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RESEARCH FELLOWSHIPS

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Final report

Monitoring agricultural land conversion induced by urban sprawl and transportation in Northeast Iran (Monalisa-T)

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CHAPTER 1
PROGRESS

Development of ideas

During the sojourn, I cultivated many ideas how to step forward Monalisa-T, not only during the time period of the sojourn but also after phasing out of the study. Thanks to the broad network of Prof. Dr. Frank Witlox[1], I could enlarge my network not only in developed countries (including Netherlands and USA) but also in many developing countries (including Ethiopia and Mexico). This has resulted in submitting a few joint project proposals with Prof. Witlox in Ethiopia and Uganda in which a couple of recent hot issues are raised. In Ethiopia, "transnational land deal" is questioned for further investigation whether it could be considered as an "agricultural outsourcing" or "land grabbing". In Uganda, "ecosystem services loss" is proposed to be monitored whether it could be induced by oil and gas acquisition. Both the issues are appreciated novel and understood as time being challenges in these countries that can result in agricultural land conversion (ALC). Furthermore, the issue of land grabbing is now being studied by an Ethiopian PhD candidate who has joined SEG under the common supervision of Prof. Witlox, Prof. Jan Nyssen, and myself. All these new developments together with several joint publications are well appreciated by SEG by expanding the third research cluster, which was previously named "land use" but is recently called "land use, agro-environment and geography of enterprise". Thanks to these new developments, and with strong support and encouragement of Prof. Witlox, I am now doing my second PhD as a significant output of Monalisa-T. Such new developments clearly show mutual win-win benefits of SEG and ESRI[2] that meets the main goal of the non-EU postdoc fellowship.

[1] Head of Socio-Economic Geography (SEG), Department of Geography, UGent
[2] Environmental Sciences Research Institute (my host institute)

Publications[3]

As mentioned above, I could successfully manage publishing and submitting a couple of journal-articles during my stay. I am also busy with drafting a couple of more articles as the longer term results of the sojourn.

[3] The full list of these articles is provided in the annex.

CHAPTER 2
QUALITATIVE STUDY

Summary

This chapter reports the results of the first phase of this study which examined the trend and the main drivers of agricultural land conversion (ALC) in Northeast Iran. Using a multi-stakeholder analysis approach, data were obtained from agricultural land use policy makers in the Khorasan-e-Razavi province. The results showed that the ALC in this province is on the rise. The policy makers identified different drivers for ALC and found it a very complex process. They categorized the main ALC driving forces to "economic", "political", "institutional", "technical", "infrastructural", "social", and "environmental" factors. The results also showed that, in the view of the policy makers, the "political and economic reforms" should be the first and the most important priorities to respond to ALC followed by establishing proper "legislation and law" processes and "institutional arrangements" while "technical" and "environmental" aspects remain as their last priority.

Introduction

As human civilization evolved, people began planting crops, rearing animals, developing complex irrigation schemes, building cities, and devising technologies to make life more comfortable and less vulnerable. This transformed landscapes over 40 percent of the Earth's ice-free land surface (Foley et al., 2005). Among the various factors that change Earth's surface, agriculture plays a key role (Billington, Kapos, Edwards, Blyth, & Iremonger, 1996). Land management practices and cropping patterns have a vast effect on biogeochemical cycles, freshwater availability and soil quality. Land also plays an important role in emitting and storing greenhouse gases (Roson & Palatnik, 2009; The World Bank, 2010). Cropland areas are also being converted from small holdings to increasingly large areas. This is affecting the stability of landscape patterns (Lambin, Geist, & Rindfuss, 2006).

According to IFAD (2012), about 2 billion people live in and work on small farms in developing countries. This large group of farmers, who produce about 70 percent of the

developing world's food, struggle to make a living from small-scale intensive farms (Murshed-E-Jahan and Pemsl, 2011, Koczberski and Curry, 2005). Many of these farmers are also facing the prospect of land dispossession (Palmer et al., 2009). Such uncontrolled land instability shows why we are currently at a "tipping point" for the future of family farming and rural societies (Anseeuw et al., 2012).

Uncontrolled agricultural land conversion (ALC) has great impacts on environment in general and agricultural products in particular. ALC is a phenomenon that is almost unavoidable during economic development and population growth periods (Tan, Beckmann, van den Berg, & Qu, 2009). The phenomenon of ALC in different countries is varied in terms of intensity, trend, and drivers. Among others, high population density, rapid economic growth and the urbanization process are known as the main drivers of ALC (Ho & Lin, 2004). ALC is the result of many interacting processes and drivers which operate over a range of scales (both temporal and spatial) and have an impact on the human environment (Munroe & Müller, 2007; Schneeberger, Bürgi, & Kienast, 2007).

Climate change is also one of the most complex challenges of our young century and no country is immune (The World Bank, 2010). Although this global environmental change has many interacting components, but land use/land cover change or land conversion probably representing the single most important factor affecting ecological systems (Mondal & Southworth, 2010; Turner II, 2002, 2009; Vitousek, 1994). Among the various types of land conversions, ALC is the most important ones. This is not only because it currently has been the biggest transformative power of 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, there have even been a decrease (Ramankutty et al., 2006). For example, according to the 2012 edition of the FAO Statistical Yearbook, Iran has one of the highest rates of ALC (- 2.1% Arable land per person during 1970-2009) (FAO, 2012). While, agriculture is one of the most important sectors of Iran's economy, the sector currently constitutes 10% of the country's GDP and 18.2% of total employment. Agricultural products form about 30% of Iran's non-oil exports (based on reports of The Statistical Center of Iran). As FAO has reported, Iran ranks amongst the top seven countries in producing 22 important agricultural products. 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 the ALC. Apparently, so far not only all the government policies and plans have failed to control the ALC, but also some of them have exacerbated it.

This study aims to examine the trend and the main drivers of ALC in Northeast Iran. First the methodology of the study is described followed by the drivers of land use change. Afterward, the rapid changes of agricultural land conversion in Iran are explained. Later, the main drivers of ALC in the study site are presented and the respond to land conversion is discussed. Accordingly, an effort is made for understanding the combination of driving forces behind land conversion. At last, a conclusion is drawn on the main findings of this study.

Methodology

The study benefitted from a mixed-method approach that included both qualitative and quantitative measurements. Data were collected using a multi-stakeholder approach (Azadi, Ho, & Hasfiati, 2011). The main stakeholders were: farmers, executive officers and policy makers.

During the first stage, policy makers were interviewed using the Delphi technique (Linstone and Turoff, 1975). The technique was carried out in three stages. In the first stage, an open questionnaire included six open questions was designed. Then, during a focus-group interview (Krueger and Casey, 2000), the opinions of agricultural land use policy makers toward the five research questions were asked. These questions were focused on the following issues:

1. The trend of agricultural land use change (increasing, decreasing or stable), its future, and the most important causes of this trend.
2. The characteristics of farmers who are more willing to change their agricultural land.
3. Farmers (large, medium and small) who are most vulnerable to ALC.
4. The most important public policies to support vulnerable farmers (to encourage them to keep agricultural land).

5. The alternative strategies which farmers can take to deal with or to face ALC.
6. Most proposed ways to preserve agricultural lands.

In the second stage, the main keywords and variables of these interviews were extracted. Then, these keywords and variables were included in the second round of the Delphi questionnaire which used a five-point Likert continuum (from 1 to 5 that correspond "fully disagree", "partially disagree", "no opinion", "partially agree", and "fully agree"). The answers were coded and entered into SPSS (version 20). Finally, using descriptive statistical methods, the main ALC driving forces were recognized and the answers of the questions were acknowledged.

Drivers of land use change

There are many processes which are driven by biophysical and socioeconomic drivers that shape landscape patterns and determine their spatial organization (Van Doorn & Bakker, 2007). Some researchers such as Setiawan and Purwanto (in Firman, 1997) classified these drivers in two main groups; namely, internal and external. The main external drivers include industrialization (Ho & Lin, 2004; Lichtenberg & Ding, 2008), urbanization (Han & He, 1999; Ho & Lin, 2004), road infrastructure development (Ho & Lin, 2004; Lichtenberg & Ding, 2008; Nelson, 1990), and government policy. Internal drivers mainly include land productivity (Levia & Page, 2000) and technology intensity.

Hersperger (2007) divides these driving forces into five groups, cultural, natural/spatial, political, economic, and technological. The cultural driving forces set the societal framework while the natural/spatial configurations drive the physical background for other driving forces. Individual actors of landscape change can rarely modify these two groups of driving forces. Political and economic driving forces are strongly interlinked since economic needs and pressures are reflected in political programs and economic instruments are used to implement political driving forces. Lastly, technological driving forces are discussed in the context of political and economic change of agricultural lands. Such a complex nature of ALC has made its driving forces, their relationships, and processes extremely important for different stakeholders including scientists, agricultural land managers and policy makers to create appropriate strategies which can preserve agricultural

lands from being converted to other uses. Many countries have tried to preserve agricultural land from being converted to other uses (Lichtenberg & Ding, 2008) while others have been acting passively or launched inappropriate plans to control ALC.

