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What Does Resilience of Social–Ecological Systems Mean in Burundi? A Qualitative Approach

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Abstract

To gain a better understanding of social–ecological resilience in Burundi, a country facing increasing demographic and climate-induced pressures, this study aimed to identify local perceptions of resilience and list disturbances experienced by rural communities that undermine social–ecological resilience. Focus group discussions explored possible challenges for the nexus of (1) rights–governance–knowledge and (2) access to ecosystem services–restoration–conservation. Theme clusters emerging from the focus groups were structured from political, economic, social, technological, environmental and legal perspectives to identify major stakeholder concerns. Then, this study applied an indicator-based assessment tool designed for development projects in production landscapes. Questionnaire results revealed the absence of income diversity, limited adaptation strategies, and a large prevalence of climatic and agricultural disturbances among rural households. The study findings underscored substantial variations between the different study regions. To enhance the adaptive capacity of local communities, policy-making should focus on diversification within and beyond agriculture, supported by adequate extension services. Adequate ecosystem governance is necessary to maintain or restore the remaining ecosystems, given their pivotal role in social–ecological resilience.

Keywords: resilience; social–ecological systems; Burundi; stakeholder; participatory assessment; PESTEL; adaptive capacity

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1. Introduction

Sub-Saharan Africa, the most food-insecure region in the world, has been facing many pressures, including anthropogenic climate change, conflicts and economic downturns [1].

Burundi, a small and densely populated landlocked country in East Africa, epitomizes the continent's struggles. We chose Burundi as a case-study to assess how local experts and stakeholders perceive social–ecological resilience as a possible foundation or entry point for sustainable development in an agricultural landscape, given climate change and other human-induced pressures, including urbanization, soil erosion and pollution.

The concept of resilience in the context of social–ecological systems can be defined as 'the capacity of a social–ecological system to absorb or withstand perturbations and other stressors such that the system remains within the same regime, essentially maintaining its structure and functions. It describes the degree to which the system is capable of self-organization, learning and adaptation' [2–5]. The concept gained traction in the late 1990s in related fields, such as development economics [6]. Macroeconomic resilience can be considered to be made of two components: instantaneous resilience, which is the ability to limit the magnitude of immediate production losses for a given amount of asset losses, and dynamic resilience, which is the ability to reconstruct and recover from losses [7]. Rural economic resilience and sustainable development are often correlated in developing countries [8]. However, generally, the resilience of social–ecological systems regarding development has remained the subject of intellectual debate, rather than solution-oriented actions, despite the urgent need for action in the face of the triple ecological crisis posed by climate change, biodiversity loss and pollution [9]. Regarding Burundi, Central Africa and developing countries in general, studies on resilience often discuss armed conflicts, natural disasters, climate change, gender or livelihoods [10–12]. More generally, social–ecological resilience is often considered an end-point or an indicator to remain within a safe operating space within planetary boundaries, though more recently, this concept has integrated social aspects within the scope of 'safe and just Earth system boundaries' [13,14].

Within the fields of development cooperation—now more often referred to as 'international cooperation'—and, more generally, sustainable development in developing countries, there is a need to assess whether the high dependency of local rural populations on ecosystem services [15] can remain sustainable by increasing or maintaining system resilience. This approach might generate perspectives regarding more efficient and more sustainable poverty alleviation mechanisms or strategies. Indeed, in the seminal paper of Lade et al. [16], who used insights from resilience research to better understand possible poverty traps, models applied to rural agricultural landscapes show that interventions that ignore nature and culture reinforce poverty and that transformative change can open new pathways for poverty alleviation.

Like most Sub-Saharan countries, Burundi faces difficulties in its developmental trajectory while coping with environmental and anthropogenic pressures. Such challenges necessitate identifying critical areas of social–ecological resilience within a safe operating space [17]. Despite the recent increased scientific interest in social–ecological resilience assessment, this field still faces challenges stemming from the intricate nature of the concept of resilience [18]. Creating standardized assessment tools using a set of indicators has facilitated resilience assessment. This development has bridged the gap between science and policy, allowing a wider range of stakeholders to identify patterns in these complex systems across diverse contexts [19].

The framework developed by Sterk et al. [17] offers an interesting benchmark against which we can evaluate local resilience in social–ecological systems. They distinguish seven principles to operationalise resilience in social–ecological systems: (1) maintaining diversity and redundancy, (2) managing connectivity; (3) managing slow variables and feedbacks, (4) fostering complex adaptive systems, (5) encouraging learning, (6) broadening participation and (7) promoting polycentric governance systems.

The objective of this study is to contribute to the better understanding and assessment of social–ecological resilience in the context of development in Burundi, answering the following corresponding research questions: (1) What are the specific disturbances that rural communities in Burundi face? (2) What issues undermine the adaptive capacity of rural communities in Burundi? (3) What issues undermine the ecological resilience of social–ecological production landscapes?

To assess the resilience of a social–ecological system, it is imperative to be aware of both the current state of the system (resilience of what?) and the disturbances impacting it (resilience against what?) [20]. Although precisely calculating the resilience of a social–ecological system is theoretically possible, it is rarely achieved owing to the large amount of data required and its abstract nature [21,22]. Instead, resilience assessment is often approached using standardized tools based on a theoretical framework of the social–ecological system [23]. The exact content of these tools will depend on the purpose and scale (temporal, social and spatial) of the assessment [20]. The 'Indicators of Resilience in Socio-ecological production landscapes and seascapes' [24], hereafter referred to as the 'SEPLS toolkit', is an indicator-based social–ecological resilience assessment toolkit developed for development projects for social–ecological production landscapes. Social–ecological production landscapes are defined as dynamic mosaics of habitats and land uses shaped over the years by the interactions between people and nature in ways that maintain biodiversity and provide humans with goods and services needed for their well-being [25]. These landscapes, typical for Burundi, are characterized by traditional land use systems, contributing significantly to global food security while imposing a lesser burden on the environment in comparison to industrial agriculture [26]. To answer the three research questions, we conducted a multi-stakeholder workshop, followed by local workshops, alongside issuing a complementary questionnaire in Burundi, applying the SEPLS toolkit and its set of indicators of resilience.

2. Materials and Methods

The study comprised two main parts. The first exploratory part brought together the main local experts and stakeholders for social–ecological systems in Burundi in a participative workshop to assess their level of understanding of social–ecological resilience. The second part involved applying the SEPLS-toolkit in three rural areas of Burundi. This included a survey and a series of local workshops designed to test resilience perception in selected villages.

2.1. Multi-Stakeholder Participative Workshop

In an exploratory phase, a multi-stakeholder workshop was held in Burundi in June 2022 to explore the mainstreaming of 'resilience' in the framework of climate change and biodiversity loss into development cooperation. Participants (n = 28 persons) were civil society representatives (9 local NGOs (14 persons), 6 Belgian NGOs (8 persons)), decision makers ('Office Burundais pour la Protection de l'Environnement' (1 person)), academics (University of Burundi (3 persons)) and donors (Belgian development cooperation (2 persons)). The workshop collected the perceptions of the participants, the majority of whom were from civil society organizations most closely associated with the rural landscapes of Burundi.

