Relationship between farmers' heterogeneity and adoption of fertilizers and hybrid seeds in Rwanda

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Abstract

The use of one size fits all model to deliver agricultural inputs to boost low crop yield is an alarming debate in Rwanda. This study was conducted in 17 districts distributed in three provinces of Rwanda to assess the one size fits all model use efficiency and develop key farm typologies. Similarly, by assessing Farm types' characteristics that explain the uptake of agricultural production intensification options such as mineral fertilizers and hybrid seeds. Two-stage cluster sampling techniques were used to select randomly 2754 from 250000 families that worked with One Acre Fund and agro-dealers. Data were subjected to principal component analysis (PCA), a series of regression, and cluster analysis. The results reveal three main principal component (low, medium, and high adopters) associated with socioeconomic aspects. The cluster analysis reveals different ten clusters from 1 up to 10 equivalently farm types. The results show that farm types 1, 2, 3, 4 are low adopters and farm types 5, 6 and 7 are medium adopters while farm types 8, 9, 10 are high adopters of inputs. Farm types scattering between provinces are unevenly distributed ($\chi2$, $p < .001$). There is a significant discrepancy in adoption behavior across provinces, particularly farm types 2, 6, 8 and 10 which are uncommon in the Eastern but common in the Western Province. Farm type 7 is more common in the East and South regions than in the West region. Moreover, farmers' characteristics such as irrigation and agroforestry users and agricultural training receivers, affect significantly ($p=0.01$) fertilizers adoption and hybrids seeds. The current farm typologies should be applied nationally, and support programs tailored to them as one size does not fit all.

***Keywords**: Adoption, farm types, hybrid seeds, fertilizers, and Rwanda.*

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Introduction

Soil fertility and crop yields decline are crucial problem which undermine the prospect of food security (FAO, 2020). Food insecurity is aggravated by different form of soil degradation being acidity and water erosion linked to poor seeds quality. The Rwanda average for topsoil loss is approximately 25t/ha/year (IUCN, 2022). This calls upon agricultural inputs application as the adoption of demonstrated agricultural technologies in developing countries are important aspects for poverty reduction, food security, and improved farmers' livelihoods in rural areas (Berhun et al., 2014). The implementation of agriculture technologies such as exemplified by the green revolution has shown a considerable impact on agricultural productivity in many Asian countries (Otsuka and Kalirajan, 2006).

The imitations of the Asian green revolution in sub-Saharan countries are the foundation to increase agricultural productivity in African countries where agriculture is dominated by subsistence farming (Mitchel, 2008). However, the adoption level of agricultural technologies in small-scale farming systems differs among farmers and mainly accounts for agricultural inputs access, labor availability, and ability to manage the changes in soil quality (Frossard and Vlek, 2014). Several studies have been conducted on agricultural inputs adoption although few of them pay attention to farmer diversity and it has been proven that the uptake of inputs is affected by different subsets of farmer characteristics (Daadi et al., 2020).

The impacts of farm household diversity on agricultural productivity, food security resilience, farmer income, and rural development remain inconclusive (Dimitris, 2015). In Rwanda, agriculture is dominated by small-scale, subsistence, rain-fed farming, relying on traditional technologies and practices which make the sector vulnerable to rainfall variability. Around 96 percent of rural households in Rwanda rely directly or indirectly on agriculture for their livelihoods (Minagri, 2018). Subsistence agriculture in Rwanda faces a complex set of challenges such as limited access to finance, insurance, technology, agricultural mechanization, improved seeds, chemical fertilizers, and other key inputs such as lime or travertine. As a result, the agricultural yield is always below the expected potential and food security and nutrition remain a major concern in Rwanda at the household level (Minagri, 2018).

The Government of Rwanda adopted several measures including the use of improved seed and inorganic fertilizers, promotion of land use consolidation, crop intensification programs, and soil management strategies to improve agricultural production. Unfortunately, the level of consumption of those inputs is still low and it is estimated to be 75kg from 39kg ha^{-1} on fertilizers use in 2018, and 75% of farmers are expected to be using improved seed from 52 % by 2024 (Minagri, 2018) whereas 100kg ha^{-1} of fertilizers is recommended (Riccardo et al., 2016).

Private projects have also been implemented to encourage the use of different agricultural technologies to diversify farming systems but their adoption is still limited in Rwanda and it is linked to farmers' diversity (Bidogeza et al., 2009; Niyitanga et al., 2015). Still, a weak understanding of farm household heterogeneity in the context of resource endowment, objective, production goals and consumption decisions, level of education, farm management skills, experience, and attitude to risk is often a hindrance to the designed target, implementation and scaling out of agricultural development projects (Tittonel et al., 2010).

