Journal of Agricultural Economics and Development

Homepage: https://jead.um.ac.ir

Full Research Paper
Vol. 36, No. 2, SUmmer 2022, p. 115-128

The Effect of Socio-Economic Dimensions on Deforestation: Application of Spatial Econometrics

H. Amirnejad[1*], A. Mehrjo[2], M.H. Eskandarinasab[3]

Received: 13-06-2020 Revised: 17-07-2021 Accepted: 19-02-2022 Available Online: 06-09-2022	**How to cite this article:** Amirnejad H., Mehrjo A., and Eskandarinasab M.H. 2022. The Effect of Socio-Economic Dimensions on Deforestation: Application of Spatial Econometrics. Journal of Agricultural Economics & Development 36(2): 115-128. **DOI:** 10.22067/JEAD.2022.17787.0

Abstract

In the second half of the twenty-first century, economic change, population growth and globalization were the main factors driving the deforestation in the South Asian countries. To identify the effects due to socio-economic factors affecting deforestation in such countries, this study applied the spatial econometrics model based on data from 18 selected countries for the period between 2005 and 2015. The spatial correlation tests were showing that ignoring the effects of spatial correlation cause bias in results. The results of the model also confirmed the environmental Kuznets curve hypothesis for the selected countries with a turning point of $ 5,107. Our findings illustrated that increasing GDP per capita in neighbouring countries through interregional mobility of inputs of production will increase deforestation in the target country. The increase in the exchange rate in neighbouring countries due to the increase in imports of forest products and the non-cutting of domestic forest resources will reduce deforestation in the target country. Increased population density and unemployment in neighbouring countries due to reduced job opportunities and increased migration to the target country, followed by increased demand for food and increased land demand, led to increased deforestation in the target country. Finally, increasing the human development index variable has reduced deforestation in the target country. However, changing this variable in neighbouring countries has not affected the deforestation of the target country. Therefore, in a world with increasing economic growth, it is suggested that to prevent deforestation by improving the human development index, eradicating the problem of unemployment, and eradicating poverty redouble efforts. As the results of this study showed, the population had a direct and significant effect on deforestation in selected countries. Due to the increase in population growth in different years, it is recommended that the population issue be given more attention by looking at the requirements of sustainable development to reduce environmental degradation, mainly deforestation. Because according to the results of this study, the lack of rapid population growth reduces deforestation in selected countries.

Keywords: Deforestation, Spatial econometrics, Spatial Kuznets curve, Sustainable economic development

1 and 2- Professor and Ph.D. Student of Department of Agricultural Economics, Sari Agricultural Sciences and Natural Resources University, Sari, Iran, respectively.
(*- Corresponding Author Email: h.amirnejad@sanru.ac.ir)
3- M.S. of Department of Agricultural Economics, Faculty of Agriculture, Tarbiat Modares University (T.M.U), Tehran, Iran

Introduction

Increased human activity has led to a significant reduction in forest areas through deforestation (Lewis *et al*., 2015). Deforestation began about ten thousand years ago with the advent of agriculture and ancient civilizations, but its speed has increased with the increasing population (Angelsen, 1999). Today, deforestation is one of the most critical environmental issues of the 21st century, causing drastic climate change (Van der Werf *et al*., 2009). Estimates show that deforestation is the second-largest source of greenhouse gas emissions after fossil fuels (Stern and Stern, 2007). According to the FAO in 2015, population growth, and increasing demand for food products, has reduced the world's forests in the last 25 years from about 4.1 billion hectares to less than 4 billion hectares, which means a 3.1 Percentage reduction (FAO, 2015). Because of the issue's importance, the United Nations has recently stepped up its efforts to prevent deforestation, rehabilitate degraded forests, and achieve the Sustainable Development Goals by 2030 (Morita and Matsumoto, 2017).

According to global statistics, in the 1980s about 15.4 million hectares (FAO, 2015) and from 1990 to 1995, 12.7 million hectares (FAO, 1997) and in the 1990s to 2000, 9.391 million hectares (FAO, 2003) and from 2000 to 2015, 7.6 million hectares (FAO, 2015) of tropical forests were lost annually. Given that 80% of the world's known plant and animal species live in forests (FAO, 2003), deforestation is undoubtedly a severe crisis. Asia has 571577 thousand hectares or 18.5% of the world's forests. Overall, between 1990 and 2005, Asia lost 0.5 percent of its forests (FAO, 2005). World forest per capita decreased from 0.8 hectares in 1990 to 0.6 hectares in 2015, while the forest per capita in Asia is only 0.2 hectares. Figure (1) shows the trend of net deforestation as a percentage of gross national income from 1980 to 2018 for different world regions. As can be seen, this trend is increasing with a steeper slope for sub-Saharan Africa and with a lower slope for South Asia (World Bank, 2020).

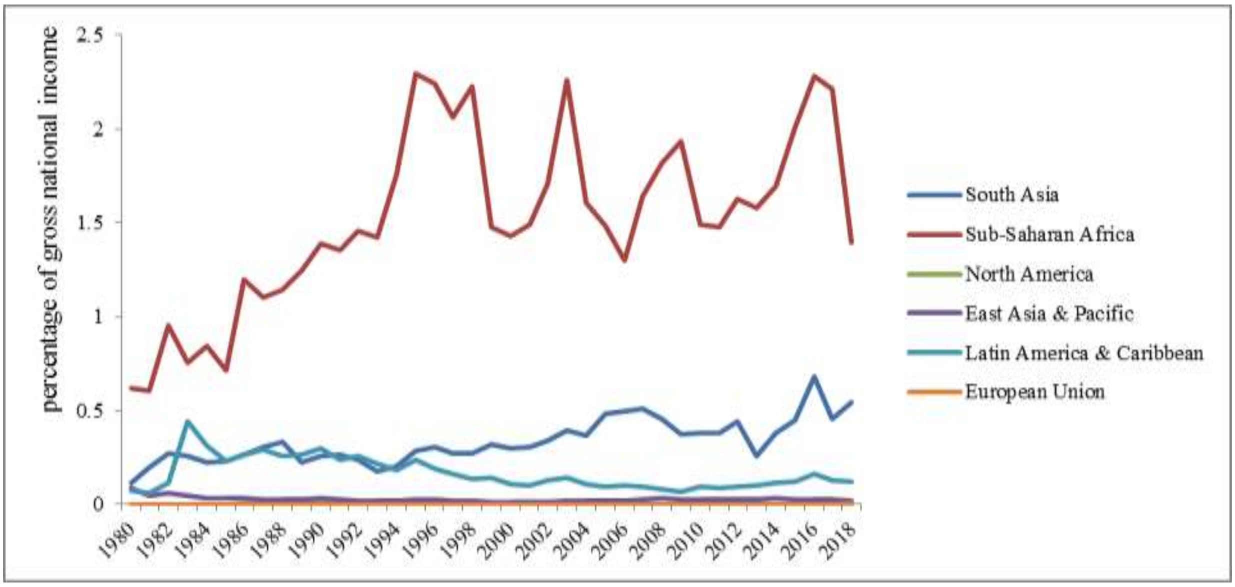

Figure 1- The trend of the net forest depletion from 1980 to 2018

In addition, deforestation reduces the value of the forest as a source of environmental diversity, carbon storage, and timber production and alone causes an annual reduced emission of 25% of carbon dioxide and 15% of greenhouse gases (Heerink *et al*., 2001). Accordingly, various studies worldwide have been conducted in different ways on the causes of deforestation, some of which are mentioned.

