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Nurdin Kyai Baderan:

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Thank you and looking forward to your participation in this event.
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Analysis of Quality and Land Characteristics that Controlling of Local Maize Productivity in Gorontalo

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Abstracts. Increased productivity of maize is one of the main indicators in the development of the food crop sub-sector, but the yield is still low because maize is grown on land that is not suitable with land quality. This study aims to determine the land quality that control local maize productivity. This research was conducted in the Gorontalo Regency. A total of 33 mapping units has been established which contain data of soil properties, climate and terrain divided into land quality, as well as data of local maize productivity. Partial least square of structural equation models (PLS-SEM) analysis was used to determine the land quality and characteristics that controlling of local maize productivity through testing the validity and reliability of variables, as well as testing structural models. The results showed that the manifest variables were air temperature, rainfall, wet months, dry months, LGP, drainage, coarse materials, effective depth, pH H_2O, pH KCl, C-organic, total N, available P, available K, ESP, slopes, soil erosion, inundation height, inundation time, surface rock, and rock outcrops were valid and able to explain well the latent variables. 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. Land quality that most influences of local maize productivity were the oxygen availability (X1), rooting media (X2), nutrient retention (X3), nutrients availability (X4), erosion hazard (X5), and land preparation (X6) with the best equation: Y = 1.805 + 0.276X1 + 0.303X2 + 0.353X3 + 0.346X4 - 0.337X5 - 0.303X6. The land characteristics that most influence of local maize productivity were drainage (X1), coarse material (X2), effective depth (X3), pH KCl (X4), C-organic (X5), total N (X6), available K (X7), slope (X8), soil erosion (X9), surface rock (X10) and rock outcrop (X11) with the best equation: Y = 2.447 + 0.187X1 - 0.212X2 + 0.153X3 + 0.349X4 + 0.166X5 + 0.169X6 + 0.313X7 - 0.352X8 - 0.230X9 - 0.237X10 - 0.187X11.

Keywords: Quality, characteristic, land, productivity, maize, local.

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Thank you and looking forward to your participation in this event.

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Keywords: Quality, characteristic, land, productivity, maize, local.

INTRODUCTION

Increased productivity of maize is one of the main indicators in the development of the food crop sub-sector. 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} (BPS RI, 2019). 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} (Yasin *et al.* 2014).

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 (BPS Kabupaten Gorontalo, 2019). Meanwhile, the average of local maize productivity has only reached 3.0 tonnes ha^{-1} (IAARD, 2009). One of the maize local varieties of Gorontalo is Motoro Kiki (Yasin *et al.* 2007). 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 (IAARD, 2009). In addition, local maize has better growth than hybrid and composite maize, but yield components show the opposite pattern (Kaihatu and Pesireron, 2016). 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 productivity was caused maize grown on land with low productivity potential (Swastika, 2002). Land productivity was determined by the land quality and characteristics. Land quality has a close relationship with maize productivity (Subardja and Sudarsono, 2005) and each land quality has a significant effect on land suitability for certain uses (FAO, 1976) especially for maize crops. Research on land quality that controls maize productivity has been conducted by Subardja (2005) 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 productivity was only carried out by Syaf (2014) 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 productivity.

Land quality that controlling of maize productivity is 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 (Syaf, 2014). The use of SEM is very helpful in determining the effect of indicators and producing better models than other multivariate analyzes (Elisanti *et al.* 2013). 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 (Hair *et al.* 2013). 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 characteristics that controlling of maize local productivity in Gorontalo.

MATERIALS AND METHOD

This research was conducted in the Sustainable Agriculture Area of Gorontalo Regency and the Soil Laboratory, Faculty of Agriculture, Brawijaya University. The timing of this research was started in December 2019 - 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 productivity data.

Soil characteristics, climate and terrain characteristics data from the study area were divided into land quality. Furthermore, local maize productivity data were obtained from the results of ubinan as well as the results of direct interviews with farmers in each LMU. Then, land characteristics data of various sizes and units (ratio data) are converted into interval data which is 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 variable was the land quality which were 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 was the land characteristic which were consists 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 KCI ($X_{5.2}$), 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:

Testing the Validity and Reliability of Research Variables. The basic evaluation carried out in the SEM-PLS analysis is 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 is seen from the size of the outer loading of each indicator against its latent variable. A loading factor value above 0.70 is highly recommended, but a loading factor value of 0.50-0.60 can 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 is the strongest or most important measure in reflecting the latent variable in question. Discriminant validity is 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 is greater than the other latent variables, then the latent variable is able to predict the indicator better than other latent variables and is said to be valid. Composite reliability and alpha cronbach 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 are said to be good, if the value is >0.60.

Structural Model Testing. Testing of the structural model (*inner model*) is carried out after the relationship model is built in accordance with the observed data and the suitability of the overall model (*goodness of fit model*). Testing of structural models and hypotheses is carried out by looking at the estimated value of the path coefficient and the critical point value (t-statistic) which is significant at $\alpha = 0.05$. 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 are shown by the correlation coefficient and t-statistic, and also seen in the path diagram.

RESULTS AND DISCUSSION

a. Validity of research variables

The loading factor value of the research variables on the indicators was mostly more than the critical limit of 0.7 with a confidence level of 95% (Table 1). The value of the loading factor which was below the tolerance value of 0.5 at the 95% confidence level where the t-statistic value of each indicator was smaller than the t-table (1,960) on the soil texture indicator of the latent variable root media which was amounting to 0.173 only.

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)	0.981	Valid
Wet months ($X_{2.2}$)	->		0.989	Valid
Dry months ($X_{2.3}$)	->		0.827	Valid
LGP ($X_{2.4}$)	->		0.968	Valid
Drainage ($X_{3.1}$)	->	Oxygen availability (X_3)	1.000	Valid
Texture ($X_{4.1}$)	->	Rooting media (X_4)	**0.173**	**Not valid**
Coarse material ($X_{4.2}$)	->		-0.921	Valid
Effective depth ($X_{4.3}$)	->		0.912	Valid
pH H_2O ($X_{5.1}$)	->	Nutrient retention (X_5)	0.768	Valid
pH KCI ($X_{5.2}$)	->		0.772	Valid
C-Organic ($X_{5.3}$)	->		0.710	Valid
CEC ($X_{5.4}$)	->		**0.399**	**Not valid**
Base saturation ($X_{5.5}$)	->		**0.482**	**Not valid**
N Total ($X_{6.1}$)	->	Nutrient availability (X_6)	0.799	Valid
Available P ($X_{6.2}$)	->		0.521	Valid
Available K($X_{6.3}$)	->		0.886	Valid
ESP ($X_{7.1}$)	->	Sodicity (X_7)	1.000	Valid
Slope ($X_{8.1}$)	->	Erosion hazard (X_8)	0.974	Valid
Soil erosion ($X_{8.2}$)	->		0.957	Valid
Inundation height ($X_{9.1}$)	->	Flooding hazard (X_9)	0.993	Valid
Inundation period ($X_{9.2}$)	->		0.991	Valid
Surface rock ($X_{10.1}$)	->	Land preparation (X_{10})	0.998	Valid
Rock outcrop ($X_{10.2}$)	->		0.998	Valid
Productivity ($Y_{1.1}$)	->	Local maize productivity (Y_1)	1.000	Valid

It also the CEC indicator and the base saturation indicator of the nutrient retention latent variable which were only 0.399 and 0.482 respectively. This means that these indicators has not been able to properly form or explain their latent variables. The standard of loading factor was greater than 0.50 (Igbaria *et al.* 1997; Mattjik and Sumertajaya, 2011; Ulum *et al.* 2014). 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 cross loading value for the indicators of latent variables on average was above the cross loading value of the indicators for other latent variables (Table 2). The greatest cross loading value on the indicator was found in the latent variable too, except for the texture indicator of the root media variable, the CEC indicator and base saturation of the nutrient retention variable whose cross loading value was still smaller (<0.5) than the cross loading value of other latent variables. The standard of loading factor was ≥0.50 (Igbaria *et al.* 1997; Mattjik and Sumertajaya, 2011; Ulum *et al.* 2014). Thus, the indicators of each of these latent variables were mostly able to explain their own latent variables better than other variables, so that the research variables are said to be discriminant valid.

b. Reliability test of research variables

Composite reliability and Cronbach alpha were used to test the reliability value between 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 (Sujarweni 2014). 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 are 0.6 so that the latent variable has good composite reliability and high reliability. A construct was said to be reliable if the Cronbach Alpha value must be> 0.6 (Abdilah and Hartono, 2015). Thus, all indicators used in this study have met the criteria or are feasible to be used in the measurement of all latent variables because they have good validity and high reliability. The results of the evaluation of convergent validity and discriminant validity of indicators or variables as well as composite reliability and alpha cronbach for indicators or variables can be concluded that indicators as measures of latent variables are valid and reliable measures respectively.

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)	0.970030	0.965126
Oxygen availability (X_3)	1.000000	1.000000
Rooting media (X_4)	**0.020314**	**-1.055192**
Nutrient retention (X_5)	0.770518	0.628062
Nutrient availability (X_6)	0.788289	0.681393
Sodicity (X_7)	1.000000	1.000000
Erosion hazard (X_8)	0.964615	0.927731
Flooding hazard (X_9)	0.992053	0.984010
Land preparation (X_{10})	0.997657	0.995304

