# The effects of adopting Technological innovations on rice value chain actors in Cameroon.


## Abstract

In spite of its importance, outcomes from adopting technological innovations remain debatable. This study examines the effects of adopting innovations on rice value chain actors in Cameroon. The multi-stage sampling technique was applied to identify and collect data from 800 rice value chain actors, using a structured questionnaire. Descriptive statistics and binary logistic regressions were performed to identify adopted innovations; and their income effects respectively. Female actors (55%) dominated the rice value chain compared to males (45%). Mean rice production per actor was 8,011kg/year, generating a mean income of FCFA 1,201,650.00 (US$ 2,031.23). The number of adopted innovations varied across value chain actors (farmers:7, millers:8, wholesalers:5, and retailers:4). Overall, 13 of the 21 adopted innovations (~62%) had significant effects on actors' incomes ($P$ = 0.000). Some innovations (owning mobile phones, mobile money accounts, and engaging in mobile money transfers) were adopted by all actors; however, most adopted innovations were actor-specific; indicating differences in actors' technology preferences. The most important effect of technology adopted was increased food consumption, reported by 100% of all actors. We contend that food security is a prime motive for adopting rice innovations in the study site. We further recommend active participation of actors along the rice value chain in selecting preferred techologies prior to dissemination, to enhance high adoption rates. Future research should identify why only 38% of available innovations were adopted along the rice value chain in this Cameroonian case study, and which factors influenced the choices of different actors. A retrospect on effects other than income can provide stronger relevance for policies promoting adoption of innovations among rice value chain actors in the study site.



***Key words: Technological innovations, adoption rate, effects, Rice value chain actors, Cameroon***




## 1. INTRODUCTION

The importance of technology development, transfer and adoption on the agricultural sector cannot be overemphasized. In many countries adopting innovative agricultural technologies up-scaled productivity, and enhanced the wellbeing of farmers and entire communities, for instance through increased income, economic growth and reduced food insecurity risks [1, 2]. In fact, adopting innovations in the wheat and rice subsectors are responsible for the dramatic improvements in global food production and supply, reduced hunger and malnutrition, and improved livelihoods, particularly for smallholder farm families in developing countries [3]. In general, rice production has benefitted from development and dissemination of innovations, given that its relevance for global food security is only second to wheat [4]. Rice is a staple food for about half of the world's population, and accounts

for at least 20% of human caloric needs [5]. However, the rice subsector's technology development and adoption outcomes have remained mixed and skewed. For instance, while development, diffusion, and adoption of innovations, transformed the Asian continent into a net exporter of rice (4), Sub-Saharan African rice production has remained lower than the demand, pushing the sub-continent to depend on huge rice imports to meet its food needs [6].

The effects of technology adoption in agriculture remains contested [6, 2, and 4]. However, there seems to be a consensus on the fact that agricultural innovations have changed the way actors in agricultural value chains function [5, 7, and 8]. In general, a value chain describes organizational arrangements and actors that are interconnected through a network in which value is added to a product [9]. It encompasses the full range of upstream actors (such as input suppliers and farmers), midstream actors (such as brokers) and downstream ones (such as processors, wholesalers, retailers, and consumers); and the activities these actors perform to bring a product from its conception to the end-users [10 and 11].

Small-scale agricultural actors who dominate the agricultural value chain in many developing countries often have limited options for selecting, from the vast set of alternative innovations available for agriculture, due to factors such as inadequate knowledge on adoption outcomes, and costs assigned to innovations [8]; but also due to socio-cultural, infrastructural, and institutional challenges [12 and 6]. In general, large-scale agricultural actors often take advantage of innovations to improve their performances by changing how they operate, while small-scale actors often find technology adoption very challenging [13]. These observations while interesting, fall short of explaining why actors in the same value chain adopt certain technological innovations while others do not; why not all actors within the same adoption stream adopt available technologies; and even why not all adopters benefit from new technologies with the same magnitude.