Thus, this study aims to assess the relationship between farmers' heterogeneity and the adoption of fertilizers and hybrid seeds in Rwanda and generating scientific data that will assist policymakers and development partners to design a new orientation to improve yields household income, food, and nutrition security through the adoption of hybrid seeds and fertilizers.

Materials and Methods

From June up to July 2018, a survey was conducted in 17 districts of Rwanda distributed in three agro-ecological zones namely the Eastern savanna, Congo-Nile watershed divider, and the central plateau (Table 1) where scaling agricultural inputs partners are working to eradicate farmers' challenges that weaken the uptake of agricultural intensification options such as mineral fertilizer and improved crop varieties.

Sampling and sample size

The two-stage cluster sampling was used to select respondents; a total of 15 districts where different organizations that are delivering agricultural inputs are working and 2 districts as control (without operating organization): Fifteen (15) cells in each district were randomly selected (Table 1).

A sample size of 2754 from 250000 families worked with One Acre fund organization which provide fertilizers and improved seeds on credit and other private agro-dealers were purposively and randomly selected to undertake the interview.

Farm types were developed by combining different variables from a review of literature, principal component analysis (PCA), by performing a series of regression models, and finally from cluster analysis based on crop productivity, access to information, livestock ownership, education level, poverty level, opinion to input efficacy, use of input and land area.

Thereafter descriptive statistic and logistic regression analysis were performed to test the significance of household-based factors via stata software 14th.

Theoretical model and specification

A farmer was considered an adopter of agricultural inputs if they used organic or chemical fertilizers or sowed improved seeds either together or independently. The outcomes were dichotomous 1 for adopters and 0 for none adopters. The logit econometric model was used as adoption status was a dummy variable and also to determine the probability to adopt agricultural inputs

$$Y = \begin{cases} 1, Y i \geq 0 \\ 0, \acute{Y}i \leq 0. \end{cases}$$

Thus Y is equal to 1 for adopters and equally to zero for none adopters.

The logit model becomes

$Y= \beta 0 + \beta nXn+ \epsilon$

Where β0: Intercepts and β1… βn stand for coefficients of explanatory variables, Y and X stands for dependent and independent variables respectively and ϵ is a normal distribution of error terms.

Table 1. ***Respondent distribution***

Province	AEZ	District	Respondent
Western	Congo-Nile watershed divider	Karongi	160
		Ngororero	160
		Nyamasheke	160
		Rusizi	160
		Rutsiro	160
Southern	Central plateau	Gisagara	160
		Huye	160
		Nyamagabe	160
		Nyanza	160
		Nyaruguru	160
		Ruhango	177
Eastern	Eastern savanna	Gatsibo	160
		Kayonza	160
		Kirehe	177
		Ngoma	160
		Nyagatare	160
		Rwamagana	160
Total			**2754**

Note: Ruhango and Kirehe districts were taken as control where there is no scaling up organization

