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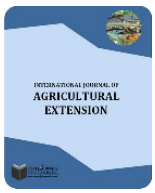

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DETERMINANTS FOR ADOPTING AGRICULTURAL INNOVATIONS BY RICE FARMERS IN THE NORTH WEST REGION OF CAMEROON

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ABSTRACT

The importance of adopting agricultural innovations for farm productivity is well known. However, the rate of adoption is generally sub-optimal. This study investigates the determinants for adopting agricultural innovations by rice farmers in the North West Region of Cameroon. A multi-stage sampling technique was employed to identify and collect data from 800 rice farmers in Ngoketunjia division, the most important rice-producing area in Bamenda Highlands agro-ecological zone in that region of Cameroon. A structured and pretested questionnaire was used to catalogue technologies available to rice farmers and factors that might influence their adoption. Descriptive statistics were used to analyze the adoption of available technologies, and binary logistic regression to identify key determinants for their adoption. Rice farmers adopted eight of the twenty-one technologies identified. The results showed that ten of the thirty-three variables tested in the regression analysis significantly influenced the adoption of innovations by rice farmers. Household size, farm size, level of motivation, number of extension visits, and the ongoing socio-political crisis had statistically significant and positive influence while, type of labour use, qualified personnel or hired labour, innovation institutions, property rights, and social norms affected innovations adoption negatively. Based on these results, it has been recommended that major rice-producing institutions in the study area should consolidate the positive drivers while addressing the negative ones. Given that the regression model explained less than 50% of the factors influencing technology adoption in the area, future research should expand the list of independent variables so that generated results could be of greater relevance to policy-makers interested in improving rice production in the study area.

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INTRODUCTION

The role of technology adoption for agricultural development and food security is well-established in topical scholarship. Technology adoption remains a vital growth lever even for the productivity of smallholder farms in many developing countries and to transform subsistence agricultural systems into commercial ones (Emerick and Dar, 2021). Agricultural innovations have up-scaled global food production, particularly in the wheat and rice subsectors (Aryal *et al.*, 2018; IFAD, 2019). Agricultural innovations encompass all kinds of improved techniques and practices aimed at positively affecting agricultural output or other parameters of interest, such as shelf life and nutritional content (Luis *et*

al., 2018). These innovations are diverse, spanning from new varieties and improved soil fertility management practices; through weed and pest management and water management, to post-harvest loss reduction and value addition (Li *et al.*, 2019; Arslan *et al.*, 2022). Unfortunately, despite ongoing efforts to develop appropriate agricultural technologies, adoption levels have often remained dissatisfactory (Fani *et al.*, 2020; Petridis *et al.*, 2018).

Rice is one of the agricultural sectors where developing and diffusing innovations has been prioritized, given its high relevance for global food security. Rice is a staple food for almost half of the world's population, accounting for at least 20% of human caloric needs (Xu *et al.*, 2020). However, the rice subsector's technology development and adoption outcomes have remained mixed. Development, diffusion, and adoption of innovations, for instance, transformed the Asian continent into a net exporter of rice (Olum *et al.*, 2019), while Sub-Saharan Africa continues to rely on substantial rice imports for its food needs (Kariuki, 2018; Yovo and Ganiyou, 2021).

Despite Cameroon's efforts to promote the rice subsector and the huge production and consumption capacity, it remains a net importer of rice. In 2017, for instance, Cameroon's annual per capita consumption of rice was estimated at 37 kg, 2.73% higher than in the previous year, while national rice production stood at 360,000 tons of paddy, 240,000 tons short of the 600,000 tons estimated local demand (FAO, 2018; IFAD, 2019). Cameroon imported rice worth FCFA 183.7 billion (US$.317.2 million) in the same year (Fani *et al.*, 2020). The low level of local production and consistent imports raise Cameroon's national security concerns, especially in urban areas with high population densities.

