AJAB

Asian J Agric & Biol. 2019; Special Issue:160-166.

Original Article

A path analysis on the impact of population increase on rice field conversion

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Received:
March 10, 2019
Accepted:
October 17, 2019
Published:
December 05, 2019

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Abstract

Rice field conversion is a transformation of rice field function from rice production to other uses. The accumulation of the case will threaten Indonesian food security in the future if early anticipation is not prepared. The objectives of this research were to figure out the amount of rice field conversion and to identify a path of the impact of population increase on the rice field conversion in Padang city, Indonesia. This research was conducted in Padang city from July to September 2017. Data was collected from Statistics of Padang city and official documents of Padang city from 2006 to 2017. Variables are the number of population, per capita income, land for settlement, length of road constructed, price of rice, and area of rice field. The methods of analysis were trend analysis and path analysis using IBM SPSS 23 and Smart PLS 3 softwares. The result showed that there was about 31.9 ha/year of rice field converted to other uses in Padang city within the last ten years. The population increase cause the indirect impact on the rice field conversion. The impact of population increase on the rice field conversion passes through per capita income and land for settlement as mediating factors.

Keywords: Path analysis, Population increase, Rice field conversion

How to cite this:

Khairati R and Syahni R, 2019. A path analysis on the impact of population increase on rice field conversion. Asian J. Agric. Biol. Special Issue: 160-166.

Introduction

Land conversion is a transformation of land resource allocation from one use to other uses (Kustiwan, 1997). Related to this terminology, rice field conversion could be described as a case where the function of rice field is transformed from rice production to other uses. Land conversion principally occurs because of competition in land use between agriculture and non-agriculture sectors, while the competition occurs because of limitedness of natural resources, population growth, and economic growth (Irawan, 2005).

There are some factors that cause land conversion, such as population growth, need for non-agriculture activities, economic factors, socio-cultural factors, environment degradation, regional autonomy, and the weakness of law enforcement (Isa, 2004). Furthermore, some factors that indirectly affect the land conversion from agriculture to non-agriculture uses are the change of economic structure, population growth, urbanization, and the inconsistence of land use regulation; while factors that directly affect the land conversion are the growth of transportation infrastructure, land for industry, and land for settlement (Pakpahan, 1993).

One of the important determinant of land conversion is the population growth. This factor is important to

consider since Indonesia is classified as a country with high population number. According to Statistics Indonesia (2017), total population of Indonesia in 2010 was about 237.6 million people. That number brought Indonesia to the fourth position of the most populous countries in the world, after China, India, and United State of America. With growth rate 1.34%, Indonesian population became 261.9 million people in 2017. This means during the last seven years there were on average 3.47 million population increase every year in Indonesia.

The population increase, in one hand, will increase the need for agriculture land, especially rice field, to meet people need for rice. On the other hand, the availability of agriculture land will decrease due to the increase of land for settlement, industries, transportation and other public facilities which were also needed by the people. For this reason, the rice field conversion is somehow unavoidable. It will apprehensively threaten the Indonesian food security if there is no early anticipation. To find out the solution of the rice field conversion problem, it is important to understand how the population growth occurs, and how it affects the rice field conversion along with other factors.

A number of studies about agriculture land conversion have been done in Indonesia and some other countries, such as Pakpahan (1993), Kustiwan (1997), Sumaryanto and Suhaeti (1999), Isa (2004), Irawan (2005), Anneke (2012), Hao et al. (2017), Gurung et al. (2016), and Halim et al. (2013). However, there was no study examined how the population increase cause an impact on land conversion along with other factors. Based on the fact, the research was done in Padang city, as one of the populous city in West Sumatera Province, Indonesia. The objectives of this research were to figure out the amount of rice field conversion, and to identify the path of population impact on the rice field conversion in Padang city.

Material and Methods

This research was conducted in Padang city from July to September 2017. The data was collected from Statistics of Padang city and official documents of Padang city statistical office, such as: Padang City Regional Middle Term Development Plan 2014-2019 and Padang City Regional Land Use Plan 2010-2030. The observed variables were the number of population, per capita income, land of settlement, length of road constructed, price of rice, and area of rice field.

