



CASE STUDY

An analysis on the economic development and deforestation

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ABSTRACT

BACKGROUND AND OBJECTIVES: This study aimed to investigate endogenous variables namely, economic development and deforestation, in North Sumatra, and examine their determinants. Both variables are substantial in a country community welfare with harmonized environmental sustainability as a legacy for future generations.

METHODS: In this quantitative study, secondary data in the form of time series data from 1991 to 2020 with a total of 30 years were analyzed. The novelty of this study is its aim to combine deforestation variables and their determinants in a research model related to economic development. In this study, the determinants of economic development used were education, health, mineral resources and forest resource, whereas those of deforestation, were forest resource, institutional factors, population density, and economic development.

FINDINGS: The data analysis revealed that the economic development in North Sumatra was significantly influenced by education, health, and mineral resources, excluding forest resources. Simultaneously, the determinants influenced economic development by 74.15 percent. Education contributed 27 percent, health 71 percent, mineral resources 12 percent and forest resources 29 percent to economic development. Forest resources and institutions had a significant influence on deforestation in North Sumatra, whereas population density and economic development did not have a significant effect. Simultaneously, the determinants influenced deforestation by 77.24 percent. Partial, forest resources and institutions were identified and significant effect but population density does not significantly affect it. Forest resources contributed 14 percent to deforestation, institutional factors 72 percent, population density 3 percent and economic development 57 percent.

CONCLUSION: The findings of this study, indicated that education and health have a major effect on economic development whereas forest resources do not however, forest resources significantly affect deforestation. This means that an increasing environmental damage removes forest cover. Thus, it is recommended that the government increase human resource in terms of education and health, which are essential in prioritizing human resource development as a fundamental factor. It is also important to set the limit to long-term natural resource exploitation, consider environmental damages, and improve institutional quality. The government needs to explore alternative sources that are more sustainable and environmentally friendly, such as ecotourism, and renewable energy. Renewable energy can be a reliable source of energy that will help reduce reliance on fossil fuels while also minimizing environmental impacts.

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INTRODUCTION

Economic development is a substantial aspect of a nation, as it deals with the attempts to improve community welfare and eradicate poverty. Gross domestic product (GDP) is the popular parameter of a nation’s economic development (Sun and Tang, 2011). The success of economic development is reflected on economic growth, in which these two variables are intercorrelated. Economic development can encourage economic growth, and increased economic growth, in turn, will assist in the process of economic development. Community welfare can be improved by increasing national and per capita income, providing employment opportunities, and reducing poverty rate. Natural resources also significantly influence economic development, particularly in Indonesia. Abundant natural resources encourage the production of various products and services. The government, in cooperation with private sectors, create, and encourage employment opportunities to enhance economic development. Redmond and Nasir (2020) highlighted the significant contribution of natural resources to economic development, hence natural resource exploitation needs to be regulated. Exploration of natural resources needs to consider the possible environmental damages. Natural resource exploration is linked to deforestation, in which the trees cover area decreases due to the direct exploration of natural resources and land conversion. North Sumatra has the largest population on Sumatra island and ranked fourth in Indonesia following West Java, Central Java and East Java, with a total of 15,136,522 people. With a fairly

dense population, its economic development is similar to that of Indonesia in general. The enactment of regional autonomy encourages the local governments to strive to improve the welfare of their community and eradicate poverty by accelerating economic development. Economic development is affected by a variety of factors. Kamaroellah and Kutsiyah (2018) perceived environment as a factor affecting economic development. Deforestation is a major environmental issue that emerges after economic development. Cuaresma and Heger (2018) stated that countries with high economic development also have high deforestation rates. Fig. 1 presents economic development as reflected by the gross regional domestic product (GRDP), in North Sumatra between 2016 and 2020.

Fig. 1 presents the data on the GRDP and deforestation which continue to fluctuate. GDP is the total goods and services produced within one period, usually within 1 year (y). It is defined as economic performance in social welfare. GRDP increased by 5.12 percent (%) and 5.17% in 2017 and 2018, respectively. Furthermore, in 2018, the deforestation rate has drastically decreased by 67.54% or 7,319.10 hectares (ha), which is not an ideal situation. Various factors can affect economic development, including social, economic and environmental factors (Klapper et al., 2016). Then Kamaroellah and Kutsiyah (2018) also mentioned some economic factors that influence economic development, including natural resources, human resources, capital formation, and expertise, or entrepreneurship. No economic factors include sociocultural environment, political conditions and

