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Orthogonal Factor Model for the Factors Affecting the Production of Maize in Rwanda

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Abstract: **Rwanda agricultural is today characterized by low productivity due to some factors inputs. Maize production in the country is becoming increasingly important in Rwanda agriculture market. So the purpose of this research is then to determine the variance covariance relationship between variables which main factors could be identified and subsequently give more investment weight for maize quality and volume production development. These variables include organic fertilizer, cultivated area, improved seed, average temperature and annual rainfall**

The analysis of data done by using an orthogonal factor model to describe and determine the variance covariance relationship among many variables in terms of a few underlying called latent factors which can be not observed.

The finding give the answer to our objectives. We found that there is a linear relationship between variables where annual rainfall indicates a negative correlation effect on production of maize. But other variables as average temperature, improved seed, organic fertilizer and cultivated area have positive correlation with production of maize. Next, we found that the improved seed variable shows a high correlation than other variables this suggests that is the most likely increase production of maize in Rwanda. Finally, the variance covariance relationship between factors was determined by estimating loading using rotation method. We found that in oblique rotation the variances explained by the first and second factors are greater than orthogonal rotation. In the oblique cases, the common factors are correlated and display a covariance variance value which is seems acceptable.

Keywords: **Covariance Relationship, Orthogonal Factor Model, Agriculture market.**

1. INTRODUCTION

1.1 Background of the study:

The agricultural sector generates around 30% of Rwanda's GDP and as such is one of the most important sectors to Rwanda's development and to achieving the national goals set out in the EDPRS and Vision 2020.

Crop Intensification Program (CIP) is a program implemented by the Rwanda Agriculture Board (RAB) to attain the goal of increasing agricultural productivity. The purpose is to increase the production of food crops across the country. It is based on three pillars: (1) Land use consolidation; (2) Improved seed and fertilizer use and; (3) Proximity of Extension Service to farmers CIP is targeted at beans, cassava, maize, bananas, rice and sorghum. (MINAGRI, 2012).

During the year 2013-2014 maize production in the country was adversely affected by the effects of climate change such as unreliable rainfall patterns, new diseases such as Maize Lethal Necrosis (MLN) disease which has significantly increased in incidence, severity and spread in the whole country. With the focus on improved productivity, breeding objectives changed from the development of adapted Open Pollinated Varieties (OPVs) to hybrid varieties (inbred line development) that are high yielding and stress tolerant or resistant (MINAGRI, 2013).

Maize crop has become a major food security and income generating crop for small scale farmers in the country. Maize cropping systems have undergone an unprecedented development and radical changes in the past seven years where the national production increased from 97,251 MT in 2005 to 525,679 MT in 2011 (MINAGRI, 2013).

In Rwanda, farmers still need to pursue sustainable intensification to maintain food security, mitigate the effects of weather variability and climate change, protect land and increase incomes (IFDC, 2002). ISFM is a sustainable approach that acknowledges the need for both organic and mineral inputs to sustain soil health and crop production due to positive interactions and complementarities between them.

1.2 Objectives:

1.2.1 General Objective:

The general objective is to determine the major factors that affect yield production of maize in Rwanda using orthogonal factor model.

1.2.2 Specific objectives:

These include:

1. To determine the relationship between maize production and factors affect the production of maize.
2. To establish which factors are most likely impacting the increase the production of maize in Rwanda.
3. To measure the covariance variance of factor of average temperature, annual rainfall, improved seed, organic fertilizer and cultivated area on the productivity of maize.

1.3 Research Hypothesis:

1. There is a linear relationship between maize production variable and factors affecting the production of maize.
2. There exist a factor which is most likely impacting the increase the production more than others.
3. There is common factors and specific factors affecting the production of maize

2. LITERATURE REVIEW

2.1 Maize production in Rwanda:

Maize crop has become a major food security and income generation crop for small scale farmers in the country. The table below indicate how maize production in the country has been increase from 2003-2014.

Table 1: Production of maize in Rwanda

Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Production (MT)	80518	88209	97251	96662	101659	166853	286943	438739	200789	573038	560867

2.2 Factors affecting maize production:

There exist many factors that influence productivity of maize where are classified into three category. The quantity and quality of inputs used including land, labor and capital, fertilizer, seeds farm and farmer characteristics and external factors such as government policy (Wiebe, 2001). Capital inputs among others include seed, fertilizer, and farm equipment. Farm and farmer characteristics on the other hand include factors such as size and topography of area cultivated, location of the farm with respect to input and output markets, age, gender, education level, household size, access to extension services, and access credit (Michele, 2001).

