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Effects of Self-Selection on Transaction Costs Economics through Sustainable Agro-Ecosystem Irrigation

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Abstract

The study relied in the effect of self-selection on transaction cost economics through sustainable agro-ecosystem irrigation, from cross-section and longitudinal data collection methods obtained at household level and group level records in each irrigation scheme. Heckman selection model and mixed effect model were used to analyze data, which were collected using a well-prepared record sheet form, which obtained recorded information by the scheme over the period of ten years (2009-2018) to compare groups dynamics and individual effects (heterogeneity) on institution quality across the schemes over time period. Findings show that self-selection effect has greater impact on farmers' survival, and transaction costs related to contact, contract and control influence institutional quality in agro-ecosystem irrigation group members. The study concludes that self-selection effect factors are important criteria for collective action member recruitment, and that the institutional quality is improved by managing transaction costs.

Keywords

Self-Selection, Transaction Costs Economics, Sustainability, Agro-Ecosystem Irrigation

1. Introduction

A sustainable economy activity generally refers to the continued, intensive activity that promotes the standard of living in a specific area (Gelashvili et al., 2020; Pankov et al., 2021). Agriculture sector has an exceptional opportunity to transform itself from subsistence to a modern and highly commercial sector (Florián

Castillo et al., 2022; Chowdhury et al., 2019). Irrigation has an important role to play in the realization of the primary objectives of re-energized agriculture and water sectors. Sound irrigation development has the potential to transform the predominantly traditional subsistence rain-fed systems into profitable, mixed scales (small, medium and large) and commercial operations environmentally. Self-selection in the study explains that farmers engaged in irrigated agriculture tend to make choices related to their preferences in terms of irrigation and rainwater of the farming system type and the surrounding available livelihood opportunities. Based on observed and unobserved (heterogeneity) characteristics (Shahzad & Abdulai, 2021), choices are often influenced by the economic opportunities surrounding them. The specific identification of self-selection factors is essential to understand the behavior of irrigation farmers and to develop recruitment and retention strategies for irrigators. Self-selection farming members are committed to playing a greater role in the irrigation system (Chang et al., 2017). The regression model includes many explanatory variables in the exclusion constraints (to avoid the collinearity problem) (Breunig, 2021), determines farmers' behavior through sample selection, and studies the influence of self-selection effect on farming type selection commitment.

Objective of this study was the effect of self-selection on transaction costs economics through sustainable agro-ecosystem irrigation. The null hypothesis that Self-selection factors and transaction costs do not affect participation of farmers in agro-ecosystem irrigation, where results indicate that null hypothesis that transaction costs as governance mechanisms, market factors and rainfall characteristics do not influence institutional quality in irrigation groups was rejected.

According to Rindfleisch (2020), transaction comprises a legal transfer of ownership, which, include exchange of rights and duties it correlates law, economics and ethics. As such, collective action involves varying degrees of transaction costs in order for the farmer organizations to function and realize benefits from efficient coordination of resource utilization (Busse et al., 2021). The coordination of economic activities creates costs due to imperfection and uncertainty in the economic system. According to Schmidt and Wagner (2019), transaction costs have been grouped into three categories of costs 1) contact costs, which are related to search and information cost aspects. 2) Contract costs, which comprise negotiation issues and concluding contracts such as service costs of an agent, and 3) control cost, which entails monitoring and enforcement costs to ensure compliances of the agreements among parties. Thus aim of this study was to fill such gaps by analyzing in detail the serf-selection effect and transaction costs of collective action and the factors behind the institutional quality influence on the pineapple irrigation systems performance in the Lake Mugesera basin of Rwanda. In particular, evaluate the attitudinal behavior among farmers and the nature of collective action survival: self-selection effects, commitments there in and transaction costs involved and institution quality status, building on

the work of Carlton (2020), and the various studies e.g. Li and Fang (2022), and Deng and Zhang (2020). The two-step regression of Heckman selection model and mixed effect model were used in this study (Cerulli, 2014).

1.1. Theoretical Review

Worldwide, natural resources management, particularly common natural resources (common pool resources) like irrigation systems management is studied based on self-selection farming theory (Sabates-Wheeler, 2002). Self-selection farming consist institution design with principles, which are thought to motivate the successful resource management. Some of these self-selection farming institution design principles consist of a list of attributes such as social identity and resource importance for users, availability and predictable condition for the resources e.g. sustainable irrigation system and functional predictable physical state, congruence between the rules linking social structure, ecology and technology, self-selection decision making (Wannaviroj & Sriburi, 2019). It is acknowledged that self-selection farming theory seeks to understand how individuals in groups cooperate to undertake their common concern, given that they are self-interested and the conditions under which the interaction takes place is full of uncertainty (Sabates-Wheeler, 2002). The argument is that individuals treat more carefully when they own the resource, because the returns generated by the possession of the resource accrue to them and not to others. This notion of property rights is important in rights appropriation (assigning property rights) to legitimize members on resource utilization there by excluding non-members, but not sufficient condition to overcome the problem of self-selection farming, because an individual using the resource might not necessarily be the owner due to the right of disposal, the owner can legally transfer temporarily part of his/her bundle of property rights control to someone else. For example, renting out or in the land within the irrigation command area; hence this may result into inefficiency in contributions commitment because may not necessarily continue the activity in the subsequent period.

In this regard, the theory of property rights has ignored the individual incentives, and other important drivers in the self-selection farming coordination such as issues of self-selection effects, perceptions and non-tangible aspects, because group benefits are inherently shared based on lumped self-selection incentives in the common property rights (Vyrastekova et al., 2012). However, Mitani and Shimada (2021) put forward additional elements in the theory of property rights as facilitating factors to enhance overcome the self-selection farming problem in the common. The additional elements are external forces such as aid, enforcement of rules, and leadership with broad experience. Game theory is another paradigm, which has extensively been used to study the problems of self-selection farming in the common pool resources management. The theory emphasizes on strategic interaction by observation of individuals' behavior, taking into account the decisions that others might make (Bayer & Juessen, 2012).

A large variety of theoretical studies in the self-selection farming problem in the common has been modeled as strategic form game. Yet, game theory is making moral judgments either for or against is essential in overcoming self-selection farming problem. At the same time, game theorists have also criticized the neoclassical paradigm in solving the problem of private provision of public/common goods in a self-selection farming setting. They argued that neoclassical economic theories have limitations on the aspect of type of behavior analysis, because they assume no syndicates and coalition are formed in the interactions, no cheating or lying is done, no threats or conflicts are made (Briscese et al., 2021).