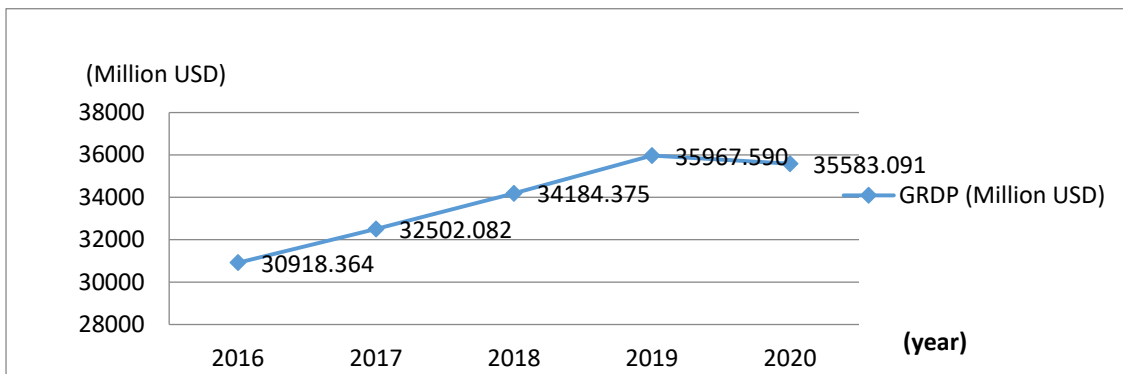


Fig. 1: Economic development shown in GRDP in North Sumatra in 2016 to 2020 (Badan Pusat Statistik, 2021)

Table 1: Determinants of economic development in North Sumatra in 2016–2020 (Badan Pusat Statistik, 2021)

Tahun	Education (year)	Health (year)	Mineral resource (Million USD)	Forest resources (Million M3)
2016	9,12	68,33	564,96	2,24
2017	9,25	68,37	593,55	0,95
2018	9,34	68,61	636,8	0,15
2019	9,45	68,95	677,37	1,08
2020	9,54	69,1	691,56	1,65

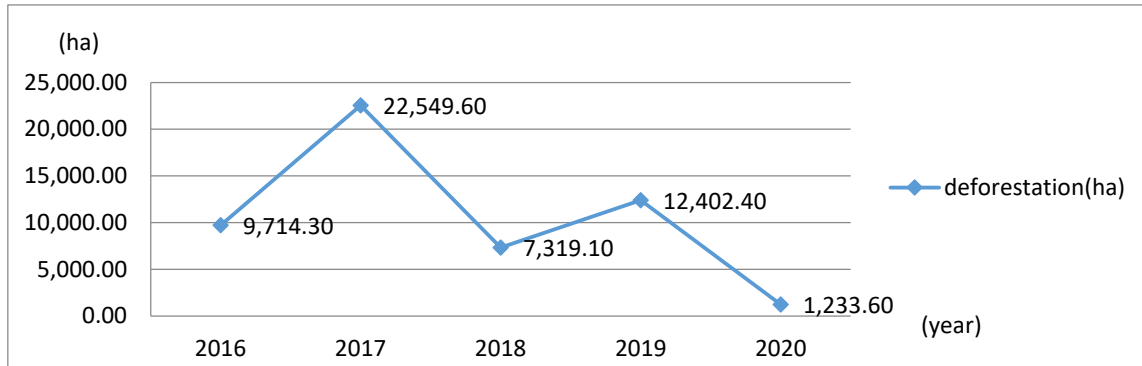


Fig. 2: Deforestation in North Sumatra in 2016-2020 (Badan Pusat Statistik, 2021)

institutions. [Atalay \(2015\)](#) explained that human capital relates to the knowledge, skills, experience, behavior and talents possessed by individuals which can be improved through education. Furthermore, health is the factor that constructs human capital. On the other hand, natural resources such as forests, mineral resources, and mining products also contribute to the production process that drives the national economy. In this study, economic development is defined as government performance for welfare as measured by GDP. Based on several studies, the determinants of economic development in this study are human resources, natural resources and the linkage of economic development to deforestation as environmental factor. Human resources are more broadly described as education and health, whereas natural resources are described as mineral and forest resources. Adequate natural and human resources are the capital of a nation in carrying out the development and providing government support to encourage investment while handling environmental issues ([Azam, 2015](#)). [Oryani et al. \(2022\)](#) evaluated the environmental impact of economic activities. [Table 1](#) presents the determinants of economic development in North

Sumatra.

