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Modeling the Influence of Expropriated Farmers' Determinants on Compensation Payments Using Multiple Regression

Donatien Ntawuruhunga[1],* and Mathias Twahirwa[2]

[1]*Department of Development and Strategic Studies, Sokoine University of Agriculture, Tanzania*

[2]*Faculty of Theology, Kibogora Polytechnic, Rwanda*

Abstract: In recent years, Rwanda's economic shift has been triggered by expropriation for land conversion in areas of urbanization, roadways, modern village settlements, and agricultural modernization. Even though various studies on expropriation have been carried out to elucidate constraints associated with expropriation, as far as we know, no multiple linear regression (MLR) analysis models have been used to determine the land-lost farmers' profiles' association with compensatory payments. This study was carried out in the Eastern Province of Rwanda. This study investigated how the expropriated farmers' profiles can influence both the compensatory payment appraisal and expropriation for land conversion. The MLR model was utilized to ascertain the relationships between the response variable (compensatory payments) and the explanatory variable (expropriated farmer profiles). Data were obtained using a questionnaire administered to 90 expropriated farmers selected using purposive and multi-stage sampling techniques and analyzed using STATA. The MLR showed a good fit of the model ($R^2 = 0.6900$) with the results that farmer's age, means of acquiring land (the fact of owning land from inheritance), cropping systems (the fact of mono-cropping practice), and satisfaction (the fact of being satisfied) showed statistically significant ($p \leq 0.05$) association with compensatory payments, whereas "ubudehe" (the fact of being a high-income earner) and civil status (the fact of being married) were statistically significant at 10%. An important implication of these results is that in the perspective of expropriation for infrastructure developments that affect farmers' properties, the MLR model can solve several issues associated with this process. As a recommendation, governments, investors, expropriating agencies, and property valuers are encouraged to carry out the process of land expropriation by exploring and controlling the significant factors influencing the process.

Keywords: expropriation, valuation, correlation, multiple linear regression, Rwanda

1. Introduction

Expropriation denotes a process in which a public or private investor drives out owners from their privately owned properties as a result of the development in the public interest. Privately owned properties can be expropriated for large-scale farming projects, the construction of roadways, airports, industrial areas, protected areas for wildlife conservation, power stations, modern village settlements, and many more. As such, the government can move residents from dangerous areas, e.g., a heavily polluted locality or high-risk zones, to safer places with a cleaner (safer) environment and safer settlements or for humanitarian causes in case of natural cataclysms caused by sea rise, volcanic eruption, earthquakes, hurricanes, floods, and landslides in rainy seasons. Elsewhere, some residents may be forced to move from their ancestral land (property) following armed conflicts prevailing in their areas. In normal processes, expropriation denotes a public authority taking property from its owner against his wishes for land conversion in the public interest in exchange for compensation [1].

The process of expropriation involves two parties (expropriating agency and property owners) who based on a mutual agreement accept to give up his/her property for compensation which can be paid in monetary form or in any other form [2]. Yet globally, during the last century, both expropriations and nationalizations happened, particularly in relation to energy companies, telecommunication companies, railways, infrastructures, financial institutions, coal mines, wartime manufacturing, and many more [1].

Cao et al. [3] expressed concern about the adverse impacts that land expropriation has on populations whose lands are lost. Yet, during the expropriation process, adequate compensation for those who lose their lands differs markedly between countries, and between the global North and the global South. In the global South, compensation provided is usually monetary and generally considered insufficient [4]. Usually, the compensatory value given to the land-expropriated farmers is substantially insignificant and they lack the right to challenge the amounts they receive [5]. So, the impact on expropriated farmers themselves is multifaceted. Following the loss of their cultivated land, they are moved into new settlements where they encounter financial difficulties and survival. Land-expropriated farmers become vulnerable because

*Corresponding author: Donatien Ntawuruhunga, Department of Development and Strategic Studies, Sokoine University of Agriculture, Tanzania. Email: donatien.ntawuruhunga@sacids.org

compensation standards do not match their losses and cause discontent among them.

The Rwandan expropriation law enforced since 2007 governed expropriation processes until its amendments in 2015 [6]. This law brought many controversies regarding its implementation that resulted in discrepancies in terms of fair compensation (largely paid in monetary value) and satisfaction with the paid compensation to the expropriated property owners [7]. The issues of unfair compensation and dissatisfaction during expropriation processes have triggered various conflicts between expropriating agencies and property owners [8, 9]. Past studies have focused on law enforcement for expropriation passed in 2007 which was later amended in 2015. These studies overlooked the necessity to discuss in-depth different determinants associated with compensation and property owners' satisfaction. The above law sets out procedures to be followed by the expropriating agencies so as to determine fair or just compensation value to be paid to property owners. The just compensation value is defined as the value of the expropriated property determined at market worth [10]. According to the procedures vested in current Rwandan expropriation law that may lead to just compensation, expropriation procedures have to use the latest market prices, which are frequently revised to suit the market prices (Law No 32/2015 of 11/06/2015 Relating to Expropriation in the Public Interest, Government of Rwanda, 2015).

