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Land Change Detection and Identification of Effective Factors on Forest Land Use Changes: Application of Land Change Modeler and Multiple Linear Regression

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Abstract

Reducing forest covered areas and changing it to pasture, agricultural, urban and rural areas is performed every year that makes great damages in natural resources in a wide range. In order to identify the effective factors on reducing the forest cover area, the multiple regression was used from 1995 to 2015 in the Mazandaran forests. A multiple regression perfectly enables to explain the relationship between reducing the forest area (dependent variable) and its influencing factors (independent variables). In this study, Landsat TM data of 1995 and Landsat ETM$^+$ data of 2015 were analyzed and classified to investigate the changes in forest area. The images were classified in two classes of forest and non-forest areas and also forest map with spatial variables of physiography and human were analyzed by regression equation. Detection satellite images showed that during the studied period there was found a reduction of forest areas up to approximately 257331 ha. The results of regression analysis indicated that the linear combination of income per capita, rain and temperature with determined coefficient 0.4 as independent variables were capable to estimating the reduction of forest area. The results of this study can be used as an efficient tool for managing and improving forests regarding to physiographical and human characteristics.

Keywords: Land change Modeler, Multiple linear regression, remote sensing, Mazandaran forests

Introduction

Land use always has been one of the most important factors through which man have impressed his environment. Usage is a key activity that man can provide the cause of social-economic growth and development through consuming natural resources and at the same time can change the existing structures and processes (Helming, 2008). Land use term usually defined more strictly and refers to the way in which, and the purposes for which, humans employ the land and its resources (William 2000). Land cover refers to the habitat or vegetation type present, such as forest and agriculture area. Land-use and land-cover change (LUCC) also known as land change is a term for the human modification of Earth's terrestrial surface. It is widely accepted that LULC have an important effect on both the functioning of the Earth's systems as a whole (Lambin et al. 2001) and the majority of ecosystems (Hansen et al. 2001; Millennium, 2005; Fischlin et al. 2007). This change is based on the purposes of need, which is not necessarily only making the change in land cover but also change in intensity and management (Verburget al. 2000). historically, the most important change in land use which is done by people, has been destroying forests and converting them into agricultural lands and habitats (Laosh and Herzabery, 2002). The values related to the goods and service that forest ecosystems present are evident. Forests present the vast domain of ecosystem service, from balancing carbon cycle till maintaining and wetting water cycle and maintaining genetic reservoirs and many other known and unknown materials (Selli, 2007). The amount of forest cover is changed during time, whether by natural factors or by the man himself that the most important factors of decrease in the level of these regions include: changing forest usage to agricultural and residential lands because of high ratio of population growth, using woods as the resource of fuel and energy by local people specially in bereaved sectors, roads, communication and power (electricity, gas, etc.), presence and cattle in forest arenas, firing and gradual destruction of forest and decrease in its vastness due to pollution of environment and warmness of earth (Ding Change, 1990). So it is determined that human activity is the most important factor of destroying forests. North forests of Iran and Alborz mountains have special importance with respect to scope and environmental issues, maintain water and soil resources that during past decades have lost their production capability because of the impact of social and economic factors, lack of comprehensive management of natural resources, it lost its production capability so that this procedure has compromised the future of forests of the region (Mahdavi; Fallah, Shamsi, 2012). So, for stable management and maintaining of these resources, knowing the extent and place of deforestation, the speed and surface, the causes and reasons of reducing forest land cover are necessary.

Remote sensing by satellite image provides an important resource of data related to usage and land cover (Rafiean et al, 2007). The data is used for detecting, quantifying and mapping local pattern of changes of land use (Abdolkavi et al, 2011). Not only the capabilities of analysis of geographical information can provide ground of analyzing the type, condition and extent of destruction, but only detecting forest land cover changes by remote sensing data in GIS medium can present suitable cognition of how the change forest land cover and recommend suitable strategies in its management (Baker et al, 2010). Regression relations is one of the using tools of planners to control the procedure of forest land cover changes. According to the fact that environmental science are dealt with different phenomena, so in ecological issues, multiple regression has much importance (Bihamta; Zare; Chahoki, 2011). The linear multiple regression is a technique to analyze the relation between some variables. In linear multiple regression, we assume that there is a linear relation between dependent and independent variables (Salman Mahini and Kamyab, 2012). Using remote sensing data and linear multiple regression equation in GIS medium provide suitable cognition of how to change forest land cover and determining the factors effective on it.