The rice value chain in Cameroon is overwhelmed characterized by multiple small-scaled actors with very limited operational capacities. Adoption of rice innovations tend to remain suboptimal, leaving the sector unable to cover the local demand for rice and rice by-products [5 and 7]. Consequently, and in spite of its production potential, Cameroon remains a net importer of rice; which was worth FCFA 183.7 billion (US$.317.2 million) in 2019 [14].

Scholars tend to agree that adopting agricultural innovations can enhance productivity effectiveness and efficiency of different agricultural actors along the rice value chain. Innovative technologies such as improved seeds varieties which can positively impact yields by enhancing climate and pest resistance [15,16,17]; mechanical transplanters which ensure optimal planting density [18]; and modern milling technologies including paddy cleaners, destoners and graders; have positively impacted rice production and management by different actors in the rice value chain; producing desired effects such as quality, higher prices, reduced milling costs and postharvest losses; with cumulative outcomes such as increased food security, higher revenues and better livelihoods for different rice actors in different parts of the world [19,18,7,31]. In more recent times, innovative mobile money payments are facilitating safe transfer and receipt of money, reducing the risks involved with physical cash movements [20, 8]. A summary of innovations available to different actors in the rice value chain as reported in some related studies on small-scale rice production systems are summarized in the table 1.

***Table 1: Type of available innovations and actors involved***

| Innovation | Type | Drivers/role | Actors involved |
|---|---|---|---|
| NERICA Rice variety | Biological and biotechnological | Low yields of local varieties, difficulties in production in marshy areas | Producers, Researchers, Policymakers |
| Mechanical transplanters | Technical | Low rate of planting and labor-intensive | Producers and Researchers |
| Use of organic manure (wood ash, chicken dung) | Agronomic | Poor soil fertility, low yields, high pest infestation, high prices for synthetic fertilizers | Producers and Researchers |
| Modern processing mill and destoners | Technical | Use of obsolete mills to process rice which leads to a high level of breakage and the presence of stone particles | Millers Researchers |
| Improved parboiled technology | Technical | Milling and rice quality issues | Millers Researchers |
| Modern storage | Technical/ | Poor storage facility to lead to high post- | All actors |

| | | | |
|---|---|---|---|
| warehouse | Management | harvest loss | |
| Market Information System | Informational | Little knowledge about prices, location of wholesalers and limited linkages with consumers | Producers, traders, millers, retailers |
| Formation of agricultural actors into groups (e.g. Common Initiative Groups and Cooperatives) | Management | Formerly, stakeholders are not organized and may easily exploit innovations. Also, individually, they could not easily sell to the wholesaler or these buyers dictated prices for them. | All actors |
| Irrigation system | Technological | Farmers could not produce much, even with large unexploited fields | Producers |
| Mobile phones innovations | Technological | Access to information, finance, and its related challenges | Producers, Researchers, Policymakers |

Sources: Adapted from: [21; 22; 15; 23; 24; 25; 4; 30; 31]

To summarize, it is plausible to say that empirical evidence exists on the impacts of technology adoption on rice value chain actors especially from smallholder systems common in many developing countries [26; 4; 27*; 28; 24*; 3; 31]. However, most of these studies are limited to analysing the effects of one technology on one value chain actor (e.g. the study of innovation that focus on rice producers in Ghana [25], and [7] on young male and female entrepreneurs in Cameroon). Studies that examine the effects of adopting multiple and diverse technologies on different rice value chain actors are extremely difficult to find. Such studies can clearly identify winners and losers of technology adoption, and showcase (de)motivations for technology adoption, which can be of high policy relevance in different contexts. To stem this knowledge gap, this study sets out three objectives: (1) to examine the socio-economic characteristics of the rice value chain actors in Ngoketunjia Division, an important rice basin in Cameroon, (2) to examine the adoption rate of rice innovations by actor type, and (3) to assess the effects of innovations adopted by different actors.

