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Causes of Deforestation: Evidence from Top Deforested Countries

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ABSTRACT

This study investigates the causes of deforestation using panel data for top deforested countries from 1995 to 2022. We apply Panel Corrected Standard Error (PCSE) technique. The findings affirm that urbanization and water stress has negative and significant effect on deforestation and unemployment and agricultural exports have positive and significant effect on deforestation. The results of this study serve as the basis for the recommendations presented in the present research strategy such as labour opportunity cost might be increased to reduce agricultural rent. Stabilization and regeneration of the forest cover should be prompted by a greater demand for and a restricted supply of forest products. Labour opportunity cost should be increased to reduce agricultural rent. Stabilization and regeneration of the forest cover should be prompted by a greater demand for and a restricted supply of forest products.

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1. Introduction

Deforestation is a critical environmental issue in the modern world (Mondal, 2023). The concept underpinning the phenomena may involve reducing vegetation cover, transitioning from dense forests to sparse forests, and from either dense or sparse forests to developed open areas (Olagunju, 2015). Deforestation is the clearing and removal of forest trees to make way for non-forest uses, such as turning forest reserves into neighborhoods or commercial spaces, taking down trees to build roads or railroads, repurposing land for farming, and felling trees for charcoal, firewood, timber and paper (Mba, 2018). Due to industrialization and other purposes cutting down trees, forest area has diminished, rising temperature, unequal rainfall distribution, desertification, and seasonal irregularity (Mondal, 2023). Numerous factors pertain to urbanization, which exacerbates deforestation owing to inadequate replanting strategies (Mba, 2018). Rapid urbanization and population growth have increased human economic activity's ecological footprint and forest vulnerability (Sohag, Gainetdinova, & Mariev, 2023). Most countries are seeing land cover changes, which have impacted the earth's system (Juniyanti & Situmorang, 2023).

Deforestation has caused habitat damage, biodiversity loss, and drought. As a developing nation, roads, rails, houses, dams, and oil explorations are built daily. Deforestation and forest degradation rank as the second-largest anthropogenic source of carbon emissions, following energy production. Alterations in land cover affect the hydrological cycle and water catchment, resulting in flooding and droughts. Tropical deforestation reduces resource productivity, diversity, and food security (Juniyanti & Situmorang, 2023). From the late 1970s until 1990, deforestation in the humid tropics was about 11 million hectares, along with an additional 16.8 million hectares lost owing to forest degradation caused by the extraction of fuelwood and other minor products (Oyetunji, Ibitoye, Akinyemi, Fadele, & Oyediji, 2020). From 1990 to 2000, the annual rate was 16 million hectares; from 2000 to 2010, it decreased to 13 million hectares per year. Over the past decade, it was projected that 5.2 million hectares of forest would be destroyed per year (Chakravarty, Ghosh, Suresh, Dey, & Shukla, 2012). Statistics indicate that the global rate of deforestation is exceedingly erratic. The rate of forest cover change has diminished in various regions globally throughout the decade from 2010 to 2020 (FAO, 2020). Global deforestation is widely recognized as one of the world's leading environmental problems (Ewers, 2006; Sodhi, Koh, Brook, & Ng, 2004). With rising global costs, many adverse effects have been linked to deforestation (Nawab, Bhatti, & Nawaz, 2021; Uusivuori, Lehto, & Palo, 2002). Fires, soil erosion, watershed degradation, and shifts in microclimate are all linked to deforestation on a local scale. Deforestation can lead to extensive environmental consequences, such as disturbances to timber availability, hydrological equilibrium, biodiversity, global elemental cycles, and substantial rises in carbon emissions (Hussain, Nawaz, Ahmad, & Bhatti, 2021; Indarto, 2016). The main reasons of deforestation, such as logging, agricultural land conversion, wildfires, tree removal for fuel, and land rights disputes, are predominantly driven by population growth and the demand for additional land, primarily for agricultural use (Clark, 2012; Nawaz et al., 2021).

