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ARTÍCULO

# The Role of Agriculture and Forestry on the Transition to Bio-economy: Empirical Evidence from ASEAN Countries

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**Abstract:** Currently, the transition towards bio-economy has become a global requirement due to the degradation of the environment globally and capturing the attention of researchers and policymakers. Thus, the current research examines the impact of agricultural and forestry resources on the transition towards bio-economy in ASEAN countries. The researchers have used secondary sources of data collection, such as world development indicators (WDI), and extracted the data from 2012 to 2019. For the analysis purpose, the current study has used the STATA and executed the correlation matrix, variance inflation factor (VIF), robust standard error, and fixed-effect model (FEM) to examine the relationships among the constructs. The results indicated that agricultural resources (agricultural land, agriculture, forestry and fishing, and agricultural irrigated land) and forestry resources (forest area and forest rent) have a positive association with the transition towards bio-economy in ASEAN countries. The current study provides the guidelines to the upcoming researchers while examining this area in the future and also provides help to the policymakers while developing regulations regarding the transition to bio-economy.

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## 1. Introduction

In the coming years, when the need for economic as well as domestic activities will increase, people will see growing competition for finite or limited natural resources. A secured and safe food supply will be required for the increasing global population. The primary production systems like agriculture, forestry, fishery, and aquaculture will be affected by climate change (Imbert et al., 2017). So, there is a need for the transition to the most efficient use of renewable biological resources. It is required to pay attention to sustainable primary production and processing programs which may give more food, paper, fiber, adhesives, fuel additives, and other bio-based products by applying fewer inputs, with lower environmental influences, and causing the lower amount of greenhouse gas emission (Patermann et al., 2018). In order to achieve higher competitiveness, every country needs to have enough supplies of energy, raw materials, and industrial products with the reduced use of fossil carbon resources. The progress of the bio-economy leads to a chance to address and remove the complicated but interconnected concerns arising while getting high economic development because of its cross-cutting nature (Heimann, 2019).

Bio-economy is useful for every country in developing resource-efficient society that is mostly dependent on renewable biological resources to fulfill consumers' demands, meet industrial requirements, and handle climate changes (Wilde et al., 2021b).The Bio-economy, which includes the consistent production of renewable resources from agriculture, forestry, fisheries, and aquaculture context, as well as their conversion into feed, feed, fiber, bio-based products, and bio-energy along with related public goods, is a key component of a country's response to the challenges in the fact (Patermann et al., 2018). Primary production like agriculture, fisheries, aquaculture, and forestry, including the companies that use or process biological resources, such as food pulp and paper, elements of the chemical, biotechnology, and energy industries, are all part of the bio-economy (Popp et al., 2021).

The global population is estimated to increase up to 9 billion in 2050. In order to meet the needs of the increased population, a 50% increase in the production of food and energy will be required, according to United Nations (Chandel et al., 2020). Now it is the challenge to fulfill the basic needs minimizing the negative environmental influences. The bio-economy includes heat, energy, food, bio plastics, construction, and textiles by potentially holding the solutions to the challenges people face in the present or future (Tsui et al., 2019). The bio-economic activities are not all sustainable, and they may impart both good and bad impacts on biodiversity and the planet's climate. The majority of marine resources have been depleted, and many have been overexploited. Many forests are being depleted at a faster rate than they can be replenished. In many places of the world, agricultural land is deteriorating. We, as a species, must accept that we have a poor track record when it comes to natural resource management(Saleem et al., 2019).

The aim of the study is to analyze the influences of agricultural land, agriculture, forestry, and fishery, agricultural irrigated land, forest areas, and forest rent on the transition to bio-economy and its development for ASEAN countries. ASEAN is the international body that facilitates and promotes cooperation and co-integration among ten countries in Southeast Asia named as Philippines, Cambodia, Indonesia, Brunei, Laos, Malaysia, Myanmar, Singapore, Thailand, and Vietna (Bi et al., 2021). The combined GDP of ASEAN economies is USD 3.0 trillion, according to the statistics of 2018. This GDP accounted for a 5.3% annual growth rate during 2000 and 2018. In ASEAN countries the portion of agriculture including forestry into the annual GDP growth is as follows: Philippines: 7.4%, Cambodia: 25.3%, Indonesia: 13.7%, Brunei: 1.2%, Laos: 20.9%, Malaysia: 7.1%, Myanmar: 8.9%, Singapore: 0.5%, and Vietnam: 15.3%, and Thailand: 8.4% (Donner et al., 2021). These countries produce and export significant crops, plants, trees, and livestock which are critical to the safety and security of food products, energy sources, other Bio-based products, and a healthy labor force that assures economic sustainability. But, as the agriculture contribution to GDP is less than industrial and service sector contribution, which cause air, water, and land pollution, increase in the harmful wastes, toxic chemicals, destroy quality or natural resources, and skills or labor-force, the combined ASEAN government and Individual governments want to focus on the transition of bio-economy from typical economy and bio-economy development (Masud et al., 2018).

