. The climate varies from Aw to Cf and Cw according to Koppen–Geiger classification (Figure S6) [35]. The topography is also diverse, ranging from low-altitude forested areas in the south and west to steep slopes, hills, and mountains along the Mitumba mountain range (Figure 1). The province is rich in forest cover, ranging from primary to secondary forests, with mountainous terrain prevalent along the Mitumba range, boasting peaks reaching up to ~3200 m in the high altitudes near Minembwe and Mount Kahuzi at ~3540 m. Hydrologically, South-Kivu is rich, featuring a diversity of rivers and lakes, including the Tanganyika and Kivu lakes.

Socioeconomically, a mix of rural and urban populations engaged in agriculture, trade, and other economic activities characterizes the province. The province remains facing challenges such as limited infrastructure, socio-political instability, and the presence of armed groups, which affect livelihoods and development efforts. Despite these challenges, South-Kivu is rich in cultural diversity and natural resources, offering opportunities for sustainable development and growth [36]. The population, ethnic diversity, religious dynamics, and land tenure arrangements in South-Kivu as elsewhere in the world contribute to the unique cultural and social fabric, while also presenting challenges and opportunities for governance, development, and conflict resolution. South-Kivu province has a diverse population (~6.2 million, among which 47% living in rural areas) comprising various ethnic and religious groups, as well as different forms of land tenure [33,37–40]. Firstly, ethnically, South-Kivu is home to numerous groups, including the Bashi, Lega, and Hunde among others. These ethnic communities have distinct cultural traditions, languages, and social structures, contributing to the province's rich cultural diversity [33,41]. Secondly, South-Kivu religiously reflects a mix of beliefs and practices. While Christianity (particularly Catholic and Protestant) is prevalent, there are also adherents of Islam and traditional African religions. This religious affiliation often plays a significant role in shaping social norms, community dynamics, and daily life and is supposed to affect community perceptions [37]. Thirdly, it exhibits a variety of arrangements in terms of land tenure.

Traditional land tenure systems, based on customary practices and communal ownership, are prevalent in rural areas, where land is often passed down through generations within families or clans. However, there are also instances of individual land ownership, particularly in urban and peri-urban areas, where formal land titling processes may apply. Additionally, land tenure in South-Kivu is influenced by legal frameworks, customary laws, and historical factors, leading to a complex landscape of land rights and access. In general, the majority of land belongs to the church, the state, or local authorities (commonly referred to locally as "mwami", who allocate them to these notable figures, who then become landowners). This makes access to land difficult for small-scale farmers, who therefore remain tenants of small plots of land [42,43].

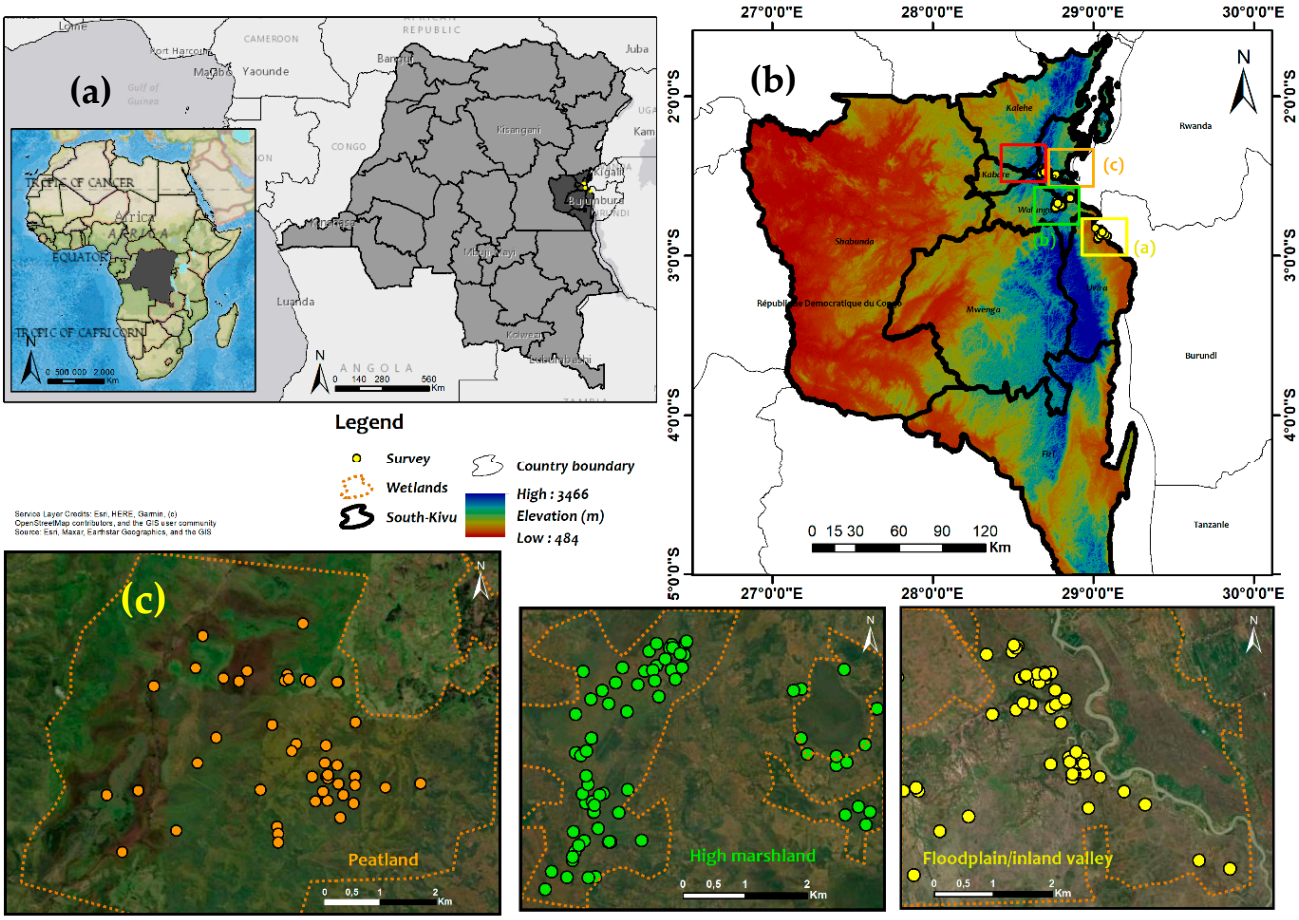


Figure 1. Study area showing the Democratic Republic of Congo (DRC) (**a**), the South-Kivu province (**b**), and wetland types selected in the South-Kivu province in eastern DRC. Dots represent the farms surveyed during field works (**c**). The overlay at the South-Kivu province represents the digital elevation model from ALOS PALSAR of 12.5 m spatial resolution (downloaded from: https://www.eorc.jaxa.jp/ALOS/, accessed on 20 May 2024).

2.2. Wetland Diversity in South-Kivu

Given that a diversity of wetlands exists in South-Kivu, we hypothesized that perceptions and their drivers varied from one type of wetland to another [32]. Other factors such as accessibility, morphology, and water regime in these areas would also influence their perceptions. In fact, water regime (permanently or temporary) is a potential source of influence on local community perceptions when it comes to wet ecosystems [2,44]. Based on the spatial distribution and morphological characteristics obtained from Chuma et al. [19], coupled with topographic, climate, and accessibility factors, we conducted a multifactorial analysis followed by hierarchical clustering. Four types of wetlands were

therefore identified in South-Kivu. Taking into account security, financial, and accessibility constraints, one wetland per type was selected as case study (Figures 1 and S1).

In the following paragraph, we provide a summary of these four types, namely marshes, swamps, floodplains/inland valleys, and peatlands. Overall, while marshes and swamps differ primarily in their vegetation composition, floodplains/inland valleys are characterized by periodic inundation, and peatlands are distinguished by the accumulation of organic matter (OM). Marshes are wetlands characterized by shallow water and the presence of emergent herbaceous vegetation, such as grasses, sedges, and reeds [45,46]; while swamps are wetlands dominated by woody vegetation, such as trees and shrubs, in addition to herbaceous plants [47–49]. They typically have standing water for most of the year and are found in low-lying areas with poor drainage, such as river floodplains and coastal regions. Floodplains/inland valleys refer here to low-lying areas or depressions in the landscape that are periodically inundated by water, often during heavy rainfall or seasonal flooding events mainly used for rice production and vegetables (Figure S1). These valleys may support various types of vegetation depending on factors such as soil type, water depth, and frequency of flooding [30,50]. Peatlands, also known as bogs or mires, are wetlands characterized by the accumulation of organic matter (peat) derived from partially decomposed plant material. They typically have acidic, waterlogged conditions and are dominated by mosses and other moisture-loving plants. They are mostly identified as high-altitude peatlands [51,52]. Figure S1 shows satellite images (extracted from Google Earth Pro) of the four types of wetlands considered in this study.

2.3. Methods

2.3.1. Sampling Strategy and Questionnaire Survey

A socioeconomic household survey was conducted from December 2023 to January 2024. We conducted structured interviews in Kiswahili and other local languages (Mashi and Kifuliru). A total of 510 households (out of 123,562 households) in the community living in the vicinity of the selected wetlands were interviewed with the designated head of each household (used questionnaire available at the link: https://ee.kobotoolbox.org/x/fYETA7Fe, accessed on 20 February 2024). Two field technicians, seven students from UEA, and two field assistants (e.g., local leaders, local NGO members) helped with performing the interviews. To ensure an identical manner of undertaking interviews, collaborators were trained and agreed on the questioner standard before field deployment. We adopted a systematic random sampling (based on an estimation of the minimal number of respondents needed to reach accuracy of 5%) in the villages around the selected wetlands. The sample size was calculated by applying the formula implemented by (https://www.surveymonkey.com/mp/sample-size/, accessed on 5 November 2023) as suggested by Israel [53]. A total of 510 households (HH) were necessary to achieve representative results, leading to 250 users of marshes, 124 of floodplains/inland valleys, 74 of swamps, and 62 of peatlands. To ensure the data's reliability, we proposed to work exclusively with the users of wetlands. Since perception is better analyzed when the people concerned are directly in contact with the object being analyzed, we went to meet the users in the wetland areas where they work.

(a) Household characteristics

Seven sociodemographic characteristics were considered including age class, gender, ethnicity, religious belief, educational level, main activity, and household's monthly income. These factors were chosen based on the existing literature in the region regarding the socioeconomic determinants of perception [7,31,41,54]. Only religious belief and land tenure were considered typically relevant due to their connection with land status in South-Kivu [43]. Indeed, the majority of the land in rural South-Kivu designated for agricultural activities belongs to traditional chiefs (locally known as "mwami") and the church (either Protestant or Catholic). This allowed us to hypothesize that perception would vary

depending on the community's religious affiliation as well as these aforementioned demographic variables.

(b) Farm characteristics

Information related to fields and activities in the wetlands was collected. Four supplementary variables were integrated, including the seniority in activities in the wetlands, land tenure, the farm size, and the drainage type (whether it is complete, partial, or not drained). Since the majority of wetlands are used for agriculture and brick making [20,21], coordinates were collected for all surveyed wetland users. To highlight the accessibility and use of wetlands, these coordinates were exported into a GIS tool, and the Euclidean distance (ED) to the nearest road, village, and market was calculated, then the values were extracted. This represented the distance between the utilised fields in the wetland and these infrastructures, depending on whether they are closer to or farther from these ecosystems.

2.3.2. Perceptions of Wetland Ecosystem Services (WES)

To evaluate the ES perceptions of wetland community users, 35 direct questions were formulated according to the advices from the RAWES (Rapid Wetland Ecosystem Services) as suggested by [1], among which questions on regulating (13), supporting (7), cultural (7), and providing (8) services were considered (Supplementary Table S1). The scale for these questions was a five-point Likert-type scale ranging from −2 to +2: "strongly disagree" (−2), "disagree" (−1), "agree" (+1), and "strongly agree" (+2). Respondents could also choose "I do not know" (0) as an answer. The local community respondents were asked and encouraged to justify answers through a short explanation after selecting the scale for each answer. In all cases, the term "ecosystem services" was rarely used explicitly during the interviews; however, we encouraged participants to describe the specific benefits that they receive directly from wetlands but also the neglected ones. To accurately capture the statements of the respondents, an audio recording was made throughout the survey to ensure a clear understanding of the explanations given by the users.

2.3.3. Driving Factors of WES Perceptions

The factors that influence how local communities perceive ESs provided by wetland in the study area were also identified. First, we identified the most reported WESs to local communities using the answer datasets. The answers to 35 questions were coded as binary values with "0" to each ES not identified and "1" for identified ones. Secondly, the abovementioned variables in Section 2.3.1 that combine households and farm characteristics were used to assess the factors driving the WES perceptions. Globally, 14 variables were used to assess the factor affecting the perception of WES. These factors are known to shape people's attitudes, beliefs, and understanding of ecosystem nature and functions [29,55,56]. The work diagram used in this study is provided in Figure S5.

We first evaluated the correlation/dependency between these variables and the WESs assessed. We adopted the structural equation model (SEM) to evaluate the driving factors of the WES. SEM was used for a variety of reasons, mainly related to its ability to handle complex relationships among high number of variables [29,57]. First, it helps with examining the complex relationships simultaneously and distinguishes direct and indirect effects. SEM also helps to understand the pathways through which variables are influencing each other. Secondly, SEM enables creation of latent variables (that were not observed) and which are inferred from observed ones, while at the same time measuring error and improving the accuracy of the estimation between variables. Due to its flexibility and versatility, SEM integrates multiple regressions and factor analysis, while handling different type of data [58]. Overall, SEM is advantageous when the research involves complex relationships among multiple variables, including latent constructs. Its flexibility, ability to handle different data structures, and robust model fit assessment make SEM a powerful tool in social sciences, psychology, education, earth and natural sciences, and many other

fields. Structural equation modeling (SEM) is seen as an extension of path analysis [59–61]. Before analysis, we hypothesized that, the HH income and educational level could change her/his WES perceptions and that being Christian or originating from the dominant ethnic group directly affects community's ability to perceive WES. Indeed, it is widely evidenced that the accessibility, the water regime, type of drainage, and the wetland landscape combined with personal characteristics would strongly influence people's perceptions.

