UNIVERSITÀ DEGLI STUDI DI PADOVA

Dipartimento Territorio e Sistemi Agro-forestali

Department of Land, Environment Agriculture and Forestry

Corso di laurea magistrale/Second Cycle Degree (MSc)

in Forest Science

Thesis Title

"Socio-economic Impact on Global Wood Consumption and the Path to Sustainable Use."

Relatore/Supervisor

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ANNO ACCADEMICO/ACADEMIC YEAR 2023

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Index

1. List of Figures

2. List of Tables

3. **Abbreviations and Acronyms**

4. **Acknowledgement**

5. **Summary**

Acronyms and abbreviation

EKC: Environmental Kuznets Curve

EU: European Union

USA: United States of America

GDP: Gross Domestic Product

N.A.: not available

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1. Introduction

The utilisation and management of forest resources, particularly fuelwood and industrial roundwood, have become the focal points in discussions around sustainable development and energy consumption. Eurostat data reveal a 4% increase in fuelwood production in the European Union compared to 2020, reaching 118.5 million cubic metres in 2021 (Eurostat, 2022). The increase in production reflects a larger shift towards the adoption of renewable energy, with a significant 18% increase in 2019 compared to 2016. However, the COVID-19 pandemic caused an unexpected decrease in 2020 (Eurostat, 2022). France, Germany, Finland, Romania, and Sweden collectively contribute about 65% of the EU's fuelwood production, indicating a high concentration level (Eurostat, 2022). The oscillations highlight the complex relationship between energy regulations, environmental factors, and market dynamics. The past research findings suggest that the diverse patterns of using fuelwood are affected by factors just like GDP, population, and the forest area (Shafron, 2019). Due to this, understanding the connection among these factors requires an in-depth analysis to be performed to understand which factor brings how much change. The importance of these elements increases the requirement for a detailed evaluation as the balance between consumption and sustainability of fuelwood is a very big challenge for both developed nations as well as emerging ones (Ajanaku and Collins, 2021).

With the continuous growth in the global economies and with the increasing population in the regions, the change in forest resources has become more concerning for environmental experts and politicians (Nabavi *et al*., 2020). The global market for wood is highly competitive and the movements in the market are relatively very quick. The economy, especially the changes in the economic growth of the countries (i.e., GDP), has a substantial role in these movements as they also bring change in the wood usage trends (Hung, 2022). As per research performed by Global Wood (2023), the amount of Roundwood used will increase to 10%while reaching 2.2 billion cubic metres by 2030, significantly increased by the strong economic and population growth. One of the most important aspects of the environmental study is the link between social factors and the use of forest resources, and this is true, especially when looking at global forestry and how it brings changes in climate change as well as carbon pollution.

Nguyen *et al*. (2023) have shown in their research the complicated links between the changes in population, changes in economic growth, and changes in forest areas. Deforestation, which is a key issue in this discussion, has been linked to formal economic factors as well as common ones, just as farming and mining (McCallister *et al*., 2022). As per the Environmental Kuznets Curve, which looks like an upside down "U", the constant increase in the income levels or GDP has a negative effect on the health of the environment; however, after reaching a peak level, when there occurs an increase in the income levels, the adverse influence eventually changes with decline in the forest degradation. However, the practical implementation and outcomes of this theory vary on the basis of amount of resources and the pattern of changes in the regions (Adila *et al*., 2021). The specific connection of tourism and private economic activities with forest decline has been considered by the researchers in different countries, and research has shown that on the basis of different locations, there are several patterns in forest decline (Brown and Pearce, 2023).

The past research data also shows that there is a complicated connection between income levels with the forest cover while showing a U-shaped pattern as suggested by the Environmental Kuznets Curve (Leal and Marques, 2022). There is a link between a rise in GDP and an increasing number of trees being cut down (Andrée *et al*., 2019). However, as countries get better and people make more money, there is a move towards planting, which is in line with the ideas of sustainable development (Ajanaku and Collins, 2021). The way the industry works is changing because of the link between countries' economies like China and the wood markets. According to Global Wood (2023), this growth has caused a huge 760% increase in the sale of wood products, which shows a big change in how wood is used around the world. Although there is an increasing amount of literature on the subject, there are still gaps in our understanding of how these socioeconomic elements influence fuelwood and industrial roundwood use.

Problem Statement

Research has been done on factors affecting deforestation and wood consumption, but uncertainties remain about the impact of economic expansion and population dynamics on wood use. Global Wood (2023) predicts a 10% increase in global roundwood use by 2030, driven by economic growth in Asia. The European Union saw a 4% increase in fuelwood production since 2020, indicating a growing demand.

This study aims to investigate how economic and social factors influence the use of fuelwood and industrial roundwood. Based on previous research, the objective is to explore the connections between GDP growth, population changes, and forest coverage. The focus is on identifying trends, interpreting their implications and implications, and addressing challenges related to increased demand for increased fuelwood and changing management of forest practices.

Objectives and research questions

Based on the problem discussed above, the following are the research questions of the present research:

1. The status of global wood production and its variations between regions and countries must be examined.
2. The relationship of some selected main economic and social factors on the use patterns of fuel wood and round industrial wood should be investigated.
3. Recommendations for optimising wood consumption strategies based on the analysis of economic and social factors that affect the use of fuel wood and industrial roundwood.

How the relative increase in bioenergy is impacting the sustainable harvest in years?

i. Analyse the state-of-the-art of global wood consumption.
ii. Analyse how economic and social variables influence fuel wood and industrial Roundwood.
iii. Formulate recommendations for optimising wood consumption strategies by integrating insights from the analysis of economic and social variables that impact the use of fuel wood and industrial round wood.

Structure of the thesis

The thesis begins with Chapter 1, which establishes the context for the research. The research problem is introduced by providing a detailed analysis of the background of the use of roundwood and industrial roundwood. This analysis emphasises the importance of this issue in the broader context of global economic and environmental dynamics. Chapter 2 of the thesis provides a detailed look at the existing literature. The study offers appropriate hypotheses and conceptual

frameworks that form the basis of the research, including subjects related to the use of natural resources, economic expansion, expansion, and the promotion of sustainable development.

Chapter 3 outlines the research methods used in this study. The text begins with a concise summary of the study strategy and defines the strategy as the methodological framework. Research findings are described in Chapter 4. This chapter presents an intricate examination of the results that encompasses many statistical indicators and data representations. Chapter 5 is specifically devoted to the examination and analysis of these findings. This process establishes a connection between the observed data, the theoretical frameworks, and the previous prior research examined in Chapter 2. Chapter 6 serves as the final conclusion of the thesis. The chapter provides a summary of the main findings and highlights how important they are to the study questions and objectives. Goals. This section contained a lot of information. Statistical analysis showed what the study meant for future policy, practice, practice, and research in the areas of wood use and environmental sustainability.

2. Theoretical Background

Historical Context of Fuelwood and Industrial Roundwood Consumption

Fuelwood and industrial roundwood are very important raw assortments among tree products all over the world as their utilization in the past clearly represents that there is a critical connection between environmental concerns, energy needs, and social as well as economic growth. In the past few years, researchers have been focusing more and more on the many things which bring changes in how these resources of a particular country are used. The increasing social growth in these countries has a sufficiently great influence on how much fuelwood and roundwood are used by their residents. This is especially true within the developing areas where all these resources are an important part of the energy mix while having significant consumption. According to Amoah and Korle (2020), nearly 58% of Africa's energy comes from fuelwood and charcoal due to which the increasing need for fuelwood for cooking and heating is known to be one of the major causes of deforestation.

The lack of money and the need to survive are closely related to the need for fuelwood, as in many African countries, just like Ghana, the price as well as the supply of fuelwood are highly affected by how the market works, along with the characteristics of the species. There are different types of plants that emit less smoke as compared to others, plus more calories, and are sold at prices higher than that of other plants. The research of Atinga *et al*. (2023) in the Bono area of Ghana showed that the market for fuelwood harvesters is not pretty much centralised, and the price trends are highly influenced by several factors which either increase or decrease these prices. There are sufficiently great differences in how much non-fossil fuels, just like fuelwood, are used around the globe; however, the overall amount that is being used is steadily going downward. The study found that between 1985 and 2015, population growth was one of the key factors that influenced the amount of non-fossil fuels used around the globe while representing how big changes in population can have on fuelwood demand (Chen *et al*., 2019).

Along with this, the growth of cities as well as the sale of agricultural goods also has a sufficiently great role in the loss of wood, while including those that are cut for commercial purposes as well. Previous research has used satellite data and regression analysis in order to show the link between these factors and the increasing losses of trees and revealed that there is a substantial influence of

these factors on the decreasing number of trees (Amoah *et al*., 2023). In historical settings, there is also the problem related to how to increase agricultural output and food security without cutting down more and more trees in wooded areas. This clearly represents how difficult it is to manage land use so that food production needs are met while also protecting trees for their timber and other environmental services. Manzoor *et al*. (2022) in their research brought this issue to light and reported that land rich in trees is under a lot of pressure around the globe, especially in developing countries that deal with large population growth as there are increasing chances of wood loss in these countries.

Several research has looked very closely at the link between the utilization of resources and the economic growth of a country, especially in the context of the Environmental Kuznets Curve (EKC) which states that at the start the environmental degradation increases when the economic growth of the country increases and reaches a certain peak point after which when the income continues to increase over time, the environmental degradation eventually decreases This inverted U relationship suggests that with increase in the development of the economy, the resources to invest in cleaner technologies increases and so does the ability to comply with the environmental regulations, due to which the environmental degradation eventually decreases. EKC is specifically relevant to our study as it provides us with a framework to better understand the connection between the economic growth and the forest cover changes or its consumption (Lau *et al*., 2018).

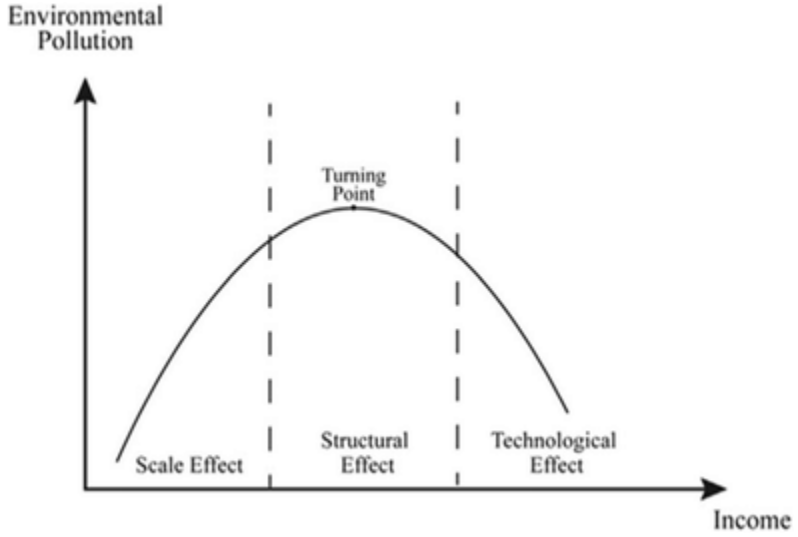

Figure 1 Environmental Kuznets Curve

(Source: Can and Gozgor, 2017)

In the similar way, the forest transition theory (FTT) also focuses on the pattern of changes in the overall forest areas due to changes in socio-economic factors while focusing on the early stages of the economic development of a country (Singh *et al*., 2017). This theory also states that the initially due to increase in the economic development in a country, the forests are reduced in number to a significant level which keeps on increasing unless the income level of the country reaches to a point where the ability of the country to adopt more environment friendly methods increases which helps in playing a positive role in the environment while increasing the forest areas. The theory also highlights the highly dynamic connection between the socio-economic factors and the changes in the forest cover while focusing on the role of policy, market forces, technological advancements which results in all these transitions (Kozak and Szwagrzyk, 2016).