Literature shows that most of the studies concentrate on the government laws governing expropriation, their complexities, and their challenges. Law on land expropriation has received much attention from researchers in recent years. Most studies used qualitative approaches to analyze and formulate recommendations aimed at improving compensation standards [11–14]. So far, little attention has been paid to sociodemographic determinants affecting land compensation. This study is carried out to determine the interplay between compensatory payments and expropriated farmers' determinants, namely age, gender, education, civil status, family, "ubudehe" (social category), land tenure status, means of acquiring land, cropping systems, and satisfaction by means of multiple linear regression (MLR) model construct.

In fact, according to geographers and other investigators in various disciplines, the fact of expropriation has raised many concerns about residential relocation [1]. Based on personal knowledge of the area, this particular expropriated group (farmers in Eastern Rwanda) was chosen for study because project undertakings in this area and the association between sociodemographic attributes and compensation have been little studied in Rwanda.

While there exist many types of regression analysis to analyze the influence of one or more independent variables on a dependent variable, linear regression is the most used of all statistical techniques [15]. With the growth of knowledge in this scientific field, new techniques and methods have been explored, namely the MLR model.

Testing the MLR model has become a standard method for predicting variable value (response variable) based on the value of two or more other variables (predictor variable). The MLR model aims to develop a regression equation that allows the calculation of the dependent variable (compensatory payments) based on predictor variables (expropriated farmers' determinants) [16–18]. In addition, the MLR analysis involves correlation analysis, where both correlation and regression testing may be used to implement multivariate analyses [19]. The objective of this study was to determine the interplay between compensatory payments and expropriated farmers' determinants by means of a MLR model construct.

2. Research Methodology

2.1. Study area

The study took place in December 2019 in drought-prone areas of the Eastern Province of Rwanda at the Howard Buffet Irrigation Scheme in low land of Nasho Sector (Kirehe district), the Bugesera International Airport Project in Rilima Sector (Bugesera district), and the Rwanda Institute for Conservation Agriculture (RICA) in Gashora Sector (Bugesera district) (Figure 1). This area is known for erratic rainfalls and intermittent food insecurity.

Research in Kirehe district aimed to characterize the association of expropriated farmers' determinants with compensatory payments during expropriation by the Kirehe irrigation scheme that was leased by the Howard G. Buffet philanthropist and implemented in Nasho Sector. Nasho Sector has a land area of 103 km^2 with 26,954 inhabitants and population density of 261.4 per km^2 [20].

In Bugesera district, research took place in two sites (Rilima and Gashora Sectors). In Rilima Sector, research aimed to characterize the association of expropriated farmers' determinants with compensatory payments during expropriation by the construction of the new Bugesera International airport. Rilima Sector has a land area of 81.5 km^2 with a population of 26,803 and density population of 328.9 per km^2 [20]. In Gashora Sector, research aimed to characterize the expropriated farmers' determinants associated with compensatory payments during expropriation by the newly established RICA. Gashora Sector has a land area of 98.8 km^2 with a population of 22,001 and density population of 222.6 per km^2 [20]. Table 1 shows areas where research was conducted.

2.2. Data collection and sampling

The study applied purposive and multi-stage sampling techniques. In the first step, the two districts of Eastern Rwanda described above were purposively selected because of their geophysical characteristics in the country and because they have been used for the pilot projects which impacted farmland holders with land conversion for infrastructure development. In the second stage, three different sites (sectors) from the two districts were separately chosen based on a documentation from published reports on land expropriation for development projects taking place in this region. Village leaders assisted in the preparation of lists of expropriated farmers from the selected villages and 90 expropriated farmers were randomly picked for interviews, 30 from each site (sector). Interviewed participants were expropriated farmers affected by aforementioned developmental programs.

The questionnaire devised by authors was the main data collection tool used on selected expropriated farmers in Kirehe and Gashora districts. Elsewhere, observations on the ground, focus group discussions, and interviews with key informants completed our survey.