2.4. Data Treatment and Analysis

The final database downloaded from the Kobo Collect was analyzed with descriptive statistics. RStudio and R 4.2.1 were used for data visualization, graph creation, and data analysis. The Chi-square (χ^2) and Cramer-V tests were used to analyze dependency and the strength of association between categorical variables at 5% threshold probability. In all the analyses made, wetland types and ES categories were considered as the main factors. Our analysis focused on the significance and magnitude of the influence of selected variables on perception of WESs. As above mentioned, we adopted SEM analysis, which is a special form of multivariate analysis used to examine the hypothetical causality among multiple variables and how their inter-relationships may play a role in determining a particular outcome, or the WESs in this study [17,60,62]. The relationships were represented using a final path diagram in which the standardized partial regression coefficients and χ^2 or V are presented and thus can be interpreted as the magnitude of direct or indirect causal influence. The fitness of the SEM analysis was performed using "lavaan" and "semPlot" packages. The process consisted of data preparation, importing into RStudio, conversion, and properly formatting to fit the SEM analysis. The SEM model specification helped to specify the relationships between latent and observed variables. For model estimation, the fitness indexes were used for assessment comprising, the χ^2 test value of the overall model, Chi-Square divided by degrees of freedom "CMIN/DF", Root Mean Square Error of Approximation "RMSEA", RFI, and Comparative Fit Index "CFI". These were used to evaluate adequacy and ability of the model to represent the relationship among selected variables. The reliability of the analysis was conducted using Cronbach's α test.

3. Results

3.1. Descriptive Analysis of Surveyed Communities

3.1.1. Socioeconomic Profile of the Participants

The results of the socioeconomic characteristics of the households surveyed to assess the wetland ecosystem services (WESs) and their perceptions are presented in the Table 1. The data from this table revealed that nearly half (47%) of wetland users were elderly individuals (>61 years old), while young people made up a minimal portion of wetland users (23%). Among the few young users, they tend to engage in more energy-intensive and profitable activities, such as brick making or vegetable farming. Men (62%) were more prevalent users of wetlands compared to women (38%), particularly in marshes and flooded plains/inland valleys rather than peatlands and swamps. Within these areas, the "Bashi" community accounted for the majority of users (77%), followed by the "Bavira" (14%) and other communities (9%). These users were predominantly Catholic Christians (57%), followed by Protestants (37%) and other religious affiliations present in the region (5%). Additionally, wetland users typically had low levels of education (no formal education: 31%, primary education: 33%). Agriculture remained the main activity for wetland users, followed by livestock, trade, and artisanal activities. Trade activities mainly focused on vegetable products and small local shops (locally known as Kiosques), while livestock farming tends to be more localized, with a dominance of small-scale activities. However, households relying on wetlands typically had very low monthly incomes, with over half

living on less than USD 50 per month (53%). Overall, these characteristics varied significantly depending on the type of wetlands ($p < 0.05$) upon which their usage depends.

Table 1. Sociodemographic characteristics of households surveyed for WES in South-Kivu province.

Variables	Modalities	Floodplain (124)	Marshes (250)	Peat (62)	Swamp (74)	Percent (510%)
Age class	<30 years	21 (17%)	57 (24%)	17 (27%)	19 (21%)	144 (23%)
	31–60 years	35 (28%)	81 (32%)	20 (31%)	20 (23%)	155 (30%)
	>61 years	68 (55%)	113 (44%)	25 (42%)	35 (56%)	241 (47%)
Gender	Female	43 (35%)	98 (41%)	25 (38%)	29 (32%)	195 (38%)
	Male	81 (65%)	152 (59%)	38 (63%)	45 (68%)	316 (62%)
Ethnicity	Bashi	58 (47%)	220 (86%)	49(92%)	47 (84%)	393 (77%)
	Other	23 (18%)	15 (7%)	7 (4%)	12 (5%)	47 (9%)
	Bavira	43 (35%)	15 (7%)	6 (4%)	15 (11%)	70 (14%)
Religious (belief)	Catholic	61 (49%)	152 (59%)	38 (69%)	37 (61%)	293 (57%)
	Other	7 (6%)	12 (5%)	6 (2%)	14 (9%)	28 (5%)
	Protestant	56 (45%)	86 (36%)	18 (29%)	23 (30%)	189 (37%)
Educational level	Illiterate	41 (33%)	78 (31%)	16 (25%)	24 (32%)	159 (31%)
	Primary	39 (31%)	84 (33%)	20 (33%)	26 (36%)	169 (33%)
	Secondary	38 (31%)	80 (32%)	22 (40%)	24 (32%)	165 (32%)
	University	3 (2%)	5 (2%)	5 (2%)	-	10 (2%)
	Vocational training	3 (2%)	3 (1%)	-	-	7 (1%)
Main activity	Agriculture	107 (86%)	212 (83%)	44 (83%)	47 (86%)	428 (84%)
	Craftsman	2 (2%)	10 (4%)	7 (6%)	-	18 (4%)
	Livestock breeder	5 (4%)	15 (6%)	7 (6%)	10 (2%)	28 (6%)
	Trading	10 (8%)	13 (6%)	5 (4%)	16 (9%)	34 (7%)
HH income	<USD 50	48 (39%)	163 (61%)	23 (38%)	38 (64%)	272 (53%)
	>USD 300	3 (2%)	2 (1%)	-	-	5 (1%)
	USD 101–300	24 (19%)	21 (11%)	13 (17%)	19 (20%)	73 (14%)
	USD 51–100	49 (40%)	64 (28%)	2 (46%)	17 (16%)	160 (31%)

3.1.2. Characteristics Linked to Farm in Wetlands

Information regarding farm characteristics and wetland utilization is presented in Table 2. The table provides details on the seniority in wetland use, land tenure, farm size, and drainage quality. A diversity of usage patterns is observed based on the users' experience with wetland utilization. Indeed, there are those with over twenty years of experience (32%), compared to those with less than five years (25%). Almost half of the users, however, have over ten years of experience in wetland utilization. These farms in wetlands are mostly categorized as communal (57%), with only about a third being privately owned (family-owned) and 5% belonging to religious institutions. The exploited areas are generally small (less than 0.5 ha: 66%), or 0.5 to 1 ha (26%). As for the drainage system, these areas are partially drained (71%), while few remain intact (19%), meaning they are preserved and not drained. The type of use of wetlands and service provided are presented in Figures 2 and 3 respectively.

To assess the services provided by wetlands to the community, we first identified the types of usage of these areas by the communities. This was followed by perception of these WESs. Initially, we found a dependency between the type of use and the four types of wetlands found in South-Kivu ($\chi^2 = 47.9$, df: 12, $p < 0.001$). Figure 3 showed that agriculture remained the main dominant activity (65%) in wetlands (except for peatlands), followed by brick making (15%), artisanal activities, forage harvesting, and various other activities. Although they are less represented, few activities are observed in swamps. These activities are more observed in marshes and floodplains/inland valleys than in swamps and peatlands. With few activities, swamps remain the type where less anthropogenic pressure is seen.

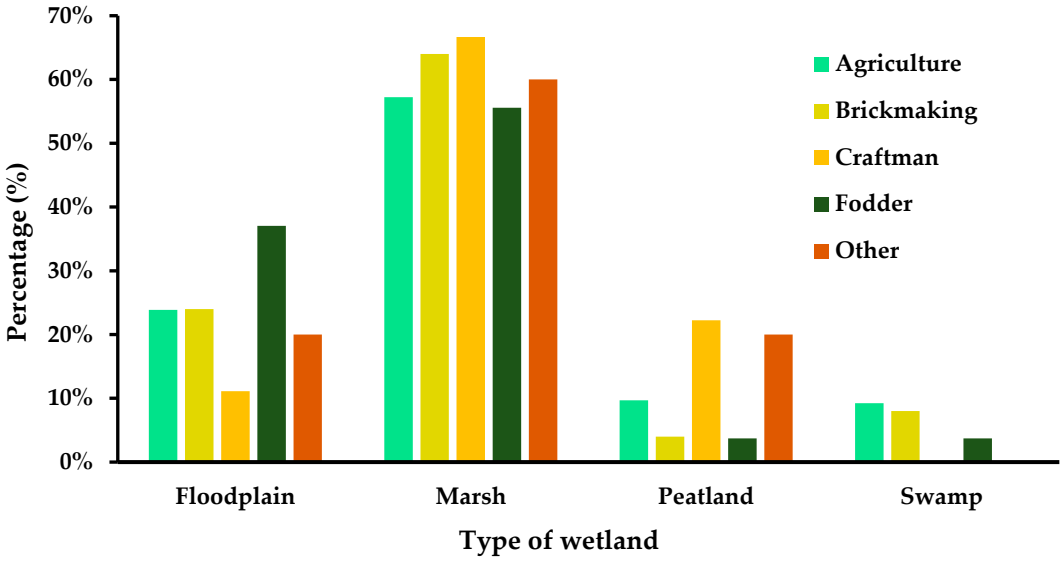


Figure 2. Type of use of wetlands in South-Kivu province, eastern DRC.

Figure 3. Wetland ecosystem services (WESs) in South-Kivu, eastern DR Congo.

Table 2. Characteristics linked to farming in the wetlands in South-Kivu.

Variables	Modalities	Floodplain (124)	Marshes (250)	Peat (62)	Swamp (74)	Percent (510%)
Seniority	<5 years	30 (24%)	58 (26%)	15 (23%)	21 (25%)	127 (25%)
	6–10 years	40 (33%)	53 (24%)	12 (19%)	26 (36%)	136 (27%)
	11–20 years	16 (13%)	77 (18%)	16 (19%)	15 (16%)	161 (17%)

	>21 years	37 (30%)	78 (32%)	23 (40%)	15 (23%)	161 (32%)
Land tenure	Community farm	33 (27%)	174 (64%)	34 (65%)	56 (82%)	289 (57%)
	Private Catholic	9 (8%)	6 (4%)	6 (4%)	5 (2%)	23 (5%)
	Private family	38 (31%)	46 (20%)	16 (27%)	13 (16%)	117 (23%)
	State	44 (35%)	20 (12%)	6 (4%)	-	81 (16%)
Farm size	<0.5 ha	63 (51%)	192 (73%)	35 (67%)	38 (64%)	337 (66%)
	0.6–1 ha	48 (39%)	49 (22%)	8 (21%)	21 (25%)	135 (26%)
	1.1–2 ha	10 (8%)	8 (4%)	13 (48%)	9 (9%)	31 (6%)
	>2.1 ha	3 (2%)	2 (1%)	6 (4%)	6 (2%)	7 (1%)
	Completely	37 (30%)	7 (4%)	8 (2%)	-	53 (10%)
Drainage quality	Not drained	4 (3%)	48 (24%)	24 (42%)	5 (2%)	94 (19%)
	Partially	83 (67%)	190 (71%)	30 (56%)	67 (98%)	363 (1%)

3.2. Perceptions of Wetland Ecosystem Services (WESs)

Ecosystems Services

The results obtained showed that all wetland types are referred to as "tingi tingi" or simply as "marais", a general term commonly used in the area. When asked if there was a difference between these zones in the region, the communities gave mixed responses. According to the perceptions of the majority of the respondents, marshes, peatlands, swamps, and floodplains/inland valleys are all similar, with only slight differences related to the water regime and the species abundant. Therefore, the distinctions between these wetlands appeared to be more scientific than practical from a user's point of view. When the local communities were asked about the 35 questions regarding WESs, we tried to determine if the local community recognized these ESs. It turns out that provisioning services (38%) were more reported than supporting services (22%); in contrast, cultural services (16%) were less frequently mentioned than regulating services (24%) (Figure 4). These reported WESs varied from one wetland type to another. For the users of the floodplains/inland valleys, out of all the services, those related to provisioning and supporting (42% and 28%) were frequently more reported, while regulating (18%) and cultural (12%) services were often less mentioned. For marshes, supporting (37%) and regulating (33%) services were the most reported. Only 18% and 12% of provision and cultural services were recognized in marsh areas. Peatlands are mainly more recognized for their provisioning (32%) and regulating (31%) than supporting (23%) and cultural (14%) services. Finally, in the swamps, supporting, regulating, and provisioning services are recognized at 24%, 29%, and 28%, respectively (Figure 5). The floodplains/inland valleys, which are more dominant in the south (in the Ruzizi plain), were primarily perceived as areas with high agricultural potential (97% of users), contribute to the preservation of plant diversity (89%) and have rich soil fertility (90%). These wetland types are mainly used for cultivating vegetables, rice, sweet potatoes, sorghum, etc. Unfortunately, these areas are associated with a high frequency of plant diseases and pests, contribute very little to controlling bushfires, and have no connection with traditional rites. Despite having slight aesthetic value (69%), these areas significantly foster important social bonds among users (89%) (Figure 5).

