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Study of Relationship Between Roads Network Development and Agricultural Land Conversion in Iran NorthWest

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ABSTRACT: Road network (RN) can affect patterns and distribution of land uses and covers. Road network expansion has both direct and indirect impacts on land uses and covers changes. Agricultural land conversions (ALCs) are especially known as one of the main important types of land use changes. The purpose of this paper, in addition to estimation of the direct impact of RN expansion on ALCs, is to evaluate the ALCs relative to road network location. The study area is Qazvin province in the North West of Iran. To estimate the amount and the location of ALCs a couple of Landsat imageries for 1990 and 2010 were used. Also, to evaluate the relationships between ALCs and RN at first agricultural lands, based on their distance from RN, were categorized into three groups namely a. Less than 2_{Km}, b. Between 2_{Km} to 4_{Km} and c. More than 4_{Km} to 6_{Km}. Then, the area of agricultural lands that changed from 1990 to 2010 were estimated for these groups. Finally, the differences amongst these three categories were evaluated. The main results of this study showed, a) 44,845 ha (3%) of the agricultural areas during 1990-2010 were changed to non-agricultural lands; b) 10,243 ha of these lands were converted to Urban and Other Infrastructures; c) the suburban RN has been mainly developed within agricultural lands, especially, within irrigated and orchard lands. In addition, d) ALCs among the closer lands to the roads have been significantly higher than lands which have been away from the RN.

Key words: Landuse, Landcover, Agriculture, Impact Assessment, Iran.

INTRODUCTION

The road network (RN), as a part of transportation system, is a form of land use, which strongly depends on other land uses (Jaarsma, 1997). The distribution of different types of land uses in different locations stimulates the demand for transport, and vice versa the supply of transport enables the distribution of different land uses in different locations (Marshall and Banister, 2007). Then, the agricultural lands, as a type of land use, and RN, as an another type of land use and a main part of transportation, are interrelated. RN is also a dominant and an important component of public infrastructure. RN influence land use directly, by determining which land is devoted to RN, and indirectly (Litman, 2011) (for example by affecting the location and design of development or by improving accessibility to other lands such as agricultural land locations). Integrating land use and RN is also vital to sustaining the economy, improving the social interaction and minimizing the environmental impacts. Despite of this interrelation, we believe, the land is a priority. Because, as D'Odorico and Rulli (2014) also have expressed, land for each society is the ultimate foundation of livelihood, identity and it is a way of life. In addition, according to many cultures and religions soil recognizes as a source of life and prosperity. They have traditions tied to the land, its products and geographic location. Therefore, we should manage and protect with care the lands.

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One of the primary challenges of land management is managing land use and cover change (LUCC). Among various types of LUCC, agricultural land conversion (ALC) is one of the most important ones that can affect and be affected by climate change (Barati *et al*., 2015; Biro *et al*., 2013; Debolini *et al*., 2013; Lambin *et al*., 2000; Liu *et al*., 2012; Miyake *et al*., 2012; Mondal and Southworth, 2010; Salvati and Carlucci, 2010; Turner II, 2002, 2009; Vitousek, 1994) and thereby it affect all the countries in the world (The World Bank, 2010). This is despite the fact that such changes are recognized as an unavoidable phenomenon during economic development and population growth (Tan *et al*., 2009; Zhang *et al*., 2013). World population, as FAO (2011, 2013a, 2013b) reports, has expected rise to approximately 9 billion by 2050. It means more global, regional, and national demand for foods and creates new land use demands (Dyson, 1999; Ewert *et al*., 2005; Freitas *et al*., 2010; Johnson, 1999; Rosegrant *et al*., 2001). Thereupon, if current agricultural lands are not protected, besides the compromise of food security, the degradation and erosion rate of natural lands, such as rangelands and forests, will be increased.

