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Do Land Ownership and Agro-Ecological Location of Farmland Influence Adoption of Improved Rice Varieties? Evidence from Sierra Leone

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Abstract: This study investigates the impact of farmland ownership and agro-ecological location on the adoption of the two most important sources of improved rice varieties (NERICA and ROK) in the context of Sierra Leone. In terms of farmland ownership, the results showed that farmers who cultivated their own land had a higher tendency of remaining as non-adopters of improved varieties, but those who rented farmland or were engaged in sharecropping had higher adoption rates of improved rice varieties. Also, the location of farmland (uplands or inland valley swamps) determined the rates of adoption of improved varieties differently. For instance, upland regions showed faster adoption of ROK varieties, but inland valley areas showed faster adoption of NERICA varieties. We also examined the survival rates of local rice varieties. The adoption of improved varieties was only occurring at a very low rate, and the farmers' adoption of ROK varieties was swifter than for NERICA varieties. This study recommends that policies advocating the adoption of improved rice varieties in Sierra Leone must take into consideration the patterns of farmland ownership and location.

Keywords: land ownership; agro-ecological locations; adoption rate; improved rice variety; Sierra Leone

1. Introduction

The adoption of improved technologies notably improved rice varieties to boost food production, and rice self-sufficiency is increasingly becoming a crucial element in the formulation of food security strategic policies of many Sub Saharan African countries [1,2]. This is seen in the importance rice holds as an economical food [3,4], essential staple, and significant source of food energy for a population of more than 750 million in Sub Saharan Africa [5–7], and Sierra Leone is not an exception [8]. However, it is critical to produce enough rice required to feed the rapidly growing population. Besides a few countries, the demand for rice has outstripped production in Sub Saharan Africa. Consequently, significant quantities of rice are imported to meet the demands at a considerable cost in foreign currency in Sub Saharan Africa [5,9]. A study in 2014 indicated that the rice consumption and production levels in Sub Saharan Africa were, respectively, 26 million tons and 14.4 million tons of milled rice, which means that about 46% (equal to 11.9 million tons and more than 5.9 billion dollars' worth) of the domestic requirements in Sub Saharan Africa was imported [5]. To date, the problem of rice self-sufficiency continues and will continue until there are effective measures to encourage the production of more rice to prevent the over-reliance on rice importation.

Recent studies suggest that the effective adoption of improved rice varieties is an effective strategy sustaining adequate rice production and rice self-sufficiency [5,10–12]. Arouna et al. (5) maintain that the adoption of improved rice varieties has a positive effect on the different outcomes of agricultural growth. That includes high productivity, more food production, high income, poverty reduction, and food security in Sub-Saharan Africa. With that understanding, different governments and policymakers in Sub Saharan Africa proffer more pro-farmer strategies that encourage and support farmers in the implementation of improved rice varieties [13,14]. However, very little has succeeded so far in Sub Saharan Africa. The literature discusses the low rates of adoption of new agricultural technologies in the context of smallholder farming [15]; on average, 22% in Sub-Saharan Africa against 84% in East Asia and 78% in South Asia [16]. Also, the percentage of land area cultivated with improved agricultural technologies is 27% lower in Sub Saharan Africa compared to 82% in South Asia, notably China [17,18]. One study infers that improved farming systems, including better access to infrastructures and agricultural services, gave the Asian farmers better access to improved agricultural techniques [19]. Farmers in Sub Saharan Africa, however, are devoid of such facilities and cannot fully exploit the benefit of improved agricultural technology. Consequently, the ineffective adoption of improved varieties limits the anticipated crop production and productivity growth for farmers in Sub Saharan Africa, notably Sierra Leone [20].

In Sierra Leone, considerable efforts have been made to achieve the objective of rice variety development and research. Improved rice varieties have been developed through plant breeding programs at the national rice research station in the country and other breeding institutions. As in most Sub Saharan African countries, importance has been placed on promoting improved rice varieties purely in line with the potential yield advantage under normal farming conditions [21]. Nonetheless, important non-yield related attributes of improved rice varieties, as well as socio-economic, environmental, and agro-ecological factors, if overlooked, could lead to ineffective adoption among farmers [22]. For instance, most of the rice farmers in Sierra Leone are actively engaged in local rice cultivation [3,23,24]. The local varieties are easily accessible, have an adaptation to local conditions, and are resistant to most disease pests. That is crucial on the one hand since the farmers want to maintain their social values and desire for crop quality. On the other hand, the unimproved or local systems of cultivation and the limited genetic potential of local varieties have caused low yield and quality performances. Thus, the local varieties cannot effectively compete with the improved rice varieties that would possess all the traits of farmers' choice.

Rice production in Sierra Leone is location-specific and largely depends on the rain-fed environment [25]. And so, the adaptation of a wide range of agro-ecological conditions, which include uplands and the diverse lowlands, for example, Inland Valley Swamp, largely determines the potential for efficient rice farming, as well as the prospect for the investment regarding the type of improved rice varieties farmer's need in Sierra Leone. The literature on rice cultivation in the different rice agro-ecological location offers different morphological traits that best suit the prevailing rice ecosystem (upland or lowland). This controls the decision of farmers in selecting the improved varieties for the right agro-ecological location. For instance, rice varieties with an early plant vigour for effective competition with weed, rainfall dependent, and the ability to strive in free-draining soils (aerobic rice systems) seem to suit the upland agro-ecology well [26,27]. Traits, such as early maturity and tolerance to salinity and iron toxicity, are an essential consideration for the lowlands agro-ecology. This implies rice production and productivity growth are likely to increase if improved rice varieties adopted by farmers are consistent with favourable agro-ecological conditions [28]. Considering that, the decision to adopt could be affected if research institutions do not encourage the farmers to adopt appropriate improved varieties in the prevailing agro-ecological location.

Even if improved rice varieties can suit the farmers' agro-ecological locations, adoption would be unsuccessful if farmers do not have credible access to farmland. This is important because the prevailing land ownership structures and rice farming, notably, the adoption of improved rice varieties, are directly related. The literature shows that the existing access to farmland through the communal land entitlement and inheritance offers subsistence to over 85% of the Sierra Leonean farming population [23]. However, it is mostly characterized by land fragmentation, marginal, and small parcels of landholdings, which limits the ability of farmers to intensively invest in improved rice varieties that could enhance rice production. At the same time, the issue of rice farming (notably improved rice varieties) by landless farmers is often clouded by uncertainties over the land ownership through rental and sharecropping [29]. On the one hand, is the fear of landowners that farmer-tenants or prospective investors could make claims over their land resulting in a reluctance to securely allocate land. On the other hand, it is the insecurity and vulnerability of tenants over being evicted from land to which temporary rights have been granted [29,30]. Such a process tends to leave the vast land uncultivated [29] and diminishes the capability of the farmers' decisions to undertake investments in improved management practices, as well as productivity-gain technologies, among others [31–33]. Active land rental markets are an economically rational strategy for landless farm households to access land. However, their contractual pre-tenancy arrangements between landowners and tenants are yet to be useful in the Sierra Leone farming systems [29].