## 2. METHODOLOGY

**The study site and data collection**

The study was carried out in Ngoketunjia division in the North West Region of Cameroon. Ngoketunjia division lies between latitudes 5° 15' and 6° 10' N and 10° 15' and 10°40' E and covers a total surface area of 2,347km$^2$ with about 230,501 inhabitants [33]. It is bordered by the Noun Division to the east, Mezam Division to the west, Bui division to the north, and Bamboutos to the south.

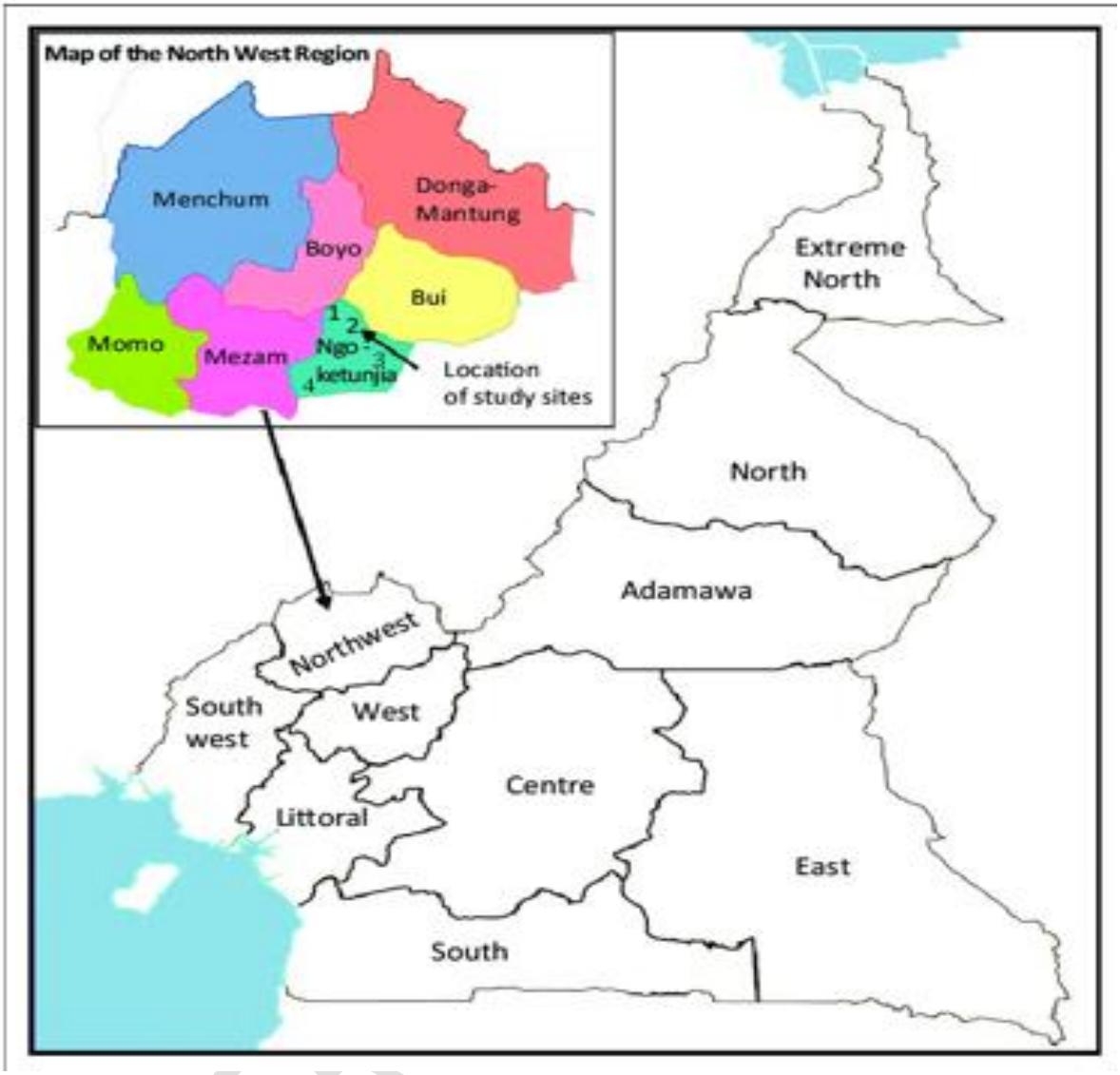


Figure 1: Map of the research area
(Source: Adopted from http://www.all-about-cameroon.com/The-North-West-Region-of-Cameroon.html; https://www.wikiwand.com/en/Northwest_Region)