Unfortunately, the rush for agricultural lands have increased at an unprecedented rate over the recent years (D'Odorico *et al*., 2013). For example, the arable land per capita (during 1970-2009) has decreased 2.1% in Iran (compared to 1.46% for the global rate) (FAO, 2012). Also, Iran's Agricultural Land Organization has reported that about 20 thousand hectares of agricultural land use have changed annually. In addition, from 1990 to 2010 the ALC trend in Iran northwest has accelerated (Barati *et al*., 2015). Although, the drivers of ALC are very various and different, but RN or road infrastructure development has been one of the main drivers (Azadi and Barati, 2013; Azadi and Hasfiati, 2011; Freitas *et al*., 2010; Han & He, 1999; Ho & Lin, 2004). Road expansion not only changed the use of agricultural and natural lands in a directly and indirectly manner (Litman, 2011), but also it causes land fragmentation. Furthermore, Roads can act as an attractor for a driving force likely to induce more changes (Freitas *et al*., 2010).

Since the road construction and improvement during recent years has accelerated in Iran. For instance, according to Statistical Centre of Iran, over the past 17 years (of 1997 to 2014) RN length (only includes freeways, highways and main roads) have increased from 24337 Km to 37986 Km which about %62 of this growth has taken place in the last five years. On the other hand, given that RN, especially high road densities, has indicated intensive use of lands and fragmentation (Azadi *et al*., 2015; Bresee *et al*., 2004; Ewers *et al*., 2006). In addition, road expansion, as one of the main components of urban sprawl, has determined such one of the main agricultural land conversion drivers in Iran and specially in the study area (Azadi *et al*., 2015; Barati *et al*., 2015).

The main purpose of this study at first was investigating the relationship between the RN and ALCs to find out the impact of distance to RN on ALCs. In addition, our second purpose was estimated the direct impact of RN expansion on ALCs (or we wanted to estimate the area of agricultural land which changed to RN during current 1990-2010).

MATERIALS & METHODS

The survey was carried out in the Qazvin province located in Northwest Iran (35°232 N- 36°492 N; 48°442 E–50°532 E) that encompasses 15,636 km2 (Fig. 1). In 2012, the province holds a population of 1.2 million, of which 72% live in urban and 27% in rural areas. Although this province covers less than 1% of the total area of Iran, its contribution to the country's economy reaches up to 5% and more than 3% of Iran's agricultural products are produced in this province (Barati *et al*., 2015). Therefore it is evident that agricultural sector of Qazvin has an important role in the country's economy.

Agricultural land conversions were estimated with two land-use and cover maps were generated using Landsat satellite imageries (1990 and 2010). The

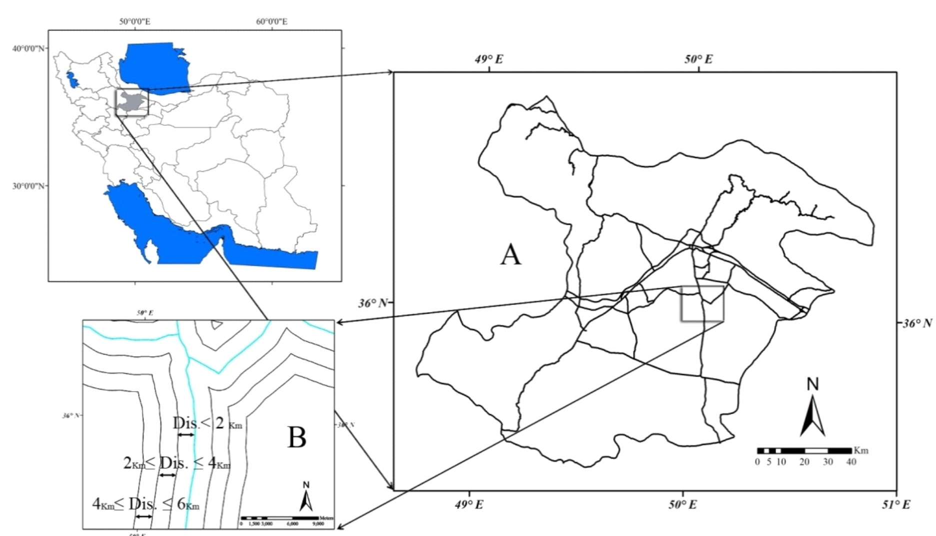

Fig. 1. Location of the Qazvin province (the study area) in northwest Iran, road network (blank lines) (A) and dividing agricultural lands (ALs) with respect to their distance of RN (B)