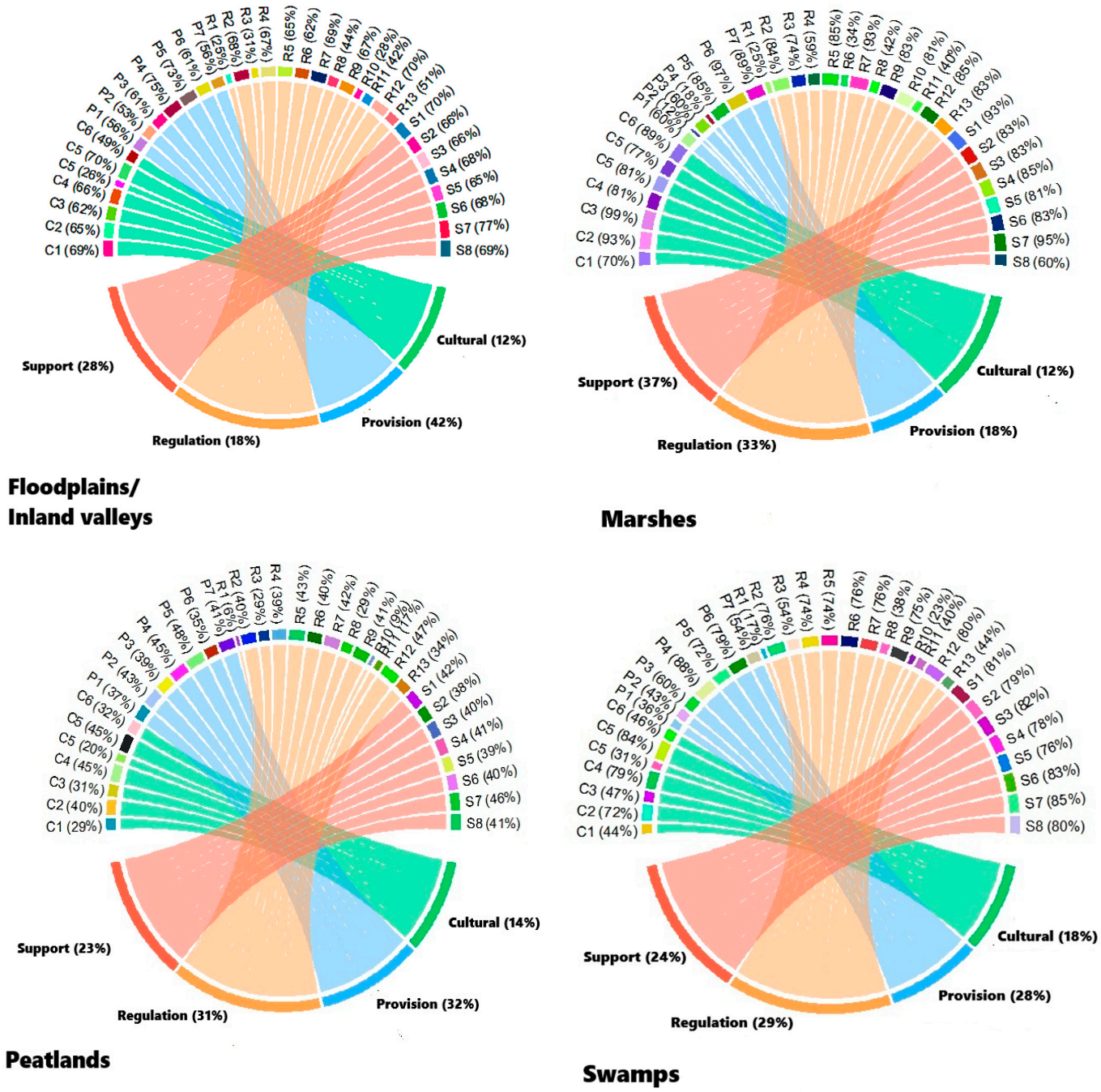


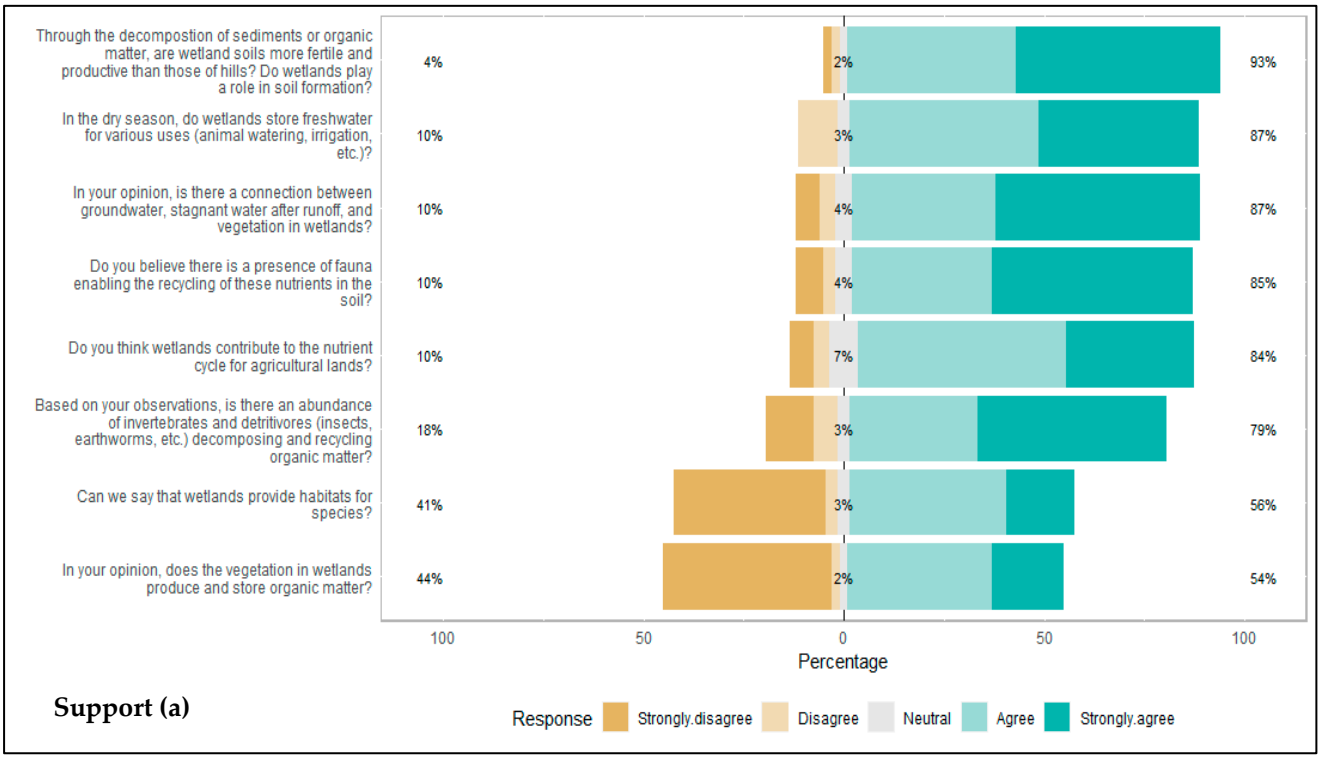
Figure 4. Categories of ecosystem services (ESs) reported for the four wetland types in South-Kivu province in eastern DR Congo (C1 to C6, S1 to S8, R1 to R13, and P1 to P7 present the questions used to assess cultural, supporting, regulating, and providing WESs, respectively). These questions are presented in the Table S1, Figure S2 and are available at the link (https://ee.kobotoolbox.org/x/fYETA7Fe, accessed on 20 May 2024).

Marshes are perceived by users as rich habitats, with the presence of high-quality freshwater. These areas have recently attracted scientific interest and are rich in soil fertility and significant carbon storage. In comparison to floodplains/inland valleys, marshes are perceived as less productive in terms of agriculture, fodder harvesting, and less provision of fibers and non-timber products. Although users noted that there is export of aggregates, marshes are still perceived as poor in biodiversity. They are also reported as areas where solids and wastewater are deposited (Figure 4). For peatlands, users reported

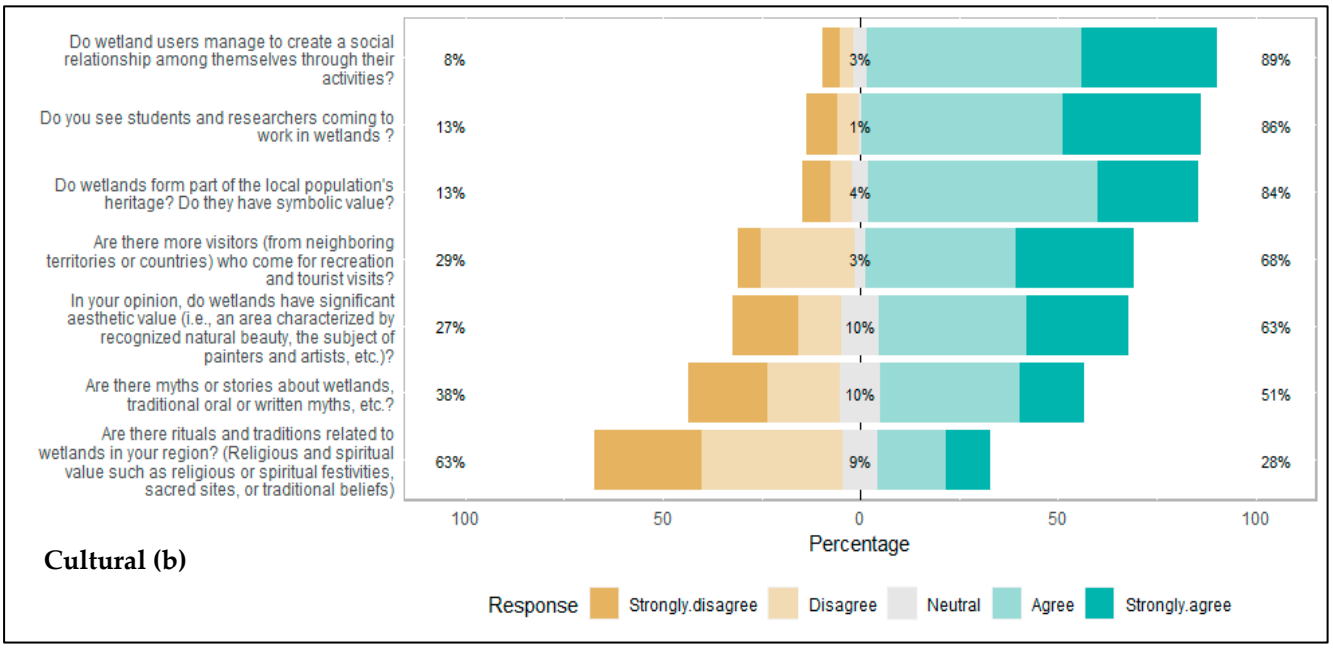
that they remain rich habitats, often home to wild species and endemic species. The soils are also more fertile, and people from surrounding cities come for visits and recreation (Figure 4). However, peatlands are perceived as wetlands with low agricultural productivity due to the high permanence of water and the dark organic soil layer (peat) that must be removed before any use. For those engaged in livestock farming, peatlands remain a significant area for forage harvesting. Finally, like peatlands, swamps are recognized as rich habitats with high biodiversity. Their water quality is good and is perceived to create good weather. However, swamps are associated with the emergence of diseases and have a low contribution to forage harvesting, flood regulation, and pollination (Figure 4).

(a) Perceptions of ecosystem services

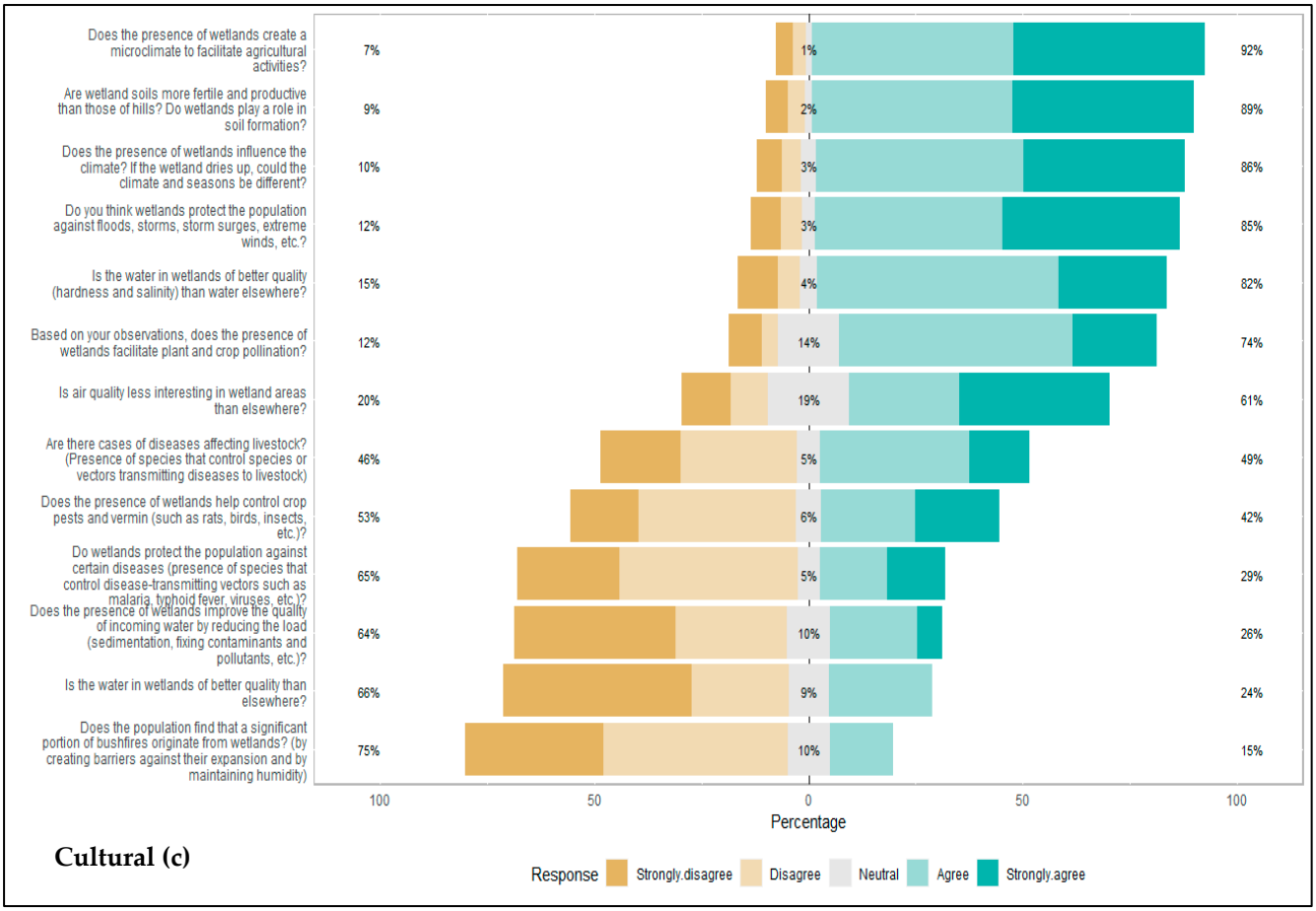
For supporting services, the results shown in Figure 5a indicate that local communities had a positive view of six out of the eight support services provided by wetlands. Whether it was their role in the decomposition of sediments and organic matter (OM), the high fertility of their soils compared to hillside soils, or their ability to provide fresh water during drought periods for animal watering, irrigation, or domestic use, the communities recognize their importance. The local communities were also positive about the presence of biodiversity, which allows nutrient recycling and thus contributes significantly to agricultural fertility and productivity. However, they were ambivalent about viewing wetlands as habitats for endemic species or their capacity to store organic matter (Figure 5b). For cultural services, the majority of respondents strongly agree that wetlands help create social bonds among users and all actors involved. They also agree on the educational value of these areas, particularly through field visits and practical work conducted by university students from the major cities of the province. The communities also agree that wetlands are part of the local heritage of the region's population. On the other hand, a large portion of respondents strongly disagree that these areas are subjects of paintings and artists, or that they contain stories and myths related to the tradition of these areas. Myths or traditions related to wetlands are rarely present in the region, except among some indigenous peoples surveyed (locally called the Twa). For regulation services, out of the thirteen questions proposed to assess the perception of wetlands, local communities agreed on seven services, but were rather in disagreement regarding the others. Indeed, local communities recognize the role of wetlands in creating a microclimate favorable to agricultural activities, their contribution to soil formation in the region, and their ability to regulate seasonality, extreme precipitation events, violent winds, and floods. They also believe that wetlands contribute to good air quality in the surrounding regions or villages. However, these communities disagree with the idea that wetlands play an important role in fighting bushfires by creating barriers against their spread and maintaining a certain level of soil moisture. They also do not believe in their effectiveness in regulating the physico-chemical quality of water. Additionally, these areas are associated with the presence of vectors of certain diseases, including malaria and typhoid, which affect not only humans but also plants and animals (Figure 5c). According to providing services (Figure 5d), it appears that the majority of the seven provisioning services have been recognized by the communities. Most users believe that wetlands offer better agricultural production, are rich in plant diversity, and could serve as sources of genetic resources. Wetlands are also perceived as providers of wood for domestic use, peat, some non-timber products, and fibers. They also yield ornamental products and medicinal plants. However, users remain divided on the issue of aggregate exportation (clay, nutrients, gravel, etc.). A portion (60%) agrees with this view, while 38% disagree (mostly for communities with brick making as main activities).