In order to main the growth rate, ASEAN member countries felt the need for capitalizing on the opportunities given by innovativeness and applying the bio-economy concept as a critical factor to sustainability Bio-economy is the fundamental concept of value-creation of resources (Wilde et al., 2021a). For innovation growth and bio-economy development initiatives in ASEAN countries, the Office of the Permanent Secretary, Ministry of Higher Education, Science, Research and Innovation (MHESI), with the cooperation from the National Science and Technology Development Agency (NSTDA) and the Office of National Higher Education Science Research and Innovation Policy Council (NXPO), hosted ASEAN Innovation Roadmap & Bio-economy Forum at Shangri-La Hotel, Bangkok in Nov. 2020 (Gouvea et al., 2021). The aim of the forum is to represent the capacity of ASEAN economies as a power station of innovation and bio-based industries. That event was held in conjunction with the Global Bio-economy Summit 2020, which Thailand was co-hosting(Samdin et al., 2019). The event included the webcasting of speeches and policy recommendations on the bio-economy from representatives and leaders from world economies. It was aimed to exhibit projects and programs which support bio-economy like biological products, society development and ecotourism, and investment incentives to encourage new businesses in the bio-economy sector Nathaniel et al. (2020).

The environmental impacts of economic activities and resulting social issues, along with a threat to future economic development, have become a severe concern for people across the world. Though ASEAN countries are making rapid progress in the present, as the portion of the agriculture sector to GDP growth is low, it is getting a threat to sustainable economic development (Ylimartimo, 2018). Thus, there is a need to find a way to sustain economic development. Considering this need, the authors focus on the bio-economy, which is the key to sustainable economic development. They want to highlight the ways how to promote the bio-economy. The main objective of the study is to elaborate the nexus among agriculture land, agriculture, forestry, fishery, agriculture irrigated land, forest area, and forest rents, and bio-economy transition and development. Prior to the current study, mostly the authors have discussed the influences of agriculture as a complete term on the transition to and sustainable development of bio-economy. However, some studies have checked the influences of agricultural land, agriculture scope, and agricultural irrigated land on bio-economy development but individually in separate time duration. Thus, our study, which analyzes the role of agriculture land, agriculture, forestry, fishery, and agriculture irrigated land in bio-economy transition and sustainable development, makes a great contribution to literature. This study first time combines the impacts of agriculture and forestry on bio-economy transition and its sustainable development. An ample light has been thrown on agriculture, forestry, and fishery development, agriculture land, irrigation, and forests rents in the ASEAN countries. But a

little research has been made to investigate the role of agriculture land, agriculture, forestry, fishery; agriculture irrigated land, forest area, and forest rents in bio-economy transition and sustainable development for ASEAN economies. Our study removes this literary gap.

The current study was structured as follows. The part next to the introduction deals with the literary reviews about the influences of the agricultural land, agriculture, forestry, and fishery, agricultural irrigated land, forest areas, and forest rent and resultant impacts on the transition to bio-economy and its development. The part of the study is the nature of methodology applied to collect the relevant data from ASEAN economies in support of the concepts and the ways applied for the analysis of data in hand. Then, the data analysis provides suitable results for the constructs under discussion. In the discussion section, the study results are supported by past studies. Afterward, the paper provides the study implications, its conclusions, and ends with the future recommendations for authors.

## 2. Literature Review

Bio-economy refers to the knowledge-based production of renewable and sustainable biological resources and the use of biological products further in the production of semi-finished or finished bio-based industrial products (Priya et al., 2018). In the bio-economy, biological laws or processes are applied in performing economic activities that allow the provision of economic products and services in an ecological friendly manner (Sanz-Hernández et al., 2019). Bio-economy has the potential to mitigate the environmental impacts of economic activities and improve the environmental or social well-being of the people. Considering the economic, social, and environmental advantages of the bio-economy, economists and government want to transit to the bio-economy from the traditional economy {Ubando, 2020 #2009]. For transition to bio-economy and its sustainable development, it is necessary to encourage the basic sources of natural or biological resources. Agriculture and forestry are the major sources of natural products; thus, the development of agriculture and forestry could be contributing to the bio-economy. Our study explores the influences of agriculture and forestry factors such as the agricultural land, agriculture, forestry, and fishery, agricultural irrigated land, forest areas, and forest rent and resultant impacts on the transition to bio-economy and its development. In the past literature, several authors have argued on the role of the agricultural land, agriculture, forestry, and fishery, agricultural irrigated land, forest areas, and forest rent and resultant impacts in transition to bio-economy and its development. With the help of these literary views, the concepts of the current study are presented.

Agricultural land is traditionally the portion of land which is devoted to agriculture, (Woźniak et al., 2021) the systematic and administrated utilization of other forms of life—especially the production of crops and the rearing of livestock —to produce food and provide other basic natural products for humans Liobikiene et al. (2020). In general, it is also known as farmland or cropland, as well as pasture or rangeland. According to United Nations Food and Agriculture Organization (FAO), it is the collection of arable land, permanent cropland, and permanent pasture. Both the quality and the area of agricultural land can affect the capacity of a country to turn its traditional carbon and chemical-based economy into a bio-based economy. The study by Ashukem (2020) analyzes the role of sustainable development goals, agricultural land, and bio-economy development. This study is based on an analysis of bio-economy development in Africa. The study implies that the farmlands which have enough and dependable water supply from irrigation or precipitation, growing season, favorable temperature, acceptable alkalinity or acidity, an acceptable amount of salt or sodium content, and minimum quantity of rocks have strengthened the position of a country to apply bio-economy. According to the arguments of Ingrao et al. (2018), bio-economy is a transition to an equitable, sustainable, post-fossil-carbon society, and it is possible in the case of a large area of good quality agriculture land. The research data were collected from papers based on Virtual Special Issue (VSI), providing meta-studies for cross countries. This research concludes that the government or economists of a country's tendency to convert a significant portion of the country's land into agricultural land (arable land, land under permanent crops, pastures, and hayfields) are an initiative to the sustainable development of bio-economy because more agriculture land increases the production of renewable biological resources for food, energy, and industrial products.