2.2.1 Climatic factors:

Maize is grown in tropical, sub-tropical and temperate climates (FAOAGL, 2002). The highest production of maize occurs in range of 21 and 27^0C with annual precipitation of 500 to 2000 mm.This is especially true for summer annual crops such as maize, which exhibit yield reductions in response to soil water deficits at any growth phase (Roygardet al., 2002). Moisture stress is thought to cause average annual yield losses in maize of about 17% per year in the tropics (Edmeadeset al., 1992), but losses in individual seasons have approached 60% in regions such as southern Africa.

2.2.2 Improved seeds:

In Rwanda CIP imported seeds from neighboring countries as Kenya and Tanzania. In 2008, 765 tons of seeds of maize and wheat were imported for cultivation in season A. The amount seed increased from 1200 tons in season A of year 2009 up to 3512 tons in season A of year 2011.

In addition, improved planting materials (cuttings) of cassava and potato were also distributed to farmers under CIP, the use of improved seeds by farmers has risen from 3% to 40%. For encouraging farmers to use improved seeds, CIP has substantially increased the local demand and the capacity for seed production. With the exception of hybrid seeds, the open pollinated varieties of maize and self-pollinated varieties of wheat, rice and beans are multiplied by public (RAB) and entrepreneurial farmers in the country (MINAGRI, 2011).

2.2.3 Fertilizer use:

The government of Rwanda imported fertilizers and distributed to farmers through various service providers. Through an auction process, the CIP auctions the imported fertilizers to private distributors. To access these fertilizers at subsidized prices, CIP distributes vouchers to farmers through service providers. The farmers buy fertilizers from the distributor/dealer by presenting the vouchers. The distributor transacts the vouchers at the financial bank outlets which in turn collect from MINAGRI/MINICOM. The estimates suggest that as result of these efforts, the national average fertilizer use per year has increased from 8 Kg/Ha to 23 Kg/Ha in 2010. Some of fertilizer used for maize production are DAP and UREA (MINAGRI, 2011).

2.2.4 Consolidation land to use:

Land can growing demographic because of the pressure on ground, the agricultural lands in Rwanda are highly fragmented. Since the agro inputs such as the improved seeds and fertilizer can be transformed into profitability for smallholder farmers only if the land fragmentation is overcome, the land use patterns need to be organized. With the help of government’s policy reforms, the maize crop advocated consolidation of land use by farmers. The consolidation of land use involves successfully rearranged land parcels to consolidate the use of farm holdings. Under the land consolidation policy, farmers in a given area need to grow specific food crops in a synchronized fashion that will help to improve the productivity and environmental sustainability. It also required resettlement of family housing in an administrative area (village) from the agriculturally productive lands (MINAGRI, 2011).

2.3 Modeling maize yield:

Some authors have discussed on maize production and using some model therefore, one is Braimoh and Vek (2006), work on five variables yield maize in Northern Ghana: soil quality index, fertilizer use, household size, distance from main market, and the interaction between fallow length and soil quality by using multiple regression model. They found that soil quality is the most important of maize determinant of maize yield in Northern Ghana, they also suggest that inorganic fertilizer is necessary to correct the depleting soil quality, because organic techniques and inputs alone cannot restore depleted soils and can only sustain crop yields at limited levels.

Another author is Xu et al. (2006), they attempt to determine whether fertilizer use is profitable for small in Zambia, or whether high prices and low response rates make fertilizer use unprofitable. To determine fertilizer profitability, Xu et al. estimate maize yield response to fertilizer under a range of small farm conditions, they found that the marginal product of nitrogen is highest for households that obtain fertilizer on time and use animal draft or mechanical power for land preparation; these farmers are also more likely to find fertilizer use profitable than other households within the same district.

We consider literature on other determinants of yield to help us to control for confounding factors affecting maize production. Based on the assortment literature, it’s shown that there is a negative effects of total farm size on crop yield, known as the inverse farm size-productivity relationship.

3. METHODOLOGY

The preparation model is the orthogonal factor model which has resolution to describe if possible, the covariance relationships among many variables in terms of few underlying, but unobservable, random quantities called factors. Basically, the factor model is motivated by the following argument: suppose variables can be grouped by their correlations. That is, suppose all variables within a particular group are highly corrected among themselves.