Economic Growth and Resource Consumption

Li (2023), in his research, stated that EKC shows that when pollution increases due to an increase in GDP, it increases continuously until it reaches a certain level, after which it then starts decreasing as the economic condition of the country increases. Several research studies have shown that the EKC's view related to carbon dioxide emissions is a reality and these studies show a strong link between this idea and how technological progress and economic activities bring changes in each other. Improvements in technology have had different effects on the amount of energy used and the amount of pollution released in different areas of the economy. An inverted U-shaped graph shows a link between economic growth and emissions, especially in industrialised countries, where there is evidence of a clear link between emissions and income per capita (Lau *et al*., 2018).

China and India are two newly industrialised countries that have been compared in terms of environmental health. The environmental Kuznets curve (EKC) was found at both the individual and panel levels. This study showed that economic growth would eventually improve the environment, but the rates of change would be different between the two countries due to differences in how much energy they use (Sen and Abedin, 2021). Still, an environmental Kuznets curve (EKC) that is not linear and formed like an "N" has been seen for forestry in Ghana. This makes the normal EKC scheme even more complicated. This study shows that deforestation first decreases when GDP increases to a certain point. After that, it goes back up when GDP goes up

and then goes down again when GDP goes up. This means that economic growth might be able to stop trees from being cut down, but only if the groups that are supposed to protect wood become stronger (Minlah *et al*., 2021).

In a study by Singhania and Saini (2020), they used an autoregressive distributed lag (ARDL) method that helped them learn a lot about the connection between economic growth and environmental damage. The developed and growing countries were studied in the seven countries. The results made it clear that high economic growth and energy use are the main causes of environmental damage. FDI and financial growth also have different effects in emerging and industrialised countries. Furthermore, Bader and Ganguli's (2019) study of the GCC countries showed that most of them did not show an EKC trend when it came to greenhouse gas emissions. However, in places like Bahrain and Saudi Arabia, there were signs of a U-shaped link. The study looked more closely at the link between health and GDP and found that rising wealth has led to better health standards, although expected EKC has not been observed in these places.

Population Dynamics and Consumption Patterns

Much research is being done on the link between population growth and the use of natural resources. This study has many applications to support sustainable development. Population changes have been studied in depth to find out how they affect how people use resources and what they buy. According to Ester Boserup's hopeful view, population pressure leads to better farming, which goes against the Malthusian view that farming methods determine population (Oyinlola *et al*., 2020). This view is supported by the idea that when we need something, we come up with new ways to do it. For example, when the population grows, factories start to use more efficient ways to make things, which boosts the economy. According to Simon Kuznets, more people may mean more use of natural resources and more specialised job assignments, which could lead to higher production and national production (Adeosun and Popogbe, 2021).

In Pakistan, a scientific study looked at the relationship between economic growth and things such as population density, water supplies, and tree cutting. The results show how complicated the link between population change and resource use is. They say that as populations grow, resources can run out, and economies can suffer (Shabbir *et al*., 2020). The idea that economic growth should not be linked to environmental damage is a key idea in this field. The idea includes "impact

decoupling" and "resource decoupling," which aim to lower the amount of resources used for each unit of economic production and to lessen the damage that using resources and economic activity does to the environment. Several countries have shown some signs of separation, but it is less common for resource use to completely drop. To make room for the world's growing population, the population needs resources; they use much less than we do now (Simonis, 2013).

A study by Rahman *et al*. (2017) looked at how population growth, natural health, and trade freedom affect economic growth. They found that population growth helps economic growth in developing countries. Research also found that CO2 emissions and population growth are linked in a way that goes both ways and that population growth and economic growth are linked in a way that goes only one way. Meyers and Kalaitzandonake's (2015) study of the increase in food supply compared to population growth over the next forty years emphasized how important it is to keep investing in technology to boost output by making people more productive. The study proposed that the main obstacle to future food security lies not in production but in the need to improve access for families experiencing food insecurity, especially in places projected to see substantial population expansion.

Forest Area and Resource Utilisation

The link between the number of forested areas and the exploitation of resources, including deforestation and reforestation, has a significant meaning for both environmental sustainability and the economy as it brings significant changes over time. Several studies have focused on understanding the extent of these links and found different results while showing how difficult it is to manage forest resources so that it does not harm the environment and society as well. A study looking at forest loss in Ghana found that when there are clearly established property rights, it brings a decrease in the rates of deforestation as both are inversely related. Countries with strong property rights laws are seen to have been much better in allocating their resources and have lower rates of deforestation while protecting their environment as compared to countries with no or weak property rights laws (Baragwanath and Bayi, 2020). On the other hand, illegal logging, as well as destruction, can get have an adverse influence, especially when people don't have enough property rights, when there are problems with the government, or when they are cut off from the management of forests (Amoah and Korle, 2020).

Pakistan is working to stop climate change by planting trees again as part of its plan. Using this method means participating in the REDD+ system, an international climate policy tool that links financial rewards with protecting and managing forest resources. A complete forest survey is needed to provide the correct data for REDD + programmes, which will lead to better management of forests and protection efforts (Ismail *et al*., 2018). Ghana and China exchange wood with each other, showing how foreign trade deals can have a direct effect on forest supplies. Ghana's forests are managed by the government, which is paid by companies doing this work. However, logging companies also have social responsibilities for people who live near their forests. The relationship with China is based on mutual benefits, with trade, help, and money being the mainstays of the partnership. As global demand for wood goods increases, China's imports have made the supply situation worse, which has changed the way forest resources are used (Kombat and Chen, 2022).

A study by Waruingi *et al*. (2022) conducted in Kenya examined the ability of forest-dependent households to pay (WTP) for forest conservation. The research found differences in WTP based on household characteristics and the level of dependence on the forest. This research has emphasised that there is a need to engage local people in conservation initiatives, which can increase the possibility of receiving non-monetary support for conservation from households that are heavily relying on forests only. Shabbir *et al*. (2020) performed the research while using time series data from Pakistan from 1972 to 2016 to understand whether the economic changes eventually bring significant changes in the forest areas or not. This research incorporated GDP, population density, and water resources to explore their effect on deforestation, and the results indicated that there is a negative correlation between deforestation and economic growth while highlighting the importance of implementing sustainable management of forest strategies to promote economic development.

Socioeconomic Factors and Environmental Impact

Socioeconomic factors, just like income levels, urbanisation, or industrialisation, significantly change the utilization level of resources as well as the environmental effects of their utilization. The shift to urban environments has been linked with evolving economic expansion; however, this correlation has been found to be not linear. Urbanisation has the potential to bring an increase in the economic progress of a country to a certain point, but after that point, further expansion may

differ (Nguyen, 2018). The quality of urbanisation is very important as it is directly linked with people's lives and their consumption habits while shaping resource utilisation and environmental sustainability. The connection between environmental income and economic growth represents that there is an effect of local environmental amenities on consumption levels. Similarly, the fiscal policies of environmental revenue can also bring changes in savings and consumption, while impacting the patterns of capital accumulation as well as bringing changes in the renewable resource stocks. Moreover, investing in ecological initiatives, especially those which promote cleaner production and consumption, can bring changes in economic growth while reducing environmental influences (Wang *et al*., 2019).

Industrialisation results in damaging the environment by directly releasing pollutants such as CO2; however, it can indirectly bring a decrease in environmental deterioration by increasing per capita income and also encouraging better environmental management practices. Over time, the positive influence of industrialisation on the promotion of more sustainable economic systems brings changes in immediate negative effects that occurred as a result of urbanization. Moreover, it also has a direct effect on environmental deterioration and brings indirect consequences as well, such as an increase in income or changes in consumption habits, which can improve environmental quality overall (Raheem and Ogebe, 2017).

Furthermore, the allocation of income, particularly in rural regions, is inherently linked to industrialisation. Redistributive measures to reduce income inequality can occasionally promote economic development and welfare by encouraging industrialisation. Consequently, this has implications for the manufacturing and use of products, exerting an influence on the environment by altering how land is used, and resources are allocated (Wang, 2019). Urbanicity, which refers to the level of urban development, impacts the amount and type of food that people consume. Although it can improve the availability of various nutritious meals in highly developed regions, it can also result in greater consumption of processed sugary or fatty foods, especially in densely populated cities with higher living expenses. The net result of these factors determines whether urbanicity will eventually have a favourable or unfavourable influence on environmental quality (Sun *et al*., 2021).

Global Market Trends and Wood Consumption

The way people use wood is greatly affected by changes in the global market, especially when it comes to new goods and how trade works. Especially between Ghana and China, international trade in wood shows how global market trends can change the way wood resources are used (Zhang *et al*., 2020). China's growing economy may have made more people want wood goods, which put pressure on the world supply because China does not have many forests, and there is a lot of demand from other countries (Kombat and Chen, 2022). This situation clearly reveals that how complicated global trade deals are and how people use wood in order to affect each other. Technological improvements, as well as changes in what people want are also very important for the growth of the wood industry as a while. Cross-laminated wood (CLT) is one of the substantial steps taken as it has several benefits, such as lower carbon pollution and perhaps even economic benefits compared to traditional materials (Dong *et al*., 2019). All these qualities are likely to bring massive changes in the way the market behaves in the future and the way clients feel regarding certain products. Ingin *et al*. (2023), in their research also stated that the significant upward trend in CLT and other similar innovations' adoption clearly represents that people want more sustainable and eco-friendly wood products.

A detailed evaluation of the global wood furniture market from 2023 to 2030 was done by the Intellect Insights Journal (2023), which revealed that as of 2022, the market was worth USD 104060 million, and it was projected to grow at a rate of 4.91% per year, hitting USD 138742million by 2030. Intellect Insights Journal (2023) also stated in its research that the market has many diverse types of wood furniture, such as solid wood as well as wood-based panel furniture, which are used for the purpose of creating different things, such as office and home furniture. The study further revealed that all the new products, the division of the market into groups, and the wide range of products available around the world are very important factors that bring significant increases the overall growth. The COVID-19 virus and the war between Russia and Ukraine have had a big impact on the market, changing how people buy things and how businesses run. The need to make good use of wood furniture during the pandemic and our growing reliance on digital platforms have greatly increased market demand. However global conflicts have

caused changes in the market, which affects how people feel and what they buy (Ratnasingam *et al*., 2021).