Koop and Toole (1999) examined the relationship between economic development and deforestation using panel data from developing countries, including Asia, Latin America, and Africa. They used two models with fixed effects for 66 countries from 1962 to 1986 and one model with random effects for 76 tropical developing countries from 1961 to 1992. Explanatory variables used in the model include GDP per capita, population distribution, population change rate, and GDP growth rate. Their results did not confirm the existence of the Environmental Kuznets Curve (EKC) for deforestation. Mahapatra and Kant (2005) investigated deforestation in the tropics using multiple logistics models. They obtained more results than the dual logistics model and the ordinary least squares (OLS) method using this model. Finally, they concluded that population growth, agriculture, and road construction are the main factors of deforestation.

Culas (2007) examined the impact of institutional factors and deforestation and analyzed the environmental Kuznets curve across Latin America, Africa, and Asia. The explanatory variables studied were agricultural production, population, economy and government policies. The results show that better property rights and environmental policies reduce deforestation rates without hindering economic growth. Boubacar (2012) examined the determinants of deforestation in 24 sub-Saharan African countries using spatial econometric methods from 1990 to 2004. The results showed a positive correlation between deforestation of a country and neighboring countries. In Indonesia, Wheeler *et al.* (2013) investigated deforestation using spatial econometric analysis. Their study aimed to examine short-term changes in prices, demand for wood products, exchange rates, interest rates, the opportunity cost of forest land, quality of government, poverty, population density, infrastructure, and transportation costs. The results showed that all economic variables are significant on deforestation. Faria and Almeida (2016) examined how international trade has affected deforestation change in the Brazilian Amazon. Their analysis was based on the expansion of agricultural products, livestock activities and GDP per capita. Using panel data from 2000 to 2010 and spatial econometrics, they found that international trade increased deforestation; also, property rights significantly impact deforestation, and deforestation increases with increasing GDP. Reddy *et al.* (2018) assessed deforestation in South Asia since the 1930s using satellite data and remote sensing. The region includes seven countries: India, Bangladesh, Bhutan, Nepal, Pakistan, Afghanistan, Sri Lanka, and the Maldives. The results showed that 29.62% of forest cover was lost in these countries.

A study of the existing literature shows that before 2004 no study has been conducted to investigate the relationship between environmental quality and economic growth in Iran. The oldest research in this field is the study of Sadeghi and Saadat (2004). Using time-series data from 1987 to 2001 and the causality test method, these two researchers estimated the causal relationships between economic growth, population growth, and environmental pollution. After that, much research was done on economic growth and environmental degradation. These include the studies of researchers such as Salimifar and Dehnavi (2010), Daryani (2015), Alishiri *et al.* (2017), Hoseini *et al.* (2018), and Mansorabadi and Khodaparast (2019) to study the effect of economic growth on quality the environment has done using modern econometric methods.

A review of past studies shows that the study of socio-economic factors of deforestation in Iran using spatial econometrics has not been studied; however, studies in this field have been done by examining the environmental Kuznets curve and specifying the deforestation function as a panel by Nasirnia and Esmaeili (2009, 2008). In the first study, based on Kuznets environmental theory, the definition of deforestation function for Iran and five neighboring countries was done as a panel. The results of this study showed that in Asia, the hypothesis of the existence of the environmental Kuznets curve for selected countries is rejected, and the only variable affecting the deforestation process in this function is the population variable. Also, in the second study, using environmental Kuznets curve theory, the factors affecting deforestation were examined for 71 selected countries. The results showed that the environmental Kuznets curve hypothesis is not valid for selected countries.

There is disagreement about the factors affecting deforestation. Culas (2007) believes that in many low-income countries, high population density and extreme poverty are the leading causes of deforestation and increasing demand for forests and agricultural products. Allen and Douglas (1985) showed that deforestation results mainly from high population growth and timber exports. Bohn and Deacon (2000), Ferreira (2004), and Mendelsohn (1994) argue that high deforestation rates in countries are linked to weak institutions and a lack of definition of property rights. Humphreys (2004) believes that the influx of multinational corporations and the intensification of foreign debt will increase the gap between rich and emerging countries and lead to more deforestation in poorer countries. Lopez and Galinato (2005) identified income, trade, macroeconomic policies, population, and geographical conditions as essential and immediate causes of deforestation.

According to the World Bank, in 2018, about 766 million people in Asia live below the poverty line ($ 1.9 per day) (World Bank, 2016). Therefore, given the high population, high poverty, and low forest per capita, preventing deforestation is a vital issue that needs to be examined. Accordingly, given that a large proportion of deforestation has taken place in the southern half of Asia (FAO, 2015). In this study, the socio-economic factors affecting deforestation will be examined in Japan, China, Singapore, Indonesia, Bangladesh, Thailand, Philippines, Malaysia, Vietnam, India, Iran, Pakistan, Uzbekistan, Tajikistan, Kazakhstan, Kyrgyz Republic, Azerbaijan and Armenia with the use of spatial econometrics. Other countries in the southern half of Asia were not surveyed due to a lack of data.