The adoption of innovations in the Cameroon rice subsector remains minimal and disappointing (Fani *et al.*, 2020; Andrianarison *et al.*, 2021). Critics attribute this disappointing outcome to socio-cultural, institutional, infrastructural, and economic challenges (Dhraief, Bedhiaf*, et al.*, 2019; Arslan *et al.*, 2022; Talom and Tengeh, 2019). Studies that focus on cataloguing available technologies and understanding factors influencing rice farmers' decision to adopt and sustain innovative technologies in Africa and Cameroon, in particular, are limited. This knowledge gap is bridged by examining three objectives; (1) the socioeconomic characteristics of farmers, (2) available innovations and their rate of adoption, and (3) finally looking at the factors influencing the adoption of innovations among rice farmers in the Ngoketunjia division in the North West Region, one of the essential rice-growing areas in Cameroon.

METHODOLOGY

The study was carried out in Ngoketunjia Division of the North West Region of Cameroon. Mezam Division borders the division to the west, Noun Division to the east, Bui and Bamboutos Divisions to the north and south, respectively. It lies between latitudes 5° 15' and 6° 10' N and 10° 15' and 10°40' E (Wirsiy, 2011). The division covers a surface area of 2,347km2 with a population of about 230,501, and about 80% is active in farming (Mbarga, 2010).

According to (Fuh and Sama, 2015), there are 11,285 registered rice farmers in the database of the Upper Nun Valley Development Authority (UNVDA) amongst those active in farming. The area in particular and the country, in general, has a suitable ecological landscape for rice production.

The registered rice farmers of the division comprised the population for the study, given that they are readily reached by rice innovation institutions. A multi-stage procedure and purposive sampling techniques were used in sample selection. The principal rice production zones in the Ngoketunjia Division (Bangolan, Babungo, Lower Bamunka, and Upper Bamunka) were purposely selected. Study participants were limited to members of the UNVDA to guarantee that only participants exposed to innovative technologies in the rice subsector were sampled. Eight hundred (800) farmers (200 per community) were randomly selected.

The rest of the farmers in each community were kept in replacement lists, and a farmer was randomly selected from this lot; each time, a previously selected farmer was unavailable or declined to respond. The choice of random sampling was to give every farmer an equal chance of being selected. A structured questionnaire was developed and pretested on 15 of the respondents after that, the necessary modifications were made, ambiguous items were amended, and those considered irrelevant were removed.

Variables for each category were largely drawn from previous studies (Dhraief, Bedhiaf*, et al.*, 2019; Arslan *et al.*, 2022; Talom and Tengeh, 2019). The selection was based on the frequency of occurrence. A variable was

only selected if at least 2 articles mentioned/ used the variable in their studies).

It was then used to collect data on demographic characteristics, available technologies, and possible drivers for technology adoption by the researchers with the support of 8 trained enumerators with minimum bachelor's degrees. The enumerators undertook prior theoretical and practical training to understand the background of the research, its purpose and the contents of the research questionnaire. During the survey, they were closely monitored and supervised to ensure the reliability of data from respondents.

