Analysis of Quality and Land Characteristics That Control Local Maize Production in Gorontalo

by Nurdin , M. L Rayes Soemarno And Sudarto

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ABSTRACT

Increase national maize production has not been followed by an increase in maize productivity per unit area because maize was grown on land that was not suitable with these land quality. This study aims to determine the land quality that control of local maize production. This research was conducted at the Gorontalo Regency. A total of 33 mapping units had been established containing data of soil properties, climate and terrain divided into land quality, as well as data of local maize production. A partial least square of structural equation models (PLS-SEM) analysis was used to determine the land quality and characteristics that control of local maize production through testing the validity and reliability of variables, as well as testing structural models. The results showed that the all manifest variables were valid and able to explain well the latent variables, except for texture, cation exchange capacity, and base saturation. Furthermore, the latent variables temperature, water availability, oxygen availability, nutrient retention, nutrients availability, sodicity, erosion hazard, flood hazard, and land preparation used has good composite reliability and high reliability because of the composite reliability and alpha cronbach >0.6, except for rooting media. Land quality that control of the local maize production were the oxygen availability (X_1), rooting media (X_2), nutrient retention (X_3), nutrients availability (X_4), erosion hazard (X_5), and land preparation (X_6) with the best equation: $Y = 1.805 + 0.276X_1 + 0.303X_2 + 0.353X_3 + 0.346X_4 - 0.337X_5 - 0.303X_6$. The land characteristics that control of the local maize production were drainage (X_1), coarse material (X_2), effective depth (X_3), pH KCl (X_4), C-organic (X_5), total N (X_6), available K (X_7), slope (X_8), soil erosion (X_9), surface rock (X_{10}) and rock outcrop (X_{11}) with the best equation: $Y = 2.447 + 0.187X_1 - 0.212X_2 + 0.153X_3 + 0.349X_4 + 0.166X_5 + 0.169X_6 + 0.313X_7 - 0.352X_8 - 0.230X_9 - 0.237X_{10} - 0.187X_{11}$.

Keywords: *Quality, characteristic, land, production, maize, local*

1. INTRODUCTION

Increasing maize productivity is one of the main indicators for the development of food crops. Various activities have been carried out in order to achieve these goals, but the results has not yet reached the expected potential results. This was indicated by the achievement of increasing maize production in an agricultural area which has not been followed by an increase of maize productivity per unit area. Nationally, the achievement of maize productivity was 5.5 tonnes ha^{-1} [1]. In fact, maize in Indonesia can produce 10-11 tonnes ha^{-1}, but productivity in farmers' lands was still in the range of 3.2-8 tonnes ha^{-1} [2].

Sustainable agricultural areas in Gorontalo Regency also experience this phenomenon. Until 2019, maize productivity in this area averaged only 5.2 tonnes ha^{-1} or still far below the average national maize productivity [3]. Meanwhile, the average of local maize productivity has only reached 3.0 tonnes ha^{-1} [4]. One of the maize local varieties of Gorontalo is Motoro Kiki [5]. This local maize, aged of 70-80 day after planting, resistant to downy mildew and leaf rust, and well planted in the lowlands to the highlands [4]. In addition, local maize has better growth than hybrid and composite maize, but yield components show the opposite pattern [6]. The existence of maize local Gorontalo was starting to become extinct because farmers prefer to plant composite and hybrid maize with the free maize seed subsidize program from the Government through the agriculture agency.

One of the causes of low maize production was caused maize grown on land with low productivity potential [7]. Land productivity was determined by the land quality and characteristics. Land quality has a close relationship with maize production [8] and each land quality has a significant effect on land suitability for certain uses [9], especially for maize crops. Research on land quality that controls maize production has been conducted by [10] on sukmaraga maize composite varieties in the Bogor area with stepwise regression analysis. Meanwhile, the use of structural equation model (SEM) analysis in determining the land quality and characteristics that control plant production was only carried out by [11] but on mature cocoa trees in Kolaka Timur Regency, Southeast Sulawesi Province. There is no research report on the use of SEM analysis to assess the relationship between land quality and maize production.