3.1 Orthogonal factor model:

We describe the orthogonal factor model by using (Richard, 1998). First of all, we define the observable random vector X, with p components, has mean μ and covariance matrix $\sum$. The factor model is assumes that X, is linearly dependent upon a few unobservable random variables $F_1, F_2, ..., F_m$, common factors, and p addition sources of variation $\varepsilon_1, \varepsilon_2, ...\varepsilon_p$, called errors or specific factors. In specific, the orthogonal factor model with common factors m is express as:

$$X_{(P\times1)} = \mu_{(P\times1)} + L_{(P\times m)}F_{(m\times1)} + \varepsilon_{(p\times1)} \qquad (1)$$

The coefficient l_{ij} is called the factor loadings. Note that the ith variable on the jth factor, so the matrix L is the matrix of factor loadings. Note the ith specific factor ε_i is associated only with the ith response X_i. the p deviations $X_1-\mu_1, X_2-\mu_2, ...X_P-\mu_P$ are expressed in terms of $p+m$ random variables $F_1, F_2, ..., F_m$, which are unobservable.

There exist three assumptions of the orthogonal factor model as follow:

- $E(F)=0, \quad Var(F)=E(FF^{'})=I,$ The measurement error has constant variance and zero average.
- $E(\varepsilon)=0, Var(\varepsilon)=E(\varepsilon\varepsilon^{'})=\psi=diag\{\psi_i\}, i=1,..., p$ There is no association between errors.
- F, ε are independent, so that $Cov(F,\varepsilon)=0.$ It implies that there is no association between the factor and measurement error.

3.2 Methods of Estimation:

3.2.1 Principal Component method (PCA):

The goal of PCA is to find components or factors which are linear combination of the original variables that achieve maximum variance. The PCA seeks to maximize the variance so it is sensitive to scale difference in the variable. It is best to standardize the data and work with correlations rather covariance among the original variables. The solution is obtained by performing an eigenvalue decomposition of the correlation matrix. The eigenvalues represent the direction of principal axes.

Mathematically the principal component factor analysis of the sample covariance matrix S is specified in terms of its eigenvalue-eigenvector pairs $\begin{pmatrix}\hat\lambda_1\,\hat e_1\end{pmatrix}, \begin{pmatrix}\hat\lambda_2\,\hat e_2\end{pmatrix} ... \begin{pmatrix}\hat\lambda_{m1}\,\hat e_m\end{pmatrix}$ where $\hat\lambda_1 \geq \hat\lambda_2 \geq ... \geq \hat\lambda_p$. Let $m \prec p$ be the number of common factors. Then the matrix loadings $\left\{\hat{l}_{ij}\right\}$ is

$$L=\left[\sqrt{\hat\lambda_1\,\hat e_1}, \sqrt{\hat\lambda_2\,\hat e_2}, ...\sqrt{\hat\lambda_m\,\hat e_m}\right] \qquad (2)$$

The estimated specific variances are provided by diagonal elements of the matrix $S-\tilde{L}\,\tilde{L}'$, so

$$\tilde\psi = \begin{bmatrix} \tilde\psi_1 & 0 & .... & 0 \\ 0 & \tilde\psi_2 & ... & 0 \\ ... & ... & ... & ... \\ 0 & 0 & ... & \tilde\psi_p \end{bmatrix} \text{With } \tilde\psi_i = S_{ii} - \sum_{j=1}^{m} \tilde{l}_{ij}^{\,2} \qquad (3)$$

Communalities are estimated as

$$\tilde{h}_i^2 = \tilde{l}_{i1}^2 + \tilde{l}_{i2}^2 + ... + \tilde{l}_{im}^2 \qquad (4)$$

3.2.2 Maximum likelihood factor analysis:

The Maximum Likelihood Estimation Method we must assume that the data are independently sampled from a multivariate normal distribution with mean vector μ and $\sum$ variance-covariance matrix that takes this particular form: $\sum = LL' + \psi$ where L is the matrix of factor loadings and ψ is the diagonal matrix of specific variances. Let the data vectors for n subject will be represented as show $X_1, X_2, \ldots X_n$ the maximum likelihood estimation involves estimating the mean vector μ, the matrix of factor loadings L, and the specific variance ψ. We obtained the notation $\hat{\mu}$, $\hat{L}$ and $\hat{\psi}$ that maximizes the log likelihood, which is given by the following form:

$$l(\mu, L, \psi) = -\frac{np}{2}\log 2\pi\left|LL'+\psi\right| - \frac{1}{2}\sum_{I=1}^{n}(X_i-\mu)'(LL'+\psi)(X_i-\mu) \qquad (7)$$

Where the log of the joint probability distribution of the data is to be maximized. We want to find the values of the parameters, (μ, **L**, and ψ), that is most compatible with what we see in the data. As was noted earlier the solutions for these factor models are not unique. Equivalent models can be obtained by rotation. To obtain a unique solution an additional constraint to be imposed is that $L'\psi^{-1}L$ is a diagonal matrix.