This study intends to investigate the adoption rate of improved rice varieties in Sierra Leone. Further, it provides empirical evidence on how agro-ecological locations (upland and lowland), as well as the land ownership structure (sole ownership, rental, and sharecropping), influence the rate and waiting time to change from local varieties to the adoption of the two main improved rice varieties (ROK and NERICA). This has received little attention in the existing literature. Farmers' decision on rice cultivation in Sierra Leone mainly constitutes local varieties or landraces that have existed longer than farmers could remember. Also, new varieties, such as ROKU-PR (ROK is a derivation from Rok-upr, the location of the Roku-pr Rice Research Centre in Sierra Leone. (See Dahniya (1993) Linking science and the farmer: pillars of the national agricultural research system in Sierra Leone)), introduced among farmers within the last two decades and improved rice varieties, such as New Rice for Africa (NERICA), are not uncommon [3,23,24]. ROK is an improved rice variety developed by the main rice research centre in Sierra Leone (Rice Research Station, Rokupr) during the 1970s and 1990s. It is a cross between the native varieties of the Asia origin *Oryza sativa*, which over the years had been developed into several varieties to suit Sierra Leone's ecological and rain-fed (upland and lowland) farming conditions [8,25]. ROKs reveal attributes of high yield potential, high protein content, short life span, and palatability, and could minimize the risk of crop failures. ROK produces substantially better harvests (2.0 to 4.5 tons per hectare), and its adoption could minimize the risk of crop failures [23,24]. Currently, ROK is making swift progress in the Sierra Leone rice production system and is also widely adopted among farmers in neighbouring countries of Guinea and Liberia [23].

NERICA, on the other hand, is a hybrid between local traditional African rice (O. glaberrima) and O. sativa, which have gained prominence throughout most Sub Saharan Africans [11] including, Uganda, Ethiopia, Madagascar, Malawi, Mozambique, and Tanzania. It combines attributes of higher yields, tolerance to salinity and iron toxicity, resistance to drought and pests. NERICA rice varieties are extensively promoted in Sierra Leone by the government in an attempt to achieve food security in the country. Most farmers consider NERICA varieties an excellent crop. That is because the varieties are relatively high yielding with good weed suppression ability and tall plant height, which makes harvesting easier [11]. It yields more than either of the two parent varieties of African and Asian rice. Each panicle (or branch cluster) of the African rice consists of about 100 grains, and each panicle of the Asian rice carries about 250 grains. In contrast, the panicles of the NERICA variety can hold an average of 400 grains. Potentially, NERICA can yield 2 to 3.5 tons of rice per hectare. In the fields, even with very modest applications of fertilizer, could boost the output to 4 tons per hectare. Also, each grain of NERICA rice has more protein than either of the parents. While the old varieties have a protein content of about 8–10 per cent, NERICA can reach 10–12 per cent. The NERICA varieties have a shorter duration (about 90–100 days compared to 120–180 days of typical upland varieties), allowing for a second crop during the rainy season. That will not only enable farmers to earn money sooner from their market sales but also save time for planting other crops.

However, the extent to which farmers have changed from the cultivation of the local rice to the adoption of ROK and NERICA varieties is unavailable in the literature. Also, the influences of agro-ecological locations and land ownership on the adoption rates of improved rice varieties are concerns that need careful consideration in Sierra Leone. Addressing these concerns is crucial for evaluating the ability of the research system to put up with the growth in rice production in the future, as well as the adoption of improved rice varieties in Sierra Leone. This study intends to address these concerns using a duration analysis model and available cross-sectional data obtained from rice farmers in rural Sierra Leone.

The later sections of the paper proceed as follows. Section 2 discusses the analytical model, data collection procedures, and the variables used in the analysis. In Section 3, we present the analytical results. Section 4 presents the discussions, and conclusions are provided in Section 5.

2. Materials and Methods

2.1. Duration Analysis

Several studies on technology adoption have focused on a range of socioeconomic factors influencing farmers' adoption decisions including, age, gender, education [17,19,28], farm size, land type, and extension services, and input/output market [34]. Other studies consider farmers' perception of the individual farmer and his/her preferences for technology attributes, notably crop variety attributes as significant determinants of farmers' adoption behaviour. Institutional factors that are beyond the farmer's control and relate to the environment in which adoption occurs are also considered in adoption behaviour. Among these factors, the availability of information networks has been significant, as they allow farmers to collect relevant information for better decisions [32]. Other institutional factors that could influence farmers' decisions about improved technologies are related to fundamental political changes or policies based on agricultural innovation [21]. Also, an emerging body of literature, particularly in the application of agro-ecological and environmental measurements, emphasizes the significance of farmer attitudes in that adoption decision [15,22]. At the same time, the effects of the factors mentioned above on the farmers' decisions to either adopt or failure to adopt could be perceived in respectively opposite directions, which could either be positive or negative.

Most of these studies have employed cross-sectional data to estimate a binary-like model for static analysis of their technology choice decisions [34–36]. Nonetheless, the adoption of technology is a dynamic process that considers time as a crucial factor, and the explanatory variable may change during the observation period [37,38]. Traditional approaches used in analyzing the technology-adoption decision have limitations in their inference about the stochastic adoption process.

This study employs duration analysis. Duration analysis has been applied in the agricultural economics literature. For example, to predict the duration of time to the event of adoption of a given technology by farmers [39], and also the time taken to change from growing one variety to a newer variety of the same crop [40]. The approach can model the potential factors (e.g., agro-ecological locations and the prevailing land ownership) that induce changes (e.g., adoption of improved rice varieties decision) in a decision process. In this approach, the variable of concern is the time length until an occurrence of a certain event (adoption of improved rice variety) (Greene, 2008). The main trust is the probability that a farmer will adopt or abandon improved rice variety at time t, given the farmer has not adopted or failed to adopt at that time. To gain a better understanding, this paper assumes that a farmer whose state as a non-adopter of an improved rice variety but a local rice variety cultivator will end. The farmer is then expected to become an improved rice variety adopter, (ROK or NERICA in our case), which is envisaged to occur at the earliest time interval.

Let T be the total time duration of farming experience. The dependent variable is the years of farming, which is assumed to have a non-negative continuous probability distribution function $g(t)$, indicating the probability of the time taken by a farmer to be at risk of adopting the new rice varieties is less than t. However, the survivor function and hazard function are the key concepts in duration analysis. Since they are based on the cumulative distribution function $g(t)$, there is a relationship between the functions:

$$g(t) = P(T \leq t) = \int_0^t g(s)ds. \quad (1)$$

The survival function $s(t)$, which expresses the probability of the time during which an individual farmer remains a non-adopter can be illustrated as:

$$s(t) = 1 - g(t) = P(T \leq t). \quad (2)$$

The survivor function $s(t)$ denotes the probability that the random variable T is larger than t [37]. $s(t)$ is equal to 1 when $t = 0$ and decreases towards 0 as t tends to infinity [41].

Considering the survival function, $s(t)$, the hazard rate $\delta(t)$ is the instantaneous failure rate that is of concern. It depicts the probability that the time period of being a non-adopter will end in the next short time interval t, only if the individual farmer has survived up to time t given by:

$$\delta(t) = \frac{g(t)}{s(t)}. \quad (3)$$

The hazard function can range from 0, indicating no risk of failure (adoption), to infinity, indicating certainty of failure (adoption) at that time [38,42].

Also, the paper uses the Kaplan–Meier survival function to measure the probability of survival (maintaining non-adopter status) after time t, or the probability of failing (assuming the status of an adopter) after time t:

$$K\left(t_j\right) = \prod_{j|t_{j \leq t}} \frac{R_j - E_j}{R_j} \quad (4)$$

where R_j is the number of farmers at risk at t_j. E_j is the number of failures (farmers that have become adopters) at t_j. Consequently, Equation (4) measures the probability of survival (maintaining non-adopter status) past time t, or the probability of failing (assuming the status of an adopter) after time t.

The paper compares the rates of adoption among farmers based on the hypotheses being tested: that the rate at which rice farmers are adopting NERICA and ROK rice varieties is dependent on (1) farmland location being cultivated, either upland, IVS, or both and (2) farmland ownership structure of the farmer, in terms of sole ownership, rental, or sharecropping. In each case, we test whether survival rates are equal for the two sets of categories and examine which of them adopts the improved varieties faster.