Land quality that controlling of maize production was important to know because the response of maize to various land quality and characteristics will vary. The dynamics of various land qualities and characteristics require a comprehensive analysis technique capable of describing the complexity in one analysis system. The use of SEM analysis is one option that can be done. How much influence each indicator (*manifest*) of soil physical and chemical properties (*latent*) has on production can be determined by SEM analysis [11. The use of SEM is very helpful in determining the effect of indicators and producing better models than other multivariate analyzes [12]. Partial Least Square (PLS) is a variant of SEM which has a higher level of flexibility because PLS based on variants, so the number of samples used does not need to be large, ranging from 30-100, while CB-SEM has a minimum data sample size of 100 and requires that the data is multivariate normal distribution [13]. Therefore, based on the consideration of the complexity of the land quality and characteristics, as well as the limitations of the land mapping unit of the study area, a research on land quality that controls the local maize productivity was carried out using SEM-PLS analysis. This study aims to determine the land quality and land characteristics that control local maize production in Gorontalo.

2. MATERIALS AND METHOD

This research was conducted at the Sustainable Agriculture Area of Gorontalo Regency and the Soil Laboratory, Faculty of Agriculture, Brawijaya Universityfrom December 2019 to March 2020. The tools used consisted of SmatPLS version 2.0 and the SPSS software. The materials studied were data on soil characteristics, climate and terrain characteristics, as well as local maize production.

Soil characteristics, climate and terrain characteristics data from the study area were divided into land quality. Furthermore, local maize production data were obtained from the results of tile plots as well as the results of direct interviews with farmers in each LMU. Then, land characteristics data of various sizes and units (ratio data) were converted into interval data which was represented as follows: 1 (very low), 2 (low), 3 (medium), 4 (high), and 5 (very high) followed by an analysis using a SEM-PLS.

In this study, the latent variables were variables that can not be measured directly, in this case the land quality consisting of: temperature (X_1), water availability (X_2), oxygen availability (X_3), rooting media (X_4), nutrient retention (X_5), nutrient availability (X_6), sodicity (X_7), erosion hazard (X_8), flood hazard (X_9), and land preparation (X_{10}). Meanwhile, the manifest variable were variables that can be directly measured, in this case the land characteristic consisting of: air temperature ($X_{1.1}$), rainfall ($X_{2.1}$), wet months ($X_{2.2}$), dry months ($X_{2.3}$), long growth periods-LGP ($X_{2.4}$), drainage ($X_{3.1}$), texture ($X_{4.1}$), coarse material ($X_{4.2}$), effective depth ($X_{4.3}$), pH H_2O ($X_{5.1}$), pH KCl ($X_{5.2}$), C-organic ($X_{5.3}$), cation exchange capacity-CEC ($X_{5.4}$), base saturation ($X_{5.5}$), total N ($X_{6.1}$), available of P ($X_{6.2}$), available of K ($X_{6.3}$), exchangeable sodium percentage-ESP ($X_{7.1}$), slopes ($X_{8.1}$), soil erosion ($X_{8.2}$), inundation height ($X_{9.1}$), inundation period ($X_{9.2}$), surface rock ($X_{10.1}$), and rock outcrop ($X_{10.2}$). The use of SEM-PLS in this study consists of:

2.1. Testing the Validity and Reliability of Research Variables.

The basic evaluation carried out in the SEM-PLS analysis was to evaluate the measurement model (*outer model*) with the aim of knowing the validity and reliability of indicators in measuring research latent variables through convergent validity, discriminant validity, and composite reliability. Convergent validity testing on SEM-PLS was seen from the size of the outer loading of each indicator against its latent variable. A loading factor value above 0.70 was highly recommended, but a loading factor value of 0.50-0.60 could still be tolerated with a t-statistic value of more than 1.96 or a small p-value of 0.05. The loading factor of an indicator with the highest value was the strongest or most important measure in reflecting the latent variable in question. Discriminant validity was an evaluation of the outer model in SEM-PLS using cross loading values to test valid and reliable indicators in explaining or reflecting latent variables. If the correlation of the latent variable with the measurement core of each indicator greater than the other latent variables, then the latent variable is able to predict the indicator better than other latent variables and was said to be valid. Composite reliability and Cronbach's alpha values were used to test the reliability value between the indicators of the latent variables that formed them. The composite reliability value and Cronbach's alpha were said to be good, if the value was >0.60.

