Open Access Library Journal
2026, Volume 13, e14696
ISSN Online: 2333-9721
ISSN Print: 2333-9705

Farmers' Perceptions of the Impact of Rice Cultivation on the Environment in the Sudano-Sahelian Zone

Benoît Maralossou[1*], Hyacinthe Angoni[1], Celestin Dabandata[1], Nentcherse Mbere[2], Hebri Sanda[1], Albert Menkamla Tchopwe[1], Joseph Messi Effa[1], Tchobsala[3]

[1]Department of Plant Biology and Physiology, University of Yaoundé 1, Yaoundé, Cameroon
[2]Department of Biological Sciences, University of Ngaoundéré, Ngaoundéré, Cameroon
[3]Department of Biological Sciences, University of Maroua, Maroua, Cameroon
Email: *maralossoubenoit57@gmail.com

How to cite this paper: Maralossou, B., Angoni, H., Dabandata, C., Mbere, N., Hebri, S., Tchopwe, A.M., Effa, J.M. and Tchobsala (2026) Farmers' Perceptions of the Impact of Rice Cultivation on the Environment in the Sudano-Sahelian Zone. *Open Access Library Journal*, **13**: e14696.
https://doi.org/10.4236/oalib.1114696

Received: December 2, 2025
Accepted: January 17, 2026
Published: January 20, 2026

Abstract

Rice is a staple food in the Sudano-Sahelian zone of Cameroon, but its production is associated with significant environmental challenges. This study assessed farmers' perceptions of these impacts and the key agricultural practices contributing to degradation. Data were collected between August 31 and October 7, 2023, in the Yagoua and Lagdo rice basins, using interviews with 589 rice farmers. Results indicate a strong preference for sandy-clay soil (79.28% ± 2.50) and reveal predominant practices including mechanical plowing (54.99% ± 29.14), indirect seeding (94.84% ± 2.04), and heavy reliance on chemical fertilizers (83.59% ± 0.31) and pesticides (76.10% ± 0.18). Farmers widely perceive these methods and the expansion of rice fields (89.74% ± 2.21) as driving environmental decline, notably soil degradation (95.26% ± 0.77), deforestation (94.41% ± 0.77), and biodiversity loss (94.13% ± 0.36). This degradation is directly linked to declining soil fertility (71.15% ± 5.05) and reduced rice productivity (72.57% ± 7.32), which farmers identify as a major contributor to food insecurity (98.16% ± 0.70). The study concludes that current rice cultivation practices in the region are unsustainable, creating a critical conflict between food security and environmental integrity. There is an urgent need for integrated approaches that promote sustainable land management, reduce chemical inputs, and mitigate the adverse environmental effects of rice farming.

Subject Areas

Ecology, Agrosystem

Keywords

Rice Cultivation, Environmental Impact, Sustainability, Farmer Perceptions, Sudano-Sahelian Zone, Cameroon

1. Introduction

Rice (*Oryza sativa*) is one of the world's most vital cereal crops. It serves as a primary staple food for over half of the global population. For billions of people, particularly in developing nations, it is a fundamental source of calories and livelihoods [1] [2]. In Cameroon, its significance is profoundly felt in the Sudano-Sahelian zone. Here, rice has become a cornerstone of dietary regimes for both rural and urban populations. It plays an indispensable role in the food security strategy of the region's most vulnerable communities [3].

[4] Recognizing this critical importance, the Cameroonian state has actively promoted the expansion and intensification of rice cultivation since the late 20th century. This has been done through the establishment of large-scale development schemes. The most notable examples are the Société d'Expansion et de Modernisation de la Riziculture de Yagoua (SEMRY) and the Lagdo Hydro-Agricultural Project (PHAL) [5]. These initiatives were fundamentally designed to achieve national self-sufficiency. They also aimed to alleviate pervasive food insecurity and curb the financial burden of rice imports.

However, this drive for increased production exists within a complex and often fragile socio-ecological context. The global literature unequivocally demonstrates a significant trade-off. The intensification and expansion of agricultural land, including rice fields, are frequently associated with substantial environmental costs [6] [7]. Documented negative impacts range from localized problems to larger-scale consequences. Local issues include soil degradation, water pollution from agro-chemical runoffs, and the emergence of water-borne diseases. Broader consequences involve deforestation, loss of biodiversity, and the transformation of entire landscapes [8]-[10]. While these global patterns are well-established, their specific manifestations are highly context-dependent. They are shaped by local biophysical conditions, historical trajectories, and prevailing farming practices.

A critical gap exists in understanding these dynamics within the specific context of northern Cameroon. Existing studies on Cameroonian rice cultivation have predominantly focused on agronomic productivity, institutional frameworks, or macroeconomic analyses of the value chain. There remains a conspicuous scarcity of comprehensive research. This research would need to systematically investigate the environmental dimensions of this agricultural expansion from the perspective of rice farmers themselves. Farmers are both the primary agents of land transformation and the first witnesses to its consequences.

The perceptions, experiential knowledge, and localized observations of farmers constitute an invaluable, yet underutilized, repository of information. Their insights are crucial for understanding environmental change. They are key to identifying the most pressing local environmental issues and assessing the acceptability of different management practices. Ultimately, they are essential for designing sustainable intensification strategies. These strategies must be ecologically sound, socially legitimate, and practically feasible.

This study, therefore, seeks to fill this salient research gap. It places farmers' perceptions at the very center of its analytical framework. We posit that a deep, nuanced understanding of local realities is a prerequisite for any successful intervention. Such interventions must aim to mitigate the environmental footprint of rice cultivation. The principal innovation of this research lies in its integrative, bottom-up approach. It quantitatively and qualitatively captures the views of nearly 600 rice farmers across the two major production basins of Yagoua and Lagdo. It moves beyond a purely technocratic assessment of environmental impacts. Instead, it foregrounds the lived experiences and cognizant interpretations of the local actors.