The methods were trend analysis and path analysis using IBM SPSS 23 and Smart PLS 3 softwares. The trend analysis was used to figure out the trend of population and the trend of rice field during the last 10 years. To identify the tendency of population number or the trend of rice field magnitude, we used the trend analysis with simple regression model between time (year) as independent variable and population number or area of rice field as dependent variable.

The trend model was:

$$Y_t = \beta_0 + \beta_1 t + \epsilon_t$$

where Y_t is population number or area of rice field in year t, t is year, and ϵ_t is the residual effect in year t.

The regression coefficient was to measure the population increase or the size of rice field conversion every year. The reliability of regression equation was measured by coefficient of determination R^2 which represented the amount of variation on population number or rice field conversion explained by the year.

The path analysis was used to identify the impact of population growth along with other variables on rice field conversion. The analysis consisted of 5 regression models which identifying the path impact of population on rice field through related variables. First model was to identify the effect of population to per capita income. Second, third and fourth models were used to investigate the effect of population and per capita income to length of road constructed, land for settlement and price of rice. Furthermore, fifth model was to identify the effect of length of road, land for settlement, and price of rice to rice field conversion. All models were summarized as following models:

1. $X_2 = \rho_{21} X_1 + \rho_{2\epsilon} \epsilon_1$,
2. $X_3 = \rho_{31} X_1 + \rho_{32} X_2 + \rho_{3\epsilon} \epsilon_2$,
3. $X_4 = \rho_{41} X_1 + \rho_{42} X_2 + \rho_{4\epsilon} \epsilon_3$,
4. $X_5 = \rho_{51} X_1 + \rho_{52} X_2 + \rho_{5\epsilon} \epsilon_4$,
5. $Y = \rho_{y3} X_3 + \rho_{y4} X_4 + \rho_{y5} X_5 + \rho_{y\epsilon} \epsilon_5$

where X_1 is number of population, X_2 is per capita income, X_3 is length of roads constructed, X_4 is land for settlement, X_5 is price of rice, Y is area of rice field, and ρ_{ij} is path coefficient for each variable. These models formed a path diagram, as depicted in Figure 1. In this model, the number of population could affect the land for rice field through per capita income, length of road constructed, land area for settlement,

and price of rice. The effects were measured by the path coefficient for each variable.

Each variable was also selected by diagnostic tests for the model classical assumptions. The tests included multicollinearity test, heteroscedastisity test, and autocorrelation test. The final model includes only the variables which meet these assumptions, free from multicollinearity, heteroscedastisity, and autocorrelation problems. Variables would remain in the model when available data supports the model, otherwise they were removed from the model. [Figure 1]

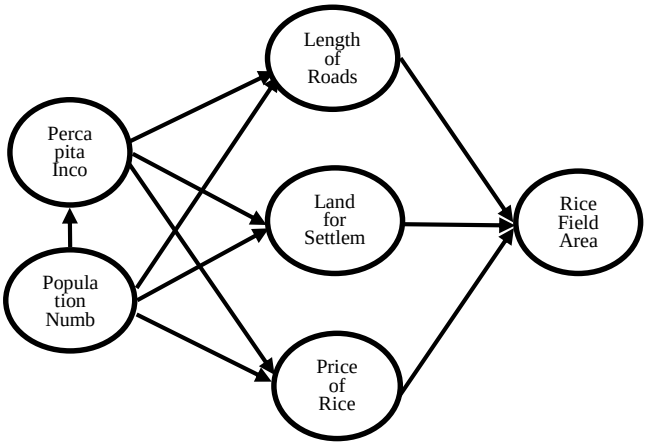

Figure-1: Research framework

Results and Discussion

Description of location

Padang City is the capital city of West Sumatera which is located at the west coast of Sumatera Island, of Indonesia. According to Statistics of Padang Municipality (2017), Padang City covered an area of 1,414.93 km^2 where 694.93 km^2 is land and 720.00 km^2 is ocean. Land use of Padang city are as follows: 35,448 ha (51.01%) of the area consisting of forest, 6,989.41 ha (10.06%) for settlement, 6,474 ha (9.31%) for rice field, and 20,590.59 (29.62%) for other uses. Population of Padang City in 2015 were recorded as 902,413 people, with 450,578 males and 451,835 females. This number continually increased since the last survey, where it became 914,968 people with 457,090 males and 457,878 females in 2016. The total population of Padang city was the highest among other cities in West Sumatera. The increase of Padang City population during the period of 2006-2016 was about 81,406 or about 13,568 per year. [Table-1]The population of Padang City were distributed in 11 sub-districts which highly variated and concentrated in the center of urban area. The highest population was found in Koto Tangah with 177,908 people (19.44%), and the lowest population was found in Bungus Teluk Kabung with 25,132 people (2.75%). Meanwhile the highest density of the population in Padang City was Padang Timur with 10,487 people/km^2 followed by Padang Utara with 9,390 people/km^2, Nanggalo with 7,790 people/km^2, and sub-district with the lowest density of population was Bungus Teluk Kabung with 249 people/km^2 (Table 1).