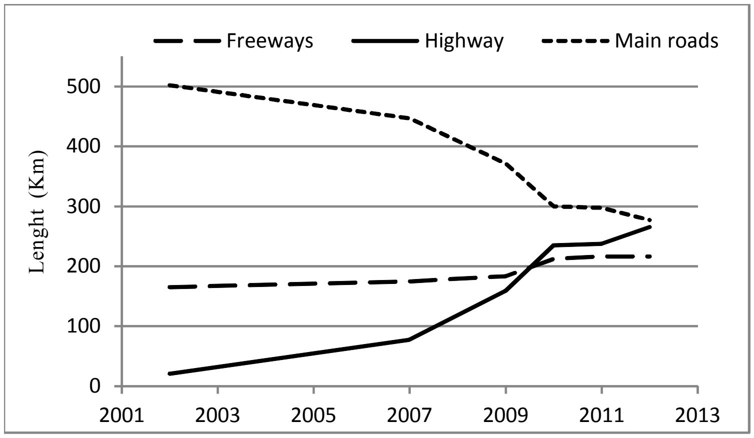

Fig. 2. The expansion of road network (RN) in the study area from 2002 to 2012

classification method was the supervised with a MAXLIKE module in IDRISI Kilimanjaro software, in which each pixel assigned to a class based on its multispectral composition (the best composites of the bands were 3, 5, and 7). The classes are determined based on the spectral composition of training areas defined by the user (Eastman, 2003). The total area was divided into nine classes, including rangeland (RL), dry land (DL), irrigated land (IL), orchard land (OL), saline land (SL), forest (F), water body (WB), urban areas and infrastructures (UI) and other land covers (OC). For this study agricultural lands include RL, DL, IL and OL.

Road network data were obtained from a 1:50,000 topographic maps based on 2010 and the statistical yearbook of Iran in 2002-2012. The RN in the study only contained three main types of suburban roads: freeway, highway and main roads which indicated in Fig. 1. (A) According to Statistical Center of Iran (2011, 2013), the length of Qazvin RN during 2002-2012 was increased from 687.7Km to 758.9Km (Fig. 2). This RN includes 10.5% of freeways, 2.3% of highways and 1.3% of the main roads of Iran. Given that this province only covered 1% of the country area, this means the RN density of Qazvin is much more than other provinces. On the other hand, Iran's Agricultural Land Organization reported that between 2005 and 2012 the rate of Qazvin ALC was the most and accelerated. Regarding to this fact, we aimed to examine the relationships among RN and ALC.

To explore the relationship between DN and ALC, Pearson Chi-Square and Cramer's V test were used (Field, 2009). For this aim, at first agricultural lands (ALs) with respect to their distance of RN was divided into three groups. A) agricultural lands which have less than two kilometers to RN, B) agricultural lands which located between two to four kilometers to RN, and C) agricultural lands which located between four to six kilometers to RN. Next, the number of ALs pixels which their uses changed to non-agricultural lands during 1990-2010 were we counted, using two land-use and cover maps of 1990 and 2010. Then, to see whether there's a relationship between these three groups, Pearson's chi-square test was applied. This is an extremely elegant statistic based on the simple idea of comparing the frequencies you observe in certain categories to the frequencies you might expect to get in those categories by chance (Field, 2009). Finally, to explore the strength of association between the type of ALs and distance to RN Cramer's V test was carried out.

RESULTS & DISCUSSION

According to Fig. 3 and Tables 1 and 2 agricultural lands were the dominant land use and covers in Qazvin both in 1990 and 2010. In 1990, RLs, DLs, ILs, and OLs respectively that covers 55.22%, 25.31%, 10.71%, and 4.59% of the study site (about 1,498,000 ha or 95.8% of the whole area). But, in 2010, the agricultural areas, decreased to 94.7%, which indicates that during this period of time 44,845 ha (3%) of these lands have changed to non-agricultural lands. At the second time, the shares of RLs, DLs, ILs, and OLs separately have been 55.04%, 28.6%, 7.33% and 3.74%. As shown in these tables, the percent of RLs, ILs and OLs areas one by one have decreased -0.18, -3.37, and -0.84%. Conversely, the share of the DLs areas increased by 3.28%, from 1990 to 2010. However, among the RL, IL and OL areas, the share of the IL areas decreased more intensely (-3.37%) than the others.