Mahapatra and Kant (2005) used least square regression method to study the changes of forest land cover in India, the results obtained of the model showed that increase in changing forest land cover has significant relation with increase in population, developing agricultural lands and the roads constructed in the region Rafiean et al (2007) conducted a research in west of Gilan province in order to study the changes of forests in Iran and to provide the backgrounds of evaluating protection programs for these forest. The comparison between the maps extracted of the maps of topography of 1374 and the new maps obtained of satellite in ages showed that 2465 hectare of forest level have been decreased (2.4 percent). Non-forest land invasion such as gardens and pastures, developing on-forest regions inside the forest and destructing forest domain resulted from developing factors, especially in northern borders of the forest are the factors of decrease Bagheri and Shataee Joybari (2010) were estimated the extent of destruction of forest land cover of Chehel Chay of Golestan province by satellite data and GIS. Studying the features effective on destruction forest by logistic regression showed that slope and distance from village have adverse relation with destructing the forest, so that with increase in height from sea level in this region, destruction has increased, so destruction has been more around high population villages. Zare Garixi et al (2012) were dealt with employing logistic regression method in modeling local pattern of contingency of charging vegetative cover in Auriferous district of Chehel Chay of Golestan province in which the results imply that the variables of distance from forest margin, distance to road, distance to village, land slope and distance to waterway have the most importance in relation with change in forest land cover in the studied aquifers district, respectively. Jafarzade and Arkhi (2012) were dealt with stimulating destruction in the forests of north of Iran. The objective of this study is to predict local distribution of deforestation and detect the factors effective on it in northern forest of Ilam province. In order to estimate local distribution of deforestation, logistic regression method was used for modeling. The results of modeling show that most deforestation has been occurred in discrete forest land cover and in the regions near to forest and non-forest border. Additionally, slope and distance from roads and residential regions have negative relation with the ratio deforestation. Miranda et al (2012) proceeded to model. The general objectives of the present paper are to estimate the land use changes over the time. For this study, analysis is performed by a remote sensing based Land Change Modeler (LCM) method. Based on past trend (from 1995-2015) of land use changes of Mazandaran Province and later, the study and determine the factors effective on changing forest land cover in the forest region.

Study Area

The Mazandaran forest (MF) located in the north-east region of Iran (See Fig. 1). The case study forests, extend from Babol in the middle of Mazandaran province to Behshar in the east and cover the northern slope of the Alborz Mountain with 350 km length and 20–70 km width. The annual growth of the forests differs with regard to the tree species, site, age and density and ranges from 2 to 8 m^3/ha in a year (Abbasi and Mohammadzadeh, 2010). The MF extends the region ranging from sea level to 2,800 m and mainly consists of mixed forests of Beech, Maple, Oak, Hornbeam, and Alder. The climate of the region is wet Mediterranean. The average annual temperature of the plateau region is 16–18 °C, with high relative humidity especially in the summer. Appropriate climatic conditions of the region have made it habitable to many hardwood species. More than 83 tree and 51 shrub species are recognized in the MF (Mohammadian, 2001; Abbasi and Mohammadzadeh, 2010). The forest area was estimated to be 1,295,237 ha in the past; today, however, it decreased to 794,014 ha [15% of the total forest area (12.4 million ha)] or 1.1% of the total area of Iran (Mohammadian, 2001). Forestry has a relatively long history in Iran, e.g., more than 80 years. Forest management runs on the basis of regulations documented in forest management plans and are provided by the FRWO (Forest, Range and Watershed Management Organization) of Iran. Planned forest management has a history of 40 years in Iran which looks young in comparison to experienced countries having at least 200 years of relevant practices. The areas of forest covered by the plans developed from 450,000 ha in 1988 to 1,300,000 ha in 2010 (Abbasi and Mohammadzadeh, 2010). Forest per capita is one of the environmental indices. In Iran, this index is 0.2 ha per person, while globally, it is 0.8 ha. This amount indicates poverty and shortage of our country. On the basis of FAO's statistics in 2011, forest areas of 149 and 45 countries were lower and larger than Iran, respectively. Unfortunately, despite the low per capita situation, about one-third of the forests (about 7 million ha) has been destroyed in the recent four decades, i.e., 200,000 ha annual deforestation. Of 200,000 ha of our forests, 45,000 ha belongs to MF (Abbasi and Mohammadzadeh, 2010). Reports showed that the rate of deforestation is 2.3% and 1.1% for north and other parts of the country, respectively (Agheli, 2003; Abbasi and Mohammadzadeh, 2010).