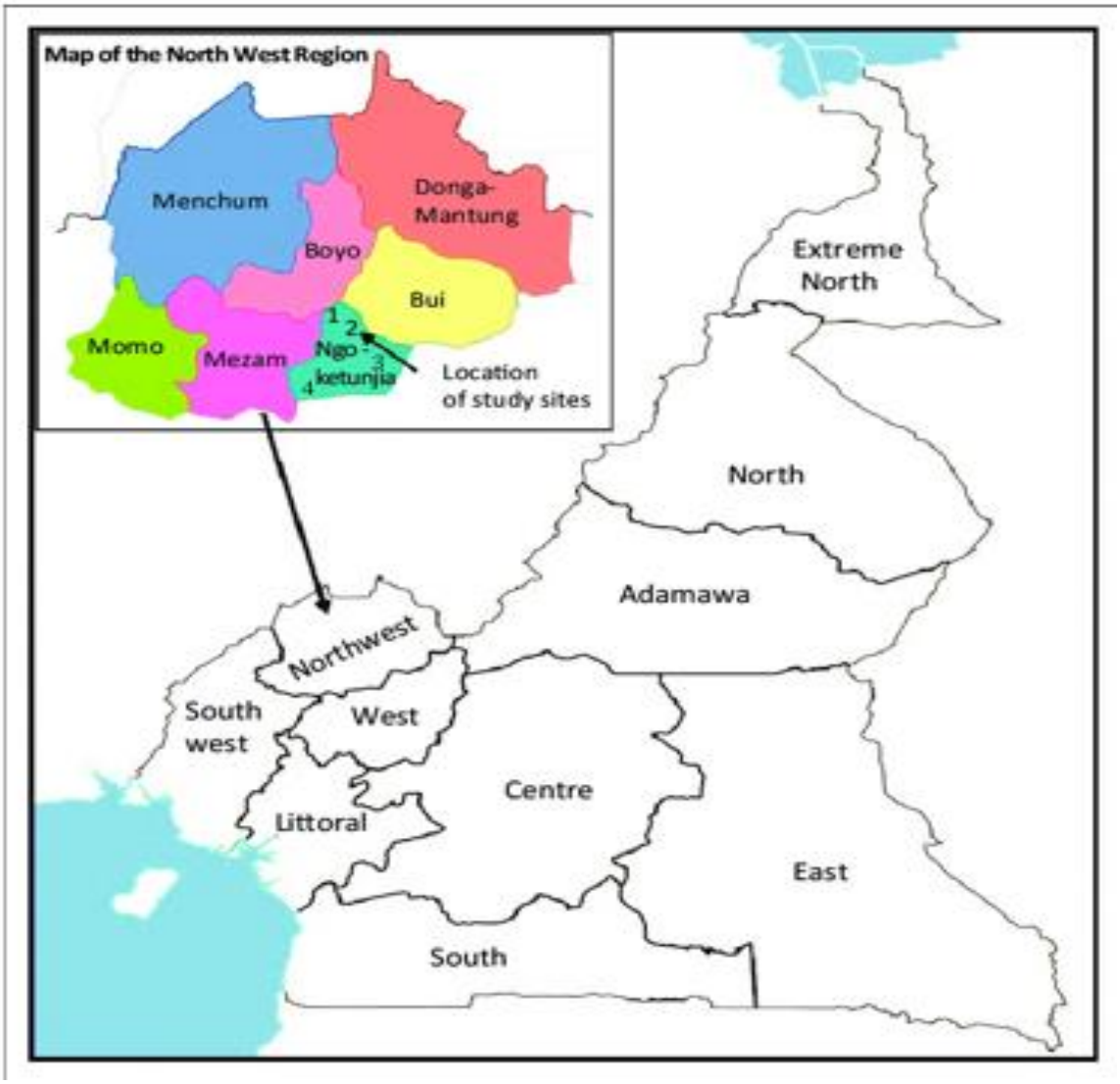

Figure 1. Map of the research area (Adapted from: http://www.all-about-cameroon.com/The-North-West-Region-of-Cameroon.html; https://www.wikiwand.com/en/Northwest_Region).

Data analysis

Twenty-one innovative technologies available to farmers at the study site were identified. A binary variable that defines whether the available technological package was 'satisfactorily' adopted to separate adopters from non-adopters was developed. An adoption rate of 60% proposed by Donkoh *et al.* (2019) and Anang (2019) to separate adopters from non-adopters was applied. Those who adopted up to 60% of all available technologies were considered adopters, while those below were non-adopters. However, given that all sampled rice farmers adopted at least some of the available technologies, we used the terms low adoption rate to describe those who adopted less than 60% of the

technologies, and those greater than 60% were considered high technology adopters. This binary variable was then used to conduct the binary regression analysis with the dependent variable (Level of innovation adoption), taking 1 for high adoption and 0 for low adoption.

To classify factors that obstruct or facilitate the adoption of innovations in the rice subsector in the research area, a binary logistic regression was used. The reason for binary logistic regression was that the outcome variables adopting innovation are dichotomous. The regression model was represented as follows:

$$Qi = \beta 0 + \beta iXi + \beta iXn + e \quad (1)$$

$$Li = (Pi / [1 - Pi]) = \beta 0 + \beta iXi + \beta iXn + e \quad (2)$$

Where:

β0 = is the intercept or constant;

βi = is the vector of coefficients;

Xi = Explanatory variables; (The explanatory variables are; X_1 = Age of the actor (years); X_2 =; X_3 = Household size (Number); X_4 = Level of education (years); X_5=Farm size (hectares); X_6 = Experience (years); X_7 = Group membership (1=member; otherwise = 0); X_8 = Number of contacts with rice development expert).