Consequently, this research is guided by the following specific objectives: (i) to document and characterize the predominant rice farming practices in the Sudano-Sahelian zone of Cameroon, from land preparation to harvesting; (ii) to assess, through the lens of farmer perceptions, the levels and primary causes of degradation in rice field ecosystems; (iii) to analyze farmers' understanding of the importance of rice cultivation and their observations regarding its spatial expansion over the past decade; (iv) to establish and quantify the perceived causal linkages between rice cultivation activities and a spectrum of environmental and socio-health impacts, such as deforestation and disease proliferation.

By bridging the gap between global environmental concerns and localized knowledge, this study aims to generate a robust, evidence-based foundation. The findings are expected to provide critical insights. These insights will aid policymakers, development practitioners, and researchers. They strive to reconcile the imperative of food security with the urgent need for environmental sustainability in Cameroon's Sudano-Sahelian region.

2. Material and Methods

2.1. Description of Study Sites

This research was conducted within the two principal irrigated rice-growing perimeters of Cameroon's Sudano-Sahelian zone: the Yagoua zone, managed by the Société d'Expansion et de Modernisation de la Riziculture de Yagoua (SEMRY) in the Far North Region, and the Lagdo zone, developed under the Projet Hydro-Agricole de Lagdo (PHAL) in the North Region (**Figure 1**). These sites were strategically selected for this investigation due to their paramount importance in the national rice production landscape, collectively representing the most extensive and historically significant areas of irrigated rice cultivation in the country [4] [11].

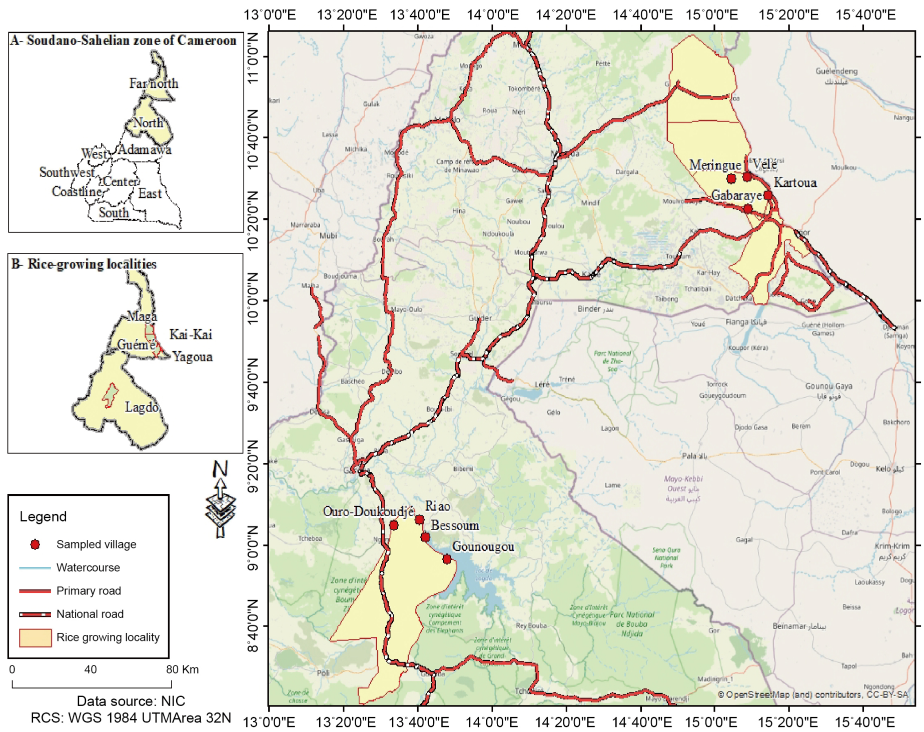

Figure 1. Location map (Maralossou).

The Yagoua rice perimeter is situated in the Mayo-Danay Division, with its geographical coordinates spanning between 10˚0'0" and 11˚0'0" North latitude and 14˚40'0" and 15˚20'0" East longitude. This area is strategically positioned within a transboundary context, bordered to the north by the Logone and Chari Division, to the west by Mayo-Kani, to the east by the Republic of Chad, and to the south by the communes of Gobo, Guéré, and Wina [12]. Its location places it at the heart of a complex hydrological and agricultural system.

Conversely, the Lagdo rice perimeter is located in the Bénoué Division, extending between 8˚40'0" and 9˚20'0" North latitude and 13˚0'0" and 14˚60'0" East longitude. This irrigated scheme is enclosed by a constellation of municipalities, sharing its northern and western boundaries with Ngong and Bibémi, its southern limits with Tcholliré and Poli, and its eastern frontier with Rey Bouba and Bibémi [13]. The presence of the Lagdo dam on the Bénoué River is a critical feature of this site, providing the essential water resources that underpin its hydro-agricultural operations.

2.2. Sampling Device

2.2.1. Determining the Optimal Sample size

To establish a statistically representative sample for this study, the sample size was calculated a priori using the standard formula for estimating a population proportion with a specified confidence level and margin of error [14] [15]. This calculation is essential for ensuring the precision of the survey findings and the validity of generalizations drawn from the sample. The formula is applied as follows:

$$n = \frac{t^2 * p(1-p)}{e^2}$$

The variables are defined as: **n**: The minimum sample size required; **t**: The z-value for the desired confidence level (1.96 for a 95% confidence level); **p**: The estimated prevalence of the characteristic of interest within the population. A proportion (p) of 0.5 was selected, as this maximizes the sample size and provides the most conservative estimate in the absence of previous studies; **e**: The desired margin of error (precision), set at ±5% (0.05).