Environmental factors also play considerable role. Deforestation can lead to other environmental problems. Human activities on land, increase, land conversion also increase causing environmental damages such as decreased tree cover that will result in climate change problems, loss of plant diversity, and even landslides, floods and erosion ([Waluyo and Terawaki, 2016](#)). On the other hand, exploration of natural resources creates opportunities for economic development, but also affect deforestation

strong interaction between forest cover and economic development in relation to the deforestation ([Ewers, 2006](#)). Similar view was also shared who found a significant relationship between economic development and the level of deforestation. [Table 2](#) presents the determinants of deforestation in North Sumatra. In 2016, the deforestation in North Sumatra reached 9,714.30 Ha which then significantly increased by 132.13% in 2017. In the same year, the economic development as seen from the GRDP also increased by 5.12%. Contrarily, in 2018, the deforested area decreased by 67.54%, but the economic development somehow increased by 5.17%. Unlike the general expectation

Table 2: Determinants of deforestation in North Sumatra in 2016 – 2020 (Badan Pusat Statistik, 2021)

Tahun	Forest resources (Milion M3)	Institutional (Total of role)	Population density (People)	GRDP (Million USD)
2016	2,24	32	193	30918,36
2017	0,95	50	196	32502,08
2018	0,15	55	198	34184,38
2019	1,08	41	200	35967,59
2020	1,65	49	203	35583,09

where increases in deforestation would lead to higher economic development, the aforementioned findings were opposite. Angelsen and Kaimowitz (1999) mentioned the factors that influence deforestation namely, economic development, demographics, institutions and macroeconomic factors. Deforestation increases following the increases in investment in land and property, which eventually enhance land productivity (Liscow, 2013)

Increasing population also leads to higher deforestation rates, particularly people living in rural areas who tend to explore the forest for living. Institutional factors also contribute to this matter, where regulations should be elucidated to provide no loophole for anyone to conduct deforestation. This matter also relates to capital formation and economic development, which are macroeconomic factors that can affect the extent of deforestation. Economic development is a key variable, where GDP is generally used as the main indicator in the development of a nation or country which, in turn, encourages improvement in community welfare (Sun and Tang, 2011; Kenzheguzin and Yessekina, 2004). Economic development is carried out by reorienting and improving human factors on all sides, for example, education, and community culture so that they can stimulate creativity. Investment in human resources and capital is the most important and effective means to improve community welfare. To date, economic development remains the main parameter for community welfare, where improvement should be made in all aspects, including human and capital resources and various other variables deemed to have influences. The model of sustainable economic development balances the management of capital, human, and natural resources by adding features of the social environment, institutions and economic politics (Ravago et al., 2015). Furthermore the factors that

affect a nation’s economic development include human labor and capital inputs (Sun and Tang, 2011). The main goal of economic development is poverty eradication. In this study, we used the Solow growth model, a neoclassical aggregate production function, and focused on the factors that directly affect the growth using Eq. 1 (Onyinye et al., 2017).

$$Y_t = f(K_t, A_t L_t) \tag{1}$$

where

Y : real output or GDP

K : capital ability (human capital and tangible capital)

L : workforce input

A : technology

Health and education are the main parameters of economic development. Several studies conducted by Satrianto explained that human resources are the main key to increasing economic productivity. The concept of human development also indicates that the role of education is important for enhancing the ability of developing countries to absorb modern technology and develop capacities to achieve sustainable growth and development (Satrianto and Juniardi, 2023; Aravind et al., 2016). Health is central to human well-being, and education is essential for a quality life. Education affects the ability to adopt and utilize the technology, whereas health supports productivity. Hence, human capital is seen as a vital component in development as input for aggregate production function (Todaro and Smith, 2012). Effective and efficient management of natural resources as well as quality human resources will accelerate a nation’s economic development. Deforestation is an equally crucial issue. Intensified human activity reduces the tree cover. Deforestation is the consequence of continuous human activity

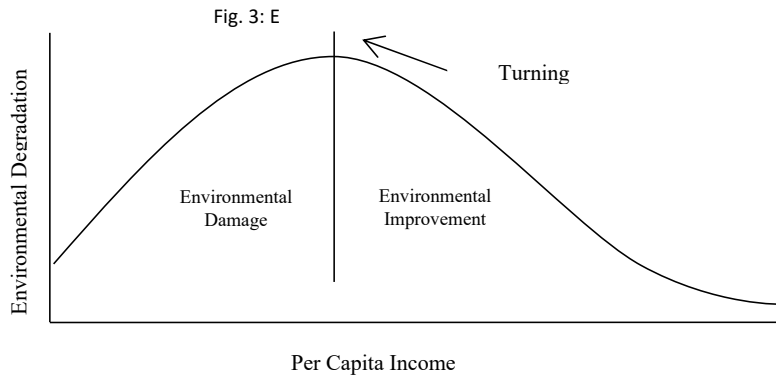


Fig. 3: Environmental Kuznets curve (Singh and Yadav, 2021)