The maximum likelihood estimates of the communalities is equal to:

$$\hat{h}_i^2 = \hat{l}_{i1}^2 + \hat{l}_{i2}^2 + \ldots \hat{l}_{im}^2 \text{ for } i = 1,2,.., p \qquad (8)$$

$$\text{So} \begin{pmatrix}\text{Proportion of total sample} \\ \text{variance due to jth factor}\end{pmatrix} = \frac{\hat{l}_{1j}^2 + \hat{l}_{2j}^2 + \ldots + \hat{l}_{pj}^2}{s_{11} + s_{22} + \ldots + s_{pp}} \qquad (9)$$

3.2.3 Factor Rotation:

Factor rotation is a dimension method to reduce common factor analysis or exploratory factor analysis. Common factor analysis recognizes that model variance contains both shared and unique variance across variables. Orthogonal factor model examines only the shared variance from the model each time a factor is created, while allowing the unique variance and error variance to remain in the model.

Factor rotation is motivated by the fact that factors models are not unique. To obtain with, we recall that factor model for the data vector $X = \mu + LF + \varepsilon$, is a function of mean μ plus a matrix of factor loadings times a vector of common factors, plus a vector specific factors.

Moreover, we should note that this equivalent to rotated factor. $X = \mu + L^*F^* + \varepsilon$, where $L^* = LT$ and $F^* = T'F$ for some orthogonal matrix T where $T'T = TT' = I$. Note that there are an infinite number of possible orthogonal matrices, each corresponding to a particular factor rotation.

4. RESULTS AND DISCUSION

The purpose of current research is to determine the variance covariance relationship between variables from which main factors could be identified and subsequently give more investment weight for maize quality and volume production development. Orthogonal factor analysis use to explore the data for patterns, confirm our hypotheses, or reduce the many variables to a more manageable number and appearance the correlations between variables.

The data and findings examine by the use of Stata software to present the findings and serve to in depth analysis then interpretation.

4.1. Collect and explore data: choose relevant variables:

In our study, we use secondary source of data. The data were collected on yield of maize crop from Meteo-Rwanda and Rwanda agricultural board (RAB) office, of past year 2003-2013. The appropriate sampling technique to be using is systematic sampling with a size of eleven years.

4.1.1. Variable Identification /Variable Considered In the Study:

The study variables to this research are: Independent (factor or explanatory) variables and X is dependent variable (production of maize).

i. Temperature (X_1) (°C)
ii. Rainfall (X_2)(mm)
iii. improved seeds (X_3)(mt)
iv. organic fertilizer used (X_4) (mt)
v. cultivated area (X_5) (ht))

The model becomes as:

$$X_j = l_{ji}X_1 + l_{ji}X_2 . + l_{ji}X_3 + l_{ji}X_4 + l_{ji}X_5 + \varepsilon_{ij} i = 1,..., p \qquad (10)$$

Where ε_{ij} is distribute with $E(\varepsilon_{ij}) = 0, Var(\varepsilon_{ij}) = E(\varepsilon_{ij}\varepsilon'_{ji})$ where X and ε are independent

4.2. Method of estimation:

4.2.1. Principal component factors:

The PCF has goal to analyze variance and reduce the observed variables. We first determine the number of factors retained precise by eigenvalues and the second the factor loading matrix.

Table 2: Principal component method

(Obs=11)
Factor analysis/correlation Number of obs = 11
Method: principal-component factors Retained factors = 2
Rotation: (unrotated) Number of params =9

Factor	Eigenvalue	Difference	Proportion	Cumulative
Factor1	2.58804	1.28038	0.5176	0.5176
Factor2	1.30766	0.57422	0.2615	0.7791
Factor3	0.73344	0.45189	0.1467	0.9258
Factor4	0.28155	0.19224	0.0563	0.9821
Factor5	0.08931	.	0.0179	1.0000

The sum of all eigenvalues is equal to total number of variables. By using (Kaiser, 1958) Criterion suggests to retain those factors with eigenvalues equal or higher than 1.