The application of Schwartz's formula (1995) with a 95% confidence level (t = 1.96) and a 5% margin of error (e = 0.05) yielded specific sample sizes for each study site. The calculation incorporated the known proportion (p) of rice farmers relative to the total agricultural workforce in each area, which was 0.1894 for Lagdo and 0.3582 for Yagoua. This resulted in minimum sample sizes of 236 and 353 farmers for Lagdo and Yagoua, respectively, leading to a total sample of N = 589.

To ensure the data's relevance and quality, a purposive sampling strategy was employed. This "reasoned choice" technique involved deliberately selecting participants who were active rice farmers with substantial practical experience, thereby ensuring that the respondents possessed the direct knowledge necessary to inform the study's objectives [16].

2.2.2. Choice of Study Villages

The survey respondents were strategically selected from six villages that serve as major hubs for irrigated rice production within the Lagdo and Yagoua perimeters. As presented in Table 1, the sample distribution reflected the relative scale of rice cultivation in each locality. In total, 40.07% of respondents (n = 236) were surveyed across three villages in the Lagdo zone: Gounougou (13.24%), Ouro Doukoudje (14.09%), and Bessoum (12.73%). The remaining 59.93% (n = 353) were surveyed in the Yagoua zone, specifically in the villages of Vele (20.20%), Kartoua (21.05%), and Gabaraye Widi (18.68%).

Table 1. Survey methodology.

Localities	Villages	Number of respondents	Frequency of respondents by village (%)	Frequency of respondents by locality (%)
Lagdo	Gounougou	78	13.24	40.07
	Ouro doukoudje	83	14.09	
	Bessoum	75	12.73	
Yagoua	Vele	119	20.20	59.93
	Kartoua	124	21.05	
	Gabaraye-Widi	110	18.68	
Total		589	100	100

To ensure the data reflected a multi-tiered understanding of the rice production system, a diverse cohort of stakeholders was purposively selected for interviews. The participant pool comprised not only active rice farmers but also key institutional actors. This included agricultural production managers, presidents of Water User Associations (AUE), management staff from SEMRY and PHAL, and technical representatives from pertinent government ministries (MINADER, MINEE, MINEPDED, MINFOF, MINSANTE). This methodological approach, which integrates grassroots and institutional perspectives, is well-supported in the literature [17] [18].

2.3. Data Collection

A mixed-methods approach centered on field surveys was employed to assess the environmental impact of rice farming in the Sudano-Sahelian zone. Primary data were collected through a combination of semi-structured and structured interviews, facilitated by a comprehensive questionnaire specifically designed for this study. The instrument incorporated a blend of closed-ended (yes/no), open-ended, and multiple-choice (guided) questions to capture both quantitative data and nuanced qualitative perspectives [19].

The questionnaire was organized into four thematic sections: rice farming practices, levels of rice field degradation, importance and expansion of rice cultivation, and adverse environmental effects.

Rice farming practices

Documenting production methods (suitable soil types, plot cleaning, plowing techniques, rice varieties, sowing types) and maintenance practices (fertilization, weed, pest, and disease control, and harvesting methods).

Levels of rice field degradation

Investigating causes of soil degradation and water pollution, tracking changes in soil fertility, input usage on 0.5-hectare plots, and yields over the past decade, and documenting the consequences of productivity decline.

Importance and expansion of rice cultivation

Examining the socio-economic role of rice and historical changes in land use since the development of the irrigation perimeters.

Adverse environmental effects

Identifying the perceived negative impacts of rice cultivation on the local ecosystem.

To triangulate and validate the self-reported data, post-interview field visits and direct observations were conducted in the rice fields of both Lagdo (PHAL) and Yagoua (SEMRY).

2.4. Statistical Analysis of Data

All collected data were systematically entered into a Microsoft Excel 2016 spreadsheet for initial management, descriptive analysis, and the creation of preliminary graphs and tables. To identify statistically significant differences, the data were subjected to Analysis of Variance (ANOVA) followed by Duncan's test for post-hoc comparisons, using Statigraphics Centurion 5.0 software. This analysis facilitated comparisons across the two study locations (Lagdo and Yagoua) and among the various agricultural practices and perceptions.

The results are presented through a combination of summary tables and figures. Frequency tables were constructed to display the modalities of key categorical variables, including rice production techniques, field maintenance practices, causes of soil degradation, and the perceived environmental effects. Conversely, graphical representations were employed to illustrate trends in rice-growing areas, the socio-economic importance of rice cultivation, and farmers' awareness of its environmental impacts.

3. Results

3.1. Rice Cultivation Practices

Rice cultivation is carried out on suitable soil and through practices such as preparing plots, tilling the soil, choosing varieties and maintaining rice paddies.

3.1.1. Soil Appropriate for Rice Cultivation

An analysis of rice production methods in the study area identified several key variables, detailed in Table 2. Farmer responses indicated a strong preference for clay-sandy soil, which was reported as the most suitable type for cultivation by 79.28% ± 2.50 of respondents.

Table 2. Rice production process.