in a long period of time, resulting in a significant decline in forest area, particularly in the tropics (Lee and Lemieux, 2010). Lewis also stated similar view, where they found that human activities can degrade and decrease environmental quality (Cuaresma and Heger, 2018). Countries with abundant natural resources have greater opportunities to accelerate their economic development. Utilization of natural resources such as forests for timber production and land conversion reduce forest area but increase economic activities, which later increase the GDP of a country. Therefore, deforestation affects economic development. In 1955, Kuznets analyzed the relationship between per capita income and environmental quality as described in the environmental Kuznets curve (Fig. 3).

During the initial phase of economic development, damage to the environment will continue to increase, but after economic growth reaches a certain threshold, a reverse movement will occur, where income will continue to increase along with environmental quality (Singh and Yadav, 2021). Angelsen stated that the factors underlying deforestation indirectly affect deforestation through various models, such as institutional factors, economic development, demography, and other macroeconomic factors (Damette and Delacote, 2012). Previous empirical studies viewed institutional quality as a critical factor in deforestation. (Afawubo and Noglo (2019) found that weak governance, high corruption rate, and low institutional quality are often associated with higher rates of deforestation. Bhattarai and Hammig demonstrated that improving the quality of politics and governance institutions

can effectively reduce the deforestation rates (Bhattarai and Hammig, 2001). They specifically analyzed the political rights and civil liberties as key institutional variables that influence deforestation. Improvement in institutional quality promotes democracy, strengthens individual and civil liberties, and establishes the rule of law, leading to better forest area conservation that ultimately reduces environmental degradation. Aquilas et al. (Aquilas et al., 2022) also suggested that institutions, population growth, and GDP are important factors that influence deforestation. As stated by those experts, sustainable development requires balance between economic development and environmental sustainability. While economic growth is necessary to address social and economic issues, it should not bring environmental damages. A healthy environment should be preserved to prevent the occurrence of natural disasters such as floods and landslides that occur during the rainy season as tree roots fail to hold water when the rainfall is high, loss of biodiversity, and other environmental problems that can severely impact the society. Environmental sustainability should be a top priority. Despite the challenges that follow, balance between economic development, and environmental sustainability should be realized for a better future. Based on the initial data presented, it can be concluded that economic development and deforestation in North Sumatra have not shown ideal conditions. Imagine if this is allowed to continue, welfare will not be achieved, people's trust in the government will decrease, the poverty, rate will increase, and unemployment, and economic growth will decline.

In terms of deforestation, climate change, increased emissions, and the threat of natural disasters. This study, investigated the determinants of economic development namely, education, health, mineral resources and forest resources. Education and health are used to explain the role of human resources in more detail, whereas mineral, and forest resources are used to determine the types of natural resources that affect economic development. Deforestation determined in forest resources, institutional, population density, and economic development. This study addresses the following question: How do these determinants affect economic development and deforestation in North Sumatra? At present, the government of North Sumatra has integrated sustainable development into regional development plans to minimize deforestation by ensuring the preservation of ecosystems based on international agreements. Implementing global afforestation, and deforestation, restoring degraded land, inhibiting the hunting and trading of protected flora and fauna, and integrating ecosystem values into poverty reduction budgeting plans (Dinas kehutanan, 2022). This issue is a problem faced by countries worldwide, particularly the developing ones; thus, it is a shared responsibility. Lambin et al. (2018) highlighted multinational companies also take initiatives to reduce deforestation such as collective aspirations of stakeholders to determine common goals in reduced deforestation and establishment of company commitments, code ethics and sectoral standards in produced goods with a moratorium of sanctions for companies that ignore reduced deforestation. This study aimed to prove the effect of the identified endogenous variables on economic development and deforestation in a model. The

study is expected to compensate for the lack of previous research. It has been conducted in North Sumatra, Indonesia, during 2021 to 2022.

MATERIALS AND METHODS

Method of the study

This quantitative study was conducted using descriptive and associative methods. Secondary data collected from the North Sumatra Central Bureau of Statistics were used. The observation year ranged from 1991 to 2020, a period of 30 years. The determinants of economic development used in this study were education, health, mineral resources and forest resources. Deforestation was affected by forest resource, institutions, population density, and economic development.

Operational definition of the variables

Measurement of the data of each variable is presented in Table 3. The data was collected from the documentation, annual reports or records issued by the North Sumatra Central Bureau of Statistics

As can be seen from the conceptual framework in Fig. 4, the mathematical measurements are expressed using Eqs. 2 and 3 (Kamaroellah and Kutsiyah, 2018; Angelsen and Kaimowitz, 1999).