Support (a)



Cultural (b)



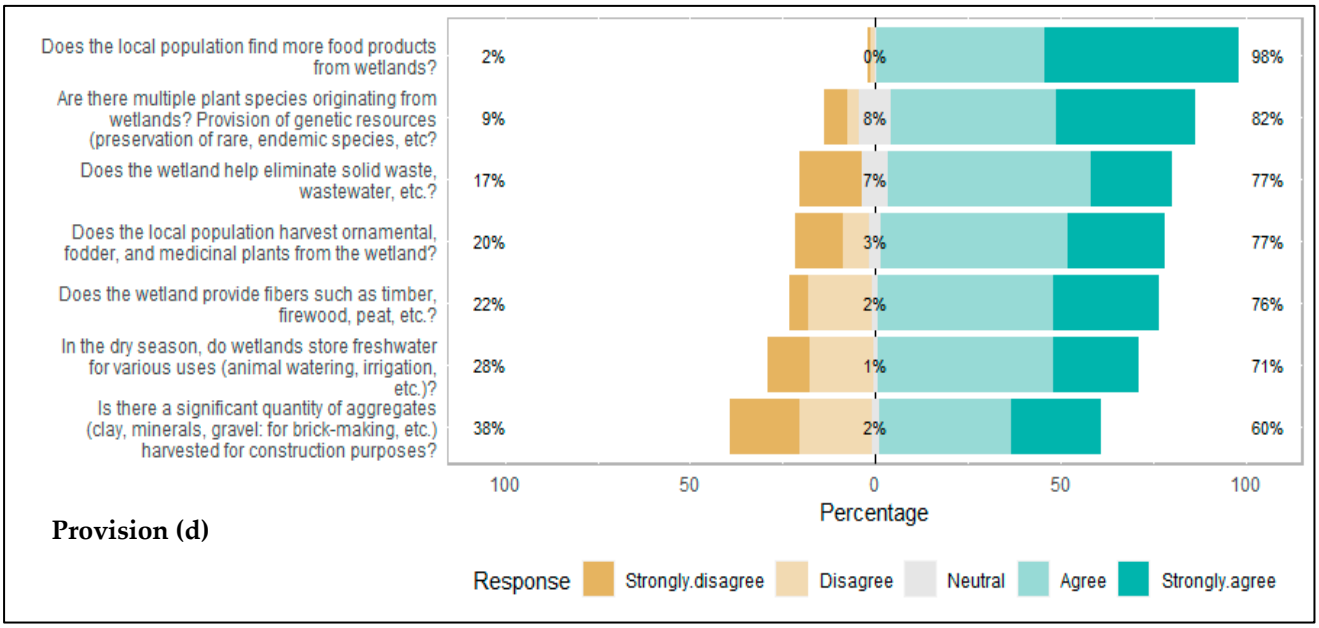


Figure 5. Perception of local communities on wetland ecosystem services (WES): (**a**) supporting, (**b**) cultural, (**c**) regulating, and (**d**) providing services.

3.3. Gender Analysis

The analysis conducted between the type of activity carried out in wetlands and gender, as well as the source of labor, showed a strong dependence between the main type of activity ($\chi^2 = 12.34$, df = 4, $p = 0.023$), the type of labor ($\chi^2 = 17.4$, df = 3, $p = 0.001$), and gender.

These analyses showed that men are focused on activities that generate quick income, such as brick making and artisanal activities (making chairs, mats, pots, etc.), in addition to agricultural activities than women. A very small proportion of women participate in brick making and artisanal activities in wetlands (Figure 6a). According to field discussions and observations, these women are either involved in selling bricks (mainly made by their husbands or acquaintances) or working as laborers transporting bricks from the place of manufacture to the place of firing or sale. Since women seemed to be mainly involved in labor activities, we also analyzed the source of this labor used by gender. It appears that men carry out their own activities in 68% of cases, compared to 32% for women (Figure 6b). These men also use collective labor (87%), meaning family members or external labor. Regarding labor outside the household, women (55%) and men (45%) both rely on this type of labor.

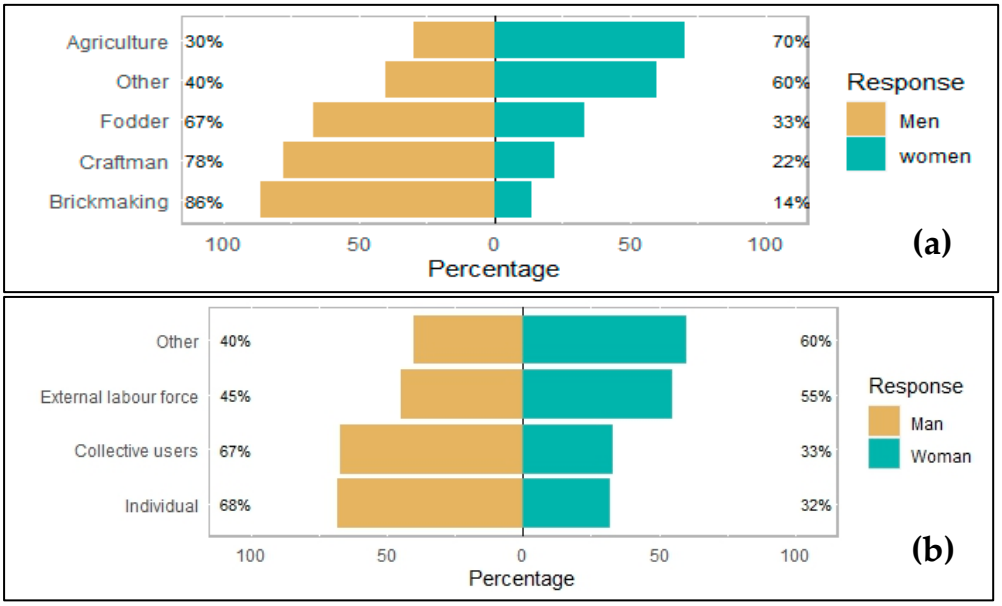


Figure 6. Main activity (**a**) and type of labor (**b**) used in the observed wetland operations based on gender.

3.4. Driving Factors of Community Perception of Wetland Ecosystem Services (WES)

The results on factors driving the perceptions of local communities to ecosystem services (ES) were assessed using a structural equation model (SEM). The results obtained from the SEM showed that factors associated with the perception of WESs varied from one type of wetland to another, i.e., WES perceptions models were slightly different for the four wetlands (Figure 7). First, we evaluate the goodness-of-fit measures (GOFs) for the SEM following the indicators presented in Section 2.4. To assess if the model fits the data, metrics (χ^2, CMIN/DF, RMSEA, RFI, and CFI) were used. The values indicated an excellent fit as the values are above the recommendation thresholds. The CFI values were above 0.95 for all types of wetlands; the RMSEA was also good (≤0.05). The standardized loading values of the factors against the created latent variables remained above 70%, with such loading; the values indicated that the observed variables are well represented by their respective latent constructs. The integration of the fourteen variables into the model allowed the creation of four latent variables, which were grouped into (1) geographical factors, (2) knowledge-related factors, (3) well-being factors, and (4) personal factors specific to each household. The contribution of each variable varied depending on the type of wetlands (Figure S4); therefore, four SEM models were created.

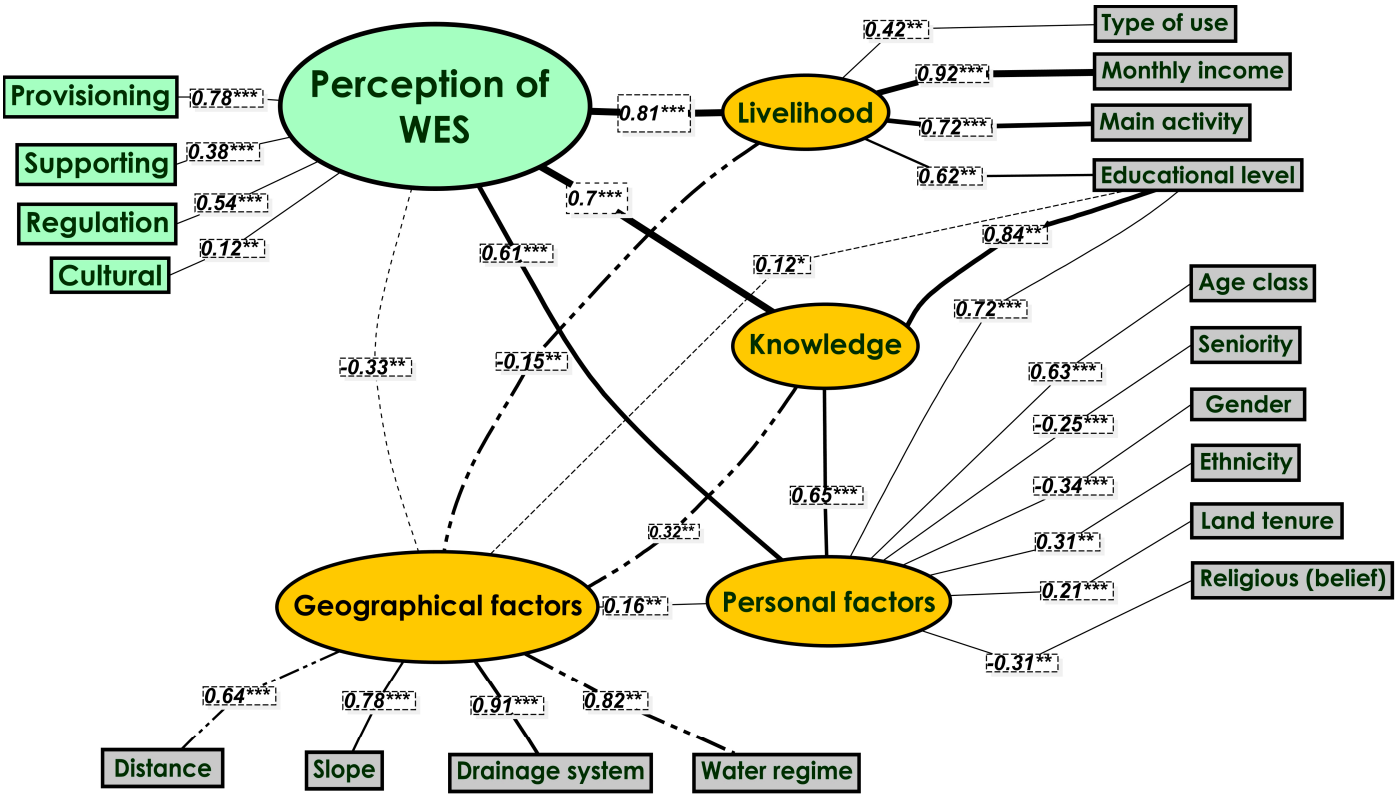


Figure 7. Driving factors of perception of wetland ecosystem services in South-Kivu, eastern DR Congo. The plot was produced following the SEM (Structural Equation Model) analysis of wetland ecosystem services (WESs) perceptions; *, **, and *** indicate the significance at the level of 5%, 1%, and 0.1% threshold, respectively. Dashed lines indicate a non-significant loading path, while the width represents the strength of the relation.

Geographical factors were found to be related to perception and their inclusion could improve the model's power. The geographical factors as a latent variable had three indicators, namely distance from wetland to households' place of residence, the water regime (whether it is permanent or seasonal), the drainage system availability, and the terrain morphology mainly related to topography, notably the slope. This explained more community perceptions for peatlands and marshes than swamps and floodplains/inland valleys. Although significant, these combined factors contributed weakly to the communities' perception. Livelihood factor as a latent variable significantly contributed to the perception of the WESs provided. This new factor included variables such as the main activity of the household head, the type of use, the educational level, and the household's average monthly income. Personal factors specific to each household also contributed to the perception of the ESs provided by wetlands. These factors encompass six variables: the gender of the household head, the land tenure status of the field, the length of time the wetlands have been exploited, and religious affiliation (whether Protestant, Catholic, or another religion), the user's age, and ethnic origin (whether Mushi, Muvira, or another). Another factor was linked to the latent variable related to people's knowledge, primarily associated with the level of education, well-being, and other personal factors. As mentioned above, these determinants of WES perception varied from one type to another. For peatlands, the order of factor contribution to perceptions is livelihood > knowledge > personal factors > geographical factors, while for marshes it was knowledge > livelihood > personal factors > geographical factors. For swamps: livelihood > personal factors > knowledge > geographical factors, and for floodplains/inland valleys: livelihood > knowledge > personal factors > geographical factors (Figure S4).