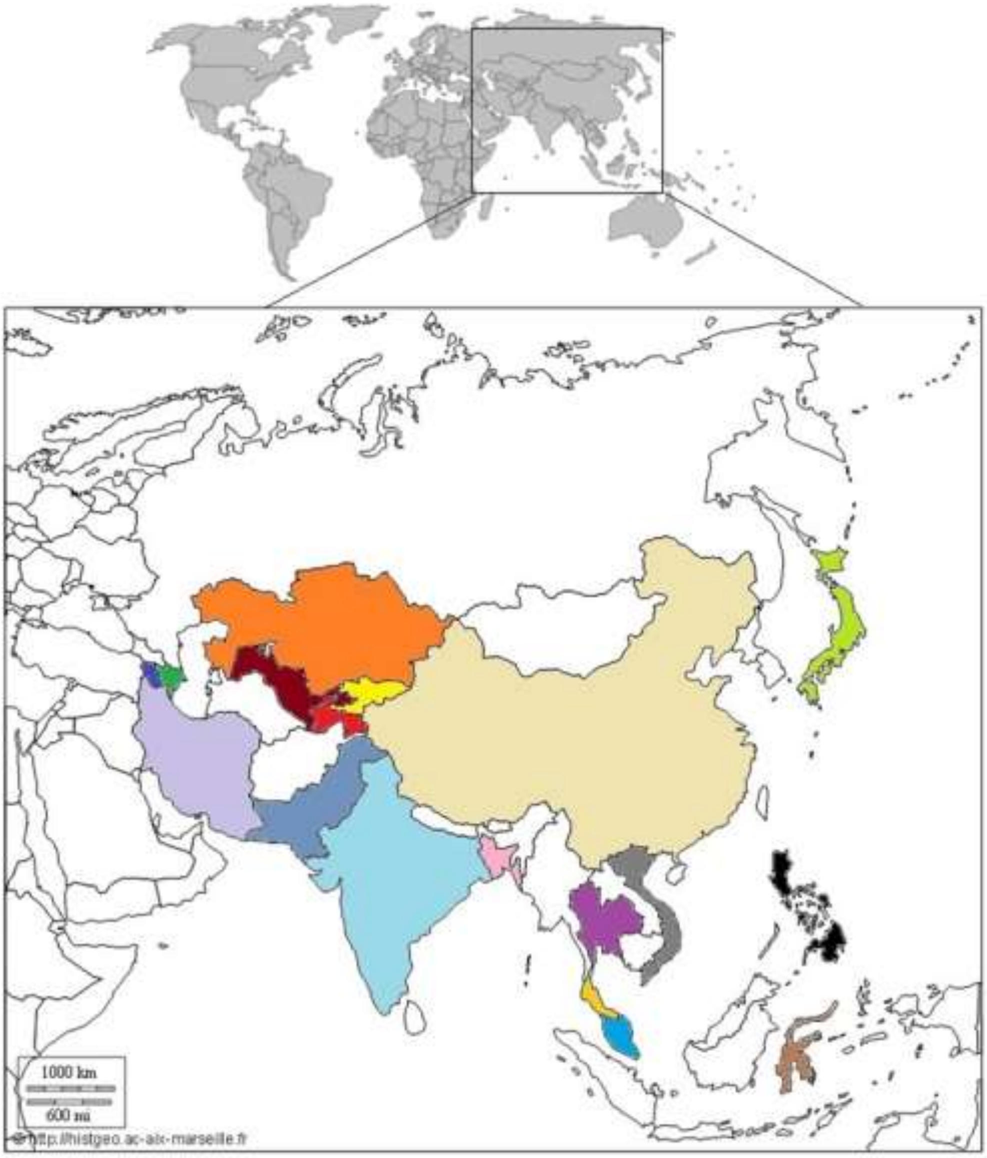

Figure 2- Spatial distribution map of 18 selected countries in the South Asia

Materials and Methods

The general form of the cross-sectional deforestation function for N countries is according to the equation (1) (Allen and Douglas, 1985).

$$i = 1, 2, \ldots, n$$

$$F_i = a + \sum_{j=1}^{k} \beta_j X_{ij} + \varepsilon_i \qquad (1)$$

where, F_i is the forest area of the country *i*, X_{ij} is the explanatory variable *j* affects the deforestation process in country i, α and β are the constant and the slope, respectively.

According to Anselin and Bera (1998), the conventional econometric method based on Gauss–Markov theorem is not suitable for regional studies because the explanatory variables are constant in a repetitive sampling. There is also an individual linear relationship between the observations in the data. Such assumptions are consistent with time-series data, but regional study data encounter two phenomena and the problem of spatial dependence between observations and spatial heterogeneity in the model. Spatial dependence violates the first hypothesis (The average error term is zero), and spatial heterogeneity leads to violation of the second hypothesis (lack of autocorrelation between error terms). Conventional econometrics largely ignores these two issues. Therefore, three standard spatial econometric models were introduced that explain the y-changes as a linear combination of adjacent areas and consider what is happening in adjacent areas as important. These models are the spatial lag model (SLM), spatial error model (SEM), and spatial Durbin model (SDM) (LeSage and Pace, 2009; Hao *et al*., 2016; Lv and Li, 2021). The SLM is expressed as Equations (2) and (3) when the dependent variable is spatially correlated with its lags.

$$y = \rho Wy + X\beta + \varepsilon \qquad (2)$$

$$\varepsilon : N(0, \sigma^2 I_N) \qquad (3)$$

When the dependent variable is spatially correlated with the error term of the equation, the SEM is expressed as Equations (4), (5), and (6).

$$y = X\beta + u \qquad (4)$$

$$u = \lambda W_u + \varepsilon \qquad (5)$$

$$\varepsilon : N(0, \sigma^2 I_N) \qquad (6)$$

Finally, when the dependent variable is spatially correlated with its lags and the error terms, the spatial Durbin model is expressed as Equations (7) and (8).

$$y = \rho Wy + X\beta + WX\theta + \varepsilon \qquad (7)$$

$$\varepsilon : N(0, \sigma^2 I_N) \qquad (8)$$

In the above equations, *y* is a vector $(n \times 1)$ of dependent variables. *X* is a matrix $(n \times k)$ of explanatory variables. λ is a spatial lag parameter. β and θ are a vector $(k \times 1)$ of trend parameters. ρ is a spatial auto regression parameter. *W* is also a spatial weight matrix $(n \times n)$ with elements W_{ij} , defined as equation (9):

$$S_0 = \sum_{i=1}^{n} W_{ij} = 1 \qquad (9)$$

The elements of this matrix are such that they take the number one and otherwise the number zero for both countries with a common border. Since a country cannot be its own neighbor, the elements of the original diameter are all zero. To show the spatial correlation, Moran's I and Wald tests are used, such as equations (10) to (13) (Florax *et al*., 2003).

$$I = \left[\frac{n}{S_0}\right] \times \left[\frac{(z'Wz)}{z'z}\right] \qquad (10)$$

$$t_1 = tr\left(W \times B^{-1}\right) \qquad (11)$$

$$t_2 = tr\left(WB^{-1}\right)^2 \qquad (12)$$

$$t_3 = tr\left(W \times B^{-1}\right)'\left(W \times B^{-1}\right) \qquad (13)$$

In the above equations, *z* is a vector $(n \times 1)$ of observations. Also, *B* is equal $(I_n - \lambda W)$ and, λ represents the maximum likelihood estimator. Moran's test has two interpretations: A) the positive value of the Moran test statistic indicates positive spatial autocorrelation, and the closer the values are to +1, the more complete the correlation. B). The negative value of Moran's test statistic indicates the phenomenon of negative autocorrelation, and the closer the values are to -1, the more complete the scattering indicates. Also, the values of zero represent a random spatial pattern. The null Hypothesis of the Wald test also shows spatial autocorrelation. Lagrange Multiplier Lag and Lagrange Multiplier Error tests also are used to detect spatial correlation independent variable observations and spatial correlation in error terms, respectively. Suppose the null hypothesis of spatial non-correlation is rejected in the observations of dependent variables. In that case, the spatial lag model is used, and if the null hypothesis of spatial non-correlation in error terms is rejected, the spatial error model is used. If both null hypotheses are rejected, the spatial Durbin model is used to estimate (Hamidi, 2015; Mahmodpor *et al.*, 2018, Hao *et al.*, 2016).