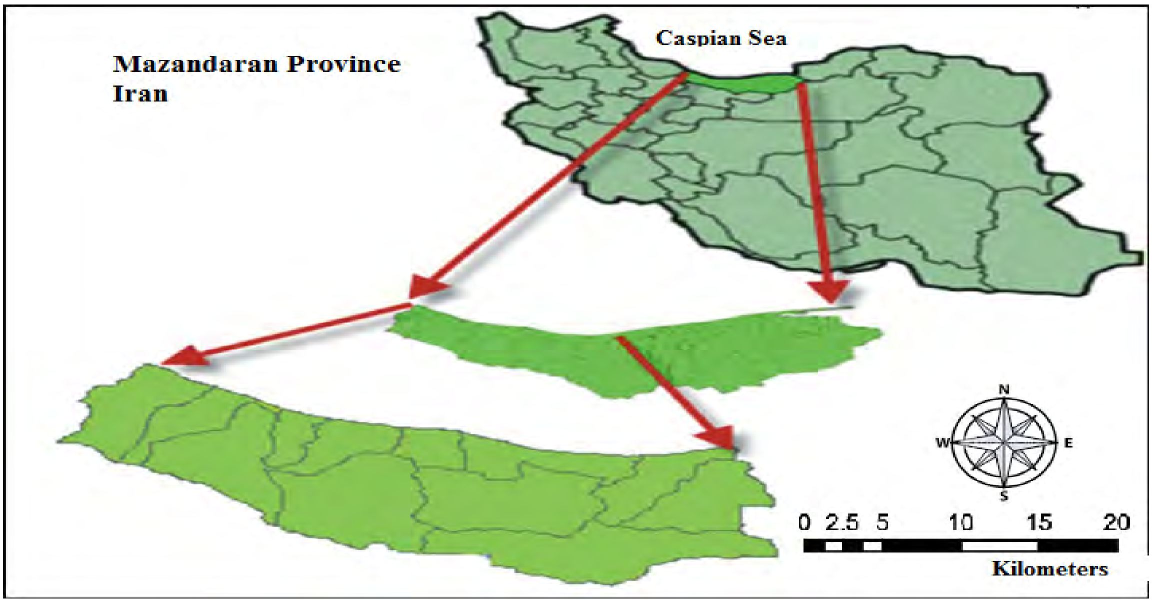

Figure 1: **Location Map of Mazandaran Forest, North of Iran**

Used data: In order to attain the qualified and qualified changes occurred in the forest region, measuring Landsat satellite images TM of 1988 and ETM (Enhanced Thematic Mapper Plus) of 2007 were used which both are related to column 167 and row 39. Similarly, topographic maps with scale 1:50000 related to 2015 prepared by the geographical organization of Army to make EDM (Digital Elevation Model), Selecting the land control points to perform geometrical corrections and evaluating the accuracy of classifying satellite images as well as preparing road data and residual regions, were used.

Classifying satellite images: In this research each image related to both temporal domains was classified through the supervised classification. Educational samples were selected by suitable transmittance proportional with condition of homogeneity of covering classes of two forest and non-forest classes so that these samples imply all properties of the existing condition in both given classes. After selecting suitable educational samples the size of resolution and contrast between classes was studied. Usually contrast between two classes implies that those two classes have the most statistical distance and the highest possibility for the accurate classifying. To measure the extent of resolution of classes towards each other, divergence criteria was computed. It should be considered that the method of maximum classifying of contingency is the most common (Darvish sefat and Pire Bavaghar, 2012) and the most accurate method among the existing classifying method (Zabiri, Majd, 2011). According to this issue, classifying was done with maximum contingency.

Preparing the map of earth reality: In this study, in order to prepare the map of earth reality, 170 samples were selected in forest and non-forest regions in random on the images obtained of classifying in the regions that haven't changed in the image of both periods. The place of samples was localized by colored combination images related to both periods as well as the images captured by Google Earth and was codified. In order to evaluate the map of earth reality, a sample with the results of classifying was converted to raster format. The results obtained of classify by the method of maximum contingency were evaluated by the made earth reality map and general accuracy and kappa coefficient of each were obtained.