Table-1: Distribution and density of population of Padang city in 2016

Sub district	Area (km^2)	Percent of area	Number of people	Percent of people	Density of people/km^2
Bungus Teluk Kabung	100.78	14.50	25,132	2.75	249
Lubuk Kilangan	85.99	12.37	53,671	5.86	624
Lubuk Begalung	30.91	4.45	116,826	12.77	3,780
Padang Selatan	10.03	1.44	63,355	6.92	6,317
Padang Timur	8.15	1.17	85,473	9.34	10,487
Padang Barat	7.00	1.01	49,812	5.44	7,116
Padang Utara	8.08	1.16	75,869	8.29	9,390
Nanggalo	8.07	1.16	62,686	6.87	7,790
Kuranji	57.41	8.26	139,105	15.2	2,423
Pauh	146.26	21.05	64,999	7.1	444
Koto Tangah	232.25	33.42	177,908	19.44	766
Padang	**694.93**	**100.00**	**914,968**	**100.00**	**1,317**

Source: Statistics of Padang Municipality 2017

Population trend

The population trend was depicted by the graph in Figure 2. In the period of 2006-2009, the population number increased rapidly from 819,765 to 875,548 people. In period of 2009-2010, the population decreased from 875,548 to 833,562. The decrease occurred due to the 2009 earthquake catastrophe where a great number of people leaved Padang City to other towns and districts. The population increased continually since 2010 and became 914,968 people in 2016. The population increase during the period of 2010-2015 was 68,851 people or 13,770 people per year, with growth rate of 1.52% per year. The growth rate became lower in the period of 2015-2016 (1,37%) with population increase from 902,413 to 914,968 people.

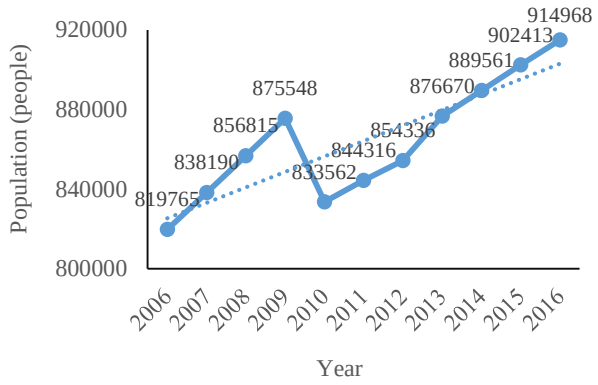

Figure-2: The population trend of Padang city in 2006-2016

The slope of population trend during period 2006-2016 was estimated using regression analysis with regression coefficient 7.765 (Table 2). The coefficient revealed that in the last ten years, the population of Padang City increased about 7,765 people every year. The regression coefficient is reliable with coefficient of determination 0.729. The increase of population was accumulated and caused the growing need of people for settlement and public facilities.

Table-2: Trend analysis of population of Padang City in period 2006-2016

Variabel	Coefficient	Std. Error	Std. Coefficient	Sig	R^2
(Constant)	825.369	9.343	-	0.000	0.729
Year	7.765	1.579	0.854	0.001	

Table-3: The decrease of rice field area by sub districts in Padang city in Period 2006-2016

Subdistrict	Rice field in 2006 (ha)	Rice field in 2016 (ha)	Change of rice field area	
			Ha	%
Bungus Teluk Kabung	790	783	-7	-0.89
Lubuk Kilangan	584	578	-6	-1.03
Lubuk Begalung	485	452	-33	-6.80
Padang Selatan	10	10	0	0
Padang Timur	104	76	-28	-26.92
Padang Barat	-	-	-	-
Padang Utara	15	10	-5	-33.33
Nanggalo	254	237	-17	-6.69
Kuranji	2,112	1,921	-191	-9.04
Pauh	1,095	1,061	-34	-3.11
Koto Tangah	1,288	1,290	2	0.16
Padang City	**6,737**	**6,418**	**-319**	**-4.74**

Source: Padang in Figures (2007-2017)

Rice field conversion

Total rice field area of Padang City in 2016 was 6,418 ha which were distributed among 11 sub-districts with the largest area was in Kuranji with 1.921 ha and the smallest areas were in Padang Utara and Padang Selatan, with 10 ha each area (Table 3).