4. Discussion

4.1. Socioeconomic Characteristics of Wetland Users in South-Kivu

The results show that most activities in wetlands remain the domain of all rural communities. Both young and old are interested in activities within these areas; the young are more inclined towards activities that quickly generate profits, such as brick making, while the elders are more interested in agriculture, harvesting medicinal plants, and various other activities. A similar trend is observed in gender analysis, with women being more focused on agricultural activities (mainly subsistence farming) while men are more involved in brick making. Overall, the significant contribution of women to the agricultural sector in South-Kivu is well documented [63–65]. Regarding activities in wetlands, the results indicate that agriculture remains the dominant activity, followed by brick making and grass cutting for forage. These activities are more prominent in marshes and inland valleys/floodplains than in swamps and peatlands due to high water levels and the presence of trees and peat, which limit the expansion of agricultural activities. For the surveyed user communities, agricultural exploitation is a revenue-generating activity that helps meet household needs [21,66]. However, there is a noticeable difference in the perception of this activity among different age groups. It was found that young people are more interested in any activity that generates income quickly. Although generating significant income is more appreciated as an activity among the youth, this still needs to be nuanced because, once outside the region, an identity is attached to these youth beyond their area. For the youth, an identity is even created around it (mainly for brick making). This was exemplified in Hogola and Namubanda, two wetlands visited. The youth living in and around these areas (mainly Nyangezi) are commonly known as "brick makers" wherever they go. "*... the wetlands give us, the people of Nyangezi, the name of brick maker. All the young people from here who go to Bukavu or other cities are called brick makers, even though I have never made bricks, I do prefer raising cattle and growing vegetables. People from Bukavu call us villagers…*".

Another important issue is the place of activities such as brick making in these wetlands. Brick making involves stripping the soil layers, destroying all surface vegetation, and removing peat (often down to two or three meters deep) to reach the fine clay layer used for brick making. After making the bricks, another consequence is cutting all the grass to cover the bricks. When firing the bricks, trees are cut again to ensure proper cooking. All these steps lead to significant degradation of these ecosystems, with all possible consequences for the biodiversity in these areas and their capacity to perform their functions.

> "*The fields in the marshes are my whole life. I was brought here by my father. Since he did not have enough money for my education, I only went to primary school and then started working in this marsh. It allowed me to buy a plot of land, a cow to marry my wife, and today, although I did not study further, my son is now attending university from income from this farm. Unfortunately, he does not want to continue this family activity; he wants to be involved in politics or work for NGOs. Sometimes he comes here, and instead of farming, he makes some bricks, sells them, and returns at ISDR in Bukavu*"

Based on the above outline, we can say that rural communities in South-Kivu maintain a deeply interconnected relationship with their natural environment, particularly wetlands. These communities heavily rely on wetlands for their livelihoods, engaging in activities such as agriculture, fishing, brick making, and the collection of water and other resources. Wetlands provide fertile land for crop cultivation, especially rice and vegetables, which are crucial for food security and income generation. Fishing is another vital activity, providing both sustenance and economic benefits to local families. In addition to these provisioning services, wetlands play a crucial cultural and social role. For many, wetlands are part of their heritage and identity. Traditional practices and knowledge related to wetland use are passed down through generations, reflecting the cultural

importance of these ecosystems. However, this relationship is not without its challenges. The increasing pressures on wetlands from human activities and environmental changes threaten their sustainability and the services they provide [20,21,44]. There is also a noticeable generational shift in how wetlands are perceived and utilized. Younger community members often seek education and employment opportunities outside of traditional wetland-based activities. This shift can lead to a loss of traditional knowledge and a change in the community's relationship with the wetlands. Understanding these dynamics is essential for developing effective conservation and management strategies. By incorporating the perspectives and knowledge of local communities, conservation efforts can be more culturally appropriate and sustainable. This approach not only supports the ecological health of wetlands but also the social and economic well-being of the communities that depend on them.

4.2. Which Wetland Ecosystem Services (WESs) Do the Communities Perceive?

A wide range of WESs were proposed to local communities. Based on 35 WESs formulated as questions, provisioning and regulating services were more reported by the communities than supporting and cultural. Our findings also showed that these perceptions varied among the locals. This finding confirmed that geographic and sociodemographic factors influenced their choice in perceiving ES. Many studies have highlighted the contribution of those factors in ES perceptions [49]. The majority of respondents highly perceive that wetlands provide freshwater and fertile soil and are exploited for their high soil fertility. These findings are similar to many studies in eastern Africa highlighting the preference of provisioning and regulating WESs [30,67,68]. Our results agree with the findings of Wang and Tian [57,69] that suggested diverse perceptions about the importance of wetland ESs in China where wetlands were perceived to be providing more ESs than supporting and cultural ES.

Farmers in wetlands also perceived that high yield and crop production are not the only criterion for selecting farm activities in wetlands. Other criteria included water availability, soil fertility, and other geographical conditions, among others that lead to their choice in using wetlands. Overall, farmers weigh multiple criteria when practicing agriculture in wetlands, aiming to maximize productivity, minimize risks, and ensure sustainable use of natural resources [10].

The roles of wetlands in climate mitigation by reducing pollutant loads, sequestering carbon, or regulating the water cycle were not recognized by the users (Figures 4 and 5). Although some respondents acknowledge the importance of wetlands in creating an environment with good air quality and temperature, this perception is mainly local and not linked to climate mitigation. The role of peatlands is not recognized by users. Many households do not know that peat could help reduce household energy needs rather than being exposed to the air and contribute to greenhouse gases emissions. Utilizing peat would reduce pressure on the trees and shrubs found in these areas [70].

Local community evolution and sustainable development cannot be separated from the natural ecosystem since human activities depend on it. Ecological impacts of anthropogenic activities are also seen at all scales from global, regional, to local scales and are very difficult to eliminate. Ecosystem services (ESs) and local community well-being are very complex mutualistic feeding systems that are promoting and influencing each other. In the case of wetlands in South-Kivu, users seem to have a more comprehensive understanding of WESs since their livelihoods are dependent on these ecosystems. In fact, most users (89%) believe and agree that marshes and inland valleys provide more fertile soil than hillslope farms, while 98% are perceived to obtain high yield in cultivating marshes. This is similar to perceptions of wetlands mentioned in many studies in eastern African regions [31,68,71,72]. However, on the other hand, few people perceive other functions that wetlands can serve. Whether it is their role in climate mitigation by storing carbon, reducing the pollutant load of wastewater, or regulating the water cycle, these aspects are barely (or not at all) perceived by the users. Although few cultural services are recognized

by the users, it is still important to highlight that during fieldwork and discussions with users, their attachment and dependence on these areas become evident.

Since wetlands are predominantly used for agriculture in South-Kivu [20,21], we assumed that services related to agricultural production and other goods would be more perceived. Therefore, we ask the question, does the local population find more food products from wetlands? Our finding showed that this is not the case; many other services were perceived by the users. Many goods and services are derived from these wetlands, from medicinal plants to fishing and forage crops harvesting. Brick making is the second activity in these wetlands. Unfortunately, users are not aware of the negative impact of brick making on wetland ecosystems. This should be analyzed in further research in the future. As mentioned earlier, agriculture, brick making, and fishing are significant activities in these areas and shape people's perceptions of these zones and the services they provide. This is evident, for instance, among poor small-scale farmers who engage in fishing in these zones to meet their nutritional needs for protein, lipids, etc., through foods such as fish, frogs, and wild rats.

"…*As someone who loves meat, I can't sustain myself solely on vegetables. Every time I come here to the marsh, my wife works in the fields and I assist with field preparation and water evacuation. Then, I go fishing for fish and frogs in the drainage canals and the main river that runs through the wetland. Without these fish, I would suffer from Kwashiorkor. I'm not wealthy enough to buy fish from Bukavu and the ponds; is that only reserved for the rich*…" The above example of a wetland user, a household head, illustrates both the role of gender in analyzing activities in the wetlands of South-Kivu and the importance of provisioning services to ensure nutritional security in poor households. This provision of goods and services has also been demonstrated worldwide. Globally, in rural areas, wetlands are known and are perceived to have exceptional value. For instance, in the Amazonian Piedmont of Colombia [73], in Kilomero wetlands in Kenya [74], in Rwanda [75], and Uganda [76,77], the majority of livelihoods rely directly on wetland ecosystem services. Fishing and hunting are crucial for household incomes, followed by the utilization of wetland plants for various purposes such as stream protection, medicinal applications, ornamental use, handicrafts, food, fodder, and construction materials [30,74]. Additionally, South American palm swamps, specifically those containing Mauritia flexuosa, yield fruits and other plant-based products that are processed and traded in local markets, serving as ingredients in food, cosmetics, and furniture [73].

From all the questions on cultural services, two significant responses caught our attention. To the question, "are there more visitors (from neighboring territories or countries) who come for recreation and tourist visits? and do wetland users manage to create a social relationship among themselves through their activities?" It emerges from the perspectives of local communities that these areas are often visited by institutions for practical work, acknowledging their educational dimension. Although most visitors or scientists are national rather than international, the recreational and tourism aspects are not ignored. Some users noted the occasional presence of youth and sports enthusiasts who create activities around these areas, though it is unclear if they are drawn by the wetlands themselves or the surrounding landscapes: "*...yes, we see visitors here, often researchers from research institutes conducting studies, or university students working on their dissertations or field practicals. During the dry season, right here nearby, we have young people, groups of friends who come to play football on the field next to us and then stay to watch how we work. This often happens on holidays or Sundays...*".

Moreover, tourism is emerging as a significant wetland ecosystem service in both inland and coastal regions in numerous areas; tourism constitutes a vital economic activity supporting local livelihoods [69,78]. Given the current security situation, tourism related to wetlands has not been widely observed in South-Kivu, except for a few visitors from surrounding urban areas. The development of tourism is constrained by this security aspect, despite its potential to be a significant source of income for the region and the

province. Furthermore, tourism could strengthen conservation policies and promote the sustainable and wise use of these areas.

4.3. Driving Factors of Wetland Ecosystem Services

Several factors are recognized as determinants of the perception of wetland services. Understanding these factors is important for effective management and conservation of wetland ecosystems, as it helps identify the underlying factors that influence human behavior and decision-making related to the use and conservation of wetlands [21,57,76]. In our case, we used the SEM model, integrating fourteen variables. Four new latent variables were created, which constitute the determinants of the perception of services provided by wetlands. Several authors have already demonstrated the role of biophysical and socioeconomic factors in the perception of ecosystem services. Research exploring the relationship between these perceptions and the biophysical and geographical characteristics of the landscape is necessary to enhance our understanding of socio-ecological dynamics and landscape interactions [55,79,80].

The four developed latent variables are (1) livelihoods, (2) geographic factors, (3) personal factors, and knowledge (4). These are all driving forces behind the perception of WESs in South-Kivu. Livelihoods are influenced by economic activities such as the main activity of the household's head and the wetland type of use; the main activity and the educational level shape how individuals interact with wetlands and perceive their value. Geographic factors include the physical characteristics and wetland accessibility [81,82]. Other personal factors such as gender, land tenure, seniority, religious beliefs, age class, and ethnicity were the determinant factors contributing to latent variable formation. Additionally, knowledge, both traditional and scientific, informs individuals' understanding of wetland ecosystems and their benefits and is a significant variable in wetland perception. Since these factors shape human behavior and decision making related to wetlands, their understanding can be essential for effective management and conservation of wetland ecosystems. Many studies have discussed some of these factors [20,21,71]. In our discussion and based on local conditions in the South-Kivu province, we will focus solely on three main factors that are specific to the region. These are accessibility, religious belief, and ethnicity.

4.4. Do Local Communities Understand WESs in Similar Ways? Are Their Perceptions Linked to the Same Properties of the Environment?

In this study, we adopt the local communities as participants. Such participation was recognized as a process where local communities are actively engaged in shaping research outcomes and effectiveness. Such processes emphasize the local knowledge, experiences, and needs. During fieldworks and interviews, wetlands users were involved in the research process in responding to questions and discussion and highlighting their responses. We found, however, that a large number of users lacked familiarity with some ecological relationships among wetland ecosystem components. One example is the ecological process behind wetland carbon sequestration and contribution to climate change mitigation, elimination of solid waste, and fixation of contaminants and pollutants were not well understood. These local communities did not clearly differentiate the four wetland types; however, they tried to create "wetland landscape units" showing differences among these wetland types during discussion. This perspective suggests that a qualitative approach, such as group discussions with these stakeholders, could lead to a locally valid classification. However, this would require extended discussions and meetings, which should be guided and directed by a specialist, such as a geographer, ecologist, agronomist, etc. This specialist would play the role of a knowledge broker [81–84].

Globally, the understanding of a given ecosystem service by a community can vary depending on various factors, including cultural background, socioeconomic status, and level of environmental awareness. While some stakeholders may have similar perceptions of a particular service, others may interpret it differently based on their individual

perspectives and experiences. Additionally, their perceptions may be influenced by the biophysical properties of the environment in which the service is provided [76,85]. One example is users living in areas with abundant water resources may perceive the service of water provision differently from those in water-stressed regions. Similarly, the ones residing in wetland areas with high green spaces may prioritize the value of WESs such as plant diversity, pollination, and high plant genetic resources differently compared to those in brick making or settlement settings.

Local communities often have diverse understandings of WESs due to their varying roles, experiences (referred to as seniority), and personal interests [57,76,80]. For example, respondents with agriculture in wetlands as their main activity may prioritize provisioning services like crop production, while conservationists focus on regulating services such as carbon sequestration and biodiversity conservation. These perceptions are influenced by observable biophysical properties of the environment; however, some services, like carbon sequestration, might be less visible and require scientific communication for better understanding. Knowledge brokers, such as ecologists or geographers, play a crucial role in bridging the gap between scientific knowledge and local perceptions by ensuring stakeholders are aware of the full range of ecosystem services and their underlying ecological processes [57,76]. Consequently, while there might be some shared understanding of easily observable services, conflicting views often arise regarding the importance of different services, necessitating participatory approaches to align local perceptions with scientific understanding for effective environmental management [57].

It is important to mention that farmers and brick makers are not only providers and beneficiaries of ESs, but also the main objects of ecosystem management. As users with significant heterogeneity, their socioeconomic characteristics affect personal choice preference [21]. In this study, results showed that sociodemographic characteristics played an important role in driving user's perceptions of ESs. These characteristics varied from one wetland type to another. The results showed that personal factors such as gender, land tenure, seniority in wetland use, age class, and mostly religious belief and ethnicity contributed significantly to local community perceptions. The higher the households' educational level and monthly income, the stronger the users' perceptions for regulating and supporting WESs.

Some biophysical properties of the environment, such as water quality, vegetation cover, and habitat diversity, can influence stakeholders' perceptions of ecosystem services [55,77,78]. For instance, wetland users may associate clean water bodies with higher recreational value or aesthetic appeal, leading to a shared understanding of the service of water quality regulation. Unfortunately, in the constructed SEM model, biophysical variables were not integrated to assess perception. Therefore, it should be assumed that the integration of such information would refine the perception that communities have of these areas.