1.2. Empirical Review

According to Williamson (2010), transaction cost economics theory concentrates on the relative efficiency of different exchange processes. While, da Fonseca et al. (2018) categorized the total costs of production into transformation costs the cost of inputs involved in the transformation of physical resource into goods and services, and transaction costs—the cost of defining, protection and enforcement costs. Apata (2015) argued that successful self-selection farming has to be governed by a third part based on the institutions. Thus understanding the organization (coordination) and institutional performance require a thorough analysis of the transaction costs involved in the self-selection farming as a tool for smallholder irrigation systems management. Resource users usually enter into various kinds of explicit and implicit agreements in order to initiate collective farming and agree to exchange or transfer goods or services, which involve costs or contributions (Ton et al., 2017). These contributions are normally incurred in the form of negotiation, monitoring and enforcement costs, as part of resource utilization.

For example, the transaction costs for individual resource users, include the costs related to participation, opportunity cost of time involved in meetings, time required to acquire information and communication, direct monetary expenses e.g. costs for travel, communication like phones costs and information or knowledge search and acquisition-based on training such as costs involved in attending trainings, seminars, and so on through extension advisory services or other kind of capacity building offering body (Marjosola, 2021). The contradictory arguments arise due to the fact that resource users attach/value differently the importance of the resources for their livelihood (Qureshi et al., 2018). It is also a result of heterogeneity that self-selection farming members are never having common interests that motivate them cooperate (Mishra et al., 2018). Although such studies identified important aspects in predicting factors influencing collective farming, they have limitation in that they did not adequately address in a linked way the transformation costs-the physical cost-benefit position of enterprises (Pradhan & Ranjan, 2016), and transaction costs imposed (contract, contact, and control) in regard to resource use. They have also not explicitly presented the extent and type of transaction costs related to group size.

On the other hand, Bhattarai and Bhusal (2017) identified the type of transaction costs in farmer managed irrigation in Nepal on the basis of transactions undertaken by farmers, which included time of meeting in the formation of organization, and travel costs and statute preparation costs. However, the study did not provide the extent of their effects on the irrigation performance. Human and resource use interactions and sociability aspects have extrinsic or intrinsic motivation for the household decision; this is likely a result of unobserved characteristics, which can be expressed in differences among households such as choice of the type of farming agro-ecosystems, crops grown, inputs used and, and off farm engagement as a proxy indicator of entrepreneurial characteristics. These aspects are important in understanding the problems in collective farming and its organizational mechanisms, which are the subjects of this very study.

1.3. Brief Summary

Results of empirical research in emerging and developing countries have demonstrated that credit and exchange are two main passages of transmission, with asset prices and interest rates receiving relatively little support. In Sub-Saharan Africa (SSA), research has revealed that agro-ecosystem irrigation is the primary ones, similar to research on developing economies. It is clear that irrigation is the most substantial one on Rwanda's economy especially. Unlike previous studies on the Rwanda economy, this study employs the most recent data available, contributing to the accuracy of the analysis of microeconomic variables. In addition, also the previous scholars on channels of irrigation agro-ecosystem on Rwanda only analyzed one or two channels at most; this is an evidence of gap in literature. In this context, this study filled the gap in literature by considering two main channels on Rwanda including irrigation and agro-ecosystem channels.

2. Methodology

The study was conducted in the Lake Mugesera in 2020 covering five irrigation schemes, where they have different agro-ecological system defined by different farming system zonation that is characterized by the interactions of cultural, agro-biological aspects like dominant soil types, rainfall distribution and socio-economic factors such as input-output markets, own farmers' priority on crops cultivated and resources capabilities. The empirical results presented in this paper are based on two types of data collection methods: first type longitudinal/panel data set (repeated observations over the same unit of analysis), which is relying on secondary data set obtained at group level records in each irrigation scheme.

The study relied on primary information collected to cover mainly the governance, environmental economics, technology characteristics and the social capital variables in the form of their various proxies. Farm household was used as a

unit of observation for the analysis. To identify the causality, the design compared farmers participating in the irrigation farming by creating clusters during analysis: those engaged in irrigation; those engaged in both irrigation and rain fed in each of the scheme surveyed.

The panel data set collected as group level was used as a unit of observation for the analysis. Data collection was done in a total of five irrigation schemes drawing information from water users groups in each irrigation scheme, both traditional and modern which are distributed along Lake Mugesera water basin. In terms of irrigation schemes characteristics, Mugatare, Nyamugari and Akabungo irrigation schemes are traditional improved schemes, whose depend on temporary rivers for their water source. Rugazi and Nyange are also traditional improved scheme but with reservoir/dams constructed to collect rain water during the season. Ntanga irrigation scheme is traditional which use electrical pump for water abstraction from the main source of water of Lake Mugesera; hence it is the only irrigation scheme that operates all year round in the selected schemes lake zone. Data were collected using a well-prepared record sheet (form), which obtained recorded information by the scheme over the period of ten years (2009-2018) to compare groups dynamics and individual effects (heterogeneity) on institution quality across the schemes over time period. Second type is primary cross sectional data set was engaged to study the individual farmers and groups' aspects at household level; a household survey was implemented involving face-to-face interview using structured questionnaire to capture information from the household head involved in the irrigation farming. From each scheme individual farmer irrigation group level analysis household level analysis were randomly sampled.

2.1. Two-Step Sample Selection Technique

Heckman two step sample selection technique was explored the determinants of how farmers self-select into irrigation farming techniques, and describe their characteristics and effects on sustainable sustainability economics. Based on the theoretical foundation of self-selection analysis technique as described by Heckman (Donald, 1995), the dependent variable data type was constructed to suit two step choices: choice made in accordance with farmer types as the first step, and measurement of those farmers who chose the farming type if they value/depend on the choice based on their observed and unobserved characteristics (abilities, preferences and attitudes). The outcome variable (farming type) (y_1) data were measured as dummy variables; either the farmer chooses/select into type or not (coded as 1 = irrigation and 0 = otherwise), given that they value the choice or not as measured in perceived responses on irrigation reliance (y_2) defined as 1 = depend on irrigation, 0 = otherwise. The independent variables were constructed from data set/information related to household characteristics, and irrigation group characteristics. The former included measurements of the appreciation of non-tangible benefits like information sharing (in frequency), far-

mer to farmer helpfulness, and "respect for the law" or commitment, and the latter included proxies for group regulations/management and governance (leadership style and managerial discretion) like number of meetings convened, and contract compliance rates which were captured in a likert scale technique in the survey based on factor reduction analytical approach to ascertain individual's commitment behaviour on operation and maintenance in a self-selection farming setting. The analysis involved estimation of probit Heckman selection model, which controls for self-selection to identify factors that explain the choices made by farmers. The idea is that factors affecting selection into the type may simultaneously affect the outcome of interest; this situation motivated the use of probit Heckman selection model. Probit models are based on utility maximization theory, which is centred on consumer preferences. Based on utility maximization, we assume that the optimal expected utility U = 1 if the utility exceeds a certain threshold level of preference for the choices made by the farmer given that they value such particular choice. The modeling proceeds in a sequential process, where individuals first decide whether to choose in the farming type under question (y_1) based on the underlying and unobserved expected utility y*. After the choice is made, then decide whether to value the choice or not (endogenous variable, y_2), again based on unobserved expected utility y*. The analysis proceeded by implementing the two-step procedures as proposed by Heckman (Donald, 1995).