c. Structural Model Testing

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

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})	Productivity (Y_1)
Air temperature ($X_{1.1}$)	1	0.952309	0.059098	-0.08736	-0.37805	-0.06653	0.38176	0.016269	-0.10297	0.19833	0.042282
Rainfall ($X_{2.1}$)	0.968555	0.980906	0.114576	0.052348	-0.24379	0.058536	0.356547	-0.0379	-0.04621	0.056015	0.156751
Wet months ($X_{2.2}$)	0.926635	0.989185	0.173659	-0.005903	-0.25644	0.062873	0.374745	-0.06373	-0.04367	0.060342	0.177251
Dry months ($X_{2.3}$)	0.759123	0.82697	0.141078	-0.238735	-0.42612	-0.10563	0.47553	-0.11715	0.027746	0.215367	0.076041
LGP ($X_{2.4}$)	0.900431	0.96821	0.13569	-0.003834	-0.28223	0.056251	0.459669	-0.12209	-0.04398	0.059938	0.193991
Drainage ($X_{3.1}$)	0.059098	0.144225	1	0.129338	-0.24128	0.057861	0.084339	-0.50344	0.236555	-0.22277	0.400657
Texture ($X_{4.1}$)	-0.02057	-0.01261	-0.16957	**0.172551**	0.242032	0.12283	0.217308	0.196875	-0.00074	-0.02261	0.09248
Coarse material ($X_{4.2}$)	-0.00333	-0.1005	-0.13244	-0.921096	-0.38256	-0.6112	0.18822	0.322934	-0.26391	0.846957	-0.35202
Effective depth ($X_{4.3}$)	-0.17758	-0.09256	0.165016	0.912088	0.3519	0.355112	-0.23141	-0.19005	0.095721	-0.76736	0.180089
pH H_2O ($X_{5.1}$)	-0.40346	-0.38437	-0.3719	0.29356	0.767791	0.27088	-0.17175	0.151553	-0.02966	-0.08478	0.186569
pH KCl ($X_{5.2}$)	-0.25953	-0.22811	-0.44804	0.342269	0.771872	0.272936	-0.02729	0.167533	0.098977	-0.18312	0.268161
C-Organic ($X_{5.3}$)	-0.29516	-0.13852	0.096529	0.248076	0.710022	0.612498	0.073184	-0.4692	0.063874	-0.1793	0.384332
CEC ($X_{5.4}$)	0.066756	0.115697	0.003345	0.084182	**0.399393**	0.421251	0.373179	-0.05735	0.15285	-0.01387	0.281455
Base saturation ($X_{5.5}$)	-0.30026	-0.25724	-0.10527	0.412102	**0.481624**	0.361795	-0.60079	-0.0895	-0.13592	-0.48759	0.136266
N Total ($X_{6.1}$)	0.002878	0.137879	0.07154	0.268606	0.545283	0.798694	0.030267	-0.37884	-0.10212	-0.2485	0.427705
Available P ($X_{6.2}$)	-0.09821	-0.09791	-0.44547	0.211821	0.409315	0.520984	-0.28705	-0.057	0.033581	-0.26033	-0.02547
Available K($X_{6.3}$)	-0.09732	-0.01031	0.06693	0.614343	0.51245	0.885686	-0.3292	-0.29441	0.237691	-0.6422	0.49531
ESP ($X_{7.1}$)	0.38176	0.405078	0.084339	-0.186069	-0.06947	-0.21259	1	-0.01035	0.201152	0.361936	-0.0249
Slope ($X_{8.1}$)	-0.02207	-0.12714	-0.51717	-0.295103	-0.1643	-0.40295	-0.03466	0.973779	-0.34215	0.324431	-0.64795
Soil erosion ($X_{8.2}$)	0.064136	-0.00224	-0.44709	-0.166166	-0.11161	-0.32907	0.021581	0.956588	-0.12926	0.257787	-0.48649
Inundation height ($X_{9.1}$)	-0.08956	-0.02635	0.225421	0.194354	0.082178	0.127762	0.193925	-0.26735	0.992798	-0.13415	0.175472
Inundation period ($X_{9.2}$)	-0.11594	-0.06329	0.244833	0.199427	0.048584	0.078386	0.205739	-0.2425	0.991369	-0.11616	0.135302
Surface rock ($X_{10.1}$)	0.212772	0.074279	-0.23401	-0.854273	-0.28568	-0.55023	0.376036	0.319248	-0.13208	0.997623	-0.28655
Rock outcrop ($X_{10.2}$)	0.183196	0.051703	-0.21067	-0.868319	-0.29655	-0.55537	0.34638	0.290608	-0.12053	0.997697	-0.28228
Productivity ($Y_{1.1}$)	0.042282	0.177277	0.400657	0.304774	0.418519	0.534535	-0.0249	-0.59733	0.157534	-0.28507	1

Table 4. Path coefficient and significance testing

Exogenous variables	Endogenous variables	
	Local maize productivity (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 shows a negative correlation and has a significant effect on local maize productivity. This indicates 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 productivity. The physical properties of rooting media, especially drainage and aeration conditions will directly or indirectly affect of root formation (Taghvaei *et al.* 2012). Land quality that greatly influenced the maize productivity were nutrient retention and nutrient availability (Subardja and Sudarsono, 2005). Furthermore, Nurhayati *et al.* (2015) reported that an increase of erosion hazard will result in a decrease of land productivity, conversely a decrease of erosion hazard results in an increase in land productivity.

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

Based on the previous structural model testing, the land quality that most influences of local maize productivity 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 productivity as follows:

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

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 most influence of local maize productivity were drainage, coarse material, effective depth, pH KCI, 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 productivity as follows:

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

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 productivity 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 productivity. This indicates that the better drainage, effective depth, pH of KCI, C-Organic, N total, and K availability with an increase of 1% will be followed by an increasing of local maize productivity 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 very significant effected on local maize productivity. This indicates that decrease of 1% in coarse material, slopes, soil erosion, surface rock and rock outcrops will be followed by an increasing of local maize productivity on 40.3% to 71.7%.

The correlation of each land characteristics was quite strong and strong to influencing of local maize productivity. Coarse material is rock fragments measuring in 2 mm of diameter or more which affected to soil moisture storage, infiltration, erosion, and land use (Indonesian Soil Research Institute, 2004). Slopes had a significant effect on local maize production, where the steeper the slopes of local maize production are lower (Nurdin *et al.* 2020). Soil erosion is the same, the more erosion increases, the lower the production of maize (Suparwata *et al.* 2012). Surface rocks and rock outcrops are limiting factors in the land suitability of maize (Elfayetti and Hedi, 2015).

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

Land characteristics	Coefficient of correlation	Contribution on land quality (%)
Air temperature ($X_{1.1}$)	-0,033	2,9
Rainfall ($X_{2.1}$)	0,089	18,5
Wet months ($X_{2.2}$)	0,098	19,8
Dry months ($X_{2.3}$)	-0,013	3,8
LGP ($X_{2.4}$)	0,123	20,3
Drainage ($X_{3.1}$)	**0,350***	40,4
Texture ($X_{4.1}$)	0,098	5,0
Coarse material ($X_{4.2}$)	**-0,455****	-74,9
Effective depth ($X_{4.3}$)	**0,294***	54,5
pH H_2O ($X_{5.1}$)	0,234	13,7
pH KCl ($X_{5.2}$)	**0,333***	18,7
C-Organic ($X_{5.3}$)	**0,405****	59,7
CEC ($X_{5.4}$)	0,249	33,2
Base saturation ($X_{5.5}$)	0,278	30,7
N Total ($X_{6.1}$)	**0,436****	63,0
Available P ($X_{6.2}$)	0,076	25,3
Available K($X_{6.3}$)	**0,569****	73,2
ESP ($X_{7.1}$)	-0,107	-2,6
Slope ($X_{8.1}$)	**-0,717****	-75,9
Soil erosion ($X_{8.2}$)	**-0,516****	-62,9
Inundation height ($X_{9.1}$)	0,195	34,5
Inundation period ($X_{9.2}$)	0,168	30,5
Surface rock ($X_{10.1}$)	**-0,403***	-68,4
Rock outcrop ($X_{10.2}$)	**-0,408****	-68,0

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

CONCLUSION

The manifest variables were air temperature, rainfall, wet months, dry months, LGP, drainage, coarse materials, effective depth, pH H_2O, pH KCl, C-organic, total N, available P, available K, ESP, slopes, soil erosion, inundation height, inundation time, surface rock, and rock outcrops were valid and able to explain well the latent variables. Furthermore, the latent variables were 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. Land quality that most influences of local maize productivity 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 most influence of local maize productivity 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: $Y = 2.447 + 0.187X_1 - 0.212X_2 + 0.153X_3 + 0.349X_4 + 0.166X_5 + 0.169X_6 + 0.313X_7 - 0.352X_8 - 0.230X_9 - 0.237X_{10} - 0.187X_{11}$.

ACKNOWLEDGMENT

Thank you to Ecan Adam, SE, MM for helping with SEM-PLS analysis. Thank you also went to Rival Rahman, SP, MSi for helping of the land resources mapping.

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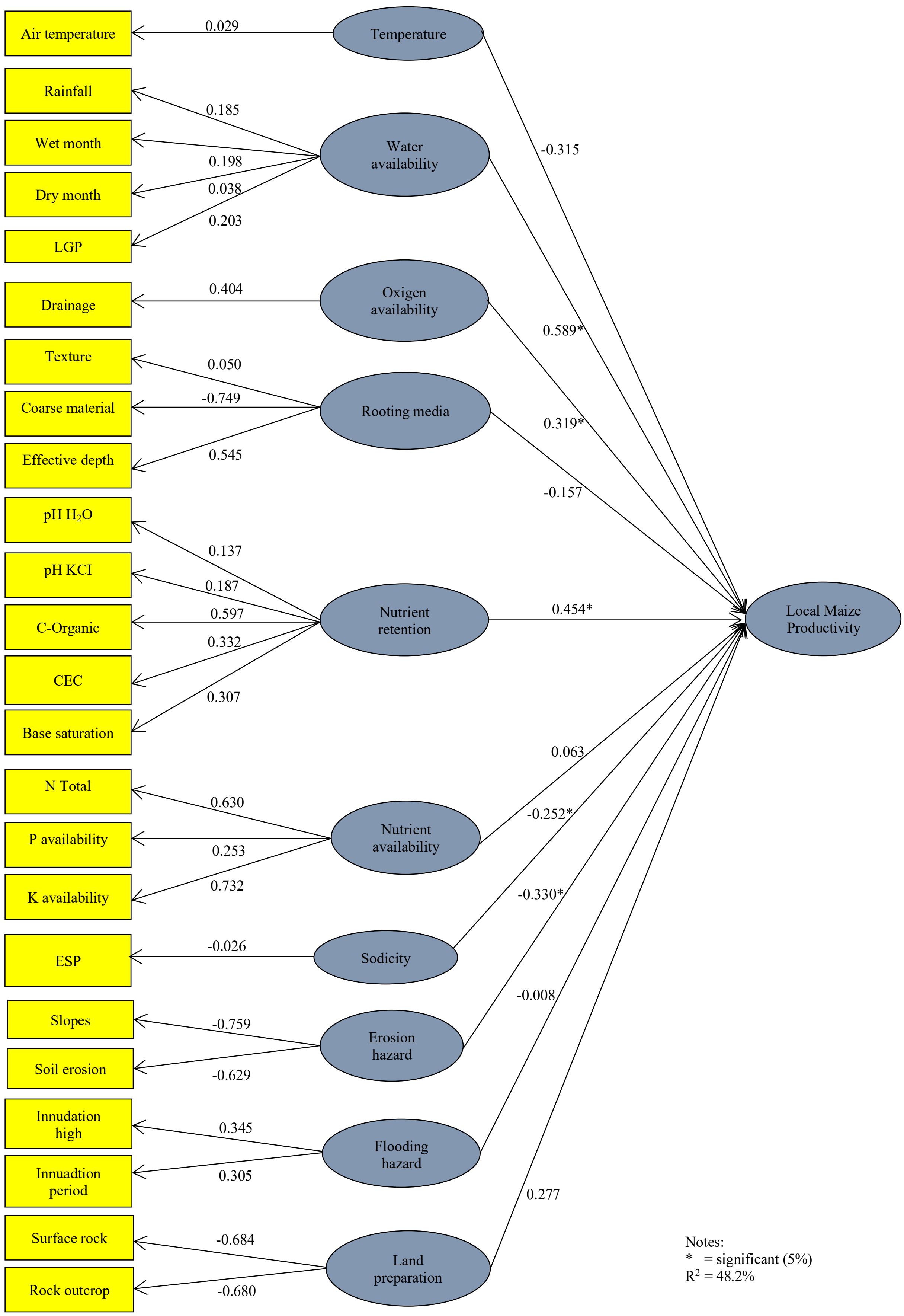