2.3. Research design and study population

The study used a cross-sectional design to characterize association of expropriated farmers' determinants with compensatory payments during expropriation for land conversion in Kirehe and Bugesera districts. The study populations are all expropriated farmers during land conversion in these districts. Additionally, the social categorization ("ubudehe") was counted during the research process because it is used to assess and monitor the poverty levels among the Rwandan population. The "ubudehe" process involves categorizing all households into one of a range of appropriate categories of

Figure 1
Map of Rwanda indicating districts where the study was carried out

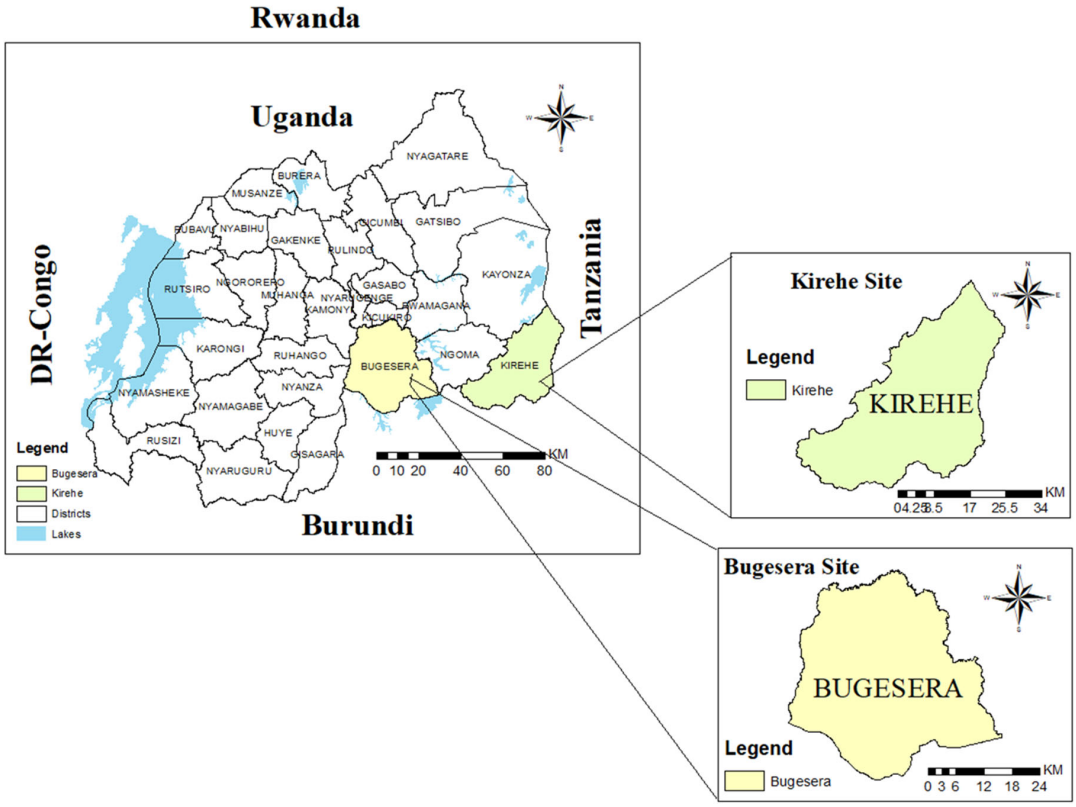


Table 1
Sites under study

Country	Province	District	Sector	Cell	Village
Rwanda	Eastern	Kirehe	Nasho	Rubirizi	Masizi Kabigembe 2
		Bugesera	Rilima	Kimaranzara	Akintwari Gihushi
			Gashora	Mwendo	Kabahaya Kayovu Gaharwa

poverty level as Table 2 shows [21]. Figure 2 shows the steps we followed from beginning to culmination of this study.

2.4. Data analysis

This study used both descriptive statistics and regression analysis to analyze the data, using STATA software, version 15.0 (Stata Corp LLC, Texas, USA). Frequency tables were used to describe the data. In addition, we used the Spearman's rank correlation coefficient to test the relationship between compensatory payments (dependent variables) and expropriated farmers' determinants (independent variables). The analysis of Spearman's rank correlation gives either a positive or negative correlation value which indicates positive or negative relationship between the two variables involved in the analysis. The analysis of variance (ANOVA) was also used to explain the "usefulness" of the linear regression model with $P < 0.05$. Finally, an MLR method was adopted to ascertain significant determinants from potential explanatory variables.

2.5. The study variables

The dependent variable was the compensatory payments given to expropriated farmers in study areas. The independent variables were age, gender, education, civil status, family, "ubudehe," land tenure status, land source status, cropping systems, and satisfaction (Table 3).