Explanatory variables are also considered partly as personal factors and the other part as social factors influencing innovation adoption.

Qi = Adoption of rice Innovation; 1= adopt, otherwise = 0. i = 1, 2, 3, 4, 5, 6, etc as innovations tested)

e = error term.

Pi = is the probability that the event occurs to an individual with a given set of characteristics,

Li = logit; = odds ratio of probability of occurrence of events;

The data were managed using the statistical package for the social sciences software – SPSS version 25.0.

RESULTS

Socioeconomic characteristics of rice farmers

In this study, 360 (45%) respondents were male, while 440 (55.5%) were female. Among rice farmers, about 36% were widows, 34% were married while those singles were about 21% of the total population, and lastly, 8% constituted widowers. Widows may be growing rice on land previously owned by their deceased husbands. The level of education in the sample is low, as about 13% had attended the secondary school level while 51% of respondents had only primary school level and 36% never had any formal education.

Table 1. Sex, marital status and educational level of farmers.

Characteristics	Category	Frequency	Percentage
Sex	Male	360	45.00
	Female	440	55.00
Marital status	Married	271	33.88
	Singles	169	21.13
	Widows	288	36.00
	Widowers	64	8.00
Education	No	286	35.75
	Primary	408	51.00
	secondary	106	13.25

N= 800

In addition to this, the mean age of the respondents was about 49 years, while the mean number of years respondents have in rice farming was 23 years, with an average household size of 5 persons. Furthermore, the average farm size is about 0.256 hectares.

Available innovations and adoption rates by rice farmers

The distribution in Table 3 indicates that 8 (38.1%) of the 21 innovations farmers have been exposed to were not adopted. These innovations include; the use of bio-fertilizers, power tillers, winnowing machines, modern processing mills, Destoners in processing, improved parboiled technology, and a modern storage warehouse. Almost 70% (13) of the innovations identified in this study were found to have been adopted and used by the farmers in Ngoketunjia Division. The distribution showed that the most adopted innovations are the use of irrigation systems (reported by all the respondents), the use of modern crop management such as line planting

(reported by over 96% of the respondents), the use of agrochemicals (reported by 92% of the respondents) as well as the use of tractors during cultivation (reported by over 78% of the respondents).

Table 2. Age, years of experience, family and farm size of farmers.

Farmer	Age	Years of experience	Family size	Farm size
Min.	17	3	1	0.07
Max.	74	55	12	0.61
Mean	49.029	23.070	4.5596	0.2564
N	800	800	800	800
Std. Deviation	15.01458	9.66485	1.52073	0.10963

Table 3. Type of innovations adopted and used by rice farmers.

Technological Innovations available to rice farmers	Adoption and use in %	
	Yes	No
Irrigation system (simple water control techniques)	100	0.0
Modern crop sowing method (Line planting)	96.2	3.8
Use of inorganic manure	93.0	7.0
Agrochemicals (Pesticides and Herbicides)	92.0	8.0
Mobile phones	87.6	12.4
Use of tractors for land preparation	78.2	21.8
Mobile money account	56.2	43.8
Crop rotation	28.0	72.0
Use of internet on mobile phone	27.4	72.6
Improved rice variety (NERICA)	22.6	77.4
Use of social media (WhatsApp, Facebook, etc.)	16.0	84.0
Formation of agricultural actors into groups (e.g., CIGs)	11.8	88.2
Group Marketing	8.0	92.0
Use of power tillers	0.0	100
Use of rice threshers	0.0	100
Use of winnowing machines	0.0	100
Modern processing mill	0.0	100
Destoners in processing	0.0	100
Improved parboiled technology	0.0	100
Modern storage warehouse	0.0	100
Bio-fertilizers (wood ash, chicken dung etc)	0.0	100