Agriculture, forestry, and fishery are the three interconnected economic sectors (von Braun, 2018). As these sectors are a source of biological resources which may be utilized by consumers directly or as a raw material for the production of food, energy, and many other bio-based industrial products, the effective administration and development of these sectors lead the country towards bio-economy (Lokko et al., 2018). Agriculture is the process of producing feed, food, fiber, energy, and many other desired products through the cultivation of particular plants and the rearing of domesticated animals (livestock). The processes of agriculture, its production, and earnings determine the possibility of a bio-economy whose motive is to produce renewable and sustainable biological resources and recycle the wastes into food, bioenergy, feed, biochemical, and other bio-based products (Philp, 2018).Wreford et al. (2019), present solid arguments on the agriculture role in developing a sustainable bio-economy. When farmers apply traditional or modern environmentally friendly technology and processes for the preparation of land, plantation, cultivation, and harvesting the crops and breeding livestock instead of using chemicals, harmful fertilizers, pesticides, or feed, it becomes easy to apply the principles of sustainable bio-economy. The literary article of D'Amato et al. (2019) on Circular economy (CE), Green Economy (GE), and Bio-economy (BE) supports the development of the role of agriculture forestry and fishery for sustainable bio-economy. Content analysis was undertaken on 123 reports from DJSI Global companies dealing in five land-use intensive sectors (forest, food, beverages, mining, and energy). This article focuses that the development of agriculture, forestry, fishery, or related firms are key to the sustainable bio-economy as in bio-economy renewable biological resources are extracted from land or sea to produce food, energy, raw material, and finished products to ensure the production of maximum output in minimum input and reduces the emission of harmful gas. The research investigation by Lainez et al. (2018)reveals that agriculture, forestry, and fishery produce natural resources such as crops, hay, weeds, and meet as well as bio-based products such as pulp and paper, chemical building blocks, textiles, detergents, medicines, and food. As a result, agriculture contributes to the creation of a bio-economy whose goal is to produce replenishing natural resources by promoting biological processes and recycling operations, allowing economic growth to continue without compromising environmental integrity.

According to the views of Marttila et al. (2020), agricultural irrigation land is useful for establishing or flourishing the bio-economy. Agriculture irrigated land refers to the agricultural lands that are supplied with a sufficient amount of water through ditches, pipes, spraying, or administration of rainfall water and floods (Juerges et al., 2018). Irrigation is helpful in growing agricultural crops, maintaining landscapes, and re-vegetating damaged soils in dry areas and the areas under less than average rainfall. In crop cultivation, irrigation is also useful for frost protection, weed suppression in grain fields,

and soil compaction prevention. Irrigation improves agriculture production, ensures the availability of biological products from land in abundance for bio-economic activities. The research by Lopes et al. (2018), investigates the impacts of irrigated cropping systems on environmental quality in the Brazilian semi-arid region (State of Bahia) and declares it an initiative to bio-economy whose objective is to ensure the liveable clean planet and the provision of sufficient healthy food for all. It highlights that with the implementation of clean irrigation processes for carrot production, the negative environmental impacts can be minimized by 16-69%. This encourages bio-economy, and the reduced cost as a result of clean irrigation and quality production enables the economists to apply biological technology and processes. A study was presented by Kircher (2021)to investigate the bio-economy transitions and development through agriculture progress. This study focuses that the ability to irrigate land in far-off areas for agricultural purposes, which benefits the environment by clearing the atmosphere, is a useful tool for dealing with biological wastes by using it as fertilizers and provides the raw material for energy production or other bio-based products, all of which contribute to the establishment of a bio-economy.

Forest area is the area of land covered by trees higher than 5 meters. Forests are taken as a critical part of national economies, as they provide a wide range of production inputs, food, fuel, environmental goods, medicines, household equipment, raw materials for industrial processing, and building material Lovrić et al. (2020). The inputs, raw material, food, medicines, and other products received from forests are biological, renewable, and less harmful. The objectives of the bio-economy are sustainable resource management, food security, healthy security, resilient planet, economic & social prosperity, and sustainable consumption. All these objectives become easy to be achieved, in case a larger area of land is dominated by forests (Fischer et al., 2020). Vermaat et al. (2020), wrote an article to examine the relationship between agriculture, forestry, and the development of bio-economy. The study analyzes the 67% forests 1006 km$^2$ in Norway while 83% cropland area 4.7 km2 in Denmark, and their impacts on bio-economy development in the respective countries. The study concludes that an increase in both agriculture and forest areas enhances the development of the bio-economy. The increased agriculture and forest areas develop bio-economy in several ways like the reduction of pollution by absorbing heat from the air, excessive water from land, and carbon from the atmosphere and using the biological wastes for fertilizing, enhancing the number of natural resources, and increasing the financial resources which could be used for sustainable economic development. The study conducted by Refsgaard et al. (2021) suggests that a large area of land dedicated to forestry aids in the establishment of a bio-economy because trees are a source of renewable and sustainable biological resources. As a result, it aids in achieving bio-economy goals such as sustainable resource management, adequate healthy food for everybody, a pollution-free economy, social and economic prosperity, and changing consumer behavior.