First, the economic development:

$$Y_{1t} = \alpha_0 + \alpha_1 X_{1t} + \alpha_2 X_{2t} + \alpha_3 X_{3t} + \alpha_4 X_{4t} + \epsilon_{1t} \tag{2}$$

Second, the deforestation equation model:

$$Y_{2t} = \alpha_5 + \alpha_6 Y_{1t} + \alpha_7 X_{4t} - \alpha_8 X_{5t} + \alpha_9 X_{6t} + \epsilon_{2t} \tag{3}$$

Identification test

The order condition in identification from in model of *M* simultaneous equations. To identify an

Table 3 : Operational definition of the research variables

Variable	Measurement	Unit	Sources
Economic development (Y1)	GRDP	billion/y	Badan Pusat Statistik, 1991_2020
Deforestation (Y2)	Area of deforestation	ha/y	Badan Pusat Statistik, 1991_2020
Education (X1)	Average school period	y	Badan Pusat Statistik, 1991_2020
Health (X2)	Life expectancy rate	y	Badan Pusat Statistik, 1991_2020
Mineral resources (X3)	Mining output value in	Billion/y	Badan Pusat Statistik, 1991_2020
Forest resources (X4)	Number of timber production	M ³ /y	Badan Pusat Statistik, 1991_2020
Institutional factors (X5)	The number of regulations and law	No./y	Badan Pusat Statistik, 1991_2020
Population density (X6)	The population every kilometers	km ² /y	Badan Pusat Statistik, 1991_2020

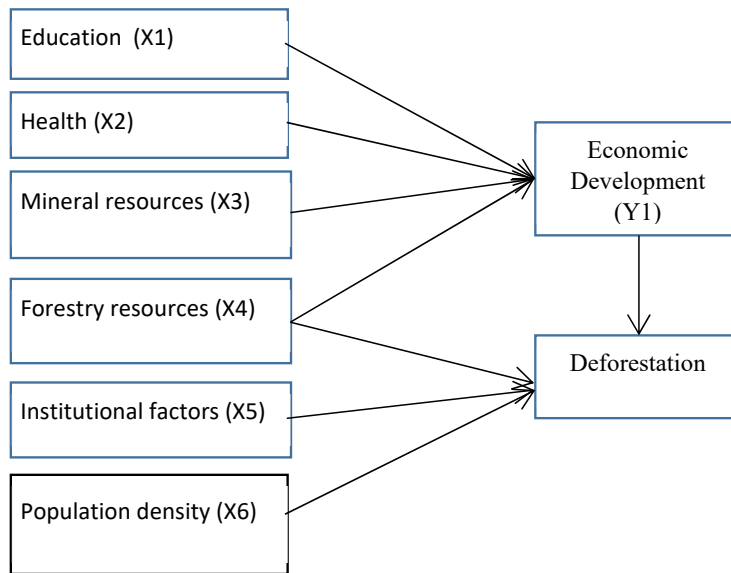


Fig. 4: Conceptual framework

equation, the number of predetermined variables excluded from the equation must not be less than the number of endogenous variables included in that equation less 1, that is, $K - k \geq m - 1$.

If $K - k = m - 1$, the equation is just identified, but if $K - k > m - 1$, it is overidentified

The identification test using order condition in this study is explained using Eqs. 4 and 5 (Gujarati and Porter, 2009).

$$K - k = 6 - 4 = m - 1 = 1 - 1 : \text{therefore, } 2 > 0 \text{ (overidentified) (4)}$$

$$K - k = 6 - 3 = m - 1 = 1 - 1 : \text{therefore, } 3 > 0 \text{ (overidentified) (5)}$$

The comparative test using order conditions for the two agreements showed that some equations were overidentified, thereby, they can be measured using the *two-stage least squares* (TSLS).

Research hypothesis

1. Education, health, mineral resources, and forest resources toward economic development in North Sumatra, using Eqs. 6 and 7 (Redmond and Nasir, 2020 ; Todaro and Smith, 2012).

$$H_0 : \alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = 0 \tag{6}$$

$$H_a : \alpha_1 \neq \alpha_2 \neq \alpha_3 \neq \alpha_4 \neq 0 \tag{7}$$

2. Forest resources, institutions, population density, and economic development toward deforestation in North Sumatra, using Eqs. 8 and 9 (Damette and Delacote, 2012).