The Upper Nun Valley Development Authority (UNVDA) is the main institution in charge of promoting rice production in the study site. There are 11,285 registered rice farmers in the database of UNVDA [21]. As an important rice-producing area in the country, Ngoketunjia division lends itself as an ideal site to access different actors of the rice value chain, as rice activities run from farm to fork in this area. This was a key reason for purposively selecting the division.

Multi-stage sampling techniques were used to select the specific communities and respondents for this study. First, the principal rice production zones in the Ngoketunjia Division (Lower Bamunka, Upper Bamunka, Babungo, and Bangolan) were purposely selected. Second, study participants were limited to members of the UNVDA to guarantee that only participants exposed to innovative technologies in the rice subsector were sampled. Third, five hundred and eighty (580) farmers and two hundred and twenty (220) other actors were randomly selected proportionally from the four zones, based on lists obtained from UNVDA.

Those that were not immediately selected were kept in replacement lists, as an actor was randomly selected from this lot per zone each time, a previously selected actor declined or was unavailable to respond. As such, the random sampling technique gave every actor the chance of being selected. A pretested structured questionnaire was used to collect data on demographic characteristics, available innovations, and effects of innovations adoption by the principal researcher with the support of 8

trained enumerators with minimum bachelor's degrees. This was done between June and December 2021.

**Data analysis**

Both descriptive and inferential analyses were performed on the data collected. First, an Analysis of Variance (ANOVA) test was conducted to explore the number of innovations adopted by the different actors. Kendall's tau-b non-parametric test was used to examine the relationship between actors' roles and innovations adopted. For each of the several innovations available or promoted by UNVDA, their mean and standard deviations were considered before finally comparing their adoption rate by actors in the different stages of the rice value chain. Chi-square distributions were used to test for statistical significance, adopting a 95% confidence interval.

Logistic regression analysis was used to examine the relationship between actors' anticipated effects of adopted innovations. In the logistic regression models, we predict the probability of an outcome (Y) occurring given known values of X1 (or Xn), as indicated below:

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

$$Qi = \beta 0 + \beta iXi + \beta iXn + e \quad (2)$$

Where:

Li = logit; = odds ratio of probability of occurrence of events;
Pi = is the probability that the event occurs to an individual with a given set of characteristics,
β0 = is the intercept or constant;
βi = is the vector of covariates,
Xi = Explanatory variables; (The explanatory variables are; X1 = Age of the actor (years); X2 = Sex; X3 = Household size (Number); X4 = Level of education (years); X5=Farm size or business size (hectares or tons); X6 = Experience (years); X7 = Membership of cooperative (1=member; otherwise = 0); X8 = Number of contact with rice development expert). Explanatory variables are also considered partly as personal factors and the other part as social factors influencing innovations adoption.

Qi = Adoption of rice Innovation; 1= adopt, otherwise = 0.
i = 1, 2, 3, 4, 5, 6, 7, 8, 9, 10; 11 are the identified innovations
e = error term.

The regression was employed after estimating the adoption rate of available innovation for actors, using the adoption rate of 60% proposed in 2018 [25 and 29] per innovation adopted. The regression was done firstly for all the actors and subsequently per category of actors in the chain. Finally a p-value <0.05 was used to identify statistical significance.