With respect to a parametric approach, proportional hazards (PH) model and an accelerated failure time (AFT) models have been proposed for observing covariate effects in the literature [43,44]. The PH models assume a multiplicative effect of the covariates on a baseline hazard function, whereas the AFT model assumes a direct effect on duration time or the time to the event of adoption rates. In this study, we have used the AFT models not only because observation of the improved rice adoption occurs with the respective covariate violates the Proportional Hazard (PH) model assumptions but for the vital reason of our interest in the direct effects on the time to the event of adoption, which might also assume various distribution patterns. The AFT models can be expressed in a linear functional form, for instance,

$$Logt = \alpha Y + \varepsilon \quad (5)$$

where t is a non-negative random variable denoting the time of event (adopt or abandon); α is a vector of the coefficients of the regression model, Y is a vector of the covariates (explanatory variables), and ε denotes the stochastic error term. As a standard practice in duration analysis literature, the distributional form of the error term and the trend of the hazard rates (probabilities of moving from the state of a non-adopter to an adopter) are the determinants of the type of AFT model to use. For example, if has a logistic distribution, then log-logistic survival regression should be used. Additionally, it is accepted that the Weibull distribution is appropriate for modelling data that show monotonic hazard rates of either increasing or decreasing time trends. As a result, the paper considers a positive coefficient to imply duration of time that increases with changes in the values of variables (i.e., increases the hazard and thus reduces the time to adopt) and a negative coefficient suggests the opposite [37].

Before the above analyses, we conducted a series of statistical analyses, including *t*-tests and chi-square tests to determine any significant differences between the relevant characteristics of adopters and non-adopters. The Holm–Bonferroni probability adjusted some of the chi-square tests in cases where rice farmers gave multiple responses [45].

2.2. Data

The data used in this study were based on a cross-sectional survey conducted on rice farmers in Sierra Leone during April–September 2017 using a well-structured questionnaire. The study comprised data collected from a sample size of 624 rice farmers in 13 rural districts across the four administrative regions of Sierra Leone (Figure 1).

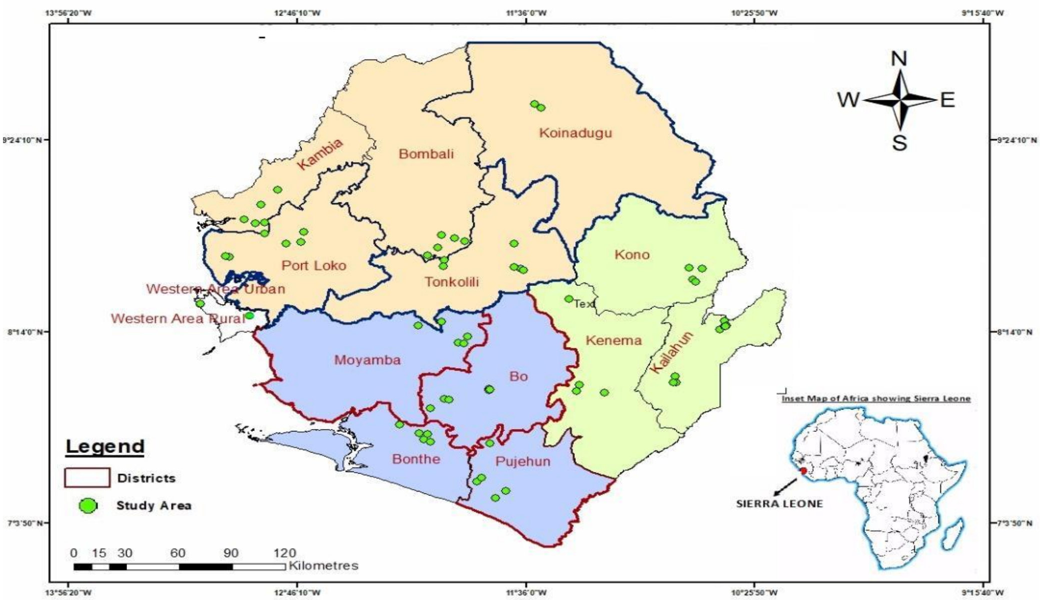


Figure 1. Map of Sierra Leone indicating data collection towns (points) and districts. Source: Authors' survey, 2017.

We employed a multi-stage random sampling technique. The multi-stage random sampling was chosen since the sample size for this survey was appropriate to produce reasonable and precise estimates of particular importance with a geographically defined population [46]. The multi-stage sampling is a multipart procedure of cluster sampling. It is a probability sampling method that is carried out in several stages such that the sample size gets smaller at each step until the ultimate sampling was chosen [47]. In this study, the multi-stage sampling process in this study has involved a random sampling of two chiefdoms from each of the thirteen rural districts. The chiefdoms were selected based on their agricultural potential, accessibility, and operations of the MAFFS. That was followed by a random selection of at least three towns or villages from each of the chiefdoms, making a total of 26 chiefdoms and 87 towns/villages. The towns or villages were selected based on conditions of intense rice farming as the main agricultural activity. Also, issues of the availability of the different agro-ecology in the communities were considered. The third stage involved the random selection of rice farming households proportionately according to the number of farmers in the towns or villages.

At least eight farm household heads (the final units of sampling) were interviewed. An overall sample size of 624 farm households from equal sub-samples of 48 farmers from each district was used.

The survey captured a range of relevant issues on improved ROK and NERICA rice varieties, length of years in farming (this reflects farmers' years of farming and adoption of ROK and NERICA varieties), land ownership, and farmland location. It also included a set of socioeconomic characteristics of farmers, which were anchored as explanatory variables in a way that was reflective of farm households' endowment of the different forms of farm capital. In this study, variables such as the age of farmer, the educational level of the farmer, and farmer's gender signify farm household human capital [39]. These variables were included to control for human capital endowments at the farm level, and they influence both adoption decisions and effective farmland access. Relating to financial capital, we considered farm household income and accessibility to credit facilities, which are considered in the existing literature as factors influencing adoption [17]. Farm income and credits could be used as a means to access improved rice varieties of different morphological traits that best suit the prevailing rice ecosystem, as well as smoothening easy access to farmland for landless farmers. Accordingly, access to income through credit and other farm incomes comprised financial capital. Also included are labour, irrigation facilities, and input/output market to represent physical capital. With regard to social capital, the farmer's access to government extension services, and membership to farmers organisations have been considered as crucial institutional factors. Social capital is hypothesized to be essential in influencing farmers' adoption decisions [15]. As well, it enables the flow of relevant information that may lead to a reduction in search costs of both tenants and landlords in land rental markets [33].

2.3. Descriptive Statistics of Variables Used in Analyses

Table 1 presents the descriptive statistics of the variables used in the analysis. We show the percentage distributions based on the farmer categories of adopters and those surviving as non-adopters. The farmers who adopted a NERICA variety were older in age, earned a higher previous year's income, and also attained a higher level of education compared to non-adopters. This is consistent with a previous study [48]. In contrast, we found no differences between ages, previous year's income, and education level of adopters and non-adopters of ROK varieties.

The results revealed significant differences between non-adopters and adopters of both NERICA and ROK varieties with respect to gender. Also, a significantly greater proportion of adopters of NERICA varieties had access to irrigation facilities than the non-adopters, whereas there was no significant difference between adopters and non-adopters of ROK varieties. There are no differences between adopters and non-adopters of both rice varieties in terms of membership in farmers' organisations and access to credit. Nonetheless, a significantly greater proportion of adopters of both varieties had access to markets compared to non-adopters. Similarly, sources of labour used by proportions of farmers growing both improved varieties differed significantly from those remaining with local rice varieties, except in cases where farmers used inconsistent sources of labour. This implied that sources of labour might influence whether a farmer adopts an improved rice variety.