Results

Results indicate that farmers differ based on their education, poverty status, livestock ownership, crop productivity, Access to agriculture training, input use efficiency, and land area. Farm Types 1(6%) and 2 (7% of the study population) respectively represented households who decided not to cultivate maize and were less engaged with the modernization of agriculture, they followed traditional agricultural practices, focusing on tuber crops and beans. Farm Type 1 reported low access to agricultural information or training sources, with a limited intention to modify their practices. Farm type 2 (7%) focuses on traditional crops, but has low livestock ownership, low perception of the efficacy of inputs, low input use, and could be classed as very poor. They were mostly located in Ruhango District (Southern Province) which is an area where scaling partners had no activities at the time of data collection. Farm Types 3 and 4 were grouped primarily because of their disconnection from sources of agricultural advice or training. Farm Type 3 (10% of the study population) was the poorest of all farmers. The single women with no education and very little land were the household heads. They reported a low perception of input efficacy and low training or advice opportunities. Farm Type 4 (16%) showed similar levels of disconnection from agricultural advice and training but were not as marginalized in terms of physical assets or human capital. Farm Type 4 was also more commonly located in the Eastern Province, which may suggest low penetration of governmental and/or NGO extension services. Farm Types 5 (9%) were distinct from other farm types in that they typically owned cattle, and despite small land sizes, were very prosperous. They also grew crops, including maize, but derived the majority of their incomes from livestock (Table 2). Farm Types 6, 7, and 8 also showed moderate engagement in the modernization of agricultural activities. Farm Type 6 (15% of the study population) had any formal education (Table 2). They generally showed lower adoption rates than Farm Types 7 and 8, which consisted of households with more education but otherwise similar characteristics (Table 2). The lower-adopting farm types (3, 4, and 6) all had low levels of education – which suggests the development of accessible and appropriate training materials may be important for increasing adoption among these types (Table 2). Farm Types 7 and 8 had the similar feature and were mainly differentiated by livestock ownership and location. In farm Type 7 (10% of the study population) the household economy was based on a combination of crops and small livestock (chicken and goats). These farms were located mostly in the West or South. In farm Type 8 (12% of the study population) the livestock did not feature heavily in the household economy. This type was more prevalent in the East and showed lower engagement with scaling partners than Farm Type 7. Farm Type 9 (6% of the study population) cultivated and owned much more land than the other types and was the most prosperous in terms of income, food security, and livestock ownership. They also showed high adoption of agricultural modernization activities and a high proportion of yields traded. Due to this high asset base, Farm Type 9 had dissimilar characteristics from all the farmers' classes; it would be unlikely that households from other farm types could transition into Farm Type 9 as a result of agricultural development interventions. Farm Type 10 (9%) appeared to be the most innovative and keen to develop their cropping systems and is prevalent in West and South province. They showed the highest engagement with scaling partners, the highest use of inputs, very high crop sales, many positive plans and changes relating to agriculture, and significantly higher maize yields per hectare than all other farm types.

Table 2. ***Main characteristic of developed Farm types***

Farm type	Farmers characteristics
1 (6%)	Less modernized agriculture, traditional practices, tuber crop, and beans focus, low access to agriculture information and training
2 (7%)	Focus on the traditional crop, low livestock ownerships, low perception of the efficacy of inputs, low input use, and very poor.
3 (10%)	Single women without education and small land, low perception of input efficiency, and little training or advice opportunities
4 (16%)	Disconnection from agricultural advice and training but were not as marginalized in terms of physical assets or human capital,
5 (9%)	Owned cattle, small land sizes, the majority of their income from livestock
6 (15%)	None any formal education,
7 (10%)	The household economy was based on a combination of crops and small livestock (chickens and goats)
8 (12%)	Formal education, no livestock
9 (6%)	Owned much more land than the other types and were the most prosperous in terms of income, food security, and livestock ownership
10 (9%)	Very high crop sales, many positive plans, higher maize yields, and engagement in agriculture training

Notices: the number in parenthesis indicate farmers per farm types

Logistic regression model for inorganic fertilizers adoption

Regression analysis indicated that farm type and their features affect the inputs use as well as other household-based factors such as irrigation use and agricultural training which affect statistically highly significant at (p=0.01) and were positively related with inorganic fertilizers adoption while access to credit was statistically significant at (p=0.05). The probability of adoption is estimated by the logit coefficient by dividing it by 4 factors as the linear probability is not straightforward (Maddala, 1983). Therefore, keeping other variables constant, the probability of adoption for farmers from type 9 (Cropping champion was greater at 89.5% compared to traditional farm types) and having irrigation and agricultural training was 57% and 75% respectively for inorganic fertilizers adoption. Moreover, results indicated that access to credit influenced positively the adoption of inorganic fertilizers at 34% whereas farm labor (reciprocal) and cropping system (intercropping) were negatively related to the adoption of inorganic fertilizers adoption at 26% and 77% respectively (Table 3). Farm labor (reciprocal) and cropping system (intercropping) were negatively related and statistically significant (p=0.05) affect inorganic fertilizers adoption.