Mathematically, the model is represented as;

$$y_1 = 1\left(x_1\beta_1 + e_1\right) \tag{1}$$

$$y_2 = 1\left(x_2\beta_2 + e_2\right) \tag{2}$$

where, Equation (2) is the sample selection equation and y_1 is observed only when $y_2 = 1$.

x_1, x_2 = Vector of explanatory variables, which require at least one variable in x_2 that determines selection, should not be in x_1.

e_1, e_2 = These are a zero mean unit variance bivariate normal random variable with correlation.

$\left(e_1, e_2\right) = \rho$.

β_1, β_2 = Parameters to be estimated.

2.2. Mixed Effect Linear Model

Mixed effect modeling technique was employed to analyze the data of how and to what extent the governance/institution mechanisms implemented based on property right enforcement legitimacy, market characteristics, and rainfall variability affect the institutional quality (compliance) in the group over time. Data types required were generated from panel set recorded in repeated backward observations for the period of 10 years (2009-2018), which were obtained from schemes' records. The data set consisted of ex-post transaction costs, and other external factors like market characteristics and rainfall variability, which were

constructed to suit mixed effect linear regression model to identify factors influencing institutional quality within and between irrigation schemes. Main data were based on ex-post transaction costs, which have various forms: the cost of contracting (compliance); cost of negotiating or search (contact); and the cost of establishing and functioning of the governance structures dealing with resolving various disputes (control) (Shahzad et al., 2018). The dependent variable was thus constructed from contract agreement end point implementation outcome indicator result, measured in compliance rate (percent) on operation and maintenance of infrastructure and water supply services.

The independent variables, included outcome indicator results derived from coordination elements, such as presence or absence of water distribution calendar (dummy), clear existence of information sharing mode such as farmer to famer network, frequency of communication (numbers of meetings). Other independent variables included the cost of functioning of governance (Control) variable outcome indicator, like number of sanctions implemented through formal and informal mechanisms (number of penalties) such as fines, court cases, and other punishments. Trend of number of farmer participants in different groups over time, market characteristics e.g. irrigation output market access-proxied by market distance (km) and quantity sold (kg), output prices, rainfall variation over time (measured in mm on annual backward looking trend), and presence of institutional support services (number/frequency of extension services), and periods (years) were also captured as independent variables.

The analysis used panel data set. The panel data analysis is suitable in this setting because the interest is on describing changes over time. Also, since observations on the same scheme (cluster) are likely to be similar than observation in other scheme, therefore, the analysis should take into account the intra cluster (intra scheme) correlation rather than assuming independence among all observations. Accordingly, panel data analysis technique was implemented to allow controlling for variables, which cannot be observed or measured such as differences in practices or cultural factors across the scheme (individual/entity heterogeneity), and variables that change over time (Schielzeth et al., 2020). Economists studying institutional aspects in irrigation systems e.g. Alrubaye and Yusuf (2021) run into problem by using cross section design in which each individual (entity) provides different scales of response, rendering interpersonal or enter entity responses meaningless, as opposed to the panel data where the metric used for individual entity is time invariant. In this case, the time invariant accounts for any specific effects that are not included in the regression such as the unobservable entrepreneurial or management skills. Thus the use of panel analysis is best suited in this objective function.

Various methods/techniques of panel data analysis have been published (Wooldrige, 2017; Yu et al., 2022). Example of panel data analysis techniques include the fixed effect, random effect, mixed effect models and dynamic panel like

Allellano and Bond panel analysis. Fixed effect and random effect linear models are basic technique frequently used in the panel data analysis. Fixed effects are designed to study causes of change within the individual or entity, while random effect studies across entities. The Fixed effect technique allows endogeneity of all the regressors with individual effects. In contrast, random effect assumes normal distribution and that the variations between entities are uncorrelated with the independent variables included in the model with the random individual effects. Mixed effect linear model is a combination of fixed effect and random effect model that permit random parameter variations to depend on observation (Schielzeth et al., 2020).

Therefore, the aim is to study the impact/changes of intuitional quality within and across the schemes over time, thus mixed effect model technique was implemented in this analysis. Mixed effect is particularly useful in this setting because it encompasses both fixed effect and random effect. The fixed effect such as the mechanism of governance (leadership style) and the random effect are the differences for the irrigation schemes (entity).

Mathematically, the mixed effect model as specified by Säfken et al. (2021) is represented as;

$$y_{it} = a_i + \beta X_{it} + ux_{it} + \varepsilon_{it} \tag{3}$$

where,

y_{it} = dependent variable for entity, i and time, t

a_i = n-entity specific intercept for long panel with few individuals can be parameters estimated by running separate regressions

x_{it} = independent variable

β = parameter (coefficient) to be estimated

u_{it} = random effect slopes for the predictors

ε_{it} = error term

The model was estimated by maximum likelihood (ML) method using STATA 11.

3. Results Analysis and Discussions

The summary descriptive statistics and variable definitions used in the two-step regression of Heckman selection model are listed in **Table 1** while **Table 2** describe regression analysis of Heckman two step estimates selection model while the other summary used in mixed effect model are shown in **Table 3**.

3.1. Two-Step Regression

Consistently, the results of Heckman's two-step sample selection regression are given in **Table 2**. As a result, the dataset contains missing values, so observations with missing data are deleted, so only 263 samples of observations are left for econometric estimation. The Wald chi square test of model fitting showed that there was a significant difference between the model and zero at the level of less than 1% (Chi square probability = 0.000). In addition, the correlation factor

Table 1. Summary statistics and definition of variables used in Heckman two step regressions.