The most important application of the SDM is in the study of spatial spillover; because, according to the study of Anselin (1988), the direct effect is obtained by using the partial derivative, the effect of increasing the explanatory variable in country *i* on the dependent variable of country *i* (the partial derivative is equal to $\frac{\partial y_i}{\partial x_i}$). Also, in this model, in addition to the spatial lag variable, the product of the standardized spatial weight matrix in the vector of explanatory variables creates a new variable that shows the average effect of explanatory variables of other countries on the dependent variable of the target country. In other words, it shows the effects of spatial spillover of neighboring countries. The total effect of increasing the explanatory variable on all study areas equals the sum of direct and indirect effects.

Taking into consideration the spatial relationships between the variables in the equation, the relationship between economic development and deforestation will also be dependent on the location of environmental impacts. If the relationship between deforestation and economic growth is confirmed, three turning points can be estimated as Equations (14), (15), and (16) (Balado-Naves *et al.*, 2018; Caravaggio, 2020; Khezri *et al.*, 2021).

$$GDP = e^{-(\beta_1 / 2\beta_2)} \tag{14}$$

$$GDP = e^{-(\rho_1 / 2\rho_2)} \tag{15}$$

$$GDP = e^{-((\beta_1+\rho_1) / 2(\beta_2+\rho_2))} \tag{16}$$

$$\hat{\eta} = \frac{\partial LnF}{\partial LnGDP} = \hat{\beta}_1 + 2\hat{\beta}_2 LnGDP \tag{17}$$

Equation (14) represents a direct turning point that can only be estimated by considering the GDP of the target country. Equation (15) represents the indirect turning point which is estimated only by considering the GDP of neighboring countries, and finally, Equation (16) represents the total turning point which is obtained by considering the GDP coefficients of the target country and neighboring countries. Equation (17) is also used to calculate income elasticity. $\hat{\beta}_1$ and $\hat{\beta}_2$ represents the coefficient of variable *LnGDP* and *(LnGDP)*^{2} respectively.

In this study, according to the studies of Boubacar (2012), Miyamoto (2020) and Santiago and do Couto (2020), this model was used as a relation (18):

$$\begin{aligned} \ln F_{it} &= \beta_0 + \beta_1 \ln GDP_{it} + \beta_2 (\ln GDP_{it})^2 + \\ &\beta_3 \ln EXC_{it} + \beta_4 \ln POP_{it} + \beta_5 \ln UNEM_{it} \\ &+ \beta_6 \ln HDI_{it} + \beta_7 \ln AGRI_{it} + \varepsilon_{it} \end{aligned} \tag{18}$$

In equation (18), F_{it} Forest area of country *i* at year *t*, GDP_{it} GDP per capita of country *i* at year *t*, $(GDP_{it})^2$ GDP per capita square of country *i* at year *t*, EXC_{it} exchange rate of country *i* at year *t*, POP_{it} population density of country *i* at year *t*, $UNEMP_{it}$ unemployment rate of country *i* at year *t*, HDI_{it} Human Development Index of country *i* at year *t*, $AGRIP_{it}$ Agricultural product price index of country *i* at year *t* and ε_{it} indicates error term. To achieve accurate results, natural logarithms were taken from all variables used. Data on forest area, GDP per capita, exchange rate, population density, and unemployment from the World Bank, agricultural price index from the FAO database and data on the Human development index were collected from hdr.undp.org. The above data were analyzed in MATLAB software.

Results and Discussion

To estimate the model according to the latitude and longitude coordinates of observation, a standardized spatial weight matrix is defined, which indicates the spatial dependence between the selected countries. Each row of this matrix represents a set of spatial dependencies related to one of the countries (Figure 2).

Rows and columns 1 to 18 in the top matrix represent Japan, China, Singapore, Indonesia, Bangladesh, Thailand, Philippines, Malaysia, Vietnam, India, Iran, Pakistan, Uzbekistan, Tajikistan, Kazakhstan, Kyrgyzstan, Azerbaijan, and Armenia, respectively. If a country is spatially related to another country, it is indicated by the number one in the matrix. Since no country can have a spatial dependence on itself; therefore, all numbers on the original diameter of the matrix are zero.

Moran and Wald tests are used to determine the existence or absence of spatial effects, and the outcomes of these two tests are shown in Table 1.

$$\begin{bmatrix}
0 & 1 & 0 & 1 & 0 & 0 & 1 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\
1 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 1 & 1 & 0 & 0 & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
1 & 1 & 0 & 0 & 0 & 1 & 0 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 1 & 0 & 1 & 1 & 0 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
1 & 1 & 0 & 0 & 0 & 1 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 1 & 0 & 1 & 1 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 1 & 1 & 1 & 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 & 1 & 1 & 0 & 1 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 1 & 0 & 0 & 0 & 0 & 1 & 1 \\
0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\
0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 1 & 1 & 1 & 0 \\
0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 0 & 1 & 0 & 1 & 0 & 1 & 0 \\
0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 0 & 1 & 1 & 0 \\
0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 1 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 1 & 0 & 1 & 0 & 0 & 1 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 1 & 0 & 1 & 0
\end{bmatrix}$$

Figure 2- Representation matrix of selected countries in the southern half of Asia

Table 1- Moran's I and Wald test results

Statistics	Statistics value	Statistics	Statistics value
Moran's I	0.9535	Wald	1593.8
Average I	-0.0177	Significant level	0.0000
Variance I	0.0020	χ^2 distribution	6.63
Significant level	0.0000		

Source: Research findings

The rejection of null hypothesis of Moran's I and Wald tests confirmed the spatial autocorrelation effects. As can be seen, the null hypothesis has been rejected in both tests; Therefore, spatial econometrics should be used. According to the results of Table 1, it is observed that the value of Moran test is 0.9535, positive and shows a positive spatial autocorrelation in selected countries.

Table 2- Results of Lagrange Multiplier (LM) tests

Statistics	Statistics value	Significant level	X^2 distribution
LMERROR	83.79	0.0000	**6.64**
LMLAG	324.93	0.0000	**6.64**
LMERROR(Robust)	33.82	0.0005	**6.64**
LMLAG(Robust)	244.96	0.0000	**6.64**

Source: Research findings

Table 2 displays the results of Lagrange Multiplier testing showing that all test statistics are considerably greater than the critical value of 6.64; therefore, the SDM should be used to estimate the model.

Outputs of the SDM

The results of estimating the SDM are presented in Table 3. The estimated coefficients for GDPPC and $(GDPPC)^2$ indicate that the environmental Kuznets curve hypothesis is confirmed for selected countries. First, by increasing GDP per capita, deforestation increases by maximum level, and then decreases.