The use of rented lands was significantly higher among NERICA adopters than farmers still cultivating traditional varieties (Table 1). Additionally, the use of sharecropping as a component of the land ownership structure was more important among non-adopters than adopters of ROK varieties. This was consistent with studies that show a positive and significant impact of secured land ownership rights on investment in farming practices [49,50]. As expected, access to extension services played a significant role in creating awareness of the NERICA varieties. This was because a sizable proportion of the NERICA adopters learned about the varieties through extension services, consistent with studies suggesting that better conditions in the agricultural extension services would have direct and corresponding effects on improved rice adoption [51]. However, our results showed that the friends/neighbours and relatives were more relevant sources of awareness of local rice than of NERICA varieties. A well-coordinated social network can be crucial in addressing supply and demand challenges, such as information deficiencies with respect to technology adoption. We observed no significant differences between sources of awareness of ROK and traditional varieties, likely because ROK varieties were hybrids derived from local rice varieties and might have few dissimilar features.

Table 1. Descriptive statistics of variables employed in the analysis.

Variable	Description	Adopt NERICA			Adopt ROK		
		No	Yes	*t*-Test	No	Yes	*t*-Test
Farmer Characteristics		**Mean**	**Mean**	***p*-Value**	**Mean**	**Mean**	***p*-Value**
AGE	Age of the farmer (years)	42.97	45.17	0.03	44.73	44.40	0.75
TIME	Time to adopt/at risk	14.26	12.48	0.12	13.34	9.41	0.00
INCOME	Previous year's income (million Le) [1]	1.826	4.222	0.00	3.244	3.570	0.65
EDUC	Level of education (years)	3.37	4.53	0.02	4.08	4.21	0.80
Dummy variables		%	%	Chi^2 *p*-value	%	%	Chi^2 *p*-value
GEND	Sex of the farmer, male = 1, 0 otherwise	78.42	70.09	0.03	67.48	74.51	0.08
IRRIG_FAC	Use of irrigation facility = 1, 0 otherwise	6.84	15.42	0.00	15.34	11.87	0.26
FARM_ORG	Farmers' organiations membership = 1, 0 otherwise	85.26	89.25	0.16	85.28	89.01	0.21
CREDIT	Have access to credit = 1, 0 otherwise	27.89	33.64	0.16	28.22	33.19	0.24
MKT_INF	Have easy access to market = 1, 0 otherwise	25.79	48.13	0.00	35.58	43.30	0.09
Sources of labour							
HIRE_COM_LAB	Hired/communal labour	69.27	78.24	0.02	64.85	79.30	0.00
HH_LAB	Household labour	5.21	9.26	0.09	11.52	6.75	0.05
HH_COM_LAB	Household and communal labour	23.96	11.57	0.00	22.42	12.85	0.00
INCONSIS_LAB	Inconsistent labour source	1.56	0.93	0.49	1.21	1.09	0.90
Farmland ownership							
LAND_OWNED	Land owned by farmer	68.33	61.85	0.13	59.01	65.71	0.13
RENTAL_L	Rented land	23.89	33.17	0.02	30.43	30.24	0.96
SHARE_CROPP	Share cropping	7.78	4.99	0.19	10.56	4.05	0.00
Source of awareness							
EX_SERV	Extension services	30.56	63.34	0.00	54.66	52.62	0.66
FRD_NGB_REL	Friends/neighbours/relative	65.00	31.67	0.00	42.86	41.67	0.80
RADIO_TV_R	Radio/television/research stations/others	4.44	4.99	0.78	2.48	5.71	0.10
Location of farmland							
UPLAND	Upland areas	40.56	7.98	0.00	12.42	20.24	0.03
IVS	Inland valley swamps	40.56	48.88	0.06	65.84	38.81	0.00
UPLAND_IVS	Both inland valleys and uplands	18.89	43.14	0.00	21.74	40.95	0.00
Observation		186.00	412.00		161.00	437.00	

[1] Sierra Leonean currency, the Leone (Le); at the time of data collection Le7500 = US$1. Source: Authors' survey, 2017.

Also, there were significant differences in the location of farmland between adopters of improved rice varieties and non-adopters. For instances, a greater number of local rice variety growers were located in upland regions compared with NERICA adopters; however, the opposite was the case for ROK adopters and non-adopters. More NERICA adopter farmers were found in IVS than non-adopters, and non-adopters of the ROK variety showed a more significant presence in IVS than adopters. Also, a greater proportion of farmers with farms located in both uplands and lowland regions tended to adopt the improved compared with local rice varieties. The implication of these observations was that farmland location might be an essential determinant of whether farmers will adopt improved NERICA and ROK varieties.

Next, we examined the initial sources of NERICA and ROK varieties among farmers. Comparing NERICA and ROK varieties showed that a substantial percentage of farmers acquire their first seed rice from external sources (Table 2). It is noteworthy that about 76% of the farmers obtained their first NERICA seeds from the Ministry of Agriculture Forestry and Food Security (MAFFS), exceeding the 60% for ROK.

Table 2. Sources of first improved seed.

Source of First Improved Seed	NERICA			ROK		
	Non-Adopters	Adopters	chi^2/p *	Non-Adopters	Adopters	chi^2/p *
MAFFS	27.86	76.56	0.00	76.15	60.10	0.00
SLARI	1.43	2.00	0.67	3.08	1.46	0.70
Own produce	3.57	5.74	0.32	6.15	4.87	0.56
Other farmers	11.43	2.74	0.00	3.08	5.60	0.50
Purchased	55.71	12.97	0.00	11.54	27.98	0.00

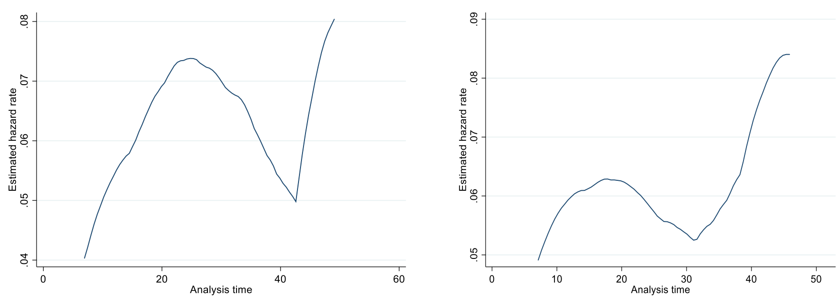
***,** Value herein are the p values of the chi^2. Source: Authors' survey, 2017.

Similarly, there were significant differences between farmers that adopted both NERICA and ROK varieties and those who have not, with reference to the initial source of purchased seed. However, there were no significant differences between the two adopter categories (NERICA and ROK) and the corresponding non-adopters in line with obtaining seed rice from Sierra Leone Agricultural Research Institutes (SLARI) and own-produce sources. Also, the results indicated that a significantly greater percentage of farmers who adopted NERICA obtained their seeds from other farmers in their social network. It is also interesting that the category of ROK showed no significant difference between adopters and non-adopters in terms of other farmers (network) as a source of first ROK seed. Nonetheless, the most important and prominent source of first improved seeds included MAFFS, purchase, farmers' own production, other farmers, and SLARI, in that order.