This study explored these drivers based on a stakeholder assessment for the case of Northeast Iran.

Agricultural land in Iran: rapid change

The study area is located in Northeast Iran and called the Khorasan-e-Razavi province (Fig.1). According to Iran's Statistical Center, this area covers 11.6 million hectares (116,000 km^2) and includes 5,994,402 people, which is about 7 percent of the country's population. About 28 percent (1,683,192 people or 281,857 households) of the population lived in rural areas which in 2011, count for 3,335 villages. Compared to 15 years ago (1996), this amount has fallen more than 10 percent. More than 64 percent of the people living in the villages are engaged in agricultural occupations. About 2.32 million hectares of rural areas are under cultivation (for agricultural productions). Based on Iran Agricultural Land Organization (IALO) data, legally or illegally, about 2,435 hectares of agricultural lands of this province have changed to other uses between 1995 and 2010.

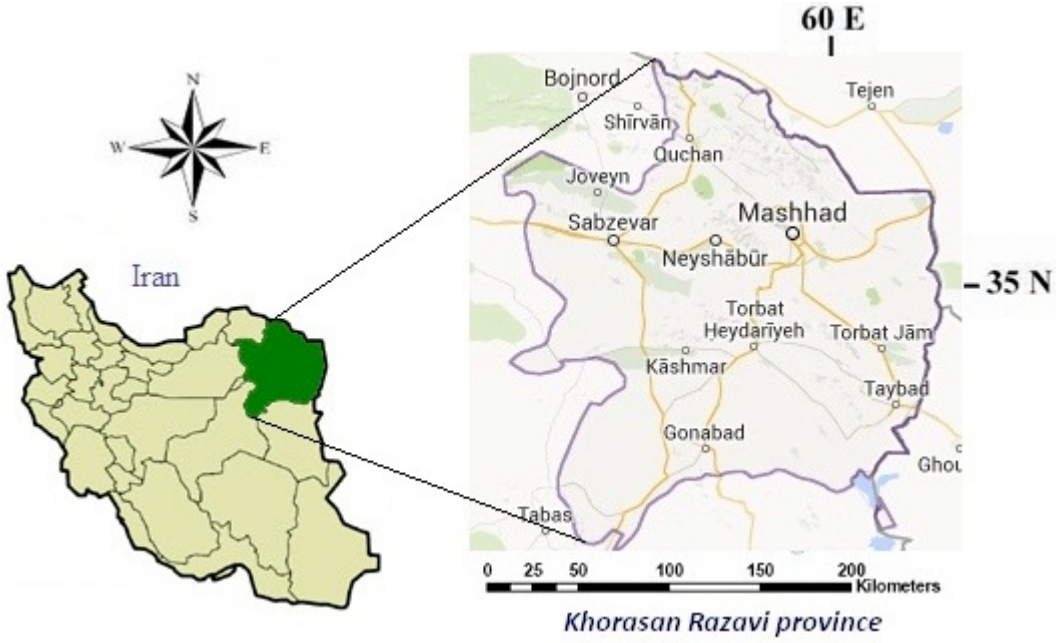

Fig. 1. The location of study area in Iran

Drivers of agricultural land conversion

According to the policy makers interviewed, the trend of ALC during current decades has intensely increased and will be on the rise. They mentioned twelve causes for this trend, among which the most important factor was realized as "low profit and high risk of the agricultural sector" which all the policy makers remarked on. This factor is followed by two other important factors which are "government abandonment of the agricultural sector" and "migration from rural to urban areas".

Table 1. The main driving forces of ALC and their importance according to the policy makers.

ALC drivers	Category	%	Sum	Mean	Std. Deviation
1. Low profit and high risk of the AS	Eco	100	25	5.00	0.00
2. Government abandonment of the AS	PolIns	80	17	4.25	1.50
3. Migration from rural to urban areas	Soc	60	12	4.00	1.00
4. Existing gap between urban and rural development	Soc	60	10	3.33	0.57
5. Unfamiliarity of advocates with land conservation laws	PolIns	40	8	4.00	0.00
6. Developing the settlements, industrial areas and transportation infrastructure within the agricultural high quality lands	TecInf	40	9	4.50	0.70
7. Uncontrolled increasing of land prices	Eco	40	8	4.00	0.00
8. Inconsistent government policies on AS	PolIns	40	7	3.50	0.70
9. Instability of Iran's Agricultural Land Organization, Judiciary, and Police systems to deal with ALC	PolIns	40	6	3.00	0.00
10. Lack of agricultural water	Env	20	5	5.00	0.00
11. The lack of a suitable cropping patterns	TecInf	20	4	4.00	0.00
12. Lack of enough experts and facilities (fuel, vehicle, etc.) for monitoring and auditing of agricultural lands	TecInf	20	3	3.00	0.00

- Eco: Economic
- PolIns: Political and Institutional
- Soc: Social
- TecInf: Technical and Infrastructural
- Env: Environmental
- AS: Agricultural Sector

Although there is not a full consensus on the characteristics of farmers who are more willing to change their agricultural lands among the interviewees, there are three following general agreements: first, the farmers who changed their agricultural lands may belong to

both small and large-scale farmers. However, poor farmers have no choice to change their agricultural lands because they are pushed to do so while rich farmers are never pushed to convert their land and mainly do it to gain more benefits. In other words, given poor farmers have no other income and resources than their small plot of land, they remain vulnerable to the impact of ALC, whereas rich farmers try to control such impacts. Most of the interviewees believe that the smallholders will be more affected by ALC because after converting their agricultural lands, they are often more marginalized in urban areas where they have to live in an urban subculture which is a more passive way of living in a society. In case they still prefer to remain in rural areas, their social status will severely decline because they will have no land any more. Second, more educated (especially those with a college education) and younger farmers are more likely to change agricultural lands since they are more capable to understand the drivers of ALC. Finally, farmers who are members of government bodies (such as the village council or governor of a rural district) are more probable to go for ALC since they have more authority to receive the permission of their ALC.

Responding to land conversion

As shown in Table 2, according to the interviewees the main governmental coping strategy to deal with ALC was "giving real priority to the agricultural sector and developing a long term programme for agricultural development". Due to the standard deviation of this strategy (SD = 0), all the interviewees had an agreement on the strategy. Also, the next most important governmental coping mechanism was realized as "legislation based on the social, political and cultural realities of the society to prevent separation of agricultural lands and the registered land deeds". This mechanism was emphasized by 80% of the interviewees.

Table 2. The main governmental coping strategies to deal with ALC.

ALC governmental coping strategy	Categories	%	Sum	Mean	Std. Deviation
1. Giving real priority to the agricultural sector and developing a long term program for agricultural development	PolEco	100	25	5.00	0.00
2. Legislation based on the social, political and cultural realities of the society to prevent separation of agricultural lands and the registered land deeds	LegLaw	80	13	4.33	0.57
3. Implementing agricultural protection policies (insurance, guaranteed purchase and guaranteed prices)	PolEco	40	9	4.50	0.70
4. Institutional reform of the agricultural ministry and organizations	InsInf	40	7	3.50	0.70
5. Preventing agricultural lands from the settlement of industrial areas and transportation sector	InsInf	40	10	5.00	0.00
6. Preventing from the expansion of villages to towns and townships	PolEco	40	9	4.50	0.70
7. Transferring non-agricultural capitals and investments to suitable (nonagricultural) lands	PolEco	40	8	4.00	0.00
8. Implementing the proper watershed management plans for the conservation and development of water resources	Tec	20	4	4.00	0.00
9. Providing human resources with specialists	Tec	20	4	4.00	0.00
10. Developing a suitable cultivation pattern for the country's agricultural sector	Tec	20	5	5.00	0.00

- PolEco: Political and Economic
- LegLaw: Legal and Lawful
- InsInf: Institutional and Infrastructural
- Tec: Technical

Half the interviewees believed that farmers have no coping strategies to face ALC; however, the other half believed that the main farmers' coping strategies are: "preventing land fragmentation", "using new technologies such as sprinkle and trickle irrigation system" and "rehabilitation and the promotion of participatory approaches in agricultural production" (Table 3). Moreover, "increasing the profitability of the agriculture sector", "educating the laws of agricultural land use to farmers"; "reforming inheritance laws and registration of deeds in order to prevent lands from fragmentation"; and "resolving the problem of instability and overlapping the tasks of the institutes and the organizations which operate in the field of agricultural lands" were other suggestions of the interviewees.

As shown in Table 3, there are other suggestions on which the majority of policy makers were not agreed.

Table 3. The main farmers coping strategies to deal with ALC.