Variables	Modalities	Lagdo	Yagoua	Mean ± Standard deviation	p-value
Soil types suitable for rice cultivation	Clay	4.66	9.63	7.15 ± 2.49	
	Sandy	3.39	3.12	3.25 ± 0.14	2.525E−06
	Loam	2.54	1.42	1.98 ± 0.56	
	Clay-loam	7.20	10.48	8.84 ± 1.64	
	Clay-sandy	81.78	76.77	79.28 ± 2.50	
Plot cleaning	Land clearing	24.15	22.95	23.55 ± 0.60	
	Burning	8.05	8.50	8.27 ± 0.22	
	Land clearing and burning	39.41	58.07	48.74 ± 9.33	0.04384829
	Clearing and depositing of residues on the dikes	27.97	10.48	19.22 ± 8.74	
Field tillage technique	Tractor	25.85	84.14	54.99±29.14	
	Hoe	58.90	8.22	33.56±25.34	0.48077893
	Animal	15.25	7.65	11.45 ± 3.80	
Varieties of cultivated rice	IR46	53.39	53.54	53.47 ± 0.08	
	Tox	8.90	10.20	9.55 ± 0.65	3.0162E-05
	Nerica	37.71	36.26	36.99 ± 0.73	
Type of sowing	Direct seeding	7.20	3.12	5.16 ± 2.04	
	Indirect seeding	92.80	96.88	94.84 ± 2.04	0.00103695

3.1.2. Land Preparation and Tillage

The initial preparation of plots is dominated by the practice of clearing and burning rice residues and weeds (48.74% ± 9.33). This is followed by clearing alone (23.55% ± 0.60), clearing and depositing residues on dykes (19.22% ± 8.74), and burning alone (8.27% ± 0.22). Subsequent tillage is primarily achieved through mechanical ploughing (54.99% ± 29.14), while hand hoeing (33.56% ± 25.34) and animal-drawn ploughing (11.45% ± 3.80) are also employed (Table 2).

3.1.3. Crop varieties and Establishment

Rice farmers cultivate several varieties, with IR46 (53.47% ± 0.08) and Nerica (36.99% ± 0.73) being the most widespread. The Tox variety accounts for a smaller portion of cultivated area (9.55% ± 0.65). For crop establishment, indirect sowing is the overwhelmingly dominant method (94.84% ± 2.04), while direct sowing is practiced minimally (5.16% ± 2.04) (Table 2).

3.1.4. Cleaning of Rice Fields and the Contribution of Bunds

Rice field management is characterized by manual practices, including the clearing of weeds and the construction of water-retaining embankments, often reinforced with the cleared biomass itself (Figure 2). While this approach reduces the need for chemical herbicides—promoting aquatic biodiversity and reducing pollution—it also entails considerable occupational hazards. Farmers are directly exposed to humid, hot conditions and are at heightened risk of contracting waterborne diseases and other pathogen-related illnesses.

Figure 2. Cleaning rice fields.

3.1.5. Rice Field Maintenance

Rice field maintenance relies heavily on manual labor and chemical inputs, according to the data. The vast majority of farmers (96.82%) harvest their crops by hand. For fertilization, chemical fertilizers are dominant (83.59%), with organic options used by a minority (16.41%). Pest and disease control is primarily achieved through chemical means (76.10%), while manual weeding is the most common method for weed control (60.04%). Although chemical weeding is practiced, it is most often used in combination with manual methods (27.65%) rather than alone (Table 3).

Table 3. Field maintenance practices (%).

Variables	Modalities	Lagdo	Yagoua	Mean ± Standard deviation	p-value
rice fertilization	Chemical fertilizer	83.90	83.29	83.59 ± 0.31	4.1512E−05
	Organic fertilizer	16.10	16.71	16.41 ± 0.31	
methods of weed control	Spray	6.36	6.52	6.44 ± 0.08	4.7859E−06
	Weed control	58.90	61.19	60.04 ± 1.15	
	Labour	7.20	4.53	5.87 ± 1.34	
	Spraying and Weed Control	27.54	27.76	27.65 ± 0.11	
farming practices to limit pests and diseases	Biological control	8.05	7.37	7.71 ± 0.34	5.0704E−08
	Chemical control	76.27	75.92	76.10 ± 0.18	
	Resistant varieties	11.86	11.61	11.74 ± 0.12	
	Crop rotation	3.81	5.10	4.46 ± 0.64	
field harvesting technique	Manual	97.03	96.60	96.82 ± 0.22	1.0709E−05
	Mechanical	2.97	3.40	3.18 ± 0.22	

3.2. Degradation of Rice Fields

3.2.1. Causes of Soil Degradation and Water Pollution

Data analysis from Lagdo and Yagoua reveals a high level of community awareness regarding environmental issues in rice cultivation, with several significant causes of soil degradation and water pollution identified. Statistical analysis indicates a non-significant difference between the two localities ($p = 0.64$) but a very significant difference among the perceived causes ($p = 0.0089$), reflecting variation in their prevalence and impact (Table 4).

Table 4. Causes of soil degradation and water pollution (%).

Causes of soil degradation	Lagdo	Yagoua	Mean ± Standard deviation	p-value
Fertilizer	83.47	87.54	85.50 ± 2.03	
Flood	86.02	90.08	88.05 ± 2.03	
Erosion	83.90	78.19	81.04 ± 2.86	
Overexploitation of rice paddies	87.29	88.39	87.84 ± 0.55	0.0089
Deforestation	89.83	92.35	91.09 ± 1.26	
Poor water management	91.53	90.93	91.23 ± 0.30	
Pesticides	94.49	98.30	96.40 ± 1.90	
p-value	0.64			

The primary cause, identified by 96.40% of respondents, was the excessive and often uncontrolled use of pesticides, leading to the contamination of soils, groundwater, and surface waters, thereby threatening aquatic ecosystems and human health. This was closely followed by poor water management (91.23%) and deforestation (91.09%). Poor water management, through inefficient irrigation and the return of agrichemical-laden water, promotes salinization and biological degradation. Deforestation, driven by agricultural expansion, exacerbates soil erosion and diminishes water retention capacity.