Variable	Variables Definition	Unity measure	Mean	Std. Deviation
TypeIrrig	Irrigation farming ecosystem choice	Dummy	0.75	0.43
Totfarmlan~e	Total farmland (household) size owned (acres)	Acres	1.53	0.52
Gender_sex	sex respondent's	Dummy	1.39	0.49
Age	age respondent's	Years	44.61	8.70
Hhlaborfarm	Household member eligible for farming	Number	2.74	0.51
Education_~u	education of respondents	Categorical	2.96	0.86
Trust	Trust in group members regarding irrigation resources utilization	Dummy	0.62	0.49
Irigntyp	Irrigation type depended	Dummy	0.38	0.49
Farmsacco	Farmers financial support from saccos	Dummy	0.54	0.50
Imprvseed	Use of improved seed	Dummy	0.93	0.25
Soilirrfer~y	Farmers perception on soil fertility status in irrigation scheme	Dummy	0.79	0.40
Income	Household average annual income (off farm)	Rwf (currency)	1105128	289648.8
Econopport	Recognize economic opportunities availability	Dummy	0.56	0.50
Irrigreliab	Irrigation farming reliability	Dummy	0.84	0.36
Irrgnetarea	Irrigation net area sown: (acres)	Acres	2.32	1.88
Nontangible	Non tangible benefits	Categorical	1.78	0.85
Irrgdist	Distance of irrigation scheme from the homestead	Km	2.92	5.25
Irrgtrain	Training Technology Irrigation	Dummy	1.23	0.42
Positionirr	Position of farmer plot in the irrigation scheme	Categorical	1.86	0.49
Factor 1	Respect of public services provision	Likert scale	3.18	0.80
Factor 2	Dodging contributions	Likert scale	2.27	0.50
Factor 3	Violation of rules	Likert scale	2.76	0.58
Contragrmnt	Contract agreement compliance measured in non-monetary cost contribution payment of pineapple after harvest (kg)	Number of Kg	123.88	26.27
Grpleader	Group leadership	Dummy	1.13	0.33
Rules	Rules of working and enforcement	Dummy	1.11	0.32
	Valid N (list wise)	**312**		

Source: Author 2022.

(inverse mills ratio) of the model was negative, but significant when it was lower than 5% ($p = 0.001$), which provided evidence for the existence of self-selection. Therefore, it indicated that the selection of irrigated agro-ecosystem (type 1) farmers was non-random selection.

The absolute value of the inverse mill ratio shows that these data have a positive

Table 2. Heckman two step estimates selection model regression analysis.

Variables	Coef.	Std. Err.	Z
Type1irrg			
Totfarmlan_acre	0.0217	0.0382	0.57
Gender_Sex	0.2630	0.0441	5.97*
Age	0.0028	0.0023	1.23
HhlaborFarm	−0.1106	0.0424	−2.61**
Education_Edu	−0.0445	0.0230	−1.93***
Primary	0.2983	0.1433	2.08**
Secondary	0.2823	0.1396	2.02**
Tertiary	0.2222	0.1641	1.77***
Trust	−0.5269	0.3060	−1.72***
Irigntyp	−0.3538	0.3098	−1.14
FarmSacco	−0.4893	0.0686	−7.14*
ImprvSeed	−0.2337	0.1221	−1.91*
SoilIrrFertil~y	0.1127	0.05154	2.19**
Income	−7.47e−07	7.57e−08	−9.86*
Econopport	−0.5758	0.0553	−10.42*
_cons	2.2022	0.2422	9.09*
IrrgReliab			
Irrgnetarea	0.0667	0.0804	0.83
Nontangible	−0.2072	0.1428	−1.45
Farmer to farmer	−0.5544	0.2936	−1.89***
Irrgdist	−0.0019	0.0224	−0.09
IrrgTrain	−0.2103	0.3583	−0.59
PositionIrr	1.2757	0.2907	4.39*
Factor 1	−0.5855	0.1679	−3.49*
Factor 2	−1.2992	0.3848	−3.38*
Factor 3	0.4239	0.2792	1.52
Contragrmnt	0.0182	0.0054	3.37*
GrpLeader	6.5176	1.0228	6.37*
Rules	−0.7920	0.3505	−2.26**
_cons	−4.6806	.	.
/mills			
Lambda	−0.2671	0.0797	−3.35*
Rho	−0.8176		
Sigma	0.3267		
Wald Chi2(12)	303.43		
Prob > Chi2	0.0000		
N	263		

Notes: Significance levels: * = $p < 1\%$, ** = $p < 5\%$, and ***= $p < 10\%$. Source: Author 2022.

Table 3. Summary statistics and definition of variables used in the mixed effect model regression.

Variable	Definition	Unit measure	Mean	Std		
				Overall	Between	Within
Compliance	Institutional quality of CF group	Number of farmers turning up over the years	211.346	21.174	24.851	0
Watercalendar	Presence of water distribution arrangement calendar	Dummy	0.577	0.495	0.234	0.477
Infosharedmode	Information sharing mode like farmer to farmer network	Dummy	0.843	0.364	0.444	0.343
Meeting	Number of meetings held pertaining to irrigation collective action issues annually/seasonally	Number	5.093	1.501	0.567	1.492
Extsuport	Extension advisory services support frequency offered to farmers	Number	12.372	3.651	1.415	3.544
Controlguard	Presence of control guard in the irrigation scheme	Dummy	0.962	0.193	0.022	0.192
Monitoringhrs	Hours spend on monitoring the irrigation scheme	Hours	7.859	1.419	0.483	1.410
Formalpenalt	Control mechanism implemented to constrain adverse human behaviour through court cases and	Number of penalties	0.692	0.356	0.114	0.353
Infopenalt	Control mechanism implemented informally through sanctions or self-enforcing to restrain adverse human bahaviour in the irrigation scheme	Number of penalties	2.452	0.498	0.288	0.464
Qtysol	Output quantity sold as a proxy for market access and product demand at scheme level (Kg)	Kg	5666.67	720.248	297.723	696.205
Mktdist	Proximity to the output market distance as a proxy for market access	Km	6.849	0.358	0.249	0.305
Outputprice	Output price per unit (piece)	Rwf	444.231	49.746	42.656	41.296

Continued

Timet	Time period for event occurrence	Years	2017.45	4.729	2.181	4.625
Rainfall	Rainfall amount over years	Mm	52.897	0.996	0.589	0.946
Infpenty	Interaction between informal penalty and time	Number	2206.44	10.402	9.099	9.878
Extime	Interaction between extension advisory service and time	Number	18908.92	2136.446	4662.911	1999.034
Quantprice	Interaction between quantity sold and output price	Number	49365.38	5577.673	12173.74	5218.918
Raintime	Interaction between rainfall and time	Number	11725.24	1325.007	2891.689	1239.798

Source: Author 2022.

selection effect, and the people who choose irrigation agriculture are most dependent on the ecosystem rather than random sampling of populations with similar characteristics. Therefore, unobserved factors that make selection more likely are often associated with higher levels of irrigated agriculture participation in selection, thus implying the self-selection farming commitment.