3. Results

3.1. Non-Parametric Analyses

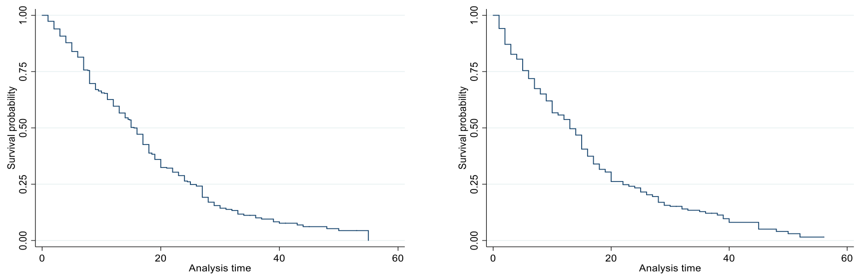
Graphical representations of the hazard estimates for farmers shifting from cultivating local varieties to adopting NERICA and ROK varieties are given in Figure 2A,B, respectively. The figures show undulating patterns of duration or time dependence. Specifically, the instantaneous risk of a local rice farmer adopting a NERICA or ROK variety rose from about six and eight years of farming, respectively. Among farmers adopting a NERICA variety, the rise reached an initial peak at about 25 years of farming, then continually decreased until 45 years, and then persistently increased until nearly 60 years. Similarly, the change from growing traditional to cultivating ROK varieties reached its initial peak at 18 years of farming and then declined until 32 years before increasing again.



(**A**) (NERICA) (**B**) (ROK)

Figure 2. Smooth hazard estimates for the adoption of (**A**) NERICA and (**B**) ROK varieties. Source: Authors' survey, 2017.

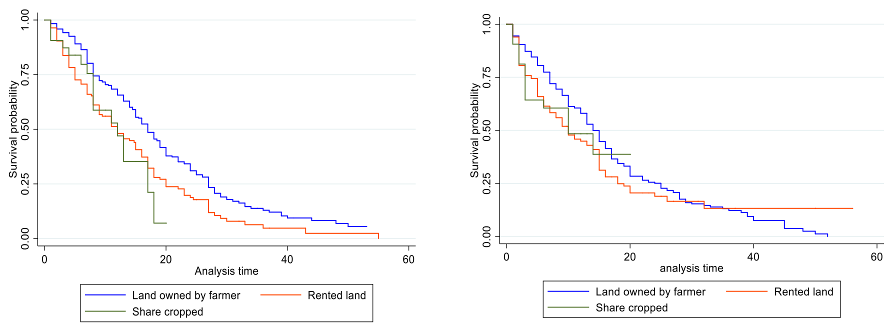
The Kaplan–Meier estimates of survival functions of adoptions of NERICA and ROK varieties, and the survival rates of non-adopters with respect to both improved varieties are shown in Figure 3A,B, respectively. The survival estimates for the adoption of both NERICA and ROK showed nearly similar trends. The chances of survival as a non-adopter of improved rice varieties were slightly weaker in terms of adopting ROK than NERICA varieties. In other words, farmers adopted ROK more swiftly than NERICA varieties, and the rate of adoption of new varieties increased as the survival rate decreases with years of farming. This again showed that the farmers were at slightly higher risk of adopting ROK than adopting NERICA. Empirically, therefore, the rate at which farmers were becoming ROK and NERICA adopters was slow in Sierra Leone. The implication was that several farmers would continue to cultivate local rice varieties for a long time unless some structural policy interventions occur.



(**A**) (NERICA) (**B**) (ROK)

Figure 3. Kaplan–Meier survival estimate for the adoption of (**A**) NERICA and (**B**) ROK varieties. Source: Authors' survey, 2017.

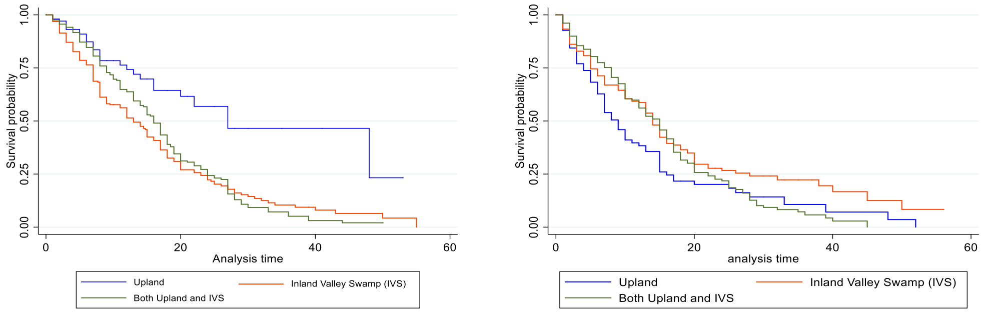
This study further examined whether conditions such as differences in land ownership arrangements and location of farms either in lowlands or uplands influenced the survival of cultivation of traditional varieties or adoption of improved rice varieties. Farmers who cultivated their own land had higher survival rates as growers of local rice compared to adopting improved varieties (Figure 4A,B). In contrast, farmers who rented land or engage in sharecropping have higher adoption rates of improved rice varieties. Thus, farmers who owned farmland had a greater tendency to remain as local rice growers, but those who rented farmland or practice sharecropping adopted both NERICA and ROK varieties faster. The chi-square test for equality in survival functions showed significant differences between adoption rates of NERICA and ROK varieties for the different land ownership structures (Table A1 in Appendix A). Thus, type of land ownership may have implications for adoption rates of improved varieties. However, there were no distinct differences in the survival functions for ROK varieties (Table A1 in Appendix A). This indicated that land ownership structure used by the farmer might affect the adoption of NERICA but not ROK varieties. Consequently, policies intended to influence improved rice adoption should consider the land ownership structure practised by farmers.



(**A**) (NERICA) (**B**) (ROK)

Figure 4. Survival curves for the adoption of (**A**) NERICA and (**B**) ROK varieties by land ownership structure. Source: Authors' survey, 2017.

In line with the location of farmland, farmers cultivating rice in upland areas had the highest survival of cultivating local varieties than changing to improved NERICA varieties significantly (Figure 5A,B). Thus, these farmers also had the lowest rates of changing from the state of cultivating local rice to adopting NERICA varieties. That observation contrasted with farmers located in IVS and those cultivating both IVS and upland regions. Farmers in IVS were more likely to adopt NERICA varieties quickly than those cultivating upland regions; however, beyond 30 years of farming, the individuals cultivating both uplands and IVS were more likely to adopt NERICA varieties faster than those located in uplands or IVS only.

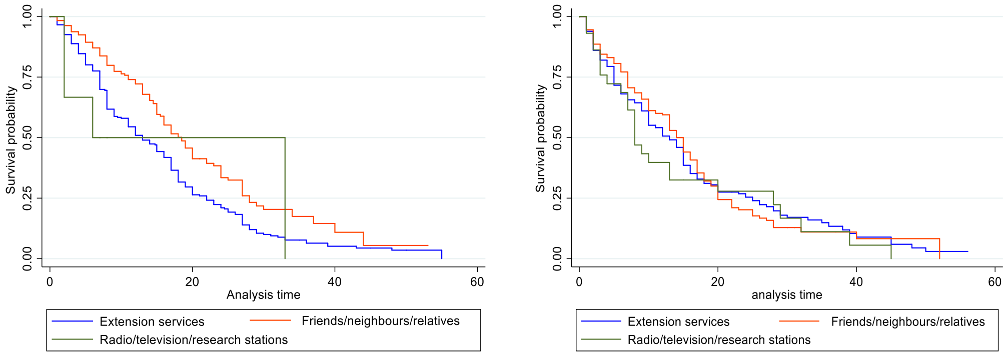


(**A**) (NERICA) (**B**) (ROK)

Figure 5. Survival curves for adoption of (**A**) NERICA and (**B**) ROK varieties according to farmland location. Source: Authors' survey, 2017.