1.1. Causes of Deforestation

Deforestation is caused by various factors, including agricultural expansion, timber exploitation (e.g., logging or harvesting wood for home fuel or charcoal), and infrastructure development such as road construction and urbanization (Mondal, 2023). Population expansion is frequently seen as the primary driver of tropical deforestation (Wunder & Sayer, 2000). When the population are increased day by day in town, city and village then requires more land to establish housing and settlements and also to meet the demand for food and farmland to grow food and raise livestock then the peoples and farmers are clearing the forest for agricultural land. Also develop the transport and communication system it automatically requires many more roads and highways that's why to build roads the trees are cutting which is the result of decrease the forest land —all these results in deforestation (Mondal, 2023).

Increasing urban consumption contributes massively to deforestation. The urban growth drives deforestation in two ways: firstly due to rural migration to town or city for their better life style and another is requiring more cropland to meet the foods for rising urbanizing population in the world. Urbanization indirectly results in forest loss by promoting agricultural growth into forested regions (Mondal, 2023). Urbanization will elevate the demand for essential infrastructures, including transportation, construction, and energy, hence augmenting CO2 emissions (Liu & Bae, 2018). As the economy expands, there are more off-farm job options available away from the borders, which discourages farmers from removing trees (Angelsen, 1999). Moreover, the availability of finance enhances forest management and fosters public awareness regarding forest preservation. Therefore, an augmentation in income resulting from economic growth is anticipated to mitigate deforestation (Rudel & Roper, 1997). Particularly vulnerable are migrant workers from poor countries who lose their jobs, which lead to reverse migration (mostly to rural areas), decreased remittances, loss of livelihood, and worsening poverty and food insecurity. Rising rural unemployment may exacerbate strain on forests and woods, resulting in deforestation and degradation (Nair & Rutt, 2009). In addition to agriculture and horticulture, rural populations participate in dairy farming, poultry, handicrafts, and small-scale trading, all of which contribute to the depletion of forest vegetation, the primary driver of deforestation (Liu, Lan, Chien, Sadiq, & Nawaz, 2022; Mondal, 2023). The demand for forest products is rising, yet the space accessible for their cultivation is diminishing due to agricultural needs, urban expansion, and infrastructure development (Adedire, 2002). Exports occur from one nation to many nations, encompassing various forms of forestry and agricultural products. The conversion of forestland to pasture is more prevalent in Latin American countries than in Africa and Asia, where extensive cow ranching is primarily motivated by meat exportation (Koop & Tole, 2001). Because of the focus on meat exports, with the export of forest goods (Culas, 2007).

This study aims to explore the reasons for deforestation from top deforested countries. The scope of the study is limited to the top deforested countries in the world. Moreover, the time coverage in this study is from 1990 to 2022. By reviewing the literature, it is identified that most of the earlier studies have analyzed the causes of deforestation by considering the primary data. To the best of our knowledge, no prior study has examined the factors that contribute to deforestation by taking into account panel data from the most deforested nations and therefore this study contributes significantly to the literature.

The succeeding portions of the study are structured as follows: A brief summary of the relevant literature is provided in Section 2. Section 3 presents the data and techniques. Section 4 presents the results and discusses them, while Section 5 concludes the paper and offers policy suggestions.

2. Literature Review

Diarrassouba and Boubacar (2009) evaluated the reasons for deforestation in 27 countries in Sub-Saharan Africa (SSA). They used annual data from 1990 to 2004 in their study. Deforestation tends to reduce in proportion to trade and urban population. In contrast, they discovered compelling evidence supporting the presence of the environmental Kuznets curve about Sub-Saharan African deforestation. similarly Oyetunji et al. (2020) analyzed the impact of Nigeria's expanding population on the country's rate of forest loss from 1991 to 2016. The Johansen cointegration test and the Augmented Dickey-Fuller (ADF) test determined the long-term connection between Nigeria's growing population and deforestation. Forest cover in Nigeria has decreased as the country's population has increased. Contrarily Ferraz (2001) examined the factors that led to the opening of new frontiers and the destruction of forests in the Brazilian Amazon throughout the 1980s and 1990s by employed OLS, fixed and random effects, as well as panel-corrected standard error models to examine the data's time-series cross-sectional arrangement. Numerous insights have been gleaned from that inquiry. The Amazon's urban population grew at an average annual rate of 5.9%, significantly faster than the 2.7% national rate. It was discovered that changes in land prices, government agricultural credit, and road infrastructure all affect the growth of crop area; on the other hand, the decrease in cattle prices and the development of the road network are the main factors driving the growth of cow herds.