Another significant factor is accessibility, which greatly influences community perceptions. In fact, wetland accessibility significantly influences people's perceptions of ecosystem services. Easy access enables direct experiences with wetlands, fostering a deeper understanding of the services they offer [31,86]. Regular exposure to wetland environments increases awareness and knowledge about their ecological functions, such as habitat provision and water filtration. Accessible wetlands can also promote a sense of ownership and stewardship among nearby communities, encouraging active involvement in conservation efforts [69]. Overall, cultural and social ties to wetlands are strengthened when they are easily accessible, influencing perceptions of their value and importance. Wetland accessibility plays a crucial role in shaping positive perceptions of ecosystem services by facilitating direct engagement, knowledge acquisition, and community involvement. In our case, wetlands located near or around inhabited areas are more likely to be perceived as sources of disease agents, particularly malaria, and as places for dumping various types of waste. In contrast, those that are farther away are often still intact and primarily used for agriculture [20].

We found also that belief and ethnicity are determinant of people's perception of wetlands' ES (Figure 7). In South-Kivu, as in other part of sub-Saharan regions, religious beliefs often shape cultural values and practices, which in turn influence how local communities perceive and interact with their natural surroundings, including wetlands. For example, on one hand, certain religious teachings may emphasize the importance of environmental stewardship and preservation, leading to more positive perceptions of wetland ecosystem services among adherents [7,31]. On the other hand, in South-Kivu where the majority of land is owned by churches, some users of wetland areas perceive that belonging to one congregation or another would grant them greater access to land (both in wetland areas and on dry land), thus leading to a different perspective on these zones [36].

Ethnicity is also closely linked to traditional practices and knowledge related to wetlands. Different ethnic groups may have distinct historical relationships with wetland ecosystems, which can shape their perceptions of the services provided. For instance, indigenous communities (in our case referred to as Twa) may have unique cultural practices and spiritual connections to wetlands that influence their perceptions and attitudes toward conservation. Since religious belief and ethnic identity can contribute to social cohesion and community solidarity, sharing them may foster collective attitudes toward wetland conservation and management. Conversely, divisions based on religious or ethnic differences could lead to differing perceptions and priorities, resulting in conflicting uses that make the protection of wetland ecosystems difficult or even ineffective. In our case, we find differences between types of usage, types of wetlands, and the perceptions that communities have of these ecosystems and both their ethnic origin and beliefs. Even in terms of definition, for example, the Bafulero assume that there are no wetlands in their area and that they do not utilize them, despite their region being endowed with wetlands. They also do not consider flooded valleys or rice ponds as wetlands, or other activities such as fishing, brick making, or forage harvesting as activities to be practiced in these zones. Religious and ethnic identity contribute also to social cohesion and community solidarity. Shared beliefs and cultural practices can help foster collective attitudes toward wetland conservation and management. Conversely, divisions based on religious or ethnic differences could lead to conflicting perceptions and priorities regarding the use and protection of wetland ecosystem services [87,88].

4.5. Sustainable Wetland Management in South-Kivu

Many case studies showed that the perception and use of the ES concept contribute to wetland conservation [13,67,85]. In fact, the local community's involvement is essential to assess the relative value of different management options. Framing the ecosystem services (ES) that wetlands offer as "nature's contributions to people" creates a vital connection between ecosystems and society. In this study, we build a path analysis and create four latent variables explaining the drivers of local community perceptions of WESs (Figure 7). We find that for local communities in South-Kivu, users inherently link the significance or value of wetlands to their accessibility, which is further influenced by human value systems and shifts in those values. Accessibility by people can be a significant driving factor in the perception of wetlands. When wetlands are easily accessible, communities are more likely to interact with them regularly, leading to a greater appreciation and understanding of their ecosystem services. Accessible wetlands facilitate the use of resources for agriculture, water, and recreation, enhancing their perceived value. Additionally, accessible wetlands provide opportunities for educational programs, raising awareness about their ecological importance and promoting conservation efforts. This frequent interaction and increased awareness foster a stronger perception of the wetlands' provisioning, cultural, and recreational services, making accessibility a crucial element in shaping how communities value and manage these ecosystems. Whether it involves accessibility in terms of roads, zones, proximity to cities and villages, proximity to local markets, or proximity to institutions, these are all factors of accessibility that can affect the perception of wetland usage [20,31,48,55]. In the case of South-Kivu, for example, the closer a

wetland is to roads and villages, the easier it will be to access and carry out activities, transport products extracted from the wetland, bring in work materials, labor, and easily monitor activities within the wetlands [20]. Overall, while local communities may not always understand a given service in exactly the same way, their perceptions can be influenced by common biophysical properties of the environment. Understanding these dynamics is essential for effectively engaging stakeholders in ecosystem management and decision-making processes.

Community engagement, collaboration, and partnerships play vital roles in the development and execution of wetland restoration regulation frameworks. Engaging local communities ensures that restoration efforts are informed by their needs, values, and traditional knowledge, fostering a sense of ownership and long-term commitment. Collaboration among diverse stakeholders facilitates the pooling of resources, expertise, and perspectives, leading to more robust and innovative restoration strategies. Partnerships further enhance the effectiveness and sustainability of restoration initiatives by leveraging the strengths and networks of various organizations, amplifying their collective impact. By integrating these elements into regulatory frameworks, we can create inclusive, adaptive, and resilient approaches to wetland restoration that address complex environmental challenges while fostering community participation and support. This collaborative approach ultimately promotes the conservation and sustainable management of wetland ecosystems for the benefit of both people and nature.

Sustainable management of wetlands in South-Kivu and eastern DRC in general involves maintaining their ecological character through ecosystem approaches within sustainable development. This is advisable based on the results obtained and the evidence from existing studies [10]. It includes biodiversity conservation, water quality ensuring, and natural hydrological regimes preservation. It also encompasses the sustainable use of resources, involving local communities in decision-making, and collaborating with other various stakeholders. Effective policy and legal frameworks are essential, along with adherence to international agreements like the Ramsar Convention to achieve such a goal. Ongoing research, monitoring, education, and public awareness campaigns are crucial to understanding wetland dynamics, assessing management strategies, and fostering a broader appreciation of wetlands' importance. This integrated approach ensures wetlands continue to provide vital ecosystem services for future generations. The Ramsar Convention on Wetlands defines the "wise use" of wetlands as maintaining their ecological character through the application of ecosystem approaches within the framework of sustainable development.

In general, the scientific literature is full of recommendations to capitalize on "win-win" situations between the local community and nature [89,90]. On one hand, most of these recommendations involve situations where the economics of conservation actually encourage practical measures in favor of conservation. However, the recommendation made here is slightly different. Even though some conservation practices have been deemed profitable for farmers, such as water quality management, drainage, and integrated pest management, not all farmers and other users engage in the practice. On the other hand, when perceptions of ecosystem services (ESs), biophysical performance, and economic profitability are not aligned, an opportunity exists to emphasize certain categories of ESs in extension programs to conserve specific types of wetlands, such as provisioning services for riparian marshes and farm ponds and regulating services for basin marshes. Promoting a balance between practices that are beneficial for the environment and appealing to farmers and other activities in wetlands is a common-sense idea; however, this balance is not always navigated properly. Several studies suggest that consulting with users in an engaging process is also a learning experience in itself that can generate their buy-in to programs that would otherwise be unappealing if simply imposed on them. These users are key stakeholders in the promotion of programs and potentially valuable resources to disseminate information; they should be fully involved in determining solutions.

From the results obtained, we assume that community engagement coupled with the establishment of a regulatory framework could serve as the entry point for the wise use of wetlands in eastern DR Congo. This means involving local communities who use these areas in the decision-making processes regarding wetland management. It ensures that their needs and concerns are considered, promoting sustainable use of wetland resources. This should be followed by the development and enforcement of regulations and policies that protect wetland ecosystems from exploitation and degradation, including zoning regulations, water quality standards, and habitat protection measures. For a policy aimed at the "wise use" of these areas, regular monitoring and research to assess the health of wetland ecosystems, identify threats, and track changes should also be promoted. In areas where degradation is already observed, ecosystem restoration interventions to rehabilitate degraded parts, including efforts to control invasive species, restore native vegetation, and improve water quality, should also be encouraged (Figure 8). Here is an example of a proposed framework of wetland drivers:

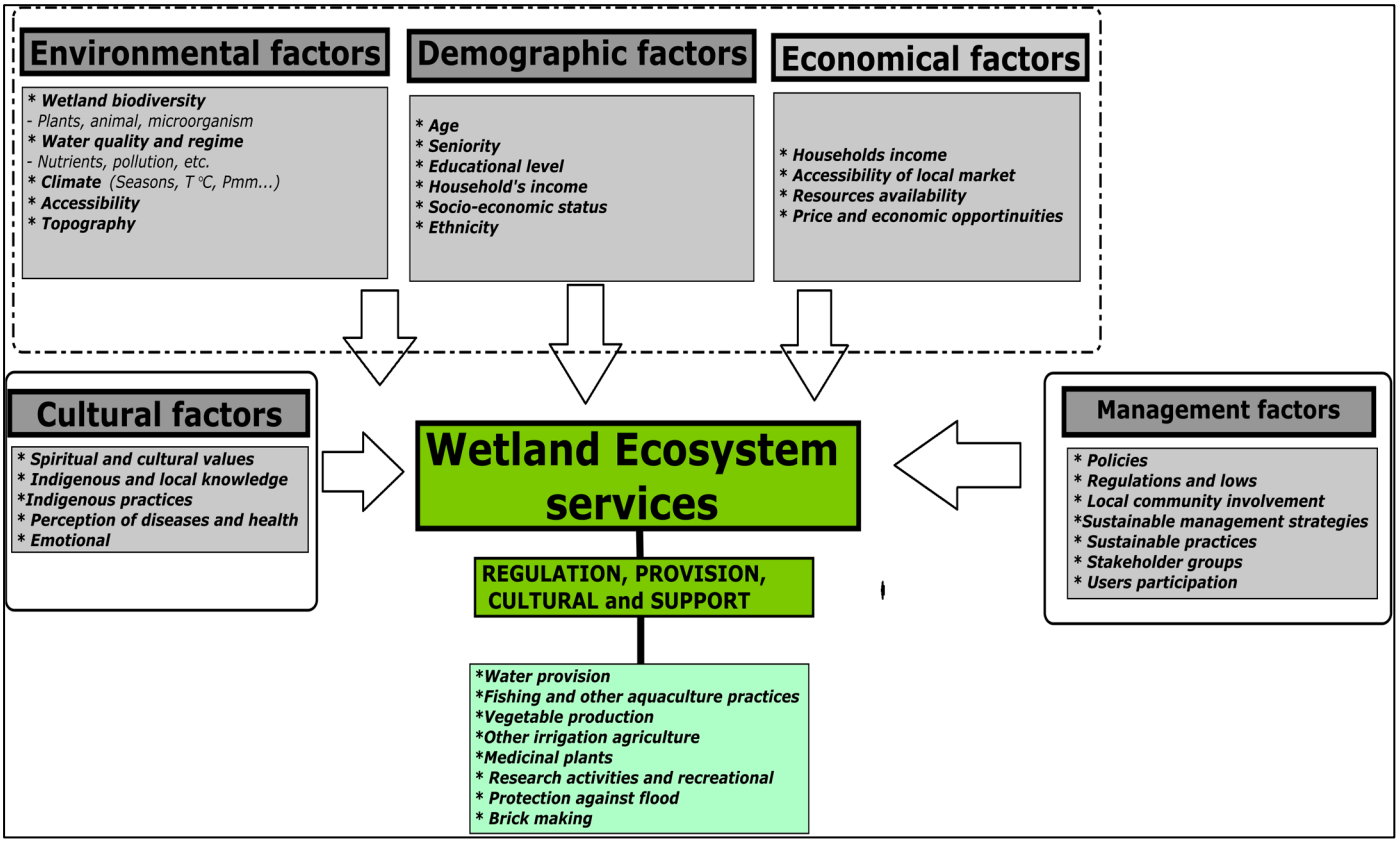


Figure 8. Synthetic framework of driving forces of WES perception in South-Kivu, eastern DRC.

4.6. Study Limitation

Although the results obtained presented a more detailed view of the perception of ESs provided to local communities, being one of the first studies to highlight this in the eastern part of DR Congo, there is still room for discussions. Firstly, our target population consisted only of users of wetlands. Including other stakeholders such as institutions, students, and recreational visitors could provide a more detailed and comprehensive view of wetland perceptions. Secondly, due to security issues, it was challenging to access wetlands in certain territories, preventing a comprehensive view. This is the case for territories like Fizi, Mwenga, and Shabunda, which have significant wetland areas [19]. It was difficult to access these areas, yet discussions with their users would significantly contribute to understanding local community perceptions. This includes the mining use of

wetlands, particularly for the artisanal extraction and processing of minerals, which is developing in these territories [91].

Regarding the choice of model, although the SEM model is widely used in current analyses, several limitations of the SEM model warrant attention as they guide the interpretation of results and the appropriate use of the analytical approach [58,59]. Based on these limitations, several recommendations could be formulated. Firstly, although SEM has helped suggest an explanation for causal relationships between variables, this does not imply that other potential explanations, which may equally or even better fit the data, are not possible. This issue has been extensively discussed in the literature. Readers interested in this, as well as other limitations of SEM, are encouraged to refer to the discussion provided by Rose et al [92]. Future research is encouraged for a better understanding of the impacts of the biophysical environment on the perception of ecosystem services. For instance, studies on how spatial characteristics such as landscape composition and configuration at a fine level (e.g., field level, village level, etc.) could influence the perception of WES for the conservation of still intact spaces are needed, as these factors are known to influence the perception patterns in different types of areas. Overall, the created SEM models did not prove causality, but rather provide indications of potential relationships between variables.

Our results are specific to wetlands in the South-Kivu province, but the framework and methods have broader utility. Opportunities for further study abound, including the already mentioned exploration of the perceptions of other stakeholders, not only those utilizing wetlands, and the extension of research to include other ecosystems found within the area (bamboo forests, mountain forests, urban green spaces, and artificial wetlands, etc.). Conducting a similar study in an agricultural region with even greater wetland loss, such as the southern part of the country (in Katanga province), or even in the central region where all these anthropogenic pressures are very low, could provide insights into some of the social legacy impacts of wetlands. Additionally, measuring user perspectives in areas with very high wetland drainage would provide more detailed explanations of how they perceive and adapt to the loss of ESs from the wetlands, or the scarcity of particular features.