2.2. Structural Model Testing

Testing of the structural model (*inner model*) was carried out after the relationship model was built in accordance with the observed data and the suitability of the overall model (*goodness of fit model*). Testing of structural models and hypotheses was carried out by looking at the estimated value of the path coefficient and the critical point value (t-statistic) which was significant at α = 0.05. Testing the relationship model and hypothesis between variables can be done by testing the direct correlation coefficient between variables. The results of testing the relationship between the X variables and the Y variable in this study were shown by the correlation coefficient and t-statistic, and also seen in the path diagram.

3. RESULTS AND DISCUSSIONS

3.1. Validity of research variables

The validity test showed that most of the indicators in the research variables had loading factor values greater than the critical limit of 0.70 with a 95% confidence level (Table 1). While the loading factor value that was below the tolerant value (0.50) and the t-statistic value was smaller than the t-table (1.96) was found in the latent variable of rooting media (X4) with a soil texture indicator was 0.173 and nutrient retention of the latent variable (X5) on the CEC indicator (X5.4) was 0.399 and the base saturation indicator (X5.5) was 0.482. This meant that these indicators had not been able to properly form or explain their latent variables. The standard of loading factor was greater than 0.50 [14] [15] [16]. However, in general, based on the indicated values, it can be concluded that the latent variables of land quality has been able to be well established or explained by each indicator and can be said to be convergent valid on these indicators.

The average cross-loading value for indicators in latent variables was above the cross-loading values of indicator in other latent variables (Table 2). This meant, the highest cross-loading value on an indicator was also the highest value on its latent variable, except for the rooting media variable (X4) with the texture indicator (X4.1), and the nutrient retention variable (X5) with the CEC indicator (X5.4) and base saturation indicator (X5.5) with a smaller cross-loading value <0.5. The standard of loading factor was ≥0.50 [14] [15] [16]. Thus, the indicator of each latent variable was able to explain their own latent variables so that the research variables were said to be a valid discriminant.

Table 1. Outer loading research variables

Effect of indicators on latent variables			**Loading factors**	**Status**
Air temperature ($X_{1.1}$)	->	Temperature (X_1)	1.000	Valid
Rainfall ($X_{2.1}$)	->	Water availability (X_2)	0.983	Valid
Wet months ($X_{2.2}$)	->		0.995	Valid
Dry months ($X_{2.3}$)	->		0.845	Valid
LGP ($X_{2.4}$)	->		0.972	Valid
Drainage ($X_{3.1}$)	->	Oxygen availability (X_3)	1.000	Valid
Texture ($X_{4.1}$)	->	Rooting media (X_4)	0.182	Not valid
Coarse material ($X_{4.2}$)	->		-0.895	Valid
Effective depth ($X_{4.3}$)	->		0.922	Valid
pH H_2O ($X_{5.1}$)	->	Nutrient retention (X_5)	0.787	Valid
pH KCl ($X_{5.2}$)	->		0.874	Valid
C-Organic ($X_{5.3}$)	->		0.923	Valid
CEC ($X_{5.4}$)	->		0.481	Not valid
Base saturation ($X_{5.5}$)	->		0.326	Not valid
N Total ($X_{6.1}$)	->	Nutrient availability (X_6)	0.829	Valid
Available P ($X_{6.2}$)	->		0.642	Valid
Available K($X_{6.3}$)	->		0.969	Valid
ESP ($X_{7.1}$)	->	Sodicity (X_7)	1.000	Valid
Slope ($X_{8.1}$)	->	Erosion hazard (X_8)	0.992	Valid
Soil erosion ($X_{8.2}$)	->		0.965	Valid
Inundation height ($X_{9.1}$)	->	Flooding hazard (X_9)	0.990	Valid
Inundation period ($X_{9.2}$)	->		0.993	Valid
Surface rock ($X_{10.1}$)	->	Land preparation (X_{10})	0.999	Valid
Rock outcrop ($X_{10.2}$)	->		0.995	Valid
Productivity ($Y_{1.1}$)	->	Local maize productivity (Y_1)	1.000	Valid

LGP: Long growth period; CEC: Cation exchange capacity; ESP: Excangeable potassium percentage