Similarly da Silva, Prasad, and Diniz-Filho (2017) examined the impact of deforestation, urbanization, public investments, agriculture, and state policies on the changing human welfare across different Brazilian Amazonian municipalities using panel data from 2005-2012 and simultaneous autoregressive models. This area has a long-standing reputation for experiencing boom-and-bust cycles in terms of economic prosperity. The municipalities in the region exhibit a lower proportion of their population residing in urban centers compared to the national average, despite a timeframe in which governments enacted various efforts to mitigate deforestation throughout the region. The majority of the region's population presently inhabits less than 1 percent of the land; if urban areas were less dependent on the resources produced in adjacent rural regions, deforestation may potentially be mitigated.

Likewise Ajanaku and Collins (2021) examined the correlation between deforestation rates and economic development in African nations from 1990 to 2016. Alterations in forest cover data were elucidated using Generalized Method of Moments (GMM) estimators. A statistically significant positive correlation existed between net deforestation and real GDP per capita in Africa. Moreover Pablo-Romero, Sánchez-Braza, and Gil-Pérez (2023) examined the correlation between wooded area and economic growth in a sample of 19 Latin American nations from 1991 to 2014. The methodology employed was generalized method of moments quantile regression. The quantile regression indicates a positive, increasing correlation between per capita wooded area and economic factors. In contrast, López and Galinato (2005) compared estimates from a cross-country analysis with elasticities from microstudies to find structural correlations explaining deforestation in Brazil, Indonesia, Malaysia, and the Philippines between 1980 and 1999. The amount of forest cover is negatively and significantly impacted by economic expansion.

Similarly, Klarić, Pirc Barčić, and Basarac Sertić (2023) investigated the effect of Chain of Custody certifications from the Forest Stewardship Council (FSC) on Croatian timber exports to EU countries. The Generalized Method of Moments (GMM) Estimator was used to analyze dynamic panel data. According to the findings, there was a statistically significant inverse relationship between the number of FSC certificates and deforestation between 2000 and 2021. In contrast, Amirnejad, Mehrjo, and Eskandari Nasab (2022) examined the impact of socioeconomic factors on deforestation in various nations. The researchers utilized a spatial econometrics model and analyzed data from 18 countries from 2005 to 2015. The study employed the Spatial Durbin Model. The study found that the unemployment variable positively and significantly impacted deforestation. Moreover Schmitz et al. (2015) used a spatially explicit economic land-use model and a biophysical plant model to examine how trade and tropical deforestation might be linked in the future and what policies might be needed to stop this. The results show that more trade liberalization causes more trees to be cut down in Amazonia because farming is more profitable in South America.

Moreover Leblois, Damette, and Wolfersberger (2017) Utilized recently published and universally accessible forest loss data collected using high-resolution remote sensing to revise the evaluation of the factors influencing deforestation in developing nations across different countries. Deforestation rates are positively correlated with agricultural production, which is measured by the lag of the Crop production index. Contrarily, Zambrano-Monserrate, Carvajal-Lara, Urgilés-Sanchez, and Ruano (2018) assessed the France, Germany, Greece, Portugal, and Turkey's deforestation rate to examine the Environmental Kuznets Curve (EKC) theory. Time-series data from 1974 to 2013 were analyzed using the autoregressive distributed lag bounds testing technique. The findings show that agricultural exports have statistically significant negative coefficients. Consequently, agricultural exports exert negative influence on the deforestation rate. Likewise Carreira, Costa, and Pessoa (2024) examined the extent to which commerce and agricultural productivity contributed to deforestation in different Brazilian towns from 2000 to 2017. By utilizing remote-sensing data, clear and separate impacts of these two events on land utilization can be discerned. Increased adoption of genetically modified soy seeds is linked to accelerated deforestation due to the expansion of agricultural areas. There is no notable connection between the proximity to Chinese demand and deforestation. However, the involvement in trade with China helps reduce the negative effects of deforestation caused by using modern soy technology.