Factors influencing rice farmer's rate of innovation adoption

Binary regression analysis in Table 3 with 33 independent variables was performed to identify the key determinants for technology adoption in the selected rice-producing communities. The adoption rate of 60% was proposed by Anang (2019) and Donkoh *et al.* (2019) to separate 'adopters' from 'non-adopters'. As previously mentioned, the dependent variable: level of technology adoption, took the value of 1 (high adoption rate) and 0 (low adoption rate) when the cut-off adoption rate of 60% was applied as previously have been reported by Anang (2019) and Donkoh *et al.* (2019). Based on this cut-off point, only around one-third of the respondents (278: 34.8%) fell in the high adoption rate category, while the rest (522:65.2%) were in the low adoption rate category: a fair representation of the situation in the ground.

Furthermore, the Omnibus Tests of Model Coefficients (Table 2) confirm a significant relationship between the dependent variable (Level of innovation adoption) and the independent variables (X^2 = 342.827, p = 0.000). In addition, our model explains 48.1% of the factors that affect the rate of innovation adoption amongst the

sampled rice farmers, which in general is acceptable as reported by Cohen (1960).

Table 4. Omnibus tests of model coefficients.

		Chi-square	df	Sig.
Step 1	Step	342.827	32	.000
	Block	342.827	32	.000
	Model	342.827	32	.000

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	690.590	.349	.481

The regression results show that 10 of the 33 tested variables had influenced the adoption of innovations by rice farmers in the study site when a 10% significance level was adopted (Table 5). The variables with positive influence included; household size, farm size, level of motivation, number of extension visits, and socio-political crisis positively while the type of labour use or hired labour, innovation institutions, property rights, and social norms affect negatively. The fact that farm size (β = 0.14.581, p = 0.047) did show not only very strong but also a significant positive contribution towards innovation adoption indicates that as the level of access to more farmland, especially for smaller households increases, the probability of adopting more innovations by the farmers also increases. Thus, farmers with higher access to farmlands are likely to adopt innovations than farmers who do not. Any unit increase in farm size for rice cultivation increases the probability of adopting innovation by 23.6 times (see Exp (β) values).

Table 5. Key Factors influencing technology adoption by rice farmers.

Factor category	Specific variables	Beta	S.E.	Wald	Sig.	Exp(β)
Economic factors	Household size	.236	.130	3.294	.070	1.267
	Farm size	14.581	7.349	3.937	.047	21.51
Human-specific Factors	Level of motivation	.190	.106	3.210	.073	1.210
	Type of labor used	-2.257	.287	61.796	.000	.105
	Qualified personnel	-.204	.103	3.900	.048	.815
Institutional factors	Innovation institutions	-.474	.284	2.793	.095	.622
	Property rights	-.205	.096	4.578	.032	.815
	Extension visits	.590	.335	3.101	.078	1.804
Social factors	Social norms	-.226	.130	3.031	.082	.797
Political factors	Socio-political crisis	.121	.085	2.031	.077	1.129
	Constant	3.315	1.865	3.158	.076	27.514

Note: The dependent variable is the level of technology adoption (1=high adoption rate, 0=low adoption rate).

The level of motivation of the farmers (β= 0.19, p = 0.73) and their household sizes (β = 0,236, p = 0.070) showed positive correlations with innovation adoption. A unit increase in the level of motivation of the farmer significantly increases the probability of that farmer adopting innovations by 1.21 times, while having larger families increases the probability of adopting innovations by 1.267 times. In addition, larger households are more motivated to adopt labour-increasing technologies (e.g. fertilizer application) for rice production than smaller ones.

While the provision of extension services (β = -22.408) negatively affected innovation adoption in the Ngoketunjia Division, the number of times farmers receive extension visits had a positive and significant effect on innovation adoption (β = 59, p = 0.078). Thus, providing extension services to rice farmers is not enough, but providing consistent services or having

numerous interactions with farmers seem to have significant positive contributions to the rate of innovation adoption. Based on our results, a unit increase in the number of extension visits provided to farmers significantly increases their probability of adopting innovations by 1.804 times.

