Analyzing and modeling the impacts of agricultural land conversion

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Land use change, Agricultural Lands, Economic impacts, Social impacts and Environmental impacts.

Abstract

Agricultural Land Conversion (ALC), as a result of human activities during over the past 50 years, is converted to a main challenge of 21 century. This is especially important because of its direct relations with the other issues such as food security and environmental sustainability. According to the 2012 FAO report, the per capita of arable land in the world declines 1.46% from 1970 to 2009. This decrease for Iran has been 2.054%. It represents that ALC in Iran is worse than the most of the other areas of the world. The main object of this study was determining the effects of ALC. The study group consisted of the experts who were working in Agricultural Lands Organizations and Administrations in 2012. For data collection a questionnaire which was completed with interview method was used. The numbers of interviewees were 101 persons. These studies showed, according to interviwees the main impacts of ALC at the first are economic impacts and then respectively are social and environmental impacts.

1. Introduction

1.1. Land use changes and its challenges

The problems associated with land, water and air are the major challenges facing humanity in the 21st century (FAO, 2012, FAO, 2011). Unreasonable and unsustainable exploitation of these resources facing human with diverse challenges such as climate change or emitting and storing greenhouse gases which will led to many problems such as decline in agricultural production and increasing hunger, disease and malnutrition (The World Bank, 2010). Now, on over 40 percent of the Earth's ice-free land surface transformed (Foley et al., 2005).

Although this global environmental changes has many interacting components, land use/land cover change (LUCC) or land conversion probably represents the most important factor affecting ecological systems (Mondal and Southworth, 2010, Turner II, 2002, Turner II, 2009, Vitousek et al., 1997). Among the various types of land conversions, ALC is the most important one. Uncontrolled agricultural land conversion (ALC) has great impacts on the environment in general and agricultural products in particular. ALC is a phenomenon that is almost unavoidable during economic development and population growth periods (Tan et al., 2009). The importance of ALC is not only because it currently has the biggest transformative power on the earth (Billington et al., 1996) but also because in the last 50 years, several regions of the world have seen cropland areas stabilize, and in some areas, there has even been a decrease (Ramankutty et al., 2006). For example, according to the 2012 and 2013 edition of the FAO Statistical Yearbook, during 1970-2009 Iran arable land per person has decreased 2.1% (FAO, 2012, FAO, 2013). While, based on reports of the Statistical Center of Iran (SCI) agriculture is one of the most important sectors of Iran's economy, the sector currently constitutes 10% of the country's GDP and 19% of total employment. Agricultural products form about 30% of Iran's non-oil exports (Statistical Center of Iran, 2012). As FAO (2013) has reported, Iran ranks amongst

the top seven countries in producing 22 important agricultural products (FAO, 2010). In recent years, the pace of change in agricultural lands to non-agricultural lands is intensifying in the country. Now the lands are fragmented and crumbling. This process has intensified ALC. Apparently, so far not only have all the government policies and plans failed to control ALC, but some of them have exacerbated it (Azadi and Barati, 2013).

1.2. Land use changes impacts

Although in recent years, the studies which attended to the causes of land use change have been many (Zhang et al., 2013, Wyman and Stein, 2010, Wood et al., 2004, Verburg et al., 2010, Verburg et al., 2006, Serra et al., 2008, Rounsevell et al., 2005, Mottet et al., 2006, Hersperger and Bürgi, 2007) and these causes are well known, but its effects or impacts and especially socio-economic impacts are still mostly unknown. Then, **s**tudies in this scope is just beginning and little. Which some of them are mentioned in the following.

Mahoney (2003) and Mudgal (2008), for example, believed that the impacts of land use changes have environmental, social and economic aspects. But Scholte et al. (2012), Barca (2012) and Ronneberger et al. (2005) have divided these to environmental and socio-economic impacts. Some environmental impacts are reduced biodiversity, reduced quantity and quality of air, water and soil, changes in the global carbon cycle, increase energy consumption, forest degradation, increasing the number of environmental disasters and their severity, increases greenhouse gases emission and raising the global temperature. Change the level of employment and unemployment, income, demographic changes (population, age pyramid, population density, etc.), food security and health, poverty, rising crime, health and social security, immigration, change the investment levels, change in agricultural and livestock products, and change the land prices are the main social and economic impacts of ALC and LUCC (Farrington et al., 2008, Helming et al., 2008, Litman, 2011, Petit et al., 2008, Petit and Frederiksen, 2011).