Table 2. Cross-loading of research variables

Indikator	Temperature (X_1)	Water availability (X_2)	Oxygen availability (X_3)	Rooting media (X_4)	Nutrient retention (X_5)	Nutrient availability (X_6)	Sodicity (X_7)	Erosion hazard (X_8)	Flooding hazard (X_9)	Land preparation (X_{10})	Production (Y_1)
Air temperature ($X_{1.1}$)	1	0.974058	0.061454	-0.091173	-0.428317	-0.073652	0.406783	0.02159	-0.13792	0.219821	0.068223
Rainfall ($X_{2.1}$)	0.976513	0.991684	0.209631	0.064295	-0.275923	0.063868	0.397465	-0.04381	-0.05146	0.065735	0.217651
Wet months ($X_{2.2}$)	0.941357	0.979657	0.193703	-0.017931	-0.263141	0.079163	0.409261	-0.06920	-0.06095	0.071259	0.191355
Dry months ($X_{2.3}$)	0.863195	0.873285	0.158622	-0.252786	-0.513267	-0.136801	0.497352	-0.11903	0.03372	0.247653	0.080792
LGP ($X_{2.4}$)	0.910319	0.959821	0.149654	-0.017432	-0.327742	0.064218	0.468817	-0.14008	-0.05893	0.068362	0.218919
Drainage ($X_{3.1}$)	0.068901	0.251132	1	0.209845	-0.286975	0.059325	0.094359	-0.53642	0.28566	-0.311688	0.401756
Texture ($X_{4.1}$)	-0.015049	-0.007345	-0.196751	0.186113	0.294305	0.139764	0.287013	0.258671	-0.00085	-0.042531	0.184273
Coarse material ($X_{4.2}$)	-0.004233	-0.111890	-0.145526	-0.953261	-0.419651	-0.721693	0.199112	0.394225	-0.29371	0.859705	-0.422011
Effective depth ($X_{4.3}$)	-0.185577	-0.096322	0.170192	0.908772	0.381729	0.383752	-0.25416	-0.21069	0.098172	-0.808412	0.200913
pH H_2O ($X_{5.1}$)	-0.463045	-0.438571	-0.419653	0.317653	0.788691	0.281776	-0.19573	0.192374	-0.03595	-0.097455	0.219885
pH KCl ($X_{5.2}$)	-0.373956	-0.446223	-0.452037	0.342269	0.897732	0.326971	-0.03975	0.185291	0.096937	-0.213928	0.327627
C-Organic ($X_{5.3}$)	-0.199271	-0.210951	0.100925	0.268721	0.775314	0.684290	0.082439	-0.52642	0.072896	-0.295211	0.408752
CEC ($X_{5.4}$)	0.044986	0.225247	0.004199	0.091538	0.422697	0.495236	0.413522	-0.06933	0.175312	-0.029783	0.354434
Base saturation ($X_{5.5}$)	-0.200728	-0.204165	-0.118215	0.458627	0.490752	0.387158	-0.69050	-0.09115	-0.16297	-0.491375	0.156315
N Total ($X_{6.1}$)	0.003976	0.192784	0.083764	0.277583	0.573833	0.849673	0.042763	-0.42870	-0.11392	-0.265862	0.435072
Available P ($X_{6.2}$)	-0.099112	-0.089772	-0.469732	0.226971	0.418925	0.598021	-0.31781	-0.06398	0.041585	-0.300791	-0.037419
Available K($X_{6.3}$)	-0.098631	-0.021351	0.075881	0.709523	0.601578	0.898672	-0.38288	-0.31495	0.327361	-0.675525	0.529322
ESP ($X_{7.1}$)	0.390526	0.582752	0.093465	-0.236799	-0.074953	-0.283745	1	-0.02586	0.262957	0.417664	-0.039527
Slope ($X_{8.1}$)	-0.031307	-0.200893	-0.697107	-0.310086	-0.173356	-0.425937	-0.04295	0.981242	-0.35516	0.351329	-0.675983
Soil erosion ($X_{8.2}$)	0.068254	-0.001981	-0.527713	-0.207321	-0.131759	-0.367951	0.029383	0.978553	-0.13629	0.277838	-0.519375
Inundation height ($X_{9.1}$)	-0.096746	-0.037425	0.311655	0.218953	0.093587	0.142765	0.225976	-0.35211	0.990897	-0.145263	0.192408
Inundation period ($X_{9.2}$)	-0.206352	-0.079142	0.300928	0.288375	0.058273	0.083762	0.298112	-0.30075	0.991132	-0.12889	0.143589
Surface rock ($X_{10.1}$)	0.246673	0.080191	-0.224112	-0.936221	-0.308922	-0.573560	0.410359	0.381927	-0.14180	0.995132	-0.366956
Rock outcrop ($X_{10.2}$)	0.198478	0.058290	-0.270531	-0.893546	-0.317591	-0.567215	0.382927	0.312774	-0.13055	0.998015	-0.311954
Production ($Y_{1.1}$)	0.045581	0.189973	0.510087	0.368871	0.503795	0.595307	-0.03915	-0.63852	0.26923	-0.307327	1