Based on these results, the null hypothesis was rejected and replaced by alternatives, and it was concluded that farmers chose the type of agro-ecosystem (type 1 farmer) on the basis of transaction costs (controls, contracts and contact), and location specific attributes of transaction costs, such as the economic opportunities in the region, and the recognition of intangible benefits, such as the use of self-selection farming as a bridge to support service acquisition, may increase or decrease the participation morale of irrigated agriculture, and there are also features that cannot be directly measured. Specifically, the results of the first stage (results) regression are helpful to understand the characteristics of individual farmers (type 1 farmers) engaged in irrigation agriculture. Five factors (variables) play an important role in explaining the selection of irrigation agro ecosystem.

The variable age coefficient is positive, but not significant, which indicates that the young farmers are more likely to choose irrigation agroecosystem type 1 than older farmers. For every 1% (year) increase in the age of farmers, participation in irrigated agricultural choices may increase by 0.3%. The index is low, this may be due to the fact that older farmers have no energy to take on family responsibilities and business orientation, and therefore older farmers have the ability to comply with self-selection farmer social contract arrangements, rather than avoid them, because they value the resources used to make a living and sustain their livelihoods.

The coefficient of variable sex has a positive sign and is significantly lower than 1%, indicating that men are more likely to participate in irrigated agriculture than women. As male farmers, they are 26% more likely to participate in irrigated agriculture than female farmers. The possible reason may be due to the traditional and customary patterns in Africa in general, and Rwanda in particular, where men have a greater influence on access to and control of resources and the responsibility to ensure family security. Men can also tolerate the damage caused by the use of irrigation facilities by members of water users' associations, in addition to the opportunity to attend much more training than women.

The coefficient classification of variable education level (educ) categorized is: primary education; secondary and tertiary (college) levels are positive signs, the significant level is less than 5%; 5% and 10% respectively. These results show that education is an important determinant of the choice of agricultural ecosystems. People at the primary school level are more likely to choose and rely on the first type of agro-ecosystem, followed by secondary schools, and finally those with higher education. People with primary education are more likely to choose type 1 (irrigated agro ecosystem), which may be because agriculture is their main occupation, rather than other formal employment/jobs in other places easily ensured by those with higher education, such as those with secondary and tertiary education levels.

The variable trust degree and Leadership (trust) coefficient of individuals in irrigation group are negative and statistically significant at 10% level, which indicates that the improvement of trust degree may decrease the selection and dependence of type 1 agricultural ecosystem. The reason of significance is very direct; farmers require the realization of exclusive rights and benefits in the use of resources, with reasonable doubt due to the group or resource management.

The variable coefficient of soil fertility in (soilirrgat) was positive and significant at less than 5% level. 1% increase of soil fertility level in irrigation plan may increase farmers' participation and selection by 11.3%. Soil fertility status is a specific property of assets specific to the place of transaction, which can increase or decrease transaction costs. These results are not surprising. Fertile soil on irrigated land increases the possibility of farmers' participation, as farmers are sure to achieve higher yields and benefit from good soil, which requires improvement of irrigated land to reduce transaction costs associated with loss, which means efforts to maintain infrastructure and comply with contractual operations and contributions. This indicates the need for research and extension of advisory services to enhance the application of technology and good agricultural practices, which can be achieved through technology development and training.

The economic opportunity variable (econoprtnity) depicts an interesting picture as an attribute of transaction costs in the selection of agricultural ecosystems (irrigation participation and dependence). The coefficient is negative and significant at the level of 1%. Although statistically significant, from an economic point of view, the results show that the opportunity for more economic opportunities in the region increases the probability of farmers' participation in ir-

rigated agriculture by 57.6%, perhaps because they can engage in agriculture and earn a living from other, broader areas. This implies the importance of irrigation resources to users. These results are consistent with the findings of O'Keeffe et al. (2018), that is, if resources are not important to users, then the possibility of effective resource management is doomed.

The variables related to SACCOS/financial farmer support coefficients have negative sign, and the significant at 1% level. Although statistically significant, the negative sign indicates that the choice of irrigated agro ecosystems is likely to be influenced by the presence of SACCOS/financial support to farmers to increase capital investment. This is particularly important because irrigated agriculture requires capital investment to meet its operational and maintenance and other own production and sales cost obligations. Therefore, these results suggest that a well-managed financial irrigation planning linkage model is needed to support farmers' full participation in the irrigated agro ecosystem.

The symbols defined as 1 = modern and 0 = traditional variable irrigation type are negative and not significant. Although the effect of irrigation type variables on the selection is not important, the results show that farmers in traditional irrigation systems are less likely to choose and rely on irrigated agro ecosystems, because farmers are unlikely to evaluate irrigation systems when only 1% of irrigation types are used. The choice of irrigation systems and catchment farming will reduce by 35.4%, possibly due to the unreliable physical availability of rainfall dependent water resources in most irrigation schemes, which also makes farmers vulnerable to production risks. These results indicate that the hardware of irrigation scheme needs to be improved to improve the effective and reliable utilization of physical resources.

The coefficient of the improved seed use (imprvseed) is negative and statistically significant at the level of 10%. Although statistically significant, the results highlight the influence of matching direction on the selection of irrigation ecosystem. The possible explanation may be that the improved seeds are easily available in the formal seed system and therefore more easily relied on. Other explanations may be due to the fact that the improved seeds require a lot of input and management, which is very laborious and requires the human skills that farmers lack, thus adding another transaction cost attribute. On the other hand, reliable water is needed for the intake and drainage of the community at different stages of crop growth (e.g. during sowing, fertilization and harvest) to ensure that good practices are labor and cash intensive. At the same time, the input is expensive, and farmers can-not implement the proposed scheme. Therefore, compared with irrigation investment, the income is lower, but through improving seeds, it has good production, sales and consumption characteristics.

The coefficient of variable total household income (totincome) is negative, but it is statistically significant at the level of 1%. Although the coefficient is negative, the statistical significance indicates that the individual farmers with higher total income may choose to irrigate the agro ecosystem. The total household in-

come increased by 1%, and the proportion of people who were likely to choose to participate in irrigation agriculture increased by 0%. These results are not surprising because irrigated agriculture requires a lot of cash and non-cash capital investment.