Policies and Sustainable Management

In places like Poland, healthy management of forests has led to good results. Forest cover, cutting down trees, planting new forests, and collecting wood are all things that show how important it is to use comprehensive plans to manage forests in a sustainable way (Bartniczak and Raszkowski, 2018). Teaching people about the environment is also very important. Farmers in China have increased their investments in forests since the joint forest tenure reform was implemented. This shows that policy changes aimed at making money work. The introduction of funding programmes, forest right mortgage loans, and forest cooperative organisations has played a crucial role in boosting the level of investments within the management of forests (Song *et al*., 2023). Big data has been seen as a very important strong tool that helps in the growth of sustainable practices in the management of forests. For example, big data can be used in order to improve the evaluation of the ecosystem services that are provided by forests and also help to detect forest fires before time. Hasan *et al*. (2019) stated inn their research that big data also helps in improving the control and security of resources in forests. Likewise, the forestry community in Cameroon also shows the benefits as well as drawbacks of REDD+ projects, whose focus is to prevent trees from being cut and forests from getting worse by reducing emissions. However, the perfect working of all these foreign policy tools eventually depends on how things are managed and set up in each country (Bele *et al*., 2022).

A literature study has comprehensively analysed the interaction between socioeconomic development and environmental effects. Research has indicated that economic expansion, urbanisation, and industrialisation can worsen environmental degradation. However, they can also improve environmental quality using technical progress and increased awareness of environmental issues. Expanding on these findings, the methodology chapter will present a research plan that investigates and expands upon these theoretical frameworks. This document will provide the methodology for analysing the correlation between socioeconomic determinants and environmental outcomes, considering the small differences emphasised in existing research. The chosen methodologies will target the deficiencies highlighted, including the requirement for

extensive study over an extended period and incorporating individual and collective actions within the broader economic and environmental framework.

Theoretical frameworks relevant to the study

Different research models based on theories usually help researchers in figuring out how natural resources that are used over time worsen with time. The present research focuses on different theories and models which have considered a lot of environmental factors, like CO2 emissions, rates of deforestation, and loss of species, to provide better information about changes in the environment and factors influencing them (Mitić *et al*., 2019; Bhattacharya, 2019; Sarkodie and Strezov, 2019).

The resource scarcity model is a very important theoretical paradigm that argues that as a resource becomes scarce, its cost eventually increases while creating economic incentives for conservation and exploring alternative options (Krautkraemer, 1998). Along with this, the Hotelling rule also provides valuable information related to the temporal distribution of natural resources while stating that the rate at which an asset that is not renewable is extracted should rise over time after the interest rate. This clearly reflects that how the scarcity and value of the resources change over time (Cannon *et al*., 2019).

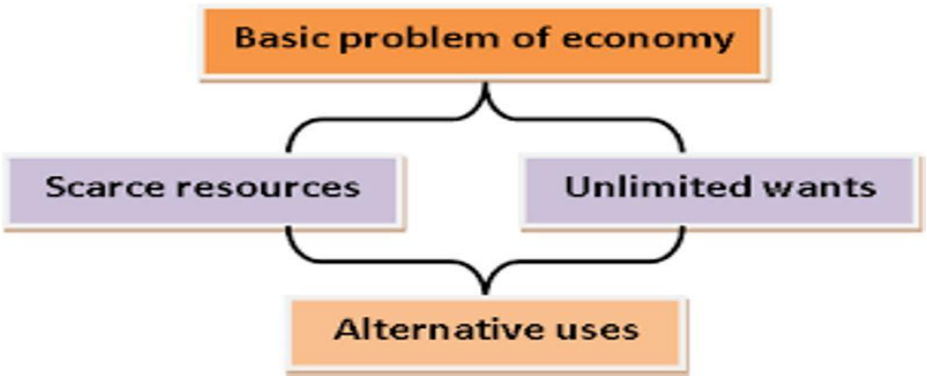

Figure 2 Resource Scarcity Model

Along with this, another theory that is also relevant to our research is the tragedy of the Commons and the theory of ecological modernisation, where the Tragedy of the Commons talks about how hard it is to use resources that many people share too much. Whereas the Theory of Ecological Modernisation states that growth in the economy, as well as better protection of the environment,

can be done altogether by using new technologies and big changes in society and the economy (Ostrom, 2008; Frischmann *et al*., 2019).

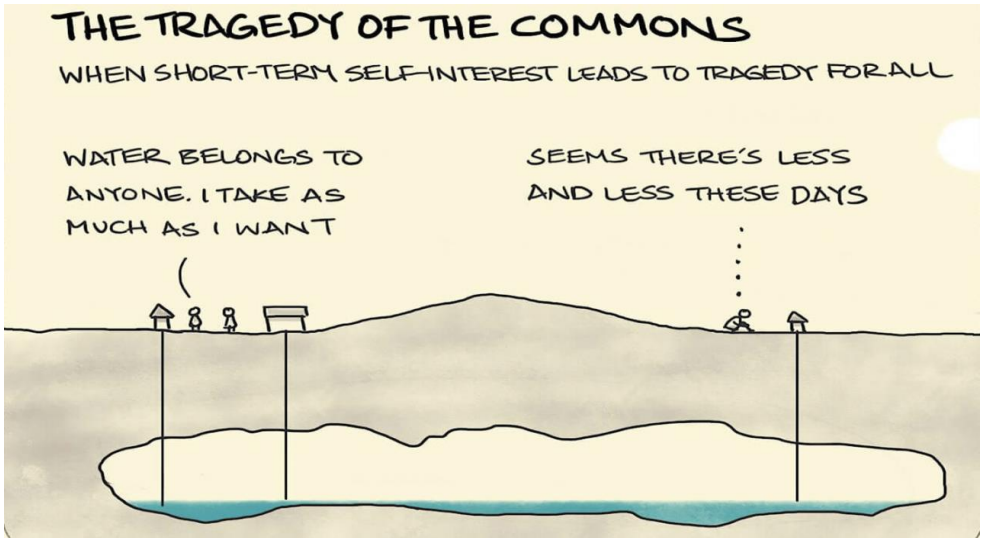

Figure 3 The Tragedy of the Commons

Gaps in the Literature

There are still gaps in our understanding of the relationship between social factors and environmental effects, although much research has been done on this topic. There is a gap because there is not much actual study that shows a link between what people and businesses do on a small scale and what happens to the world on a large scale.

More research needs to be done to find out what long-term effects conservation efforts and the shift towards more sustainable spending habits have, especially as the economy reaches its peak. We need to do more research to find out how cultural and behavioural factors affect how people use and protect resources. Most of the time, studies do not look at how political structures and government affect environmental policies and outcomes. We need to do more research to fully grasp how global economic factors, such as trade deals and international environmental rules, affect the management of local and national resources.

This study fills these gaps in our knowledge by carefully looking at how economic growth, changes in population, and policy changes affect the desire for natural resources and the loss of forests. The objective is to combine individual actions with broader environmental results,

considering cultural, political, and global economic factors that previous research may have overlooked. Doing this aims to offer a detailed understanding that can guide the development of a more efficient and fair environmental policy.

Conceptual Framework and Hypotheses

Based on the above findings and the gap, the following is the conceptual framework developed for the present research.

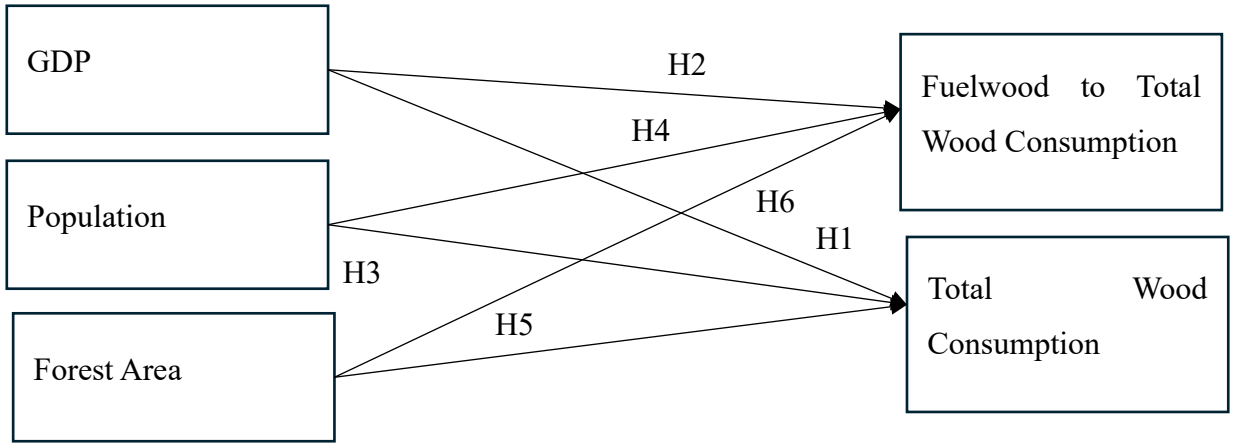

Figure 4 Conceptual Framework of the Research

The following are the hypotheses developed on the basis of the above model.

1. The proportion of fuelwood in relation to total wood consumption globally is significantly and positively influenced by GDP.

2. The size of the population has a positive and significant effect on the proportion of fuelwood to total wood consumption on a global scale.

3. The forest area plays a positive and significant role in influencing the proportion of fuelwood to total wood consumption around the world.

3. Research Methodology

This chapter presents the technique used to analyse the connections between GDP, Population, Forest Area, Fuelwood, and Industrial Roundwood Use in 39 countries over 20 years. The technique is formulated to fully understand the aspects that impact the use of natural resources, specifically within the forest sector.

Research Approach

The research method selected to perform this research is quantitative in nature while using secondary data from reliable sources such as World Bank statistics and Food and Agriculture Organization (FAO) production, import and export figures for the calculation of consumption are available on their websites which helped in ensuring that the analysis is properly done with accurate information gathered from appropriate sources (Sileyew, 2019). The research has selected this approach as it is helpful in carefully examining in detail all the factors that bring changes in how forest resources are used. Quantitative methods are used by the researchers to carefully look at the logical connection of important factors like GD, population, or the forest area on the fuelwood usage as well as the usage of industry roundwood (Ruggiano and Perry, 2019).

We have sued secondary statistics from the World Bank and FAO as they have many benefits, including easily gathering information which is consistent as well as reliable. Moreover, this method helps the researcher in carefully looking at large datasets while easily finding the changing patterns or trends and connections among factors, which are important to understand the reason behind the change in the dependent variable (Ahmad *et al*., 2019; Ghauri *et al*., 2020). This research primarily focuses on analysing secondary data from useful and reliable sources, which can help in finding basic trends and connections while helping in making policy as well as managing resources in the wood sector.