We used the analytical tools PESTEL and SWOT (Strengths-Weaknesses-Opportunities-Threats), which are usually used in strategic planning, decision-making and action planning [27,28]. The PESTEL (Politics, Economy, Social, Technology, Environment, Legal) analysis method was used to allocate information gathered during the workshop.

Three focus group discussions with randomly assigned participants were carried out. Participants were assigned a number (1, 2 or 3) and joined their numbered group. They explored elements that could contribute to the resilience of rural social–ecological systems in Burundi via a simplified SWOT analysis, which considered 'best practices' (Strengths,

Opportunities) and 'possible challenges' (Weaknesses, Threats). This analysis was carried out for the nexi of (1) rights–governance–knowledge and (2) access to ecosystem services–restoration–conservation. The choice of these two nexi was based on two axes: a more social and a more bio-physical axis, such as that in Mao et al. [29]. Both nexi were chosen as they are known to be proxies or key entry points for reflections on the resilience of social–ecological systems [30,31].

Interpretation and analysis followed a tiered approach. All ideas were noted on flip charts on individual cards. All results were subjected to ex-post encoding treatment by (1) disaggregating multiple ideas on one card into separate ideas, (2) clustering the themes, (3) eliminating redundant information and (4), whenever possible, pairing best practices and challenges.

Then, in the second step of the coding process, the themes were further ex-post-classified according to the PESTEL approach [32] to anchor the results into a structured and recognized framework to ensure ease of interpretation.

2.2. Rapid Assessment of Social–Ecological Resilience In Situ

2.2.1. Study Area

This study was conducted in three natural regions of northern Burundi: Bugesera, Mugamba and Buyenzi (Figure 1). The selection of these regions was motivated due to their climatological and environmental characteristics or pressures:

1. The northern regions of Burundi are disproportionately affected by climate change, experiencing more extreme rainfall events, while also suffering from more droughts, compared to the other regions [33,34];
2. The selected communes are situated in the province of Butanyerera, one of the most densely populated provinces (formerly made up of the subdivisions Kirundo, Ngozi and Kayanza) of Burundi [35];
3. The presence of protected landscape elements, such as the Kibira National Park in Mugamba and the northern lakes in Bugesera, or the lack thereof in Buyenzi;
4. The climatological gradients of these regions are useful for temperature and rainfall due to topographical differences between the regions, as clarified in the following sections.

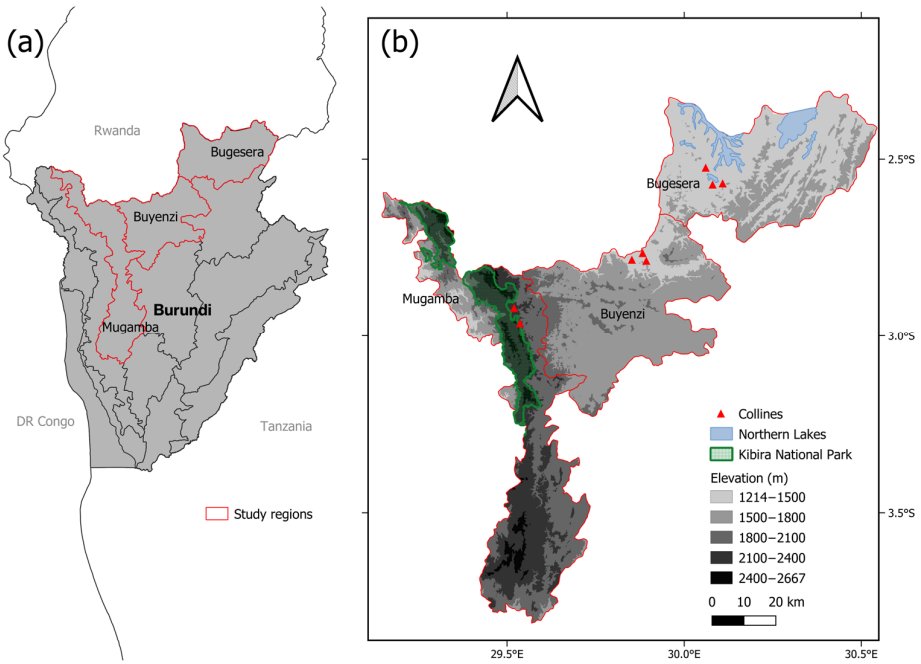

Figure 1. (**a**) The natural regions of Burundi; (**b**) an elevation map of the study regions with the locations of the sampled hills or 'collines' (an administrative unit) and the protected ecosystems.

2.2.2. Data Collection with SEPLS Toolkit

Data were collected in June and July 2023. Permission to conduct this research was obtained at the national level from the Office Burundais pour la Protection de l'Environnement (OPBE), an environmental agency of the Ministry of the Environment, Agriculture and Livestock in Burundi (MINEAGRIE). Additional permission was acquired from governmental authorities at both the provincial and hill levels.

Participants were verbally asked to provide consent beforehand and signed a written form confirming their approval of our use of the shared data afterwards.

The SEPLS-toolkit provides an analytical framework for managing development projects in social–ecological production landscapes. For this approach, local communities are actively engaged in the social–ecological assessment of their landscape, thereby enhancing their adaptive capacity and involving them in policy-making processes [19]. Within the context of development projects, the purpose of the assessment is to identify critical areas for sustaining the vital social and ecological processes of the landscape amid social, economic, and environmental pressures and shocks. The SEPLS toolkit can also play a role in scientific research, contributing to the identification of research gaps and a better comprehension of social–ecological resilience dynamics from a local perspective [24]. The key element of the SEPLS toolkit is the assessment workshop, where the local populations' perceptions are captured by 20 indicators on a Likert scale (1–5) [21]. These indicators assess different aspects of the key systems (ecological, agricultural, cultural and socio-economic) and are clustered into five categories: 1. Landscape diversity and ecosystem protection; 2. Biodiversity (including agricultural biodiversity); 3. Knowledge and innovation; 4. Governance and social equity; 5. Livelihoods and well-being. The indicators are adapted from the studies of Mijatovic et al. and Van Oudenhoven et al. [36,37], who created a general analytical framework of social–ecological resilience indicators for production landscapes. This framework is based on the principle that resilience depends on biodiversity at different scales (from the genetic to the landscape level) [36]. The indicators were adapted in the SEPLS toolkit to be perception-based, engaging the local population, and presented in simpler language to facilitate discussions [21].

2.3. Survey

We conducted an exploratory survey in local communities addressing 3 topics.

1. The diversity of the local food system and income diversity (these factors are closely related in Burundi). The corresponding questions were adapted from indicators 5 and 18 of the SEPLS toolkit. This topic focused on the descriptive agricultural characteristics of the household, including the agricultural surface area, the crops harvested in the last 12 months and food security.
2. Agricultural knowledge and innovation, adapted from indicators 8, 9 and 10 of the SEPLS toolkit. This topic focused on agricultural practices utilized by households and whether households have access to agricultural support systems that can exchange and extend agricultural knowledge. These first two topics played an important role in answering the research questions by allowing us to assess the underlying quantitative variables of several indicators of the SEPLS toolkit.
3. Disturbances experienced by rural households. Respondents were asked about the disturbances that their household had experienced in the past decade, adversely impacting their livelihoods. This topic of the survey was necessary for identifying the shocks and pressures on the social–ecological system (resilience against what?).