The variable coefficient of family total cultivated land (totfarmland) was positive, and there was no statistical significance. However, although it was not statistically significant, the results showed that the total farmland area increased by 1%, which may lead to the participation of farmers in choosing irrigation agricultural ecosystem to be 2.1%, which is a low selection index. This means that families with larger total cultivated land area are likely to participate fully in irrigated agriculture and undertake collective agricultural activities. This may be because they can lease more land ownership to other farmers and obtain benefits at lower transaction costs, that is, they do not directly participate in collective agricultural activities. These results require an equitable distribution of land among farmers to ensure full participation and ownership of irrigation resources.

The results of selection regression show that several factors are important determinants of farmers' self-selection of agricultural types. The model fitting and correlation factor results described above have confirmed the existence of sample selection. The coefficient of variable household labor force (hhlabor) is negative and significant, which indicates that families with more members who are qualified to engage in agriculture choose the type of irrigation agriculture on their own, which may be due to their "uncompromising" freedom of division of labor. According to the requirements of the irrigation group organization, meet the tasks of the family and comply with the social contract arrangements for self-selection farming. Farmers can also make their own choices about intangible benefits, including the following options: Farmers' help to farmers (reciprocal information/material sharing), and using self-selection farming as a bridge to obtain external service support (e.g., research, extension of advisory services), and business development.

The sign of variable intangible income (non-tangible) coefficient, especially the choice of farmer to farmers' help (reciprocal information/material sharing), is negative and has statistical significance. Every 1% increase in the utilization rate of farmer to farmers' help (reciprocal information/material sharing) is likely to make farmers make choices and make efforts on irrigation commitment, which is about 55.4%. This is particularly important for farmers who are committed to and strategically want access to external information services to improve their livelihoods. These findings suggest that there is a need to strengthen public-private partnership models aimed at strengthening support services, with particular emphasis on business development and chain collaboration.

The variable rule work in the coefficient of irrigation group (ruleworkdum) has negative sign, which is statistically significant at the level of 5%. This importance indicates that farmers evaluate the enforcements and implementation of

rules related to the benefits to be realized in the irrigation system. In this regard, farmers make their own choices based on the "perceived" good functioning of the rules, and thus observe the choice of irrigation ecosystems. Therefore, the impact of this self-regulation may be compliance with irrigation contractual arrangements, as they respect authority due to good rules and enforcement, and therefore comply with the participation and contribution of irrigation self-selection farming activities. In different irrigation plans, the implementation of rules varies between groups and leadership styles, so it is important to explain non-random selection based on Farmers' preferences and attitudes. These results indicate the need for careful screening/selection of community members and leaders who will implement and enforce the rules in order to expect to perform well in the irrigation system. Farmers believe that good rules and enforcement are characterized by equitable consideration of resource allocation and warehouse accountability for the benefit of all members.

The variable net irrigation area of sowing is also an important determinant of self-election. The coefficient was positive and had no statistical significance. In the irrigated area, every 1% increase in the planting area of crops may have a huge positive impact, increasing the workload of irrigated collective agriculture by about 6.6%. This means that farmers make their own choices according to the crops sown in the net irrigated area. Therefore, the farmers with large net planting area do attach importance to participating in irrigated agriculture, which clearly shows more commitment to self-selection farming social contract agreement.

Therefore, no irrigated agro-ecosystem (type 1) was observed. This is not surprising because farmers are rational, so in terms of transaction costs involved, the cost-effectiveness of participating in self-selection farming is implicitly assessed, and perhaps the availability of household labor, compared with other available economic opportunities. In other words, the impact of this self-selection may be related to the moderate morale/motivation to choose the first type of irrigated agro ecosystem in this regard. Therefore, these findings require an equitable distribution and distribution of tasks requiring self-selection farming in irrigation plans, depending on the area of crop planted by individual farmers, rather than equal collective farming assignments.

The coefficient of (grpleader) in group members and leaders was positive, which was significantly at lower than 1%. The results showed that the choice of irrigation agro ecosystem was observed on the basis of trust. An increase of 1% of the group leader in irrigation may affect 65.2% of self-selected participation in irrigation. Leadership plays an important role in social interaction, especially in strengthening the provision of public goods and services. These findings are similar to other studies such as Vos et al. (2020), which also show that trust in leadership reduces transaction costs and predicts/encourages participation in local public goods production. The impact of this self-selection may encourage farmers who choose irrigation ecosystem type 1 to cooperate voluntarily in public

goods supply activities, such as irrigation schemes, by reducing free riding and thereby respecting the self-selection farming laws. However, it is not easy to predict/display individual leadership performance, which indicates the need to design fair resource allocation and responsibility mechanism, which can be used as proxy indicators of leaders.

On the other hand, according to the irrigation location of the cultivated land in the irrigation plan, the farmers choose their own irrigation tillage types based on the following choices: head, middle and tail. The coefficient of the variable irrigation position (irrigation) tail ender option is positive and significantly less than 1%. The distance from the irrigation location to the end increased by 1%, that increased the observation participation of irrigation agricultural selection by 12.7%. When farmers are at the header end of the water source, they are more likely to choose to irrigate agricultural ecosystems. This may be due to the fact that at the tail end of the water source, there is a tendency to have a lower chance of getting enough water for crops, especially in the case of poor water management and control, therefore, no tail enders, who chose to irrigate agriculture, was observed. The impact could be free riding, avoiding donations and breaking rules. This requires a fair distribution of resources among water user associations.

The variables related to attitude and behavior factors are calculated by factor reduction analysis method with the right of choice, including: public service provision in the form of respecting frequency contribution (factor 1); contribution avoidance/dodging (factor 2); rule violation (factor 3) are important determinants of farmers' self-selection choice of agricultural type.

The variable aspect of public service payment (factor 1) coefficient is negative, and the significant level at less than 1%. Attitudes related to regular contributions and respects for public services are related to the commitment to irrigated agro ecosystems under self-selection farming. Among self-selection farming members, an increase of 1% in respect of and compliance with contributions may result in 58.6% choosing to enter irrigated agriculture. The effect of this self-selection is related to the retention of self-selection farming members committed to participating in irrigation agro-ecosystem type 1.

Factor 2 is equivalent to free riding and opportunistic behavior. Free riding is to maximize one's own welfare without compensating others' efforts, such as avoiding contribution to these efforts. Opportunistic behavior refers to cheating or hides relevant information when the actor intentionally seeks his own interests at the cost of this situation and damages others. Farmers who are not committed or worried about contribution due to poor management may choose their own type, although they rely on irrigated agro ecosystems. The increase of dodge contribution by 1% may not affect the self-selection of irrigated agriculture by 12.9%. The impact of this self-selection is important for the recruitment of self-selection farming members and understanding of the contribution/target rate. It is also important to develop control mechanisms that can be implemented at a

lower cost.