## 3. RESULTS AND DISCUSSIONS

### 3.1. Socio-economic characteristics of actors

Almost 62% of interviewed farmers in the study area are female, and 38.28% male. Millers are 25% female as compared to 75% male. Around 34% wholesalers are female compared to 66% male. 59% of retailing actors are female compared to only 41% male. Overall, female actors dominated the rice value chain as they constitute 55% of all the actors compared to 45% male. Generally other authors found the opposite that there are more male than female in rice value chains [25,7,17]. Males were found to be more likely to adopt rice technologies in Ghana than females as the latter are restricted access to resources, compared to men [25]. Therefore, in the research area, expensive innovations may not be adopted. Rice production seems to offset the patriarchal inheritance which is dominant in the North West region of Cameroon [32]; probably because women are allowed to rent rice fields in the study site.

In terms of the level of education, 36% of farmers had no formal education, 51% had the primary school leaving certificate, while 13% completed the secondary schools level. 33% of miller had no formal education while 67% had completed the primary level. This was similar to wholesalers, where

16% had no formal education, 80% had a primary level, and only 4% had completed the secondary school level. Finally, for retailers, 11% had no formal education while up to 83% had completed the primary education level and some respondents had completed the high school level, which represented 7%. Previous research suggests that, higher level of education is positively correlated with innovations adoption [17,8]. Based on this logic, and given the low level of education across all actors, we expect a limited level of technology adoption in the study area

In terms of years of experience of farmers showed that about 11% of farmers have less than 5 years, while 7% have between 6 to 10 years. More to that, 28% had between 11 and 15 years as 17% fall between the 16 and 20 years of experience range and most farmers, 37.24 % had 20 and above years of experience. The trend in years of experience are similar for millers in which about 28% of millers had less than 5 years, while 8% has between 6 to 10 years. In addition, 20% had between 11 and 15 years as 10% fall between the 16 and 20 years of experience range and most farmers 35 % had 20 and above years of experience. This was not different for wholesalers, as 22% of wholesalers had less than 5 years, while 2% had between 6 to 10 years. More to that, the majority of wholesalers, 35% had between 11 to 15 years, while 15% fall between the 16 to 20 years of experience range, and around 17 % had 20 and above years of experience. For retailers, 30% of had less than 5 years, while 2% had between 6 to 10 years. The majority of retailers; 35% were found between 11 to 15 years of experience, while 16% and 17 % had 16 to 20 years and 20 and above years of experience respectively. It has been reported in previous studies that years of experience were positively and significantly influence the adoption of innovative technologies like NERICA rice varieties [16], and modern rice mills [19]. A similar trend is expected in the study site.

The average farm size per farmer was 0.26 hectares and the average yield for the 2020 farming season was 1837kg. The maximum number of bags actors handled in the same year was 800 bags, (of 100kg at the price of FCFA 15,000,0) which was equivalent to FCFA 12,000,000.00 (US$ 20284.44), and the minimum was 4 bags that were also equivalent to 60,000.00 FRS CFA (US$103.3). The average number of bags of rice for all actors was about 80.11, resulting in an average income of FCFA 1,201,650.00 (US$ 2,031.23) for actors. Wholesalers had the highest income of FCFA 4,025,000.00 (US$ 6,699.02) while farmers had the least income of FCFA 60,000.00 (US$ 103.3). This is logical, given that wholesalers buy rice from multiple farmers, who at individual level have limited quantities of rice. The income for farmers from rice is almost the same as that found in recently [7]. It may be expected that, actors with higher income will adopted most available innovations [6]. More to that, some actors have integrated their functions along the chain and this is elucidated as forward and backward integration [11]. This means a farmer may adopt an innovation designed for millers and or vice versa.