Forest rents are the distinction between the costs of planting trees in forests or hiring a forest and the market prices of forests products. The increase in forest rents enhances the profits for forests producer or owner firms and reduces their costs. Consequently, this encourages the growth of forests, and the decrease in costs enhances the financial position. These results of high forest rents are favourable for transition to bio-economy or the sustainable bio-economy D'Amato et al. (2020). The tendency to plant trees in larger areas for meeting basic needs for life and the needs of own companies or with selling purposes in itself is a contribution to the sustainable development of bio-economy as it is the long-lasting source of renewable, sustainable, and clean biological resources which are part and parcel of bio-economy (Näyhä, 2019). Kylkilahti et al. (2020), are of the view that the increase in the forests rents encourages forests growth on the part of firms themselves which results in the decrease in total costs and increase in the profitability. The increased financial resources enable the firms to apply technology that can work with biological resources in the business processes. This study also highlights that when the forests rents are high, the firms can afford energy-efficient production and operational technologies and logistics, which give maximum output in minimum input and keep the environment free of pollutants like greenhouse gases. In-depth research was conducted by Toppinen et al. (2018), to explore the influences of forest rents on bio-economy development. Toppinen et al. (2018), defines forest rent as the gap between the costs of forestry and the processed products from forests. When forest production costs less than market prices, economists prefer to plant trees in order to meet economic needs (energy, food, or other biological manufacturing products) and increase profits. As a result, the biological raw material increases while environmental quality and human health are preserved.

## 3. Methodology

The researchers examine the impact of agricultural and forestry resources on the transition towards bio-economy in ASEAN countries. The researchers have used secondary sources of data collection such as WDI and extracted the data from 2012 to 2019. For the analysis purpose, the current study has used the STATA, and the estimation equation for the study is given as below:

$$BT_{it} = \alpha_0 + \beta_1 AL_{it} + \beta_2 AFF_{it} + \beta_3 AIL_{it} + \beta_4 FA_{it} + \beta_5 FR_{it} + e_{it} \quad \textbf{(1)}$$

Where;

| | | |
|---|---|---|
| BE | = | Bio-economy |
| i | = | Country |
| $t$ | = | Time Period |
| AL | = | Agricultural Land |
| AFF | = | Agriculture, Forestry and Fishing |
| AIL | = | Agricultural Irrigated Land |
| FA | = | Forest Area |
| FR | = | Forest Rent |

The present article has used the transition towards bio-economy as the predictive variable measured as the percentage use of biotechnology in production. In addition, two predictors have been used by the researchers such as agricultural resource measured as the agricultural land (% of land area), agriculture, forestry and fishing (% of GDP), and agricultural irrigated land (% of total agricultural land) while forestry resources measured as the forest area (% of land area) and forest rent (% of GDP). These variables, with their measurements, have been given as below in Table 1.

Table 1: Measurements of variables

| S# | Variables | Measurements |
|---|---|---|
| 01 | Bio-economy | % use of bio-technology in production |
| 02 | Agriculture | Agricultural land (% of land area) |
| | | Agriculture, forestry, and fishing (% of GDP) |
| | | Agricultural irrigated land (% of total agricultural land) |
| 03 | Forestry | Forest area (% of land area) |
| | | Forest rent (% of GDP) |

The current study shows descriptive statistics with respect to countries, years, and variables. It shows the minimum values, maximum values, standard deviation, mean, and observations of all the constructs. In addition, a correlation matrix was also executed by the researchers that shows the relationships between the constructs. It provides the direction of the nexus but does not show the significance of the nexus. Moreover, the VIF has also been executed by the researchers that show the verification of multicollinearity assumption. If the VIF values are larger than five, then multicollinearity issues exist and vice versa. The estimation equations for VIF are given as below:

$$R^2_Y \longrightarrow Y_{it} = \alpha_0 + \beta_2 X_{2it} + \beta_3 X_{3it} + \beta_4 X_{4it} + \beta_5 X_{5it} + e_{it} \quad \textbf{(2)}$$

$$j = R^2_Y, R^2_{X1}, R^2_{X2,} R^2_{X3,} R^2_{X4,} R^2_{X5} \quad \textbf{(3)}$$

$$Tolrance = 1 - R^2_j VIF = \frac{1}{Tolerance} \quad \textbf{(4)}$$

The current research has executed the robust standard error to examine the nexus between the constructs. It provides the best estimation when the data is cross-sectional dependence (cross-section are more than time series) (Munir et al., 2020), and the current study has taken ten countries and eight years in their analysis; thus, the data is cross-sectional dependence, and robust standard error has considered the best approach in this case. In addition, the robust standard error also provides the best results when the data has autocorrelation issues that generally exist in the data (Latif et al., 2018). Thus, the estimation equation for robust standard error is given as under:

$$BT_{it} = \beta_1 AL_{it} + \beta_2 AFF_{it} + \beta_3 AIL_{it} + \beta_4 FA_{it} + \beta_5 FR_{it} + \varepsilon_{it} \quad \textbf{(5)}$$