Figure 1. The coefficient pathways diagram of land quality on the level of local maize productivity

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Tulis

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Letter of Acceptance - Oral Presentation

Kotak Masuk ×

ISEPROLOCAL Universitas Bengkulu <iseprolocal@unib.ac.id>
kepada saya

Jum, 28 Agu 2020 14.41

Dear Mr. Nurdin Kyai Baderan

We are pleased to inform you that your paper has been accepted for an oral presentation in The 2nd Iseprolocal 2020, and I herewith attached a Letter of Acceptance. **The deadline for full paper submission is September 20th, 2020.**

A Whatsapp group is organized for the purpose of sharing further information and communication (https://chat.whatsapp.com/BUF1Hv0rvLO5SBnERgvgVj). Hope to see you at the seminar.

Best regards,

Dr. Nurmeiliasari,
Secretary

Satu lampiran • Dipindai dengan Gmail

The 2nd ISEPROLOCAL
International Seminar on Promoting Local Resources for Sustainable Agriculture and Development
University of Bengkulu, Bengkulu, Sumatera-INDONESIA

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===

Ref. No	: 205-344-1-SP-8
Date	: August 26, 2020
Registration No	: 205-344-1-SP

Dear Mr. Nurdin Kyai Baderan

Thank you for submitting an abstract titled:

"Analysis of Quality and Land Characteristics that Controlling of Local Maize Productivity in Gorontalo."

We are pleased to inform you that your research has been **accepted** for ORAL PRESENTATION at the 2nd International Seminar on Promoting Local Resources for Sustainable Agriculture and Development 2020 (2nd ISEPROLOCAL 2020). The scientific program, including date and time of presentation, will be sent to you soon. The full paper, after review and meeting the criteria, will be published in Web of Science (WOS) - indexed proceeding managed by ATLANTIS PRESS. Please follow author guideline for full paper template at *https://semcon.unib.ac.id/index.php/iseprolocal/iseprolocal*. **The deadline for full paper submission is September 20, 2020.**

The payment for registration and publication fee can be made through this account.

Account name	: **RPL 016 UNIB UTK DANA KELOLA**
Account number	: **0072004772**
Bank's name	: **Bank Negara Indonesia**
Late Payment	: **September 26, 2020**

Please send a copy of transfer receipt to email: *iseprolocal@unib.ac.id* and joint our Whatsapp Grup (WAG): *https://chat.whatsapp.com/BUF1Hv0rvLO5SBnERgvgVj* for further information and communication.

Thank you very much and hope to see you in the seminar.

Best Regards,

Dr. Agustin Zarkani
(Chair of Organizing Committee)

The 2nd ISEPROLOCAL
International Seminar on Promoting Local Resources for Sustainable Agriculture and Development
Faculty of Agriculture, University of Bengkulu, Bengkulu, Sumatera- INDONESIA
e-mail: iseprolocal@unib.ac.id; website: iseprolocal.unib.ac.id

November, 30, 2020

LETTER OF CONFIRMATION

To who it may concern

I hereby confirm that

Nurdin

has submitted a paper tittled

"Analysis of Quality and Land Characteristics that Controlling of Local Maize Productivity in Gorontalo"

to the 2nd Iseprolocal 2020. The paper is under review and will be publihed in **Atlantis Press** (Web of Science indexed) proceeding.

Best regards,

Agustin Zarkani, Ph.D
Chair of Organizing Committee

Today Reminder: 2nd ISEPROLOCAL 2020

1 pesan

ISEPROLOCAL Universitas Bengkulu <iseprolocal@unib.ac.id>
Bcc: nurdin@ung.ac.id

8 Oktober 2020 pukul 05.34

Dear,
The 2ND ISEPROLOCAL participants

It is a friendly reminder of the 2nd iSEPROLOCAL 2020, 8th October 2020. The details of the 2nd ISEPROLOCAL 2020 are listed below:

I. The keynote speaker presentation session, from 09.00 a.m. to 12. a.m.
The link will be opened on Oct 8, 2020, at 08:45 a.m. (Jakarta Time). Please check the time zone carefully as it may be different from your local time. To join, simply click the link below.
LINK ZOOM: https://zoom.us/j/99299764419
or type Zoom ID: 992 9976 4419
and if it is possible to join Live Youtube: https://www.youtube.com/watch?v=SUy292sJ1mQ

It is recommended to join 15 minutes prior to the meeting. After the session ends, the participants leave the meeting. There are different links to the parallel sessions (see book of abstracts).

II. Break 12-13.15 p.m. (Jakarta time). The participants may prepare for the next session. There are 16 rooms with different zoom meeting IDs.

III. Parallel sessions.
The presenters and participants are given links to the meeting of parallel sessions. Please check the abstract book to find a meeting ID and passcode to enter the room. There is an award to the best presenter in each room. Presenters are assessed and judged for their performance and quality of work. **We recommend that all participants use a virtual background** (attached files). After the parallel session, all participants leave the meeting and join **a closing ceremony when the best presenters are announced.**

IV. Closing
The closing of the event using a zoom webinar LINK ZOOM: https://zoom.us/j/99299764419 or type Zoom ID: 992 9976 4419 will be held at 3.45 p.m. (Jakarta time). The committee will open 10 minutes before the closing ceremony. The best presenter of each room will be announced.

We hope you enjoy the scientific sharing session during The 2nd Iseprolocal 2020. Meet and greet scientists from many different countries and start to create a global good network.

Regards,
The committee

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Room 16
Session 1

ORAL PRESENTATION

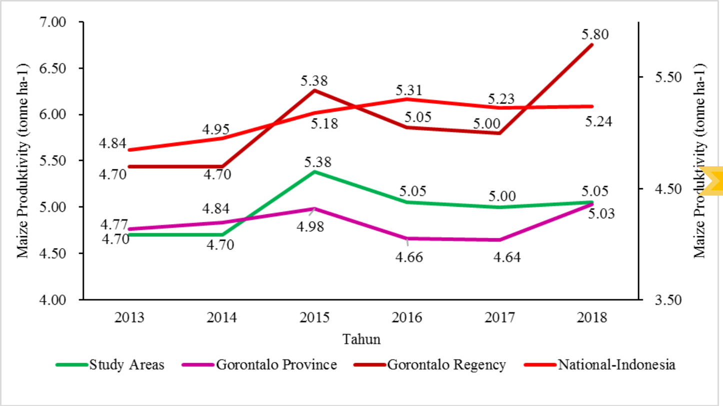
Analysis of Quality and Land Characteristics that Controlling of Local Maize Productivity in Gorontalo

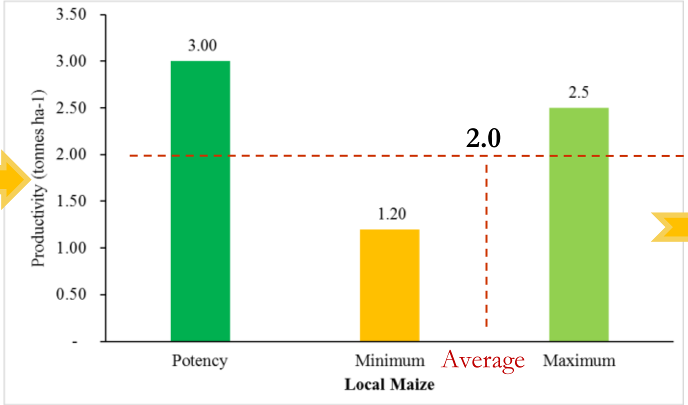
Nurdin, S.P, M.Si
Prof. Dr. Ir. Moch. Lutfi Rayes, M.Sc
Prof. Dr. Ir. Soemarno, M.S
Dr. Ir. Sudarto, M.S

The 2nd International Seminar on Promoting Local Resources for Sustainable Agriculture and Development (2nd ISEPROLOCAL 2020)
BENGKULU October, 08, 2020

INTRODUCTION

- Increased productivity of maize is one of the main indicators in the development of the food crop sub-sector, but the yield is still low
- Its because maize is grown on land that is not suitable with land quality.





Land productivity was determined by the land quality and characteristics.
Land quality has a close relationship with maize productivity

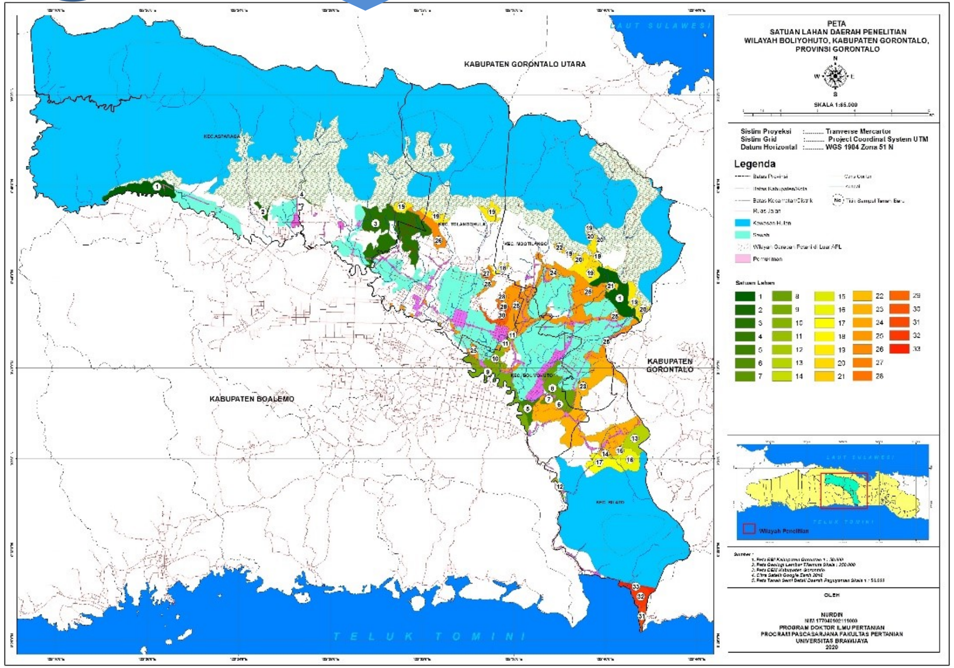
THE OBJECTIVE OF THE RESEARCH

- To determine the land quality that controlling of maize local productivity in Gorontalo
- To determine the land characteristics that controlling of maize local productivity in Gorontalo

MATERIALS AND METHOD

Map of Study Areas

1



- Number of soil mapping unit were 33 units
- Soil survey has done to soil morphology, soil sampling, and terrain observations.
- Collecting climates data
- Survey of maize farming
- Survey of maize productivity with ubin plot.