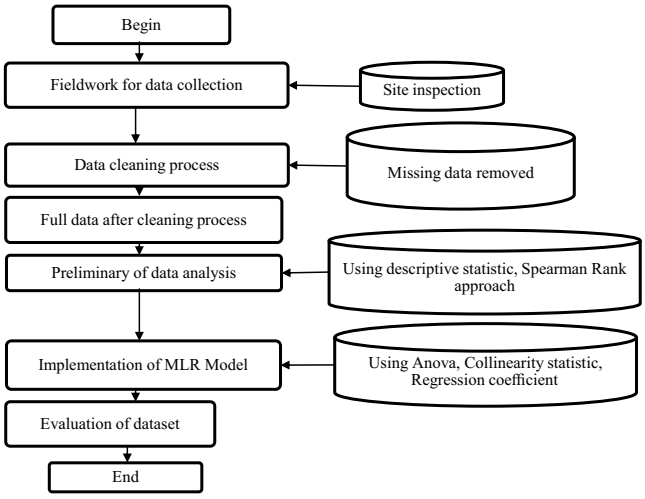
2.6. Multiple linear regression

The study utilized an MLR method to ascertain significant determinants from potential predictor variables. Hence, the

Table 2
"Ubudehe": Poverty characteristics of households in Rwanda

Category	Characteristics
Category 1	Very poor and vulnerable citizens who are homeless and unable to feed themselves without assistance
Category 2	Citizens who are able to afford some form of rented or low class owned accommodation, but who are not gainfully employed and can only afford to eat once or twice a day
Category 3	Citizens who are gainfully employed or are even employers of labor. Within this category are small farmers who have moved beyond subsistence farming, or owners of small and medium scale enterprises
Category 4	Citizens classified under this category are chief executive officers of big businesses, employees who have full-time employment with organizations, industries or companies, government employees, owners of lockdown shops or markets, and owners of commercial transport or trucks

Figure 2
Methodology process



associations between the compensatory payments and 10 determinants of expropriated farmers were performed using an MLR model (additive method). The general form of an MLR model is given by Montgomery et al. [22]:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_k X_k + \varepsilon_i \quad (1)$$

where Y is the compensatory payments in Rwf; β_0 is the intercept; $\beta_1, \beta_2, \ldots, \beta_k$ are coefficients of the variables; $X_1, X_2, \ldots, X_k$ are independent variables, and ε_i is the error term [22].

3. Results

3.1. Descriptive results

3.1.1. Demographics of expropriated farmers

This section shows the results on demographics of the sampled expropriated farmers (Table 4). Of the total of 90, 66.67% of them were male against 33.33% of female, while 80% were under category 3 of "ubudehe". With regard to their age, 60% was aged between 31 and 50 while 92.22% was married. As to education, 73.33% attended school, whereas 93.33% had between 5 and 10 household members.

3.1.2. Land holding in expropriated farmers

Land tenure status, land source, cropping systems, and satisfaction are expressed in terms of the number of respondents while the compensatory payments are expressed in Rwandan francs (Rwf) – local currency of Rwanda. Of the total 90 survey participants, 60% legally owned the dispossessed land while 40% farm on rented land. Land was mostly acquired through inheritance from parents (33.33%), whereas 53.33% cropped in pure stand (mono-cropping). Majority (66.67%) of expropriated farmers received lower compensation (below Rwandan francs (Rwf) 500,000). As expected, 80% of expropriated farmers were dissatisfied (disappointed) with the amount of compensation received (Table 5).

3.1.3. Results on regression analysis

This section aims to characterize expropriated farmers' personal determinants associated with the compensatory payments in Nasho Sector (Kirehe district) and Rilima and Gashora Sectors (Bugesera district) using MLR approach.

In this fashion, determinants associated with the compensatory payments for the expropriation of farmers using an MLR were studied. The predictor variables that were used in the model are age, gender, education, civil status, family, "ubudehe" (social category), land tenure status, means of acquiring land, cropping systems, and satisfaction. The descriptive statistic of compensatory payments for expropriation is shown in Table 6.

Table 6 shows a computed mean of compensatory payments of Rwf 1,336,667 with a standard deviation of Rwf 2,562,640. In terms of range, the minimum and maximum values of compensatory payments were Rwf 0 and Rwf 8,200,000, respectively. The distribution of compensatory payments indicates the skewness of the distribution which was skewed to the right (skewness = 40.73, Prob $> \chi^2 = 0.000 < 0.05$). This indicates that most of the compensations were at lower prices compared to expectations of expropriated farmers.

The correlation analysis was used to test the strength of relationship between couples of quantitative variables. Relationship was tested between dependent variable and predictor variables (Table 7).

There was a strong positive linear correlation between land tenure status and compensatory payments ($\rho = 0.639$, p-value $= 0.000 < 0.05$) and satisfaction ($\rho = 0.652$, p-value $= 0.000 < 0.05$). Moreover, there was a medium positive linear correlation between compensatory payments and gender ($\rho = 0.553$, p-value $= 0.000 < 0.05$). Furthermore, the result shows a weak positive linear correlation between compensatory payments and family ($\rho = 0.236$, p-value $= 0.002 < 0.05$), ubudehe ($\rho = 0.391$, p-value $= 0.000 < 0.05$), civil status ($\rho = 0.227$, p-value $= 0.031 < 0.05$), education ($\rho = 0.236$, p-value $= 0.025 < 0.05$), and land source ($\rho = 0.332$, p-value $= 0.001 < 0.05$).