LGP: Long growth period; CEC: Cation exchange capacity; ESP: Excangeable potassium percentage.

3.2. Reliability test of research variables

Composite reliability and Cronbach alpha were used to test the reliability value among the indicators of the latent variables that make up them. The composite reliability value and Cronbach alpha were said to be good if the value was above 0.60 [17]. The composite reliability value on each research variable was more than the limit value (> 0.6), except for the root media variable (Table 3). The composite reliability value and Cronbach's alpha value were 0.6 so that the latent variable has good composite reliability and high reliability. A variable was declared reliable if the Cronbach Alpha value was >0.6 [18]. Thus, all of the indicators used in this study had fit the criteria or were feasible to be used in the measurement of all latent variables because they haad better validity and high reliability. The results of the evaluation of convergent validity and discriminant validity and reliability of the composite and Cronbach alpha for indicators or variables showed that indicators as a measure of latent variables were valid and reliable measures.

Table 3. Composite Reliability and Cronbach's Alpha values of research variables

Laten variables	**Composite reliability**	***Alpha Cronbach***
Temperature (X_1)	1.000000	1.000000
Water availability (X_2)	0.961142	0.973650
Oxygen availability (X_3)	1.000000	1.000000
Rooting media (X_4)	0.041428	-1.093362
Nutrient retention (X_5)	0.863572	0.736147
Nutrient availability (X_6)	0.877398	0.784295
Sodicity (X_7)	1.000000	1.000000
Erosion hazard (X_8)	0.952163	0.942263
Flooding hazard (X_9)	0.988236	0.972114
Land preparation (X_{10})	0.995317	0.994206

3.3. Structural Model Testing

The structural model (*inner model*) was evaluated by looking at the coefficient value of the path coefficient parameter between latent variables. The land quality of oxygen availability, rooting media, nutrient retention, and nutrient availability showed a positive correlation and had a significant effect on local maize production (Table 4)

Table 4. Path coefficient and significance testing

Exogenous variables	**Endogenous variables**	
	Local maize production (Y)	
	Path coeffisient	**t-statistics ($t_{critics}$= 2.00)**
Temperature (X_1)	-0.315	-0.012
Water availability (X_2)	0.583	0.912
Oxygen availability (X_3)	**0.326***	2.540
Rooting media (X_4)	**0.037***	2.470
Nutrient retention (X_5)	**0.452****	2.936
Nutrient availability (X_6)	**0.104***	2.642
Sodicity (X_7)	-0.186	-1.217
Erosion hazard (X_8)	**-0.333****	-2.992
Flooding hazard (X_9)	0.003	0.400
Land preparation (X_{10})	**-0.204***	-2.476

*Significant on level test of 5%; ** Significant on level test of 1%

The land quality of erosion hazards and land preparation showed a negative correlation and had a significant effect on local maize p production. This indicated that the increasing of oxygen availability, rooting media, nutrient availability, and nutrient retention and a decrease of erosion hazard and land preparation along with the increase in local maize production. The physical properties of rooting media, especially drainage and aeration conditions might directly or indirectly influential to root formation [19]. Land quality that greatly influenced the maize production were nutrient retention and nutrient availability [8]. Furthermore, [20] reported that an increase of erosion hazard would result in a decrease of land productivity, conversely a decrease of erosion hazard resulted in an increase in land productivity.

c. Land quality and characteristics that controlling of local maize productivity

Based on the previous of structural testing model, the land quality that most influences of local maize production were oxygen availability, rooting media, nutrient retention, nutrient availability, erosion hazard, and land preparation. This was also based on the results of multiple regression tests with the best equation (equation 1) of land quality that affects local maize production as follows:

$$Y = 1{,}805 + 0{,}276X_1 + 0{,}303X_2 + 0{,}353X_3 + 0{,}346X_4 - 0{,}337X_5 - 0{,}303X_6 \quad (1)$$