### 3.2. Adoption rate of available innovations among rice value chain actors

It was observed that 8 (38%) of the 21 innovations made available to actors were not adopted and these innovations are characterised by their high tech nature and high cost. While 13 innovations were adopted, bringing the overall rate of adoption to above the 60% as suggested [25 and 29]. Significant differences were observed in the mean number of innovations adopted by different rice value chain actors in Ngoketunjia (on average 7 for farmers, 8 for millers, 5 for wholesalers, and 4 for retailers). Innovations not adopted were; power tiller, thresher, winnowing machines, modern processing mill, destoner, improved parboiled technology, modern storage warehouse and bio-fertilizer. These innovations not adopted could be as a result of their high tech nature and cost which small scale actors dominated by females cannot afford. Irrespective of the integrated nature of functions by some actors, the F statistics and *P*-values suggest a significant relationship between major innovations adopted and functions of an actor in the rice value chain. For example, modern crop management practices were adopted mainly by millers, then farmers and wholesalers (100%, over 96% and close to 45% respectively, $P = 0.000$). The above result is similar concerning the use of agrochemicals like pesticides and herbicides, tractors, organic manure, and irrigation systems. High rate of adoption of the said innovations had been shown [4]; suggesting that low-cost innovations are more likely to be adopted than high-cost ones.

In general, technology adopted tended to be actor-specific, even for innovations adopted by all actors. Although all actors adopted the use of mobile phones (Table 3), adoption rates were significantly different among actors ($P = 0.001$), as observed from Table 3. (farmers, millers, wholesalers and

especially retailers (about 88%, 77.5%, 80%, and 100% Similar trends were observed for instance in use of social media platforms by different actors. In addition the percentage of those who adopted mobile money increases progressively from farmers (56%) through wholesalers (68%) to retailers (100%). This is contrary the suggestion that the adoption of mobile money results in the adoption of other innovations as all retailers adopted mobile money but the least number of available innovations [8]. It is plausible that transaction costs increase with the use of mobile money and this limited profit that could be used to acquire innovations [23]. Therefore, it cannot be assumed that actors may benefit the same way from innovations made available to them in the rice value chain, given variation in adoption.

Table 2: Innovations adopted by different actors in Ngoketunjia division, Cameroon.

| | Mean | Std. Deviation | Std. Error | Minimum | Maximum | F-distribution |
|---|---|---|---|---|---|---|
| Farmer | 7 | 2 | .065 | 3 | 12 | |
| Miller | 8 | 2 | .235 | 6 | 11 | F = 115.858<br>*P* = 0.000 |
| Wholesaler | 5 | 3 | .259 | 0 | 12 | |
| Retailer | 4 | 1 | .051 | 2 | 4 | |

Note: n = 800 *(Farmers 580, millers 40, wholesaler 135 and retailers 45)*

Table 3: Innovations adopted by different actors along the rice value chain

| **Innovations** | **Farmer** | **Miller** | **Wholesaler** | **Retailer** | **Chi-square** |
|---|---|---|---|---|---|
| NERICA Rice variety | 22.3% | 35% | 11.2% | 2% | 0.000 |
| Modern crop management (Line planting) | 96.4% | 100% | 44.8% | 0% | 0.000 |
| Use of organic manure (wood ash, animals dung) | 92.6% | 100% | 44% | 0% | 0.000 |
| Crop rotation | 28.5% | 12.5% | 1.5% | 0% | 0.000 |
| Irrigation system | 100% | 100% | 74.8% | 69% | 0.000 |
| Formation of agricultural actors into groups (e.g. CIGs) | 12.1% | 10% | 1.5% | 0% | 0.000 |
| Group marketing | 8.3% | 2.5% | 0.7% | 0% | 0.002 |
| Mobile phones | 87.7% | 77.5% | 79.9% | 100% | 0.001 |
| Use of internet on mobile phone | 27.1% | 25% | 37.3% | 97.9% | 0.000 |
| Use of social media | 16.1% | 10% | 28.4% | 93.6% | 0.000 |
| Mobile money account | 56.1% | 57.5% | 67.9% | 100% | 0.000 |