On the contrary to the population number, the rice field area decreases during the last 10 years. The decrease of rice field was 319 ha from 6,737 ha in 2006 to 6,418 in 2016, or on the average about 31.9 ha/year. The decrease of rice field area took effect to most sub-districts in Padang City, except Padang Selatan and Koto Tangah sub-districts. The sub-districts with the largest rice field decrease were Kuranji, as much as 191 ha from 2,112 ha in 2006 to 1,923 ha in 2016, followed by Pauh 34 ha, from 1,095 ha in 2006 to 1,061 ha in 2016. Meanwhile, Padang Selatan was a subdistrict without changing in rice field area and Koto Tangah sub-district with small increase within the last ten years. The trend of rice field and settlement area in the last 10 years is presented in Figure 3. The trend of rice field area was variative. The decrease of rice field area was slower during 2006 to 2007, deeper during 2007 to 2008, slower again during 2008 to 2010, deeper during 2010 to 2015, and much deeper from 2015 to 2016. The decrease was deepened from 2015 to 2016 due to the intensive work on some road construction and settlement in Kuranji. In general, the decrease of rice field was mostly due to rice field conversion for settlement area. In the same figure we can also see the trend of settlement area. The area of settlement in Padang city tended to increase from 6,293 ha to 7,007 ha throughout 2006-2016 with total increase 71.4 ha every year. almost half of the conversion area (45%).

Figure-3: The rice field and settlement trend of Padang city 2006-2016

The trend line estimate of rice field change showed that the trend of rice field area decreased in the last 10 years about 24.94 ha/year, which was highly significant with significant level 1%, and coefficient of determination 86.1% (Table 4). The conversion of agriculture land for housing and social economic facilities in Indonesia not only occurs in Padang City, but also in many places, as like as Banjarmasin (Rusastra and Budhi, 1997), Bali (Budhi et al., 2017), and other country as like as Kenya (Wanyonyi, 2012) and Ethiopia (Thesome, 2014), where land conversion occurred mostly in the urban area.

Impact of population increase on rice field conversion

The relationship between population and rice field area in Padang City could be described as scattered plot in Figure 4. There was negative relationship between population and rice field area. In the last 10 years, the increase of population was followed by the decrease of rice field area. In fact, as described above, there was an increase of population of 9,520 per year, followed by a decrease of rice field availability in Padang City of 31.9 ha per year.

Table-4: Trend analysis of rice field and settlement area of Padang city in period 2006-201

Variabel	Coefficient	Std. Error	Std. Coef.	Sig	R^2
Rice Field					
(Constant)	6741.955	19.788	-	0.000	0.861
Year	-24.936	3.345	-0.928	0.000	
Settlement					
(Constant)	6734.389	52.983	-	0.000	0.882
Year	73.630	8.956	0.939	0.000	

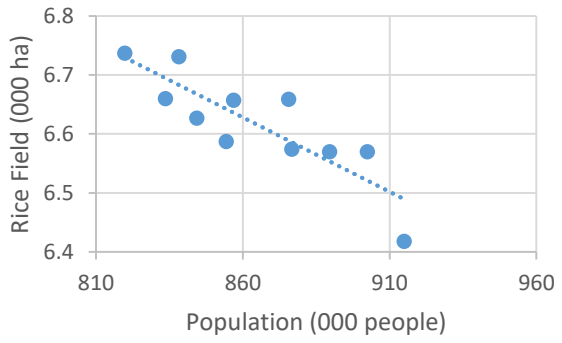

Figure-4: Relationship of population and rice field in Padang city 2006-2016

One impact of population growth to Padang City was a decrease of rice field area. This problem occurred because of the increasing public demand for housing and public facilities, which required large areas. Such conversions also decreased the availability of land for food production. Some cities in West Sumatera experienced higher population growth rate compared to food growth rates (Khairati, 2013).