Table 3
Description of the variables used in the MLR model

Variables	Description	Code
Dependent variable		
Y	Compensatory payments	Discrete (in Rwf)
Independent variables		
Age	Age of household head	Continuous (in years)
Gender	Gender of household head	Dummy (1 = male, 0 = female)
Education	Education of household head	Dummy (1 = literate, 0 = illiterate)
Civil status	Civil status of household head	Dummy (1 = married, 0 = unmarried)
Family	Household composition	Discrete (counts)
"Ubudehe"	Social category of family	Dummy (1 = high income, 0 = low income)
Land tenure status	Land ownership of household	Dummy (1 = owned, 0 = rental)
Land source status	Land acquisition of household	Dummy (1 = inherited, 0 = purchased)
Cropping systems	Farming practices of household	Dummy (1 = pure stand, 0 = intercropping)
Satisfaction	Attitude toward compensatory payments in expropriation	Dummy (1 = yes, 0 = no)

Table 4
Outline of demographic determinants of survey participants

		Sites			
Variables	Parameters	Nasho Rate	Rilima Rate	Gashora Rate	Total Rate
Gender	Male	12 (13.33%)	30 (33.33%)	18 (20.00%)	60 (66.67%)
	Female	18 (20.00%)	0 (0.00%)	12 (13.33%)	30 (33.33%)
	Total	30 (33.33%)	30 (33.33%)	30 (33.33%)	90 (100.00%)
"Ubudehe"	High	30 (33.33%)	30 (33.33%)	12 (13.33%)	72 (80.00%)
	Otherwise	0 (0.00%)	0 (0.00%)	18 (20.00%)	18 (20.00%)
	Total	30 (33.33%)	30 (33.33%)	30 (33.33%)	90 (100.00%)
Age	<30	0 (0.00%)	0 (0.00%)	6 (6.67%)	6 (6.67%)
	31–50	18 (20.00%)	24 (26.67%)	12 (13.33%)	54 (60.00%)
	51–70	12 (13.33%)	6 (6.67%)	6 (6.67%)	24 (26.67%)
	>70	0 (0.00%)	0 (0.00%)	6 (6.67%)	6 (6.67%)
	Total	30 (33.33%)	30 (33.33%)	30 (33.33%)	90 (100.00%)
Civil status	Married	30 (33.33%)	30 (33.33%)	23 (25.56%)	83 (92.22%)
	Otherwise	0 (0.00%)	0 (0.00%)	7 (7.78%)	7 (7.78%)
	Total	30 (33.33%)	30 (33.33%)	30 (33.33%)	90 (100.00%)
Education	Literate	24 (26.67%)	24 (26.67%)	18 (20.00%)	66 (73.33%)
	Illiterate	6 (6.67%)	6 (6.67%)	12 (13.33%)	24 (26.67%)
	Total	30 (33.33%)	30 (33.33%)	30 (33.33%)	90 (100.00%)
Family	<5	0 (0.00%)	0 (0.00%)	6 (6.67%)	6 (6.67%)
	5–10	30 (33.33%)	30 (33.33%)	24 (26.67%)	84 (93.33%)
	>10	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)
	Total	30 (33.33%)	30 (33.33%)	30 (33.33%)	90 (100.00%)

Alternatively, as revealed in the above results, two variables might not be correlated, but in contrast, they may be significantly associated in regression once other variables are controlled. The main objective of this study was to characterize some personal attributes that may connect with the compensatory payments to farmers for land expropriation in Kirehe and Bugesera districts. Thus, the ANOVA table analysis shows the model fitness of MLR (Table 8).

In Table 8, the regression analysis result shows that the general regression model was significant to study the compensatory payments as indicated by ANOVA at the significance of F-value ($p < 0.05$). The table explains the use of F-test and R^2 and their usefulness in regression analysis. F-test in regression analysis compared the fits of the linear model, while the R^2 (coefficient of determination) indicates how well our model fits the data. The ANOVA output shows the F-test 17.59 with $p - value = 0.000 < 0.05$, which indicates that the data scrutiny provides sufficient evidence to conclude that our regression model fits the data.

Equally, the overall regression model is significant to study the compensatory payments for expropriation ($R^2 = 0.69$). Thus, Table 9 shows the collinearity statistic result.