The first two topics play an important role in answering the research questions by assessing the underlying quantitative variables of several indicators of the SEPLS toolkit. Furthermore, performing a comparative analysis of these variables for the different study

regions allowed for a comprehensive understanding of the social–ecological resilience dynamics present.

The survey was conducted among 206 households in three communes within the study regions: Kirundo (Bugesera, n = 92), Nyamurenza (Buyenzi, n = 64) and Muruta (Mugamba, n = 50). Each commune's surveyed area spanned two or three collines: Kanyinya (n = 28), Murama (n = 37) and Cewe (n = 27) in Kirundo commune; Masama (n = 22), Martyazo (n = 17) and Nyabikenke (n = 24) in Nyamurenza commune; and Rwegura (n = 22) and Remera (n = 28) in Muruta commune. Since the end of the study period, the above-mentioned administrative subdivisions have since been reformed and are now designated as follows: Bugesera, n = 92; Buyenzi, n = 64; and Mugamba, n = 50. Each region's surveyed area spanned two or three collines: Kanyinya (n = 28), Murama (n = 37) and Cewe (n = 27) in Bugesera; Masama (n = 22), Martyazo (n = 17) and Nyabikenke (n = 24) in Buyenzi; and Rwegura (n = 22) and Remera (n = 28) in Mugamba.

Collines, which translates to 'hills' in English, are an administrative division below the level of communes. Questionnaires were conducted in Kirundi with the head of each household. If the head of household was unavailable, a relative (spouse or child) was interviewed instead.

The questionnaires were administered along with a bilingual (French-Kirundi) University of Burundi student who has experience with similar surveys. Following a training session on key terminology and corresponding Kirundi vocabulary, students facilitated interviews in Kirundi and independently conducted surveys to accelerate data collection while ensuring methodological consistency.

2.4. SEPLS-Workshops

A total of 31 people participated in the three different assessment workshops in three collines: Murama (Bugesera region), Masama (Buyenzi region) and Remera (Mugamba region). The largest represented stakeholder groups were subsistence farmers (n = 24) and civil servants (n = 5). The remaining two participants were an entrepreneur and a bricklayer. Gender parity was almost achieved, with 14 women and 17 men participating. The average age of participants was 39.8 years (SD $\pm$ 13.8 years), with the youngest participant being 22 and the oldest participant being 72.

The objective of the workshops was to conduct a rapid and comprehensive assessment of the social–ecological resilience dynamics of the study communities. The workshops applied 19 of the 20 indicators in the SEPLS toolkit, thereby addressing all three research questions. Due to financial and time constraints, effort was made to keep the workshops as short as possible, with a total workshop duration of about four hours. The structure of these streamlined workshops comprised three phases:

1. Introduction: The facilitators introduced themselves and the research project. They explained key terms necessary for the further course of events, such as 'resilience' and 'biodiversity'. The facilitators also outlined the course of the workshop and explained the mechanics of the scoring process.
2. Scoring: The participants scored the 19 indicators (see theindicators as listed in the first column of Table 3, see below) included in the SEPLS toolkit using a Likert scale, ranging from 1 (very poor performance) to 5 (very good performance). Indicator 20 was omitted from the workshop due to not being relevant in the study areas. The indicators and their corresponding questions, as outlined in the SEPLS toolkit, were translated beforehand from English to the local Kirundi language. For each indicator, the facilitators also provided site-specific examples, aiding the participants' comprehension of the indicators.

3. Discussion: A discussion round followed each scoring round, during which all participants were free to give specific examples or explanations related to the indicator or elaborate on the rationale behind their score. These rounds were guided with the complementary 'discussion questions', which are mentioned for certain indicators in the SEPLS toolkit. The results of the discussion rounds were written down by a facilitator, allowing for further analysis of and insights on why community members gave the assigned scores.

One workshop was organized in each of the three study regions after the questionnaire stage had been completed. This approach enabled us to gather information about the social–ecological production landscape before the workshops were conducted. As such, we could provide site-specific examples and adapt the asked questions for the scoring and discussion rounds. Carrying out the workshop with the same communities as included in the survey also facilitated the integration of findings from both the survey and workshop, allowing for a cohesive analysis.

Participants were selected and contacted beforehand by the local head of the colline. For this selection process, they were asked to assemble a diverse group of stakeholders, ideally representing the various layers of society concerning gender, education level, age and occupation. Given the predominance of subsistence farming in rural Burundi, the participants' occupational diversity was limited but was still reflective of broader society. However, the requirement of basic literacy skills for participation could have introduced potential bias into stakeholder selection. For the individual scoring process, participants were required to be able to read numbers up to 19 (the amount of indicators) and write the numbers 1 to 5 (their score).

2.5. Data Analysis

The analysis of questionnaire data was conducted using RStudio 2023.06.01. Contingency tables and chi-square tests were used to find significant differences in the household characteristics and experienced disturbances between the different regions. Analyses of contingency tables with low frequencies, where the chi-square test may be unreliable, were performed using Fisher's exact test. All statistical tests were performed at a significance level of $p < 0.05$. The scoring results of the workshops were analyzed qualitatively. The key ideas from these discussions were further condensed into 'thought units', encapsulating the scoring rationale for each indicator. This approach, used by [38], allowed for performing a comparative analysis of the different regions and their corresponding influencing factors. Small sample sizes in some cells, as is often the case in such social–ecological work, were acknowledged as an inherent limitation. However, the combination of data sets (which were triangulated by combining workshops, SEPL and surveys) allowed us to make sufficiently robust conclusions about the real-world realities (see Guerrero et al. [39] for recommendations about integrating several methods in social and environmental studies).

3. Results

3.1. Key Disturbances and Shocks in the Study Regions

3.1.1. Key Perceptions by Experts on Social and Bio-Physical Nexi

In an exploratory multi-stakeholder participatory workshop, comprising local civil society organizations, decision makers, scientists and donors, participants held discussions for a whole day (in three focus groups) about what factors could contribute to resilience of rural social–ecological systems in Burundi. They provided answers using cards with flip charts, representing, respectively, the nexi of thematics, a more 'social' nexus dealing with 'rights–governance–knowledge' (Supplementary Materials Table S1), and a more 'bio-physical' nexus dealing with 'access to ecosystem services–conservation–restoration'

(Supplementary Materials Table S2). Both nexi were represented by two flip charts, representing the SWOT elements 'strengths and opportunities' and 'weaknesses and threats', respectively. For the nexus 'rights–governance–knowledge', we noted strengths and opportunities, as well as weaknesses and threats, for all PESTEL categories (Supplementary Materials Table S1). In the Political category, participants mentioned advocacy and a better understanding of land ownership and governance attributions as possible solutions for increasing resilience. In the Economic category, they highlighted the need for more conscious consumption patterns. In the Social category, the exchange of good practices, capacity building, education and awareness were mentioned as key factors. Clear strategies, participatory approaches, synergies, better gender inclusion, better communication, outreach and proximity to communities were also mentioned as important. In the Technological category, participants highlighted the need for increased knowledge of ecosystems, action research, better valorization of achievements and better data availability. For the Environment category, they identified water and climate as the main issues. Finally, for the Legal category, law enforcement and strengthening legal frameworks were mentioned.