Table 3- Results of estimation of Spatial Durbin Model (SDM)

Variables	Significant level	Coefficients
Ln(GDPPC)	0.000000	1.673***
(Ln GDPPC)^2	0.000000	-0.700***
Ln(Exchange rate)	0.000000	0.486***
Ln(Population density)	0.000979	0.233***
Ln(Unemployment)	0.000000	0.740***
Ln(HDI)	0.003157	-0.060***
Ln(Agricultural price index)	0.538625	0.056ns
R-squared	0.9378	

*** Indicates significance at 1% level. ns indicates that the desired variable is insignificance

Source: Research findings

As presented in Table 3, the effect of the exchange rate on deforestation is positive and significant; in other words, the weakening of the national currency increases the export of forest products and reduces the area of forests.

The coefficient of the population density variable is statistically positive and significant. It makes sense that population growth would reduce forest land; because population growth represents an increase in demand for food and an increase in demand for residential land.

In this study, the unemployment variable also had a positive and significant effect on deforestation; thus, unemployment and ultimately poverty increase deforestation in the selected countries.

The negative and significant coefficient of the human development index on deforestation indicates a decrease in forest degradation due to improving this variable. As economic growth grows, so do government expenditures on health, education, and health, fostering human development. The conviction in the idea of capital, which encompasses solely physical capital, is thus a hazy term. Therefore, human capital should be addressed for environmental improvement (reduction of deforestation).

The estimated coefficient of the price index of agricultural products is not significant; this shows that the change in the price of agricultural products does not affect deforestation in selected countries.

Direct and indirect effects (spillover) for 18 selected countries in South Asia

The direct effect of each variable on deforestation shows that if that variable changes in country *i*, on average, what effect it will have on deforestation in that country. The indirect effect (spillover) of each variable on deforestation shows that if that variable changes in other countries, on average, what effect it will have on deforestation of the target country, which means the spatial spillover of that variable on deforestation in the target country. The total effect is also obtained from direct effects and indirect effects (Anselin and Bera, 1998).

Table 4- Direct and indirect effects in the form of spatial regression for 18 selected countries of South Asia

Variables	direct effect	Indirect effect	Total effect
Ln(GDPPC(-1))	0.1050*** (0.0000)	0.0060* (0.0652)	0.1110** (0.0256)
(Ln (GDPPC))^2(-1))	-0.0200* (0.0721)	0.0040** (0.0234)	-0.0160** (0.0478)
Ln(Exchange rate(-1))	0.0730*** (0.0003)	-0.0025** (0.0344)	-0.0705*** (0.0004)
Ln(Population density(-1))	0.0200*** (0.0000)	0.0002** (0.0424)	
Ln(Unemployment(-1))	0.0440** (0.0384)	0.00028** (0.0221)	0.0442** (0.0440)
Ln(HDI(-1))	-0.0800* (0.0521)	-0.0002ns (0.3522)	-0.0802* (0.0511)
Ln(Agricultural price index(-1))	0.0138ns (0.6720)	-0.0042ns (0.3563)	-0.0096ns (0.7524)

***, **and * indicate significance at the level of 1, 5 and 10%, respectively. ns indicates that the desired variable is insignificance

Source: Research findings

According to the results presented in Table 4, the direct effect of GDP per capita variable is positive and significant; this means that by increasing this variable by one percent, deforestation in the target country increases by 0.1050 percent. This is because economic growth is one of the most important factors in the source of environmental effects and increasing economic growth stimulates demand for agricultural and forestry products and increases deforestation. Exchange rates, population density, and unemployment have also had a positive and significant effect on deforestation. By increasing each of these variables by one percent, forest degradation in the target country increases by 0.0730, 0.0200, and 0.0440 percent, respectively. A change in the exchange rate causes a change in the export and import of various goods and services. One of these goods is the production of wood and its products for use in domestic markets and its export to international markets; In other words, increasing the exchange rate reduces the import of wood and more use of domestic forest resources and increases deforestation. In the literature on environmental economics, population growth is one of the most important factors in environmental degradation. As the population expands, the demand for agricultural land, energy resources, and water resources increase, increasing deforestation. In addition, the growing population will provide a large workforce that will affect the labor market with downward pressure on wage rates, leading to higher unemployment and further increased pressures on forests. Also, the direct effect of the human development index variable is negative and significant, which indicates that by increasing this variable by one percent, the amount of forest destruction decreases by 0.08 percent in the target country.

The results of estimating the indirect effects (spillover) show that the variable of GDP per capita in other countries has a positive and significant effect on deforestation in the target country. Increasing the economic growth of a country makes neighboring regions benefit from access to labor, capital, and knowledge; therefore, the growth of a region can increase the economic growth of the target country through trade communication channels, demand communication, and interregional mobility of production factors. As a result, if economic growth increases in other countries, it will spread to the target country.

Population growth reduces job opportunities and increases migration from neighboring countries to the target country, and this increase in migration will increase the demand for food, increase the demand for land for shelter, and cut down trees illegally to generate income, followed by an increase in deforestation in the target country. Also, spillover of population density and unemployment variables in neighboring countries has shown a positive and significant effect on deforestation in the target country; this means that the weighted average of the above explanatory variables has affected the deforestation of the target country. In countries of the southern half of Asia, the spillover of variable exchange rates in neighboring countries has a negative and significant effect on deforestation. Therefore, it is concluded that the increase in exchange rates in neighboring countries causes the country to import forest resources from neighboring countries instead of cutting down forest resources, reducing deforestation in the target country. Similarly, the total effect was significant for all variables except the price index of agricultural products.

Table 4 shows that the coefficients *lnGDPPC* and $(lnGDPPC)^2$ for the total effects are positive and significant and negative and significant, respectively. As a result, the relationship between deforestation and GDP is inverted U-shaped, and the environmental Kuznets curve hypothesis is confirmed. According to Equation (16), the GDP per capita for selected countries was estimated at $ 5,107 per year. This number indicates the turning point of the environmental Kuznets curve; this means that to prevent the increase of deforestation in selected countries and be in the descending part of the environmental Kuznets curve, the amount of GDP per capita must exceed this amount. According to Equation (17), the income elasticity at the turning point for the selected countries was estimated at 8.53. Using the average GDP per capita over the past 30 years, the income elasticity values and the location of selected countries before or after the turning point are shown in Table (5).