Results in Table 9 indicate that the final model from the MLR entirely includes significant independent variables. The MLR analyses assume no multicollinearity in the data—that the independent variables are not highly correlated with each

Table 5
Land holding and expropriation outcomes

Variables	Parameters	Sites			Total Rate
		Nasho Rate	Rilima Rate	Gashora Rate	
Land tenure status	Owned	18 (20.00%)	30 (33.33%)	6 (6.67%)	54 (60.00%)
	Rental	12 (13.33%)	0 (0.00%)	24 (26.67%)	36 (40.00%)
	Total	30 (33.33%)	30 (33.33%)	30 (33.33%)	90 (100.00%)
Land source	Inherited	12 (13.33%)	18 (20.00%)	0 (0.00%)	30 (33.33%)
	Purchased	18 (20.00%)	12 (13.33%)	30 (33.33%)	60 (66.67%)
	Total	30 (33.33%)	30 (33.33%)	30 (33.33%)	90 (100.00%)
Cropping systems	Pure stand	30 (33.33%)	12 (13.33%)	6 (6.67%)	48 (53.33%)
	Intercropping	0 (0.00%)	18 (20.00%)	24 (26.67%)	42 (46.67%)
	Total	30 (33.33%)	30 (33.33%)	30 (33.33%)	90 (100.00%)
Compensatory payments	<500,000	30 (33.33%)	0 (0.00%)	30 (33.33%)	60 (66.67%)
	500,001–2,500,000	0 (0.00%)	18 (20.00%)	0 (0.00%)	18 (20.00%)
	2,500,001–4,500,000	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)
	4,500,001–6,500,000	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)
	6,500,001–8,500,000	0 (0.00%)	12 (13.33%)	0 (0.00%)	12 (13.33%)
	>8,500,000	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)
	Total	30 (33.33%)	30 (33.33%)	30 (33.33%)	90 (100.00%)
Satisfaction	Yes	6 (6.67%)	12 (13.33%)	0 (0.00%)	18 (20.00%)
	No	24 (26.67%)	18 (20.00%)	30 (33.33%)	72 (80.00%)
	Total	30 (33.33%)	30 (33.33%)	30 (33.33%)	90 (100.00%)

Table 6
Descriptive statistic of dependent variable

Measures	Values
Mean	1,336,667
Std. deviation	2,562,640
Skewness	40.73
Std. error of skewness	0.003
Minimum	0
Maximum	8,200,000
Prob > χ^2	0.000

Table 7
Spearman's rank correlation coefficient test

Variable	Obs.	Correlation coefficient (Spearman's ρ)	p-value
Compensatory payment	90	1.000	
Age	90	0.114	0.280
Family	90	0.236	0.025*
Gender	90	0.553	0.000*
Ubudehe	90	0.391	0.000*
Civil status	90	0.227	0.031*
Education	90	0.236	0.025*
Land tenure	90	0.639	0.000*
Land source	90	0.332	0.001*
Cropping systems	90	0.000	1.000
Satisfaction	90	0.652	0.000*

Note: *Correlation significant at 0.05.

other. This assumption was tested by computation of variance inflation factor (VIF) and tolerance (1/VIF) values. In this respect, the collinearity statistics results showed that all VIF values were less than 10 which implies lack of multicollinearity in the independent variables. This was also reinforced by tolerance values of more than 0.10.

Table 10 shows the regression analysis on specific explanatory variables used in the study and that the compensatory payments for expropriation are associated with age, "ubudehe," civil status, land source, cropping systems, and satisfaction for compensation received because each of them has p-value less than 0.05 and 0.1.

If we now look at the MLR result, the fitted regression model is given: $\hat{Y}_6 = -3483724 + 64535.35X_1 + 1211019X_2 + 1470551X_3 + 2482499X_4 - 1821564X_5 + 5609988X_6$ where $\hat{Y}$ is the compensatory payments in Rwf, X_1 is the age, X_2 is the "ubudehe" (high income), X_3 is the civil status (married), X_4 is the land source (inherited), X_5 is the cropping systems (pure stand), and X_6 is the satisfaction (yes).

Results from the MLR model revealed that determinants of age, "ubudehe" (the fact of being high-income earner), civil status (the fact of being married), land acquisition means (the fact of inherited land from parents), cropping systems (the fact of cropping in pure stand), and satisfaction (the fact of being satisfied) have made statistically significant influence. That is to say, all of these determinants have significantly influenced in the compensatory payments during expropriation. Five independent variables, namely age of household head, "ubudehe" (the fact of being high-income earner), civil status (the fact of being married), land acquisition means (the fact of having inherited land), and satisfaction (the fact of being satisfied), have a positive relationship with the compensatory payments in property expropriation. As an illustration, the unstandardized beta coefficient of the social category ("ubudehe") is 1211019, which indirectly means the higher in esteem position in the society, the higher the compensatory payments for expropriation. In contrast, only "cropping systems" as an independent variable show a negative relationship with the compensatory payments. Based on the standardized beta coefficient, results show that satisfaction (β= 0.880) made the largest contribution to the model. Alternatively, the variables of family, gender, education, and land tenure did not

Table 8
ANOVA

Model	Sum of squares	*df*	Mean square	*F*	Prob > *F*
Regression	403,300,000,000,000	10	40,330,000,000,000	17.59	0.0000
Residual	181,180,000,000,000	79	2,293,400,000,000		
Total	584,470,000,000,000	89	6,567,100,000,000		

Note: $R^2 = 0.6900$.