The current research has executed the Hausman test that shows the appropriate model among the random and fixed models. If the probability value is larger than 0.05, then accepting the null hypothesis about the random model is appropriate, but if the probability value is less than 0.05, then accept the alternative hypothesis about the FEM model is appropriate. Thus, the current study has used the FEM that is also an appropriate model when the data is cross-sectional dependence. The estimation equation FEM is as under:

$$Y_{it} = \beta_{1i} + \beta_2 X_{2it} + \beta_3 X_{3it} + \beta_4 X_{4it} + \beta_5 X_{5it} + u_{it} \quad \textbf{(6)}$$

In the above estimation, subscript (i) highlighted the individual country and made the different countries according to their characteristics. In contrast, (i) represents the years. The estimation equation for FEM with understudy constructs are given as under:

$$BT_{it} = \beta_{1i} + \beta_2 AL_{it} + \beta_3 AFF_{it} + \beta_4 AIL_{it} + \beta_5 FA_{it} + \beta_6 FR_{it} + u_{it} \quad \textbf{(7)}$$

## 4. Research Findings

The current study shows descriptive statistics with respect to countries. The figures highlighted that the minimum BE is 1.708 percent in Brunei while the maximum BE is 7.069 percent in Lao. In addition, AL is the minimum in Singapore, which is only 0.946 percent, while the maximum in Thailand is 43.216 percent. The figures highlighted that the minimum BE is 1.708 percent in Brunei while the maximum BE is 7.069 percent in Lao. In addition, AL is the minimum in Singapore, which is only 0.946 percent, while the maximum in Thailand is 43.216 percent. Moreover, the figures highlighted that the minimum AFF is 0.032 percent in Singapore while the maximum AFF is 26.424 percent in Cambodia. In addition, AIL is minimum in Brunei, which is only 1.300 percent, while the maximum in Thailand is 24.471 percent. Similarly, the figures highlighted that the minimum FA is 23.203 percent in Singapore while the maximum FA is 72.577 percent in Lao. In addition, FR is minimum in Singapore, which is only 0.000 percent, while the maximum in Myanmar is 2854 percent. These values are mentioned in Table 2

Table 2: Descriptive statistics (Country)

| | BE | AL | AFF | AIL | FA | FR |
|---|---|---|---|---|---|---|
| Brunei | 1.708 | 2.709 | 0.950 | 1.300 | 72.106 | 0.056 |
| Cambodia | 7.154 | 31.296 | 26.424 | 21.323 | 50.496 | 1.738 |
| Indonesia | 5.221 | 32.170 | 13.215 | 21.454 | 51.598 | 0.473 |
| Lao | 7.069 | 10.450 | 17.028 | 11.369 | 72.577 | 2.732 |
| Malaysia | 5.075 | 25.427 | 8.487 | 5.289 | 58.665 | 1.984 |
| Myanmar | 6.418 | 19.512 | 25.768 | 3.663 | 45.710 | 2.854 |
| Philippines | 6.611 | 41.717 | 10.962 | 12.852 | 23.583 | 0.257 |
| Singapore | 3.615 | 0.946 | 0.032 | 2.790 | 23.203 | 0.000 |
| Thailand | 3.515 | 43.216 | 9.374 | 24.471 | 39.174 | 0.458 |
| Vietnam | 6.306 | 37.631 | 16.522 | 13.794 | 45.671 | 1.825 |

The current study shows descriptive statistics with respect to the years. The results indicated that BE was minimum in the year 2019 that was 4.414 percent, while maximum in 2012 that was 5.894 percent. In addition, AL was minimum reported 23.796 percent in 2012 while a maximum of 24.901 percent in 2017. The results also indicated that AFF was minimum in the year 2019 that was 10.996 percent, while maximum in 2012 that was 15.034 percent. In addition, AIL was a minimum reported 10.624 percent in 2012 while a maximum of 13.859 percent in 2019. Moreover, the results indicated that FA was minimum in

the year 2019 that was 47.480 percent, while maximum in 2012 that was 49.170 percent. In addition, FR was a minimum reported 0.725 percent in 2019 while a maximum of 1.700 percent in 2014. These values are mentioned in Table 3.