ALC farmers coping strategies	Categories	%	Sum	Mean	Std. Deviation
1. Increasing the profitability of the AS	PolEco	80	20	5.00	0.00
2. Educating the laws of agricultural land use to farmers	Tec	60	13	4.33	0.57
3. Reforming inheritance laws and registration of deeds in order to prevent lands from fragmentation	LegLaw	60	13	4.33	0.57
4. Resolving the problem of instability and overlapping the tasks of the institutes and the organizations which operate in the field of agricultural lands	Ins	60	10	3.33	0.57
5. Appropriate legislation to define ALC as a criminal act	LegLaw	40	9	4.50	0.70
6. Resolving the conflict between basic low and judicial lows of land use and land ownership.	LegLaw	40	8	4.00	0.00
7. Reforming the Agriculture Land Organization	Ins	20	5	5.00	0.00
8. Designing a suitable cultivation pattern	Tec	20	5	5.00	0.00
9. Providing low-interest financial loans for farmers	PolEco	20	4	4.00	0.00
10. Providing adequate facilities for urban people to prevent the destruction of agricultural land with them	Ins	20	3	3.00	0.00

- PolEco: Political and Economic
- Tec: Technical
- AS: Agricultural Sector
- LegLaw: Legal and Lawful
- Ins: Institutional

Understanding the combination of driving forces behind land conversion

According to the results of this study, the ALC is increasing severely in the northeast of Iran. The main driving forces are realized as five groups: a) Economic, b) Political and Institutional, c) Technical and Infrastructural, d) Social, and e) Environmental. All these five groups have effect on ALC and each other. On the other hand, ALC may also have effect on these forces (Fig. 2).

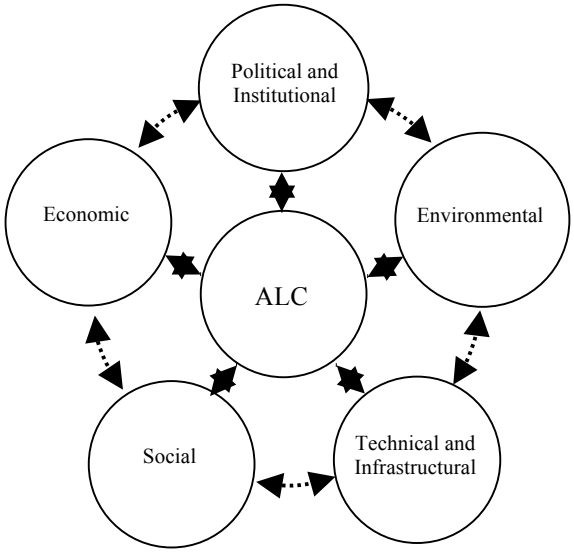

Fig. 2. The schema of ALC and its driving forces.

The main economic driver identified was "low profit and high risk of the agricultural sector". “Migration from rural to urban areas" was the most important social driver noted; and "government abandonment of the agricultural sector" was realized as the most important political and institutional driver. Among the technical and infrastructural factors, "developing the settlements, industrial areas and transportation infrastructure within the agricultural high quality lands" was seen to be more important than the rest. Finally, the only environmental driver emphasised was "lack of agricultural water". Although, all these drivers are important, depending on the temporal and spatial profile of a given society, the weight and effect of each driver can be different (Fig. 3).

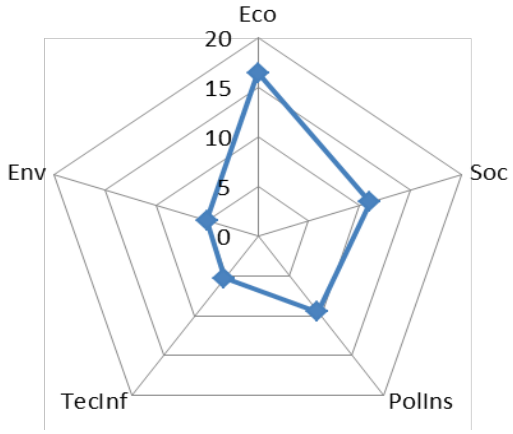

Fig. 3. The importance of the ALC drivers from the view of the policy makers.

Although the characteristics of the farmers who changed their agricultural land use are different, the younger and more educated farmers change their land use easier than the others. In addition, the membership of the farmers in the state agencies can have a positive impact on ALC. Furthermore, the ALC has more negative impacts on small compared to large-scale farmers because changes in land use can increase the vulnerability of poor farmers who lose their lands. By losing their lands, the social status of farmers will decline that often results in migrating to urban fringe areas. This makes the poor, poorer and more marginalized than before (Azadi et al., 2011; 2012).

Fig. 4 compares the main governmental and farmer coping strategies to deal with the land conversion. As the figure explains, in the view of the policy makers, the government and farmers have different responses. Both the government and farmers identify “legal and lawful” processes but also “political and economic” aspects. However, “technical” aspects receive less importance as a governmental coping mechanism (Fig. 4a), compared with “institutional” aspects emphasized as a farmer coping strategy (Fig. 4b).

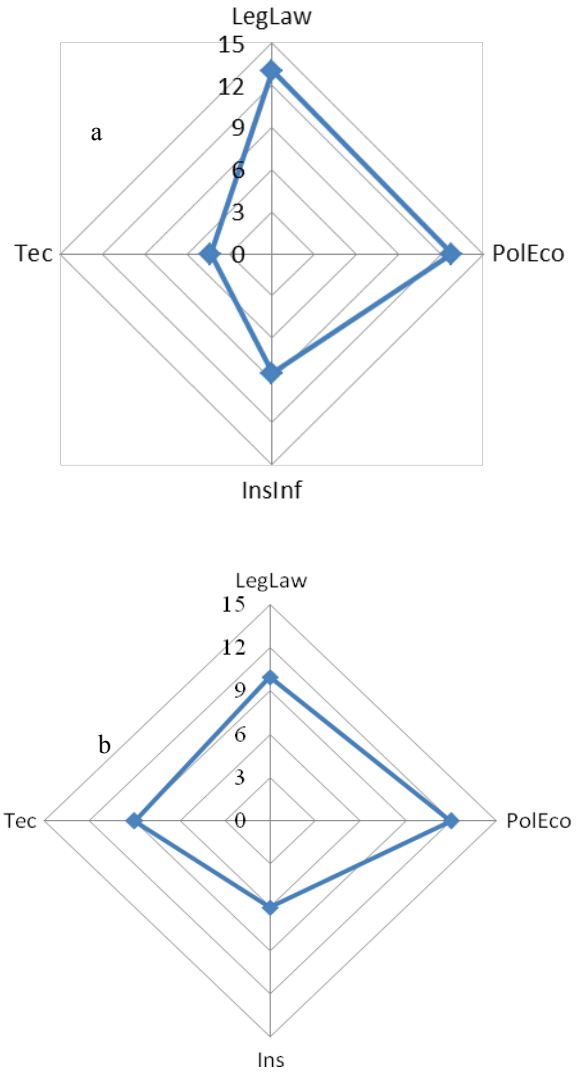

Fig. 4. Comparison of the main governmental (a) and farmes (b) coping strategies to deal with ALC.

According to the policy makers (Table 2), "legislation based on the social, political and cultural realities of the society to prevent separation of agricultural lands and the registered land deeds" should be seen as the first governmental coping strategy, whereas "giving real priority to the agricultural sector and developing a long term programme for agricultural development" was the most important political and economic reforms expected from the government. The most important institutional and infrastructural reform was "preventing agricultural lands from the settlement of industrial areas and transportation sector". Lastly, "developing a suitable cultivation pattern for the country's agricultural sector" was realized as the most important technical reforms.

On the other hand, according to the policy makers (Table 3), the main farmers' coping strategies are "increasing the profitability of the agricultural sector" followed by "legislation and law" processes, among which, "educating the laws of agricultural land use to farmers" receives the most attention from the policy makers. In their view, the only technical suggestion was "designing a suitable cultivation pattern". Finally, "resolving the problem of instability and overlapping the tasks of the institutes and the organizations which operate in the field of agricultural lands" remains as the most important farmers' institutional coping strategy to deal with ALC.

Conclusion

According to this study, agricultural land use conversion in the northeast of Iran is on the rise. The causes and drivers of agricultural land conversion are many and this phenomenon is indeed very complex. However, the economic, political and structural drivers are more important in the view of policy makers. Furthermore, although all the drivers are important, depending on the temporal and spatial profile of a given society, the weight and effect of each driver should be assessed carefully. Moreover, the ALC driving forces affect each other and have mutual interaction which should be studied systematically.

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CHAPTER 3
QUANTITATIVE STUDY

Summary

Identifying driving forces behind agricultural land conversion remains as one of the most difficult challenges that agricultural and environmental scientists must continually deal with. The difficulty emerges from the fact that in ALC, multiple actions and interactions between different factors (i.e., economic, political, environmental, biophysical, institutional, and cultural) exist and make it difficult to understand the function of the processes behind the changes. The phenomenon of ALC in different countries is varied in terms of intensity, trends and drivers. The main goal of this study was to understand these drivers in Northeast Iran through applying structural equation model (SEM). Using multi-stage stratified random sampling, 101 executive officers participated in the study. Data were collected through a structured questionnaire. A multi-stakeholder analysis and a mixed-method (qualitative & quantitative) approach were applied. Results revealed that not only from the policy makers' perspective but also based on the SEM, "economic", "political", "technological", "social" and "environmental" factors should respectively be the five major drivers of ALC. The results also showed that among other drivers, "more profitability of non-agriculture sectors", "excessive rising of land prices", "farmers' income instability", "land fragmentation", "urban sprawl" and "inheritance laws" are the main six causes of ALC. Hence, it can be concluded that policy-makers and planners need to take these drivers and subsidiaries more into consideration in order to properly respond to ALC.