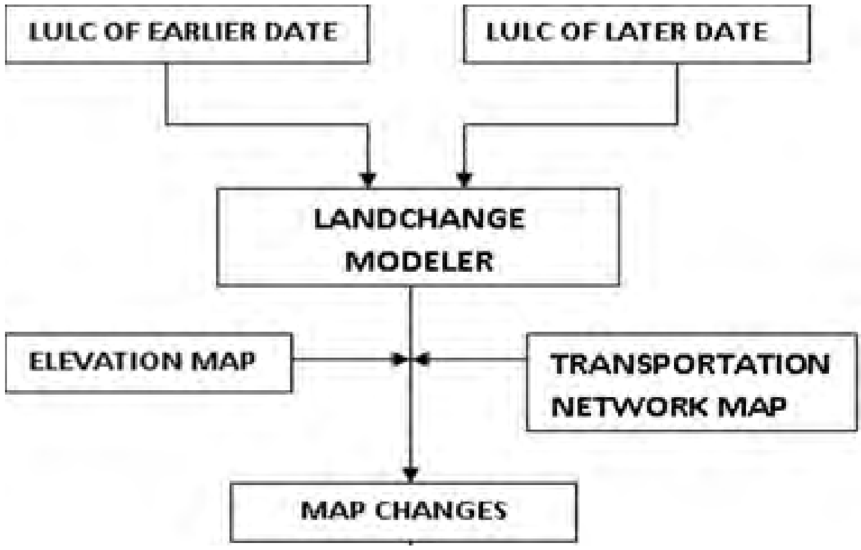

Figure.2 Flow Chart Showing the Methodology (Step 1)

Linear multiple regression: in linear multiple regression, we assume that there is a linear relation between dependent variables and independent variables. By having in dependent variable, linear multiple regression equation will be as equation 1.

$$Y = a + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_n x_n \quad (1)$$

In which Y is dependent variable, x_1, $x_{2...}$ x_n dependent variables, b_1, b_2… b_n are coefficient of dependent variables. The constant coefficient a represents the value of Y in the time being Zero of all dependent variables, also the coefficients of parameters state the change in Y for one unit increase in the related dependent variable (Istman, 2012). In this study, the map of destructing forest land cover as dependent variable from residual regions as well as direction of slope as effective parameters in the procedure of decrease in forest land cover as dependent variables in establishing the linear multiple regression relation. In order to evaluate linear multiple regression model determination coefficient (R^2) and root mean square error (RMSE) were used. By determination coefficient, it is determined that how much the changes of dependent variable is related to independent variable. The root mean square error is the difference between the expected value by the model or statistical estimator and real value that in general is obtained by equation 2:

$$\text{RMSE}=\sqrt{\frac{\sum_{i=1}^{n}(y_{obs}-y_{model})^2}{n}} \quad (2)$$

In the above relation y_{obs} and y_{model} are observed value and estimated value by model respectively and n number of data (Chang et al, 2005)

Results

After determining the extent of resolution of the classes, it is proceeded to classify the related measuring images, the results of the extent of resolution of forest and non-forest classes by divergence criteria represent the suitable segregation of classes of land cover in this study (Table 1).

Table 1: The degree of separation of land cover classes using the divergence criterion

Land use classes	Separability value	Separability statue
Forest	1.99843	Good
Others	1.98742	Good
Average Separability of all classes	1.99439	Good

The results of evaluating the accuracy of the classified images have been given in Table 2. According to the high values of Kapa coefficient (0.87), we can use these images (Fig. 3 and 4) to study the decrease in forest land cover of Mazandaran Province.