MATERIAL AND METHODs

2

Determining of land quality that controlling of local maize productivity

- Land characteristics and quality data were organized together with local maize productivity data
- Data with various sizes and units (ratio data) were converted into interval format i.e 1 (very low), 2 (low), 3 (medium), 4 (high), 5 (very high).
- Latent variables (soil quality): temperature (X1), water availability (X2), oxygen availability (X3), root media (X4), nutrient retention (X5), available nutrients (X6), sodicity (X7), erosion hazard (X8), flood hazard (X9), and land preparation (X10)
- Manifest variables (land characteristics): air temperature (X1.1), rainfall (X2.1), wet months (X2.2), dry months (X2.3), LGP (X2.4), drainage (X3. 1), texture (X4.1), coarse material (X4.2), effective depth (X4.3), pH H_2O (X5.1), pH KCI (X5.2), C-organic (X5.3) , CEC (X5.4), base saturation (X5.5), total N (X6.1), P-available (X6.2), K-available (X6.3), ESP (X7.1), slope (X8 .1), soil erosion (X8.2), inundation height (X9.1), inundation period (X9.2), surface rock (X10.1), and rock outcrop (X10.2).
- The use of SEM-PLS in this study consists of: (a) testing the validity and reliability of research variables, and (b) testing the structural model.

Room 16
Session 1

RESULTS AND DISCUSSION

1 The validity of research variables

- The loading factor values of the indicators of the research variables were mostly more than the critical limit of 0.7 with a confidence level of 95% (Table 1).
- The loading factor value which is below the tolerance value of 0.5 (t-stat <t-table) were:
  - ➢ the soil texture indicator of rooting media (X4)
  - ➢ the CEC indicator (X5.4) and the base saturation indicator (X5.5) of the nutrient retention (X5).
- This means that these indicators have not been able to properly form or explain their latent 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)	0.981	Valid
Wet months ($X_{2.2}$)	->		0.989	Valid
Dry months ($X_{2.3}$)	->		0.827	Valid
LGP ($X_{2.4}$)	->		0.968	Valid
Drainage ($X_{3.1}$)	->	Oxygen availability (X_3)	1.000	Valid
Texture ($X_{4.1}$)	->	Rooting media (X_4)	**0.173**	**Not valid**
Coarse material ($X_{4.2}$)	->		-0.921	Valid
Effective depth ($X_{4.3}$)	->		0.912	Valid
pH H_2O ($X_{5.1}$)	->	Nutrient retention (X_5)	0.768	Valid
pH KCl ($X_{5.2}$)	->		0.772	Valid
C-Organic ($X_{5.3}$)	->		0.710	Valid
CEC ($X_{5.4}$)	->		**0.399**	**Not valid**
Base saturation ($X_{5.5}$)	->		**0.482**	**Not valid**
N Total ($X_{6.1}$)	->	Nutrient availability (X_6)	0.799	Valid
Available P ($X_{6.2}$)	->		0.521	Valid
Available K($X_{6.3}$)	->		0.886	Valid
ESP ($X_{7.1}$)	->	Sodicity (X_7)	1.000	Valid
Slope ($X_{8.1}$)	->	Erosion hazard (X_8)	0.974	Valid
Soil erosion ($X_{8.2}$)	->		0.957	Valid
Inundation height ($X_{9.1}$)	->	Flooding hazard (X_9)	0.993	Valid
Inundation period ($X_{9.2}$)	->		0.991	Valid
Surface rock ($X_{10.1}$)	->	Land preparation (X_{10})	0.998	Valid
Rock outcrop ($X_{10.2}$)	->		0.998	Valid
Productivity ($Y_{1.1}$)	->	Local maize productivity (Y_1)	1.000	Valid

Room 16
Session 1

RESULTS AND DISCUSSION

1 The validity of research variables

- The cross loading for the indicators of latent variables on average was above the cross loading value (Table 2).
- Except for the texture indicator of the root media variable, the CEC indicator and base saturation of the nutrient retention variables, the cross loading value <0.5.
- The indicators of each of these latent variables are mostly able to explain the latent variable itself, therefore the research variables were discriminant valid.

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})	Productivity (Y_1)
Air temperature ($X_{1.1}$)	1	0.952309	0.059098	-0.08736	-0.37805	-0.06653	0.38176	0.016269	-0.10297	0.19833	0.042282
Rainfall ($X_{2.1}$)	0.968555	0.980906	0.114576	0.052348	-0.24379	0.058536	0.356547	-0.0379	-0.04621	0.056015	0.156751
Wet months ($X_{2.2}$)	0.926635	0.989185	0.173659	-0.005903	-0.25644	0.062873	0.374745	-0.06373	-0.04367	0.060342	0.177251
Dry months ($X_{2.3}$)	0.759123	0.82697	0.141078	-0.238735	-0.42612	-0.10563	0.47553	-0.11715	0.027746	0.215367	0.076041
LGP ($X_{2.4}$)	0.900431	0.96821	0.13569	-0.003834	-0.28223	0.056251	0.459669	-0.12209	-0.04398	0.059938	0.193991
Drainage ($X_{3.1}$)	0.059098	0.144225	1	0.129338	-0.24128	0.057861	0.084339	-0.50344	0.236555	-0.22277	0.400657
Texture ($X_{4.1}$)	-0.02057	-0.01261	-0.16957	**0.172551**	0.242032	0.12283	0.217308	0.196875	-0.00074	-0.02261	0.09248
Coarse material ($X_{4.2}$)	-0.00333	-0.1005	-0.13244	-0.921096	-0.38256	-0.6112	0.18822	0.322934	-0.26391	0.846957	-0.35202
Effective depth ($X_{4.3}$)	-0.17758	-0.09256	0.165016	0.912088	0.3519	0.355112	-0.23141	-0.19005	0.095721	-0.76736	0.180089
pH H_2O ($X_{5.1}$)	-0.40346	-0.38437	-0.3719	0.29356	0.767791	0.27088	-0.17175	0.151553	-0.02966	-0.08478	0.186569
pH KCl ($X_{5.2}$)	-0.25953	-0.22811	-0.44804	0.342269	0.771872	0.272936	-0.02729	0.167533	0.098977	-0.18312	0.268161
C-Organic ($X_{5.3}$)	-0.29516	-0.13852	0.096529	0.248076	0.710022	0.612498	0.073184	-0.4692	0.063874	-0.1793	0.384332
CEC ($X_{5.4}$)	0.066756	0.115697	0.003345	0.084182	**0.399393**	0.421251	0.373179	-0.05735	0.15285	-0.01387	0.281455
Base saturation ($X_{5.5}$)	-0.30026	-0.25724	-0.10527	0.412102	**0.481624**	0.361795	-0.60079	-0.0895	-0.13592	-0.48759	0.136266
N Total ($X_{6.1}$)	0.002878	0.137879	0.07154	0.268606	0.545283	0.798694	0.030267	-0.37884	-0.10212	-0.2485	0.427705
Available P ($X_{6.2}$)	-0.09821	-0.09791	-0.44547	0.211821	0.409315	0.520984	-0.28705	-0.057	0.033581	-0.26033	-0.02547
Available K($X_{6.3}$)	-0.09732	-0.01031	0.06693	0.614343	0.51245	0.885686	-0.3292	-0.29441	0.237691	-0.6422	0.49531
ESP ($X_{7.1}$)	0.38176	0.405078	0.084339	-0.186069	-0.06947	-0.21259	1	-0.01035	0.201152	0.361936	-0.0249
Slope ($X_{8.1}$)	-0.02207	-0.12714	-0.51717	-0.295103	-0.1643	-0.40295	-0.03466	0.973779	-0.34215	0.324431	-0.64795
Soil erosion ($X_{8.2}$)	0.064136	-0.00224	-0.44709	-0.166166	-0.11161	-0.32907	0.021581	0.956588	-0.12926	0.257787	-0.48649
Inundation height ($X_{9.1}$)	-0.08956	-0.02635	0.225421	0.194354	0.082178	0.127762	0.193925	-0.26735	0.992798	-0.13415	0.175472
Inundation period ($X_{9.2}$)	-0.11594	-0.06329	0.244833	0.199427	0.048584	0.078386	0.205739	-0.2425	0.991369	-0.11616	0.135302
Surface rock ($X_{10.1}$)	0.212772	0.074279	-0.23401	-0.854273	-0.28568	-0.55023	0.376036	0.319248	-0.13208	0.997623	-0.28655
Rock outcrop ($X_{10.2}$)	0.183196	0.051703	-0.21067	-0.868319	-0.29655	-0.55537	0.34638	0.290608	-0.12053	0.997697	-0.28228
Productivity ($Y_{1.1}$)	0.042282	0.177277	0.400657	0.304774	0.418519	0.534535	-0.0249	-0.59733	0.157534	-0.28507	1

RESULTS AND DISCUSSION

2 The reliability of research variables

- 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.
- Thus, all indicators used in this study have met the criteria or were feasible to be used in the measurement of all latent variables because they have good validity and high reliability.

Laten variables	Composite reliability	*Alpha Cronbach*
Temperature (X_1)	1.000000	1.000000
Water availability (X_2)	0.970030	0.965126
Oxygen availability (X_3)	1.000000	1.000000
Rooting media (X_4)	**0.020314**	**-1.055192**
Nutrient retention (X_5)	0.770518	0.628062
Nutrient availability (X_6)	0.788289	0.681393
Sodicity (X_7)	1.000000	1.000000
Erosion hazard (X_8)	0.964615	0.927731
Flooding hazard (X_9)	0.992053	0.984010
Land preparation (X_{10})	0.997657	0.995304

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RESULTS AND DISCUSSION

3 The structural models

- It seems that the soil quality of oxygen availability, root media, nutrient retention, and available nutrients shows a positive correlation and has a significant effect on local maize production (Table 4).
- The land quality of erosion hazards and land preparation shows a negative correlation and has a significant effect on local maize productivity.
- This indicates 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 productivity.