Introduction

Agricultural land conversion

Land conversion (LC) is widely defined as a process characterized by converting the land from one type of use to another. In most reported cases, the conversion happens from agricultural to urban uses (Azadi et al., 2011). This is a worldwide phenomenon (Firman, 1997) that is seen inevitable during periods of economic development and population growth (Tan et al., 2009). LC often goes hand in hand with land use policies that may result

in problems such as evictions, loss of farmlands, and food insecurity. Among various types of LC, agricultural land conversion (ALC) is known as the most important one (Loehr, 2012). In many countries, especially in those where agriculture is the major source of income, ALC is realized as the most important type of LC. ALC plays a key role in changing the earth's surface (Billington et al., 1996). Agricultural management practices and cropping patterns have a vast effect on the biogeochemical cycles, freshwater availability and soil quality. Agriculture also plays an important role in emitting and storing greenhouse gases (Roson & Palatnik, 2009; World Bank, 2010). Accordingly, agricultural land is fundamental to the lives of poor people in rural areas since it is the main source of food, shelter, income, and social equity for them (ILC, 2012). Hence, a realistic description and prediction of ALC is essential for land use policy makers.

ALC is the result of many interacting processes and drivers which operate over a range of scales (both spatial and temporal) and impact human and his environment (Munroe & Müller, 2007; Schneeberger et al., 2007). Uncontrolled ALC has great impacts on environment in general and agricultural products in particular. Therefore, many countries have tried to preserve their agricultural lands from being converted to other uses (Lichtenberg & Ding, 2008). Uncontrolled ALC shows why we are recently at a “tipping point”, or a crisis, for the future of family farming and rural societies (Anseeuw et al., 2012).

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 stabilization in cropland areas, 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’s arable land per person has decreased 2.1% (FAO, 2012; 2013). According to Iran‘s Statistical Center, agriculture is one of the most important sectors of the country’s economy that currently constitutes 10% of the Iranian GDP and 18.2% of the total employment and agricultural products form about 30% of the country’s non-oil exports (Azadi & Barati, 2013). In Iran, agricultural lands have more rapidly changed over the past 50 years than any time before and are expected to accelerate in the future (Bahrami et al., 2010). Iran’s Agricultural Land

Organization has reported that between 1995 and 2010, more than 74,755 ha of agricultural lands have changed to non-agriculture uses although other sources have reported these changes up to 200,000 ha. According to some studies (Azadi & Barati, 2013, Asadi et al., 2014), during the current decade, the trend of ALC in Iran has intensely increased and will be on the rise. All this shows that ALC is now becoming as one of the most important challenges and threats for agriculture and food security in the country. Nevertheless, so far, not only have all the government policies and plans failed to control ALC, but also some of them have exacerbated it (Azadi and Barati, 2013). Therefore, understanding and analyzing the drivers of ALC and its relationships are extremely important for Iranian agricultural policy makers to design the conservation strategies aiming to approach food security and sustainable agriculture.

Agricultural Land Conversion Drivers

There are many processes driven by biophysical and socioeconomic drivers that shape landscape patterns and determine their spatial organization (Van Doorn & Bakker, 2007). Hersperger and Burgi (2007) divide these driving forces into five groups: cultural, natural/spatial, political, economic and technological. The cultural driving forces set the societal framework while the natural/spatial configurations drive the physical background for other driving forces. Individual actors of landscape change can rarely modify these two groups of driving forces. Political and economic driving forces are strongly interlinked since economic needs and pressures are reflected in political programs and economic instruments are used to implement political driving forces. Lastly, technological driving forces are discussed in the context of political and economic changes of agricultural lands. Such a complex nature of ALC has made its driving forces, their relationships and processes extremely important for different stakeholders including scientists, agricultural land managers and policy makers to create appropriate strategies that can preserve agricultural lands from being converted to other uses.

Many countries have tried to preserve agricultural lands from being converted to other uses (Lichtenberg & Ding, 2008) while others have been acting passively or launched inappropriate plans to control ALC. Logical structural model connecting to the drivers or

causes of ALC has been developed based on available empirical studies and several major theories and models about ALC. According to the conceptual model shown in Fig. 1, the main drivers of ALC could be classified into the five following groups similar to Hersperger and Burgi's (2007) classification; i.e., economic (EcoC), social (SociC), political and planning (PoliC), environmental (EnviC) and technical (TechC). This model is a conceptual model which includes five latent variables and twenty observed variables. Many studies simplify reality and only focus on a small number of ALC drivers (Lambin et al., 2001). Many descriptive approaches and case studies also focus on a few drivers (e.g. Baumgartner, 2003; Antrop, 2005). Given that, since we are interested in understanding the causes of complex ALC, a comprehensive approach is chosen and probable drivers from the five types are included.

The economic factors are derived from consumer demands, market structure and structural changes, as well as governmental subsidies and incentives. According to the previous studies (Farrington et al., 2008, Helming et al., 2008, Litman, 2011, Petit et al., 2008, Petit and Frederiksen, 2011, Asadi. et al., 2014, Azadi and Barati, 2013, Azadi, et al., 2011),the main economic drivers of ALC include rising of land prices (EcoC2), rising prices of agricultural inputs (EcoC7), difficulties to obtain bank facilities (EcoC8) and financial support Poor or lack of appropriate insurance in agriculture (EcoC9) whereas the main social drivers consist of giving more attention to urban and industrial development than agriculture and rural development (SociC1), changing the life style of the new generation (SociC2), increasing the contacts of farmers with urban population (SociC7), increasing the contacts of farmers with urban population (SociC8), utilization of agricultural lands Utilization of agricultural lands (SociC10) and Low social status of farmers than other people (SociC11). The socioeconomic driving forces are primarily rooted in the economy. Today, the market economy, globalization, and the effects of WTO (World Trade Organization) agreements are especially strong drivers. Since socioeconomic requirements are expressed in political programs, laws and policies, the socioeconomic and political driving forces are strongly interlinked.

Furthermore, drivers such as urban sprawl (PoliC1), inheritance laws and its impact on land fragmentation (PoliC3), lack of a systematic approach in planning and policy making

(PoliC9), conflict of land conservation laws with other laws (PoliC10) and weakness of administrations and institutions about the ALC (PoliC11) can be considered as the main political drivers of ALC (Azadi and Barati, 2013, Azadi, et al., 2011). On the other hand, technology has shaped the landscape enormously (Grübler, 1994). When using improved and modern technologies in agriculture, demand for labor will decrease. The technologies will create labor surplus in the agricultural sector. Such laborers will look for jobs in urban areas and therefore more lands will be required for more services in response to the growing economy and population. Therefore, the more cities expand to fringe areas, the more the possibility of ALC can be expected (Azadi et. al., 2011). The environmental configurations drive the physical background for other driving forces. The environmental drivers include characteristics and processes of the natural environment such as weather and climate changes (EnviC4) and increasing plant and animal pests and diseases (EnviC5) (Verburg et al., 2004). All these five variables have considerable effects on ALC and each other as well. On the other hand, ALC may also have an effect on these variables (Azadi and Barati, 2013).