The coefficient of variable violation (factor 3) was positive, but not statistically significant. For every 1% increase in violation of the rules, the proportion of farmers choosing to irrigate their own agriculture will increase by 42.4%, insignificantly. This means that increasing farmers' attitudes towards violations of rules, such as diversion of irrigation water and other non-compliance with laws/regulations may prevent other innocent farmers from fully participating in irrigated agriculture. Other variables, such as compliance with payment in kind contracts (contrnmcst), were positive and statistically significant at the 1% level, while irrigation technologies training (irrgtrain) was not statistically significant and had a negative impact on the agro ecosystem of self-selection treatment (type 1).

On the other hand, the factors that hinder farmers from making full use of their commitment contribution in irrigated agricultural ecosystem include avoiding contribution (factor 2) and violating rules/regulations (factor 3), which are also related to farmers' self-selection. These factors should be taken into account because their impact is very important to understand the earning capacity and motivation of self-selection farming members, recruitment strategies for the provision of public services, and control mechanisms with lower development costs. They are also important in understanding the level/amount of contribution that all members can contribute to improving compliance through public-private partnerships.

3.2. Mixed Effect Model

Model aims to determine the determinants of the time-dependent change in institutional quality in an irrigation system with collection farming organization settings. It can be seen from the table that the difference between the STD statistics among dependent variables (compliance) is bigger than the within, which means that there is a big difference in the quality of institutions (compliance) between schemes.

Several field studies on public resource management have shown that communities with successful resource management under collective farmers usually show well-defined rules, the ability to monitor resource extraction and punish deviations, the ability to resolve conflicts and a forum for discussion (Sinha et al., 2021).

At the same time, scholars (Gibbons, 2020) agree that good organization and institutional characteristics appear together. In this regard, the quality of institutions, particularly the ability to take collective farming in irrigation systems (public resources), is a key factor in determining effective economic performance. However, there is little evidence to show how governance mechanisms (such as exposure and control) and external factors (such as market characteristics and rainfall variability) affect the institutional quality of collective farming in irrigation plans (Soumano & Traoré, 2017). In this section, panel data sets re-

lated to ex post transaction costs (contract compliance, control and contact results) and market characteristics and rainfall variability are used to analyze this deficiency. The null hypothesis, that is, transaction costs, market factors and rainfall characteristics do not affect the institutional quality of irrigation team members.

The mixed effect linear regression results with random intercepts are reported in Table 4. The null hypothesis was rejected (p = 0.0000) and concluded that output market factors (output prices, market distance, and quantity sold as a proxy of market access), rainfall variability characteristics and transaction costs do matter in the institutional quality (compliance) influence in the irrigation systems. The full mixed effect model likelihood ratio (LR) test results indicated that the random coefficients between and the fixed effect within irrigation schemes have statistically significant variation (p = 0.000). Taking the estimated

Table 4. Mixed effect linear model regression results.

Compliance	Coefficient	S.E.	Z value
Individuall level fixed effect			
Watercalendar	−0.442	3.99	−0.11
Infosharedmode	9.419	4.08	2.31**
Meeting	1.791	3.50	0.51
Extsuport	0.053	0.07	0.74
Controlguard	1.477	1.23	1.21
Monitoringhrs	0.253	0.16	1.61
Formalpenalt	0.008	0.62	0.01
Infopenalt	−0.794	0.59	−1.36
Qtysol	−0.002	0.0003	−4.53*
Mktdist	−3.895	1.0002	−3.89*
Outputprice	−0.003	0.008	−0.32*
Timet	0.322	0.09	3.28*
Rainfall	−1.038	0.36	−2.91**
Infpenty	−0.047	0.02	−1.91***
Extime	0.00001	0.0001	0.13
Quantprice	0		
Raintime	0		
_cons	−251.212	185.472	−1.35
Random effects Parameters	Estimate	Std. Err.	LR (prob)
Variance	47.832	22.421	0.0000

Number of obs = 312; Number of groups = 4; Wald chi2(14) = 58.39; Log likelihood = −875.369; Prob > chi2 = 0.0000. Note: Significance levels: * = p < 1%, ** = p < 5%, and ***= p < 10%. Source: Author 2022.

results for the overall intercept—for both fixed and random effects of 47.83 percentage points as a baseline (reference), the findings showed that the institutional quality (compliance) may vary (increase or decrease) by a standard deviation of 22.42 across the schemes (**Table 4**). Consistently, six variables were important determinants of (compliance) institutional quality within and across the irrigation schemes.

The coefficient for the variable information sharing (infosharemode) among farmers within and between irrigation schemes had a positive sign and significant at less than 5% level. As time goes on, for every increase of information sharing strategy by 1 percentage point the institutional quality level increases by 9.41%. This is expected because information is power and enables farmers to learn and obtain technical knowledge, technologies and market information easily and at less cost through interaction networking amongst farmers. The implication is perhaps that as time passes by then farmer to farmer network relations is strengthened because of frequent interaction and hence reduced transaction costs. Other studies on transaction cost have also confirmed the reduction of transaction costs due to frequent interaction (Sinha et al., 2021).

The coefficient for the variable related to formal penalty (formapenalt) had a positive sign and not statistically significant. Implementation of formal penalty such as court cases and or taking culprits to the village executives influenced compliance insignificantly. An increase of one percent level formal penalty influence compliance by 0.8% insignificantly, implying that farmers fear most the formal procedures like court cases.

On the other hand, the coefficient for informal penalty (infopenalt) was negative and not statistically significant, implying reduction of institution quality as time passes by, perhaps informal rules implementation is biased amongst farmers as time of interactions among farmers' increases. Frequent interactions create closeness relations and sometimes friendships, which may cause biased rules enforcement and implementation. Other studies have established that a combination of formal and informal rules provide good results on institution efficiency (Fischer et al., 2022).

The coefficient for the market characteristics variable such as quantity sold (qtysold) was negative and significant at less than 1% level. This is obvious because as output quantity increases implies that the produced products have demand and farmers have insufficiency market access. A one percent increase in the rice quantity sold decreases the institution quality by 0.2%. At the same time, the coefficient for market distance (mktdist) was negative and significant at less than 1% level. These results imply that when market distances increases by one percent the institutional quality declined by 38.9% over time. Market distance has big impact over institution quality improvement because producers need benefit out of the produced outputs and hence these results point to the need of market access improvement.

The coefficient for the interaction variable (infpenty) had a negative sign and

significant at less than 10% level. The result indicates that there is negative correlation between informal penalty and time. As time goes on, informal penalty disproves the institutional quality level. A one percent increase in informal penalty implementation over time disproves institution quality by 4.7%. This is perhaps because of frequent interaction or due to "tit for tat" (Kim & Florack, 2021), and hence trust among them is not built.