Exogenous variables	Endogenous variables: Local maize productivity (Y)	
	Path coefficient	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%

RESULTS AND DISCUSSION

4

Land quality and characteristics that controlling of local maize productivity

- **Land Quality Control of Local Maize Productivity :**

❖ Oxygen availability, root media, nutrient retention, nutrient availability, erosion hazard, and land preparation.

$$Y = 1{,}805 + 0{,}276X_1 + 0{,}303X_2 + 0{,}353X_3 + 0{,}346X_4 - 0{,}337X_5 - 0{,}303X_6 \; ; R = 0{,}80$$

- **Land Characteristics that Controlling of Local Maize Productivity:**

❖ drainage, coarse material, effective depth, pH KCl, C-Organic, N total, K availability, slopes, soil erosion, surface rock and rock outcrops.

$$Y = 2{,}447 + 0{,}187X_1 - 0{,}212X_2 + 0{,}153X_3 + 0{,}349X_4 + 0{,}166X_5 + 0{,}169X_6 + 0{,}313X_7 - 0{,}352X_8 - 0{,}230X_9 - 0{,}237X_{10} - 0{,}187X_{11} \; ; R = 0{,}90$$

Path Coefficient of Land Quality to Local Maize Productivity

CONCLUSION

1. Land quality that most influences of local maize productivity were the oxygen availability, rooting media, nutrient retention, nutrients availability, erosion hazard, and land preparation.
2. The land characteristics that most influence of local maize productivity were drainage, coarse material, effective depth, pH KCl, C-organic, total N, K-availability, slope, soil erosion, surface rock and rock outcrop.

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Thank You

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for the contribution as a

PRESENTER

Bengkulu, 8th October 2020

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Rector of University of Bengkulu

Dr. Agustin Zarkani
Chair of Organizing Committee

INSTRUKSI REVISI

Revision revision of the manuscript

1 pesan

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29 Januari 2021 pukul 01.09

Dear ISEPROCAL Universitas Bengkulu

I hereby send the revised results of my manuscript. I hope you get a good response.

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Review manuscript

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ISEPROLOCAL Universitas Bengkulu <iseprolocal@unib.ac.id> 23 Januari 2021 pukul 21.54
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Dear, Mr. Nurdin Baheran
Your manuscript has been riviewed by riviewer. If you have fix it, please send back soon. Thank you.

Best Regards,

-Iseprolocal committee

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PERINTAH	TEKS TERJEMAHAN	TEKS SUMBER	PERBAIKAN
TEKS SUMBER dibuat dalam dua kalimat/lebih untuk memudahkan penerjemahan (biar jelas subyek dan predikat kalimat).	The value of the loading factor which was below the tolerance value of 0.5 at the 95% confidence level where the t-statistic value of each indicator was smaller than the t-table (1,960) on the soil texture indicator of the latent variable root media which was amounting to 0.173only.	Nilai faktor loading yang berada di bawah nilai toleran 0,5 pada tingkat kepercayaan 95% dimana nilai t-statistik masing-masing indikator lebih kecil dari t-tabel (1,960) terdapat pada indikator tekstur tanah dari variabel laten media perakaran (X4) yang hanya sebesar 0,173 juga indikator KTK (X5.4) dan indikator kejenuhan basa (X5.5) dari variabel laten retensi hara (X5) yang masing-masing hanya sebesar 0,399 dan 0,482.	hasil uji validitas menunjukkan bahwa sebagian besar indikator dalam variabel penelitian memiliki nilai faktor loading lebih besar dari batas kritis 0,70 dengan tingkat kepercayaan 95% (Tabel 1). Sementara nilai faktor loading yang berada di bawah nilai toleran (0,50) dan nilai t-statistik lebih kecil dari t-tabel (1,96) terdapat pada variabel laten media perakaran (X4) dengan indikator tekstur tanah sebesar 0,173 dan variabel laten retensi hara (X5) pada indikator KTK (X5.4) sebesar 0,399 dan indikator kejenuhan basa (X5.5) sebesar 0,482.
Belum ditemukan TEKS SUMBER.	It also the CEC indicator and the base saturation indicator of the nutrient retention latent variable which were only 0.399 and 0.482 respectively.		
TEKS SUMBER ditulis dengan lebih JELAS dan SINGKAT.	The greatest cross loading value on the indicator was found in the latent variable too, except for the texture indicator of the root	Artinya, nilai cross loading terbesar pada indikatornya terdapat pada variabel latennya juga, kecuali indikator tekstur	

	media variable, the CEC indicator and base saturation of the nutrient retention variable whose cross loading value was still smaller (<0.5) than the cross loading value of other latent variables.	(X4.1) dari variabel media perakaran (X4), indikator KTK (X5.4) dan kejenuhan basa (X5.5) dari variabel retensi hara (X5) yang nilai cross loading masih lebih kecil (<0,5) dari nilai cross loading variabel laten lainnya.	
TEKS SUMBER ditulis dengan lebih JELAS dan SINGKAT.	The results of the evaluation of convergent validity and discriminant validity of indicators or variables as well as composite reliability and alpha cronbach for indicators or variables can be concluded that indicators as measures of latent variables are valid and reliable measures respectively.	Hasil evaluasi validitas konvergen dan validitas diskriminan dari indikator atau variabel serta reliabilitas komposit dan *alpha cronbach* untuk indikator atau variabel dapat disimpulkan bahwa indikator-indikator sebagai pengukur variabel laten, masing-masing merupakan pengukur yang valid dan reliabel.	
	It seems that the land quality of oxygen availability, rooting media, nutrient retention, and nutrient availability shows a positive correlation and has a significant effect on local maize production (Table 4)	Tampaknya, kualitas lahan ketersediaan oksigen, media perakaran, retensi hara, dan hara tersedia menunjukkan korelasi positif dan berpengaruh nyata terhadap produksi jagung lokal (Tabel 4).	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).
Ditulis dalam bentuk lampau/past tense.	The land quality of erosion hazards and land preparation shows a negative correlation and has a significant effect on local	Kualitas lahan bahaya erosi dan penyiapan lahan menunjukkan korelasi negatif dan berpengaruh nyata terhadap	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

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	maize p production. This indicates 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 will directly or indirectly affectof root formation (Taghvaei*et al.* 2012). Land quality that greatly influenced the maize production were nutrient retention and nutrient availability (Subardja and Sudarsono, 2005). Furthermore, Nurhayati*et al.* (2015) reported that an increase of erosion hazard will result in a decrease of land productivity, conversely a decrease of erosion hazard results in an increase in land productivity.	produksi jagung lokal. Hal ini menunjukkan bahwa semakin meningkatnya ketersediaan oksigen, media perakaran, retensi hara dan hara tersedia serta menurunnya bahaya erosi dan penyiapan lahan seiring meningkatnya produksi jagung lokal. Sifat fisika media perakaran terutama kondisi drainase dan aerasi, secara langsung maupun tidak langsung akan berpengaruh terhadap pembentukan akar (Taghvaei *et al.* 2012). Subardja dan Sudarsono (2005) melaporkan bahwa kualitas lahan yang sangat berpengaruh terhadap produktivitas tanaman jagung adalah retensi hara dan hara tersedia. Selanjutnya, Nurhayati *et al.* (2015) melaporkan bahwa peningkatan bahaya erosi akan berakibat pada penurunan produktivitas lahan, demikian sebaliknya penurunan bahaya	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 (Taghvaei *et al.* 2012). Land quality that greatly influenced the maize production were nutrient retention and nutrient availability (Subardja and Sudarsono, 2005). Furthermore, Nurhayati *et al.* (2015) 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.

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		erosi mengakibatkan peningkatan produktivitas lahan.	
DItulis dalam bentuk past tense/lampau.	This indicates that the better drainage, effective depth, pH of KCI, C-Organic, N total, and K availability with an increase of 1% will be followed by an increasing 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 very significant effected on local maize production. This indicates that decrease of 1% in coarse material, slopes, soil erosion, surface rock and rock outcrops will be followed by an increasing of local maize production on 40.3% to 71.7%.	Hal ini menunjukkan bahwa semakin baik drainase, kedalaman efektif, pH KCI, C-Organik, N-Total, dan K tersedia dengan peningkatan sebesar 1% akan diikuti dengan peningkatan produktivitas jagung lokal meningkat sebesar 29,4% sampai 43,6%. Sebaliknya, bahan kasar, lereng, erosi tanah, batuan permukaan dan singkapan batuan memiliki hubungan negatif dan berpengaruh nyata sampai sangat nyata terhadap produksi jagung lokal. Hal ini menunjukkan bahwa penurunan kandungan bahan kasar, lereng, erosi tanah, batuan permukaan dan singkapan batuan sebesar 1% akan diikuti oleh peningkatan produktivitas	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%.

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		jagung lokal sebesar 40,3% sampai 71,7%.	

Analysisof Quality and Land Characteristics that Control Local Maize Production in Gorontalo

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Abstracts. 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 manifest variables were air temperature, rainfall, wet months, dry months, LGP, drainage, coarse materials, effective depth, pH H_2O, pH KCl, C-organic, total N, available P, available K, ESP, slopes, soil erosion, inundation height, inundation time, surface rock, and rock outcrops were valid and able to explain well the latent variables. 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. Land quality that significantly affected 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 significantly affected 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, productivity, maize, local.

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} (BPS RI, 2019). 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} (Yasin*et al.* 2014).

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 (BPS Kabupaten Gorontalo, 2019).

Meanwhile, the average of local maize productivity has only reached 3.0 tonnes ha^{-1} (IAARD, 2009). One of the maize local varieties of Gorontalo is Motoro Kiki (Yasin*et al.* 2007). 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 (IAARD, 2009). In addition, local maize has better growth than hybrid and composite maize, but yield components show the opposite pattern (Kaihatu and Pesireron, 2016). 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 (Swastika, 2002). Land productivity was determined by the land quality and characteristics. Land quality has a close relationship with maize production (Subardja and Sudarsono, 2005) and each land quality has a significant effect on land suitability for certain uses (FAO, 1976) especially for maize crops. Research on land quality that controls maize production has been conductedby Subardja (2005) 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 Syaf (2014) but on mature cocoa trees in KolakaTimur 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 (Syaf, 2014). The use of SEM is very helpful in determining the effect of indicators and producing better models than other multivariate analyzes (Elisanti*et al.* 2013). 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 (Hair *et al.* 2013). 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.