Table 3: Descriptive statistics (Years)

| | BE | AL | AFF | AIL | FA | FR |
|---|---|---|---|---|---|---|
| 2012 | 5.894 | 23.796 | 15.034 | 10.624 | 49.170 | 1.456 |
| 2013 | 5.588 | 23.997 | 14.401 | 11.394 | 48.909 | 1.344 |
| 2014 | 5.352 | 24.063 | 13.772 | 11.355 | 48.645 | 1.700 |
| 2015 | 5.089 | 24.741 | 13.068 | 11.650 | 48.387 | 1.206 |
| 2016 | 5.180 | 24.795 | 12.507 | 11.752 | 48.102 | 1.197 |
| 2017 | 5.479 | 24.901 | 11.937 | 12.005 | 47.863 | 1.340 |
| 2018 | 5.157 | 24.883 | 11.296 | 12.005 | 47.671 | 0.936 |
| 2019 | 4.414 | 24.883 | 10.996 | 13.859 | 47.480 | 0.725 |

The researchers also run the descriptive statistics with respective to the variables. It shows the minimum values, maximum values, standard deviation, mean, and observations of all the constructs. The results indicated that the observations of the study are 80 (10 counties x 8 years). In addition, the results also show the mean value of BE is 5.269 percent while the average value of AL is 24.507 percent. Moreover, the results also show the mean value of AFF is 12.876 percent, while the average value of AIL is 11.830 percent. Finally, the results also show the mean value of FA is 48.278 percent, while the average value of FR is 1.238 percent. These values are mentioned in Table 4.

Table 4: Descriptive statistics

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| BE | 80 | 5.269 | 2.027 | 0.052 | 8.426 |
| AL | 80 | 24.507 | 14.868 | 0.931 | 43.277 |
| AFF | 80 | 12.876 | 8.774 | 0.030 | 33.520 |
| AIL | 80 | 11.830 | 8.385 | 0.310 | 25.095 |
| FA | 80 | 48.278 | 16.327 | 22.214 | 73.100 |
| FR | 80 | 1.238 | 1.145 | 0.000 | 4.157 |

In addition, a correlation matrix was also executed by the researchers that shows the relationships between the constructs. It provides the direction of the nexus but does not show the significance of the nexus. The results indicated that all the predictors have a positive association with BE. These values are given in Table 5.

Table 5: Matrix of correlations

| Variables | BE | AL | AFF | AIL | FA | FR |
|---|---|---|---|---|---|---|
| BE | 1.000 | | | | | |
| AL | 0.343 | 1.000 | | | | |
| AFF | 0.711 | 0.368 | 1.000 | | | |
| AIL | 0.206 | 0.735 | 0.341 | 1.000 | | |
| FA | 0.052 | -0.349 | 0.124 | -0.135 | 1.000 | |
| FR | 0.608 | -0.004 | 0.725 | -0.085 | 0.396 | 1.000 |

Moreover, the VIF has also been executed by the researchers that show the verification of multicollinearity assumption. If the VIF values are larger than five, then multicollinearity issues exist and vice versa. The results have been shown that the VIF values are lower than five that show no multicollinearity exists. These values are mentioned in Table 6. The results robust standard error indicated that agricultural resources (agricultural land, agriculture, forestry and fishing, and agricultural irrigated land) and forestry resources (forest area and forest rent) have a positive association with the transition towards bio-economy in ASEAN countries. The R square value indicated that 58.43 percent of variations are due to all selected predictors of the study. These values are mentioned in Table 7. The current research has executed the Hausman test that shows the appropriate model among the random and fixed models. If the probability value is larger than 0.05, then accept the null hypothesis about the random model is appropriate, but if the probability value is less than 0.05, then accept an alternative hypothesis about the FEM model is appropriate. The results indicated that the probability value is less than 0.05, which shows FEM is appropriate. These values are given in Table 8.

The results of FEM indicated that agricultural resources (agricultural land, agriculture, forestry and fishing, and agricultural irrigated land) and forestry resources (forest area and forest rent) have a positive association with the transition towards bio-economy in ASEAN countries. The R square value indicated that 57.30 percent variations are due to all selected predictors of the study. These values are mentioned in Table 9.

Table 6: Variance inflation factor

| | VIF | 1/VIF |
|---|---|---|
| FR | 3.482 | 0.287 |
| AFF | 3.442 | 0.291 |
| AL | 2.755 | 0.363 |
| AIL | 2.752 | 0.363 |
| FA | 1.541 | 0.649 |
| Mean VIF | 2.794 | . |

Table 7: Robust standard error

| BE | Beta | S.D. | t | P>t | L.L. | U.L. |
|---|---|---|---|---|---|---|
| AL | 0.120 | 0.013 | 9.231 | 0.000 | 0.010 | 0.050 |
| AFF | 0.097 | 0.012 | 7.910 | 0.000 | 0.069 | 0.124 |
| AIL | 0.109 | 0.015 | 7.267 | 0.000 | 0.044 | 1.026 |
| FA | 0.026 | 0.009 | 2.830 | 0.020 | 0.047 | 1.005 |
| FR | 0.682 | 0.089 | 7.630 | 0.000 | 0.480 | 0.884 |
| _cons | 4.070 | 0.628 | 6.490 | 0.000 | 2.651 | 5.490 |
| R-squared | 0.5843 | Prob > F | 0.0000 | | | |