$$H_0 : \beta_1 = \beta_2 = \beta_3 = \beta_4 = 0 \tag{8}$$

$$H_a : \beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq 0 \tag{9}$$

RESULTS AND DISCUSSIONS

The results of the data analysis are presented in Eq. 10 and Table 4. The estimation results of the economic development equation in Table 4 indicate that education and health have a significant positive impact, whereas mineral resources a significant negative impact on economic development. On the other hand, forest resources did not significantly affect economic development. Simultaneously, education, health, mineral resources, and forest resources have a significant impact on economic development, as shown by the F-statistic probability

Table 4: Results of the analysis of economic development variables (Y1)

Variable	Coefficient	SE	t-Statistic	Prob.
C	37.24584	12.67842	2.937736	0.0070
X1	0.270944	0.502717	5.389609	0.0000
X2	0.712908	0.240783	2.960796	0.0066
X3	-0.12E-05	4.04E-06	-2.992549	0.0061
X4	-0.29E-07	2.65E-07	-1.116627	0.2748
R-Squared	0.741531	Mean dependent var		11.51169
Adjusted R-squared	0.741531	S.D. dependent var		1.384772
S.E. of regression	0.700176	Akaike info criterion		2.435401
Sum squared resid	0.758249	Schwarz criterion		2.668934
Log likelihood	14.37352	Hannan_Quinn criter		2.510110
F-statistic	17.93085	Durbin_Watson stat		2.125756
Prob (F-statistic)	0.000000			

Table 5: Result of analysis of deforestation variables (Y2)

Variable	Coefficient	SE	t-Statistic	Prob.
C	17.23470	5.769993	2.986952	0.0062
Y1	0.570E-07	1.30E-06	0.438412	0.6649
X4	0.149E-06	4.03E-07	3.712818	0.0010
X5	-0.728867	0.321696	-2.265701	0.0324
X6	-0.031700	0.040052	-0.791467	0.4361
R-Squared	0.772362	Mean dependent var		10.25441
Adjusted R-squared	0.735939	SD dependent var		2.411007
S.E. of regression	1.238940	Akaike info criterion		3.417401
Sum squared resid	38.37429	Schwarz criterion		3.650934
Log likelihood	-46.26101	Hannan_Quinn criter		3.492110
F-statistic	21.20582	Durbin_Watson stat		1.587684
Prob (F-statistic)	0.000000			

value of 0.0000 (lower than 0.05). The partial of each variable is summarized in Eq. 10, education (X1) has a regression coefficient value of 0.27. This means that an increase in education of 1% will lead to an increase in economic development by 27% assumed ceteris paribus. Similar to health (X2) with a coefficient of 0.71, mineral resources (X3) with a coefficient of 0.12 and forest resources (X4) with a coefficient of 0.29 it means the contribution of each variable to economic development with the assumption of ceteris paribus, this is the answer to previous hypothesis, using Eq. 10 (Redmond and Nasir, 2020 ; Todaro and Smith, 2012).

$$Y1 = 37,25 + 0,27X1+ 0,71X2-0,12X3-0,29X4 \quad (10)$$

$$R^2 = 0,7415$$

$$\text{Probability F} = 0,0000$$

In North Sumatra, education has a significant, and positive impact on economic development. This highlights the importance of education in

increasing human capital, productivity, and overall development. This finding is consistent with the opinion of Raheem *et al.* (2018), who argued that human resource development is crucial for promoting economic development. According to the theory of human capital, better human capacity generates greater economic value, leading to higher labor productivity and overall economic development (Rahim *et al.*, 2021). Thus, to achieve sustainable development, it is important to prioritize human resource development as a fundamental factor. In addition to education, health significantly affects economic development in North Sumatra. Health also contributes to the improvement of human capital and positively affects economic performance. According to Inwood, health and economic development have a positive relationship (Inwood, 2017). Health is an essential input factor in the production process, and healthy working conditions can lead to higher productivity, resulting in increased production. Albarrán also viewed