Sector and study area

The current study has focused on the forestry industry, focusing on how fuelwood and industrial roundwood are used, as these materials are very important for both the world economy and also protecting the environment appropriately. The key purpose of this research is to increase our understanding related to how the forestry industry works by looking closely at how both fuelwood and industrial roundwood are used. Initially, 43 countries were selected to show different stages of

economic growth, forest cover, and population changes. Recognizing the objectives, we focus on studying the trends showing an increase and decrease in the amount in the amount of fuelwood consumption relative to the total wood consumption data. Therefore, eleven countries, namely Canada, Mexico, Malaysia, Netherland, Gabon, Indonesia, the United States of Tanzania, Nicaragua, Russian Federation, Uruguay and Sweden, were removed because of consistencies in the data. And two countries namely, Somalia and Sudan, were removed for missing data. Therefore, data from 28 countries are selected for further analysis while maintaining the reliability of the data required for analytical frameworks, socioeconomic assessments, and our understanding of how the management of forest practices influences society and the environment. The countries were divided into two sections (Global North - 13 and Global South - 19) as shown in the table below.

Table 1 List of Countries from Global North and South

Global North	**Global South**
1. USA	1. Philippines
2. Germany	2. China
3. Finland	3. India
4. Italy	4. Peru
5. Slovenia	5. Bolivia
6. Estonia	6. Guatemala
7. Latvia	7. Cuba
8. Spain	8. Honduras
9. Australia	9. Colombia
10. Japan	10. Argentina
11. South Korea	11. Venezuela
	12. Brazil
	13. Chile
	14. Paraguay
	15. Democratic Republic of Congo
	16. Kenya
	17. Uganda

A full study of overall world trends related to the usage of forest resources can only be done by looking at things from many different points of view (Strijker *et al*., 2020). The study looked at long-term trends over 20 years while taking into account how different environmental as well as social policies have changed over time (Schoggl *et al*., 2020). It is important to use a linear method to get a complete understanding of how changes in GDP, population growth, and land area bring

changes in how resources are used. Moreover, it is very important to ensure that all the gathered data is correct, due to which the main sources, just as World Bank records and forest surveys for each country, were used by the researcher. The FAO provides specific information, especially related to how much fuelwood and industrial roundwood is used. The World Bank also provides complete as well as globally recognized data related to economic and population factors of the present research and using data from these well-known sources makes sure that the study's results are accurate (Rahman, 2020).

Data

Fuelwood and Industrial Roundwood Utilisation

To understand in a better way how much fuelwood and industrial roundwood were used, we gathered data from official organizations like FAO and the World Bank to gather data related to population size, forest area (as a percentage of land area), annual GDP growth rate (percentage form), and the amount of fuelwood and industrial roundwood that was taken away in meter cubic (production + import – export). Records from 2000 to 2020 were recorded after removing all the countries which were having incomplete information from the initial dataset of 43 countries. The FAO output data (FAO, n.a.) was used by the research to gather information related to how much fuelwood and industrial roundwood were cut down in these years. This information provides specific details related to how much of both wood types were cut down by each country in all these years. Along with this, the records from the World Bank were used to gather information related to population figures, which showed how many people lived in each country during the time which was selected for the analysis of the present research.

The forest area numbers gathered for this research, which is shown as a share of the overall land area, came from forest-related information for each country gathered in the form of surveys. The FAO (n.a.) says that these surveys provide you with exact measurements of the size of forests in each country and also provide you with a lot of accurate information that is required to understand how forest area and wood usage are related to each other. The annual percentage growth in GDP was also gathered from the information available on the World Bank records on their website (World Bank, n.a.). This data provided us with much useful information concerning how the country's economy has changed (increased or decreased) over time. This information made it easier

for us to understand how economic factors bring changes in the trends related to fuelwood and industrial roundwood utilization. The information was carefully checked in order to fix all the gaps in the data as per the requirements of the research. This incorporated using standard measures while fixing all the differences in how reports are made, and making sure that data from different countries and years is able to be compared efficiently.

Potential Drivers/Predicting Variables

A careful review of the current literature on forest resource management helped us figure out the factors that affect the use of fuelwood and industrial roundwood. Through this study, we identified a set of prediction factors that can change the trends in wood usage. This research focuses on the Gross Domestic Product (GDP), Population size, and Forest Area as its main independent variables, which are hypothesized to be the drivers of change in wood consumption. Previous research, including the studies of Shabbir *et al*. (2020), Waruingi *et al*. (2022), and Wang (2019) in their studies revealed that these factors have a big effect on how resources are used and how long this environment will last. We didn't put the factors' effects in a clear order because our study was experimental. Instead, we came up with a theory about the main types of connections between these factors and wood use. Gross Domestic Product, or GDP, is a way to measure how busy a country's economy is. It is expected that GDP will go up as more industrial roundwood is bought (Kombat and Chen, 2022). People who are in the market for wood goods (Nguyen, 2018) are likely to be positively linked to both the usage of fuelwood and industry roundwood. In contrast, forest areas show how much wood is available, and this is thought to be negatively linked to the use of fuelwood and industrial roundwood because of the possible effects of cutting down trees (Amoah and Korle, 2020).

Operationalisation of Variables

To effectively analyse and analyse the relationships between the variables, each variable is clearly defined and operationalised as follows.

Table 2 Operationalisation of Variables				
Variable Category	**Variable Name**	**Description**	**Units**	**Data Source**
Independent variable	Gross Domestic Product (GDP)	GDP growth (Oliinyk and Kozmenko, 2019).	Percentage	World Bank Databases
	Population	Total population of a country (Janssen *et al*., 2019).	Number	
	Forest area	The total forested area in a country (Ceccherini *et al*., 2020).	Square Kilometres	
Dependent Variable	Fuel Wood Consumption	Fuel wood consumption (production + import - export) / total consumption (production + import - export) (Baqir *et al*., 2019).	Percentage	Food and Agriculture Organisation (FAO)
	Industrial Roundwood Consumption	Total consumption (production + import - export) (Lundbäck *et al*., 2021).	2000=100	

Data Analysis

To identify the determinants or variables that influence variations in a dependent parameter, we employ two fundamental statistical methodologies.

- Regression analysis: This approach entails the application of simple linear regression to explore the association between a dependent parameter (e.g., Fuelwood and Industrial roundwood consumption) and a single independent parameter. Subsequently, multiple linear regression is used to expand on simple linear regression by incorporating multiple independent variables.
- Correlation: This is a statistical technique which involves using the Pearson correlation coefficient in order to assess the magnitude as well as the direction of a linear relationship between two or more continuous parameters.

In this research, we have applied multiple regression analysis in order to carefully understand the data set that was gathered to evaluate the trends in the management of forests. It helped us in

deeply exploring the crucial connections among different independent variables (IDV) selected for this research and our main dependent variables (DV), which incorporate the proportion of forested area to total land area and the overall units of timber harvests. While using multivariate regression analysis, we explored the collective influence of all these IDVs on DVs of the present research to find their influence. Moreover, by utilizing this method, the researcher was able to observe how changes in the IDV brought changes in the forest-to-total-area ratio and cumulative losses over time period of this research.

Along with this, we also investigate empirical data, theoretical frameworks, and insights drawn from previous studies in order to develop a predictive model with an aim to better understand the dynamic patterns in the management of forests, and it incorporated empirical data and theoretical perspectives derived from practical research performed in the past.

We have developed a predictive model while incorporating a systematic procedure that involves data preparation, model selection, and evaluation. Moreover, to ensure optimal performance, the researcher performed data preprocessing by eliminating all the missing values, errors, and standardising variables. By leveraging a substantial dataset, the researcher has applied multiple linear regression based on the characteristics of the dependent and independent variables to find the extent of the link between the two. The effectiveness of the prediction model was also evaluated by segregating the data into training and testing sets, where evaluation metrics just like R-squared, mean absolute error, and mean squared error were used to conduct an in-depth analysis of the model's efficacy in better understanding the ups and downs in the management of forests and identifying the key factors which were influencing these patterns over these years. The predictive model developed for this study is presented below.

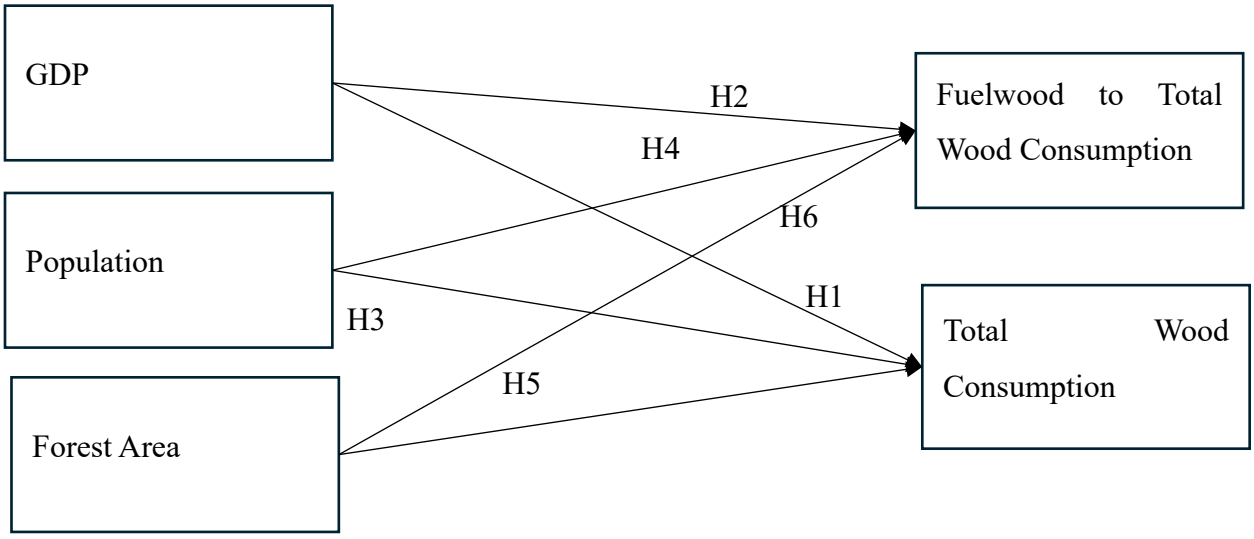

Figure 5 Model of the Study

4. Results

This chapter represents the findings based on the analysis performed to explore the composition of wood consumption activities while understanding the role of changing bioenergy in the management of forest resources. The chapter incorporates the evolving patterns of fuelwood consumption in relation to total wood harvesting while considering the condition of increase and decrease.

Analysis of Wood Consumption Trends

Two different sets of circumstances are used to look at trends: countries where total wood usage is going up and countries where it is going down.

Increasing Total Consumption Trends

The figure below represents the countries from the global north that had an increasing trend in total consumption in these years.