Other variables were not significant. The coefficient for the variable frequency of meetings (meeting) attended regarding irrigation farming issues had a positive sign and not significant. Though not significant, results indicate that a one percent increase in frequency of meetings increases institution quality/compliance by 179%. A plausible explanation can be that attending meetings enhances information and communication such that farmers internalize the institutions for compliance. Meetings are the transaction cost related to contact and coordination to enhance efficiency economic activity implementation.

The coefficient for the variable presence of control guard for the resource boundary (controlguard) was positive and not significant. Though not significant the positive sign indicates a positive effect on enhancing institution quality. A one percent increase of the presence of control guard to monitor the scheme boundaries increases compliance/institutional quality by 147.7% within the scheme. Thus irrigation schemes with control guard had intuitional quality (compliance) higher than ones without guards. However, increasing presence of control guard is costly; hence less cost based mechanism has to be devised to ensure institution quality. This can be through institutional arrangement such that there is self-enforcing by cultivating trust amongst farmers through good leadership and accountability. This result conforms to (Mosha et al., 2016) institutional design principle that clearly defined boundaries of resource appropriators are a pre-condition for a successful common resource management. Thus defining resource boundaries and ensuring control guard rather than focusing exclusively on physical characteristics of the resource may enhance institutional quality.

Other variables included in the model such as presence of water distribution calendar (watercalender) had coefficient with negative sign showing a negative relationship effect on the institutional quality. Though not statistically significant, a one percent increase in the water distribution calendar organization reduces the institutional quality by 44.2%. This is perhaps because of biasedness in water allocation and distribution among farmers, or inadequate water allocated such that farmers disobey the calendar of distribution arrangement. This calls for improvement on the administrative strategy employed on water management and control.

The coefficient of the variable extension service support (extsuppot) was also positive and not statistically significant. Though non-significant, the coefficient had positive effect on institutional quality such that a one percent increases in the frequency of extension advisory service support increases institutional quality by 5.3% within the scheme. Extension service support is an asset specific

attribute of transaction cost that influence human capital development, and hence reduces farming management transaction costs related to synthesis of information and bounded rationality on negations with regard to irrigation resource utilization.

The coefficient for the variable related rainfall (rainfall) had a negative sign and significant at less than 5% level. Though significant it had greater effect on institutional quality. A one percent increase in rainfall mm, reduces the institution quality by 103.9%. This is obvious, because under high rainfall farmers have no need of water for irrigation hence reduces compliances/ institutional quality.

The time trend/treatment effect coefficient (timet) was positive and significant at less than 1%, though significant indicates that the institutional quality augments over time. The augmentation of institutional quality (compliance) is probably due to rainfall variability which directly affects positively water availability in the irrigation schemes; hence farmers decide to obey rules because of group-interest behaviour and survival for the fittest.

The output price coefficient (outputprice) is negative and non-significant, but the sign indicates that output price contributes negatively on institution quality decrease. A one percent increase in quantity sold and prices go down or vice versa reduce the institution quality greatly by 0.3%. The results indicate negative correlation between quantity sold and prices as quantity increases the prices go down and vice versa, hence institutional quality reduces, implying that commodity price is important in leveraging institutional quality and compliance stability.

Other variable included like monitoring hours for the irrigation scheme (monitoringhrs) was positive and non-significant. The results indicate positive relations, as monitoring hours for the irrigation scheme increases so does the institution quality level improves over time. This is perhaps defaulters are easily identified in this guard monitoring mechanisms. However, there is an inevitable costs increase in terms of personal hours to ensure the institutions are maintained. So the transaction costs for the irrigation systems management are high.

On the other hand, the interaction between extension support and time (extime) coefficients was positive and non-significant, indicating positive correlation. As time goes on extension services support increases, and hence institutional quality. The increasing of extension services support is perhaps because extension advisory service provided does meet the farmers need. It might be that extension services are biased provided amongst farmers and else sometimes farmers do respect the extension agent because of frequent interaction and monotonic extension advice delivery mode.

Reasoning might be because of the government's budgetary disbursement constraints that directly affect extension services working environment. The budget has not been always reaching to 100% when compared to the approved against actual expenditures, although the allocation trend has increased in nominal terms since 2015/2016 fiscal year (NISR, 2016).

3.3. Brief Summary

This chapter examined two step estimates selection model regression analysis and mixed-effect linear model analysis. After reviewing the underlying concept, the two primary channels were analyzed.

The absolute value of the inverse mill ratio shows that these data have a positive selection effect, and the people who choose irrigation agriculture are most dependent on the ecosystem rather than random sampling of populations with similar characteristics. Therefore, unobserved factors that make selection more likely are often associated with higher levels of irrigated agriculture participation in selection, thus implying the self-selection farming commitment.

The full mixed effect model likelihood ratio test results indicated that the random coefficients between and the fixed effect within irrigation schemes have statistically significant. Taking the estimated results for the overall intercept—for both fixed and random effects as a baseline (reference), the findings showed that the institutional quality (compliance) may vary (increase or decrease). Consistently, six variables were important determinants of (compliance) institutional quality within and across the irrigation schemes.

4. Conclusion

The conclusion of this study is that the selection of irrigation agro-ecosystem (the first type of farmers) is a non-random choice, so the selection of members of organized self-selection farming establishment should be based on factors such as families with more members and more members engaged in agricultural activities in the household, the results show that the labor market is not perfect. The non-material benefits, especially the use of organized intensive agriculture as a bridge (Network), to help farmers obtain support from various external service providers to implement sustainable agricultural practices, and to participate in downstream post-harvest agribusiness activities from the perspective of value chain management; the rules of the irrigation group work well; And through good leadership and rule enforcement, attitudes related to frequent contributions and respect for the law in the provision of public services are stimulated, as they are considered positive and greatly affect the ability to choose treatment by themselves. In general, the main contribution of this study in the existing empirical literature is twofold: first, the use of a novel method of Heckman selection model to solve the problems of the establishment of self-selection farming and the survival of self-selection agriculture, in order to improve the performance of irrigation systems, and other emerging economic development involving commons and public service efforts. As far as I know, the method has not been applied in the irrigation system. Secondly, since self-selection farming's data on Farmers' use of irrigation systems are also relevant to empirical evidence from Rwanda and other developing countries, since many authors and practitioners using groups of water user association are generally considered as strategies to improve irrigation performance, this is not the case, as it does not take into ac-

count the self-selection effect among members. The conclusion of this study is that in order to improve the irrigation performance of self-selection farming successfully, the selection team members should be based on the above non-random recruitment based on self-selection factors.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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