Other major factors include flooding (88.05%), attributed to unsuitable cultivation practices which leach nutrients and disperse pollutants; overexploitation of rice fields (87.84%), resulting from a lack of fallow or crop rotation that depletes soil fertility; and the use of chemical fertilizers (85.50%), a key driver of water eutrophication and soil biological disruption. While cited less frequently (81.04%), soil erosion remains a serious consequential problem.

3.2.2. Level of Degradation of Rice Fields

The assessment of rice field degradation over time reveals a cyclical and self-reinforcing problem (**Table 5**). Data indicate a perceived decline in soil fertility (71.15%), which directly correlates with lower rice productivity (72.57%). This degradation is attributed to practices such as monoculture and the excessive use of chemical inputs. Paradoxically, in an effort to counteract diminishing yields, a majority of farmers (86.36%) report further increasing their application of chemical fertilizers and pesticides. This strategy appears to be counterproductive, as yields continue to decline despite the intensified chemical use, suggesting a state of advanced soil degradation where additional inputs are no longer effective.

Table 5. Level of degradation of rice fields (%).

Variable	Modality	Lagdo	Yagoua	Mean ± Standard deviations	p-value
Fertility	Increase	13.56	9.92	11.74 ± 1.82	0.002385
	Stable	20.34	13.88	17.11 ± 3.23	
	Drop	66.10	76.20	71.15 ± 5.05	
Quantity of chemical inputs	Increase	82.63	90.08	86.36 ± 3.73	0.000367
	Stable	9.75	7.37	8.56 ± 1.19	
	Drop	7.63	2.55	5.09 ± 2.54	
Rice yield	Increase	6.36	6.52	6.44 ± 0.08	0.00929
	Stable	28.81	13.60	21.21 ± 7.61	
	Drop	65.25	79.89	72.57 ± 7.32	

3.2.3. Consequences of the Decline in Rice Productivity

The decline in rice productivity in Cameroon's Sudano-Sahelian zone triggers a cascade of severe socio-economic and environmental consequences (**Table 6**). Survey results reveal a hierarchy of significant impacts (P = 0.01), led by near-universal food insecurity (98.16%) and rising local market prices (97.81%). This economic shock manifests in substantial income loss for farmers and traders (93.35%), which in turn drives profound social disruptions, including increased rural exodus (92.86%) and the under-enrolment of children in school (91.44%).

At a macro level, the productivity shortfall has led to increased reliance on rice imports (84.16%) and exerted pressure on other ecosystems (84.09%). No significant difference was observed between localities (p = 0.49), indicating these challenges are consistent across the study region.

Table 6. Consequences of the decline in rice productivity (%)

Terms and conditions	Lagdo	Yagoua	Mean ± Standard deviation	p-value
Loss of income	91.53	95.18	93.35 ± 1.83	
Increase in imports	83.90	84.42	84.16 ± 0.26	
Under-education	91.95	90.93	91.44 ± 0.51	
Food insecurity	97.46	98.87	98.16 ± 0.70	0.011
Rural exodus	92.80	92.92	92.86 ± 0.06	
Price increase	97.03	98.58	97.81 ± 0.77	
Pressure on other ecosystems	79.24	88.95	84.09 ± 4.86	
P-value		0.49		

3.3. Importance and Expansion of Rice Farming

3.3.1. Importance of Rice Farming

Rice cultivation in the region serves a predominantly dual-purpose function, with the vast majority of farmers (74.19%) producing for both self-consumption and market sale (**Figure 3**). A smaller segment focuses exclusively on subsistence (23.76%), while a minimal proportion (2.05%) are purely market-oriented. This pattern is statistically significant (p = 1.44E−05), confirming that the mixed subsistence-commercial model is the dominant mode of production. Beyond grain production, the crop is integral to the local livelihood system; rice straw is used as a construction material, and rice husks are repurposed as livestock feed, particularly for pigs and ducks.

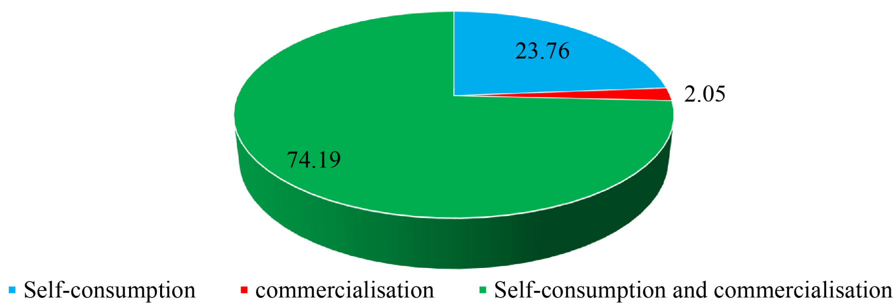

Figure 3. Importance of rice cultivation.

3.3.2. Changes in Rice-Growing Areas

Survey data demonstrate a predominant increase in the area used for rice cultivation, reported by 89.74% (±2.21) of farmers. A small minority reported stable (6.72% ± 2.06) or decreasing (3.54% ± 0.15) areas (**Figure 4**). The difference between these trends is statistically very significant (p = 8.3386E−05). Respondents identified the expansion strategies of rice companies, motivated by goals of enhancing food security and reducing imports, as a key driver. A major documented consequence of this expansion is deforestation, which raises concerns about associated biodiversity loss and soil degradation in rice-growing areas.