Table 8: Hausman test

| | Coef. |
|---|---|
| Chi-square test value | 6.843 |
| P-value | 0.033 |

Table 9: Fixed effect model (FEM)

| BE | Beta | S.D. | t-value | p-value | L.L. | U.L. | Sig |
|---|---|---|---|---|---|---|---|
| AL | 0.299 | 0.165 | 1.81 | 0.074 | 0.030 | 0.627 | * |
| AFF | 0.221 | 0.092 | 2.40 | 0.018 | 0.163 | 2.205 | ** |
| AIL | 0.170 | 0.056 | 3.04 | 0.003 | 0.282 | 0.058 | *** |
| FA | 0.324 | 0.124 | 2.62 | 0.015 | 0.223 | 1.272 | ** |
| FR | 0.880 | 0.319 | 2.76 | 0.008 | 0.242 | 1.517 | *** |
| Constant | 12.576 | 5.931 | 2.12 | 0.025 | 4.421 | 9.268 | ** |
| R-squared | 0.573 | Number of obs | 80 | | | | |
| F-test | 4.888 | Prob > F | 0.000 | | | | |
| *** p<.01, ** p<.05, * p<.1 | | | | | | | |

## 5. Discussion and Implications

The study results have indicated that agricultural land in a country has a positive association with the transition to bio-economy. These results are in line with the previous study ofWoźniak et al. (2021), which states that the tendency of the government or economists of a country to convert a significant portion of the country land into land devoted for agriculture (arable land, land under permanent crops, pastures, and hayfields), is an initiative to bio-economy or sustainable development of bio-economy, as the increase in agriculture land enhances the production of renewable biological resources to be used for food, energy, and industrial products. These results are also in line with the previous study of (Zabaniotou, 2018). This study analyzes the role of agricultural land in establishing the bio-economy. This study implies that when the large portion of land is subsidized by the government to breed and look after the livestock like animals, birds, and fish, the availability of replenishing and sustainable resources for the production of food items and industrial products is ensured like the availability of milk, eggs, meat, wool, leather, and bones for bakery products, beauty products, garments, and shoes, etc. These results are also supported by the past study of Chiranjeevi et al. (2018), which implies that when a large portion of land is spared for farming or cultivation of crops, weeds, and trees, the bio-economic activities can be carried on consistently in two manners it enhances the availability of natural or biological resources to be used for different domestic and economic purposes, and encourages the proper disposal of wastes or recycling of wastes into food, bioenergy, feed, biochemical, and other bio-based products.

The study results have also revealed that agriculture, forestry, and fishing have a positive relation to transition to bio-economy. These results are in line with the previous study of Refsgaard et al. (2021), which shows that agriculture, forestry, and fishing is a critical part of bio-economy because it uses renewable biological resources from land or sea to produce not only food, but also energy, raw material, and finished products enhancing resource efficiency and ensuring low-carbon

economic activities. These results are also supported by the previous study of Robert et al. (2020), which states that agriculture provides natural resources like crops, hay, weeds, livestock, and concerning products that are used for producing bio-based products like pulp and paper, chemical building blocks, textiles, and detergents. Thus, agriculture is helpful in establishing a bio-economy whose objective is to produce replenishing natural resources by encouraging biological processes and recycling procedures so that economic development can be maintained without affecting the environmental quality. These results are also supported by the previous study of Bell et al. (2018), according to which agriculture provides the biological raw material for biological energy resources, food products, and bio-based industrial products whose production and usage for domestic and economic purposes do not affect the quality of the environment.

It has also been indicated by the study results that agriculture irrigated land has a positive association with the transition to bio-economy. These results are in line with the previous study of Ramcilovic-Suominen et al. (2018), which analyzes agriculture irrigation and its contribution to the bio-economy. The study reveals that the capacity of a country to move to a bio-economy is determined by the areas where land or crops can be supplied with water through ditches and channels specially designed to allow water flow as it specifies the availability of sustainable and renewable biological resources from the land. These results are also in line with the previous study of Kardung et al. (2019), which shows that in bio-economy, such technologies or technological processes are used for manufacturing or other economic activities which use only biological-based clean energy. Agriculture is the basic source of raw material for biomass and biofuel. So, enhanced agriculture irrigated land assists transition to bio-economy. These results are also supported by the past study of Devaney et al. (2018), which posits that the facility to irrigate land for agriculture purposes, enhances the plantation of crops which saves the environment clearing the atmosphere, is a suitable tool to tackle the biological wastes using it as fertilizers or pesticides, and provides the raw material for energy production or other bio-based products which all collectively contribute to the establishment of bio-economy.

The study results have shown that forest area has a positive association with the transition to bio-economy. These results agree with the past study ofHurmekoski et al. (2019), which states that forestry is a critical part of bio-economy and sustainable economic development because of the provision of biological products like honey, wild meat, Fruits, Mushroom, Palm Wine, Palm Oil, Cola Nuts, and wood which are the sustainable raw material for the production of different industrial products, and these biological products can be replenished and leave no harmful wastes. These results are also supported by the previous study of(Khan et al., 2018), which shows that the devotion of more area for forestry assists in establishing bio-economy for more number of trees are the source of renewable and sustainable biological resources. Thus, it helps in getting the goals of bio-economy such as sustainable resource management, provision of sufficient healthful food for all, pollution-free economy, social and economic prosperity, and change consumers' behavior.

The study results have represented that forest rent has a position relationship with the transition to bio-economy. These results are supported by a previous study ofFischer et al. (2020), which shows that forest rent which the difference between the costs of forestry and the process products from forests. When the production of forests is less than the actual prices, economists prefer to plant trees for meeting the economic needs (energy, food, or other bio-logical manufacturing products) and to earn more profits, the biological raw material increase while saving the environmental quality and health of living beings. These results agree with the previous study of Wreford et al. (2019), which states that the high forest rent enables the economists to save the money, natural, and human resources, which can be helpful in applying energy-efficient technology and biological processes which are meant to produce bio-based products and services, to tackle with the wastes, and saves the environment and society from negative impacts of economic activities.