1.3. Objectives and structure of the paper

This study examines the main Impacts of ALC in Iran. For this aim, at first, the methodology of the paper is described. Second, the results are explained. Third, the research findings are discussed. Finally, a conclusion is drawn with regard to the main findings of this study.

2. Methodology

This study benefitted from a mixed-method approach that included both qualitative and quantitative measurements. Data were collected among executive officers and policy makers.

During the first stage and after a literature review, four policy makers and four executive officers were interviewed extract their opinion about the main impacts of ALC using the Delphi technique (Linstone and Turoff, 2002) and a focus-group interview (Krueger and Casey, 2000). Over this stage totally 23 indicators or impacts were identified. Then, these identified impacts were classified in three main groups (Mudgal et al., 2008, Mahoney et al., 2003) (economic, social and environmental) and were structured within a questionnaire. Afterward, the questionnaire was pre-tested. Finally, The final questionnaire was sent to selected executive officers and policy makers. They were asked to express their opinion in relation to each factors (impacts) of ALC by selecting a score between one to five (1 for not, 2 for little, 3 for somewhat, 4 for large and 5 for great impact of ALC). Total policy makers and executive officers were 135 persons that 101 persons randomly were selected.

The sample size is calculated based on Solvin's formula (Rivera, 2007, Azadi et al., 2011), as follow:

$$n = \frac{N}{(1+N\times e\times e)}$$

Where n is sample size, N is population and e is percentage of imprecision of sampling that can be tolerated (5%). The sample was therefore estimated as below:

$$n = \frac{135}{(1+135\times 0.05\times 0.05)} = 100.93 \approx 101$$

The method of data analysis used in this study was coefficient of variation (CV) and structural equation model (SEM) using the LISREL software V.8.8 (Jöreskog and Sörbom, 1993). For fitting the SEM model of agricultural land conversion effects or impacts (ALCE), at first, using factor analysis 10 observed variables were selected (from among 23 observed variables). These variables altogether could explained more than 75% of the total variance of which explained with all observed variables.

A composite reliability value for each latent variable was calculated to examine the reliability of the latent variables. To do this, the following formula was applied (Diamantopoulos et al., 2000).

$$Pc = {(\sum \lambda)^2}/{[(\sum \lambda)^2 + \sum \theta]}$$

Were:

Pc = Composite reliability

λ = indicator loadings

θ = indicator error variance (ie. variances of the δ or ε)

Σ = summation over the indicators of the latent variables.

Table 1 shows the composite reliability of all three latent variables included in the structural ALC model. According to this table the observed variables have been able to measure the latent variables properly. Statistical analysis was carried out using the SPSS and LISREL software.

Latent variables	Composite reliability
Economical Effects (EcoE.)	**0.36**
Social Effects (SociE.)	**0.68**
Environmental Effects (EnviE.)	**0.87**

Table 1. Composite reliability of latent variables

3. Results

3.1. The main impacts of ALC

Table 2 shows the interviewees' views about the main economical, social and environmental impacts of ALC. It represents economical, social and environmental impacts respectively (with 0.31, 0.35 and 0.37 of coefficients of variation) were the most important drivers of ALC.

Effects (Impacts)	Symbol	Mean	SD	CV
Increasing the land price as a result of ALC	EcoE4	4.37	0.78	0.18
Reducing crop yields	EcoE2	3.57	1.14	0.32
Reducing the income of rural households	EcoE1	3.31	1.06	0.32

Reducing the number of income sources of rural households and thereby increase the risk of incomes	EcoE6	3.18	1.06	0.33
Undermining the natural and rural tourism	EcoE5	3.45	1.15	0.33
Increase in rural unemployment	EcoE3	3.14	1.21	0.38
Total Economical Effects	EcoE	3.05	1.07	0.31
Motivate the other farmers to ALC	SociE6	3.83	1.07	0.28
The loss of rural lifestyle and traditions	SociE4	3.5	0.93	0.29
Reducing of food security	SociE7	3.75	0.95	0.29
change the demographic of rural communities (gender composition, age pyramid, population density)	SociE2	3.14	1.18	0.31
Increase uninhabited villages	SociE8	3.16	1.03	0.34
Increase migration from rural to urban	SociE9	2.98	1.19	0.36
Increase rural poverty	SociE1	2.98	1.18	0.40
Reduce physical and mental health of rural households	SociE3	2.89	1.19	0.41
Increase rural and urban crime and violence	SociE5	2.77	1.27	0.46
Total Social Effects	SociE	3.22	1.11	0.35
Increasing the energy consumption per unit area	EnviE6	3.45	1.03	0.30
Reduce the quantity and quality of water and soil resources	EnviE5	3.51	1.09	0.31
Destroy the natural and rural landscapes	EnviE8	3.70	1.32	0.36
Reduce the air quality	EnviE4	3.4	1.23	0.36
Increase the area temperature	EnviE3	3.05	1.19	0.39
Loss of biodiversity	EnviE1	3.21	1.27	0.40
Increase emission of greenhouse gases	EnviE2	3.12	1.28	0.41
Increase frequency and severity of environmental disasters (floods, storms, frost, etc.)	EnviE7	3.01	1.39	0.46
Total Environmental Effects	EnviE	3.31	1.23	0.37