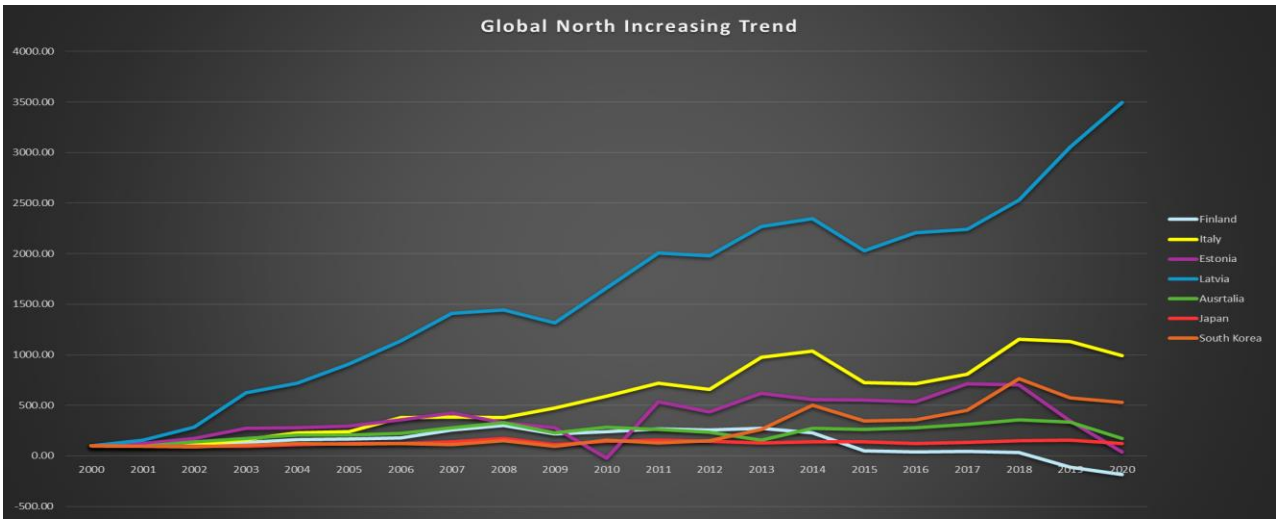

Figure 6 Global North Countries with increasing Total Wood Consumption

Figure 6 represents the trends in the total wood consumption on the countries from the global north region having increasing trends where a steady increase in Latvia can be seen above from the baseline index of 100 in 2000 to a peak value of 3,492.85 as of 2020 which represents that there was pretty much increase in the use of wood resources. Similarly, Italy has also shown an increasing trend to a peak value of 1150.97 as of 2018 before decreasing slightly as of 2020 to

990.16. Similarly, Estonia and South Korea also have an increasing trend in the past 20 years where they have sufficiently great increase up to their peak values as of 2017 and later on, where in 2020 there was a sharp increase in the consumption of South Korea, i.e., 529.71. These trends in the countries represent that there was increasing reliance of the countries in the global north on the overall wood (fuelwood and roundwood) thus revealing the increasing global demand in global north.

The figure below represents the countries from the global south that had an increasing trend in total consumption in these years.

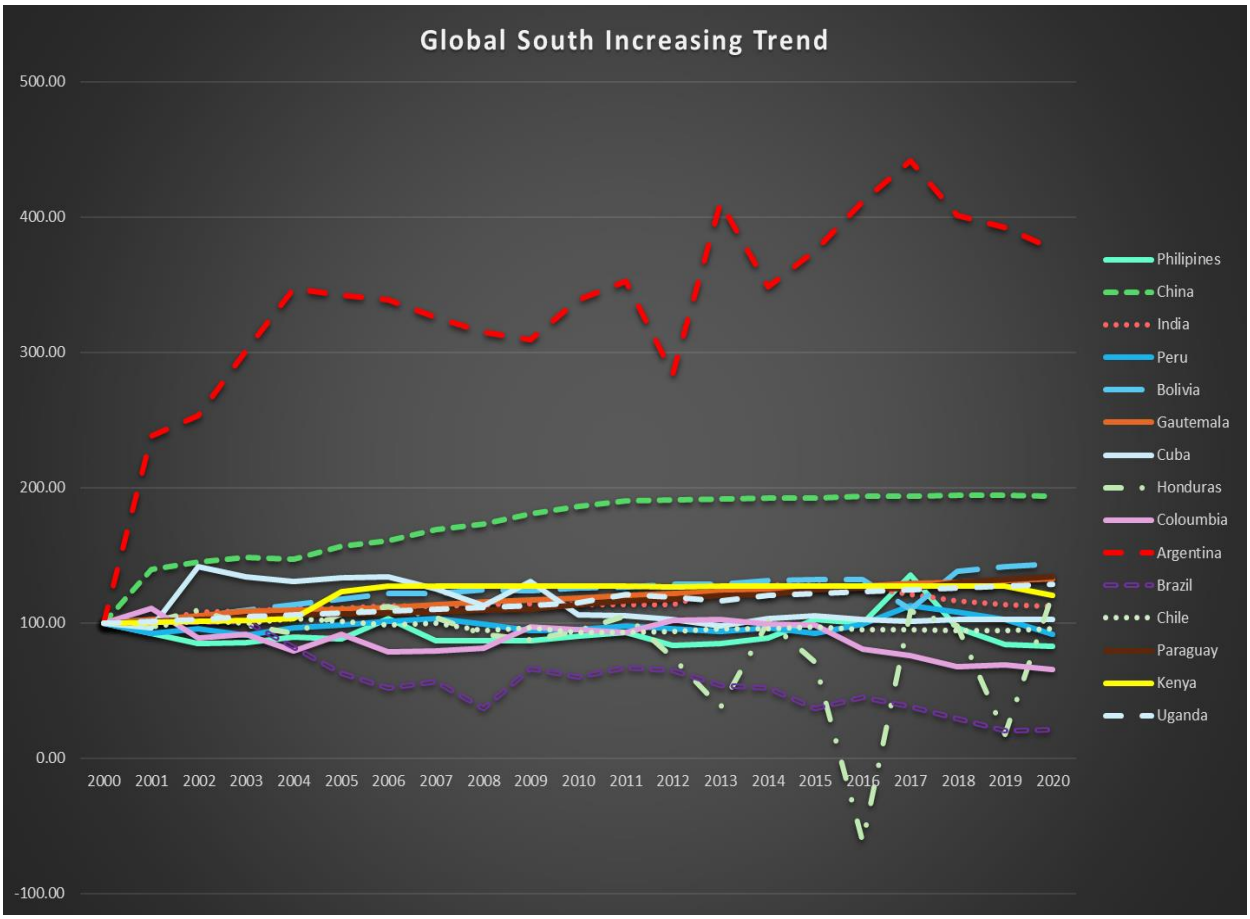

Figure 7 Global South Countries with increasing Total Wood Consumption

Figure 7 represents the wood consumption trend in the countries in global south where Argentina clearly stands out with sufficiently great increase in its total wood consumption of 376.54 as of 2020 while representing the increasing energy demands in these years. Along with this, as the

figure shows, China also had a steady increase in its overall wood consumption all these years which increased to 193.76 as of 2020 whereas the other countries including Bolivia, Guatemala, India, Paraguay, Philippines, Peru had a moderately increasing trend in all these years while showing no big changes. This represents that in some countries in the global south, there has been sufficient increase in the wood consumption in all the 20 years whereas in the other countries there has been very stable consumption level having no drastic changes.

Decreasing Total Consumption Trends

The figure below represents the countries in global north that had a decreasing trend in the total consumption in these years.

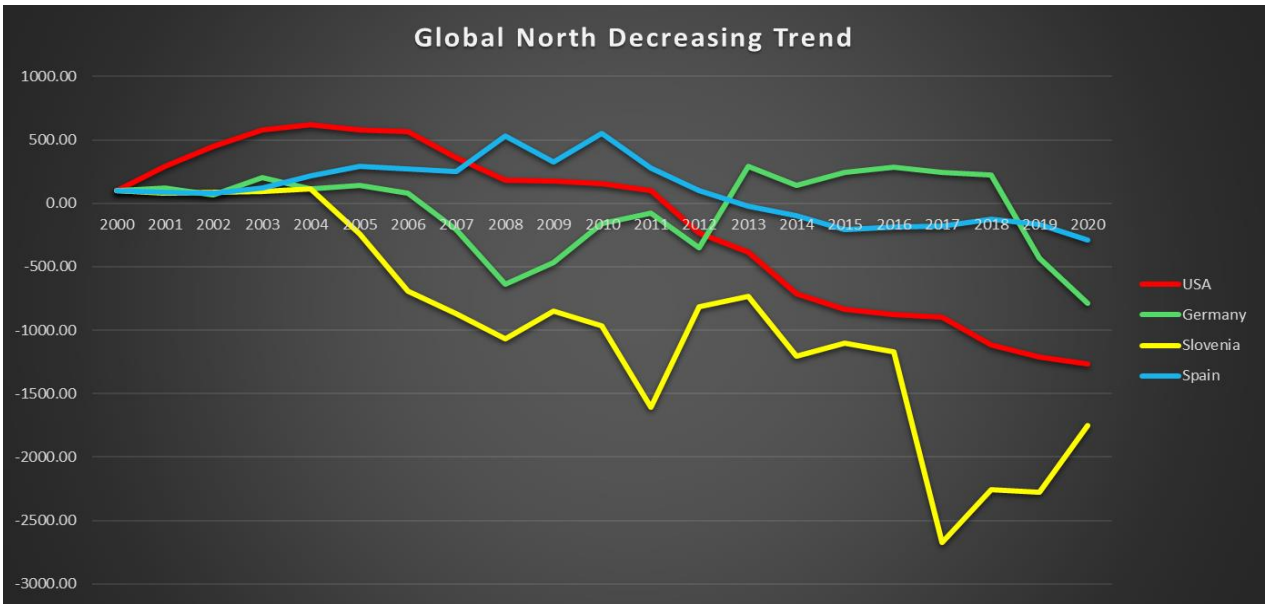

Figure 8 Global North Countries with a decrease in Total Wood Consumption

Figure 8 shows that for the global north there was drastic decrease in the consumption level of overall wood in Slovenia up to -2,279 cubic meters whereas the decrease in USA was of 1,265 cubic meters as of 2020 which represents big changes. Similarly, the decreasing from 100 to 786 cubic meter was in Germany whereas that of 290 in Spain thus showing drastic changes in Slovenia, USA and Germany.