The type of labor used in farming (β = -2.257, p = 0.000), the number of innovation institutions (β = -0.474, p = 0.095) as well as having qualified personnel (β = -0.238, p = 0.006) showed significant negative contributions towards innovation adoption. More so, the lack of innovation institutions available to these farmers and protection of property rights for existing innovations reduced the rate of adoption of innovations by 0.622 and 0.815 times, respectively.

Finally, in this study, a negative influence of social norms which were considered desirable behaviour together with sanction rules in a community that sharp farmers' behaviour toward adoption of technology (copy for fear of being left behind by other farmers) and socio-political crisis on technology adoption was observed. This observation can be attributed to traditional activities (e.g., non-farming days), which restrict farmers' capacity to take up new, time-consuming technologies.

DISCUSSION

Farmer's characteristics

In the study area, females constituted about 55.5% of the population, as well as 36% of the sample, were widows. This result overshadows contextual arguments in favour of male-dominated access and control over land, favoured by the patriarchal inheritance system dominant in the study site (Balgah et al., 2019). Given that rice is an annual crop, and if the benefits from cultivation accrue directly to the rice farmer, women will be as competitive as men, as long as they are favoured by other production factors such as access to the financial capital needed to engage in rice farming. More also, widows may be growing rice on land previously owned by their deceased husbands. This probably (at least partially) explains why more women are involved in rice farming at the study site than men.

More to that, a generally low level of education was observed (51% and 13% had respectively attended only primary school and secondary school levels) with an average farm size of 0.256 hectares. This might be a key impediment to agricultural technology adoption, as some previous studies established a positive correlation between educational level and technology adoption (Zama *et al.*, 2021) as well as farm size (Arslan *et al.*, 2022).

Rice innovations adopted by farmers

Even though some innovations made available to rice farmers in the studies area are yet to be adopted, Arslan *et al.* (2022) concluded that non-adopted innovations are either highly technical and/or costly and require an up-front investment, which many farmers could not afford. The observation was that 70% (13) of the innovations identified were adopted and used by the farmers in Ngoketunjia Division. The highly adopted technologies seem to be fundamental to rice cultivation, easy to adopt, and less costly to farmers. Olum *et al.* (2019) opined that smallholder farmers tend to exhibit an adoption preference based on their judgment of the immediate relevance for successful production and minimal cost.

Current innovations determinants in Ngoketunjia

Several factors affect innovation adoption and these factors might have been classified under different categories, demographic, socioeconomic, institutional, technology specificities, and cultural just to name a few. Although there are many categories of factors influencing technology adoption, there is no clear distinguishing feature between variables in each category. Pham *et al.* (2021) noted that categorization is done to suit the innovations being investigated, the location, and the researcher's preference, or even to suit client needs.

The first significant factor found in the study area was farm size in which any unit increase in farm size for rice cultivation, increases the probability of adopting innovation by 23.6 times. Similar reports were reported by Yovo and Ganiyou (2021) while investigating improved seed adoption among smallholder rice farmers. They found that large commercial farmers adopted new high-yielding rice varieties more rapidly than smallholders in Togo. In a separate study, Arslan *et al.* (2022) concluded that secure land tenure significantly and positively influenced technology adoption across Africa, as this generally increased property rights and farm sizes for farmers. While supporting this contention, Petridis *et al.* (2018) explain that the larger the farm size, the more likely the owner will adopt innovative technologies; especially when such

innovations require substantial initial investments. More to that, a unit increase in the level of motivation and family size of a farmer significantly increases the probability of that farmer adopting innovations by 1.21 and 1.267 times respectively. This positive correlation between motivation, household size and innovation adoption gains support from Dhraief, Sonia*, et al.* (2019) who contend that highly motivated farmers are more likely to adopt improved agricultural innovations than less motivated ones. In addition, larger households are more motivated to adopt labour-increasing technologies (e.g. fertilizer application) for rice production than smaller ones. Syafrial *et al.* (2021) reported that farmers with larger household sizes take more risks by adopting new technologies than smaller ones.