For the nexus 'access to ecosystem services–conservation–restoration', we collected strengths and opportunities, as well as weaknesses and threats, for all PESTEL categories (Supplementary Materials Table S2). In the Political category, the participants stressed the importance of involving civil society and communities in governance processes. In the Economic category, the valuation of ecosystem services was seen as useful, and agroecology was mentioned. In the Social category, greater synergy between communities, training on how to use improved stoves and agroforestry training were mentioned. In the Technological category, several sustainable practices were listed (see Supplementary Materials Table S2). For the Environment category, participants focused on four themes: (1) restoration and reforestation, (2) biodiversity, (3) water and (4) health. Finally, in the legal category, participants mentioned the lack of legislation concerning ecosystem services.

3.1.2. Diversity of Local Food System and Income Diversity

Differences in the household characteristics among the different regions regarding both the diversity of the local food system and income diversity were identified through the chi-square test (Table 1). Livelihood activities did not differ substantially among the three regions. In total, 198 of the 206 respondents indicated that agriculture is their main source of income and the activity to which most time is allocated by the household. Of the eight respondents who reported a different primary activity, three were laborers, three were employed and two were merchants. Moreover, six of these eight respondents indicated undertaking agriculture as a secondary activity. This implies that there were only two respondents in total did not engage in any agricultural activities. About 60% of the surveyed households undertook a secondary income-generating activity. Almost 90 percent of the surveyed households reported owning livestock. This percentage influences both income and food diversity, as 22% of the livestock-owning households did not generate any income with this livestock in the past 12 months.

The questionnaire asked respondents to estimate the area of agricultural land used by their household. This agricultural land measurement encompassed not only personal property but also family, rental and 'metayage' (cultivating a landowner's field in exchange for a share of the harvest) properties. The area of utilized agricultural land differed significantly ($p < 0.001$) among the three different regions. One noteworthy observation was that within Bugesera households, 55% of participants had access to less than 30 acres of agricultural land, in contrast to Buyenzi and Mugamba, where 84% and 80%, respectively, had access to agricultural land larger than 30 acres.

Table 1. A summary of the household characteristics of respondents regarding the diversity of local food system and income diversity. *, significant at $p < 0.05$; ***, significant at $p < 0.001$; ^{ns} indicates no statistical significance at $p < 0.05$.

Characteristic	Bugesera (N = 92)	Buyenzi (N = 64)	Mugamba (N = 50)	Overall (N = 206)	χ^2 Test
	% (n)	% (n)	% (n)	% (n)	
Primary Activity					1.58 ^{ns}
Agriculture	95.7 (88)	98.4 (63)	94.0 (47)	96.1 (198)	
Other	4.3 (4)	1.6 (1)	6.0 (3)	3.9 (8)	
Secondary activity					2.68 ^{ns}
Yes	57.6 (53)	56.3 (36)	70.0 (35)	60.2 (124)	
No	42.4 (39)	43.7 (28)	30.0 (15)	39.8 (82)	
Livestock					9.01 *
Yes	81.5 (75)	95.3 (61)	94.0 (47)	88.8 (183)	
No	18.5 (17)	4.7 (3)	6.0 (3)	11.2 (23)	
Farm size (ha)					35.77 ***
<0.3	55.4 (51)	16.6 (10)	20.0 (10)	34.5 (71)	
0.3–0.8	17.4 (16)	35.9 (23)	24.0 (12)	24.8 (51)	
0.8–1.3	12.0 (11)	14.1 (9)	20.0 (10)	14.6 (30)	
>1.3	15.2 (14)	34.4 (22)	36.0 (18)	26.2 (54)	
Annual crops (qty.)					32.97 ***
0–3	15.0 (21)	7.8 (5)	10.0 (5)	15.0 (31)	
4–5	48.5 (54)	51.6 (33)	26.0 (13)	48.5 (100)	
6+	36,4 (17)	40.6 (26)	64.0 (32)	36.4 (75)	
Perennial crops (qty.)					23.71 ***
0	13.0 (12)	1.6 (1)	18.0 (9)	10.7 (22)	
1	56.5 (52)	32.8 (21)	40.0 (20)	45.1 (93)	
2+	30.4 (28)	65.6 (42)	42.0 (21)	44.2 (91)	
Coffee	6.5 (6)	4.7 (3)	30.0 (15)	11.7 (24)	21.72 ***
Tea	0	0	72.0 (36)	17.48 (36)	136.11 ***

The questionnaire inquired about the crops that were harvested in the past 12 months, reflecting the diversity of the household food system. The frequencies of the categories for both annual and perennial crops exhibited significant differences ($p < 0.001$). The mean number of annual crops species was 5.0, thus this figure significantly differed ($p < 0.001$, Kruskal–Wallis test) among the regions, with the lowest recorded in Bugesera (4.23) and the highest in Mugamba (5.96). Almost 90% of all household had harvested at least one perennial crop in the last 12 months. Among perennial crops, bananas were almost frequently mentioned, with 170 households reporting their cultivation. Coffee and tea are distinctly presented in the table due to their economic importance as cash crops, and they were mostly cultivated in Mugamba (Table 1).

3.1.3. Agricultural Knowledge and Innovation

Two households were excluded from this section of the analysis as they did not perform agriculture activities. Agricultural support systems are instrumental in facilitating the implementation of agricultural practices, with more than half of the surveyed households reporting having agronomic support systems (Figure 2), ranging from 55% in Buyenzi to 76% in Mugamba. Mugamba also reports the highest percentage (74%) of households partaking in at least one type of agricultural training per growing season, i.e., twice per year. This metric starkly contrasts with the situation in Bugesera, where less than 20% of households receive seasonal agricultural training from government outreach services. About one-third of households are members of an agricultural cooperative, which generally offer support across the varied stages and scales of agricultural production.