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), nutrientavailability (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 KCI ($X_{5.2}$), 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:

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.

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 $\alpha = 0.05$. 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.

RESULTS AND DISCUSSIONS

a. Validity of research variables

The loading factor value of the research variables on the indicators were mostly more than the critical limit of 0.7 with a confidence level of 95% (Table 1). The value of the loading factor which was below the tolerance value of 0.5 at the 95% confidence level where the t-statistic value of each indicator was smaller than the t-table (1,960) on the soil texture indicator of the latent variable root media which was amounting to 0.173only.

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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 ($X_{2.1}$)	->		0.981	Valid
Wet months ($X_{2.2}$)	->	Water availability (X_2)	0.989	Valid
Dry months ($X_{2.3}$)	->		0.827	Valid
LGP ($X_{2.4}$)	->		0.968	Valid
Drainage ($X_{3.1}$)	->	Oxygen availability (X_3)	1.000	Valid
Texture ($X_{4.1}$)	->		**0.173**	**Not valid**
Coarse material ($X_{4.2}$)	->	Rooting media (X_4)	-0.921	Valid
Effective depth ($X_{4.3}$)	->		0.912	Valid
pH H_2O ($X_{5.1}$)	->		0.768	Valid
pH KCI ($X_{5.2}$)	->		0.772	Valid
C-Organic ($X_{5.3}$)	->	Nutrient retention (X_5)	0.710	Valid
CEC ($X_{5.4}$)	->		**0.399**	**Not valid**
Base saturation ($X_{5.5}$)	->		**0.482**	**Not valid**
N Total ($X_{6.1}$)	->		0.799	Valid
Available P ($X_{6.2}$)	->	Nutrient availability (X_6)	0.521	Valid
Available K($X_{6.3}$)	->		0.886	Valid
ESP ($X_{7.1}$)	->	Sodicity (X_7)	1.000	Valid
Slope ($X_{8.1}$)	->	Erosion hazard (X_8)	0.974	Valid
Soil erosion ($X_{8.2}$)	->		0.957	Valid
Inundation height ($X_{9.1}$)	->	Flooding hazard (X_9)	0.993	Valid
Inundation period ($X_{9.2}$)	->		0.991	Valid
Surface rock ($X_{10.1}$)	->	Land preparation (X_{10})	0.998	Valid
Rock outcrop ($X_{10.2}$)	->		0.998	Valid
Productivity ($Y_{1.1}$)	->	Local maize productivity (Y_1)	1.000	Valid

It also the CEC indicator and the base saturation indicator of the nutrient retention latent variable which were only 0.399 and 0.482 respectively. 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 (Igbaria*et al.* 1997; Mattjik and Sumertajaya, 2011; Ulum*et al.* 2014). 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.

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The cross loading value for the indicators of latent variables on average was above the cross loading value of the indicators for other latent variables (Table 2).The greatest cross loading value on the indicator was found in the latent variable too, except for the texture indicator of the root media variable, the CEC indicator and base saturation of the nutrient retention variable whose cross loading value was still smaller (<0.5) than the cross loading value of other latent variables. The standard of loading factor was ≥0.50 (Igbaria*et al.* 1997; Mattjik and Sumertajaya, 2011; Ulum *et al.* 2014). 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.

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b. 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 (Sujarweni 2014). 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 were0.6 so that the latent variable has good composite reliability and high reliability. A construct was said to be reliable if the Cronbach Alpha value was > 0.6 (Abdilah and Hartono, 2015). Thus, all of the indicators used in this study had met the criteria or were feasible to be used in the measurement of all latent variables because they have good validity and high reliability. The results of the evaluation of convergent validity and discriminant validity of indicators or variables as well as composite reliability and alpha cronbach for indicators or variables can be concluded that indicators as measures of latent variables are valid and reliable measures respectively.

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

Latenvariables	Compositereliability	*Alpha Cronbach*
Temperature (X_1)	1.000000	1.000000
Water availability (X_2)	0.970030	0.965126
Oxygen availability (X_3)	1.000000	1.000000
Rooting media (X_4)	**0.020314**	**-1.055192**
Nutrient retention (X_5)	0.770518	0.628062
Nutrient availability (X_6)	0.788289	0.681393
Sodicity (X_7)	1.000000	1.000000
Erosion hazard (X_8)	0.964615	0.927731
Flooding hazard (X_9)	0.992053	0.984010
Land preparation (X_{10})	0.997657	0.995304

c. Structural Model Testing

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

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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	0.952309	0.059098	-0.08736	-0.37805	-0.06653	0.38176	0.016269	-0.10297	0.19833	0.042282
Rainfall ($X_{2.1}$)	0.968555	0.980906	0.114576	0.052348	-0.24379	0.058536	0.356547	-0.0379	-0.04621	0.056015	0.156751
Wet months ($X_{2.2}$)	0.926635	0.989185	0.173659	-0.005903	-0.25644	0.062873	0.374745	-0.06373	-0.04367	0.060342	0.177251
Dry months ($X_{2.3}$)	0.759123	0.82697	0.141078	-0.238735	-0.42612	-0.10563	0.47553	-0.11715	0.027746	0.215367	0.076041
LGP ($X_{2.4}$)	0.900431	0.96821	0.13569	-0.003834	-0.28223	0.056251	0.459669	-0.12209	-0.04398	0.059938	0.193991
Drainage ($X_{3.1}$)	0.059098	0.144225	1	0.129338	-0.24128	0.057861	0.084339	-0.50344	0.236555	-0.22277	0.400657
Texture ($X_{4.1}$)	-0.02057	-0.01261	-0.16957	**0.172551**	0.242032	0.12283	0.217308	0.196875	-0.00074	-0.02261	0.09248
Coarse material ($X_{4.2}$)	-0.00333	-0.1005	-0.13244	-0.921096	-0.38256	-0.6112	0.18822	0.322934	-0.26391	0.846957	-0.35202
Effective depth ($X_{4.3}$)	-0.17758	-0.09256	0.165016	0.912088	0.3519	0.355112	-0.23141	-0.19005	0.095721	-0.76736	0.180089
pH H_2O ($X_{5.1}$)	-0.40346	-0.38437	-0.3719	0.29356	0.767791	0.27088	-0.17175	0.151553	-0.02966	-0.08478	0.186569
pH KCl ($X_{5.2}$)	-0.25953	-0.22811	-0.44804	0.342269	0.771872	0.272936	-0.02729	0.167533	0.098977	-0.18312	0.268161
C-Organic ($X_{5.3}$)	-0.29516	-0.13852	0.096529	0.248076	0.710022	0.612498	0.073184	-0.4692	0.063874	-0.1793	0.384332
CEC ($X_{5.4}$)	0.066756	0.115697	0.003345	0.084182	**0.399393**	0.421251	0.373179	-0.05735	0.15285	-0.01387	0.281455
Base saturation ($X_{5.5}$)	-0.30026	-0.25724	-0.10527	0.412102	**0.481624**	0.361795	-0.60079	-0.0895	-0.13592	-0.48759	0.136266
N Total ($X_{6.1}$)	0.002878	0.137879	0.07154	0.268606	0.545283	0.798694	0.030267	-0.37884	-0.10212	-0.2485	0.427705
Available P ($X_{6.2}$)	-0.09821	-0.09791	-0.44547	0.211821	0.409315	0.520984	-0.28705	-0.057	0.033581	-0.26033	-0.02547
Available K($X_{6.3}$)	-0.09732	-0.01031	0.06693	0.614343	0.51245	0.885686	-0.3292	-0.29441	0.237691	-0.6422	0.49531
ESP ($X_{7.1}$)	0.38176	0.405078	0.084339	-0.186069	-0.06947	-0.21259	1	-0.01035	0.201152	0.361936	-0.0249
Slope ($X_{8.1}$)	-0.02207	-0.12714	-0.51717	-0.295103	-0.1643	-0.40295	-0.03466	0.973779	-0.34215	0.324431	-0.64795
Soil erosion ($X_{8.2}$)	0.064136	-0.00224	-0.44709	-0.166166	-0.11161	-0.32907	0.021581	0.956588	-0.12926	0.257787	-0.48649
Inundation height ($X_{9.1}$)	-0.08956	-0.02635	0.225421	0.194354	0.082178	0.127762	0.193925	-0.26735	0.992798	-0.13415	0.175472
Inundation period ($X_{9.2}$)	-0.11594	-0.06329	0.244833	0.199427	0.048584	0.078386	0.205739	-0.2425	0.991369	-0.11616	0.135302
Surface rock ($X_{10.1}$)	0.212772	0.074279	-0.23401	-0.854273	-0.28568	-0.55023	0.376036	0.319248	-0.13208	0.997623	-0.28655
Rock outcrop ($X_{10.2}$)	0.183196	0.051703	-0.21067	-0.868319	-0.29655	-0.55537	0.34638	0.290608	-0.12053	0.997697	-0.28228
Production ($Y_{1.1}$)	0.042282	0.177277	0.400657	0.304774	0.418519	0.534535	-0.0249	-0.59733	0.157534	-0.28507	1

Table 4. Path coefficient and significance testing

Exogenousvariables	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 shows a negative correlation and has a significant effect on local maize p production. This indicates 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 will directly or indirectly affectof root formation (Taghvaei*et al.* 2012). Land quality that greatly influenced the maize production were nutrient retention and nutrient availability (Subardja and Sudarsono, 2005). Furthermore, Nurhayati*et al.* (2015) reported that an increase of erosion hazard will result in a decrease of land productivity, conversely a decrease of erosion hazard results in an increase in land productivity.

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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 KCI, 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 indicates that the better drainage, effective depth, pH of KCI, C-Organic, N total, and K availability with an increase of 1% will be followed by an increasing 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 very significant effected on local maize production. This indicates that decrease of 1% in coarse material, slopes, soil erosion, surface rock and rock outcrops will be followed by an increasing of local maize production on 40.3% to 71.7%.

The correlation of each land characteristics was quite strong and strong to influencing of 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 (Indonesian Soil Research Institute, 2004). Slopes had a significant effect on local maize production, in which the steeper the slopes, the lower the production would be (Nurdin*et al.* 2020). Likeweise for the soil erosion the more erosion increases, the lower the production of maize would be (Suparwata*et al.* 2012). The surface rocks and rock outcrops were limiting factors in the land suitability of maize (Elfayetti and Hedi, 2015).