2.1. Literature Gap

By reviewing the literature, it is identified that most of the earlier studies have analyzed the causes of deforestation by considering the primary data. to the best of our knowledge that none of the preceding research have conducted an analysis of the causes of deforestation by considering the panel data of top deforested countries. Thus, to fill up these gaps, our study estimates the causes of deforestation in top deforested countries.

3. Data and Methodology
3.1. Model Specification of Causes of Deforestation

The model of the study is specified on the basis of forest transition theory to fulfill the study objective. The Forest transition (FT) has been associated with economic development, industrialization, and urban growth. These procedures decrease the transformation of forest areas and release land that reverts to forest (Rudel et al., 2005). Forest transition curve can be divided into two distinct processes of land use allocation. Forest decline is driven by different variables than forest recovery. The expansion of agricultural land is expected to decrease when the land's suitability reaches its maximum capacity, farming becomes more modernized and intensified due to investments in advanced technologies, and economies reach an advanced level of development where the need for food grows at a slower pace (Wolfersberger, Delacote, & Garcia, 2015). During the initial growth phase, the growing population and food demand will exert enormous pressure on forest areas due to the expansion of agricultural land. As countries progress, there will be an increasing need for forest products and services, motivating reforestation (Indarto, 2016). Economic growth creates employment opportunities outside traditional agricultural activities, enticing rural residents to leave their land-based economic pursuits (Köthke, Leischner, & Elsasser, 2013; Rudel et al., 2005) Occurrence of a global forest transition on a global scale, identifying a consistent trend of forest depletion.

The research evaluates the impact on deforestation of economic growth, population growth, urbanization, unemployment and agricultural exports over 1990 to 2022 period. We incorporate deforestation (DEF), economic growth (GDP), unemployment (UNEMP), urbanization (URBAN) and agricultural exports (AE) in the model as follows:

$$\Delta DEF = \beta_{\circ} + \beta_1 POPG + \beta_2 URBAN + \beta_3 \, GDP + \beta_4 \, UNEMP + \beta_5 \, AE + \varepsilon_t \quad (1)$$

The equation (1) is used for the empirical assessment of study. Table 3.1 provides all necessary detail about variables of the study.

Table 1
Measurement of Variables and Data Source

Variables	Measurement	Source of data
Deforestation	Forest area (% of land area)	FAO (food and agricultural organization of the United Nations)
Urbanization	Urban population (% of total population)	World development indicator
Unemployment	Total unemployment (% of total labor force)	World development indicator
Agricultural exports	Total trade value of food and agriculture crops export per capita (in 1000US$ at constant 2010 price)	FAO (food and agricultural organization of the United Nations)
Water stress	Level of water stress (fresh water withdrawal as a portion of available fresh water)	World development indicator

3.2. Applied Methodology
3.2.1. Panel Corrected Standard Error (PCSE)

Unlike (Parks, 1967) the PCSE method proposed by GLS for resolving non-spherical disturbances in panel data (Beck & Katz, 1995) results in parameter estimates that are significantly more efficient than OLS and Parks' coefficients. The multiplication of the panel OLS parameter covariance matrix is their primary invention $(X'X)$ by Ω_T Data on the error terms' simultaneous correlation from every cross-section (T) are included in this. The sample covariance of individual parameters may now be calculated using the following improved formula:

$$COV(\beta) = (X'X)^{-1}\{X'\Omega X\}(X'X)^{-1} \tag{2}$$

where the EViews (2004) cross-sectional seemingly unrelated regression with panel-corrected standard errors technique yields (White, 1980) robust standard errors are now provided for the system of equations, and the coefficient covariance is defined as follows:

$$COV(\beta) = \left(\frac{n^*}{n^*-K^*}\right)(X'X)^{-1} \times \{X'\Omega X\}(X'X)^{-1} \tag{3}$$

where k* indicates the total number of calculated parameters and n* the total amount of pooled data. Using the diagonal elements of the computed ΩT matrix, covariance estimators resistant to heteroscedasticity are computed for each cross section (Hecht, 2008).

4. Results and Discussions

Firstly, the cross sectional dependence test is applied and its results are given in Table 1. The results indicate that cross sectional dependence exists in our data.