Also, Tables 1 and 2 indicate that up to 3% (44,845 ha) of ALs (including 2.3% of RLs, 5.8% of DLs, 0.8% of ILs and 0.5% of OLs) were converted to non-agricultural lands by 2010. 71% of these lands degraded to SLs and 22.8% converted to UIs. It means that during this period, 32,033 ha of agricultural lands (14,075 of RLs, 17,783 of DLs, 149 of ILs and 26 ha of OLs) was

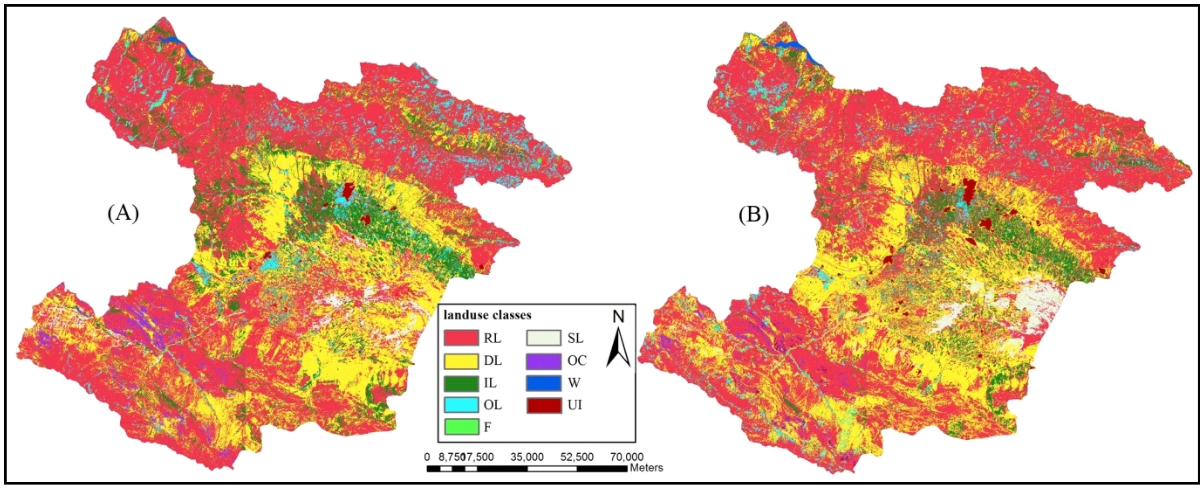

Fig. 3. The land use/covers maps of the study area: (A) 1990 and (B) 2010. RL (Range Land), DL (Dry Land), IL (Irrigated Land), OL (Orchard Land), SL (Saline Land), F (Forest), WB (Water Body), UI (Urban and Other Infrastructures) and OC (Other Land Covers)

Table 1. The transition areas matrix of different land use/covers between 1990 and 2010 (hectare).

		2010[a]									Total
		RL	DL	IL	OL	F	SL	OC	WB	UI	
1990[a]	RL	635205	146871	36587	24543	56	14075	1694	57	4321	863408
	DL	99968	243730	24540	4621	49	17783	619	4	4503	395817
	IL	76009	40832	42019	6959	196	149	181	9	1050	167404
	OL	32604	7305	10540	20369	474	26	5	1	369	71693
	F	757	90	182	1730	675	1	0	0	5	3440
	SL	7827	7411	719	163	1	11885	227	0	611	28844
	OC	8102	601	39	88	0	130	9040	0	2132	20130
	WB	22	11	11	43	0	0	0	2743	0	2831
	UI	141	276	54	23	0	642	12	0	8902	10052
Total		860636	447128	114690	58539	1451	44691	11778	2814	21894	1563620

a. RL (Range Lands), DL (Dry Lands), IL (Irrigated Lands), OL (Orchard Lands), SL (Salin Lands), F (Forest), WB (Water Bodies), UI (Urban and Other Infrastructures) and OC (Other Land Covers)

converted to SLs and 10,243 ha (including 4,321 of RLs, 4,503 of DLs, 1,050 of ILs and 369 ha of OLs) was changed to UIs. Moreover, the RLs and DLs have mainly converted to SLs. In contrast, most of the ILs and OLs were converted to UIs. Finally, during 1990-2010 the saline areas expanded from 1.84% to 2.86%. It means that 15,846 ha of the lands were degraded to saline lands. These results were the same as Ho and Lin (2004) and Wang *et al*. (2012) studies in China and Indonesia.