Table 9
Collinearity statistics

Independent variables	Parameters	Collinearity statistics	
		VIF	Tolerance (1/VIF)
Age	Age	2.57	0.389340
Family	Family	2.33	0.428529
Gender	Male	5.19	0.192648
	Female (Ref.)		
"Ubudehe"	High income	2.68	0.372723
	Low income (Ref.)		
Civil status	Married	1.94	0.516775
	Unmarried (Ref.)		
Education	Literate	3.45	0.289788
	Illiterate (Ref.)		
Land tenure	Owned	5.12	0.195417
	Rental (Ref.)		
Land source	Inherited	3.37	0.297015
	Purchased (Ref.)		
Cropping systems	Pure stand	4.23	0.236218
	Intercropping (Ref.)		
Satisfaction	Yes	2.14	0.467861
	No (Ref.)		

show any significant association with compensatory payments in property expropriation.

4. Discussion

Rwanda is a predominantly agrarian economy country where land is a particularly valuable asset, largely affected by many conflicting priorities in its management [23]. The law n° 32/2015 of 11/06/2015 sets out a list of procedures relating to land expropriation for developmental programs. The study aimed to characterize factors associated with compensations from the perspective of expropriated farmers as a problem for investigation. The MLR test results revealed that farmers' personal determinants such as age, "ubudehe" (the fact of being high-income earner), civil status (the fact of being married), means of acquiring land (the fact of owning land from inheritance), cropping systems (the fact of mono-cropping practice), and satisfaction (the fact of being satisfied) are statistically significant determinants associated with the compensatory payments in farmland expropriation.

The farmers' age showed a positive relationship with compensatory payments. Logically, landowners of mature age groups compared to younger age groups tend to understand the process faster: they make better judgments and organize better in order to negotiate with the expropriators [23]. Another research by Qu et al. [24] points out that older farmers tend to be more satisfied with paid compensation for expropriation than younger ones.

"Ubudehe" (social category) of the farmers also showed a positive association with the compensatory payments. Truth is that people exclusively relying on land for their subsistence are the same people with the lowest level of revenue, particularly in rural areas where they live in substandard living conditions and compensation rates are the lowest. In rural areas where farmers predominantly live and earn meager income, the rates applied for land compensation are the lowest. Besides, the farmers follow traditions of inheritance and rely almost exclusively on land as their source of survival. Even in case of fair compensation payment, farmers are reluctant to leave an area they were accustomed for starting over in an unfamiliar locality.

Farmers of low-income category are in weak position to negotiate fair compensation with expropriators. If the expropriated land is small, then farmers are in weak position to negotiate the compensation and accept the imposed compensation conditions [25]. These results are also in line with those by Rose et al. [7] who found that households with higher monthly incomes generally are less likely to suffer a loss of income due to expropriation.

The civil status determinant was positively associated with compensatory payments. Married adults are likely to be paid higher or fair compensation against unmarried persons. This may be explained by the reputation, maturity, and the negotiation capacity of persons affected by expropriation in respect with expropriating agencies and property valuers. In African society, which is largely patriarchal, a married person is viewed with high esteem compared to a single (unmarried person). In addition, a married person may have acquired land through inheritance, while the single person is still under dependence of his/her parents and does not own land yet. Therefore, during expropriation, negotiations and contacts with expropriating agencies and property valuers will be done by the head of household (husband and father). In logic of events, the compensation is paid in return to the head of household.

Following expropriation, if married, the head of household decides on relocation of his/her family, where they move and how to move. Ideally, the compensatory payments and relocation processes may differ with the married and unmarried persons affected by expropriation.

Land source (means of acquiring land) with land inherited from parents was positively associated with the compensatory payments. This said, farmers attach emotional value to their inherited land that would be very hard to capture in the computation of the compensation.