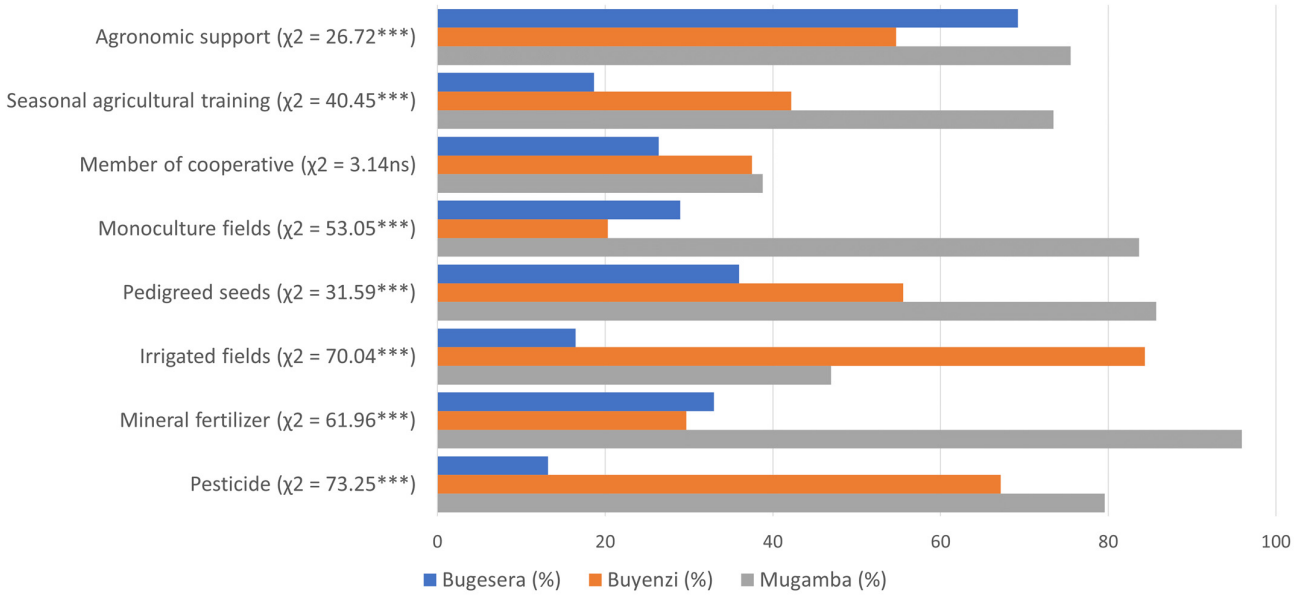

Figure 2. Percentage of respondents (N = 204) who apply agricultural practices and benefit from agricultural support systems in each region (Bugesera n = 91, Buyenzi n = 64 and Mugamba n = 59). ***, significant at $p < 0.001$; ns indicates no statistical significance at $p < 0.05$.

Figure 2 also provides insights into the adaptation of agricultural practices across the different regions of Burundi. Monoculture fields are far from omnipresent in Burundi, with intercropping being the most popular practice in Bugesera and Buyenzi. In contrast, in Mugamba, over 80% of households own one or more fields where they practice monoculture farming. Less than half of the households in Bugesera report having access to and using pedigreed seeds and mineral fertilizers. However, all households in the three regions make use of organic fertilizers. Irrigated fields in the studied regions are primarily supported by hand-made canals. The prevalence of irrigated fields is highest in Buyenzi (84%), given the presence of rivers in the surveyed landscapes. In Mugamba (47%), the canals are employed to guide the water from the forest at the top of the mountain downwards. Pesticide usage is significantly higher in Buyenzi (67%) and Mugamba (80%) than in Bugesera (13%).

3.1.4. Household Disturbances

The results in Table 2 reveal that the majority of households have experienced livelihood-impacting disturbances over the past decade. Among these disturbances, climate-related shocks are the most prominent. More than 90% of respondents in Bugesera have experienced drought, while in Mugamba, excessive rainfall has been a prevalent issue. Meanwhile, more than 80% of households surveyed in Buyenzi have experienced both rain- and drought-related shocks. Hailstorms predominantly affected households in Mugamba, with 82% of households affected. The impact of hailstorms is less pronounced in Buyenzi and Bugesera, with such storms affecting 33% and 5% of households, respectively.

The surveyed households were not only affected by climatic shocks but also experienced biological disturbances such as crop diseases, agricultural pests and human diseases. Almost half of all households experienced agricultural disruptions due to crop diseases, with significant ($p < 0.001$) differences in frequency across regions, disproportionally affecting Buyenzi (72%) and Mugamba (78%). The prevalence of agricultural pests was less substantial compared to crop diseases, except in Buyenzi, where the same percentage of households (72%) reported being impacted by this disturbance. This similarity might stem from a potential misconception, with participants confusing pests and diseases. Disturbances related to human diseases, primarily malaria, exhibited significant differences

among regions, with households in Bugesera (15%) and Buyenzi (27%) being more affected. Increased prices of food showed strong and significant ($p < 0.001$) differences among the different regions, with 84% of Mugamba reporting price increases, compared to only 42% in Buyenzi and 16% in Bugesera. Less frequently mentioned disturbances include theft, loss of land and landslides. Of those disturbances, only the frequency of landslides differed significantly ($p < 0.05$) among regions, impacting three households in Mugamba. This survey helped us to answer research question 2 (which concerned the specific disturbances that rural communities face).

Table 2. A contingency table of disturbances experienced by the household in the last 10 years in the three study areas. *, significant at $p < 0.05$; **, significant at $p < 0.01$; ***, significant at $p < 0.001$; ^{ns} indicates no statistical significance at $p < 0.05$; ‡ indicates usage of Fisher's exact test for statistical analysis.

Disturbance	Bugesera (N = 92)	Buyenzi (N = 64)	Mugamba (N = 50)	Overall (N = 206)	χ^2 Test
	% (n)	% (n)	% (n)	% (n)	
Drought	91.3 (84)	89.1 (57)	0	68.5 (141)	143.32 ***
Excess rainfall	5.4 (6)	81.3 (52)	92.0 (46)	50.0 (103)	133.37 ***
Crop disease	12.0 (11)	71.9 (46)	78.0 (39)	46.6 (96)	80.61 ***
Rising foodstuff prices	16.3 (15)	42.2 (27)	84.0 (42)	40.8 (84)	61.55 ***
Hailstorm	5.4 (5)	32.8 (21)	82.0 (41)	32.5 (67)	85.54 ***
Agricultural pest	4.3 (4)	71.9 (46)	8.0 (4)	26.2 (54)	100.31 ***
Human disease	15.2 (14)	26.7 (17)	2.0 (1)	15.5 (32)	12.92 **
					p-value ‡
Theft	6.5 (6)	1.6 (1)	2.0 (1)	3.9 (8)	0.32 ^{ns}
Loss of land	2.2 (2)	0	8.0 (4)	2.9 (6)	0.05 ^{ns}
Landslide	0	0	6.0 (3)	1.5 (3)	0.01 *
No disturbance	5.4 (5)	4.7 (3)	6.0 (3)	5.3 (11)	1 ^{ns}

3.2. Factors Limiting the Adaptive Capacity of Rural Households

3.2.1. Landscape Diversity and Ecosystem Protection

The scores for the individual indicators vary vastly, ranging from 1.2 to 4.8. Participants in Remera (Mugamba) generally had the highest scores, while the lowest scores were observed in Masama (Buyenzi). The 19th indicator (biodiversity-based livelihoods) had, on average, the lowest score across the three regions, whereas the 5th indicator (diversity of the local food system) received the highest scores (Table 3).

Participants in the three regions mentioned the lack of landscape diversity, citing the ubiquitous presence of agroecosystems. Mugamba and Bugesera feature protected ecosystems, which play a role in ecological interactions and the diversity of the landscape. The Akanyaru river in Buyenzi features some protected areas and has seen efforts to restore the buffer zone. Remera (Mugamba) is located in the vicinity of two protected forests: Kibira National Park and the necropolis of King Mwezi Gisabo. Murama (Bugesera) is situated adjacent to Lake Rwihinda, which is part of the 'Paysage Aquatique Protégé de Bugesera' and has seen efforts to restore the buffer zones, acknowledging its ecological role. Bugesera experiences drought-related shocks, with participants from Murama reporting the limited adaptation capacity of their landscape. In contrast, participants from Masama (Buyenzi) and Remera (Mugamba) face rain-related shocks including flooded marshland and soil erosion. To counter these shocks, the population has implemented measures including contour farming and drainage systems.