Here we retain two factors 2.58804 and 1.30766 because are greater than 1 (it means that the two factors explain at least as much of the variation as the original variables).

The difference displayed are the difference between two eigenvalues to one another for example 2.58804 -1.30766 = 1.28038.

The proportion indicate the relative weight of each factor in the total variance. Here the first factor explains or equal to 2.58804/5=0.5176 explain that factor 1 indicates 51.76% of total variance. The cumulative shows the amount of variance explained by n(n-1) factors. The amount of variance explained by factor 2 is 77.91%

Table 3: Factor loadings (pattern matrix) and unique variances for principal component

Variable	Factor1	Factor2	Uniqueness
Average temperature (^{0}c)	0.4129	0.7357	0.2883
Annual rainfall (mm)	-0.1691	0.7758	0.3696
Improved seed (mt)	0.9523	0.1867	0.0583
Organic fertilizer (mt)	0.8813	-0.0589	0.2198
Cultivated area (ht)	0.8399	-0.3554	0.1683

Factor loadings show the correlation between the original variables (average temperature, annual rainfall, improved seed, organic fertilizer and cultivated area) and the factors, typically the factors are named after the set of variables they are most correlated with. Here, The annual rainfall has a negative value of -0.1691 it indicates that there is an inverse impact on the production of maize. But the average temperature, improved seed, organic fertilizer and cultivated area have the positive values which indicate the positive impact on the production of maize in Rwanda.

Uniqueness is the variance that is ‘unique’ to the variable and not shared with other variables. It is equal to 1-communality (variance that is shared with other variables).

For example here improved seed has a low variance which is not accounted by other variables (5.83%). Now we interpret the correlation above 0.5 is deemed important:

The first principal component is strongly correlated with five of the original variables. The first principal component increases with improved seed, organic fertilizer and cultivated area. This suggest that these three criteria vary together. If one increases, the remaining two also increase. Further we see that the first principal component correlates most strongly with improved seed based on correlation of 0.9523. It is important to increase a lot of improved seed available.

The second principal component increase with annual rainfall and average temperature. It would be necessary to know how measuring annual rainfall and average temperature in fact to contribute on maize production.

4.2.2. Maximum likelihood factor analysis:

The maximum likelihood method seeks to maximize canonical correlations between the manifest variables and the common factors. Thus maximum likelihood may be used descriptively, even if we are unwilling to assume multivariate normality.

Table 4: Maximum likelihood method

(Obs=11)
Method: maximum likelihood

Factor	Eigenvalue	Difference	Proportion	Cumulative
Factor1	2.39962	1.43104	0.7124	0.7124
Factor2	0.96857	.	0.2876	1.0000

LR test: independent vs. saturated: chi2(10) = 23.58 Prob>chi2 = 0.0088

Stata display a likelihood-ratio test of the number of factors in the model against the saturated model. The first hypothetical testing is the testing of independent variables against saturated model it implies that the probability which is great than chi-square is statistical significant of 1% of level of for the independent variables.

LR test: 2 factors vs. saturated: chi2(1) = 0.50 Prob>chi2 = 0.4779

(tests formally not valid because a Heywood case was encountered)

Here depending also on the hypothetical testing above it implies that the probability likewise great than chi-square is statistical significant of 1% for two factors.

4.2.3 Comparison between orthogonal and oblique rotation:

Table 5: Comparison between orthogonal and oblique rotation

	Rotated		Unrotated	
Variable	Factor1	Factor2	Factor1	Factor2
Average temperature (^{0}c)	0.0424	0.7683	0.3746	0.6846
Annual rainfall (mm)	-0.2727	0.3521	-0.1155	0.3675
Improved seed (mt)	0.8022	0.3697	0.9487	0.1856
Organic fertilizer (mt)	0.8212	0.0320	0.8211	-0.1222
Cultivated area (ht)	0.8929	-0.2313	0.7774	-0.3727

Look again at the stata output gives comparison between orthogonal and oblique rotation. According to orthogonal varimax the variance of the first and second factor solution are 2.8063 and 0.7428, respectively. The explained variance of 2.8063+0.7428 is distributed over the two factors. The situation on oblique rotation is different, the variances of the first and second factors are 2.286 and 1.6208. Their variance explained is 2.286+1.6208 which is add up to more than the orthogonal case. In the oblique case, the common factors are correlated and thus partly the same variance'.