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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	2,9
Rainfall ($X_{2.1}$)	0,089	18,5
Wet months ($X_{2.2}$)	0,098	19,8
Dry months ($X_{2.3}$)	-0,013	3,8
LGP ($X_{2.4}$)	0,123	20,3
Drainage ($X_{3.1}$)	**0,350***	40,4
Texture ($X_{4.1}$)	0,098	5,0
Coarse material ($X_{4.2}$)	**-0,455****	-74,9
Effective depth ($X_{4.3}$)	**0,294***	54,5
pH H_2O ($X_{5.1}$)	0,234	13,7
pH KCl ($X_{5.2}$)	**0,333***	18,7
C-Organic ($X_{5.3}$)	**0,405****	59,7
CEC ($X_{5.4}$)	0,249	33,2
Base saturation ($X_{5.5}$)	0,278	30,7
N Total ($X_{6.1}$)	**0,436****	63,0
Available P ($X_{6.2}$)	0,076	25,3
Available K($X_{6.3}$)	**0,569****	73,2
ESP ($X_{7.1}$)	-0,107	-2,6
Slope ($X_{8.1}$)	**-0,717****	-75,9
Soil erosion ($X_{8.2}$)	**-0,516****	-62,9
Inundation height ($X_{9.1}$)	0,195	34,5
Inundation period ($X_{9.2}$)	0,168	30,5
Surface rock ($X_{10.1}$)	**-0,403***	-68,4
Rock outcrop ($X_{10.2}$)	**-0,408****	-68,0

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

CONCLUSION

The all manifest variables were valid and able to explain well the latent variables, . Furthermore, the latent variables were 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. Land quality that most influences of local maize productivity 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 most influence of local maize productivity 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: $Y = 2.447 + 0.187X_1 - 0.212X_2 + 0.153X_3 + 0.349X_4 + 0.166X_5 + 0.169X_6 + 0.313X_7 - 0.352X_8 - 0.230X_9 - 0.237X_{10} - 0.187X_{11}$.

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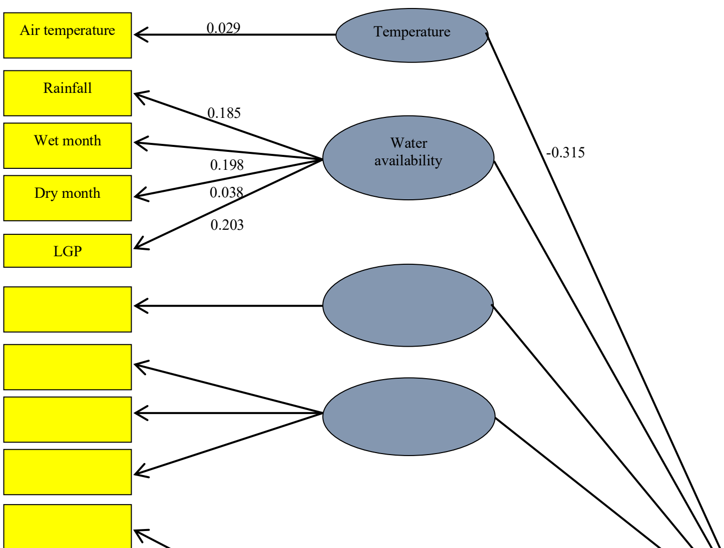

Figure 1. The coefficient pathways diagram of land quality on the level of local maize production

Analysisof Quality and Land Characteristics that Control Local Maize Production in Gorontalo

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Abstracts. 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.

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} (BPS RI, 2019). 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} (Yasin*et al.* 2014).

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 (BPS Kabupaten Gorontalo, 2019). Meanwhile, the average of local maize productivity has only reached 3.0 tonnes ha^{-1} (IAARD, 2009). One of the maize local varieties of Gorontalo is Motoro Kiki (Yasin*et al.*

2007). 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 (IAARD, 2009). In addition, local maize has better growth than hybrid and composite maize, but yield components show the opposite pattern (Kaihatu and Pesireron, 2016). 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 (Swastika, 2002). Land productivity was determined by the land quality and characteristics. Land quality has a close relationship with maize production (Subardja and Sudarsono, 2005) and each land quality has a significant effect on land suitability for certain uses (FAO, 1976) especially for maize crops. Research on land quality that controls maize production has been conductedby Subardja (2005) 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 Syaf (2014) but on mature cocoa trees in KolakaTimur 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 (Syaf, 2014). The use of SEM is very helpful in determining the effect of indicators and producing better models than other multivariate analyzes (Elisanti*et al.* 2013). 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 (Hair *et al.* 2013). 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.

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), nutrientavailability (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 KCI ($X_{5.2}$), 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:

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.

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 $\alpha = 0.05$. 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.

RESULTS AND DISCUSSIONS

a. 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 (Igbaria*et al.* 1997; Mattjik and Sumertajaya, 2011; Ulum*et al.* 2014). 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.

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

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 (Igbaria*et al.* 1997; Mattjik and Sumertajaya, 2011; Ulum *et al.* 2014). 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.

b. 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 (Sujarweni 2014). 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 (Abdilah and Hartono, 2015). Thus, all of the indicators used in this study had met 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

Latenvariables	Compositereliability	*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

c. 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 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.

Table 4. Path coefficient and significance testing

Exogenousvariables	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 (Taghvaei *et al*. 2012). Land quality that greatly influenced the maize production were nutrient retention and nutrient availability (Subardja and Sudarsono, 2005). Furthermore, Nurhayati *et al*. (2015) 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:

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

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

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 (Indonesian Soil Research Institute, 2004). Slopes had a significant effect on local maize production, in which the steeper the slopes, the lower the production would be (Nurdin*et al.* 2020). Likeweise for the soil erosion the more erosion increases, the lower the production of maize would be (Suparwata*et al.* 2012). The surface rocks and rock outcrops-were limiting factors in the land suitability of maize (Elfayetti and Hedi, 2015).

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	2,9
Rainfall ($X_{2.1}$)	0,089	18,5
Wet months ($X_{2.2}$)	0,098	19,8
Dry months ($X_{2.3}$)	-0,013	3,8
LGP ($X_{2.4}$)	0,123	20,3
Drainage ($X_{3.1}$)	**0,350***	40,4
Texture ($X_{4.1}$)	0,098	5,0
Coarse material ($X_{4.2}$)	**-0,455****	-74,9
Effective depth ($X_{4.3}$)	**0,294***	54,5
pH H_2O ($X_{5.1}$)	0,234	13,7
pH KCl ($X_{5.2}$)	**0,333***	18,7
C-Organic ($X_{5.3}$)	**0,405****	59,7
CEC ($X_{5.4}$)	0,249	33,2
Base saturation ($X_{5.5}$)	0,278	30,7
N Total ($X_{6.1}$)	**0,436****	63,0
Available P ($X_{6.2}$)	0,076	25,3
Available K($X_{6.3}$)	**0,569****	73,2
ESP ($X_{7.1}$)	-0,107	-2,6
Slope ($X_{8.1}$)	**-0,717****	-75,9
Soil erosion ($X_{8.2}$)	**-0,516****	-62,9
Inundation height ($X_{9.1}$)	0,195	34,5
Inundation period ($X_{9.2}$)	0,168	30,5
Surface rock ($X_{10.1}$)	**-0,403***	-68,4
Rock outcrop ($X_{10.2}$)	**-0,408****	-68,0

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

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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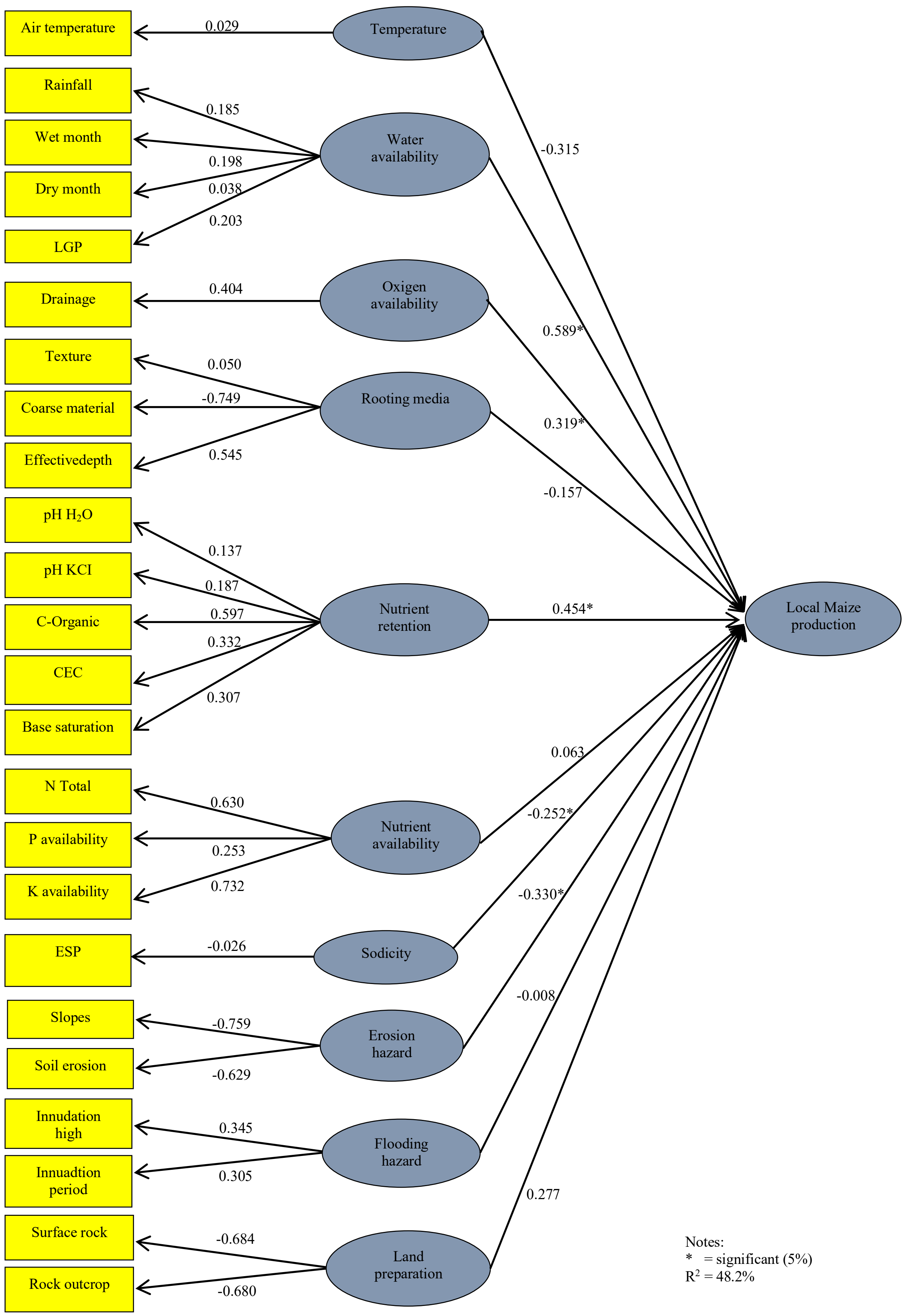

Figure 1. The coefficient pathways diagram of land quality on the level of local maize production

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Analysisof Quality and Land Characteristics that Control Local Maize Production in Gorontalo

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ABSTRACTS

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} (BPS RI, 2019). 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} (Yasin*et al.* 2014).