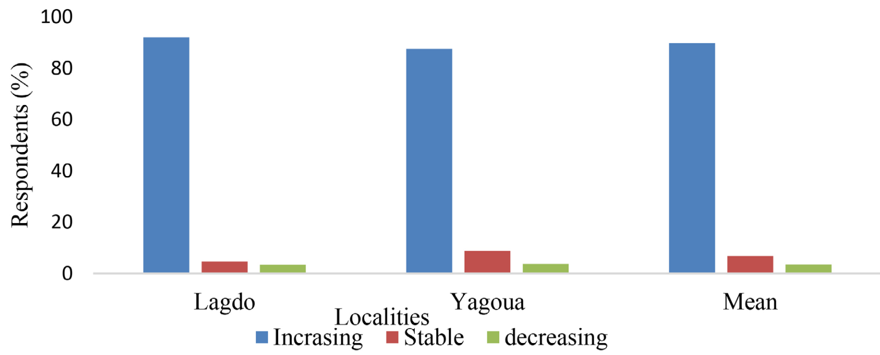

Figure 4. Increase in rice-growing areas over the last decade.

3.4. Effects of Rice Field Degradation

3.4.1. Rice Farmers' Knowledge of the Effects of Rice Cultivation

Survey results reveal a high level of local awareness (93.28%) regarding the negative environmental consequences of expanding rice farming (Figure 5). This perception is substantiated by local ecological knowledge; farmers consistently report the disappearance of numerous animal and plant species following the establishment of large-scale agricultural developments, namely SEMRY and the Lagdo Hydro-Agricultural Project. The primary cause identified for this biodiversity decline is the widespread clearance of natural vegetation.

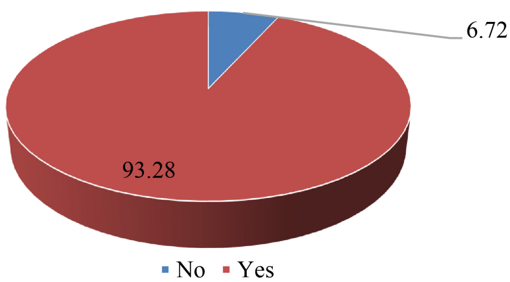

Figure 5. Rice farmers' knowledge of the effects of rice cultivation.

3.4.2. Analysis of the Adverse Effects of Rice Cultivation

The perceived environmental and socio-economic impacts of rice cultivation, as reported by farmers, are presented in Table 7. The data reveal a strong consensus on several severe negative effects. Over 90% of respondents identified soil degradation (95.26% ± 0.77), deforestation (94.41% ± 0.77), loss of biodiversity (94.13% ± 0.36), and the conversion of traditional sorghum, millet, and grazing lands (92.86% ± 0.91) as the most significant consequences. This indicates intense pressure on natural resources and a fundamental transformation of traditional agro-ecosystems.

Furthermore, a high prevalence of respondents linked rice farming to public health and climate concerns, including an increased incidence of diseases like malaria and bilharzia (91.16% ± 0.79), perceived climate variation (91.09% ± 0.41), and the proliferation of mosquitoes and mollusks (90.03% ± 1.47). A suite of other significant, though moderately perceived, impacts were also reported, including flooding (84.73% ± 0.83), water and air pollution (82.39% ± 0.61), and the eutrophication of aquatic ecosystems (80.55% ± 0.38). Indicators such as the loss of agricultural land (77.23% ± 0.11) and the proliferation of weeds (77.08% ± 1.73) further illustrate the degradation of agricultural systems.

Statistical analysis confirms that these perceptions are consistent across the two study localities ($p = 0.90$), indicating a region-wide concern. However, the highly significant difference between the perceived intensities of the various effects ($p = 2.4E-7$) underscores that rice cultivation generates a suite of multiple, distinct harmful effects, rather than a single uniform impact. The effect with the greatest regional variability was excessive water use (64.56% ± 5.35), suggesting location-specific water management challenges.

Table 7. Adverse effects of rice cultivation (%).

Effects	Lagdo	Yagoua	Mean ± Standard deviation	p-value
Soil degradation	94.49	96.03	95.26 ± 0.77	
Proliferation of mosquitoes and mollusks	88.56	91.50	90.03 ± 1.47	
Deforestation	93.64	95.18	94.41 ± 0.77	
Loss of biodiversity	94.49	93.77	94.13 ± 0.36	
Flood	83.90	85.55	84.73 ± 0.83	
Diseases	91.95	90.37	91.16 ± 0.79	
Eutrophication of aquatic species	80.93	80.17	80.55 ± 0.38	2.4E−7
Water and air pollution	81.78	83.00	82.39 ± 0.61	
Climate variation	90.68	91.50	91.09 ± 0.41	
Appearance of weeds	78.81	75.35	77.08 ± 1.73	
loss of agricultural land	77.12	77.34	77.23 ± 0.11	
Excessive water use	69.92	59.21	64.56 ± 5.35	
Transformation of sorghum fields	91.95	93.77	92.86 ± 0.91	
p-value		0.90.		

3.4.3. Anthropogenic Flooding and Its Socio-Environmental Consequences

Field observations document significant flooding in the residential Waidoua neighbourhood of Gabaraye-widi village, impacting the public school, a community borehole, and multiple residences (Figure 6). This partial submersion, characterized by prolonged water stagnation, is indicative of mismanaged water from adjacent rice cultivation. The functionality of the school is critically compromised; local reports indicate that the academic year now consistently starts late—postponed until late October or early November—due to the inundation of the school grounds.

The flooding is attributed to excess water escaping from nearby rice fields, a consequence of poorly maintained or obstructed irrigation canals. This has led to the inundation of areas not designated for flooding, resulting in material damage to infrastructure and creating a significant public health hazard. The stagnant water serves as a breeding ground for disease vectors, increasing the risk of waterborne illnesses and mosquito-borne diseases like malaria.

Beyond the immediate socio-economic impacts, this situation exacerbates environmental degradation, contributing to soil erosion, contamination of water resources, and a loss of local biodiversity. This case underscores the critical spillover effects of inadequate water management in agricultural zones, directly impacting community health, education, and local ecosystems.