life expectancy as an important component of human capital in addition to education (Albarran, 2018). Health is a source of variation in income. Meanwhile, discrepancies in life expectancy can cause income inequality. Furthermore, populations with better health are more likely to invest in new technologies, adapt to changes, and invest more leading to faster economic growth. Therefore, health is an essential component of human capital that contributes to economic development by supporting productivity and increasing production capacity. In North Sumatra, mineral resources also have a significant effect on economic development. Natural resources are products obtained from nature that can be utilized by humans to meet their needs; they are beneficial for economic development as the abundance of natural resources provides the energy required for such a development (Wang et al., 2021; Qiang and Jian, 2020). Natural resources are the foundation of economic development as regions with abundant energy and mineral resources effectively leverage their resource advantages into economic development advantages. Mineral resources, in particular, contribute to the GDP. However, continuous exploitation of mineral resources can have negative impacts on the economy. Overexploitation and improper management of mineral resources can lead to resource depletion, environmental degradation, and conflicts, which can hamper economic development. Therefore, proper management and sustainable use of natural resources, including mineral resources, are important to ensure long-term economic development. Furthermore, the utilization of forest resources does not have a significant impact on the economic development in North Sumatra, indicating that changes in forest resource yields do not lead to significant changes in economic growth. However, this finding contradicts previous research by Hao et al. (2018) which suggested that natural resource utilization, particularly forest resources, contributes to the improvement of the economy and living standards (Qiang and Jian, 2020; Hao et al., 2018). The forestry sector is closely intertwined with the economy, as sustained economic growth is often accompanied by a substantial decline in forest resources. The author of this study attributed these inconsistent findings to the long-term environmental damage and natural disasters resulting from the continued

utilization of forest resources, ultimately negatively affecting economic development. These findings are consistent with those of empirical studies, such as that by Hao et al., which demonstrated an inverted U-shaped relationship between forest resources and economic development, as seen in the GDP, which in the initial use of forest resources use leads to output growth until a tipping point is reached, after which forest depletion results in deforestation and greater losses. The results of the deforestation (Y2) are shown using Eq. 11 (Damette and Delacote, 2012).

$$Y2 = 17,23 + 0,57Y1 + 0,14X4 - 0,72X5 - 0,03X6 \quad (11)$$

$$R^2 = 0,7724$$

$$\text{Probability F value} = 0,0000$$

According to the given equation, forest resources exhibit a partial significant positive impact whereas institutions have a significant negative impact on deforestation in North Sumatra. However, population density has no significant effect on deforestation. When considered together, forest resources, institutions, and population density exert a significant effect on deforestation, as evidenced by the probability value of the f-statistic, which is less than 0.05 (i.e., 0.0000). The partial of each variable is summarized in Eq. 11, forest resources (X4) have a regression coefficient value of 0.14. This means that an increase in forest resources of 1% will lead to an increase in deforestation by 14% assumed *ceteris paribus*. Similar to institutional factor (X5) with a coefficient of 0.72, population density (X6) with a coefficient of 0.03 and economic development (Y1) with a coefficient of 0.57 it means the contribution of each variable to deforestation with the assumption of *ceteris paribus*.

According to the given information, forest resources have a partial significant positive effect on deforestation in North Sumatra, indicating that continuous utilization of forest products can lead to environmental degradation and become a factor in deforestation. Expert opinions suggest that the triggers for deforestation include the quantity of harvested forest products and development issues. Ewers suggested that high-income countries often have low forest cover and focus on afforestation by establishing of new plantations, whereas low-income countries with smaller forest tend to consume their remaining share at a proportionally

faster rate than low-income countries with larger forest. In addition, countries with large forests have a higher rate of deforestation (Ewers, 2006). Similarly Cuaresma and Heger, (2018) suggest that low-income countries tend to have high economic development with high deforestation rates. North Sumatra is one of the areas with extensive forests in Indonesia, which is developing country. Forests are a source of income for the region and will expand deforestation. In North Sumatra, Institutions have a significant negative effect on deforestation, indicating that a decrease in institutional quality, as measured by the number of existing legal regulations, can lead to an increase in deforestation, whereas an improvement in institutional quality can lead to a decrease in deforestation. This finding is consistent with Angelsen's statement that institutional factors indirectly affect deforestation through various models, including institutions (Damette and Delacote, 2012). Institutional quality associated with deforestation, where the risk of ownership provides incentives for increasing deforestation. Better institutions lead to better environmental management, forward-looking behavior, higher efficiency, and better enforcement of public policies related to the environment. In addition, empirical studies, such as those of Afawubo and Noglo, highlighted the critical role of institutional quality in the deforestation process (Afawubo and Noglo, 2019). Weak governance, high corruption, and low institutional quality often result in higher deforestation rates. In North Sumatra, population density does not have a significant effect on deforestation. This indicates that changes in population density, whether an increase, or decrease, will not directly impact deforestation in North Sumatra. However, these findings differ from those of the studies conducted by Culas and Bhattarai and Hammig, who explained that population growth and density increase demand for forest products and land use, leading to deforestation (Culas, 2007). Population growth can increase labor force and affect the labor market, ultimately leading to high unemployment rates. With a large number of unemployed workers, forests can become an alternative, leading to an increase in deforestation rates. These findings are consistent with the idea that excessive population growth and pressure in developing countries are key