Table 2. The main Impacts of ALC and their importance according to interviewees' view.

Based on Table 2, three main economical impacts of ALC respectively were "Increasing the land price as a result of ALC", "Reducing crop yields" and "Reducing the income of rural households". Among the social impacts of ALC, three main impacts were "Motivate the other farmers to ALC", "The loss of rural lifestyle and traditions" and "Reducing of food security". Finally, as mentioned by interviewees "Increasing the energy consumption per unit area", "Reduce the quantity and quality of water and soil resources" and "Destroy the natural and rural landscapes" are three main important environmental impacts of ALC (see Table 2).

3.2. Structural model of ALC Effects (ALCE)

As mentioned in section 2.2 for modeling the effects/impacts of ALC, at first using factor analysis 10 main impacts (observed variables) were selected. These variables are shown in Table 3 and Fig. 1. Table 3 indicates the parameters which estimates for measurement model. As has been indicated, all relationships are significant. This means observed variables have been able to measure latent variables correctly. In addition, according to λ values, among the Economical,

social and environmental observed variables, respectively, EcoE6, SociC11 and EnviC4 could explained the most amount of the variance of EcoE., SociE. and EnviE. Factors. Then these observed variables are the most effctive. Finally, as indicates in Table 4 (according to Pc column), the Latent Variables in sum could explained 66% of the variance of ALCE.

Latent Variables	Observed Variables	λ	SE	t-values*	R^2	Pc
EcoE.	EcoE1	0.39	0.15	2.61	0.15	0.36
	EcoE2	0.30	0.14	2.14	0.10	
	EcoE3	0.60	0.24	2.50	0.36	
	EcoE6	0.77	0.30	2.59	0.59	
SociE.	SociE3	0.63	0.11	5.96	0.40	0.68
	SociE4	0.79	0.08	10.00	0.62	
	SociE5	0.53	0.11	4.94	0.28	
	SociE8	0.84	0.11	7.83	0.71	
EnviE.	EnviE3	0.83	0.13	6.38	0.70	0.87
	EnviE4	0.96	0.19	5.19	0.91	

* if t-values>1.96 the relationship is significant

Table 3. Total Effects of ETA on Y (λ), standard errors (SE), t-values, R2 and Pc values for measurement part of the model.

Since the goodness of Fit Statistics of the measurement model are appropriate, the assessment of structural part of the model can be done. Table 4 indicates the parameters which estimates for structural part of the model. As shown, all hypothesized relationships in Fig. 1 are significant. According to Υ column ScoiE, EcoE and EnviE respectively could explained more variance of ALCEs and are the most effective of main factor or latent variables of ALCEs. These three main groups of ALC impacts together have explained 66% of total variance of ALCEs.

Latent Variable X	Latent Variable Y	Υ	SE	t-values*	R^2	Pc
ALCEs	EcoE.	0.87	0.35	2.48	0.75	0.66
	SociE.	0.96	0.17	5.62	0.93	
	EnviE.	0.42	0.13	3.14	0.18	

* if t-values>1.96 the relationship is significant

Table 4. Total Effects of KSI on ETA (Υ), standard errors (SE), t-values and Pc value for structural part of the model.