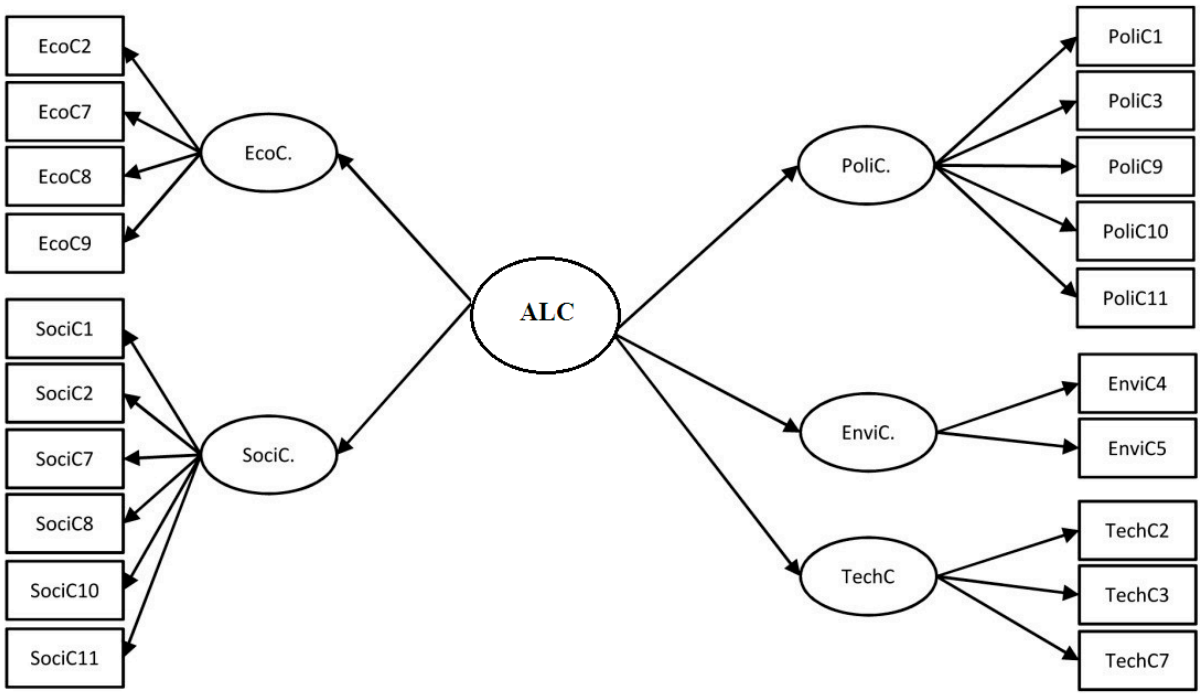

Fig. 1. Conceptual model for ALC drivers

Structural equation model

Identifying and evaluating the driving forces behind ALC remains one of the most difficult exercises that agricultural and environmental scientists must continually address. The difficulty emerges from the fact that in ALC, multiple actions and interactions between different factors (e.g., economic, political, environmental, biophysical, institutional, and cultural) come into play and make it difficult to understand how the processes behind ALC work. Since analyzing ALC generally requires an integrated approach that considers multiple disciplines, data sources and methodological constructs, using advanced methods is necessary to help us explore these factors and processes (Basse et al., 2014). In this regard, different advanced methods, such as Structural Equation Model (SEM), have been applied to date in order to investigate ALC (Paré et al., 2008; Veldkamp and Lambin, 2001; Verburg et al., 2008; Wyman and Stein, 2010).

SEM is an estimating method that can handle a large number of exogenous and endogenous factors as well as non-observed (latent) variables that are specified as linear combinations of observed (measurement) factors (Salarzadeh and Azina, 2014). SEM also called simultaneous equation model that is a multivariate (multi-equation) regression model. Unlike the traditional multivariate linear model, the response variable in one regression equation in an SEM may appear as a predictor in another equation. In other words, variables in an SEM may influence one-another reciprocally, either directly or through other variables as intermediaries. These structural equations are meant to represent causal relationships among variables in the model (Fox, 2002).

Objectives

The main objective of this study is to examine the main drivers of ALC in Northeast Iran using SEM. To achieve this aim, first, the methodology of the study 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.

Methodology

Study Area

The study area is located in the Khorasan-e-Razavi province in Northeast Iran. The province covers about 11.6 million hectares (see page 9). According to Iran's Statistical Center, this area, with a population of 5,994,402 people, allocates 7.98 percent of Iran's total area. In 2011, about 28 percent (1,683,192 people or 281,857 households) of people lived in rural areas. Compared to 15 years ago (1996), this amount has fallen more than 10 percent. The number of inhabited villages is 3,335 according to the last census report in 2011. More than two-third (64%) of people living in these villages are engaged in agricultural occupations. About 2.32 million hectares of rural areas are allocated to agriculture. Based on the Iran's Agricultural Land Organization data, between 1995 and 2010 about 2,435 hectares of agricultural lands have legally or illegally changed in this area.

Data collection and sampling method

The present study was based on a field survey using a structured questionnaire to collect the executive officers' views about the main drivers of ALC. A panel of experts approved the content validity and Cronbach's alpha coefficient was used to test the reliability of the questionnaire. The first step to prepare the questionnaire was to conduct a literature review followed by a qualitative interview on the main drivers of ALC. At last, the main drivers of ALC (totally 47 indicators) were identified. Next, these identified drivers were classified into five main groups (economic, social, political, environmental, and technical). Afterwards, these drivers were translated into a questionnaire. Then, the questionnaire was pre-tested. Finally, the final questionnaire was sent to the executive officers (EOs) who were totally 135 persons among whom 101 officers were randomly selected. EOs are professional managers who specialize in resource and system. In other words, an EO is generally a person responsible for running an organization although the exact nature of the role varies depending on the organization performance. The officers were asked to express their opinions with regard to each driver using the Likert continuum (1: "no effect on ALC", 2: "little effect on ALC", 3: "somewhat effect on ALC", 4 "large effect on ALC", and 5 "great effect on ALC"). According to Equation 1, the sample size was calculated based on Solvin's formula (Azadi, et al., 2011; Rivera, 2007), as follow:

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

Where n is sample size, N is population and e is the percentage of the imprecision of sampling that can be tolerated (no more than 5%). The sample was therefore estimated using Equation 2 as below:

$$n = \frac{135}{(1+135\times0.05\times0.05)} = 100.93 \approx 101 \quad N = 135/\ (1+135\times0.05\times0.05) = 100.93 \simeq 100$$

(Equation 2)

The data analysis method used in this study was coefficient of variation (CV) and structural equation model (SEM) using the LISREL software V.8.8 (Jöreskog & Sörbom, 1993). For fitting the SEM model of agricultural land conversion drivers (ALCD), at first, through factor analysis, 20 observed variables were selected (out of 49 observed variables). These variables altogether could explain more than 75% of the total variance of which explained by all the observed variables. The composite reliability value for each latent variable was calculated to examine the reliability of the latent variables. To do so, the Equation 3 was applied (Diamantopoulos, Siguaw, & Siguaw, 2000).

$$Pc = {(\sum\lambda)^2}\Big/{[(\sum\lambda)^2 + \sum\theta]} \qquad \text{(Equation 3)}$$

Where Pc is Composite reliability, λ is Indicator loadings, θ is Indicator error variance (i.e., variances of the δ or ε) and Σ is Summation over the indicators of the latent variables.

Table 1 shows the composite reliability of all five latent variables included in the structural ALC model. The statistical analysis was carried out using SPSS and LISREL software. According to this table, the observed variables have been able to measure the latent variables properly. Since composite reliability of the latent variables is more than 0.7, according to George and Mallery's (2003) rules, all they are probably a reasonable goal, among which the most important variable is respectively realized as economic variable

(0.801), Social variable (0.784), Technological variable (0.739), Environmental variable (0.714) and Political variable (0.700).

Table 1. Composite reliability of the latent variables.

Latent variables	Composite reliability
Economic	0.801
Social	0.784
Political and Planning	0.700
Environmental	0.714
Technological	0.739

Results

ALC drivers

According to the interviewees' opinions (Table 2), economic, political, technological, social and environmental drivers are (with 0.397, 0.399, 0.421, 0.437 and 0.459 of coefficients of variation) realized as the most important drivers of ALC, respectively.

Table 2. The main drivers of ALC and their importance according to the officers' views.

Drivers	Mean	SD	CV
Economic	3.492	1.354	0.397
Political	3.911	1.559	0.399
Technological	3.656	1.521	0.421
Social	3.222	1.395	0.437
Environmental	3.304	1.503	0.459

As Table 3 shows, three main economic drivers were respectively "more profitability of non-agriculture sectors than agriculture sector", "excessive raising of land prices during recent years" and "farmers' income instability". It also seems that some economic drivers such as lack of appropriate insurance or bank facilities and financial supports have less important roles in ALC.

Table 3. The main economic drivers of ALC and their importance according to the officers' views.

Causes	Label	Mean	SD	CV
More profitability of non-agriculture sectors than agriculture sector	EcoC1	4.260	1.190	0.279
Excessive rising of land prices	EcoC5	4.167	1.228	0.295
Farmers' income instability	EcoC6	3.542	1.075	0.304
Low prices of agricultural products	EcoC3	3.417	1.270	0.372
Fluctuation of prices of agricultural products	EcoC4	3.385	1.461	0.432
Weakness of network markets and marketing of agricultural products	EcoC9	3.354	1.487	0.443
Rising prices of agricultural inputs (fuel, fertilizer, pesticides, etc.)	EcoC2	3.219	1.445	0.449
Difficulties to obtain bank facilities and financial support	EcoC7	3.167	1.519	0.480
Poor or lack of appropriate insurance in agriculture	EcoC8	2.917	1.513	0.519
Total	EcoC	3.492	1.354	0.397

- EcoC1: Economic cause 1, EcoC2: Economic cause 2, EcoC3: Economic cause 3, EcoC4: Economic cause 4, EcoC5: Economic cause 5, EcoC6: Economic cause 6, EcoC7: Economic cause 7 EcoC8: Economic cause 8,

Among the social drives (Table 4), three drivers including “more attention to urban and industrial development rather than agricultural and rural development”, “changes in the life style of the new generation” and “less interests of farmers’ children in agricultural activities” are the main social drivers of ALC whereas “low social status of farmers than other people”, “utilization of agricultural lands “and “aging of farmers” are respectively the least important social drivers.

Table 4. The main social drivers of ALC and their importance according to the officers' views.