Figure 6. Flooding of a residential area in the Waidoua neighbourhood (Vele).

3.4.4. Direct Socio-Environmental Impacts on a Residential Community

As illustrated in Figure 7, the consequences of poor water management extend directly into the daily lives of residents in Gabaraye-Widi. The visual evidence captures the heightened vulnerability of the community, showing women and children collecting water from a borehole amidst flooded surroundings. This flooding, originating from overflowing rice paddies, has inundated homes and compromised sanitation facilities, including those at the Waidoua public school.

This constant exposure to stagnant water creates a significant public health crisis, placing families at a high risk of contracting waterborne diseases such as diarrhoea, cholera, and typhoid, as well as vector-borne illnesses including malaria and bilharzia. Consequently, the population is forced to navigate and reside in persistently unsanitary and hazardous conditions.

This case exemplifies the tangible conflict arising from the coexistence of intensive agriculture and residential areas. The competition for land and water, coupled with the externalities of flooding and unsanitary conditions, creates socio-economic tension and leads to the seasonal loss of habitable land, underscoring the urgent need for integrated land-use planning and improved water governance.

Figure 7. Exposure of residents to health risks.

3.4.5. Infrastructure Neglect and Its Consequences

Figure 8 illustrates the primary irrigation and drainage canals, which are critical infrastructure for regulating water flow within the rice cultivation scheme. Their intended functions are to deliver water to the paddies and efficiently remove excess water to prevent waterlogging, plant rot, and flooding. However, field observations reveal that these canals are heavily colonized by aquatic vegetation, including species such as *Nymphaea lotus*, *Nymphaea micrantha*, *Pistia stratiote*, *Ipomoea carnea*, and *Oryza latifolia*. This proliferation, combined with an apparent lack of regular dredging, significantly impedes the hydraulic capacity of the channels. The consequent restriction of normal water flow leads to canal overflows, which are a direct cause of the flooding observed in adjacent areas. This malfunction not only damages crop through submergence and nutrient leaching but also triggers secondary environmental impacts, including erosion and the further spread of invasive species.

(a) (b)

Figure 8. Main channels: drainage channel (a) and irrigation channel (b) of SEMRY.

4. Discussion

This study provides a rigorous empirical assessment of rice farming practices and their perceived environmental impacts in Cameroon's Sudano-Sahelian zone. Our results depict an agricultural landscape where the imperatives of food security directly conflict with environmental sustainability [8]. The predominance of intensive practices, coupled with continued land expansion, is generating unsustainable pressure on local ecosystems.

Farming Practices: Between Intensification and Input Dependency

The marked preference for sandy-clay soils and mechanical plowing indicates a partial modernization of rice cultivation. However, this modernization remains incomplete. It translates into an overwhelming dependency on chemical inputs. The massive use of chemical fertilizers (83.59%) and pesticides (76.10%) to maintain productivity is a clear indicator of declining soil fertility [9]. This dependency creates a vicious cycle. The decline in natural fertility (perceived by 71.15% of farmers) drives increased chemical application (reported by 86.36% of producers). This, in turn, exacerbates soil degradation and water pollution, as strongly evidenced by the perception of pesticides as a major cause of pollution (96.40%).

Rice Expansion and Institutional Roles: A Primary Driver of Degradation

Our study identifies the continuous expansion of cultivated areas as the main driver of environmental decline. The state's drive to increase production clashes with the ecological limits of the zone. Land conversion, identified by farmers as a major cause of deforestation (94.41%) and biodiversity loss (94.13%), represents a net loss of ecosystem services [8]. Critically, the role of large-scale development schemes like SEMRY and PHAL extends beyond promoting expansion. Their responsibility for maintaining critical irrigation and drainage infrastructure is paramount. Our field observations link the neglect of this infrastructure—evidenced by silted and vegetation-choked canals—directly to the anthropogenic flooding and public health crises documented in residential areas. This highlights a failure in water governance and infrastructure maintenance that turns agricultural externalities into community hazards.

Cascading Impacts: From Public Health to Land-Use Conflicts

The impacts extend beyond landscape ecology. They generate critical negative externalities on public health and social cohesion. The high prevalence of diseases like malaria and bilharzia (91.16%) is directly linked to the proliferation of mosquitoes and mollusks (90.03%) in stagnant water. This illustrates the hidden health cost of this production model. The documented flooding of community infrastructures due to poor canal maintenance reveals acute conflicts of use between agriculture and domestic needs. Populations are forced to live in unsanitary conditions, and access to education is compromised.

Implications for a Transition Towards Sustainability

The findings argue for a paradigm shift in policy. The current strategy of horizontal expansion and chemical intensification is reaching its limits. It generates counterproductive environmental and social costs. The priority should now be the sustainable intensification of existing land [20] [21]. In this context, sustainable intensification is defined as increasing productivity on current farmland while reducing environmental harm through practices like integrated pest management, soil conservation, and efficient water use.

This implies a strategic shift towards three interconnected pillars of intervention. First, promoting agroecological practices is essential. This includes reintegrating fallow periods, implementing crop rotation, and using organic fertilizers to restore soil health and break the cycle of dependency on synthetic inputs. Second, implementing robust Integrated Water Resources Management is critical. The rehabilitation and regular maintenance of irrigation and drainage canals must be a non-negotiable prerequisite. This is vital for preventing the flooding and public health crises currently observed. Third, systematically strengthening farmer capacity through targeted training is needed. Programs should focus on integrated pest management, soil fertility conservation, and the safer use of chemical products.

Finally, while farmers' perceptions provide an indispensable and alarming source of information, we acknowledge that this study is based on subjective data. Future research should seek to validate these perceptions with empirical biophysical measurements of soil health, water quality, and biodiversity.