Where: X_1 = oxygen availability, X_2 = rooting media, X_3 = nutrient retention, X_4 = nutrient availability, X_5 = erosion hazard, X_6 = land preparation

The land characteristics that significantly affected the local maize production were drainage, coarse material, effective depth, pH KCl, C-Organic, N total, K availability, slopes, soil erosion, surface rock and rock outcrops. This was also based on the results of multiple regression tests with the best equation (equation 2) of land characteristics that affect local maize production as follows:

$$Y = 2{,}447 + 0{,}187X_1 - 0{,}212X_2 + 0{,}153X_3 + 0{,}349X_4 + 0{,}166X_5 + 0{,}169X_6 + 0{,}313X_7 - 0{,}352X_8 - 0{,}230X_9 - 0{,}237X_{10} - 0{,}187X_{11} \quad (2)$$

Where: X_1 = drainage, X_2 = coarse material, X_3 = effective depth, X_4 = pH KCl, X_5 = C-Organic, X_6 = N total, X_7 = K availability, X_8 = slope, X_9 = soil erosion, X_{10} = surface rock, X_{11} = rock outcrops.

The correlation of each land characteristic and its contribution to land quality on local maize production was presented in Table 5 and Figure 1. Land characteristics such as drainage, effective depth, pH of KCI, C-Organic, N total and K availability had a positive correlation and significant to very significant effected on local maize production. This indicated that the better drainage, effective depth, pH of KCI, C-Organic, N total, and K availability with an increase of 1% would be followed by an increase of local maize production on 29.4% to 43.6%. Conversely, coarse material, slopes, soil erosion, surface rock and rock outcrops had a negative correlation and had a significant to a very significant effect on local maize production. This revealed that a decrease of 1% in coarse material, slopes, soil erosion, surface rock and rock outcrops would be followed by an increasing of local maize production on 40.3% to 71.7%.

Table 5. Coefficient of correlation and contribution level on land quality of the land characteristics and local maize production

Land characteristics	Coefficient of correlation	Contribution on land quality (%)
Air temperature ($X_{1.1}$)	-0,033	2,90
Rainfall ($X_{2.1}$)	0,089	18,50
Wet months ($X_{2.2}$)	0,098	19,80
Dry months ($X_{2.3}$)	-0,013	3,80
LGP ($X_{2.4}$)	0,123	20,30
Drainage ($X_{3.1}$)	**0,350***	40,40
Texture ($X_{4.1}$)	0,098	5,00
Coarse material ($X_{4.2}$)	**-0,455****	-74,90
Effective depth ($X_{4.3}$)	**0,294***	54,50
pH H_2O ($X_{5.1}$)	0,234	13,70
pH KCl ($X_{5.2}$)	**0,333***	18,70
C-Organic ($X_{5.3}$)	**0,405****	59,70
CEC ($X_{5.4}$)	0,249	33,20
Base saturation ($X_{5.5}$)	0,278	30,70
N Total ($X_{6.1}$)	**0,436****	63,00
Available P ($X_{6.2}$)	0,076	25,30
Available K($X_{6.3}$)	**0,569****	73,20
ESP ($X_{7.1}$)	-0,107	-2,60
Slope ($X_{8.1}$)	**-0,717****	-75,90
Soil erosion ($X_{8.2}$)	**-0,516****	-62,90
Inundation height ($X_{9.1}$)	0,195	34,50
Inundation period ($X_{9.2}$)	0,168	30,50
Surface rock ($X_{10.1}$)	**-0,403***	-68,40
Rock outcrop ($X_{10.2}$)	**-0,408****	-68,00

*Significant on level test of 5%; ** Significant on level test of 1%.