Causes	Label	Mean	SD	CV
Giving more attention to urban and industrial development than agriculture and rural development	SociC6	3.521	1.265	0.359
Changing the life style of the new generation	SociC7	3.385	1.226	0.362
Less interest of farmers' children to agriculture activities	SociC4	3.552	1.345	0.379
Little awareness of farmers toward the consequences of ALC	SociC9	3.188	1.308	0.410
Absence or inadequacy of NGOs[4] and CBOs[5] in agriculture	SociC12	3.438	1.428	0.415
Increasing the education of farmers and their children	SociC2	2.594	1.082	0.417
Increasing the contacts of farmers with urban population	SociC8	2.823	1.205	0.427
Increasing the migration of young people from rural to urban	SociC1	3.104	1.326	0.427
Low facilities for living in rural areas	SociC5	3.448	1.507	0.437
Inadequate public awareness toward ALC effects	SociC13	4.063	1.799	0.443
Aging of farmers	SociC11	2.781	1.370	0.493
Utilization of agricultural lands	SociC3	3.469	1.783	0.514
Low social status of farmers than other people	SociC10	2.521	1.494	0.593
Total	SociC	3.222	1.395	0.437

- SociC1: Social cause 1, SociC2: Social cause 2, SociC3: Social cause 3, SociC4: Social cause 4, SociC5: Social cause 5, SociC6: Social cause 6, SociC7: Social cause 7, SociC8: Social cause 8, SociC9: Social cause 9, SociC10: Social cause 10, SociC11: Social cause 11 and SociC12: Social cause 12.

Table 5 shows that "urban sprawl", "inheritance laws and its impact on land fragmentation" and "lack of coordination among the organizations related to ALC" are the main political drivers of ALC. The other drivers are the direct results of lack of systematic thinking, accurate planning, policy-making and also weakness in legislation. Although, according to the interviewees' opinion, "weakness of administrations and institutions" is one of the ALC drivers, it is less important than the others.

[4]- Non-Government Organizations
5- Community-Based Organizations

Table 5. The main political drivers of ALC and their importance according to the officers' views.

Causes	Label	Mean	SD	CV
Urban sprawl	PoliC14	3.885	1.195	0.308
Inheritance laws and its impact on land fragmentation	PoliC5	4.083	1.335	0.327
Lack coordination among the organizations related to ALC	PoliC8	4.115	1.368	0.332
Little awareness of policy-makers and planners toward ALC consequences	PoliC10	4.104	1.418	0.345
Lack of a long-term program for the agricultural development	PoliC1	3.969	1.425	0.359
Low stability of policies and programs in the agricultural sector	PoliC3	3.708	1.360	0.367
Low judges familiarity with the laws of lands conservation	PoliC6	3.813	1.446	0.379
Low prohibition about the ALC laws	PoliC4	3.854	1.487	0.386
Non-constant and non-professional country division	PoliC9	3.740	1.564	0.418
Political bias against agriculture compared to other sectors	PoliC2	3.688	1.682	0.456
Lack of farmers' participation in policy making and planning	PoliC11	3.354	1.542	0.460
Lack of a systematic approach in planning and policy making	PoliC12	4.104	1.955	0.476
Conflict of land conservation laws with other laws	PoliC7	3.708	1.782	0.481
Weakness of administrations and institutions about the ALC	PoliC13	4.625	2.272	0.491
Total	PoliC	3.911	1.559	0.399

- PoliC1: Political cause 1, PoliC2: Political cause 2, PoliC3: Political cause 3, PoliC4: Political cause 4, PoliC5: Political cause 5, PoliC6: Political cause 6, PoliC7: Political cause 7, PoliC8: Political cause 8, PoliC9: Political cause 9, PoliC10: Political cause 10, PoliC11: Political cause 11, PoliC12: Political cause 12, PoliC13: Political cause 13 and PoliC14: Political cause 14.

The main environmental drivers of ALC are “large fluctuations and reduced groundwater levels”, “lack of people and farmers familiarity with sustainable development issues” and “soil degradation and erosion”, respectively (Table 6). The table reveals that among the environmental drivers, those associated with land and water are more important than others whereas “lack of people and farmers’ awareness about sustainable development issues” is also important.

Table 6. The main environmental causes of ALC and their importance according to the officers' views.

Causes	Symbol	Mean	SD	CV
Large fluctuations and reduce groundwater levels	EnviC3	3.604	1.326	0.368
Lack of people and farmers' awareness toward sustainable development issues	EnviC1	3.604	1.476	0.410
Soil degradation and erosion	EnviC2	3.500	1.583	0.452
Increasing environmental disasters	EnviC5	3.094	1.515	0.490
Extreme weather and climate changes	EnviC6	3.073	1.564	0.509
Increasing plant and animal pests and diseases	EnviC4	2.948	1.552	0.526
Total	EnviC	3.304	1.503	0.459

- Envi C1: Environmental cause 1, Envi C2: Environmental cause 2, Envi C3: Environmental cause 3, Envi C4: Environmental cause 4, Envi C5: Environmental cause 5, Envi C6:

As mentioned by the respondents, "land fragmentation" plays a key role in ALC (Table 7), and "reducing water resources and water productivity" as a main input for agricultural production, is another main important driver for ALC. Furthermore, "shortage of human resources for monitoring ALC" is an important cause for ALC while the role of other inputs such as seeds, pesticides, fertilizers and technology is less than land and water inputs.

Table 7. The main technological causes of ALC and their importance according to the officers' views.

Causes	Label	Mean	SD	CV
Land fragmentation	TechC6	4.250	1.281	0.302
Reduction of water resources/productivity	TechC4	3.500	1.281	0.366
Shortage of human resources for monitoring ALC	TechC5	4.042	1.562	0.387
Lack of suitable cropping patterns for the country	TechC1	3.708	1.576	0.425
Decrease in crops yield	TechC2	3.500	1.648	0.471
Lack of appropriate agricultural inputs (seeds, pesticides and fertilizers)	TechC3	3.229	1.546	0.479
Low access of farmers to appropriate technology	TechC7	3.365	1.754	0.521
Total	TechC	3.656	1.521	0.421

- TechC1: Technological cause 1, TechC2: Technological cause 2, TechC3: Technological cause 3, TechC4: Technological cause 4, TechC5: Technological cause 5, TechC6: Technological cause 6, TechC7: Technological cause 7.

Structural equation model of ALC drivers (ALCD)

Using factor analysis to model the drivers of ALC, twenty main drivers (observed variables) were detected (Table 8 and Fig. 3). The SEM can be divided into two parts; the measurement model which relates measured variables to latent variables and the structural model that relates latent variables to one another. Table 8 indicates the main parameters which are estimated for measuring part of the SEM. As shown in the table, all the correlations are significant. This means that the observed variables could, to a large extent, estimate the latent variables. In addition, according to the λ values, the EcoC7 (Difficulties to obtain bank facilities and financial support), SociC7 (Changing the life style of the new generation), SociC11 (Aging of farmers), PoliC3 (Low stability of policies and programs in the agricultural sector), EnviC4 (Increasing plant and animal pests and diseases) and TechC3 (Lack of appropriate agricultural inputs (seeds, pesticides and fertilizers)) respectively explain the most amount of the variance of EcoC, SociC, PoliC, EnviC, and TechC. Finally, the Pc (value for structural part of the model) column indicates that these observed variables can explain an acceptable amount of the variance for the five main ALC drivers.

Table 8. Total Effects of ETA on Y (λ), standard errors (SE), t-values, R2 and Pc values for measurement part of the model.

Latent Variables	Observed Variables	λ	SE	t-values*	Pc
EcoC.	EcoC2	0.58	-	-	0.801
	EcoC7	0.75	0.14	5.39	
	EcoC8	0.72	0.15	4.93	
	EcoC9	0.72	0.15	4.96	
SociC.	SociC1	0.61	-	-	0.784
	SociC2	0.44	0.10	4.26	
	SociC7	0.69	0.14	4.95	
	SociC8	0.61	0.13	4.80	
	SociC10	0.63	0.13	4.71	
	SociC11	0.69	0.14	4.93	
PoliC.	PoliC1	0.68	-	-	0.700
	PoliC3	0.87	0.15	5.66	
	PoliC9	0.27	0.077	3.54	
	PoliC10	0.32	0.084	3.82	
	PoliC11	0.61	0.11	5.42	
EnviC.	EnviC4	0.86	-	-	0.714
	EnviC5	0.64	0.16	4.09	
TechC.	TechC2	0.67	-	-	0.739
	TechC3	0.77	0.15	5.11	
	TechC7	0.65	0.12	5.36	

* If t-values>1.96 the relationship is significant

Since the goodness of fit for the statistics of the measurement part of the model is acceptable, the assessment of the structural parts of the model can be done. Table 9 indicates the parameters which are estimated for the structural part of the model. As shown in Table 9, all proposed relationships in Fig. 3 are significant. According to the Υ column, EcoC, PoliC, TechC, SociC and EnviC have respectively greater effects on the variance of ALC and are considered as the main drivers of ALC. These five main groups of the ALC drivers together explain 82% of the total variance of ALC which is acceptable.

Table 9. Total Effects of KSI on ETA (Υ), standard errors (SE), t-values and Pc value for structural part of the model.