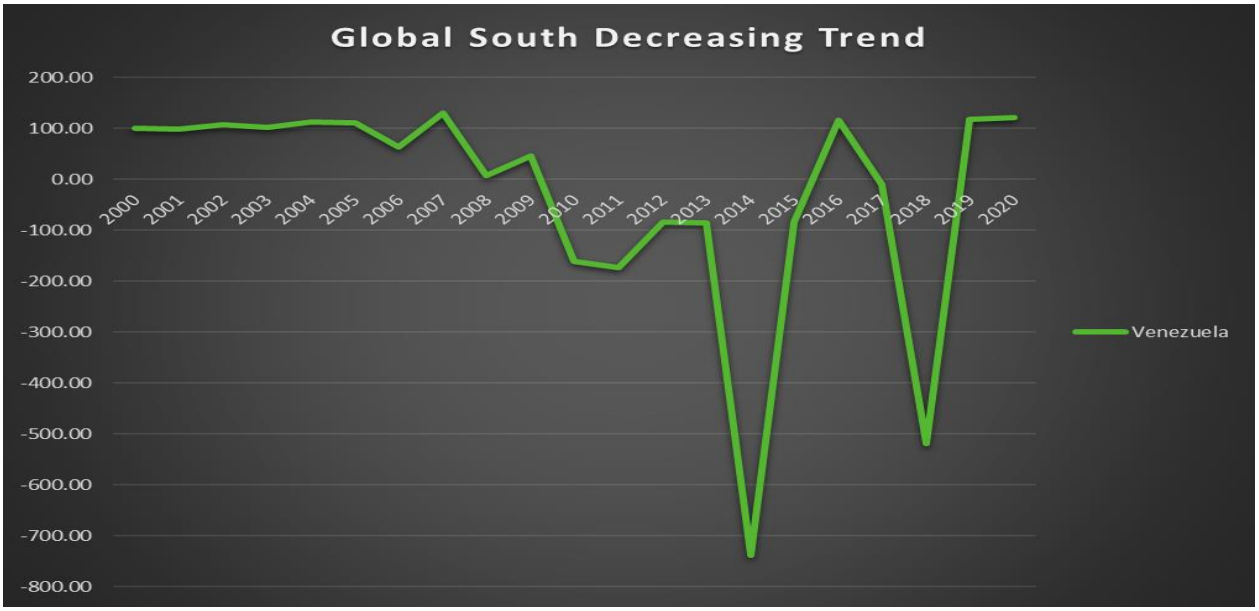

Figure 9 Global South Countries with a decrease in Total Wood Consumption

Figure 9 shows that for countries in global south, only Venezuela had a decreasing trend where there was significant drop of 600 cubic meters as of 2010 and that 519 in 2018 while having increasing trend in 2016 up to 116 and 118 in 209 after which it stayed consistent thus showing ups and downs in the consumption all these years.

Fuel Consumption and Increasing Total Consumption Trends

Now let us focus on the change in fuelwood consumption in global north when total wood consumption was increasing.

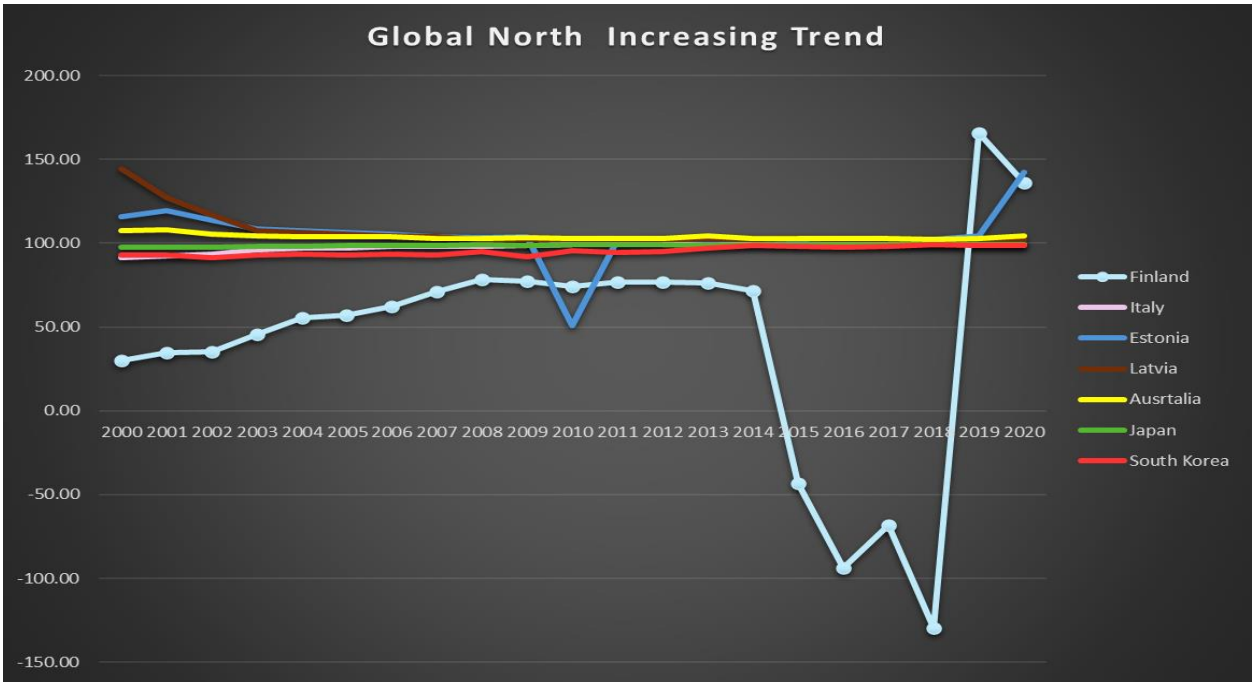

Figure 10 Percentage of Fuelwood to Total Consumption percentage in Global North Countries with an increasing Total Wood Consumption

Figure 10 shows that for the countries in global north, when the total wood consumption was increasing the proportion of fuelwood to total wood for Finland saw a gradual increase from 30.16%as of 2000 to 136.11%in 2020 with significant decrease in 2015 (43 percent), 2016 (93 percent), and 2018 (129 percent) which represents ups and downs in reliance of Finland on fuelwood when total wood consumption was increasing. Likewise, Estonia also shows an increase from 116%as of 2000 to 142%as of 2020 with decrease in 2010 up to 50%thus showing that when total wood consumption was increasing in this country, there was increase in the consumption of fuelwood. In comparison to this, other countries like Itay, Latvia, Australia, South Korea showed no big changes in their fuelwood consumption when the total wood consumption increased which means that in these countries the fuelwood consumption stayed stable.

Now let us focus on the change in fuelwood consumption in global south when total wood consumption was increasing.

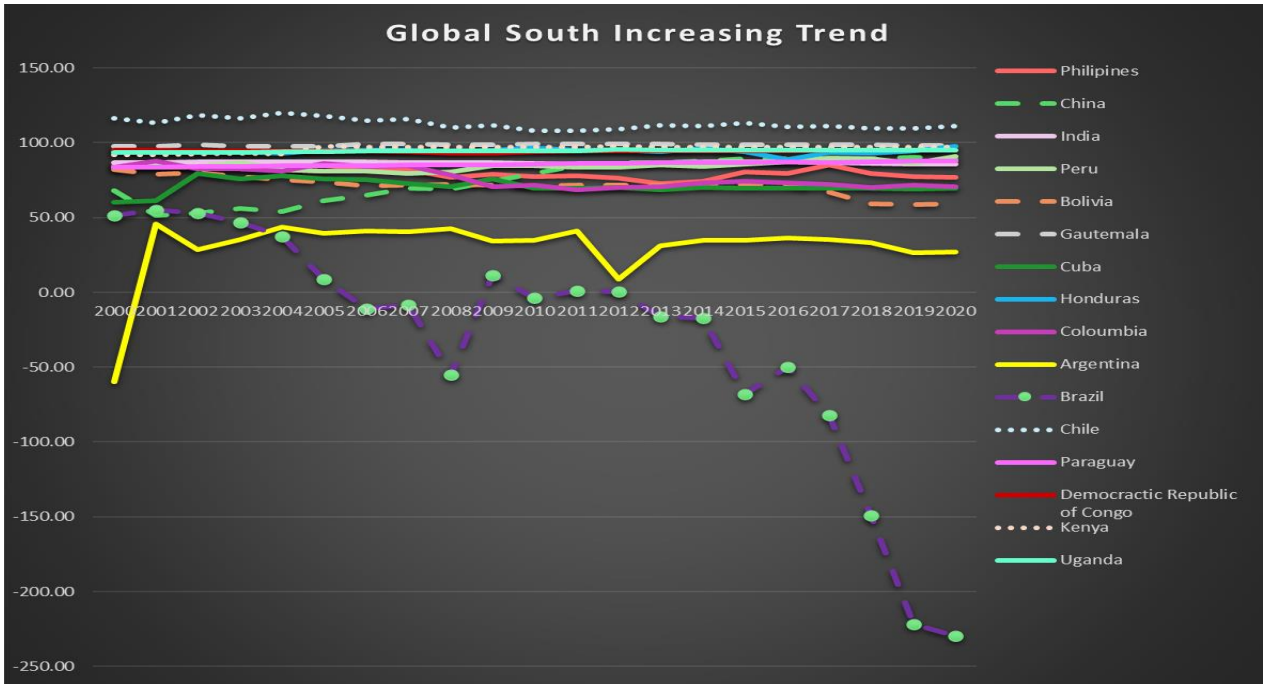

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Figure 11 Percentage of Fuelwood to Total Consumption percentage in Global South Countries with an increasing Total Wood Consumption

Figure 11 shows that changes in the fuelwood to total consumption in countries in global south when the total consumption was increasing where the countries like Brazil whose consumption of fuelwood decreased significantly from 51%as of 2000 to -229%in 2020 thus showing great decrease in the reliance of people of Brazil on fuelwood. Likewise, another country, Argentina, shows increasing trend from -59%in 2000 to 45%in 2001 after which the fuelwood consumption stayed stable till 2011 and decreased in 2012 to 8%and then increased in 2013. For other countries in this group, countries like Chile, Peru, China, Cuba and others have a stable trend with no significant increase or decrease in these years.

Fuel Consumption and Decreasing Total Consumption Trends

Now let us focus on the change in fuelwood consumption of global north when total wood consumption was decreasing.

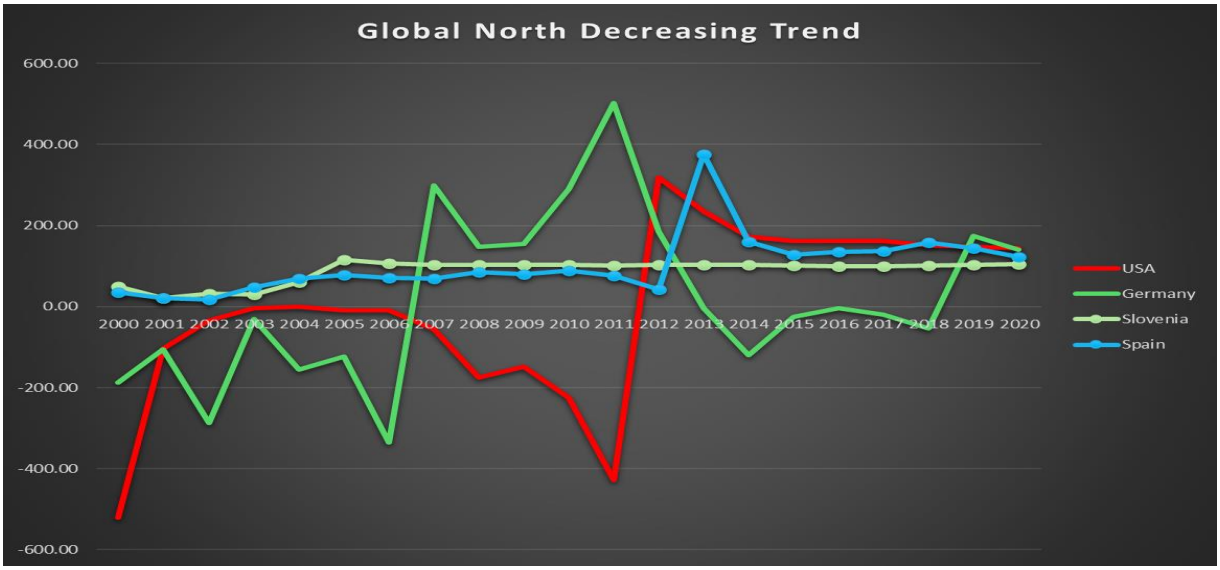

Figure 12 Percentage of fuelwood to Total Consumption percentage in Global North Countries with a decrease in Total Wood Consumption

Figure 12 shows that when the total wood consumption in global north was decreasing, there were sufficiently great variations in the fuelwood to total consumption specifically for USA and Germany which shows big ups and downs in all these 20 years whereas for Slovenia and Spain there was an increasing trend where Spain had significant increase in 2013 up to 376%of fuelwood consumption. Overall, the figure shows that with pretty much ups and downs, there was an increasing trend in the fuelwood consumption specifically when the total wood consumption in these countries was decreasing.