Table 3. *Logistic regression model for inorganic fertilizers adoption*

Significant variables	Coef.	Std. Err.	Z	P>z	[95% Conf. Interval]	
Farm type 2	0.68316	0.877968	0.78	0.004	-1.037623	2.40395
Farm type 3	3.12124	0.639808	4.88	0.000	1.867242	4.375245
Farm type 4	3.17738	0.722154	4.40	0.000	1.761983	4.592776
Farm type 5	3.38437	0.690591	4.90	0.000	2.030835	4.737905
Farm type 6	3.27628	0.696392	4.70	0.000	1.911382	4.641191
Farm type 7	3.28974	0.706979	4.65	0.000	1.90409	4.675397
Farm type 8	3.05099	0.658563	4.63	0.000	1.760237	4.341759
Farm type 9	3.12124	0.639808	4.88	0.000	1.867242	4.375245
Farm type 10	3.58610	0.642521	5.58	0.000	2.326785	4.845421
Farm labour:5	-2.62683	1.28491	-2.04	0.041	-5.145215	-0.1084616
Farm slope (gentle)	1.48459	0.5319386	2.79	0.005	0.4420096	2.527171
Farm slope (moderate)	1.703396	0.4996389	3.41	0.001	0.7241216	2.68267
Irrigation practices	0.573305	0.1514957	3.78	0.000	0.2763793	0.8702314
Agricultural training	0.759889	0.1368747	5.55	0.000	0.4916205	1.028159
Access to credit	0.343096	0.1291819	2.66	0.008	0.0899045	0.5962882
Cropping system: 1	-0.779980	0.3354335	-2.33	0.020	-1.437418	-0.1225434
Constant	-3.549383	0.9343621	-3.80	0.000	-5.380699	-1.718067

Note: Farm labor 5: reciprocal, cropping system: 1 Intercropping

Logistic regression model for hybrid seeds adoption

Regression results revealed that farm type and their features affect the inputs use as well as other household-based factors such as agroforestry practices, agricultural training, and irrigation practices which had positive relationships and affected highly significantat (p=0.01) the adoption of hybrid seeds. Moreover, land slope characteristics had a positive relationship and affected significantly (p=0.05) the adoption decision of improved seeds whereas cropping systems such as intercropping were negatively related and affected significantly the adoption of improved seeds. The adoption probability revealed that keeping others variable constant, farm types 3, 4, 5, 6, 7, 8, 9 and 10 had 72%, 71.5%, 72%, 74.75%, 70.25, 79.75%, 72% and 83.75% respectively, farm labor (hire labor) have affected at 86%, irrigation practices (59%), agroforestry practices (74.5%), agricultural training (74.1%) and access to credit (37%) the adoption of improved seeds (Table 4).

Table 4. *Logistic regression model for hybrid seeds adoption*

Significant variables	**Coef.**	**Std. Err.**	**Z**	**P>z**	**[95% Conf. Interval]**	
Farm type 2	0.351957	0.980559	0.36	0.720	-1.569905	2.27382
Farm type 3	2.881868	0.742079	3.88	0.000	1.427419	4.336317
Farm type 4	2.865643	0.658803	4.35	0.000	1.574412	4.156874
Farm type 5	2.884128	0.749094	3.85	0.000	1.41593	4.352327
Farm type 6	2.995391	0.710882	4.21	0.000	1.602087	4.388694
Farm type 7	2.811718	0.719632	3.91	0.000	1.401265	4.222171
Farm type 8	3.196258	0.731382	4.37	0.001	1.762775	4.629742
Farm type 9	2.881248	0.680700	4.23	0.000	1.547099	4.215396
Farm type 10	3.352611	0.661603	5.07	0.000	2.055892	4.64933
Farm labor:4	0.863721	0.524599	1.65	0.100	-0.1644749	1.891918
Farm slope (gentle)	1.468273	0.547465	2.68	0.007	0.3952597	2.541286
Farm slope (moderate)	1.6094	0.567885	2.83	0.005	0.4963653	2.722434
Irrigation practices	0.598518	0.173905	3.44	0.001	0.2576701	0.9393673
Agroforestry	0.745655	0.171593	4.35	0.000	0.4093393	1.081971
Agricultural .training	0.741204	0.157856	4.70	0.000	0.4318105	1.050598
Access to credit	0.371591	0.147317	2.52	0.012	0.0828552	0.6603282
Cropping system: 1	-0.679895	0.363385	-1.87	0.061	-1.392118	0.0323273
Constant	-3.425715	1.001106	-3.42	0.001	-5.387847	-1.463583

Note: farm labor 4: Hire labor

Discussion

Farm types characteristic and agricultural inputs adoption

The results indicated that land tenure has affected positively the adoption of fertilizers being organics as farmers expect the effect of added organic materials after a given period because organic fertilizers are slowly releasing plant nutrients and their application in one season reflects their use in the next season this implies that without land tenure farmers are reluctant to invest.

However, farmers are willing to apply inorganic fertilizers without land tenure since it is easily used in plant nutrition and farmers want to maximize their short time investments.