Latent Variable X	Latent Variable Y	Υ	SE	t-values*	Pc
ALCD	EcoC.	0.98	0.060	16.49	0.82
	SociC.	0.56	0.040	14.12	
	PoliC.	0.72	0.049	14.67	
	EnviC.	0.45	0.051	8.93	
	TechC.	0.68	0.049	14.06	

* If t-values>1.96 the relationship is significant.

Finally, Table 10 shows the goodness of fit for the SEM of ALCD. These statistics indicate that the ALCD model has a good fitness. Therefore, the final SEM of ALCD that is shown in Fig. 3 is acceptable.

Table 10. The goodness of fit for structural equation model of the ALCD.

Goodness of Fit Statistics	Acceptable range*	Estimated values
Root Mean Square Error of Approximation (RMSEA)	RMSEA < 0.1	0.069
Root Mean Square Residual (RMR)	RMR near to zero	0.088
Goodness of Fit Index (GFI)	GFI > 0.9	0.93
Adjusted Goodness of Fit Index (AGFI)	AGFI > 0.9	0.92
Normed Fit Index	NFI > 0.9	1.0
Comparative Fit Index (CFI)	CFI > 0.9	1.0

* Source (Kelloway, 1998)

According to the ALCD model (Fig. 3), economic, political, technical, social, and environmental drivers can respectively explain the total variance of ALCD. This finding totally confirms the executive officers' views about the main drivers of ALC although there is a little difference between the results of this model and their view in subsidiary drivers. For example, based on the ALCD model, and unlike the executive officers who selected EcoC1 (more profitability of non-agriculture sectors than agriculture sector) as the most important economic driver, EcoC9 (the weakness of network markets and marketing of agricultural products) is realized as the most important driver of EcoC. From the political dimension, the most important driver based on the ALCD model is PoliC3 (low stability of

policies and programs in the agricultural sector) while the most important one based on executive officers' view was PoliC14 (urban sprawl). Among the technical drivers, the most important one detected is TechC3 (lack of appropriate agricultural inputs (seeds, pesticides and fertilizers)) in the model while TechC6 (land fragmentation) is introduced as the most important driving force based on the executive officers' view. For the social drivers, unlike the executive officers' point of view who selected SociC6 (more attention to urban and industrial development rather than agricultural and rural development) as the most important driver, SociC7 (Change in the life style of the new generation) and SociC11 (aging of farmers) are detected as the most important drivers according to the ALCD model. Finally, among the environmental divers, EnviC4 (Increasing plant and animal pests and diseases) has the most important role among the environmental drivers in the ALCD model while EnviC3 (large fluctuations and reduced groundwater levels) was understood as the most important driver among the executive officers. As shown in Table 9, and as opposed to the respondents' view, those which explain higher variance of ALC, are different from what have been introduced by the respondents.

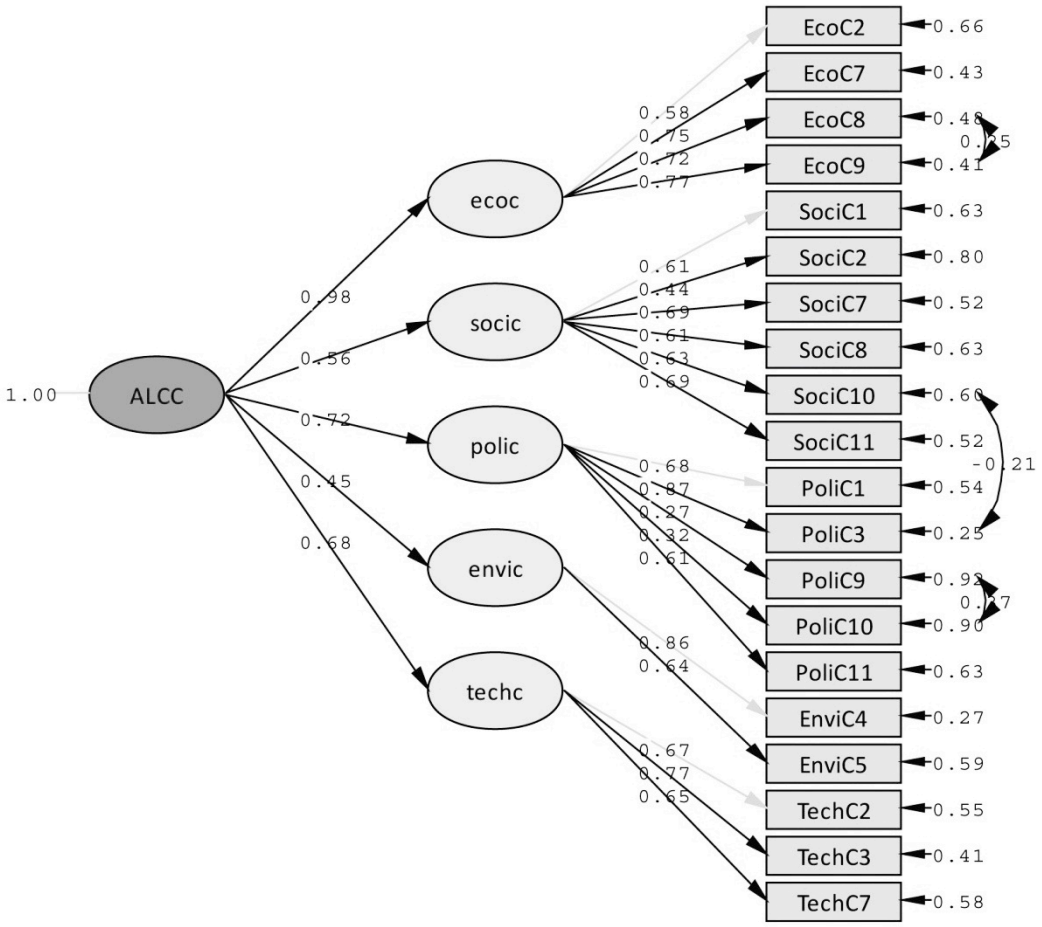

Fig. 3. The final structural equation model of ALCD.

Discussion and conclusion

Many articles (Billington et al., 1996, Bahrami et al., 2010, Azadi et al., 2011, Azadi & Barati, 2013, Asadi et al., 2014) have noted that the ALC is a very complex phenomenon and is increasing severely. As a result, exploring its drivers is one of the most important tasks and difficult challenges for agricultural policy makers. Conversion of agriculture to other uses is considered as an inevitable phenomenon around the world, especially in developing countries like Iran (Azadi et al., 2011). According to the results of this study, despite subsidiary drivers of ALC are different based on the SEM analysis and executive officers' view, economic, political, technological, social and environmental factors are respectively realized as the five major drivers of ALC (not only in the view of the

executive officers but also based on the SEM). According to these results and previous studies (Azadi & Barati, 2013 and Asadi et al., 2014), all these drivers have an impact on ALC and each other.

Based on the SEM model of ALCD, 82% of the total variance of ALCD can be explained by the five main ALC drivers. The most amount of this variance can be explained by economic followed by the political drivers. These results and the findings resulted from similar studies (Long et al. 2007; Geist & Lambin, 2001; Liu et al., 2008) confirm that socioeconomic plus political drivers can be the main drivers of ALC. According to Antrop (2005), Thapa & Murayama (2009), Weng (2007) and Hersperger and Burgim (2009), economic processes often contribute to the ALC. The high importance of economic and political drivers also is critical for agricultural planners and other people interested in managing the agriculture development. If one assumes that the relevant suite of drivers is not radically changing in the near future, agricultural planning and management clearly has to target economic drivers in order to be successful. Our study also showed a significant role of technological drivers that is confirmed by the results of a study conducted by Schneeberger et al. (2007). Hence, it can be inferred that technological innovations were a key force that contributed in changing agricultural lands. Also in agricultural areas of the tropics, the importance of technological drivers has been recognized (Geist et al., 2006). Given the complexity of ALC drivers, the need for approaches that integrate socioeconomic, political, environmental and technological drivers are now widely recognized (Dewan & Yamaguchi, 2009; Verburg et al., 2004). These studies are important for gaining a deeper understanding of the complex relationships between drivers affecting ALC.

This study showed that based on executive officers' view, the main identified economic driver was "more profitability of non-agriculture sectors" while based on SEM of ALC, "weakness of network markets and marketing of agricultural products" was the main economic factor. According to these results, we can say that since network markets and marketing of agricultural products in the study area are weak and agricultural products have consequently low prices, non-agriculture sectors are therefore more profitable. This has significant impact on agricultural products in general and farmer's motivation in particular.

When farmers have to sell their products at low prices, their motivations for agricultural activities severely reduce. On the other hand, there is more profitability in non-agriculture sectors. This means, farmlands' owners will earn much from non-agricultural activities. All these people try to convert agricultural land to other uses to earn better job or more money. It often contributes to agricultural land use changes. Therefore, it can be concluded that these two drivers are the two sides of the same coin with positive correlations that can rise ALC. Market aspects have been repeatedly introduced as important drivers of ALC (e.g. Geist et al., 2006). Findings of Azadi and Barati (2011) and Khakpour et al. (2007) confirm our result as they found that many farmers had to sell or separate their lands due to the low profit and high risk of the agricultural activities in comparison with selling the lands.. Similarly, the results of Mehrabi et al. (2013) indicate that non-economic agricultural activities and increasing the land price are the most important ALC drivers.