Now let us focus on the change in fuelwood consumption of global south when total wood consumption was decreasing.

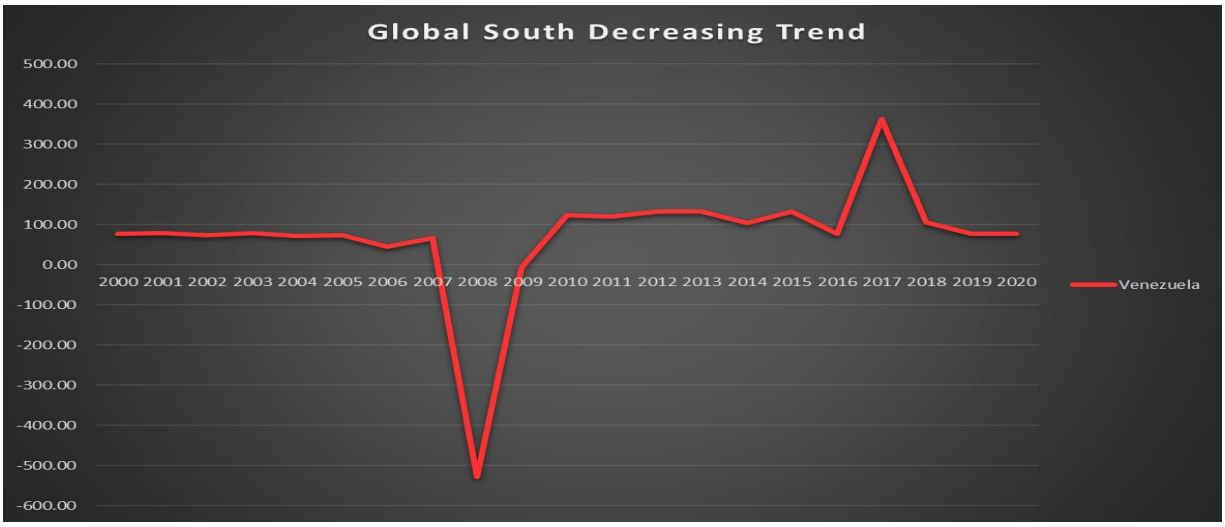

Figure 13 Percentage of fuelwood to Total Consumption percentage in Global South Countries with a decrease in Total Wood Consumption

The only one country in global south had decreasing trend of total wood consumption which has seen substantial ups and downs in its fuelwood consumption which decreased to -529% as of 2008 and increased drastically in 2017 up to 363%.

EKC on basis of Data

EKC for Fuelwood to Total Consumption

The figure below represents the EKC for fuelwood to total consumption for the global north data.

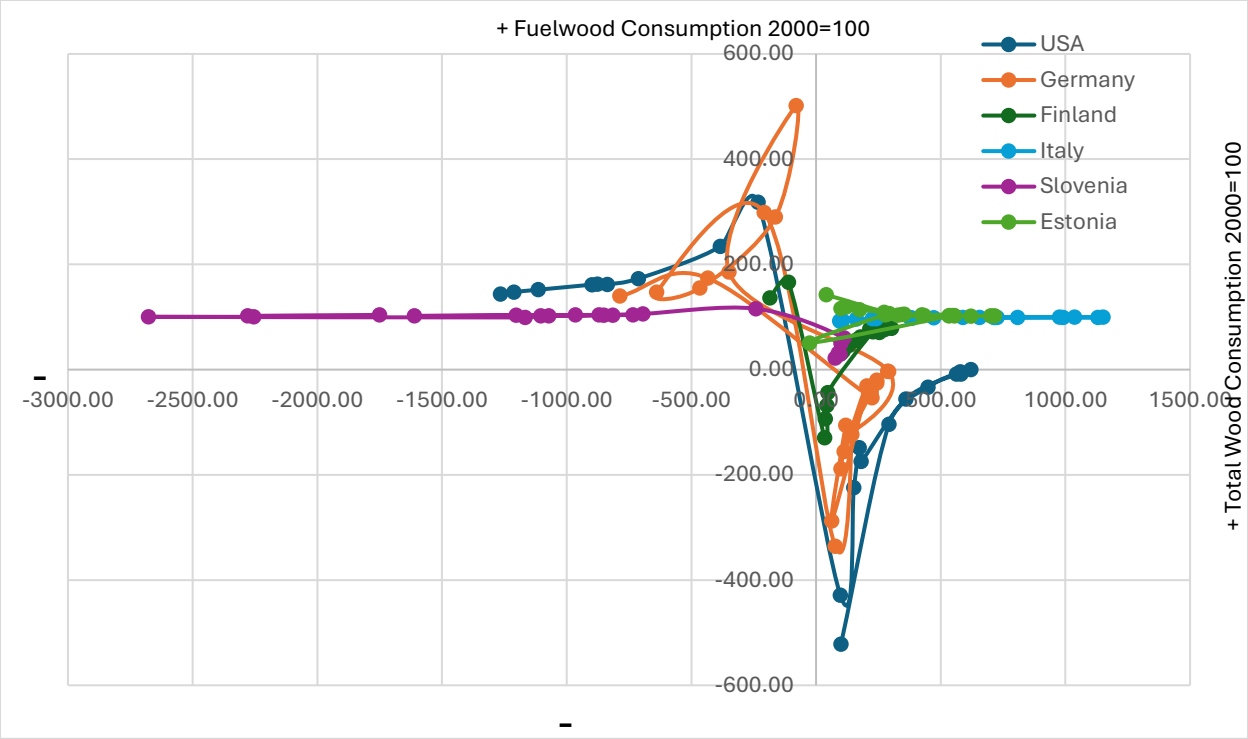

Figure 14 EKC – Fuelwood to Total Consumption Global North – A

The figure above represents that initially USA shows an increase in the fuelwood consumption proportion as compared to the total wood consumption, initially reaching the peak point and then decreasing while showing a transition from relying on the traditional wood sources towards more variations including sustainable wood usage practices as per the diversifications in the market. Similarly, Germany has also seen a sharp peak and then a decrease in its ratio just like USA, but the peak point of Germany is greater than that of USA and all other countries in the global north graph A which represents that Germany has moved towards efficiency and a broader range of wood consumption beyond fuel. Coming to Finland, there were quite less fluctuations in these years but generally there was a slight increase in the ratio during this period whereas Italy has shown a straight line in all these years which represents that there was a consistent ratio. Moreover, countries like Slovenia have shown a very stable line with very little fluctuations all these years thus showing a balanced wood source and there was not big fluctuation towards fuelwood and so did Estonia which showed very little fluctuations.

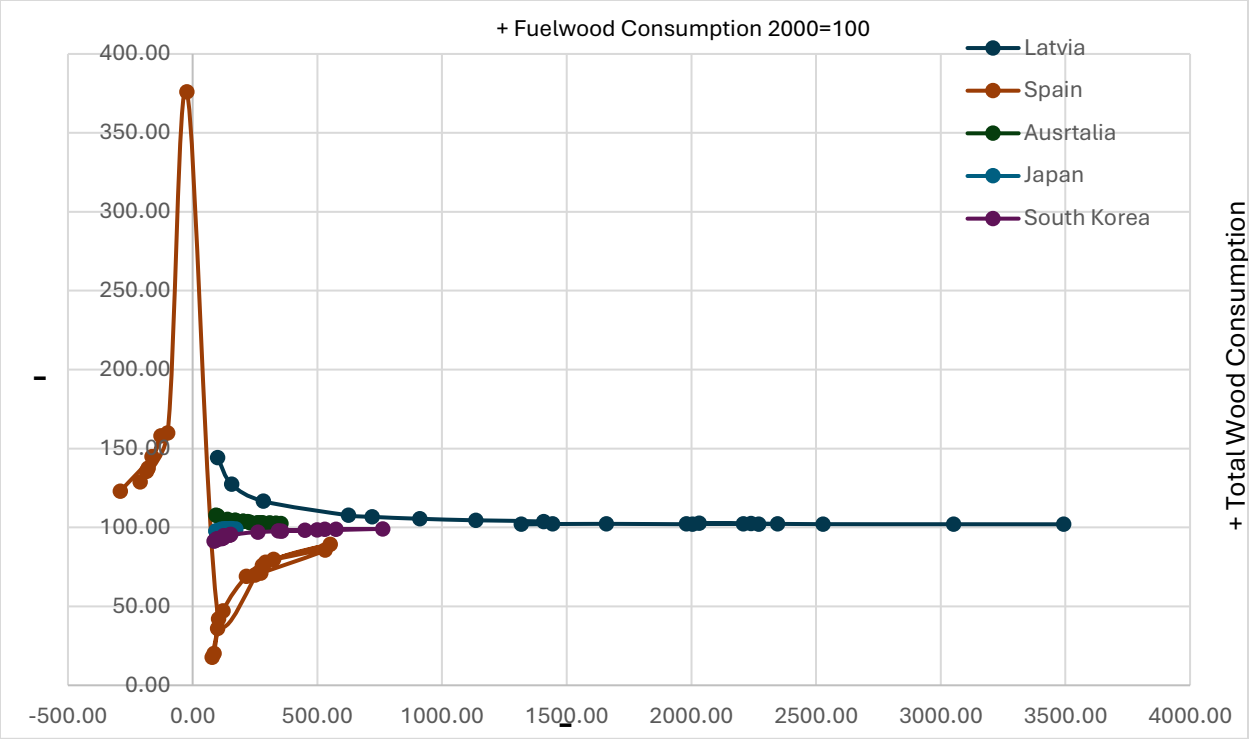

Figure 15 EKC – Fuelwood to Total Consumption Global North - B

The figure 15 shows that Spain has sufficiently great increase in the fuelwood consumption which eventually decreased significantly in the late years thus showing that there has sufficiently dynamic fuelwood consumption with increasing trend towards other wood consumption mediums by people of Spain in these years just like Latvia which has a positive trend towards other wood type consumptions from the fuelwood in these years. Moreover, with slide changes in the ratios, Australia, Japan, and South Korea also have shown a trend towards other wood consumption as compared to relying solely on fuelwood consumption.