Table 3. A comparative analysis of the indicators scoring and the corresponding thought units in the three regions.

	Murama (Bugesera)		**Masama (Buyenzi)**		**Remera (Mugamba)**	
	♀= 5	**♂= 5**	**♀= 6**	**♂= 5**	**♀= 3**	**♂= 7**
Indicator	Mean Score		Mean score		Mean score	
Landscape diversity and ecosystem protection	3.2		2.2		3.2	
(1) Landscape diversity	3.2 Lakes and wetlands		2.0 Fish pond and river		3.3 Forest and river	
(2) Ecosystem protection	4.8 Bugesera Protected Aquatic Landscape		1.7 Akanyaru river		3.5 Kibira and royal necropolis	
(3) Ecological interactions between different components of the landscape	3.2 Lake buffer zones restoration		2.0 Little effort		3.6 Protection of Kibira	
(4) Recovery and regeneration of the landscape	1.7 Droughts		3.1 Rain-related shocks		2.5 Rain-related shocks	
Biodiversity (including agricultural biodiversity)	3.9		2.5		3.3	
(5) Diversity of local food system	4.4 High diversity		3.9 High diversity		4.3 High diversity	
(6) Maintenance and use of local crop varieties and animal breeds	3.8 Seed hangars		1.4 No efforts		2.6 Invasive species	
(7) Sustainable management of common resources	3.6 Lake resource usage restricted		2.1 Fishing taxes		3.1 Kibira adequate management	
Knowledge and innovation	1.8		2.5		3.6	
(8) Innovation in agriculture and conservation practices	2.1 Little innovation		2.6 Monoculture and contour farming		3.9 Irrigation canals, contour farming and agroforestry	
(9) Traditional knowledge related to biodiversity	1.2 No traditional knowledge		3.1 Oral transmission		3.7 Oral transmission	
(10) Documentation of biodiversity-associated knowledge	1.3 No documentation		1.9 Farmer's field school		3.4 Farmer's field school, seasonal calendar	
(11) Women's knowledge	2.5 Animal and child care		2.5 Sweet potato cultivation and animal care		3.3 Crafts and animal care	
Governance and social equity	2.8		2.5		3.4	
(12) lefts in relation to land/water and other natural resource management	2.4 Mixed customary and law		3.5 Mostly customary, provides security		3.8 Legal ownership, women customary	
(13) Community-based landscape governance	3.6 OPBE agency		1.6 No governance		3.8 OPBE and local governance	
(14) Social capital in the form of cooperation across the landscape	1.7 No cooperation		1.4 No cooperation		3.7 Cooperation among agencies and locals	
(15) Social equity (including gender equity)	3.6 Equal society		3.3 Equal society		2.4 Equal society	
Livelihoods and well-being	2.7		2.2		2.9	
(16) Socio-economic infrastructure	3.5 Inadequate facilities		3.0 Inadequate facilities		3.8 Inadequate facilities	
(17) Human health and environmental conditions	3.2 Diseases, no clean water		2.9 Diseases, expensive medication		2.8 Diseases	
(18) Income diversity	1.5 No diversity		1.5 No diversity		4.1 Some diversity	
(19) Biodiversity-based livelihoods	2.5 Banana beer, mats and baskets		1.4 Banana beer, mats and baskets		2.5 Bread, banana beer, mats and baskets	

3.2.2. Biodiversity (Including Agricultural Biodiversity)

Given that a large part of the population engages in agricultural activities, locally produced food is highly diverse and imports are bought predominantly in periods of stress. Imported foods in Remera include fish, palm oil, fruits and peanuts. Participants from Masama and Remera report, to varying degrees, the lack of effort made to preserve local species and varieties or to maintain seed quality. Participants in Murama offered a more optimistic perspective, attributed to the presence of seed banks. Exotic species are actively cultivated for their economic or agricultural purposes. The sustainable management of common resources is perceived as having room for improvement for the Northern Lakes and Kibira National Park. In the Rwihinda lake, unlike in the other lakes, fishing has been

prohibited and efforts are being made to promote sustainable tourism. Participants in Masama mentioned the imposition of a levy on fishing to avoid overexploitation.

3.2.3. Knowledge and Innovation

Efforts to achieve innovation vary greatly among the different regions, with contour farming being a common denominator among the novel practices. Participants in Murama report that few efforts are being made to improve agricultural practices in the face of climatic shocks, noting the absence of drought-tolerant crop variants. Moreover, in this region, there is a lack of documentation and exchange of agricultural and biodiversity-related knowledge. In Masama, the ADISCO NGO has organized a farmers' field school and exchanged seeds of agroforestry-adapted tree varieties. Attending the farmers' field school in Remera is a recurring activity, as the facility actively tries to implement innovative methods and supplies a seasonal calendar. Women's knowledge and skills are similar to those of men in the study areas. Caring for children and animals was a general response regarding the specific role of women. In Masama, participants emphasized that women are also responsible for cultivating sweet potatoes.

3.3. Challenges to the Ecological Resilience of Production Landscapes

3.3.1. Governance and Social Equity

The Burundi government formally regulates land ownership rights via the 1986 Land Code [40]. However, in these rural collines, land ownership is predominantly inherited through patrilineal customary practices without government interference. The customary system also allows women to inherit and possess land; however, in reality, this is decided among siblings. Customary land delineation ensures secure access and use. In Remera, land tenure is legally regulated for men and regulated through customary practices for women. The 'Office Burundais pour la Protection de l'Environnement' (OPBE), an environmental governance agency, operates at the regional level in Murama and Remera, particularly governing the protected areas of Bugesera and Kibira National Park. Furthermore, the NGO 'Dukingiribidukikije' is active in Remera, cooperating with colline representatives and the OPBE for managing natural resources. Participants emphasized the equity of their regional society in terms of rights, resource access, decision-making and opportunities. The scores for the 15th indicator fail to reflect this shared notion.

3.3.2. Livelihoods and Well-Being

In all three regions, participants mention the presence of essential socio-economic infrastructure such as schools, markets, (unpaved) roads and health centers. Nonetheless, they report that the quality and accessibility of these facilities are not adequate. While modern medicine is available, medication costs limit treatment options for the local population. Drinkable water and electricity are sparsely available, often restricted to the village center. Malaria and diseases related to poor hygiene (e.g., typhoid fever) are prevalent in the surveyed regions. The scores for the 'income diversity' indicator are very low in Murama and Masama. In the discussion round, participants underscore the absence of economic alternatives to agriculture. Any income generated is derived from selling products or livestock. A contrasting score was obtained in Remera, citing the variety of local economic activities, such as commerce, civil service employment, crafts, food processing (e.g., working in a bakery) and working as a driver. The production of baskets and mats from *Eragrostis* and *Cyperus papyrus*, respectively, were consistently mentioned in the context of biodiversity-based livelihoods, as was the production of banana beer.