Table 2 shows that more than 73% of RLs remained unchanged during 1990-2010 which about 24% of them have exchanged to the other ALs classes. These findings were confirmed with Hietel *et al*. (2007) and Kamusoko *et al*. (2009) in Lahn-Dill Highlands (Germany) and Mashonaland (Zimbabwe). The rest of the RLs were mainly converted to SLs (1.6%) or other land uses and covers (0.2%). F. Zhang *et al*. (2013) reported the same changes in China. Among dry lands, about 32% of DLs converted to the other agricultural lands and more than 6% of them degraded to non-agricultural lands (4.5% to SLs 1.1% to UIs) (Tabels 1 and 2). Hietel *et al*. (2007) and Kamusoko *et al*. (2009) reported the same changes among arable land, grassland and fallow land.

These changes are espacially very important on environmental conditions because there are some dynamic feedbacks between changing land use and changing environmental conditions and vice versa (Veldkamp and Verburg, 2004). In this regards, different studies have showed that land use and cover changes leads to loss of soil physico-chemical properties such as nutrient and carbon and reduction of organic matter inputs (Agoumé and Birang, 2009; Gol, 2009; Richter *et al*., 2000).

Table 2. The transition areas matrix of different land use/covers between 1990 and 2010 (percentage).

		2010[a]									Total
		RL	DL	IL	OL	F	SL	OC	WB	UI	
1990[a]	RL	73.57	17.01	4.24	2.84	0.01	1.63	0.20	0.01	0.50	55.22
	DL	25.26	61.58	6.20	1.17	0.01	4.49	0.16	0.00	1.14	25.31
	IL	45.40	24.39	25.10	4.16	0.12	0.09	0.11	0.01	0.63	10.71
	OL	45.48	10.19	14.70	28.41	0.66	0.04	0.01	0.00	0.51	4.59
	F	21.99	2.63	5.30	50.30	19.62	0.02	0.01	0.00	0.14	0.22
	SL	27.14	25.69	2.49	0.56	0.00	41.20	0.79	0.00	2.12	1.84
	OC	40.25	2.98	0.19	0.44	0.00	0.65	44.91	0.00	10.59	1.29
	WB	0.79	0.39	0.39	1.52	0.00	0.00	0.00	96.91	0.00	0.18
	UI	1.41	2.75	0.54	0.23	0.00	6.38	0.12	0.00	88.56	0.64
Total		55.04	28.60	7.33	3.74	0.09	2.86	0.75	0.18	1.40	100

a. RL (Range Lands), DL (Dry Lands), IL (Irrigated Lands), OL (Orchard Lands), SL (Saline Lands), F (Forest), WB (Water Bodies), UI (Urban and Other Infrastructures) and OC (Other Land Covers)

Table 3. The agricultural land uses which converted between 1990 and 2010 based on their distance to RN (Pixel)

Land Type[a] >		RLs		DLs		ILs		OLs		Total Als	
ALC[b] >		Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Distance of RN[c]	A	372215	806805	268194	477211	307590	129501	106434	39710	1054433	1453227
	B	365644	928701	235208	408273	196926	74063	104552	36804	902330	1447841
	C	332631	971526	216424	354378	162470	42897	80432	31757	791957	1400558

a. RLs (Range Lands), DLs (Dry Lands), ILs (Irrigated Lands), OLs (Orchard Lands), ALs (Agricultural Lands),
b. ALC (Agricultural Land Conversion)
c. Distance of RN: A (Less than 2_{Km}), B (Between 2_{Km} to 4_{Km}), C (More than 4_{Km} to 6_{Km})

As seems ILs area decreased from 10.7% to 7.3%, which means more than 25% reduction. However, conversions of ILs and the other ALs to each other have been greater, such that 75% of ILs converted to the other ALs and on the contrary, 25% of these lands changed to ILs. In addition, less than 1% of ILs changed to non-agricultural lands (mostly to UIs). As well, for OLs, between 1990 to 2010, more than 18% of orchard areas reduced. In contrast, by 2010, around 8% of the other ALs have altered to OLs. Even so slightly more than 70% of OLs changed occurred within the agricultural lands. And nearly 1% of them altered to non-agricultural lands; mainly to the UIs.