While the results showed that the provision of extension services negatively affected innovation adoption, however, a unit increase in the number of extension visits provided significantly increases farmers' probability of adopting innovations by 1.804 times. This is particular in consistent services and numerous interactions with farmers. Pham *et al.* (2021) share a similar result: the higher the number of visits provided to farmers, the higher the rate of adopting new practices. It was further explored that labor type used in farming, the number of innovation institutions and qualified personnel had significant negative contributions towards innovation adoption. Li *et al.* (2019) reprimanded that skilled labor and qualified personnel significantly influence farmers' technology adoption levels. The lack of innovation institutions and property rights protection reduced the rate of adoption of innovations by 0.622 and 0.815 times, respectively. It, therefore, seems correct to hypothesize that, labour-enhancing activities such as training workshops, field day demonstrations, and other outreach services provided by innovation institutions can enhance technology adoption (Arslan *et al.*, 2022).

Finally, social norms can encourage or discourage the adoption of a particular technology by members of that society (Luis *et al.*, 2018; Fouzai *et al.*, 2018). In this study, a negative influence of social norms on technology adoption was observed. This observation may be attributed to the little extent to which farmers have adopted impact-driven innovations. It seems that they are rather comfortable with innovations that are fundamental to rice production and this is considered a desirable behaviour in the community. To adopt impact-driven technologies from elsewhere may require some sort of sanction from the community. More also, another negative effect of the current socio-political crisis was obvious as farm activities and movements tend to be restricted due to threats of insecurity, much in line with the contentions of Arslan *et al.* (2022) that agricultural innovations are difficult to adopt in conflict-stricken areas.

CONCLUSION AND RECOMMENDATION

It is common knowledge that farmers can improve their agricultural performance by adopting improved technological innovations. However, empirical evidence has remained mixed, vouching for continuous research. This study has catalogued agricultural innovations available to rice farmers in the Ngoketunjia division in the North West region of Cameroon and identified key drivers for their adoption. The farmers had adopted only eight of the twenty-one innovations identified in the rice sector. These were low-tech innovations that were insufficient to drive and sustain the revolution urgently needed in the rice sector in the study site, to curb imports and capital flight. Overall, the adoption of agricultural innovations was low, as most innovations made available to farmers are still to be adopted. Only modern crop management (line planting), agrochemical (pesticide and herbicides), use of tractors, irrigation systems (simple water control techniques), and mobile phones had high adoption scores.

A binary regression analysis revealed that among economic factors, household and farm size positively affected the adoption of innovations, while Human-specific and institutional factors are either positively (level of motivation and number of extension services) or negatively (type of labour used, qualified personnel, number of innovation institutions, and Property rights) affecting innovation adoption. On the other hand, social norms negatively affect adoption while political (socio-political crisis) positively propped innovation adoption, as children of school-going age were obliged to provide additional labour, due to the closure of schools in the study region.

Variables that are positively influencing adoption must first be fully exploited by respective rice innovation promotion entities, particularly UNVDA. For instance, increasing farm sizes and regular access to agricultural extension services can potentially upscale technology adoption. Both can potentially address or reduce the

negative effects of labour and social norms on technology adoption. As the socio-political crisis in Cameroon supports technology adoption at the expense of human capital accumulation for school-going members in rice farm households, it is recommended that the Government of Cameroon increase its efforts to resolve the crises. This will serve as a prerequisite for increasing access to qualified labour for technology development, diffusion, and adoption of high-impact innovations in the rice subsector in Ngoketunjia division, without compromising the future of children through disrupted education. Furthermore, reducing insecurity will motivate extension workers to develop, disseminate and follow technologies with rice farmers, thereby increasing the effects of agricultural extension on rice innovations adoption rates.

The regression model explained less than 50% of the factors influencing technology adoption in the rice-producing (Ngoketunjia) Division the second main rice-producing area of Cameroon, probably because of the contextual mismatch of variables that were tested in the study. Given this limitation, it is recommended to expand the list of independent variables in future research (for instance by up-scaling the number of context-relevant variables), to generate results of greater relevance to policy-makers interested in improving rice production in the study community.

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