## 6. Theoretical and Empirical Implications

The present research has a great theoretical significance for making a lot of contributions to green literature. This study reveals the importance of the transition to bio-economy from a typical economy from environmental, social, and economic points of view and presents the ways how to transit the typical economy to bio-economy. This study analyzes the influences of agricultural land, agriculture, forestry, and fishery, agricultural irrigated land, forest areas, and forest rent on the transition to bio-economy and its development. The role of agriculture in establishing and developing the bio-economy has not yet been as much discussed as the present study has discussed. Mostly the previously conducted studies have simply discussed the agriculture contribution to bio-economy transition and development as a complete factor without elaborating it from different perspectives like land, irrigation facility, and agriculture along with forestry and fishery or the studies have discussed agriculture from any one given perspectives while analyzing the agriculture contribution to bio-economy transition and development. So, the current study, which initiates to explore the agriculture role in the transition and development of the bio-economy, is a great contribution to the literature. The analysis of the influences of agricultural land, agriculture, forestry, and fishery, agricultural irrigated land, forest areas, and forest rent on the transition to bio-economy and its development in ASEAN countries is something new in the literary world.

This literary article has empirical significance as well. It is significant in the economies across the world irrespective of the position in the international market. The natural resources are limited in quantity, and the increasing domestic and economic activities in order to meet the needs of the increasing population disturb the balance of global climate and environmental quality within the concerned regions. Near in the future, there will be serious competition among individuals, companies, or economies for getting quality-based natural resources for sustainable development. The current study provides the guidelines to the upcoming researchers while examining this area in the future and also provides help to the policymakers while developing regulations regarding the transition to bio-economy. The current study is helpful for economists, environmental regulators, and government in making its policies for sustainable economic development as it guides how to develop a bio-economy whose basic objective is to protect the quality of the environment, global climate, and natural resources with the production of biological raw material

and encouragement of recycling of biological residues. The study guides that with the development of agriculture, forestry, and fishery, increasing agriculture land, agriculture irrigated land, forestry area, and forestry rents, transition to bio-economy is possible.

## 7. Conclusion

Though the ASEAN economies are upper-middle-income or highly developed economies with respect to their GDP growth, the economies have many environmental and social problems which would be a serious threat to the economic growth and social well-being of the public in the coming years. The main reason behind these problems is the lack of biological development, which could maintain the balance of climate, reduce the emission of hazardous substances from economic activities, and reduce wastes. The current study paid attention to this issue by addressing the concept of bio-economy. The aim of the study was to explore the role of agriculture and forestry in the transition to the bio-economy from the traditional economy. It was conducted to determine the impact of agricultural land, agriculture, forestry, and fishery, agricultural irrigated land, forest areas, and forest rent on the transition to bio-economy and its development. In order to infer the results about the contribution of agriculture and forestry into the establishment of bio-economy, authors analyzed the agricultural land, agriculture, forestry, and fishery, agricultural irrigated land, forest areas, and forest rent and resultant impacts on the transition to bio-economy and its development in ASEAN countries. The study results indicated that in the countries where a significant portion of the land is spared for agriculture activities and provides different sorts of subsidies or government support in this regard, the carbon-based economy could be transferred into the biological economy, which produces and utilizes sustainable and renewable biological resources. The results showed that energy-efficient technology and technological processes are applied to save the environment and enhance the availability of natural resources also for future use while the country is making progress in the fields of agriculture, forestry, and fishery. The study results indicated that the areas of land which have the facility of irrigation through ditches, water channels, or technological ways could be used for agriculture, forestry, and livestock breeding. This leads to the development of a sustainable bio-economy as the renewable and sustainable resources are available in abundance, and the biological residues can be recycled or reused for producing biological production. Forest areas determine the capacity of bio-economy to flourish for larger the area is devoted to forests, more amount of sustainable biological resources are available, which are part and parcel of bio-economy. The results also concluded that high forest rents encourage the production and recycling of biological products and assists transition to bio-economy.

## 8. Limitations and Future Recommendations

The current study has certain limitations that raise the point for reconsideration and adequate additions by other researchers and academics in the coming years. First, the scope of the study is limited, for authors have analyzed the influences of only agriculture and forestry factors such as agricultural land, agriculture, forestry, and fishery, agricultural irrigated land, forest areas, and forest rent on the transition to bio-economy and its development. But, there are many other factors like international trade, geographical features, and financial development factors that can influence the bio-economy development. These factors are missing here. For a more comprehensive study that could be a proper guideline for bio-economy development, authors in the future must also analyze these factors. Moreover, the study does research for the data about the influences of agricultural land, agriculture, forestry, and fishery, agricultural irrigated land, forest areas, and forest rent on the transition to bio-economy and its development, in ASEAN countries. Thus, the validity of the study conducted in the limited area of the world can be uncertain and put the readers in confusion while making decisions or policies in the concerned fields. Future authors must analyze the nexus among understudy constructs in the broader area of the world.

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