5. Conclusions

This paper shows that in South-Kivu, not all the communities understand a given wetland ecosystem service (WES) in a similar way. Their perceptions are linked to the same geographic and sociodemographic factors. All the four WES types are linked to these factors and geographic proprieties. Our results show that most of the participants reported that wetlands provide various ecosystem services (ESs) to the community. Local communities report more provisioning and regulating services compared to supporting and cultural services. These perceptions of services varied from one type of wetland to another. The perceptions of WESs are strongly influenced by different social contexts, community livelihood, well-being and some personal factors. Driving factors of perception were determined after building a causal model. The structure (paths and coefficients) of the causal model varied from one wetland type to another, suggesting that other specific factors were likely to affect individual WESs. Such a model is a comprehensive tool to understand complex interactions between local communities and wetland ecosystems in South-Kivu, in which the integration of geographical and sociodemographic perspectives will help the development of effective strategies of wetland sustainable management. We suppose that such an approach is an open door for wetlands' "wise use" and at the same time can address immediate needs and realities of local communities. This study, however, suggests further research on integrated framework to promote sustainable use and conservation of wetlands; economic and ecological quantification of WES can be studied in the future.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su16167073/s1, Figure S1: Diversity of wetlands in South-Kivu. The four types of wetlands considered in South-Kivu, eastern DRC: (a and c) *swamps* (f) *high-altitude and low-altitude* (f and g) *peatlands*, (b) *and* (d) *inland valleys/floodplains and rice ponds*, (e and h) *marshes*. Images were downloaded and georeferenced from Google Earth Pro.; Figure S2: Perception of Ecosystem services in South Kivu wetland: response for the 4 groups of ES based on the 35 questions used; Figure S3: Ecosystem services (a) Likert scale (b) used to assess the WES in South-Kivu; Figure S4: Driving factors of perception of wetland ecosystem services in South-Kivu, eastern DR Congo. The plot was produced following the SEM (Structural Equation Model) analysis of Wetland Ecosystem services (WES) perceptions, *, **, and *** indicate the significance at the level of 5%, 1% and 0.1% threshold respectively. a: *peatland*, b: *marshes*, c: *swamp* and d: *floodplains and inland valleys*. *Dashed line indicates a non-significant loading path*; Figure S5: Methodological flowchart; Figure S6: Climate type in South-Kivu, and DRC in general. The classes are based on the classification made by Koppen-Geiger as adapted by Beck et al., (2018); Table S1: Reformulated questions used to assess wetland ecosystem services (WES) in South-Kivu. These question were modified and adapted based on the Rapid assessment of wetland ecosystem services (RAWES) as suggested by RAMSAR (McInnes and Everard, 2017); Table S2: Goodness-of-fit measures (GOFs) for the structural equation models

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References

1. Simpsona, M.; Everardc, M.; Ricaurted, L.; McInnesb, R.J. 7.1 What Are Ecosystem Services? In *Ramsar Wetlands: Values, Assessment, Management*; Elsevier: Amsterdam, The Netherlands, 2022; p. 179.
2. Xu, X.; Chen, M.; Yang, G.; Jiang, B.; Zhang, J. Wetland Ecosystem Services Research: A Critical Review. *Glob. Ecol. Conserv.* **2020**, *22*, e01027. https://doi.org/10.1016/j.gecco.2020.e01027.
3. Amler, E.; Schmidt, M.; Menz, G. Definitions and Mapping of East African Wetlands: A Review. *Remote Sens.* **2015**, *7*, 5256–5282.
4. Dargie, G.C. Quantifying and Understanding the Tropical Peatlands of the Central Congo Basin. Ph.D. Thesis, The University of Leeds, Leeds, UK, 2015.
5. Dargie, G.C.; Lawson, I.T.; Rayden, T.J.; Miles, L.; Mitchard, E.T.; Page, S.E.; Bocko, Y.E.; Ifo, S.A.; Lewis, S.L. Congo Basin Peatlands: Threats and Conservation Priorities. *Mitig. Adapt. Strateg. Glob. Chang.* **2019**, *24*, 669–686.
6. Garcin, Y.; Schefuß, E.; Dargie, G.C.; Hawthorne, D.; Lawson, I.T.; Sebag, D.; Biddulph, G.E.; Crezee, B.; Bocko, Y.E.; Ifo, S.A.; et al. Hydroclimatic Vulnerability of Peat Carbon in the Central Congo Basin. *Nature* **2022**, *612*, 277–282. https://doi.org/10.1038/s41586-022-05389-3.
7. Moges, A.; Beyene, A.; Triest, L.; Ambelu, A.; Kelbessa, E. Imbalance of Ecosystem Services of Wetlands and the Perception of the Local Community towards Their Restoration and Management in Jimma Highlands, Southwestern Ethiopia. *Wetlands* **2018**, *38*, 1081–1095.
8. Schuyt, K.D. Economic Consequences of Wetland Degradation for Local Populations in Africa. *Ecol. Econ.* **2005**, *53*, 177–190.
9. Mitchell, S.A. The Status of Wetlands, Threats and the Predicted Effect of Global Climate Change: The Situation in Sub-Saharan Africa. *Aquat. Sci.* **2013**, *75*, 95–112.

10. Wood, A.P.; Dixon, A.; McCartney, M.P. *Wetland Management and Sustainable Livelihoods in Africa*; Routledge; Earthscan: Oxford, UK; 2013; ISBN 1-84971-411-8.
11. Ekalle, E. *Using Satellite Remote Sensing in Detecting Anthropogenic Threats to Freshwater Wetlands in Transforming Landscapes; the Case of Ngiri-Tumba-Mai Ndombe Wetlands; of the Cuvette Centrale in the Congo River Basin*; Università Ca' Foscari Venezia: Venezia, Italy, 2016.
12. Mirenge, Z.Z.; Chuma, G.B.; Zamukulu, P.M.; Mukungilwa, M.; Muvundja, F.A.; Karume, K. Land Use and Cover Change and Water Quality of Tropical Wetlands under Anthropogenic Pressure: A Case Study of Marshlands in the Kaziba Chiefdom in South-Kivu Province, Eastern DR Congo. *Reg. Stud. Mar. Sci.* **2023**, *64*, 103050.
13. Cohen-Shacham, E.; Dayan, T.; de Groot, R.; Beltrame, C.; Guillet, F.; Feitelson, E. Using the Ecosystem Services Concept to Analyse Stakeholder Involvement in Wetland Management. *Wetl. Ecol. Manag.* **2015**, *23*, 241–256. https://doi.org/10.1007/s11273-014-9375-1.
14. De Groot, D.; Brander, L.; Finlayson, C.M. Wetland Ecosystem Services. In *The Wetland Book: I: Structure and Function, Management, and Methods*; Springer: Dordrecht, The Netherlands, 2018; pp. 323–333.
15. Millennium Ecosystem Assessment. *Ecosystems and Human Well-Being: Wetlands and Water*; World Resources Institute: Washington, DC, USA, 2005; ISBN 1-56973-597-2.
16. TEEB. *The Economics of Ecosystems and Biodiversity: Ecological and Economic Foundations*; Earthscan: London, UK; Washington, DC, USA, 2010.
17. Duku, E.; Mattah, P.A.D.; Angnuureng, D.B. Assessment of Wetland Ecosystem Services and Human Wellbeing Nexus in Sub-Saharan Africa: Empirical Evidence from a Socio-Ecological Landscape of Ghana. *Environ. Sustain. Indic.* **2022**, *15*, 100186.
18. Lhoest, S.; Dufrêne, M.; Vermeulen, C.; Oszwald, J.; Doucet, J.-L.; Fayolle, A. Perceptions of Ecosystem Services Provided by Tropical Forests to Local Populations in Cameroon. *Ecosyst. Serv.* **2019**, *38*, 100956.
19. Chuma, B.G.; Mushagalusa, N.G.; Schmitz, S. Mapping Small Inland Wetlands in the South-Kivu Province by Integrating Optical and SAR Data with Statistical Models for Accurate Distribution Assessment. *Sci. Rep.* **2023**, *13*, 17626. https://doi.org/10.1038/s41598-023-43292-7.
20. Chuma, G.B.; Mondo, J.M.; Karume, K.; Mushagalusa, G.N.; Schmitz, S. Factors Driving Utilization Patterns of Marshlands in the Vicinity of South-Kivu Urban Agglomerations Based on Rapid Assessment of Wetland Ecosystem Services (RAWES). *Environ. Chall.* **2021**, *5*, 100297. https://doi.org/10.1016/j.envc.2021.100297.
21. Chuma, G.B.; Mondo, J.M.; Sonwa, D.J.; Karume, K.; Mushagalusa, G.N.; Schmitz, S. 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. *Environ. Dev.* **2022**, *43*, 100711. https://doi.org/10.1016/j.envdev.2022.100711.
22. Anthonj, C.; Diekkrüger, B.; Borgemeister, C.; Kistemann, T. Health Risk Perceptions and Local Knowledge of Water-Related Infectious Disease Exposure among Kenyan Wetland Communities. *Int. J. Hyg. Environ. Health* **2019**, *222*, 34–48. https://doi.org/10.1016/j.ijheh.2018.08.003.
23. Anthonj, C.; Githinji, S.; Kistemann, T. The Impact of Water on Health and Ill-Health in a Sub-Saharan African Wetland: Exploring Both Sides of the Coin. *Sci. Total Environ.* **2018**, *624*, 1411–1420. https://doi.org/10.1016/j.scitotenv.2017.12.232.
24. Anthonj, C.; Rechenburg, A.; Höser, C.; Kistemann, T. Contracting Infectious Diseases in Sub-Saharan African Wetlands: A Question of Use? A Review. *Int. J. Hyg. Environ. Health* **2017**, *220*, 1110–1123. https://doi.org/10.1016/j.ijheh.2017.07.008.
25. Cools, J.; Diallo, M.; Boelee, E.; Liersch, S.; Coertjens, D.; Vandenberghe, V.; Kone, B. Integrating Human Health into Wetland Management for the Inner Niger Delta, Mali. *Environ. Sci. Policy* **2013**, *34*, 34–43. https://doi.org/10.1016/j.envsci.2012.09.011.
26. Finlayson, C.M.; Davidson, N.; Pritchard, D.; Milton, G.R.; MacKay, H. The Ramsar Convention and Ecosystem-Based Approaches to the Wise Use and Sustainable Development of Wetlands. *J. Int. Wildl. Law Policy* **2011**, *14*, 176–198.
27. Joshi, D.; Gallant, B.; Hakhu, A.; De Silva, S.; McDougall, C.; Dubois, M.; Arulingam, I. Ramsar Convention and the Wise Use of Wetlands: Rethinking Inclusion. *Ecol. Restor.* **2021**, *39*, 36–44.
28. Lemine, B.J. Developing a Strategy for Efficient Environmental Authorisation of Activities Affecting Wetlands in South Africa: Towards a Wise-Use Approach. *Obiter* **2020**, *41*, 154–167.
29. Cebrián-Piqueras, M.A.; Karrasch, L.; Kleyer, M. Coupling Stakeholder Assessments of Ecosystem Services with Biophysical Ecosystem Properties Reveals Importance of Social Contexts. *Ecosyst. Serv.* **2017**, *23*, 108–115. https://doi.org/10.1016/j.ecoser.2016.11.009.
30. Sakané, N.; Alvarez, M.; Becker, M.; Böhme, B.; Handa, C.; Kamiri, H.W.; Langensiepen, M.; Menz, G.; Misana, S.; Mogha, N.G. Classification, Characterisation, and Use of Small Wetlands in East Africa. *Wetlands* **2011**, *31*, 1103–1116.
31. Morrison, E.H.; Upton, C.; Pacini, N.; Odhiambo-K'Oyooh, K.; Harper, D.M. Public Perceptions of Papyrus: Community Appraisal of Wetland Ecosystem Services at Lake Naivasha, Kenya. *Ecohydrol. Hydrobiol.* **2013**, *13*, 135–147.
32. Greenland-Smith, S.; Brazner, J.; Sherren, K. Farmer Perceptions of Wetlands and Waterbodies: Using Social Metrics as an Alternative to Ecosystem Service Valuation. *Ecol. Econ.* **2016**, *126*, 58–69. https://doi.org/10.1016/j.ecolecon.2016.04.002.
33. Mushi, F.M. Insecurity and Local Governance in Congo's South Kivu. *IDS Bull.* **2013**, *44*, 15–29.
34. Kulimushi, L.C.; Choudhari, P.; Mubalama, L.K.; Banswe, G.T. GIS and Remote Sensing-Based Assessment of Soil Erosion Risk Using RUSLE Model in South-Kivu Province, Eastern, Democratic Republic of Congo. *Geomat Nat. Hazards Risk* **2021**, *12*, 961–987.
35. Beck, H.E.; Zimmermann, N.E.; McVicar, T.R.; Vergopolan, N.; Berg, A.; Wood, E.F. Present and Future Köppen-Geiger Climate Classification Maps at 1-Km Resolution. *Sci. Data* **2018**, *5*, 180214. https://doi.org/10.1038/sdata.2018.214.