According to the SEM and executive officer's view, "low stability of policies and programs in the agricultural sector", "excessive rising of land prices", "farmers' income instability", "land fragmentation", "urban sprawl" and "inheritance laws" are the other most important subsidiaries of ALC. These findings are not surprising, since the economic and political drivers are strongly interlinked. Changes and low stability of policies and programs in the agricultural sector basically affect economic factors such as land price and result in increasing or decreasing of land prices (Geist et al., 2006). On the other hand, as already discussed, weakness of network markets and marketing of agricultural products influence farmers' income. As a result, farmers face instability with regard to the income. Such farmers will have a strong motivation to change the use of farmlands to other uses. Inheritance laws is another important driver which has indirect effects on ALC. Unfortunately, in Iran, farmlands in urban areas are usually divided between inheritors after the death of land owner; as a result agricultural lands are becoming smaller and smaller. This means land fragmentation is strongly increased. Consequently, because of the fact that agriculture in small size of land is not economically profitable, the possibility of agricultural lands to be converted to other uses is getting higher and higher. The effect of farm size as an internal driver of ALC has repeatedly discussed by Levia et al., (2000) and Azadi et al., (2011). Moreover, one of the most important drives of ALC in this study is

urban sprawl. Although land conversion for urban expansion is rapidly increasing, especially in mega-cities, around the word (Nguyen et al., 2014), the developed countries are more successful in managing urban development and ALC (Azadi et al., 2011). However, in the developing countries (e.g. Iran), there is no suitable strategy for managing urban development. Therefore, urban development is associated with a kind of sprawl in these countries. According to many studies (Han and He, 1999; Ho and Lin, 2004; Lichtenberg and Ding, 2008), due to the fact that urban development in developing countries is not sustainable mainly because of lacking infrastructures for urban development, urban sprawl takes place in most of those countries and it plays an important role in ALC.

In sum, although there are many drivers for ALC with high complexity, the "economic", "political", "technological", "social" and "environmental" drivers are realized as the most important causes of ALC both in the view of policy makers and according to the results of the SEM analysis. The latter showed that "more profitability of non-agriculture sectors", "excessive rising of land prices", "farmers' income instability", "land fragmentation", "urban sprawl" and "inheritance laws" are the main six subsidiary drivers of ALC although all drivers and subsidiaries are important. Therefore, it is important that land use policy-makers and planners conduct more studies to further explore these drivers. Future studies can focus on the issues of the interplay between the relevant socioeconomic and political factors, land prices and therefore actors in their construction activities that all may affect ALC. The results of such studies can create a useful tool for decision-makers, practitioners and policy-makers whose main recent concern is ALC.

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CHAPTER 4
RESEARCH CONSTRAINTS

Data acquisition

My major challenge in data acquisition for this study was the "incomplete cadastre" in Northeast Iran that made some difficulties to obtain the data. Data on urban planning settlements (as the main ALC driver) requires a cadastral layer to portray a real spatial configuration of ALC partly. All other data are dependent much on this driver and can be the basis to improve data flow among other ALC drivers. When lacking such a layer or when the layer is poor or incomplete, the spatial analysis of ALC cannot perfectly be performed. Furthermore, in the study site, the contrast between urban and peripherals has made it more difficult to configure a complete cadastral layer and comprehend the influence of urbanisation as one of the main drivers of ALC.

In sum, there were three major problems with the current situation of the study site to create a complete cadastre in urban and peripheral areas. First of all, surveying and recording (agricultural) land parcels is not compulsory for (farm) land owners in these areas. Despite many incentives offered to encourage the owners to let their plots surveyed and recorded, a holistic cadastre does not seem feasible in the near future. Moreover, the Cadastre Department of LAO[6] which normally conducts such field surveys on the plots does not have sufficient experts and technologies to record all the data on the parcels allocated to the owners in both areas. There are however, some increasing private advising companies which hold a license from the LAO and conduct such surveys by charging high rate wages that may be seen unreasonable from the view of the owners. Furthermore, until lately, when some subsidies were launched by LAO, poor coordination among different departments of LAO and private companies is yet a problem that makes handling the data acquisition difficult. Finally, there are some illegal (self) allocations of land parcels, especially in rangeland territories that are also understood as a major problem in the development of urban and peripheral cadastres. Such illegal allocations are conducted yonder the records of

[6] Land Affairs Organization (in Iran)

the government and cannot be considered as a valid cadastre set. In short, lack of a complete cadastre caused by opaque process of data acquisition remains as a major problem in organizing information for monitoring agricultural land conversion induced by urban sprawl and transportation in Northeast Iran.

Data integration

Data integration challenges are not a new issue. While it can have some positive impacts like reducing costs by lessening redundant design efforts, given multiple sub-units or involved divisions, data integration can raise the costs by increasing the size and complexity of the design problem or increasing the difficulty in getting agreement from all concerned parties. The main barriers of data integration in this study are summarized as follows:

i) Cost: data integration across different contacted organizations in Iran has caused the expenses to multiply. More specifically, conducting multiple performance evaluations has concurrently made more expenses than using each one separately.
ii) Timing: it took much more time to collect needed data from different sources across these organizations. This time lag has caused synchronization problems.
iii) Few data standards: this has made a difficulty in the vision of data strategy, and has created more complex decision support information.
iv) Overloaded-information: this has caused the profusion of information overly more complicated.

Another major problem in integrating the data of this study has been the semantic integration problem. This problem addresses not the structuring of the architecture of the integration, but how to resolve potential semantic conflicts between heterogeneous data sources; i.e., academics, policy makers, administrative officials and farmers. In investigating the ALC drivers, it means, for instance, combining subjective (social) measurements with objective (bio-physical) measurements. The strategy applied in this

study to resolve this problem was the use of voting methods which could explicitly define some methods to resolve such semantic conflicts.

CHAPTER 5
PROSPECTS[7]

Launching new research group on ALC

Thanks to the broad network, knowledge and experience cultivated during the sojourn, a new research group focusing on ALC drivers in my home institute is being launched. The idea of constructing this new group has been shaped during the sojourn while working in the multi-disciplinary environment of the Department of Geography which includes five research groups; namely, 3D Data Acquisition, Cartography and GIS, Physical Geography, Landscape Research, and Social and Economic Geography. The latter in which I was working contains three research areas; i.e., transport and logistics, globalization and world cities, and land use, agro-environment and geography of enterprise. Such diverse and holistic expertise induces a real multi-disciplinary environment which has enabled me to make close collaboration with different expertise in conducting my study and planning for future research projects mainly the new research group on ALC.

PhD study on ALC

Thanks to the explored challenges and publications on ALC during the sojourn, I am now doing my second PhD on "agricultural land conversion drivers". In this new study, I have focused not only on transportation but also other ALC drivers. In this study, the effects of the transportation driver on ALC will further be investigated according to different transportation modes (mainly roads, railways, airports) to explore their detached and attached effects on ALC. I will also assess the effects of other drivers like demographical change, urbanization, land productivity, land policy, mechanization degree, etc. All these drivers will be categorized into "internal" and "external" drivers. The former will explore the main insider drivers of ALC in a given country while the latter will try to explore outsider drivers beyond a specific region. The analysis will also be focusing at different micro, meso and macro scales. The micro scale will focus on the cause and effects of ALC

[7] To pursue the prospects, both SEG and ESRI extended my sojourn for three months.

at farmer and his household level. The meso scale will investigate the main drivers of ALC at regional (national) level. The macro scale will explore the main drivers of ALC at global level. All the external and internal drivers at the different scales will try to portray a holistic picture of "agricultural land conversion drivers" systematically.

ANNEX

PUBLICATIONS

1. Azadi, H., Samiee, A., Mahmoudi, H., Jouzi, Z., De Maeyer, P., Witlox, F. (In press). Genetically modified crops and small-scale farmers: Main opportunities and challenges. *Critical Reviews in Biotechnology*. (IF: 7.837)
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3. Barati, A.A., Asadi, A., Kalantari, K., Azadi, H. Witlox, F. (2015). Agricultural land conversion in Northwest Iran. *International Journal of Environmental Research*, 9, 281-290. (IF: 1.82)
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5. Hoeks, C., Azadi, H., Rafiaani Khachak, P., Troyo-Dieguez, E., Van Passel, S., Witlox, F. (2014). Reforming land tenure systems in South Africa: Routes to socio-economic and agricultural sustainability. *Development Policy Review*, 32(6), 647-674. (IF: 1.053)
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10. Schoonbeek, S., Azadi, H., Mahmoudi, H., Derudder, B., De Maeyer, P., Witlox, F. (2013). Organic agriculture and undernourishment in developing countries: Main potentials and challenges.*Critical Reviews in Food Science and Nutrition*, 53, 917-928. (IF: 4.820)
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12. Soltani, S., Azadi, H., Witlox, F. (2013). Technological innovation drivers in rural small food industries in Iran. *Journal of International Food & Agribusiness Marketing*, 25, 68–83. (IF: NA)
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