Note: n = 800 *(Farmers 580, millers 40, wholesaler 135 and retailers 45)*

### 3.3. Effect of adopted innovations on rice value chain actors

All respondents (100%) agreed that innovations adopted has a strong effect on increasing rice yields, reducing post-harvest losses, improving management, creating more employment, increasing profit levels, increasing rice quality, and reduce cost of production of rice. Similar effects of innovations were found in two separate meta-analysis studies of innovations adoption and their impact on the rice sector in Africa [6, 24]. More to that, Kendall's tau_b test results showed a strong positive significant relationship between actors in the rice value chain in Ngoketunjia and the size of their businesses ($r_{(800)}$ = 0.602, *P* = 0.000). Therefore, the size of the business increases as you move from one stage in the chain or from one actor to the other from upstream to downstream in the chain. This implies as you move from farmers to millers to wholesalers and to retailers, the volume of rice they deal with in their business increases, as recently shown as well, regarding product flow from producers to retailers who are actors receive the final product and hand over to consumers [13].

As indicated in the table 4, the number of innovations had positive contributions on the performance in the rice value chain for the farmers (β = 0.141), the wholesalers β = 0.139) as well as the retailers (B

= 0.069). On the other hand, it had negative contributions for the millers (β = -0.184). The negative contribution may be related to the milling services offered by millers to other actors in the chain, which is more or less seasonal, rendering investments in technology adoption dormant during some periods of the year. Of significant importance however was the effect of adopting innovations on farmers (*P* = 0.001). Thus, farmers benefit significantly from adopting innovations along the rice value chain in Ngoketunjia division in Cameroon. Such benefits by farmers have been reported in central Java, in Indonesia that available technologies had more positive effect on farmers than other actors [30]. It is argued that farmers in West Africa often have the least value shared therefore adoption of an innovation is likely to results in more benefit and value shared as compare to other others [5].

Table 4: Regression results of the effects of innovations by actor type

| Stakeholder | Constant | Beta | t-test | p-value |
|---|---|---|---|---|
| Farmer | 11.63 | 0.141 | 3.433 | 0.001 |
| Miller | 150.722 | -0.184 | -1.155 | 0.255 |
| Wholesaler | 303.92 | 0.139 | 1.618 | 0.108 |
| Retailer | 60.947 | 0.069 | 0.465 | 0.644 |

Note: n = 800 *(Farmers 580, millers 40, wholesaler 135 and retailers 45)*

## 4. CONCLUSIONS AND POLICY IMPLICATIONS

This study examined the effects of adopting innovations made available to different actors in the rice value chain in Ngoketunjia division of Cameroon; using data collected from all actors, including farmers, millers, wholesalers, and retailers. Innovations adoption rate among actors in the study site was found to be generally satisfactory as 13 of 21 available innovations were adopted while only 8 were not adopted. Interestingly, some irrigation technology was adopted by all actors in the value chain, while others were actor specific. However, other high-tech innovations (such as power tiller, thresher, winnowing machines, modern processing mill, destoner, improved parboiled technology,) were not adopted, signaling either deficiencies to credit access or reluctance to invest in long term technologies, which can characterize the value chain which was dominated by women with small operational capacities and in a context where inheritance favor male children over female ones. This might hamper access to credit for female rice actors, who are likely not to have acceptable collateral. Thus, while actors may be motivated by food security concerns and income opportunities to go into rice farming, adopting high-tech innovations may be torpedoed by inadequate access to credit, obfuscated by perverse local customs and traditions where farms sizes have remained small.

Based on the findings of this study, policies enhancing the adoption of innovations need to be promoted for the development of the rice value chain in Cameroon. This can be done by creating and building the capacities of working groups on value chain development as an appropriate tool for promoting the adoption of technologies along the rice chain. In addition, increase investment in innovations that could specifically enhance the adoption of impact-driven technologies like transplanters, thrashers, and modern rice mills that are yet to be adopted. For this to happen in the study area, there is a need to facilitate access to credit, especially for female actors who often lack collateral, due to socio-cultural biases against women in the study site. Also, a participatory approach that includes actors' interest in designing and promoting innovative technologies along the rice value chain in the study site is likely to further strengthen the development, dissemination and adoption of technologies by different actors along the value chain.

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