36. Bahati, D.S.; Bashangwa Mpozi, B.; Egesa, A.O.; Basengere, E.B. Adaptation to Land Scarcity among Small-Scale Farming Households in South Kivu in the Democratic Republic of the Congo. *Front. Sustain. Food Syst.* **2023**, *7*, 1277031.
37. Prunier, G. The Catholic Church and the Kivu Conflict. *J. Relig. Afr.* **2001**, *31*, 139–162.
38. Van Acker, F. Where Did All the Land Go? Enclosure & Social Struggle in Kivu (DR Congo). *Rev. Afr. Political Econ.* **2005**, *32*, 79–98.
39. Bisoka, A.N.; Cioffo, G.D.; Claessens, K. From Transgression to Normative Innovation: Land Conflict Resolution in South Kivu, Democratic Republic of the Congo. In *Property Rights from Below: Commodification of Land and the Counter-Movement*; Routledge: London, UK, 2019.
40. Van Overbeek, F.; Tamás, P.A. Autochthony and Insecure Land Tenure: The Spatiality of Ethnicized Hybridity in the Periphery of Post-Conflict Bukavu, DRC. In *Urban Africa and Violent Conflict*; Routledge: London, UK, 2020; pp. 98–117.
41. Cuni-Sanchez, A.; Imani, G.; Bulonvu, F.; Batumike, R.; Baruka, G.; Burgess, N.D.; Klein, J.A.; Marchant, R. Social Perceptions of Forest Ecosystem Services in the Democratic Republic of Congo. *Hum. Ecol.* **2019**, *47*, 839–853.
42. Cox, T.P. Farming the Battlefield: The Meanings of War, Cattle and Soil in South Kivu, Democratic Republic of the Congo. *Disasters* **2012**, *36*, 233–248.
43. Bahati Shamamba, D. *Enjeux Fonciers et Développement de L'agriculture Familiale au Sud-Kivu*; Gembloux Agrobio Tec, Université de Liège: Gemboux, Belgium, 2021.
44. Blackwell, M.S.A.; Pilgrim, E.S. Ecosystem Services Delivered by Small-Scale Wetlands. *Hydrol. Sci. J.* **2011**, *56*, 1467–1484. https://doi.org/10.1080/02626667.2011.630317.
45. Rebelo, L.-M.; McCartney, M.P.; Finlayson, C.M. Wetlands of Sub-Saharan Africa: Distribution and Contribution of Agriculture to Livelihoods. *Wetl. Ecol. Manag.* **2010**, *18*, 557–572.
46. Ansoms, A.; Wagemakers, I.; Madison Walker, M.; Murison, J. Land Contestation at the Micro Scale: Struggles for Space in the African Marshes. *World Dev.* **2014**, *54*, 243–252. https://doi.org/10.1016/j.worlddev.2013.08.010.
47. Denny, P. *The Ecology and Management of African Wetland Vegetation: A Botanical Account of African Swamps and Shallow Waterbodies*; Springer Science & Business Media: Berlin, Germany, 2012; Volume 6, ISBN 94-009-5504-9.
48. Fynn, R.; Murray-Hudson, M.; Dhliwayo, M.; Scholte, P. African Wetlands and Their Seasonal Use by Wild and Domestic Herbivores. *Wetl. Ecol. Manag.* **2015**, *23*, 559–581.
49. Mandishona, E.; Knight, J. Inland Wetlands in Africa: A Review of Their Typologies and Ecosystem Services. *Prog. Phys. Geogr. Earth Environ.* **2022**, *46*, 547–565.
50. Gabiri, G. Multi-Scale Modeling of Water Resources in a Tropical Inland Valley and a Tropical Floodplain Catchment in East Africa. Ph.D. Thesis, Universitäts-und Landesbibliothek Bonn, Bonn, Germany, 2019.
51. Senga, P.M.; Talbot, J.; Bonneville, S. Tropical Peat Deposits Undergoing Land-Use Change: The Case of Buhandanda and Lushala Peatlands (Democratic Republic of Congo). *Mires Peat* **2023**, *29*, 9.
52. Grundling, P.-L.; Grootjans, A. Peatlands of Africa. In *The Wetland Book*; Springer Science and Business Media, LLC: Dordrecht, The Netherlands, 2016.
53. Israel, G.D. Determining Sample Size. In *Sampling: The Evidence of Program Evaluation and Organizational Development*; PEOD-5; University of Florida: Gainesville, FL, USA, 1992.
54. Chuma, G.B.; Mondo, J.M.; Ndeko, A.B.; Bagula, E.M.; Lucungu, P.B.; Bora, F.S.; Karume, K.; Mushagalusa, G.N.; Schmitz, S.; Bielders, C.L. Farmers' Knowledge and Practices of Soil Conservation Techniques in Smallholder Farming Systems of Northern Kabare, East of D.R. Congo. *Environ. Chall.* **2022**, *7*, 100516. https://doi.org/10.1016/j.envc.2022.100516.
55. Cebrián-Piqueras, M.A.; Filyushkina, A.; Johnson, D.N.; Lo, V.B.; López-Rodríguez, M.D.; March, H.; Oteros-Rozas, E.; Peppler-Lisbach, C.; Quintas-Soriano, C.; Raymond, C.M.; et al. Scientific and Local Ecological Knowledge, Shaping Perceptions towards Protected Areas and Related Ecosystem Services. *Landsc. Ecol.* **2020**, *35*, 2549–2567. https://doi.org/10.1007/s10980-020-01107-4.
56. Pereira Lima, F.; Pereira Bastos, R. Understanding Landowners' Intention to Restore Native Areas: The Role of Ecosystem Services. *Ecosyst. Serv.* **2020**, *44*, 101121. https://doi.org/10.1016/j.ecoser.2020.101121.
57. Tian, Y.; Wu, H.; Zhang, G.; Wang, L.; Zheng, D.; Li, S. Perceptions of Ecosystem Services, Disservices and Willingness-to-Pay for Urban Green Space Conservation. *J. Environ. Manag.* **2020**, *260*, 110140.
58. Ullman, J.B.; Bentler, P.M. Structural Equation Modeling. In *Handbook of Psychology*, 2nd ed.; John Wiley & Sons, Inc.: Hoboken, NJ, USA, 2012; Volume 2.
59. Li, X.; Beretvas, S.N. Sample Size Limits for Estimating Upper Level Mediation Models Using Multilevel SEM. *Struct. Equ. Model. Multidiscip. J.* **2013**, *20*, 241–264.
60. Schweiger, E.W.; Grace, J.B.; Cooper, D.; Bobowski, B.; Britten, M. Using Structural Equation Modeling to Link Human Activities to Wetland Ecological Integrity. *Ecosphere* **2016**, *7*, e01548.
61. Musil, C.M.; Jones, S.L.; Warner, C.D. Structural Equation Modeling and Its Relationship to Multiple Regression and Factor Analysis. *Res. Nurs. Health* **1998**, *21*, 271–281.
62. Xiao, J.; Song, F.; Su, F.; Song, S.; Wei, C. Exploring the Interaction Mechanism of Natural Conditions and Human Activities on Wetland Ecosystem Services Value. *J. Clean. Prod.* **2023**, *426*, 139161.
63. Bapolisi, W.A.; Ferrari, G.; Bisimwa, G.; Merten, S. Gendered Determinants of Food Insecurity in Ongoing Regional Conflicts, North and South Kivu, the Democratic Republic of Congo. *Agric. Food Secur.* **2021**, *10*, 13.
64. Balasha, A.M.; Jean-Hélène, K.K.; Murhula, B.; John, T.K.; Jules, N.M.F. Challenges Faced by Congolese Women Farmers to Access Agricultural Productive Resources: A Review. *Open J. Soc. Sci.* **2022**, *10*, 73–91.

65. Balasha, A.M.; Fyama, J.N.M.; Lenge, E.K.; Tambwe, A.N. Women Farmers' Access to Marshlands for Agricultural Food Production in the Democratic Republic of Congo. *Soc. Sci. Humanit. Open* **2024**, *9*, 100772.
66. Ajwang'Ondiek, R.; Hayes, D.S.; Kinyua, D.N.; Kitaka, N.; Lautsch, E.; Mutuo, P.; Hein, T. Influence of Land-Use Change and Season on Soil Greenhouse Gas Emissions from a Tropical Wetland: A Stepwise Explorative Assessment. *Sci. Total Environ.* **2021**, *787*, 147701.
67. Dixon, A.B.; Wood, A.P. *Wetland Cultivation and Hydrological Management in Eastern Africa: Matching Community and Hydrological Needs through Sustainable Wetland Use*; Wiley Online Library: Hoboken, NJ, USA, 2003; Volume 27, pp. 117–129.
68. Langan, C.; Farmer, J.; Rivington, M.; Smith, J.U. Tropical Wetland Ecosystem Service Assessments in East Africa; A Review of Approaches and Challenges. *Environ. Model. Softw.* **2018**, *102*, 260–273.
69. Wang, X.; Prahalad, V.; Kirkpatrick, J.B. Public Perceptions of Wetlands and Preferences for On-Site Visitor Facilities and Communication Media: A Case Study from an Australian Ramsar Wetland. *Mar. Freshw. Res.* **2022**, *73*, 1149–1165.
70. Sakuntaladewi, N.; Rachmanadi, D.; Mendham, D.; Yuwati, T.W.; Winarno, B.; Premono, B.T.; Lestari, S.; Ardhana, A.; Ramawati; Budiningsih, K. Can We Simultaneously Restore Peatlands and Improve Livelihoods? Exploring Community Home Yard Innovations in Utilizing Degraded Peatland. *Land* **2022**, *11*, 150.
71. Balasha, A.M.; Munyahali, W.; Kulumbu, J.T.; Okwe, A.N.; Fyama, J.N.M.; Lenge, E.K.; Tambwe, A.N. Understanding Farmers' Perception of Climate Change and Adaptation Practices in the Marshlands of South Kivu, Democratic Republic of Congo. *Clim. Risk Manag.* **2023**, *39*, 100469.
72. Nabaloum, A.; Goetze, D.; Ouédraogo, A.; Porembski, S.; Thiombiano, A. Local Perception of Ecosystem Services and Their Conservation in Sudanian Savannas of Burkina Faso (West Africa). *J. Ethnobiol. Ethnomedicine* **2022**, *18*, 8.
73. Ricaurte, L.F.; Wantzen, K.M.; Agudelo, E.; Betancourt, B.; Jokela, J. Participatory Rural Appraisal of Ecosystem Services of Wetlands in the Amazonian Piedmont of Colombia: Elements for a Sustainable Management Concept. *Wetl. Ecol. Manag.* **2014**, *22*, 343–361.
74. Kangalawe, R.Y.; Liwenga, E.T. Livelihoods in the Wetlands of Kilombero Valley in Tanzania: Opportunities and Challenges to Integrated Water Resource Management. *Phys. Chem. Earth Parts A/B/C* **2005**, *30*, 968–975.
75. Nabahungu, N.; Visser, S. Contribution of Wetland Agriculture to Farmers' Livelihood in Rwanda. *Ecol. Econ.* **2011**, *71*, 4–12.
76. Bosma, C.; Glenk, K.; Novo, P. How Do Individuals and Groups Perceive Wetland Functioning? Fuzzy Cognitive Mapping of Wetland Perceptions in Uganda. *Land Use Policy* **2017**, *60*, 181–196.
77. Kadoma, A.; Perry, M.; Renaud, F.G. Stakeholders' Perceptions of Wetland Conservation and Restoration in Wakiso District, Uganda. *Environ. Dev. Sustain.* **2023**, 1–24. https://doi.org/10.1007/s10668-023-04008-z
78. Bikangaga, S.; Picchi, M.P.; Focardi, S.; Rossi, C. Perceived Benefits of Littoral Wetlands in Uganda: A Focus on the Nabugabo Wetlands. *Wetl. Ecol. Manag.* **2007**, *15*, 529–535.
79. Mitsch, W.J.; Bernal, B.; Nahlik, A.M.; Mander, Ü.; Zhang, L.; Anderson, C.J.; Jørgensen, S.E.; Brix, H. Wetlands, Carbon, and Climate Change. *Landsc. Ecol* **2013**, *28*, 583–597. https://doi.org/10.1007/s10980-012-9758-8.
80. Wang, X.; Ning, L.; Yu, J.; Xiao, R.; Li, T. Changes of Urban Wetland Landscape Pattern and Impacts of Urbanization on Wetland in Wuhan City. *Chin. Geogr. Sci.* **2008**, *18*, 47–53.
81. Yasin, H.; Tekalign, W.; Takele, S.; McMahon, B.J.; Desalegn, A. Indigenous People's Perception of the Existing Ecosystem Services and Pervasive Drivers for the Degradation of Boyo Wetland, Southern Ethiopia. *J. Environ. Stud. Sci.* **2024**, 1–13. https://doi.org/10.1007/s13412-024-00904-6
82. Basu, S.; Nagendra, H.; Verburg, P.; Plieninger, T. Perceptions of Ecosystem Services and Knowledge of Sustainable Development Goals around Community and Private Wetlands Users in a Rapidly Growing City. *Landsc. Urban Plan.* **2024**, *244*, 104989.
83. Dar, S.A.; Rashid, I.; Bhat, S.U.; Dar, J.A. Evaluation of Ecosystem Services Vis-à-Vis Perceptions and Attitudes of Local Communities Towards Wetland Conservation in Kashmir Himalaya. *Environ. Dev.* **2024**, *51*, 101041.
84. Bai, Y.; Huang, Q.; Inostroza, L.; Xu, H.; Yin, D.; Liu, Z.; Zhang, L.; Xu, F. Residents' Perceptions of Ecosystem Services in an Urbanizing Basin: A Case Study in the Guanting Reservoir Basin, China. *Geogr. Sustain.* **2024**, *5*, 430–444.
85. Janssens de Bisthoven, L.; Vanhove, M.; Rochette, A.-J.; Hugé, J.; Brendonck, L. Stakeholder Analysis on Ecosystem Services of Lake Manyara Sub-Basin (Tanzania): How to Overcome Confounding Factors. *Environ. Manag.* **2022**, *69*, 652–665. https://doi.org/10.1007/s00267-021-01466-x.
86. Pedersen, E.; Weisner, S.E.; Johansson, M. Wetland Areas' Direct Contributions to Residents' Well-Being Entitle Them to High Cultural Ecosystem Values. *Sci. Total Environ.* **2019**, *646*, 1315–1326.
87. Ndaruga, A.M. An Exploration of Teacher Perceptions and Actions to Conserve Wetlands in Kenya. Ph.D. Thesis, Rhodes University, Makhanda, South Africa, 2003.
88. Terer, T.; Ndiritu, G.G.; Gichuki, N.N. Socio-Economic Values and Traditional Strategies of Managing Wetland Resources in Lower Tana River, Kenya. *Hydrobiologia* **2004**, *527*, 3–15.
89. Hopkins, S.R.; Sokolow, S.H.; Buck, J.C.; De Leo, G.A.; Jones, I.J.; Kwong, L.H.; LeBoa, C.; Lund, A.J.; MacDonald, A.J.; Nova, N. How to Identify Win–Win Interventions That Benefit Human Health and Conservation. *Nat. Sustain.* **2021**, *4*, 298–304.
90. Zheng, H.; Wang, L.; Wu, T. Coordinating Ecosystem Service Trade-Offs to Achieve Win–Win Outcomes: A Review of the Approaches. *J. Environ. Sci.* **2019**, *82*, 103–112.
91. Mukotanyi, I.F. *The Hammer and/or the Hoe? Analysing the Linkages between Artisanal Mining and Small-Scale Agriculture in South Kivu/Eastern DRC*; University of Antwerp: Antwerp, Belgium, 2022; ISBN 90-5728-752-8.

92. Rose, S. A., Markman, B., & Sawilowsky, S. Limitations in the systematic analysis of structural equation model fit indices. *Journal of Modern Applied Statistical Methods*, **2017**. 69-85. doi: 10.22237/jmasm/1493597040.