Therefore, the cumulative proportion of variance explained by the factors is not displayed here

Most researchers would not be willing to accept a solution in which the common factors are highly correlated.

Table 6: Correlation matrix of the oblimin (0) rotated common factors.

Factors	Factor1	Factor2
Factor1	1	
Factor2	0.2601	1

The correlation or covariance variance of 0.2601 seems to be acceptable, so we think that the oblique rotation was success here.

4.3 Summary Statistics:

We summarize the descriptive statistics of the variables in the factor analysis over the estimation sample.

Table 7: Descriptive statistics

Estimation sample factor Number of obs = 11

Variable	Mean	Std. Dev.	Min	Max
Average temperature (^{0}c)	19.79545	0.6206668	18.5	21
Annual rainfall (mm)	1002.061	157.5289	731	1283.67
Improved seed (mt)	1410.418	1345.219	254	4621
Organic fertilizer (mt)	19736.89	14593.23	3033.8	45000
Cultivated area(ht)	156775.8	48158.58	106976	253697

The descriptive statistics of Stata output with data of 11 years past for factors affecting the production of maize are given in above table.

For example, the maximum amount of average temperature, annual rainfall, improved seed, organic fertilizer and cultivated are 21℃ , 1283.67 (mm), 4621 (mt), 45000 (mt) and 253697 (ht) respectively.

The standard deviation of factors affecting the production of maize temperature are in Celsius, rainfall millimeter, improved seed in mega tones, organic fertilizer used in mega tones and cultivated area are in hectare one-to-one are 0.620, 157.5, 1345.2, 14593.23 and 48158.58.

5. SUMMARY, CONCLUSIONS AND RECOMMENDATION

5.1 Summary, Conclusions:

Depending on the analysis of the result and discussion, we conclude the following main points correspondingly with our objectives:

The test of hypothesis show that some independent variables (factors) affecting maize production as cultivated area, organic fertilizer, average temperature, annual rainfall and improved seed are statistically significant at 1% level of significance with a probability greater than chi-square.

The correlation of the observed variable indicate that there are linear relationship between the different independent variables that are correlate to one another. For example the annual rainfall variable has indicates a negative correlation inverse impact in production of maize in Rwanda.

The principal component estimation output and graph show that we have retained two factors because are greater than 1 which it means that the two factors retained explain at least as much of the variation as the original variables. The interpretation for first principal component show that increases with improved seed, organic fertilizer and cultivated area this suggest that these three criteria vary together. The improved seed looks very high loading to organic fertilizer and cultivated area variables. It answer also the second objective that improved seed variable is more increase the production of maize in Rwanda.

The second principal component (factor) it proposes to look on annual rainfall and average temperature which, it gives an appearance that farmers can work and knowing the climate season.

The data has become much clearer after rotation. The comparison of oblique rotation and orthogonal rotation helped to get the better estimation loading where in oblique rotation the variances explained by the first and second factors are greater than orthogonal cases. In the oblique cases, the common factors are correlated and display a covariance variance value which is seems to be acceptable.

The descriptive statistics data set give the mean, standard deviation, maximum and minimum of each independent variables so for example the mean values of average temperature, annual rainfall, improved seed, organic fertilizer and cultivated are 19℃, 1002.061(mm), 1410.418 (mt), 19736.89 (mt) and 156775.8 respectively which shows that cultivated area is the most used up factor.

5.2 Recommendation:

In Rwanda there is low production of maize; so according to the finding of these studies the recommendations are as follows. To ensure the farmers in order to improve the production of maize there are some measurement should be taken. The agricultural sectors should be highly encourages and lead the farmers by giving more technical (professional) follow up, to get highly qualified yields and to improve the production technique. Since the production of maize crop depends factors affecting as cultivated area, fertilizer, temperature, improved seed and rainfall the Rwanda-Metrological Agency and Rwanda agricultural board (RAB) should work together with each other on this issue. Since there is no data that collected for long period of time, as result we cannot study the effect of production in detail and we cannot know the normality of the data Therefore, the agricultural office workers and each employment should be accomplish their responsibility at right time and right place in recording data from time to time for the future researchers.

Finally, improved access to finance for farmers and those that deal in agricultural produce, is another major achievement for maize production. It is not yet at the desired level, but it is hoped that with time the issue will be resolved, especially if collaboration with microfinance institutions can be achieved.

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