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 (BPS Kabupaten Gorontalo, 2019). Meanwhile, the average of local maize productivity has only reached 3.0 tonnes ha^{-1} (IAARD, 2009). One of the maize local varieties of Gorontalo is Motoro Kiki (Yasin*et al.* 2007). 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 (IAARD, 2009). In addition, local maize has better growth than hybrid and composite maize, but yield components show the opposite pattern (Kaihatu and Pesireron, 2016). 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 (Swastika, 2002). Land productivity was determined by the land quality and characteristics. Land quality has a close relationship with maize production (Subardja and Sudarsono, 2005) and each land quality has a significant effect on land suitability for certain uses (FAO, 1976) especially for maize crops. Research on land quality that controls maize production has been conductedby Subardja (2005) 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 Syaf (2014) but on mature cocoa trees in KolakaTimur 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 (Syaf, 2014). The use of SEM is very helpful in determining the effect of indicators and producing better models than other multivariate analyzes (Elisanti*et al.* 2013). 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 (Hair *et al.* 2013). 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), nutrientavailability (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 KCI ($X_{5.2}$), 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:

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.

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

a. 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 (Igbaria*et al.* 1997; Mattjik and Sumertajaya, 2011; Ulum*et al.* 2014). 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.

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

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 (Igbaria*et al.* 1997; Mattjik and Sumertajaya, 2011; Ulum *et al.* 2014). 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.

b. 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 (Sujarweni 2014). 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 (Abdilah and Hartono, 2015). Thus, all of the indicators used in this study had met 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

Latenvariables	Compositereliability	*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

c. 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 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.

Table 4. Path coefficient and significance testing

Exogenousvariables	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 (Taghvaei *et al.* 2012). Land quality that greatly influenced the maize production were nutrient retention and nutrient availability (Subardja and Sudarsono, 2005). Furthermore, Nurhayati *et al.* (2015) 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:

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

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:

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

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%.

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 (Indonesian Soil Research Institute, 2004). Slopes had a significant effect on local maize production, in which the steeper the slopes, the lower the production would be (Nurdin*et al.* 2020). Likeweise for the soil erosion the more erosion increases, the lower the production of maize would be (Suparwata*et al.* 2012). The surface rocks and rock outcrops–were limiting factors in the land suitability of maize (Elfayetti and Hedi, 2015).

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	2,9
Rainfall ($X_{2.1}$)	0,089	18,5
Wet months ($X_{2.2}$)	0,098	19,8
Dry months ($X_{2.3}$)	-0,013	3,8
LGP ($X_{2.4}$)	0,123	20,3
Drainage ($X_{3.1}$)	**0,350***	40,4
Texture ($X_{4.1}$)	0,098	5,0
Coarse material ($X_{4.2}$)	**-0,455****	-74,9
Effective depth ($X_{4.3}$)	**0,294***	54,5
pH H_2O ($X_{5.1}$)	0,234	13,7
pH KCl ($X_{5.2}$)	**0,333***	18,7
C-Organic ($X_{5.3}$)	**0,405****	59,7
CEC ($X_{5.4}$)	0,249	33,2
Base saturation ($X_{5.5}$)	0,278	30,7
N Total ($X_{6.1}$)	**0,436****	63,0
Available P ($X_{6.2}$)	0,076	25,3
Available K($X_{6.3}$)	**0,569****	73,2
ESP ($X_{7.1}$)	-0,107	-2,6
Slope ($X_{8.1}$)	**-0,717****	-75,9
Soil erosion ($X_{8.2}$)	**-0,516****	-62,9
Inundation height ($X_{9.1}$)	0,195	34,5
Inundation period ($X_{9.2}$)	0,168	30,5
Surface rock ($X_{10.1}$)	**-0,403***	-68,4
Rock outcrop ($X_{10.2}$)	**-0,408****	-68,0

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

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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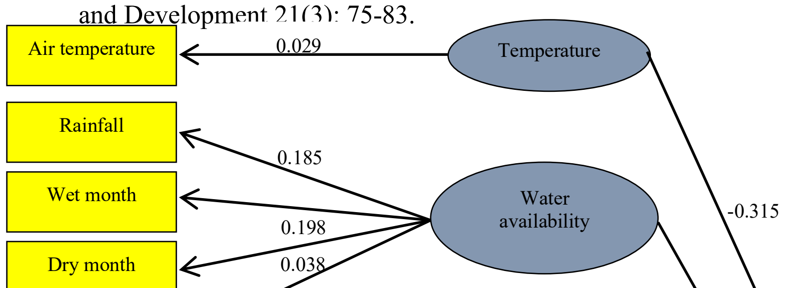

Figure 1. The coefficient pathways diagram of land quality on the level of local maize production

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PROCEEDINGS OF THE INTERNATIONAL SEMINAR ON PROMOTING LOCAL RESOURCES FOR SUSTAINABLE AGRICULTURE AND DEVELOPMENT (ISPLRSAD 2020)

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

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

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 conduc[redacted] the Gorontalo Regency. A total of 33 mapping units had been established [redacted] 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 (X1), rooting media (X2), nutrient retention (X3), nutrients availability (X4), erosion hazard (X5), and land preparation (X6) with the best equation: Y = 1.805 + 0.276X1 + 0.303X2 + 0.353X3 + 0.346X4 - 0.337X5 - 0.303X6. The land characteristics that control of the local maize production were drainage (X1), coarse material (X2), effective depth (X3), pH KCl (X4), C-organic (X5), total N (X6), available K (X7), slope (X8), soil erosion (X9), surface rock (X10) and rock outcrop (X11) with the best equation: Y = 2.447 + 0.187X1 - 0.212X2 + 0.153X3 + 0.349X4 + 0.166X5 + 0.169X6 + 0.313X7 - 0.352X8 - 0.230X9 - 0.237X10 - 0.187X11.

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

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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 KCI ($X_{5.2}$), 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 $\alpha = 0.05$. 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:

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

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:

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

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%.

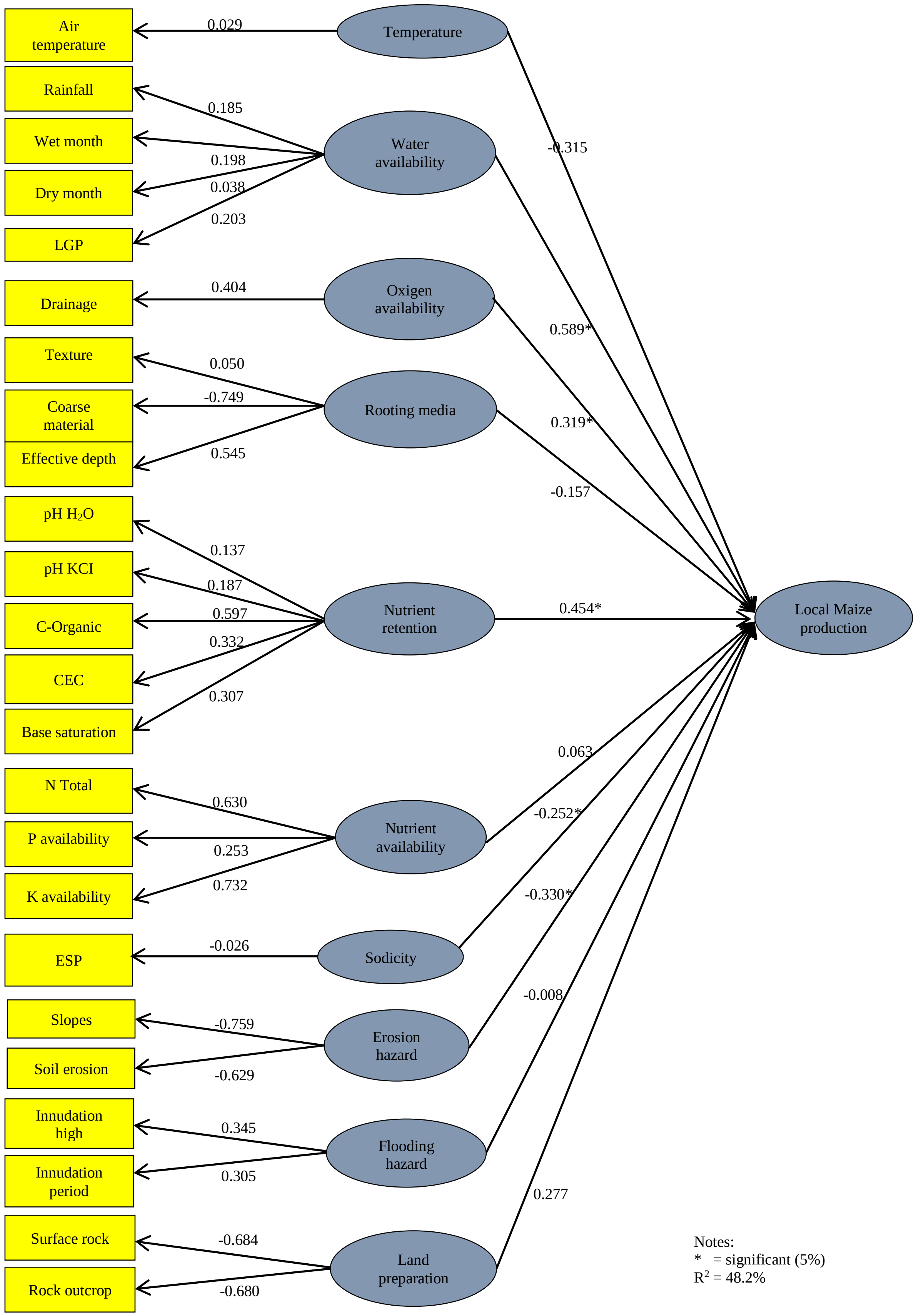

Figure 1. The coefficient pathways diagram of land quality on the level of local maize production.

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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