In contrast, within the first 25 years, the ROK varieties were adopted faster in upland regions, and so the survival of cultivating the local varieties was lower (Figure 5B). However, after 25 years, farmers in both uplands and IVS had the swiftest adoption rate of ROK varieties. In general, individuals in uplands had higher survival rates of growing traditional varieties than adopting ROK varieties. In summary, farmers in IVS were more likely to adopt NERICA varieties faster, and farmers in upland regions adopted ROK varieties faster. Farmers with access to both uplands and IVS adopted both NERICA and ROK varieties the quickest. However, survival rates for growing local rice varieties remained high, and adoption rates were low. Furthermore, the chi-square test for equality in survival functions showed significant differences between adoption rates of NERICA and ROK varieties for the different agro-ecological location of farmland. Thus, type or location of farmland may have implications for adoption rates of improved varieties (Table A1 in Appendix A).

Moreover, we considered whether a farmer's sources of information about improved rice varieties influence adoption rates of ROK and NERICA varieties. The survival curves (Figure 6) were based on whether a farmer accessing information on the rice varieties from agricultural extension agents or networks (friends/neighbours/relatives) or from the media and other sources (radio/television/research stations/others) has some influence on the adoption of improved varieties. At any given time, the survival rates of not adopting of NERICA and ROK varieties varied. However, in general terms, farmers who access information through extension agents had a higher tendency to adopt NERICA varieties, whereas the media and other sources induced more rapid acceptance of ROK varieties. Irrespective of this overall observation, the test results for equality in the survival functions revealed that they significantly differed in terms of adoption of NERICA but not ROK varieties (Table A1 in Appendix A). As a result, it was important that those policies targeting increases in rice outputs through adoption of NERICA varieties should consider the dynamism of sources of information concerning the rice varieties employed by farmers.



(**A**) (NERICA) (**B**) (ROK)

Figure 6. Survival curves for the adoption of (**A**) NERICA and (**B**) ROK varieties on the source of awareness. Source: Authors' survey, 2017.

3.2. Parametric Analyses

In this section, we investigated some factors influencing the rate of adoption of improved varieties or the survival time of cultivation of traditional rice varieties. To ensure robustness of the models, we examined the appropriateness of distribution patterns of changing from old traditional varieties to adopting improved varieties. Considering the smooth hazard distributive patterns in Figure 2, the proportional hazard (PH) function was improbable. This was confirmed by the probability value p of the Weibull estimates not being equal to 1.

We, therefore, assumed adoption as a human behavioural activity, which most often than not, was a random event. As a result, we adopted the parametric analyses of the AFT model because our primary investigations showed no proportional hazard distributional patterns. Hence, we considered a positive coefficient to imply that duration increases (and a negative coefficient suggests decreases) with changes in values of the variables.

Next, we confirmed the AFT distributional choices by conducting some basic tests of log-likelihood, the Akaike information criterion (AIC) and Bayesian information criterion (BIC), as well as the Wald test for ancillary values of the gamma distribution (Tables A2 and A3 for adoptions of ROK and NERICA varieties, respectively). These results showed that the Weibull and generalized gamma distributions were the most appropriate distributions of the adoption events. We, therefore, reported the parametric analyses of AFT models for the two distributional patterns.

Table 3 reports the AFT estimated results on factors influencing the adoption of ROK and NERICA improved varieties. The explanatory variables used in the models showed positive and negative coefficients, denoting that some variables led to faster adoption, but others increased the time taken. The results indicated that an increase in years of education led to a significant decrease in time taken for an individual farmer to adopt improved varieties, particularly NERICA. Thus, farmers with more years in school were more likely to abandon traditional varieties and adopt NERICA varieties within a shorter time than farmers with fewer years in school. These findings corroborated those of Murage et al. (2011) that farmers with increasing years of education adopted new technology faster than their counterparts. Additionally, the older the farmer, the longer it took to give up old varieties to adopt new ROK and NERICA varieties. Thus, older farmers adopted improved rice varieties more slowly than younger farmers.

Table 3. Accelerated time failure models of adoption of NERICA and ROK rice varieties.

Time	ROK				NERICA			
	Weibull		Generalized Gamma		Weibull		Generalized Gamma	
	Coefficient	Std. Err.	Coefficient	Std. Err.	Coefficient	Std. Err.	Coefficient	Std. Err.
EDUC	−0.03	0.03	−0.03	0.03	−0.05 *	0.03	−0.04	0.02
AGE	1.53 ***	0.16	1.53 ***	0.17	1.55 ***	0.13	1.53 ***	0.12
INCOME	0.08 **	0.04	0.08 **	0.04	−0.02	0.03	−0.03	0.03
GEND	0.09	0.09	0.09	0.09	0.29 ***	0.07	0.26 ***	0.06
FARM_ORG	−0.25 **	0.12	−0.25 **	0.12	−0.32 ***	0.10	−0.30 ***	0.09
CREDIT	−0.07	0.08	−0.07	0.09	0.06	0.07	0.06	0.06
MKT_INF	0.08	0.08	0.08	0.08	0.04	0.07	0.04	0.06
IRRIG_FAC	0.08	0.12	0.08	0.13	−0.01	0.09	0.01	0.08
Source of labour [1]								
HH_LAB	−0.12	0.15	−0.12	0.15	−0.21 **	0.11	−0.22 **	0.10
HH_COM_LAB	0.34 ***	0.13	0.34 **	0.13	0.18 *	0.10	0.18 *	0.10
INCONSIS_LAB	0.14	0.32	0.14	0.33	0.59	0.40	0.57	0.39
Land ownership [2]								
RENTAL_L	−0.21 **	0.09	−0.21 **	0.09	−0.07	0.07	−0.03	0.07
SHARE_CROPP	−0.30	0.19	−0.30	0.19	−0.29 **	0.14	−0.27 **	0.13
Location of farmland [3]								
IVS	0.34 ***	0.12	0.34 ***	0.12	−0.35 **	0.13	−0.36 **	0.13
UPLAND_IVS	0.28 **	0.11	0.28 **	0.11	−0.27 **	0.13	−0.30 **	0.13
Source of knowing the variety [4]								
FRD_NGB_REL	0.10	0.09	0.10	0.09	0.37 ***	0.07	0.35 ***	0.07
RADIO_TV_R	−0.27	0.16	−0.27	0.16	−0.10	0.15	−0.10	0.13
Constant term	−3.26 ***	0.63	−3.25 ***	0.68	−2.75 ***	0.52	−2.56 ***	0.49
LR chi^2	129.77 ***		128.55 ***		196.27 ***		199.28 ***	
/ln_p	0.36 ***	0.04			0.59 ***	0.04		
p	1.43	0.06			1.81	0.08		
$1/p$	0.70	0.03			0.55	0.02		
/ln_sig			−0.36 ***	0.08			−0.74 ***	0.09
Sigma			0.70	0.06			0.48	0.04
/kappa			1.01 ***	0.21			1.39 ***	0.22

Note: The dependent variable is time (time taken by a farmer to adopt); [1] we compare to household/communal labour (HIRE_COM_LAB). [2] We compare to land owned by the farmer (LAND_OWNED). [3] Upland is the reference point (UPLAND). [4] Agricultural extension services is the reference point (EX_SERV). *, **, ***: denote significance at the 0.1, 0.05, and 0.01 level, respectively. We also use 'Std. Err.' to define 'Standard Error' in the regression table. Source: Authors' survey, 2017.