Findings in this study revealed an inverse relationship between cropping (productivity) in pure stand (mono-cropping) and compensatory payments during land expropriation in the three sites (Nasho, Rilima, and Gashora). Pure stand farming refers to cropping systems consisting exclusively or largely of one species, variety, type, or cultivar. Ideally, in terms of cropping systems, the mechanized rotational mono-culture cropping systems used in developed countries [26] may not apply in Rwanda which is a small land-locked, agrarian, overpopulated country, relying on

Table 10
Summarized multiple linear regression results

Variable	Parameter	Unstandardized coefficients		Standardized coefficients		
		Coef.	Std. err.	Beta	*t*	*P*>|*t*|
(Intercept)	Intercept	−3,483,724	1,605,098		−2.17	0.033*
Age	Age	64,535.35	20,798.15	0.311	3.10	0.003*
Family	Family	−15,550.9	154,570.1	−0.009	−0.10	0.920
Gender	Male	−107,331	771,511.7	−0.019	−0.14	0.890
	Female (Ref.)					
"Ubudehe"	High income	1,211,019	653,680.2	0.190	1.85	0.068**
	Low income (Ref.)					
Civil status	Married	1,470,551	829,128.8	0.154	1.77	0.080**
	Unmarried (Ref.)					
Education	Literate	−781,521.3	670,568.9	−0.135	−1.17	0.247
	Illiterate (Ref.)					
Land tenure	Owned	−110,6930	737,108.9	−0.212	−1.50	0.137
	Rental (Ref.)					
Land source	Inherited	2,482,499	621,348.7	0.459	4.00	0.000*
	Purchased (Ref.)					
Cropping systems	Pure stand	−1,821,564	658,353.9	−0.356	−2.77	0.007*
	Intercropping (Ref.)					
Satisfaction	Yes	5,609,988	583,444.9	0.880	9.62	0.000*
	No (Ref.)					

Note: F (10, 79) = 17.59. Number of respondents = 90.
Prob > F = 0.0000; R^2 = 0.6900.
Adj R^2 = 0.6508; root MSE = 1,500,000.
*significant at 0.05, **significant at 0.1.

rain-fed farming on high fragmented land, using traditional tilling tools and fertilization.

As a rule of thumb, the high production is associated with a high cost of inputs such as technology. Conversely, in Rwanda and in other developing countries mainly the Sub-Saharan Africa, the high capital inputs (high seed use rates, the application of chemicals and fertilizers, insecticides, and fungicides) are far beyond the capacity of subsistence and smallholder farmers. Additionally, the farmer may not use a high cost technology which is inadequate to margin landholding. The inverse relationship between compensated payments and the mechanized rotational mono-culture cropping systems results from the fact that expropriated farmers were smallholders practicing mainly intercropping farming systems. In this case, such relationship implies the lack of cropping in pure stand which explains the high intercropping practices compared to mono-cropping system. Thus, cropping in pure stand was negatively associated with compensated payments.

The level of satisfaction is positively associated with the compensatory payments. This result on satisfaction is also confirmed in several studies such as Ding [27], Lin [28], Ji and Qian [13], and Hui and Bao [29]. The authors stress the low compensation to be the main driver inducing farmers' dissatisfaction. Henceforth, compensatory payments for expropriation are positively associated with farmers' satisfaction.

In this study, it was established that farmers in eastern Rwanda depend more heavily on agriculture and livestock farming. They rely on agriculture and grazing animal activities in savannah, and they are more likely to feel dissatisfied with compensatory for farm property expropriation [30].

Thus, as results suggest, there exists linear relationship between the compensatory payments and the profiles of households such as age, poverty characteristics of households ("ubudehe"), civil status, land source, cropping systems, and satisfaction. These variables should be taken into consideration before and during the expropriation process by expropriators and property valuers.

5. Conclusion and Recommendations

This study aimed to determine the association between compensatory payments and expropriated farmers' determinants during expropriation for infrastructure developments in Kirehe and Bugesera districts of Rwanda. The MLR model construct was used to test these relationships. Results showed significant statistical association with the determinants like age, "ubudehe" (the fact of being high-income earner), civil status (the fact of being married), means of acquiring land (the fact of owning land from inheritance), cropping systems (the fact of mono-cropping practice), and satisfaction (the fact of being satisfied).

An important implication of these results is that in the perspective of expropriation for infrastructure developments that affect farmers' properties, the MLR model can solve several issues associated with this process. We believe that the findings presented in this paper will appeal to scientists and policy makers specializing in the field. Hence, governments, investors, expropriating agencies, and property valuers should consider these variables before and during the expropriation process in order to allocate a just compensation. Simply put, all these determinants should be taken into consideration during determination of compensation by expropriating agencies and property valuers.

Ethical Statement

This study does not contain any studies with human or animal subjects performed by any of the authors.

Conflicts of Interest

The authors declare that they have no conflicts of interest to this work.

Data Availability Statement

Data available on request from the corresponding author upon reasonable request.

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