Table 2: The accuracy assessment of the satellite images classification

1995		2015	
General accuracy	Kapa coefficient	General accuracy	Kapa coefficient
88%	0.88	87%	0.85

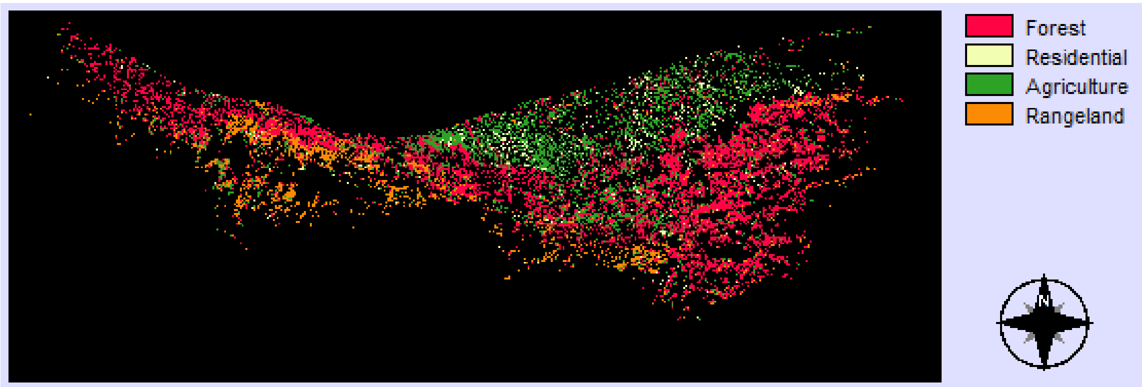

Figure 3: Land use map of study area for 1995

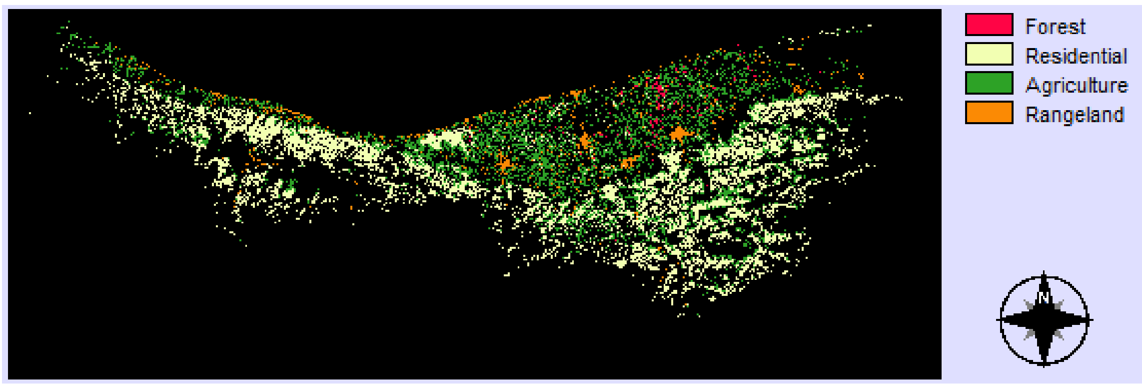

Figure 4: Land use map of study area for 2015

The results of classifying showed that of whole surface of the region, about 268901 hectares were covered by forest and 239113 hectares were covered by non-forest lands, in 1995; while the surface area of forest have been 11570 hectare in 2015 (Table 3). The result of comparison between two maps related to the beginning and end of temporal period show that 257331 hectare of forest regions have been decreased. It should be stated that according the information acquired by stated that according the information acquired by natural resources and aquifer administration of Mazandaran Province during the study period, none forestation was done in this region. The value of gains and losses and net changes in forest and non-forest land use have been shown in Fig. 5 and 6.

Table 3: Rates of change in forest cover area in 1995-2015

Land use classes	Area of 1995 (HA)	Area of 2015 (HA)	Area of Changes (HA)
Forest	268901	11570	-257331
Others	239113	496444	257331
Total	508014	508014	-