Lastly, tables 1 and 2 indicate that during the 20 years UI areas increased from 0.64% (10,052 ha) to 1.4% (21,894 ha) in the study site. This means that UIs increased to 11,842 ha (close to 118% growth), of which, 10,243 ha were the result of ALC. Other researchers (Azadi *et al*., 2011; Barati *et al*., 2015; Fukamachi *et al*., 2001; Hietel *et al*., 2007; Ho and Lin, 2004; Lichtenberg and Ding, 2008; Schulz *et al*., 2010; Tan *et al*., 2009) have importantly reported that UIs have been expanded within the agricultural lands. And according to Shrestha *et al*. (2012) in Southwest America, Su *et al*. (2011) in Hang-Jia-Hu region of China and EEA (2006) in Europe, rapid urbanization leads to agricultural land fragmentation.

Review Table 3 indicates that, ALCs among the closer lands to RN have been more than farther lands (1054433 pixels for group A, 902330 and 791957 pixels respectively for B and C groups). In addition, the number of agricultural pixels among the closer lands group to RN (A=2507660) was more than other groups (B= 2350171 and C= 2192515). Also, although the number of RL pixels within group C (13015) were more than B (1294345), and within B were more than A (1179020), but the number of transforming RL pixels within closer lands to RN has been greater (372215 in comparison with 365644 and 332631). Unlike the RL, most of the DL, IL and OL pixels were respectively located in nearest groups to RN (A and B). In addition, simultaneously with increasing distance from RN the amount of DL, IL and OL transformed pixels have been decreased. It seems that road expansion has led to land use and cover changes, Garcia-López *et al*. (2014) in Spain indicated the amount of land converted after the construction of the highway was great. Roads can determine patterns of land use and distribution. In Brazil and Golestan National Park in northeast of Iran roads had the strongest relationship with deforestation and forest fragmentation (Freitas *et al*., 2010) or in Belize, although rural roads promote economic development, but they also facilitate deforestation (Chomitz and Gray, 1996).

Table 4. Output of the chi-square tests for "Distance of RN" and "ALC" variables.

Land Type[b]	Pearson Chi-Square		
	Value	df	Sig. (2-sided)
RLs	11221.68[a]	2	.000
DLs	534.67[a]	2	.000
ILs	5441.08[a]	2	.000
OLs	164.03[a]	2	.000
Als	528571.32[a]	2	.000

a. 0 cells (.0%) have expected count less than 5.
b. RLs (Range Lands), DLs (Dry Lands), ILs (Irrigated Lands), OLs (Orchard Lands), ALs (Agricultural Lands),

To look whether there's a significant relationship between ALCs and RN we extended a Pearson's chi-square statistical test between "Distance of RN" and "ALC" categorical variables. Table 4 indicates there were a significant association between the "distance of RN" and "ALC" for all types of lands. This seems to represent the fact that, RN has affected ALCs. Moreover, to calculating the effect size of RN on ALCs we used Cramer's V test. The result shows there was a significant relationship between the "Distance of RN" and "ALC", but this relationship was not strong ($r = .28$, $p < .000$).

CONCLUSIONS

The study indicated that the surface of agricultural lands has decreased significantly and this decrease has intensified during 1990 to 2010. This result confirmed by Barati *et al*. (2015), Mazzocchi *et al*. (2013), FAO (2012), Behnassi and Yaya (2011), IFAD (2010) and Azadi *et al*. (2011). With emphasis on the important role of agricultural lands and products in food security and development (Vermeulen *et al*., 2012; World Bank, 2008) these changes can be a serious threat to food security. We, in line with Barati *et al*. (2015), Leh *et al*. (2013), Azadi *et al*. (2011; 2013, 2015), Shrestha*et al*. (2012) and EEA (2006), appeared road network as a human infrastructure had a significant relationship with land use and cover changes and it has been one of the main causes of the ALC. On the other hand, since the life of about one third of the study area people is depended to the lands, then expansion the roads within agricultural lands could accelerate conversion and degradation of these lands. Surely, it can be a serious threat for rural development (Kamusoko *et al*., 2009(Gol, 2009)). As such, Planners need to consider and to coordinate land use and road planning together.

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