This research demonstrates that farmers' perceptions provide a crucial warning about the unsustainable trajectory of rice cultivation. Ignoring these signals risks compromising the long-term viability of the very resources—soil, water, and biodiversity—upon which the sought-after food security depends.

5. Conclusion

This study underscores the critical imperative for a strategic transition in the Sudano-Sahelian zone of Cameroon, moving beyond the current paradigm of chemical-intensive expansion towards a model of sustainable intensification. To operationalize this shift, we propose targeted interventions including the promotion of integrated agroecological packages (e.g., rice-legume rotations, biofertilizers), the establishment of collaboratively-funded hydraulic infrastructure maintenance programs, and the development of local bio-input supply chains. Concurrently, future research must prioritize *in situ* evaluation of these practices' efficacy and profitability, critical analysis of irrigation governance structures to dismantle institutional barriers, and dedicated investigation into climate-resilient adaptations, particularly concerning drought-tolerant varieties and emerging pest dynamics. Ultimately, ensuring the long-term viability of rice cultivation in this vulnerable region demands a systemic policy approach that holistically balances and integrates ecological integrity with social equity and economic resilience.

Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] FAO (2011) Riz et changement climatique. OXFAM-Magasins du Monde, 12 p.

[2] Max, Z. (2018) Le réchauffement du climat pourrait réduire la valeur nutritionnelle du riz. United Nations, 6 p.

[3] Folefack, D. (2014) Booster la production locale du riz pour le renforcement de la sécurité alimentaire au Nord Cameroun. *Journal of Applied Biosciences*, **82**, 7449-7459. https://doi.org/10.4314/jab.v82i1.5

[4] Medere, N.T.M. (2023) Production rizicole et impacts socio-économiques à Lagdo au Nord Cameroun (1973 à 2020). *Revue Internationale Dônni*, **3**, 57-71.

[5] MINADER (2009) Stratégie nationale de développement de la riziculture au Cameroun. Mouture III de Minader, 21 p.

[6] IPCC (2014) Rapport national sur l'état de l'environnement du Cameroun 2013-2014.

[7] Laurance, W.F., Sayer, J. and Cassman, K.G. (2014) Agricultural Expansion and Its Impacts on Tropical Nature. *Trends in Ecology & Evolution*, **29**, 107-116. https://doi.org/10.1016/j.tree.2013.12.001

[8] Berger, R., Cissé, I., Verlinden, E. and Diakite, M. (2009) Etude d'Impact Environnemental du projet d'aménagement du casier *D* de M'Bewani. Rapport Final, 163 p.

[9] Cissé, I. and Keita, M.S. (2003) Etude d'impacts socio-économique et environnemental des plaines aménagées pour riziculture au Mali. Rapport No. 25 du Groupe de coordination des zones arides, 45 p.

[10] PULCI (2021) Etude d'impact environnemental et social détaillée de la réhabilitation de 12 210 ha de périmètres rizicoles et des ouvrages connexes dans le cadre du projet de valorisation des investissements de la vallée du Logone (VIVA LOGONE). Rapport d'étude, (version finale 3), 129 p.

[11] SEMRY (1989) Proposition pour un plan de redressement de la Société d'expansion et de Modernisation de la Riziculture de Yagoua. Rapport final, 70 p.

[12] Ngamo Africa, B., Konsala, S. and Adamou, I. (2020) Characterization of the Woody Vegetation of Savannah Ecosystems of Mayo-Danay Division in the Sudano-Sahelian Zone of Cameroon. *Journal of Plant Sciences*, **8**, 41-56. https://doi.org/10.11648/j.jps.20200803.11

[13] Banoun, S.P. and Souina, E. (2009) Monographie de la Commune de Lagdo. MINEPAT/Nord, 15 p.

[14] Daniel, W.W. (1999) Biostatistics: A Foundation for Analysis in the Health Sciences. 7th Edition, John Wiley & Sons.

[15] Singh, A.S. and Masuku, M.B. (2014) Sampling Techniques & Determination of Sample Size in Applied Statistics Research: An Overview. *International Journal of Economics, Commerce and Management*, **2**, 1-22.

[16] Abdouraman, Tchobsala, Clautilde, M. and Simon, B. (2022) Spacio-Temporal Dynamic of the Vegetation and Degradation Factors of the Vegetation Cover around Lagdo Lake, North Cameroon. *International Journal of Ecosystems and Ecology Science* (*IJEES*), **12**, 227-234. https://doi.org/10.31407/ijees12.427

[17] Bannister, M.E. and Nair, P.K.R. (2003) Agroforestry Adoption in Haiti: The Importance of Household and Farm Characteristics. *Agroforestry Systems*, **57**, 149-157. https://doi.org/10.1023/a:1023973623247

[18] Mercer, D.E. (2004) Adoption of Agroforestry Innovations in the Tropics: A Review. In: Nair, P.K.R., Rao, M.R. and Buck, L.E., Eds., *New Vistas in Agroforestry*, Springer, 311-328. https://doi.org/10.1007/978-94-017-2424-1_22

[19] Kamlaba, P. and Tchobsala (2024) Vulnerability of Woody Plants in the Agrosystems of the Mandara Mountains, Cameroon. *Journal of Animal & Plant Sciences*, **59**, 10817-10828.

[20] Pretty, J., Toulmin, C. and Williams, S. (2011) Sustainable Intensification in African Agriculture. *International Journal of Agricultural Sustainability*, **9**, 5-24. https://doi.org/10.3763/ijas.2010.0583

[21] The Royal Society (2009) Reaping the Benefits: Science and the Sustainable Intensification of Global Agriculture. The Royal Society.