4. Discussion

4.1. Regional Specificity of Disturbances and Implications for Resilience Strategies

Although Burundi is the second poorest country worldwide [41], few studies have dealt with its resilience in coping with poverty and the environmental polycrisis. For instance, Minani et al. [42] reported that 44% of the farmers surveyed in their study explicitly felt that they had some sort of resilience to climate change. They attributed it to well-organized local social networks. Other studies link resilience (or the lack of it) in Burundi to its tumultuous history of civil war and post-war impacts on issues such as mental health or food security [43,44]. However, few studies have dealt with the link between the environmental polycrisis, the resilience of rural communities, ecosystem services and sustainable development and poverty. Bitama [45] highlighted the strong positive effects of a national reforestation project on the resilience of local farmers. He concluded that the key to its success lies in participatory governance involving all stakeholders, combined with training for farmers and use of high-tech support (e.g., drone technology) for monitoring. Some other studies assessed protected [46] or specific areas, such as Kibira National Park [47], but without touching upon the concept of resilience. Both propose a more participatory approach to conservation. In a regional study covering Uganda, Rwanda and Burundi, van Soesbergen et al. [48] reported on the need for effective protection and the potential benefits of expanding the network of protected areas while still meeting agricultural production needs. This highlights the often-perceived trade-off between food security and biodiversity conservation [49].

Our multi-stakeholders' workshop reflected these above-mentioned tendencies. When matching these data against the seven working principles proposed by Sterk et al. [17], crucial for building resilience in social–ecological systems, we recognize statements connected to these principles, especially principle 1 (maintain diversity and redundancy of species, landscape types, actors and institutions): indeed, the strong monopoly of agriculture on socio-economic life in the rural communities of Burundi illustrates the relative absence of diversity in income generation. However, within the sector, diversity in crops grown may mitigate this and increase resilience against climate change and pests. For principle 5 (encourage learning by acquiring new information, skills or understanding), we found the need for learning in the surveyed communities, as they demand greater outreach by the authorities to access new agriculture techniques, skills and technology. For principle 6 (broaden participation through the active engagement of stakeholders in projects), we found, as for the previous principle, that joining forces across disciplines and sectors to share knowledge and innovative technologies contributes to increased resilience in the face of adverse conditions. The 7th principle (promote polycentric governance systems) can also be applied, as we observe polycentric circles ranging from the colline to the ministerial level, with each having their own governance and decision status (subsidiarity). However, principles 2 (manage the connectivity of resources, species and people), 3 (manage slow variables and feedbacks) and 4 (foster complex adaptive systems thinking) are more difficult to grasp and were not explicitly mentioned during the debates. This might also be due to the more abstract concepts linked to connectivity, slow variables and complex adaptive systems. In a way, these principles are linked to the other principles. Long-term strategies and action plans, when implemented and monitored, can be applied to slow variables and feedbacks. Outreach by the government also implies increased connectivity of resources and people, as well as species (crops, livestock, agroforestry). All these principles, when properly or partially applied, will contribute to fostering complex adaptive thinking, both at the governance and local community levels. These principles are crucial to maintain a more holistic view of the entire social–ecological system and its interdependencies and, thus, for anticipating future shocks and associated resilience needs. Our PESTEL-structured list of best

practices and challenges about the two nexi (Supplementary Materials Tables S1 and S2) are quite well reflected in the 19 SEPLS indicators listed in Table 3.

4.2. The Vicious Cycle of Agricultural Dependence and Limited Adaptive Capacity

Further, we presented an assessment of the social–ecological resilience dynamics of rural communities in northern Burundi. This assessment was carried out by applying the indicators outlined in the SEPLS toolkit. While it is acknowledged that conducting such a comprehensive assessment comes with inherent limitations (see Section 4.4.), the results provide key insights for addressing the issues undermining the adaptive capacity of rural communities in Burundi. The adaptation strategy of diversifying income sources is recognized for its capacity to reduce the vulnerability of households towards disturbances [50,51].

As noted in the results, agriculture stands out as the predominant income-generating activity in these rural communities, rendering the population's livelihoods vulnerable to climatic shocks such as drought and variable rainfall. The income sources reported in the workshops and questionnaire included selling livestock and (cash) crops, processing agricultural products or the sale of labor. Given the absence of diversification beyond agriculture, these communities are more vulnerable in periods of stress, leading to food shortages. During these periods, more households will resort to the sale of labor, which subsequently lowers wages and worsens general food insecurity [52].

While local agrobiodiversity is deemed to be sufficient, as observed in the assessment workshop, extension services and agricultural adaptation strategies remain underutilized, although they appear to be key to achieving increased resilience. The Ministry of Environment, Agriculture and Livestock (MINEAGRIE) employs agronomic extension agents in every commune [53]. Despite their required training and their acknowledged efforts, this program fails to reach the entire population and their needs [53]. In Mugamba, the highest implementation rate for agricultural adaptation strategies is observed, excluding irrigation, which is more prevalent in Buyenzi due to the presence of rivers. The elevated adoption rate in Mugamba could be attributed to more frequent training or more adequate extension services, likely influenced by the presence of several NGOs [54]. Another possible explanation is that these households possess higher incomes due to larger farm sizes and their cultivation of cash crops such as coffee and tea. This pattern would correspond to the trend observed in Burundi, where wealthier households tend to implement more adaptation strategies [55]. It should be noted that while agricultural practices such as monoculture farming and pesticide usage can promote food security, they also have negative externalities, leading to detrimental effects on the resilience of the entire social–ecological system [56]. To enhance the adaptive capacity of rural communities, providing adequate extension services that promote sustainable agricultural practices remains necessary [57].

Further, the largest share of disturbances reported in the study is made up by climate-related shocks. These disturbances exhibit strong inter-regional differences that can be explained by the climatological characteristics of the three regions. Given the expected increases in these climate-related shocks, transformative action will be necessary to address these challenges. Agricultural threats (pests and diseases) also posed a general threat to the livelihoods of the study communities but were less common in Bugesera, despite favorable growing conditions. This somewhat unexpected finding could be attributed to the presence of community seed banks, operated by the German NGO Welthungerhilfe, which conserves and fumigates the seeds [58]. Coinciding with the elevated prevalence of agricultural threats in Mugamba and Buyenzi, more households in these regions resorted to using pesticides in their agricultural practices. Moreover, our own observations infer that Mugamba experiences more precipitation than Bugesera, hence impacting the level of

investment and intensity of local agriculture. More intensive agriculture (Mugamba) may be prone to higher prevalence of plant diseases.

Considering the substantial representation of small farm holdings, it can be inferred that a large proportion of the study households rely on the market for food and are therefore vulnerable to volatile market prices [52]. Interestingly, rising food prices were less frequently reported in Bugesera as a livelihood-impacting disturbance. This observation is unexpected, considering that a majority of households had access to less than 0.3 ha of agricultural land. This finding could also be attributed to the presence of the aforementioned seed banks. These seed banks function as repositories for both seeds and food, contributing to the stabilization of food prices for the local population and ensuring food security [58]. Additionally, human diseases, most notably malaria, remain a widespread issue in Burundi. The observed inter-regional variations in disease prevalence do not correspond with the existing literature [59].