Finally, table 5 shows the goodness of fit statistics for structural equation model of ALCEs. This statistics indicates that the ALCEs model, statistically has a good fitness. Then the final structural equation model of ALCEs that is shown in Fig. 1 is acceptable.

fit statistics	The acceptable range*	The calculated values
Root Mean Square Error of Approximation (RMSEA)	RMSEA < 0.1	0.026
Root Mean Square Residual (RMR)	RMR near to zero	0.077
Goodness of Fit Index (GFI)	GFI > 0.9	0.94
Adjusted Goodness of Fit Index (AGFI)	AGFI > 0.9	0.90
Normed Fit Index (Greenfield et al.)	NFI > 0.9	0.93
Comparative Fit Index (CFI)	CFI > 0.9	0.99

* Source (Kelloway, 1998)

Table 5. The goodness of fit statistics for structural equation model of ALCE.

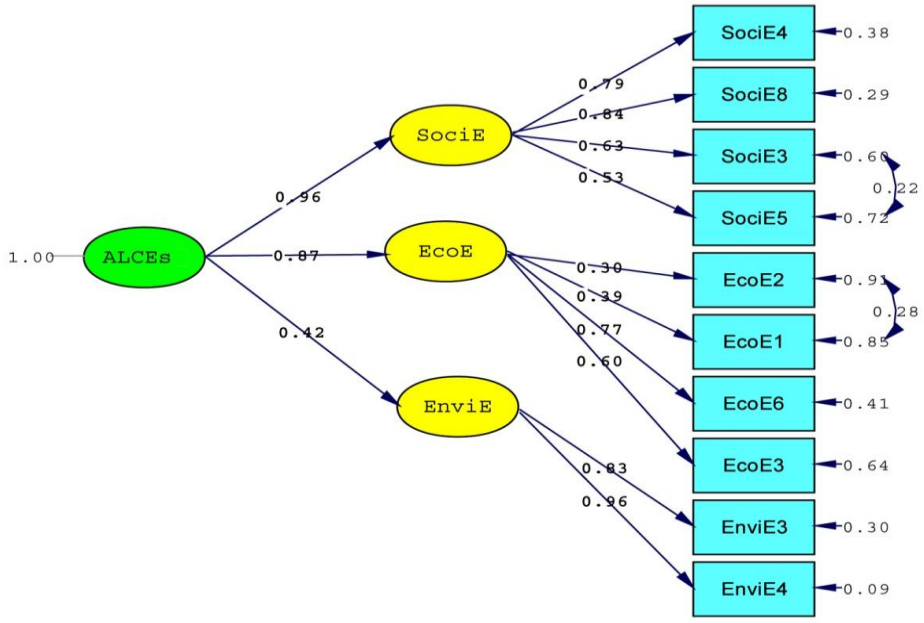

Fig. 1. The final structural equation model of ALCE

4. Discussion and Conclusion

4.1. Discussion

In this study same as some other studies (Mahoney et al., 2003, Mudgal et al., 2008) the impacts of land use change have been divided to three main groups, economical, social and environmental. It indicates that based on the executive officers and policy makers views economical, social and environmental impacts have been respectively the most important impacts of ALC. Furthermore, the agreement of respondents for social impacts are more than the other main impacts and this agreement for environmental impacts are the least. Therefore, since the economic impacts of ALC are the most effective than the other impacts (see SEM model of ALCE), agricultural and rural policy makers in confront to the impacts of ALC should be further considered to these impacts.

Although, according to interviewees' views the most important economic effects of ALC has been accelerate the raising of the land price, but based on SEM model of ALCEs (and covariance matrix of observed variables) increase the risk of rural households income is the most effective economic impacts of ALC. For social impact, the most important impact has been motivated the other farmers to ALC and the most effective impact has been increased the uninhabited villages. Finally, among the environmental impacts of ALC increasing the energy consumption per unit area and reduce the air quality orderly has been the most important and the most effective impacts. As a result, if the planners and policy makers want to reduce the impacts of ALC, their attention have focused on the following variables or impacts,

a. increase the risk of rural households income,
b. increased the uninhabited villages, and
c. reduce the air quality

Undoubtedly, due to the covariance among the observed variables, pay appropriate attentions to these variables will facilitate dealing with the ALC impacts.

4.2. Conclusion

This paper aimed to analyzing and modeling the impacts of ALC in Iran in the view of the executive officers and policy makers. It shown, the most important economic, social and environmental impacts of ALC respectively have been "accelerate the raising of the land price", "motivated the other farmers to ALC" and "increasing the energy consumption per unit area". But, based on SEM model of ALCEs the most effective impacts have been "increase the risk of rural households income", "motivated the other farmers to ALC" and "reduce the air quality". Therefore, it is recommended that the planners and policy makers pay more attention to these impacts. Because, these impacts, compared with the others, have a more cross-correlation with other impacts.

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