Table 2
Cross sectional dependency

Variable name	Breusch-Pagan LM	Pesaran scaled LM	Bias-corrected scaled LM	Pesaran CD
DEF	0.0000	0.0000	0.0000	0.0000
UNEMP	0.0000	0.0000	0.0000	0.0069
URBN	0.0000	0.0000	0.0000	0.0000
AGRI EXPO	0.0000	0.0000	0.0000	0.0000
WS	0.0000	0.0000	0.0000	0.0000

If there is cross-sectional dependency, the econometric literature recommends testing for the stationary variables if the time interval is sufficiently long. Regressions would be erroneous if the variables were not steady (Kao, 1999). The study then performs the second generation panel unit root test namely as the cross-sectional ADF (CADF) and cross-sectionally augmented IPS (CIPS) tests proposed by (Pesaran, 2007) due to the presence of cross-sectional dependence.

The CIPS and CADF test findings are presented in Table 2, which indicate that certain variables are not level-stationary. Next, the CIPS test is run for each variable's first-difference, and the results indicate that the majority of the variables are stationary at this point.

Table 3
Cross-sectionally augmented Im-Pesaran-Shin (CIPS) Panel Unit Root Test

s	Level		1st difference	
	Int	Int&trend	Int	Int&trend
FA	-0.120	0.089	-1.478	-1.938
URBAN	-0.279	-2.471	-1.862	-2.403
UNEMP	-1.640	-0.695	-2.779	-3.076
AGRI_ EXPO	-3.435	-3.429	-5.721	-5.757
WS	1.283	-1.413	-3.904	-3.106

Note: *, **, and *** represent 1%, 5%, and 10% significance levels, respectively.

Given that variables are stationary at both the level and first difference, as well as the presence of cross-sectional dependency lead us to apply PCSE technique and its results are given in Table 3.

Table 4
PCSE Findings (**Dependent Variable Deforestation)**

Variables	Coefficient	Std. err.	z-statistics	p-value
Urban	-.5563	.0368	-15.11	0.000
Unemp	2.1482	.3398	6.32	0.000
Agri-expo	1.94e-07	3..51e-08	5.52	0.000
Water stress	-.7966	.0374	-21.29	0.000

It is revealed that the impact of urbanization on deforestation is negative and significant. 1% increase in urbanization means .55% increase in forest area and decrease in deforestation. This is so because urbanization leads to lifestyle and diet changes, which in turn increase the need for food and drive the conversion of forests into agricultural land. The growth of urban populations also depresses land resources, fragmenting forests in the vicinity of cities (Destiartono, 2023). The country is experiencing deforestation due to the increase in urbanization, which requires additional agricultural land and increases the population (Nathaniel & Bekun, 2020). The urbanization process will result in a rise in the overall generation of carbon dioxide (CO_2) due to the increased demand for necessary infrastructure, which will include transportation, buildings, and electricity (Liu & Bae, 2018). This findings in line with Jorgenson and Burns (2007) and Olagunju (2015), but in contradictory to (DeFries, Rudel, Uriarte, & Hansen, 2010; Ünal, Birben, & Bolat, 2019; Yameogo, 2021) and (Sacchi & Gasparri, 2016) This implies that the shift of people from rural to urban regions due to better living conditions resulted in afforestation as the rural population fell. Along with a great demand for land, this search for better living circumstances also results in woodcuts, causing deforestation. Nonetheless, The country's negative effects of urbanization could be mitigated by using the wood from deforestation as an input for household activities or trading patterns (Yameogo, 2021)