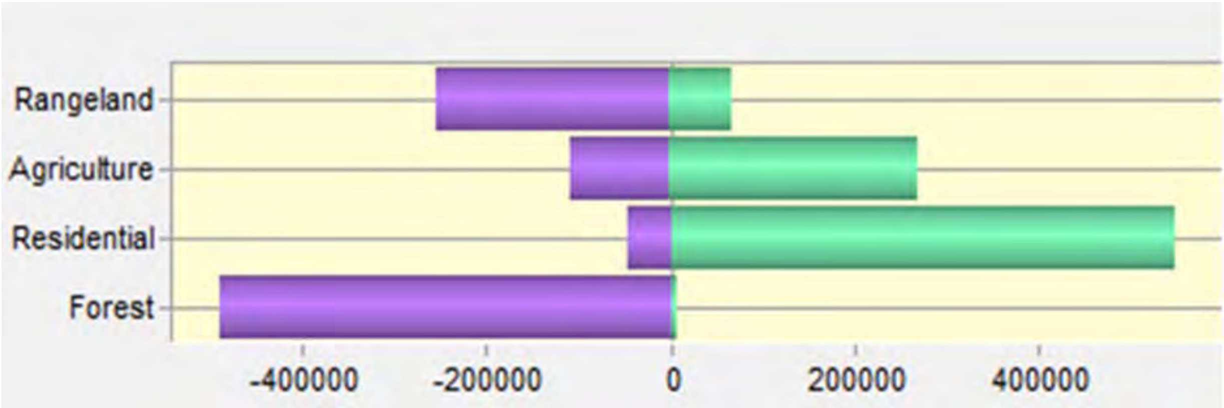

Figure 5: Gain and lose of land uses from 1995-2015

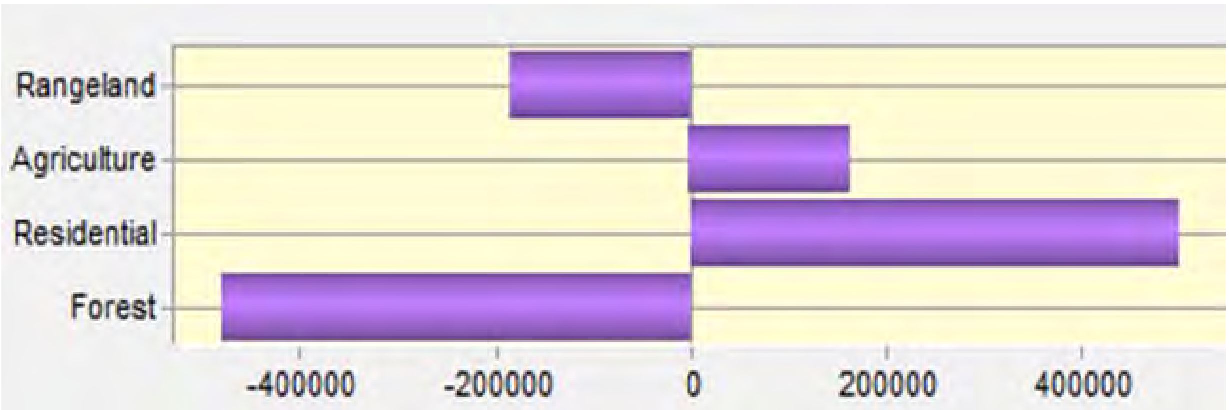

Figure 6: Net change of land uses from 1995-2015

After determining the condition and extent of regions of decrease in forest land cover, linear multiple regression was used to determine the relation of the factor effective on decrease in forest land cover Digital elevation data, distance from residual regions, distance from road and direction of slope as dependent variable were made in GIS medium, then the relation of linear multiple regression was established as dependent variable with the mentioned parameters that has been shown in Table (4).

Table 4: Results of Multiple Linear Regression Model

	a	b_1x_1	b_2x_2	b_3x_3	b_4x_4	R^2	$R^2_{(adj)}$	RMSE	RMSE (adj)
Forest Land Changes (ha)	-0.0018	0.04(X_1)	0.047(X_2)	-0.06(X_3)	-0.01(X_4)	0.4	0.356	0.652	0.592
X_1: Income per capita; X2= Population; X_3=Rain; X_4=Temperature									

By determine coefficient, it is determined that how much the changes of dependent variable is related to independent variable (Bihamta & Zare, 2011). According to the value of determination coefficient which equals 0.4, we can say that 38.89% of decrease in forest land cover in hectare have been made by independent variables and the value of RMSE shows that the contingency of model error is 0.652 hectare. According to the fact that the value of computed F (5.92) is larger than F of table with freedom degrees of 1 and 37 in the significant level of 5% (2.62) (Table 5), so we can claim that there is a significant linear relation between dependent and in dependent variables in the possibility level of 95%.

Table 5: Variance analysis of Multiple Linear Regression

	d.f.	Sum of squares	Mean of squares	F	sig
Regression	4	8012.6	2004.16	5.91	5%
Residual	37	12590.7	344.28		
Total	41	20603.3			

The values of t-statistics from T-student table are extracted for freedom degree 37 which is used to test the significance of dependent variables. According to the fact that the t-value extracted from the table for level of significance 99% and 8% with freedom degree of 37 are 2.62 and 1.2 (Table 6). It can be concluded that since the t-value of variables elevation from sea level, distance from road and direction of slope are higher than 2.62 , so the impact of these variables on change in forest cover is very significant, while the variable temperature is less significant.