The results concur with Demelash et al. (2014) who stated that organic fertilizers application has residual effects which determine the longevity of organic amendment types and also similar results were found by Goswami (2015) who reported that land ownership increases inputs use intensities and adoption of productive practices by farmers.

Likewise, results demonstrated that a high number of farm households had no access to credit which reduce their willingness to adopt inputs due to the lack of purchase ability for agricultural inputs.

The results are in line with Adjognon et al. (2017) found that access to credit is limited in sub-Saharan Africa and undermines the adoption of inputs use

The findings confirm a positive relationship between agricultural training and the adoption of agricultural inputs where farmers acquired farming knowledge. Similar results were found by Kennan and Ramappa (2017) who reported that training on inputs use and education have influenced positively and affect the adoption of soil nutrient technology. Also, Pan and Zhang (2018) concluded that agricultural training improved the knowledge of fertilizer application farmers via round table discussions on the subject matter together with facilitators.

Thus, the lack of off-farm income affected negatively the adoption of agricultural inputs adoption. Off-farm income offers the ability to household farm investment in terms of purchasing agricultural inputs and labor hiring. The findings are supported by Awondo et al. (2017) agreed that off-farm income significantly reduces threats and individual constraints of fertilizers application also Martey et al. (2019) asserted that inorganic fertilizers use is determined by off-farm income and farming history.

Lastly, livestock is a wealth indicator that determines the purchasing power of farm households. Similar results were found by Alem and Broussard (2018) admitted that fertilizers application intensity increases depending on livestock possession by farm households. Furthermore, Terefe and Ahmed (2016) demonstrated that the level of organic fertilizers application estimation is based on livestock ownership, landforms, and access to credit.

Logistic regression model for inorganic fertilizers adoption

The results indicate that inorganic fertilizers adoption varies between farm types. The significant difference is linked to wealth status, education level, and production orientation of farm households. The more adopters were from farm types 10,9,8 and 7 because they are wealthier whereas low adopters (farm types 1,2,3 and 4) are due to the low education of farmers and they are poor compare to other farm groups.

This implies education increases farm

household ability to access information and strengthened analytical capabilities for the use of inorganic fertilizers.

Furthermore, wealth status enhanced the adoption of inorganic by increasing purchasing ability of farmers. Also, the differences among farmers are due to their different farm management skills, access to information, livestock ownership, and opinion to input efficacy use and off-farm employment.

Moreover, adoption decisions differ from one farm type due to agricultural finance and access to credit (Emmanuel et al. 2016). Farm diversity affords an important aspect to maintaining innovative technology adoption and policy based on the diversity of the concerned population (Dupré et al. 2017).

Reciprocal farm labor (farmer to farmer labor exchange) affects negatively the adoption once delayed exchange occurs as fertilizers application requires intermediate activities. The negative effects are attributed to the farmer's decision since fertilizers application is labor intensive and agricultural inputs use requires manpower for every stage for effective crop productivity level (Umar et al., 2012).

Moreover, the adoption of inputs rely on other technology like irrigation practice that reduces production risk (Koundouri et al., 2006). The presence of irrigation practices influences farm households to adopt because irrigation practices supplement water required to solubilize inorganic fertilizers and water availability can intervene to solve the problem of crop failure and farm households would be probable to adopt agrochemical inputs. Irrigation practices contribute to crop water demand and farmers don't expect not only water stress but also germination failure and inefficient use of fertilizer. Harvest (2010) reported that rain-fed agriculture is challenged by rainfall variability which decreases farm investment of new. Additionally, agricultural training provides knowledge, awareness, and relevant information on the subject matter and farmers be informed and ask where obstacle has been raised to satisfy their curiosity about agriculture innovation.

Similar results were found by Kennan and Ramappa (2017) who reported that training on inputs use and education have influenced positively and affect the adoption of soil nutrient technology. Dan and Ning_(2018) agreed that agricultural training is a prerequisite for effective fertilizer management and improving farmers' knowledge of agricultural inputs use.

Furthermore, access to credit increases the adoption through increasing farm household ability to purchase the inputs used and it also helps to reduce the problems that farm households are encountered during agricultural activities. The results are consistent with Oloyede et al. (2012) reported that access to credit and formal education are the most factors that influence fertilizers used by farmers. Recent findings of Laekemariam et al. (2016) indicated that the cost of fertilizers, availability of credit, time delivery delay, and unpredicted climatic factors decrease farmers' willingness to use mineral fertilizers.