Regression analysis showed that the relationship between population and rice field area was negative, with regression coefficient -0.003, significance level 0.001, and determination coefficient 0.839 (Table 5). The regression coefficient can be interpreted as the decrease of rice field for an additional one person in the area.

Table-5: Regresion analysis of population and rice field relationship of Padang City in Period 2006-2016

Variabel	Coefficient	Std. Error	Std. Coefficient	Sig	R^2
(Constant)	8797.562	443.403	-	0.000	0.839
Population	-0.003	0.001	-0.854	0.001	

The Path of population impact on rice field conversion

The path analysis for factors that affect the availability of rice field area in Padang city is presented in Table 6. There were 6 variables used in the analysis, namely population number, per capita income, length of road, land for settlement, price of rice, and the rice field area. Since variable length of road, land for settlement, and price of rice were multicolinear, only land for settlement still remain in the model.

Table-6: Path analysis of population impact on rice field area in Padang city

Dependent Variable	Independent variable	Regression coefficient	Path coef	Sig	R^2
Per capita income	Population	0.337	0.863	0.001	0.745
Settlement area	Per capita income	19.253	0.872	0.015	0.839
	Population	0.441	0.051	0.86	
Rice field area	Settlement area	-0.3	-0.875	0	0.765

That result showed that the increase of population affected the rice field area through per capita income and land for settlement as mediating variable (Figure 5). Per capita income affected significantly the settlement area indicated by path coefficient for

income 0.872, while path coefficient for population number was only 0.051.

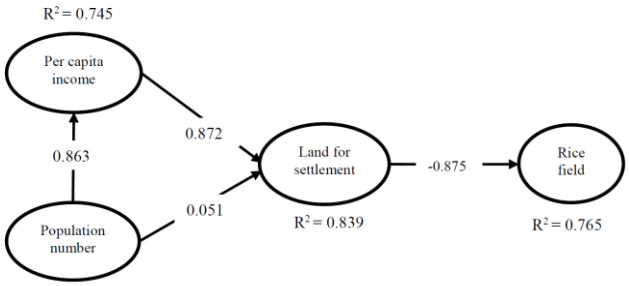

Figure-5: Path diagram of population impact on rice field conversion

The result showed that per capita income was a mediating variable of population affecting settlement area. The increase of settlement area significantly caused the decrease of rice field with path coeficient -0.875, and determination coefficient 0.765. This result shows that the effect of population increase to rice field conversion is indirect, mediated by per caita income, dan settlement area. This fact is consistent with results by previous research such as Pakpahan (1993), Budhi et. al. (2017), Halim et. al (2013), Thesome (2014), and Purnami and Santini (2017).

Pakpahan (1993) stated that the population was an indirect factor of rice field conversion. Budhi et. al. (2017) stated that the development of the population number caused negative impacts indirectly on rice production. Halim et.al. (2013) also observed that the land conversion from agriculture to non-agriculture due to a gradually increasing land demand in housing and relevant services thus adversely impact on agricultural land. Furhermore, Based on a report from Ethiophia (Thesome, 2104), the rapid growth of population has resulted in shortage of farmland which in time affected smallholder agriculture and sustainability of rural livelihood. Purnami and Santini (2017) also did a research in Pulagan Tampaksiring Village, Bali province. They found that population growth indirectly affected significantly on Subak sustainability through agricultural conversion.

Conclusion

In the period of 2006-2016, the population increase of Padang City was estimated 9,520 people/year, while the decrease of rice field area due to land conversion was estimated about 31.9 ha/year. The impact of population increase on the rice field conversion is indirect, where the increase of population caused the decrease of rice field area through per capita income and land for settlement as mediating factors.

Acknowledgement

The authors express their gratitude and high appreciation to Head of National Population and Family Planning of West Sumatera Representative for funding this research, to government of Padang city and to Statistics Indonesia of Padang city for supporting data and information.

Contribution of Authors

Khairati R: Developed idea, data collection, and write up of article
Syahni R: Conceived idea, statistical analysis, and write up of article

Disclaimer: None.
Conflict of Interest: None.
Source of Funding: National Population and Family Planning, West Sumatera Representative, Indonesia.