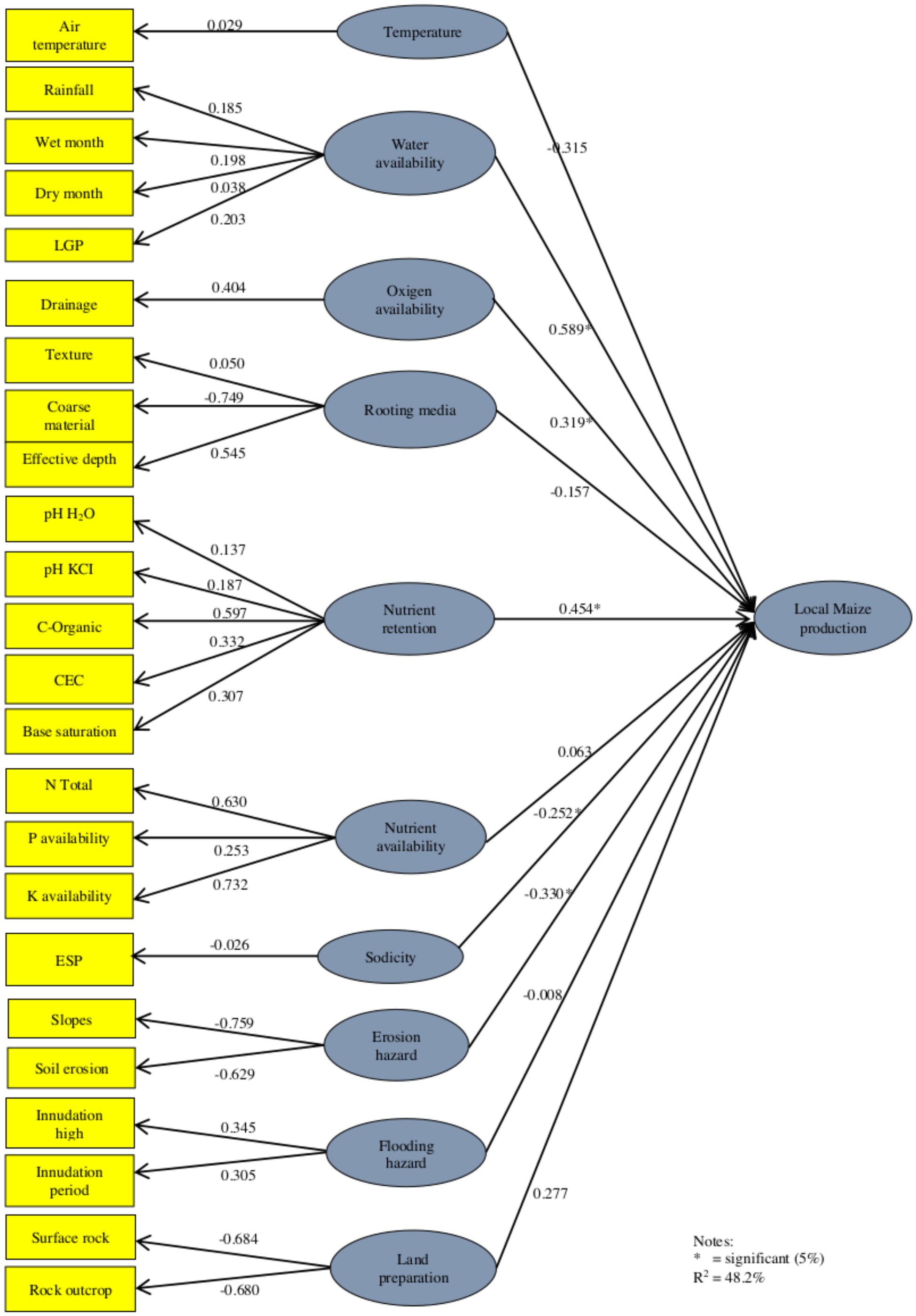

Figure 1. The coefficient pathways diagram of land quality on the level of local maize production.

The correlation of each land characteristic was strong to influencing local maize production. Coarse material was rock fragments measuring in 2 mm of diameter or more which affected to soil moisture storage, infiltration, erosion, and land use [21]. Slopes had a significant effect on local maize production, in which the steeper the slopes, the lower the production would be [22]. Likeweise for the soil erosion the more erosion increases, the lower the production of maize would be [23]. The surface rocks and rock outcrops were limiting factors in the land suitability of maize [24].

4. CONCLUSION

Land quality that control of the local maize production were the oxygen availability, rooting media, nutrient retention, nutrient availability, erosion hazard and land preparation. Meanwhile, land characteristics that control of the local maize production were drainage, effective depth, pH KCl, C-Organic, N-Total, K availability, coarse material, slopes, soil erosion, surface rock and rock outcrops.

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