Table 5: Comparison of the significance levels of independent variables

Variables	t from T-Student	t from Multiple Linear Regression	Sig. level
Income per capita	2.62	18.45	99%
Population	2.62	6.88	99%
Temperature	1.2	1.39	80%
Rain	2.63	5.32	99%

In order to determine the significance of in dependent variable, sensitization of the model was measured. Measuring the sensitization of the linear multiple regression model was done so that after performing the model with complete data series, the model is performed again for the number of in dependent variable, with the difference that this time in each stage of performing the model, one of the in dependent variables is omitted and the model is performed by the residual in dependent variables (Salman Mahini and Turner, 2003). The advantage of this affair is in measuring the sensitivity of variables and discovering the value of impact of variables in the final model. Each time after performing the model, the value of determination coefficient is extracted and the impact of in dependent variable is computed based on the difference obtained by complete data series. The in dependent variables of income per capita, population and rain have determinant effect on the extent of model efficiency because omitting these variables decrease the value of index determination coefficient significantly.

Discussion and Conclusion

This research was conducted with the objective of determining the factors effective on decreasing forest land cover in forest region of Mazandaran province. The impact of four factors income per capita, population, rain and temperature were studied on the extent of decrease in forest land cover. In order to determine the relation of mentioned factors with decrease of forest land cover, linear multiple regression statistical method was used. According to the outputs of regression equation and the value of its F, we can claim that there is a significant relation between dependent and in dependent variables, so that t-value obtained of linear multiple regression equation shows that these four factors have less significant relation with forest land cover. The value of determination coefficient shows that 38.89%of decrease of forest land cover has been conducted in forest region of Mazandaran province by in dependent variables.

According to the fact that the in dependent variable of income per capita have the highest coefficient in linear multiple regression equation, is considered the most important factor in decreasing forest land cover and the result show that by increase in income per capita more destruction has been occurred that this issue is returned to develop rural, urban and tribes population in income per capita (Gole et al, 2006). So , it can have significant effect an absorbing the factors of destruction so that residential regions, lands under cultivation, pastures suitable to feed cattle and suitable entertaining regions are placed in middle heights of the studying region, so these regions are more exposed to destruction. Baheri and Shataee (2010) and Mass et al (2004) in their research have shown that the extent of destruction increase with the increase in elevation from sea level that it confirms the results of our research. The coefficient of population is positive that shows destruction in flat lands that are suitable for agriculture and constructing home as well as east and south because of having heat and grass cover are more invaded than other directions. According to the conducted field studies of forest region of Mazandaran, it is observed that density of forest trees is more in northern directions and the presence of non-forest stains in these regions is less than other directions. Similarly, it was observed that destruction in east and south and flat lands has been occurred more than other direction because of having heatless, grass cover, and being susceptive for agriculture, feeding cattle, and constructing houses, it seems that increase in number of travels and the factor entertainment also can be another factor of destruction in this direction.

These results are consistent with the research by Amini et al (2009) and Jafarzadeh and Arkhi (2012) in which they stated that southern and eastern direction have the most and northern directions have the least amount of destruction. The third effective factor is related make roads in the region, that according to the fact that the process of making road leads to destruction in forest arenas in the path of its construction, this facilitates access to forest resources that has been lead to decrease in forest land cover in the region, Additionally, the regions near to the road have been undergone more changes than remote regions due to access facility; that the issue is consistent with the results of researches by Matte et al (2004) and Maryam and Taylor (2010) who stated making road as the main factor of destruction of forest in its studying regions. Positive coefficient of variables of distance from residential regions represents direct impact of this variable in reducing forest land cover in Mazandaran that means that by approaching to this variable, the amount of destruction increase. Increase of residential centers have direct effect on reducing forest. So that forest land cover in cities for developing the city has been converted to man-made places and in villages, the forest around the village has been destructed with the objective of preparing land for grazing cultivating agricultural crop and grazing cattle, as well as providing fuel by villagers. So that Var et al (2006) have confirmed the distance from residential centers as the effective factor in the procedure of changes in forest.

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