References

Anneke, 2012. Factors that affects agriculture land conversion and its impact on farmers income. Faculty of Economics, Andalas University. Padang.

Budhi MKS, Yasa INM and Darma K, 2017. Impacts of development of population and conversion of agricultural land on food security (Rice) in Bali, Indonesia. Int. J. Econ. Commerce Manage. 5(12): 634-643.

Gurung K, Bhandari H and Thelma P, 2016. Tranformation from rice farming to commercial aquaculture in Bangladesh: Implications for gender, food security, and livelihood. Gender Technol. Dev. 20(1): 49-80.

Halim MA, Rahman MM and Hassan MZ, 2013. Agricultural land conversion in the sub-urban area: A case study of Rajshahi metropolitan city. J. Life Earth Sci. 8: 21-30.

Hao L, Sun G, Liu L, Qin M, Huang X and Fang D, 2017. Converting paddy rice field to urban use dramatically altered the water and energy balances

in Southern China. Abstract. Am. Geophys. Union. Fall Meeting 2017, abstract no. B11C-1680.

Irawan B, 2005. Rice field conversion: Potensial impact, pattern of usage, and determinant factors [Konversi lahan sawah: potensi dampak, pola pemanfaatan, dan faktor deteminan]. Agro. Econ. Res. Forum. 23(1): 1-18.

Isa I, 2004. Strategy and policy of land conversion. National Land Authority, Jakarta, Indonesia.

Khairati R, 2013. Comparison of food production growth and population growth in the cities of West Sumatera Province [Perbandingan pertumbuhan produksi pangan dan pertumbuhan penduduk pada wilayah kota di Sumatera Barat]. J. KBP. 6(2): 371-377.

Kustiwan I, 1997. Land conversion and its implication to regional space order (Case study in Pantura Region West Java). J. Perenc. Wil. Kota. 8(1): 49-60.

Nurliani and Rosada I, 2016. Rice field conversion and its impact on food availability. Agric. Agric. Sci. Procedia. 9: 40-46.

Regional Development Planning Board of Padang. 2012. Padang City Regional Land Use Plan 2010-2030. Padang Regional Development Planning Board of Padang, Padang, Indonesia.

Regional Development Planning Board of Padang. 2014. Padang City Regional Middle Term Development Plan 2014-2019. Regional Development Planning Board of Padang, Padang, Indonesia.

Pakpahan A, 1993. Analysis of rice Field land conversion policy to non-agriculture sses [Analisis kebijakan konversi lahan sawah ke penggunaan non-pertanian]. Centre for Agriculture Social Economic Research. Agriculture Research and Development. Bogor, Indonesia.

Purnami AAS and Santini NM, 2017. The Impact of population growth to the agriculture land conversion and sustanability of Subak as world culture heritage. IOSR J. Hum. Soc. Sci. 22(8): 13-18.

Rusastra IW and Budhi GS, 1997. Agriculture land conversion and anticipative strategy to overcome the problems [Konversi lahan pertanian dan strategi antisipatif dalam Penanggulangannya]. Agric. Res. Dev. J. 16(4): 107-113.

Rustiadi E and Reti W, 2008. The urgence of sustainable food agriculture land in perspective of food security [Urgensi lahan pertanian pangan abadi dalam perspektif ketahanan pangan] in Arsyad S and Rustiadi E. Rescuing Soil, water, and environment. Crescent Press and Yayasan Obor Indonesia, Jakarta, Indonesia.

Sumaryanto and Suhaeti RN, 1999. Assesment of losses related to irrigated low land conversion. Center for Agricultural Social Economic Reserch, Agriculture Research and Development, Bogor, Indonesia

Statistics of Padang Municipality, 2007-2017. Padang Municipality in Figures. BPS-Statistics of Padang Municipality, Padang, Indonesia.

Statistics Indonesia, 2018. Statistical Year Book of Indonesia 2018. BPS-Statistics Indonesia, Jakarta, Indonesia.

Thesome M, 2014. Population growth and cultivated land in rural Ethiopia: Land use dynamics, access, farmsize, and fragmentation. Resour. Environ. 4(3): 148-161.

Wanyonyi RW, 2012. Impact of human population on land degradation Former Lugari district, Kakamega county, Kenya. Thesis in the School of Environmental Studies of Kenyatta University, Kenya.