Table 5- Average of GDP per capita, lnGDP and income elasticity for the studied countries

Countries before the turning point of the Kuznets curve				Countries after the turning point of the Kuznets curve			
Name of countries	**Average GDP per capita**	**LGDPPC**	**elasticity**	**Name of countries**	**Average GDP per capita**	**LGDPPC**	**elasticity**
Bangladesh	2627.953	7.8739603	0.008638	Azerbaijan	9110.992	9.1172368	-0.007524
India	3639.464	8.1995917	0.004405	Armenia	7443.296	8.9150689	-0.004895
Kyrgyz Republic	3917.208	8.2731343	0.003449	China	7004.509	8.8543094	-0.004106
Pakistan	3697.538	8.2154224	0.004199	Indonesia	7513.041	8.9243955	-0.005017
Tajikistan	2208.393	7.7000202	0.010899	Iran	11561.7	9.3554534	-0.010620
Uzbekistan	4126.207	8.3251137	0.002773	Kazakhstan	16849.37	9.7320688	-0.015516
Vietnam	4279.099	8.3614978	0.002300	Philippines	5568.791	8.6249332	-0.001124
				Thailand	12568.92	9.438982	-0.011706
				Japan	36739.66	10.51161	-0.025650
				Malaysia	18767.14	9.8398629	-0.016918
				Singapore	67012.98	11.112641	-0.033464

Source: Research findings

Bangladesh, India, Kyrgyzstan, Pakistan, Tajikistan, Uzbekistan, and Vietnam are ahead of the turning point of the Kuznets curve (Table 5). Estimates also show that Azerbaijan, Armenia, China, Indonesia, Iran, Kazakhstan, Philippines, Thailand, Japan, Malaysia, and Singapore are behind the turning point of the Kuznets curve, indicating an inverse relationship between economic growth and deforestation. Ullah *et al.* (2022) believe that the reason for not stopping the deforestation process in Bangladesh is the lack of government understanding of the factors affecting deforestation in this country. Bera *et al.* (2020) state that rapid urbanization and population growth are vital factors in deforestation in India. Ahmed *et al.* (2015) consider the need for agricultural land and urbanization as the leading cause of deforestation in Central Asian countries such as Kyrgyzstan, Pakistan, Tajikistan, and Uzbekistan. In a study, Cochard *et al.* (2020) stated that unemployment and poverty, lack of monitoring, and efficient management are essential factors in deforestation in Vietnam.

Finally, the estimation results confirm that when the spatial correlation is fully considered in the sample data range, the turning point of the spatial environmental Kuznets curve occurs at a higher level than when the spatial correlation is ignored (calculation 2.62 by equation (14)). These results are consistent with the findings of Hao *et al.* (2016) and Lv and Li (2021).

Conclusion and Suggestions

In this study, the effect of socio-economic variables on deforestation has been investigated. The study includes data from 18 Asian countries from 2005-to 2015. Although many studies have examined the impact of various factors on deforestation, the spatial econometric approach has rarely been used; therefore, the present study investigated the effect of socio-economic variables on deforestation using the spatial panel data model to prevent deviation of the estimated coefficients. Experimental results showed a positive spatial correlation between countries regarding deforestation. This means that deforestation in a country depends not only on the socio-economic variables of that country but also on the socio-economic variables of neighboring countries. This result is consistent with the study of Boubacar (2012) and Wheeler *et al.* (2013).

The positive and significant total effect of GDP per capita and the negative and significant total effect of GDP per capita square confirm the existence of the environmental Kuznets curve hypothesis. In addition, the results of direct effects showed that the increase in GDP per capita due to stimulating demand for agricultural and forestry products, increasing the exchange rate due to reduced wood imports and greater use of domestic forest resources, increasing population density and unemployment due to increase demand for agricultural land and downward pressure on wage rates in the labor market increase deforestation and improving the human development index due to improving the level of literacy and human capital will reduce deforestation.

Some policy recommendations can be made based on the findings of this research. First, the main findings of the spatial Durbin model can point policymakers to pay attention not only to socio-economic activities on deforestation in their own country but also to the impact of these activities on deforestation in neighboring countries. Second, the environmental Kuznets curve has not been approved in some countries, so the incomes of some of the target countries will not reach a turning point shortly. This shows that these countries will experience deforestation for a while due to economic growth, Like Brazil, which has destroyed large rainforest areas to achieve high economic growth and agricultural expansion. Therefore, until the environmental Kuznets curve hypothesis is accepted, practical efforts to reduce deforestation in the path of economic development are essential. In this regard, stricter rules should be enacted on the illegal exploitation of forests, such as the prevention of timber smuggling and forest exploitation capacity thresholds to curb deforestation associated with economic growth.

As observed, the exchange rate variable has a direct and significant effect on deforestation; therefore, it is suggested that in the framework of bilateral and multilateral business models, priority be given to the export and import of environmentally friendly goods. Given that population has a direct and significant impact on deforestation in selected countries and given the increase in population growth in different years, it is suggested to pay more attention to the issue of the population by looking at the requirements of sustainable development to reduce environmental degradation, mainly deforestation. Because according to the results of this study, the lack of rapid direct population growth reduces deforestation in selected countries.

Unemployment variable after the economic growth variable has the most impact on deforestation in selected countries; therefore, governments should anticipate the occurrence of long-term unemployment among job seekers by providing more effectual assistance, such as self-employment facilities and job creation to employers, to those most at risk of unemployment. Also, pay special attention to people who have advantages in finding a job, such as university education and technical and vocational training; therefore, efforts to eradicate unemployment to preserve forest lands, and eradicate poverty must be a priority for countries.

References

1- Ahmed K., Shahbaz M., Qasim A., and Long W. 2015. The linkages between deforestation, energy and growth for environmental degradation in Pakistan. Ecological Indicators 49: 95-103. https://doi.org/10.1016/j.ecolind.2014.09.040.

2- Alishiri H., Sajjadifar S.H., and Mohammadbagheri A. 2017. Environmental Kuznets curve hypothesis assessment (case study of water pollution). Water and Wastewater Magazine 1(28): 57-64. (In Persian)

3- Allen J., and Douglas B. 1985. The causes of deforestation in developing countries. Annuals of Association of American Geographers 75(2): 163–184. https://doi.org/10.1111/j.1467-8306.1985.tb00079.x.

4- Angelsen A. 1999. Agricultural expansion and deforestation: modeling the impact of population, market forces and property rights. Journal of Development Economics 58(1): 185-218. https://doi.org/10.1016/S0304-3878(98)00108-4.

5- Anselin L. 1988. Spatial Econometrics: Methods and Models. p. 310-330.

6- Anselin L., and Bera A.K. 1998. Spatial dependence in linear regression models with an introduction to spatial econometrics. Statistics Textbooks and Monographs 155: 237-290.

7- Atella V., Belotti F., Depalo D., and Piano Mortari A. 2014. Measuring spatial effects in the presence of institutional constraints: The case of Italian Local Health Authority expenditure. Regional Science and Urban Economics 49: 232-241. https://doi.org/10.1016/j.regsciurbeco.2014.07.007.

8- Balado-Naves R., Baños-Pino J.F., and Mayor M. 2018. Do countries influence neighbouring pollution? A spatial analysis of the EKC for CO_2 emissions. Energy Policy 123: 266-279. https://doi.org/10.1016/j.enpol.2018.08.059.

9- Bera B., Saha S., and Bhattacharjee S. 2020. Forest cover dynamics (1998 to 2019) and prediction of deforestation probability using binary logistic regression (BLR) model of Silabati watershed, India. Trees, Forests and People, 2, 100034. https://doi.org/10.1016/j.tfp.2020.100034.

10- Bohn H., and Deacon R. 2000. Ownership Risk, Investment, and the Use of Natural Resources. The American Economic Review 90(3): 526-549. https://doi.org/10.1257/aer.90.3.526.