factors that drive tropical deforestation (Bhattarai and Hammig, 2001). Once the population reaches a certain level, the production process changes to increase efficiency and preserve natural resources. The inconsistencies in the results of previous studies were likely indirectly influenced by the effect of population density on employment rather than on deforestation. As population density increases, people may migrate from rural to urban areas in search of higher-paying jobs, leading to a reduction in traditional activities such as farming and a decrease in interactions between individuals and forests. Therefore, population density may affect employment first before affecting the deforestation. Some highly populated areas have low deforestation rates, which could be attributed to public awareness of environmental preservation (Tritsch and Tourneau, 2016). Widespread deforestation will barrier various policies included the development of education and health. Deforestation also contributes to environmental problems such as loss of flora and fauna to natural disasters. This is an economic cost that must be paid. Ewer (2006) demonstrated that the occurrence of environmental problems, such as climate change, loss of biodiversity, and increased rates of soil erosion, caused by deforestation increases the frequency and severity of floods.

CONCLUSION

Based on the results of this study, it can be concluded that education, health, mineral resources and forest resources exert a significant effect on economic development in North Sumatra. Simultaneously the determinants of economic development have an effect of 74.15% (R square 0.7415). Education, health and mineral resources exert partial significant effects, whereas forest resources have no significant effect on economic development. Variable coefficient is the contribution of each variable to economic development. Education contributed 27% to economic development, health 71%, mineral resources 12%, and forest resources 0.29%. To realize economic development in North Sumatra, the government is recommended to increase human resources in terms of education and health, and prioritize human resource development as a fundamental factor. Differences in life expectancy can lead to income inequality. Populations with better health

are more likely to invent new technologies, adapt to changes, and invest more which will lead to faster economic growth. Health factor is an essential component of human capital that contributes to economic development by supporting productivity and increasing production capacity. The government must reduce the utilization of natural resources as an effort to save the environment for future generations. As an efforts to increase economic development, the government is currently focusing on household consumption, investment, and exports. The second hypothesis in this study to accepted, forest resources, institutions, population density and economic development have a significant effect on deforestation in North Sumatra. Simultaneously the determinants of deforestation have an effect of 77.24% (R square 0.7724). Partial of forest resources and institutions were identified and significant influences but population density does not significantly affect it. In North Sumatra, forest resources contributed 14% to deforestation, institutional factors 72%, population density 3%, and economic development 57%. The government continues to perform afforestation and reforestation to restore some forest cover. It is recommended that stakeholders explore alternative sources that are more sustainable and environmentally friendly, such as ecotourism, and renewable energy. Ecotourism can generate revenue for local communities while promoting conservation of natural resources and biodiversity. Renewable energy can be a reliable source of energy which will help reduce reliance on fossil fuels while also minimizing environmental impacts. The government can also implement policies and programs that promote sustainable practices in agriculture, fisheries, and forestry, such as sustainable land use planning, conservation of biodiversity, and community-based forest management. By adopting a sustainable and holistic approach to economic development, the government can ensure that economic growth is inclusive, equitable, and environmentally sustainable.

AUTHOR CONTRIBUTIONS

E.S. Siregar helped in the design and development of models in the research, collection and analysis of data, and creation of research reports. S.U. Sentosa directed and mentored the literature review. A.

Satrianto accompanied and guided the writing of the manuscript.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this manuscript. In addition, the ethical issues including plagiarism, informed consent, misconduct, data fabrication, and/or falsification, double publication and/or submission, and redundancy, have been completely observed by the authors.

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ABBREVIATIONS

%	Percent
+	Plus sign
=	Equal sign
≠	Non equal sign
>	Strict inequality (greater than)

≥	Greater equals	X5	Institutional factors
/	Per	X6	Population density
A	Alpha	Y	Real output or gross domestic product
E	Error term	Y	Year
A	Technology	Y1	Economic development
C	Constant	Y2	Deforestation
Eq	Equation		
F	Simultaneous		
Fig.	Figure		
GDP	Gross domestic product		
GRDP	Gross regional domestic product		
ha	Hectare		
i.e	Id est		
K	Capital ability (human capital and tangible capital)		
K	Number of predetermined variable in model including intercept		
k	Number of predetermined variable in a given equation		
KM	Kilometers		
L	Workforce input		
Log	Logarithm		
M	Number of endogenous variable in the model		
M ³	Cubic meter		
M	Number of endogenous variable in a given equation		
Prob	Probability		
R2	Correlation coefficient		
SD	Standard deviation		
S.E	Standard error		
T	Time		
TSLS	Two stage least squares		
Var	Variable		
X1	Education		
X2	Health		
X3	Mineral resources		
X4	Forest resources		

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