4.3. The Central Role of Governance in Building Ecological Resilience

Landscape connectivity, heterogeneity and biodiversity stand out as fundamental principles for enhancing the ecological resilience of social–ecological production [17,60]. The landscapes featured in this study are predominantly agroecosystems. Landscape heterogeneity, or patchiness, plays a vital role in the adaptive capacity of the system by regulating biodiversity and influencing the flow of resources within it [61]. Additionally, landscape connectivity, which concerns the size of the patches and the distances between them, is necessary to ensure the flux of resources across the landscape [10]. It is thus imperative for resilience that efforts are made to achieve landscape restoration and that the remaining ecosystem elements are adequately protected. However, ecosystem protection and governance in Burundi are often inadequate, stemming from the absence of enforcement and the lack of cooperation between the administrative authorities and natural management organizations [62]. Furthermore, as remarked in the workshops, decisions related to natural resource management often occur without the active involvement of the local populations (top-down approach) or necessary cooperation across the landscape.

The biodiversity observed within the study landscapes primarily originates from agrobiodiversity and the protected ecosystems. Landscape biodiversity provides varied ecosystem services upon which human well-being depends [63]. While local civil society and the local population acknowledged the ecological importance of this biodiversity during the workshops, unsustainable practices persist, linked to poverty and vulnerability traps. Given the dependence of local communities on certain ecosystem services (e.g., firewood and wild edible plants in Kibira), ecosystem governance faces a difficult challenge [47]. Implementing usage restrictions, while necessary, must be achieved in a sustainable manner to ensure that local communities are not deprived of access to essential resources [64] and retain acceptance and local ownership of these sustainable development processes. At the regional and local scales, land planning combined with the valuation of ecosystem services, as shown in the study of Córdoba Hernandez and Camerin [65] in the case of European urban planning in Spain, are best practices that can contribute to avoiding increasing vulnerability and to increasing existing resilience. However, to achieve this, more capacities need to be strengthened at all levels of governance and management.

4.4. Methodological Reflections on Applying the SEPLS Toolkit

The indicators of the SEPLS toolkit provided an adequate framework for enhancing comprehension of social–ecological resilience in rural communities in Burundi. The indicators are flexible and based on more than a decade of developmental work, including many tests and implementations [66]. Nonetheless, some indicators were difficult to adapt to the

specific context of Burundi. For example, indicator 12 (rights in relation to land/water and other resource management), given the complex interplay of statutory and customary laws, was exacerbated by war-related land disputes [40]. Moreover, indicator 15 (social equity) was challenging to assess due to potential sensitivities related to the country's long history of ethnic conflicts. These complexities underscore the need for nuanced adaptation when applying the tool in intricate sociological contexts.

The SEPLS toolkit features a practical framework that guides the user through the process of applying the tool in the field, with the assessment itself being operationalized in the 'resilience assessment workshop'. The key strength of this workshop is the participation of the local community, which provides critical local ecological knowledge, an important aspect of social–ecological resilience [67]. However, the workshop, as outlined in the tool, is difficult to operationalize in Burundi given financial and logistical constraints. Organizing such a workshop necessitates additional permissions and arranging a conference venue in a nearby city, along with further costs for transporting and accommodating the rural participants [68]. These financial constraints make it difficult for local NGOs to apply the tool as intended.

Concerning possible limitations and barriers that arose during qualitative research, the human factor is key in several aspects. Conducting surveys and workshops in remote villages requires the support of local institutions for logistical reasons and for gaining formal and informal permission, as well as taking a sensitive approach to gain acceptance by the local communities under study. Moreover, researchers must seek a just balance between respecting cultural habits that generate issues such as gender–power imbalances and reaching marginalized groups, such as women, youth or indigenous people. This renders the applicability of such research somewhat limited by local circumstances, institutional support and the participative attitude of the investigator. Further difficulties are related to the topography of the terrain, language, the representativity of the sample, time and budget constraints and social desirability bias [69].

The SEPLS workshops were conducted as grassroots focus groups and took place locally. The scores assessed in the workshop should be considered to represent a brief summary of the discussion, paired with a key point or 'thought unit' [38]. The crux of these assessments thus lies within the discussion round.

These findings show that for increasing resilience for sustainable development, a 'one-size-fits-all' approach is inadequate. Regional differences in climatic and agricultural disturbances should be recognized and integrated in differentiated local policy strategies, based on frameworks such as that of Adger [51]. A focus on 'resilience' also requires a focus on vulnerability [51]. This challenges us to incorporate governance research on the mechanisms that mediate vulnerability and promote adaptive action and resilience.

5. Conclusions

The objective of this study was to contribute to the better understanding and assessment of social–ecological resilience with regard to development in Burundi, considering the perspectives of local experts and stakeholders, as well as local communities. Social–ecological resilience of rural communities in a mosaic production landscape, as in Burundi, can be seen as a rallying concept, intrinsically linked to other domains of investigation such as the assessment of ecosystem services, resilience to climate change, and socio-economic resilience linked to poverty and livelihoods or, more generally, to the Sustainable Development Goals. Issues that undermine the adaptive capacity of rural communities in Burundi are generally linked to the poverty trap and related factors (i.e., education, skills, resources), as well as governance and management issues. Poverty prevents communities from adapting adequately to the factors identified in this study, such as climate change or crop, animal

and human disease. Weak governance and management may prevent communities from taking correct decisions about resource allocation at the bio-physical (e.g., which seeds, which crop rotation, which irrigation techniques, which manure, etc.), the spatial (e.g., which region, which 'colline' or administrative unit), and societal (e.g., which sectors, village, which age, gender, household, etc.) levels. While the multi-stakeholder participatory workshop demonstrated that local civil society and experts are well aware of key challenges and potential solutions for enhancing the resilience of social–ecological systems, the statements remain relatively strategic, generic and often vague, limiting their inferential power. In contrast, applying the SEPLS toolkit at the level of villages in the 'collines'—through a survey and community workshops—yielded more concrete, operational and quantitative data on context-specific resilience strategies. These locally tailored insights proved valuable for identifying how communities can better withstand shocks from climate change, pests and other stressors, while addressing region-specific risks of deepening poverty. This study considered the concept of resilience along a continuum, ranging from a relatively abstract connecting concept useful for initiating dialog to a more grounded, indicator-based assessment, using a set of about 20 indicators (SEPLS-toolkit) in rural communities in the hills ('collines') of Burundi, considering climate change, poverty, disease and pests. For policymakers, this study emphasizes the need for economic diversification and ecosystem governance; for NGOs and other actors aiming to enable international cooperation, it highlights the usefulness and logistical limitations of the SEPLS toolkit when adapted to local contexts; and for researchers, it recommends comparing participatory methodologies with the inclusion of territorial resilience approaches.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/land14122301/s1. Table S1. Best practices and challenges for the nexus 'rights-governance-knowledge', as discussed by three focus groups during the multi-stakeholder workshop. Black = group 1/Blue = group 2/Green = group 3. Table S2. Best practices and challenges for the nexus 'Access to ecosystem services- conservation-restoration', as discussed by three focus groups during the multi-stakeholder workshop. Black = group 1/Blue = group 2/Green = group 3.

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