11- Boubacar I. 2012. Neighboring effects of deforestation: a spatial econometric approach. Environmental

Economics (3, Iss. 3): 72-81.
12- Caravaggio N. 2020. A global empirical re-assessment of the Environmental Kuznets curve for deforestation. Forest Policy and Economics 119: 102282. https://doi.org/10.1016/j.forpol.2020.102282.
13- Cochard R., Nguyen V.H.T., Ngo D.T., and Kull C.A. 2020. Vietnam's forest cover changes 2005–2016: Veering from transition to (yet more) transaction? World Development 135: 105051. https://doi.org/10.1016/j.worlddev.2020.105051.
14- Culas R. 2007. Deforestation and the environmental Kuznets curve: An institutional perspective. Ecological Economics 61(3): 429-437. https://doi.org/10.1016/j.ecolecon.2006.03.014.
15- Daryani A. 2015. Investigating the effects of economic and demographic factors on environmental pollution in OPEC member countries. Thesis in Humanities, Persian Gulf University. (In Persian with English abstract)
16- FAO, Food and Agriculture Organization of the United Nations, Rome. 2015. Global Forest Resources Assessment. How are the world's forests changing? Second edition. Available at http://www.fao.org//.
17- FAO, Food and Agriculture Organization. 1992. Forest Resources Assessment, Tropical Countries, Forestry. Paper, 112. Available at http://www.fao.org//.
18- FAO, Food and Agriculture Organization. 1997. State of the World's Forests. FAO, Rome. Available at http://www.fao.org//.
19- FAO, Rome, Food and Agriculture Organization. 2003. State of the World's Forests. FAO: Rome, Available at http://www.fao.org//.
20- FAO, Rome, Food and Agriculture Organization. 2005. State of the World's Forests. FAO: Rome, Available at http://www.fao.org//.
21- Faria W., and Almeida A. 2016. Relationship between Openness to Trade and Deforestation: Empirical Evidence from the Brazilian Amazon. Ecological Economics 5(121): 85-97. https://doi.org/10.1016/j.ecolecon.2015.11.014.
22- Ferreira S. 2004. Deforestation, Property Rights, and International Trade. Land Economics 80(2): 174-193. https://doi.org/10.2307/3654737.
23- Florax R., Folmer H., and Rey S. 2003. Specification searches in spatial econometrics: The relevance of Hendry's methodology. Regional Science and Urban Economics 33(5): 557-579. https://doi.org/10.1016/S0166-0462(03)00002-4.
24- Hamidi D. 2015. Investigating the Convergence of Energy Intensity among OPEC Countries in the Presence of Structural Failures (A Bilateral Approach). M.Sc. Thesis, Urmia University. (In Persian with English abstract)
25- Hao Y., Liu Y., Weng J.H., and Gao Y. 2016. Does the environmental Kuznets curve for coal consumption in China exist? New evidence from spatial econometric analysis. Energy 114: 1214-1223. https://doi.org/10.1016/j.energy.2016.08.075.
26- Heerink N., Mulatu A., and Bulte E. 2001. Income inequality and environment: Aggregation bias in environmental Kuznets curves: Evidence from automobile lead emissions. Journal of Environmental Economics and Management 35(2): 126-141. https://doi.org/10.1016/S0921-8009(01)00171-9.
27- Hoseini S., Karimzadeh S., and Bakhtiari S. 2018. The relationship between financial development, economic growth and energy consumption in a selection of developing countries. Financial Economy (Financial Economy and Development) 12(45): 167-191. (In Persian with English abstract)
28- Humphreys D. 2004. Redefining the Issues: NGO Influence on International Forest Negotiations. Global Environmental Politics, 4(2): 51-74. https://doi.org/10.1162/152638004323074192.
29- Khezri, M., Heshmati, A., and Khodaei, M. 2021. The role of R&D in the effectiveness of renewable energy determinants: A spatial econometric analysis. Energy Economics, 99, 105287. https://doi.org/10.1016/j.eneco.2021.105287.
30- Koop, G., and Toole, L. 1999. Is there an environmental Kuznets curve for deforestation? Journal of Development Economics 58(1): 231–244. https://doi.org/10.1016/S0304-3878(98)00110-2.
31- LeSage J., and Pace RK. 2009. Introduction to spatial econometrics. Boca Raton: CRC Press Taylor & Francis Group.
32- Lewis S.L., Edwards D.P., and Galbraith D. 2015. Increasing human dominance of tropical forests. Science 349(6250): 827-832. https://doi.org/10.1126/science.aaa9932.
33- Lopez R., and Galinato G. 2005. Trade policies, economic growth, and the direct causes of deforestation. Land Economics 81(2): 145-169. https://doi.org/10.3368/le.81.2.145.

34- Lv Z., and Li S. 2021. How financial development affects CO_2 emissions: a spatial econometric analysis. Journal of Environmental Management 277: 111397. https://doi.org/10.1016/j.jenvman.2020.111397.
35- Mahapatra K., and Kant S. 2005. Tropical deforestation: A multinomial logistic model and some country-specific policy prescriptions. Forest Policy and Economics 7(1): 1-24. https://doi.org/10.1016/S1389-9341(03)00064-9.
36- Mahmodpor K., Saeidpor L., and Alidost N. 2018. Investigating the effect of economic openness on knowledge-based economy, Parliamentary Quarterly and Strategy 25(96): 297-320. (In Persian with English abstract)
37- Mansorabadi S., and Khodaparast Shirzadi J. 2019. The Impact of Natural Resources on Economic Growth and the Role of Institutional Quality, Agricultural Economics Research 11(1): 75-92. (In Persian)
38- Mendelsohn R. 1994. Property rights and tropical deforestation. Oxford Economic Papers 46(1): 750-756. https://www.jstor.org/stable/2663497.
39- Miyamoto M. 2020. Poverty reduction saves forests sustainably: Lessons for deforestation policies. World Development 127: 104746. https://doi.org/10.1016/j.worlddev.2019.104746.
40- Morita K., and Matsumoto K. 2017. REDD+ financing to enhance climate change mitigation and adaptation and biodiversity co-benefits: lessons from the Global Environment Facility. AGRIVITA, Journal of Agricultural Science 40(1): 118-130.
41- Nasirnia F., and Esmaeili A. 2009. Socio-economic factors affecting deforestation of selected countries: Application Kuznets Environmental Theory. Agricultural Science and Technology and Natural Resources 13(48): 367-374. (In Persian)
42- Nasirnia F., and Esmaeili A. 2008. Investigation of Deforestation in Iran and Neighboring Countries: Application Kuznets Model. Agricultural Economics 3(10): 17-31. (In Persian)
43- Reddya C.S., Saranyaa K.R.L., Vazeed S.P., Satisha K.V., Jhaa C.S., Diwakara P.G., Dadhwala V.K.C., Raoa P.V.N., and Krishna Y.V.N.M. 2018. Assessment and monitoring of deforestation and forest fragmentation in south Asia since the 1930s. Global and Planetary Change 161(3): 132-148. https://doi.org/10.1016/j.gloplacha.2017.10.007.
44- Sadeghi H. Saadat, R. 2004. Population growth, economic growth and environmental impacts in Iran (A causal analysis). Journal of Economic Research 64: 163-180. (In Persian with English abstract)
45- Salimifar M., and Dehnavi J. 2010. Comparison of the condense environmental curve in OECD member states and developing countries: Panel-Based Analysis. Journal of Knowledge and Development 16(29): 182-200. (In Persian with English abstract)
46- Santiago A.R., and do Couto H.T.Z. 2020. Socioeconomic development versus deforestation: Considerations on the sustainability of economic and social growth in most Brazilian municipalities. Environmental Development 35: 100520. https://doi.org/10.1016/j.envdev.2020.100520.
47- Stern, N., and Stern, N. H. 2007. The economics of climate change: the Stern review: cambridge University press.
48- Ullah S.M.A., Tsuchiya J., Asahiro K., and Tani M. 2022. Exploring the socioeconomic drivers of deforestation in Bangladesh: The case of Teknaf Wildlife Sanctuary and its surrounding community. Trees, Forests and People 7: 100167. https://doi.org/10.1016/j.tfp.2021.100167.
49- Van der Werf G.R., Morton D.C., Defries R.S., Olivier J.G., Kasibhatla P.S., Jackson R.B., and Randerson J.T. 2009. CO_2 emissions from forest loss. Nature Geoscience 2(11): 737-738.
50- Wheeler D., Hamme D., Kraft R., Dasgupta S., and Blankspoor B. 2013. Economic Dynamics and Forest Clearing: A Spatial Econometric Analysis for Indonesia. Ecological Economics 85: 85-96. https://doi.org/10.1016/j.ecolecon.2012.11.005.
51- World Bank, World Development Indicators. 2016. World Bank Publications, cop, Washington, DC. Available at: http://documents.worldbank.org/curated/en/805371467990952829/World-development-indicators-2016.
52- World Bank, World Development Indicators. 2020. World Bank Publications, cop, Washington, DC. Available at: http://documents.worldbank.org/curated/en/805371467990952829/World-development-indicators-2020.