The analyses also showed that with higher income, it took significantly longer to adopt ROK varieties compared to NERICA; however, the results were insignificant with respect to the adoption of NERICA varieties. Also, the sex of the farmer is essential for the adoption of the NERICA, such that it will take the male farmers a longer time to adopt the improved variety than the female counterparts. Thus, it is probable that the female farmers might use a shorter time to give up the old varieties for the NERICA than males. This finding, therefore, considered sex as a decisive factor influencing adoption and that being female increased the conditional probability of adopting improved rice varieties in Sierra Leone. Farmers belonging to farmers' organisations adopted improved varieties faster than their counterparts, implying that if more farmers were members of farmers' organisations then there would be more progress in adoption of improved rice varieties and a more rapid decline in continuous cultivation of traditional rice.

Also, farmers using only household labour (HH_LAB) were likely to adopt the NERICA varieties faster than those combining both hired and communal labour (HH_COM_LAB); however, this observation does not hold for adopting ROK varieties. On the contrary, farmers with access to both household and communal labour took longer to adopt the ROK and NERICA varieties than when using the combined labour source of hired and communal. This was likely because it took time to harness communal labour and each farmer has to wait their turn, which meant delays in farm operations, regardless of the cost of hired labour, whereas household labour ensured timely farm operations.

Farmers using rented land were adopting ROK varieties within a shorter time than those cultivating their own land. On a similar note, farmers using sharecropping adopted NERICA varieties at a faster rate than those who own the land. Thus, the land ownership structure of the farmer played a significant role in determining their rates of adoption of improved rice. Many previous studies suggest that lack of land ownership hinders adoption of agricultural technology [33,50,52,53], but this is not the situation for improved rice varieties. Our study reveals that land ownership does not increase crop variety adoption, but sharecroppers and rental show more adoption, similar to an empirical analysis of Ethiopian maize farmers [33]. As the gains from improved crop varieties are extensive in the existing literature in Africa, it is crucial to understand the role that sharecropping and renting plays in encouraging adoption of improved varieties, which makes the current study policy-relevant.

Our results showed that depending on friends/neighbours/relatives for awareness of rice varieties does influence adoption of ROK varieties, but such networks led to a significantly longer time for farmers to adopt NERICA varieties than when they source their information from extension services. Thus, extension services are more important for quicker adoption of NERICA varieties than any other available networks. Extension greatly influences the adoption behaviour of farmers, it is one institutional factor greatly influencing the adoption behaviour of farmers and ensures the supply of needed information and reinforces strategies that ultimately lead to technology adoption [54].

Our analyses indicated that individual farmers cultivating IVS took longer to adopt ROK varieties than those in upland areas. That meant that ROK varieties were being adopted in upland ecological regions quicker than in IVS. Even for farmers with farms in both upland and IVS, it took longer to accept cultivating ROK varieties than when limited to uplands only. In contrast, farmers located in IVS were adopting NERICA varieties more quickly than their counterparts in upland territories. Similarly, owning farms in both IVS and uplands encouraged swifter adoption of NERICA varieties. These observations were consistent with the non-parametric observations of Figure 5. The implication is that NERICA varieties have a better potential for faster adoption by farmers in both IVS and upland ecologies than ROK varieties.

In sum, the paper does not reject the hypothesis that rates of adoption of the improved rice varieties of the ROK and NERICA varieties are dependent on location of the farmers' farmland. Also, the results favour the assertion that the rate of adoption of improved rice varieties depends on the land ownership structures of the farmers, and on membership of farmers' organisations, source of awareness of varieties, and sources of labour.

4. Discussions

The findings provide insight into the influence of land ownership and agro-ecological locations on the adoption rate of improved rice varieties. The analyses have indicated that the possibility for farmers to adopt improved rice varieties, notably NERICA and ROK varieties starts from about six and eight years of farming, respectively. The implication might be that the farmers' changeover from the old varieties to the improved varieties in Sierra Leone is occurring at a prolonged rate, and it is likely to take long years of farming to have a full pledge adoption. That is to say that farmers cultivating local rice might not have the drive of adopting improved rice varieties for a long time devoid of the kind of incentive to motivate improved rice variety adoption. These findings corroborate with some previous assertions in the exiting literature that the adoption of improved agricultural technologies (notable rice) seems to be slow. Still, rather, most farmers consider local rice varieties as a critical element of their livelihoods and want to maintain them over time [28]. The reason might be that such varieties are easily accessible, adaptable to the farming and agro-ecological conditions, as well as conformable to the social values and crop quality preferences of farmers.

The study also provides evidence that farmers normally dis-adopt if they believe the improved technologies unprofitable because suitable varieties for the farmers' agro-ecological conditions are unavailable [28]. Otherwise, farmers may choose the attributes they found in local varieties. That implies that the rate of adoption of improved rice varieties is likely to increase if the farmers' perception of NERICA and ROK varieties is consistent with the local varieties they are used to cultivating. That is likely to be perceived during the waiting-adoption-time. The results also point out a clear distinction between upland and lowland varieties. That confirmed the effectiveness of farmer choice of rice varieties concerning the two agro-ecosystems. The analysis also confirmed that both local and improved rice varieties had the potential to grow in both locations. However, cultivating rice in both locations (upland and IVS) has significantly influenced the choices of cultivating the local rice varieties than adopting NERICA and ROK, respectively. That notwithstanding, the farmers found in the inland valley swamp areas are more likely to adopt the NERICA variety quicker than those cultivating the upland location. It is, therefore, crucial to understanding the potential of local varieties, as well as the development of new varieties, and the upkeep of genetic resources of NERICA and ROK varieties for future use.

While many previous studies indicate that the existence of land ownership encourages the adoption of improved technology [39], this is not the case for improved rice varieties. The results illustrate that farmers who cultivate their lands tend to continue with the cultivation of more local rice varieties than the adoption of improved rice varieties. Similarly, the farmers who rented the farmland or have engaged in sharecropping arrangements were observed to have high adoption rates of the improved rice varieties. That means that a stable landownership structure is an essential condition for a faster changeover of farmers into the adoption of improved rice varieties. Likewise, a unit increase in the landholdings by landowners decreases the time to the event of adopting improved rice varieties, since a higher asset value-base of the farmers might imply a greater capacity to adopt improved rice varieties. Thus, farmers with limited access to farmland are more likely to adopt but at a slower pace. The benefits of the adoption of improved rice varieties are widely recognized in the existing literature as a possible means of welfare improvement in Africa. Hence, it is necessary to re-assess the relevance of land ownership as a means of encouraging improved rice variety adoption, which makes the current study policy-relevant. The results of recent studies Empirical study of Zeng [33] offers strong support of these findings.

Furthermore, the study examines how the network of farm holders through government extension services, farmer-based organisations (FBOs), air media, and research institutions affects the distributive patterns of the survival functions. Generally, the findings have shown that farmers who accessed information through extension agents have a higher tendency of adopting the NERICA. In contrast, the media and other sources induce the acceptance of the ROK faster. We suggest that the farmers who contact extension agents and are involved in the activities of FBOs and the village network will graduate more quickly in adopting improved rice varieties than those who do not. Various researchers observed that the farmers with a regular extension contact are more willing to adopt new agricultural varieties [28,34,54]. As a result, it is essential that those strategies targeting increases in rice outputs through the adoption of NERICA should consider the dynamism sources of information of the rice varieties employed by the farmers.

The findings also recognize the effect of socio-economic variables, notably age, education, gender, and income. We suggest that the older the farmers, the longer the years it will take to give up the old varieties to adopt the new varieties of the ROK and the NERICA. That implies that an increase in the farmer's age would result in fewer chances of improved rice variety adoption [19,28,36]. On a similar note, the adoption of improved rice varieties could be regarded as a managerial concern that requires specific skills, which are often gained through education. Related to this study, the relevance and appropriateness of education make easy the introduction of innovation and in influencing farmers' decisions to adopt improved rice varieties. That means that the higher the educational level of farmers, the more likely their adoption decisions. The finding is constant with Ghimire et al. [28], who revealed a significant and positive relationship between education and new rice technology adoption. Also, the significance of gender in increasing the adoption rate of improved rice varieties has been investigated. Females often have limited resources; hence, male-headed farm households can invest better effort on their farms for better rice production [51]. However, this study suggests that it will take the male farmers a longer time than the female counterparts to adopt NERICA. That indicates that female-headed households can influence adoption decisions as well, irrespective of the constraints.