Moreover, intercropping has a risk to reduce crop yield through competition for light, soil nutrient, and water which affect actual and predicted crop yield also the high cost of farm management example weeding practices remains an obstacle to adopting inorganic to be applied on farm under the intercropping system.

Moreover, land/farm characteristics like gentle and moderate slopes define the input to use based on degradation extent where farmers are inclined to invest in agricultural inputs and the most undermining feature is steppe slope where farmers pretend a highly degraded landform due to erosion and other degradation factors. Rewarth et al. (1992) reported that after phosphate fertilizers application residual phosphorus decrease with soil depth and land slope where the high land slope has low phosphorus cycling.

Farmers invest in land based on its capability and suitability to improve the outcome. Furthermore, more applications of inorganic fertilizers on steep slopes reflect the wash away of inputs due to erosion which leads to eutrophication in low land and aquatic environment and other externalities constraint (Huang et al., 2017)

Logistic regression model for hybrid seeds adoption

The adoption of improved is different across farm types based on their demographic livelihoods, farm management, farm productivity, and perception of modernized agricultural practices. These general trends where farm types 10, 9, 8 and 7. are more users compared to farm types 1,2,3 and 4 are correlated with education, production orientation, livestock ownership, and their perception of inputs efficacy.

The effects of labor on improved seed adoption are attributed to the interconnected activities such as digging holes, and row and line planting that is labor intensive. The results are in line with Ouma et al., (2002) found that labor hiring and extension services statistically significantly affect farmers' adoption of improved maize variety.

Additionally, the results are consistent with Makate et al., (2018) who reported that the adoption of agricultural practices friendly to climate is defined by socioeconomic determinants and clusters

Moreover, irrigation practices have positive relationships and affect highly significant at (p=0.01) the adoption of improved seeds because irrigation practices control water availability problems and water stress and it can be a good solution to the problem of crop failure and farm households would be motivated to adopt improved seeds (El Balla et al. 2013). The adoption of improved seeds is positively correlated with agroforestry for the fact that agroforestry practices prevent soil erosion and nutrient loss and thereafter increase crop yield. Furthermore, agroforestry provides other sources of income not only timber, fuel wood, and stakes for climbing beans required by farm households but also works as the source of income helping the farmer to purchase agricultural inputs.

Likewise, agricultural training also indicates a positive impact on improved seeds adoption because it is a channel to deliver the benefit of the use of the improved seed, the study conducted by Pan and Zhang (2018) indicated that advocacy for farmers to be trained and advised to adopt yield-raising technologies such as organic manure, improved seeds suitable for local conditions, and modern agricultural machinery would be an added asset to facilitate their farming activities for poverty reduction. Cropping system such as intercropping has a negative relationship and affects significantly adoption of improved seeds compared to mono-cropping which makes the farm activities such as water and fertilizer management, weeding, and harvesting easier. It is also very convenient for field mechanization.

Large-scale agricultural operations like grain production and plantations usually follow mono-cropping patterns of cultivation for the efficient utilization of limited resources and it helps schedule casual work.

Experimental researches confirm crop yield reduction in intercropping systems due to competition on light water and soil nutrient, high inputs, and labor requirement (Glassman, 1985).

Also, the high requirement for crop management practices makes intercropping expensive (Willey, 1979b).

Empirical results indicate that different types of credit such as traditional credit, informal and formal allow farm households to buy appropriate inputs while access to credit, insurance, and savings may stimulate technology adoption where new methods are riskier but higher-yielding or require sunk costs (Adjognon et al., 2017; Farrin and Miranda, 2015). Additionally, access to credit increases the adoption of improved seed by increasing farm household ability to purchase inputs, hiring labor, maintenance costs, and farm management to counter the effect of climate variability (Peprah et al., 2017).

Conclusion

The findings revealed farmers' diversity based on education level, poverty status, livestock ownership, crop productivity, training, input efficacy, and land area which affect the adoption of agricultural inputs (Fertilizers and hybrid seeds). One Size fits approach is easier to deliver inputs but it does not fit all Rwandan farmers because they are distributed into different ten farm types which creates inefficient input adoption. The inputs adoption is a complex process influenced by different factors (education level, credit access, training, irrigation and agroforestry practices, farm labor, poverty, cropping system, and livestock ownership) which need to be addressed simultaneously. Moreover, further research should quantify fertilizers levels required in different agro ecological zones. And undertake a feasibility study on crop index-based insurance that allow farmers adoption of agricultural inputs.

Declaration

There is no potential conflict of interest between authors(s).

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