نشریه اقتصاد و توسعه کشاورزی
https://jead.um.ac.ir

مقاله پژوهشی
جلد ۳۶، شماره ۲، تابستان ۱۴۰۱، ص ۱۲۸-۱۱۵

تأثیر ابعاد اقتصادی-اجتماعی بر جنگل‌زدایی: کاربرد اقتصادسنجی فضایی

حمید امیرنژاد[۱*]- امیر مهرجو[۲]- محمدهادی اسکندری‌نسب[۳]

تاریخ دریافت: ۱۳۹۹/۰۳/۲۴
تاریخ پذیرش: ۱۴۰۰/۱۱/۳۰

چکیده

فعالیت‌های انسان قرن‌هاست که منجر به تخریب جنگل‌ها شده است. در قرن بیست و یکم، جنگل‌زدایی یکی از عوامل اصلی تغییرات آب‌وهوا بوده است؛ چراکه جنگل‌ها از دلایل اصلی کاهش انتشار گازهای گلخانه‌ای هستند. در نیم‌قرن گذشته کشورهای نیمه جنوبی قاره آسیا به دلیل تغییر ساختار اقتصادی، افزایش جمعیت و گسترش جهانی‌شدن، متحمل خسارت‌های عظیمی از مناطق جنگلی شده است. بر همین اساس در این پژوهش، عوامل اقتصادی اجتماعی مؤثر بر تخریب جنگل با توجه به داده‌های موجود در ۱۸ کشور منتخب در نیمه جنوبی قاره آسیا بین سال‌های ۲۰۰۵ تا ۲۰۱۵ با استفاده از اقتصادسنجی فضایی بررسی شد. نتایج آزمون‌های همبستگی فضایی نشان داد که نادیده گرفتن اثرات همبستگی فضایی باعث خطای تخمین برازش می‌شود؛ همچنین نتایج برآورد مدل، فرضیه منحنی محیط‌زیستی کوزنتس برای کشورهای منتخب را با نقطه عطف ۵۱۰۷ دلار تأیید می‌کند. مطابق با یافته‌های تحقیق، افزایش تولید ناخالص داخلی سرانه در سایر کشورها از طریق تحرک بین منطقه‌ای نهاده‌های تولید موجب افزایش جنگل‌زدایی در کشور مورد نظر می‌شود. افزایش نرخ ارز در سایر کشورها به دلیل افزایش واردات محصولات جنگلی از سایر کشورها و عدم قطع منابع جنگلی داخلی موجب کاهش جنگل‌زدایی در کشور مورد نظر می‌گردد. افزایش تراکم جمعیت و بیکاری در سایر کشورها به دلیل کاهش فرصت‌های شغلی در سایر کشورها و افزایش مهاجرت به کشور مورد نظر و به‌دنبال آن افزایش تقاضا برای غذا و افزایش تقاضای زمین باعث افزایش جنگل‌زدایی در کشور مورد نظر شده است. در نهایت افزایش متغیر شاخص توسعه انسانی باعث کاهش جنگل‌زدایی در کشور مورد نظر شده است؛ ولی تغییر این متغیر در سایر کشورها تأثیری بر جنگل‌زدایی کشور مورد نظر نداشته است؛ لذا در دنیایی با رشد اقتصادی فزاینده، پیشنهاد می‌شود به‌منظور تضمین جلوگیری از تخریب جنگل‌ها در بهبود شاخص توسعه انسانی؛ ریشه‌کن‌کردن معضل بیکاری و ریشه‌کن‌کردن فقر تلاش‌ها مضاعف گردد. همانطور که نتایج این مطالعه نشان داد جمعیت تأثیر مستقیم و معنی‌دار بر جنگل‌زدایی در کشورهای منتخب داشت و با توجه به افزایش رشد جمعیت در سال‌های مختلف، پیشنهاد می‌شود به مسئله جمعیت با نگاه به الزامات توسعه‌ی پایدار توجه بیشتری شود تا کاهش تخریب محیط‌زیست به‌خصوص جنگل‌زدایی را به همراه داشته باشد. چراکه بر اساس نتایج این مطالعه عدم رشد سریع جمعیت موجب کاهش جنگل‌زدایی در کشورهای منتخب می‌گردد.

واژه‌های کلیدی: اقتصادسنجی فضایی، توسعه پایدار اقتصادی، جنگل‌زدایی، منحنی کوزنتس فضایی

---

۱ و ۲- به‌ترتیب استاد و دانشجوی دکتری، اقتصاد کشاورزی، گرایش منابع‌طبیعی و محیط‌زیست، دانشگاه علوم کشاورزی و منابع طبیعی ساری، ساری
(*- نویسنده مسئول: Email: h.amirnejad@sanru.ac.ir)
۳- فارغ‌التحصیل کارشناسی ارشد، اقتصاد کشاورزی، گرایش منابع‌طبیعی و محیط‌زیست، دانشگاه تربیت مدرس، تهران

DOI: 10.22067/JEAD.2022.17787.0