5. Conclusions

In this paper, we employed a comprehensive survey data and survival analyses approach to investigate whether land ownership structures and farmland locations influence the adoption rate of the two main sources of improved rice varieties (NERICA and ROK) as well as the local varieties in Sierra Leone. The land ownership structure considered comprised of rightful land ownership, sharecropping, and land rental arrangements. We also included upland and lowland (particularly, IVS) as the two main agro-ecologies for rice production in Africa. Our analysis employed variations in the different land ownership arrangements and farmland locations to compare adoption patterns of improved rice varieties as well as rates of survival of old varieties among farmers. This provided the study with a good basis to understand how land ownership structure and farmland location of farmers could determine the adoption and the rate at which farmers are changing from local low-yielding to high-yielding varieties.

The empirical results revealed that the adoption rate of improved rice varieties depended on the land ownership structures practised by farmers, location of farmland, and source of awareness of the varieties among others. In particular, the results also showed that farmers using rented land adopt ROK varieties within a shorter time than those cultivating their own land, whereas farmers using sharecropping adopt NERICA varieties faster than farmers cultivating their own land. Thus, land ownership structures of farmers played a significant role in determining the rates of adoption of improved rice among farmers. Similarly, we found that those farmers cultivating IVS took longer to adopt ROK varieties, but they adopt NERICA varieties more quickly. Thus, in contrast, upland farmers adopted the ROK faster than NERICA varieties. Nonetheless, farmers owning multiple farm sites in both uplands and IVS took longer to adopt ROK varieties than when limited only to uplands, implying that NERICA varieties have better potential for rapid adoption by farmers in both IVS and upland ecologies compared to ROK. The results also revealed that adoption rates of improved rice varieties in Sierra Leone were low, and cultivation of local varieties was likely to survive for a long time.

The results have important policy implications for secure land use, a crucial issue in many African countries, particularly Sierra Leone where farmland ownership structures are quite inconsistent, and farmland location is critical in decisions among rice farmers. First, tenancy should be legalized, and an approved process should be allowed where the terms and conditions of land use and ownership rights (for instance, through sharecropping and rental) are formal and bound by law. Although our findings do not confirm the results of other studies, the influence of credible land use and ownership rights on investment in improved technology remain unchanged. For instance, Abdulai et al. (2011) argue that farmers on rental and sharecropping contracts are less likely to attract investments in soil-improvement practices (mulch and organic manure) compared to farmers who own land with secure ownership structure. However, several studies confirm that sharecropping and rental farmers are more likely to invest in yield-increasing technologies [33,55,56]. Secure land use systems (likely through land rental and sharecropping) promote farm productivity and significantly improve the welfare of land-constrained farm households [56]. Our study showed evidence that secure land use and ownership rights could help to enhance rice production in Sierra Leone since communal land ownership can slow adoption of improved varieties.

Second, careful government intervention through a better and well-organized land use contract market could remove local restrictions on land rental, as well as potentially incentivize farmers to participate in long-term land investments. Muraoka et al. (2018) attribute the increasing access to land through effective land rental markets by those who are productive but own little or no land, to farmers' cultivation of additional land that has positive effects on household income and food security. Our study supported their results in regard to issues of more land remaining uncultivated and landless farmers being unable to access land in Sierra Leone are probably due to insecure land use structures. The implication is that if uncultivated land and limited access to farmland by landless farmers in Sierra Leone limits rice production and food insecurity, then there is a need for an effective land use contract market to address issues of insecure land use and ownership rights. We submit that such policy should be preceded by detailed discussions of possible historical land claims with landowners before any negotiations of the transfer of land ownership rights. This could prevent conflicts over land use and ownership rights and also allay fears by landowners over claims by potential tenants, as well as the tenants concerning eviction from land by landowners, which can restrain large-scale investment on farmland [29].

Third, farmland locations of upland and IVS in Sierra Leone influenced the type of varieties that a farmer selected to adopt, suggesting policy implications in encouraging adoption of improved rice varieties. This included intensifying the development of farmland location-appropriate technologies (such as farmland-specific varieties) as well as providing access to infrastructure, such as irrigation facilities, as the Sierra Leone rain-fed farming system remains largely unirrigated. Studies suggest that an effective irrigation system could help farmers withstand uncertain weather conditions [2,57] and allow farmers, particularly in Sierra Leone, who are restricted to one season (rain-fed) farming to cultivate a year-round second or third crop of rice. We also suggest that improved rice varieties have low adoption rates and cultivation of local rice varieties is likely to continue for a long time unless some structural policy interventions are made in the Sierra Leonean Agricultural sector.

Author Contributions: The authors contributed significantly to the discussion and the outcome of the manuscript. B.M. developed the concept and framework, administered the data collection, and prepared the manuscript. G.S.A.H. supported the conceptualization and formal analysis. S.J. supervised the entire process and validated the quality of the manuscript.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Test for equalities in survival functions by farmland ownership, location, and source of awareness about improved rice varieties.

	NERICA		ROK	
	Observed	**Expected**	**Observed**	**Expected**
Farmland ownership				
LAND_OWNED	243.00	281.01	251.00	268.19
RENTAL_L	126.00	95.00	103.00	88.23
SHARE_CROPP	19.00	11.99	16.00	13.58
Total	388.00	388.00	370.00	370.00
Chi-square (probability)	20.86 (0.00)		4.35 (0.11)	
Location of farmland				
UPLAND	30.00	61.57	76.00	59.23
IVS	187.00	162.28	147.00	167.62
UPLAND_IVS	171.00	164.15	147.00	143.14
Total	388.00	388.00	370.00	370.00
Chi-square (Probability)	21.49 (0.0)		7.93(0.01)	
Source of awareness				
EX_SERV	243.00		204.93	190.00
FRD_NGB_REL	126.00		165.02	154.00
RADIO_TV_R	4.00		3.04	25.00
Total	373.00		373.00	370.00
Chi-square (probability)	17.77 (0.00)			0.89 (0.64)

Table A2. Tests of log-likelihood, AIC and BIC, and the Wald test for ancillary values of the gamma distribution (ROK).

	Exponential	Weibull	Log Normal	Log Logistic	Generalised Gamma
Log likelihood	−581.42	−552.33	−565.76	−562.43	−552.33
AIC	1198.83	1142.67	1169.51	1162.87	1144.67
BIC	1273.93	1221.93	1248.78	1242.13	1228.10
/kappa (standard error)					1.01(0.21)
Wald's test					
kappa = 1(chi-square Pro)					0.00 (0.96)
kappa = 0(chi-square Pro)					24.04 (0.00)

Table A3. Tests of log-likelihood, AIC and BIC, and the Wald test for ancillary values of the gamma distribution (NERICA).

	Exponential	Weibull	Log Normal	Log Logistic	Generalised Gamma
Log likelihood	−548.43	−473.22	−505.03	−494.73	−471.22
AIC	1132.85	984.44	1048.06	1027.46	982.44
BIC	1209.25	1065.07	1128.70	1108.10	1067.33
/kappa (standard error)					1.39 (0.22)
Wald's test					
kappa = 1(chi-square Pro)					3.16 (0.08)
kappa = 0(chi-square Pro)					40.53 (0.00)

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