It is revealed that the impact of unemployment on deforestation is negative and statistically significant. This is because workers in agriculture leave their farms in search of non-agricultural positions that pay more. Many agricultural enterprises become unsustainable due to the loss of labour, which drives up salaries for the remaining workers. Under these conditions, farmers forsake their less profitable fields and pastures that are farther away, and the areas eventually turn back into forests (Rudel et al., 2005). Due to an increase in nonfarm employment, some agricultural fields were converted into forests, which forced landowners to save agricultural labour and forced workers off the land (Bentley, 1989; Rudel et al., 2005). The lack of labour, not the paucity of forest products, This is the impetus behind the economic growth trajectory's forest conversion to a forest transition (Rudel et al., 2005). Unemployment commonly follows a slowdown in industrial activity, particularly in industries like logging, mining, and large-scale agriculture that directly support deforestation—reduced economic activity results in less demand for resources and land, which can cause stabilization or rise in forest cover (Angelsen & Kaimowitz, 2001). This findings in line with (Angelsen & Kaimowitz, 2001; Rudel et al., 2005) and (Amirnejad et al., 2022), but in contradict with (Nguyen & Su, 2021) and (Mujahid & Minhaj, 2020). This is because along with the rising demand for wood fuel, the high rates of unemployment in rural and urban areas lead to uncontrolled wood fuel production, which fuels deforestation and/or forest degradation, negatively affecting the forest (Mulenga, Nkonde, & Ngoma, 2015). Due to the increased demand for agricultural land and the pressure on labour market wage rates to decline, deforestation raises unemployment (Amirnejad et al., 2022). Using natural resources, people can make money. Given that unemployment will rise as the rate of deforestation declines (Mujahid & Minhaj, 2020).

It is revealed that the impact of agricultural exports on deforestation is positive and statistically significant because as the demand for agricultural products increases, countries are expected to face pressures on their forest areas. Indeed, they have managed to augment their forest areas and boost agricultural exports without significantly sacrificing forested regions (Rome, 2017). There is a direct correlation between the value of agricultural goods exported per square kilometer gathered in the previous year and the level of deforestation. The countries in question are characterized by their underdeveloped status and the presence of a substantial amount of intact forest cover. The opportunity cost of clearing an additional hectare of forest is rather modest, as some of them have the potential for agricultural expansion driven by exports (Leblois et al., 2017). The findings in line with (Leblois et al., 2017) and (Shandra, 2007), but in contradictory to (Zambrano-Monserrate et al., 2018).

It is revealed that the impact of water stress on deforestation is negative and statistically significant. This is because in situations of limited water resources, the ability to support extensive farming or transform wooded regions into agricultural land becomes challenging. This can lead to a reduction in the rate of deforestation as the viability of agriculture in these areas declines (Nepstad, Tohver, Ray, Moutinho, & Cardinot, 2007). Water scarcity can diminish the profitability of activities commonly contributing to deforestation, such as agriculture, logging, and mining. When these activities become less feasible due to water scarcity, the economic motivation to clear wooded areas decreases. Water scarcity poses significant hurdles that outweigh the financial benefits of converting forests to other land uses, resulting in decreased deforestation rates (Dubois, 2011) The findings are inline with (Armenteras, Rodríguez, Retana, & Morales, 2011; Staal et al., 2020) but contradictory to (Barbier, 2004).

5. Conclusion, Policy recommendations and Limitations.

This study examines deforestation causes using panel data from top deforested nations from 1995 to 2022 using PCSE approach. Urbanization and water stress negatively and significantly affect deforestation, while unemployment and agricultural exports positively and significantly affect it. On the basis of these findings, the governments are advised to implement programs and establish laws that would sustainably conserve forests and avoid indiscriminate use of forest resources. A significant reliance on forests may result in overexploitation. This necessitates meticulous targeting and the promotion of a hybrid forest-welfare strategy. This may encompass forest development activities that integrate economic and forest resources. The spatial separation of remnant forests from intensive producing zones should facilitate the alignment of conservation and production objectives in the future. Integrate the mild impacts of institutional quality with natural resources to ascertain if enhanced institutional quality might mitigate the resource curse in the agricultural sector. Access to data constitutes a limitation of our research. Furthermore, the study concentrated exclusively on the 10 most deforested nations, and subsequent research could incorporate additional countries to broaden the study's reach.

Authors' Contribution

Anam Aziz: conceptualized the study, performed data analysis, and drafted the initial manuscript.
Muhammad Atif Nawaz: contributed to the methodology, supervised the research process, and reviewed and edited the manuscript for critical insights.

Conflict of Interests/Disclosures

The authors declared no potential conflict of interest w.r.t the article's research, authorship and/or publication.

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