The figure below represents the EKC for fuelwood to total consumption for the global south data.

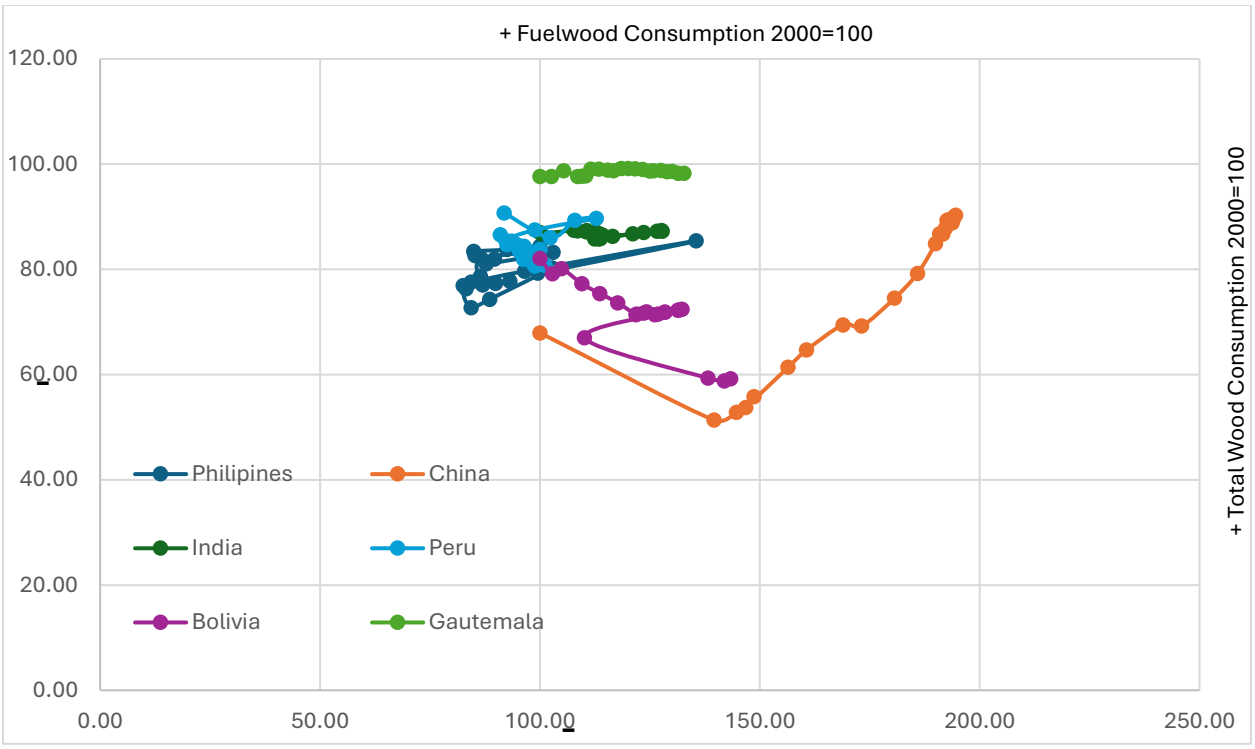

Figure 16 EKC – Fuelwood to Total Consumption Global South - A

The figure above shows that for Philippines there has been an increase in the fuelwood consumption which peaked to some extent and then decreased eventually to the levelling off point thus showing no significant changes in the overall wood consumption patterns. Similarly, for China, the graph above shows sufficient fluctuations where there has been substantial increase after stabilization for a certain time period and so did with India but the fluctuations in the utilization of fuelwood by Indian is relatively very less as compared to that by the Chinese. Also, for Peru and Bolivia from the global south, there has been significant fluctuations without any stabilization thus showing that people of both countries have shown significant variations in their fuelwood utilization as compared to other mediums. For Guatemala, there has been a moderate increase after a very slight decrease thus representing that the country has certain shifts towards fuelwood consumption but there were no significant changes.

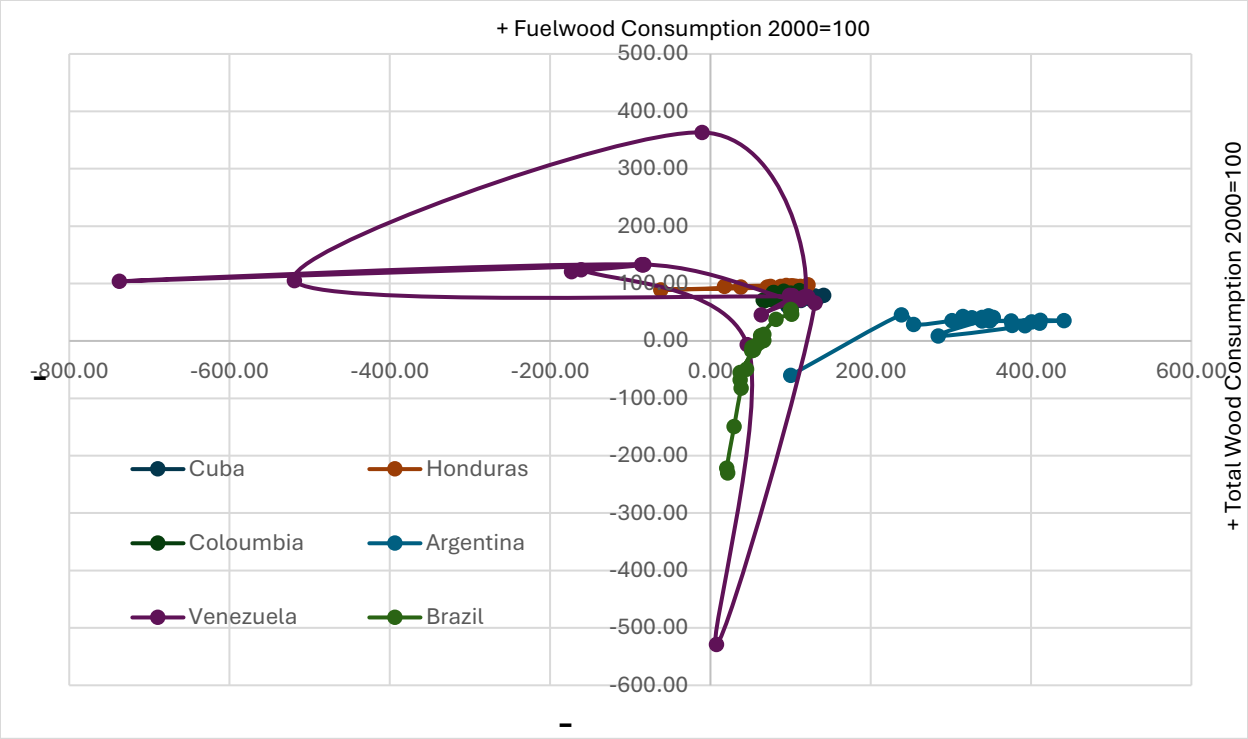

Figure 17 EKC – Fuelwood to Total Consumption Global South - B

Now, the figure above shows that for Cuba and Honduras, there has been no big fluctuations in the fuelwood consumption while having a slight stability in the wood consumption over these years and the same goes for Columbia which also shows no dramatic changes whereas the figure represents that Venezuela has seen traumatic changes where the country's fuelwood consumption increased to great extent crossing 300 and then decreased to crossing 500 and then went back to staying quite stable between 50-150 in the late years. Also, Argentina has seen several fluctuations in these respective years where initially there was substantial increase in fuelwood consumption which decreased, remained stable for a certain time, decreased again and then remained stable thus showing that there were sufficient changes in the fuelwood consumption in this country. Moreover, for Brazil, there was an increasing trend in the fuelwood consumption from the negative proportion towards the positive one as shown in the figure above thus representing that people in Brazil were considering more fuelwood consumption.

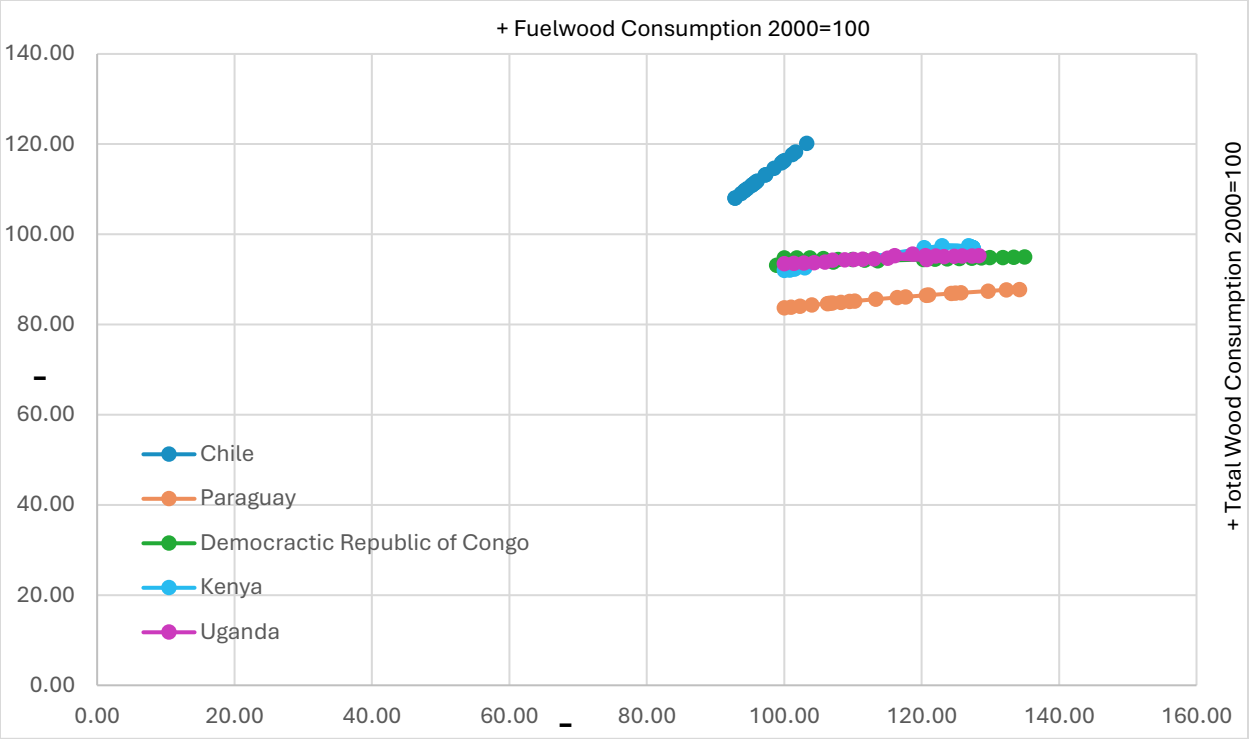

Figure 18 EKC – Fuelwood to Total Consumption Global South - C

The figure above shows that from the global south, Chile had an increasing trend towards consumption of both fuelwood and other wood which is quite similar to the increasing trend in Paraguay whereas in the democratic republic of Congo, Kenya and Uganda there has been very little variations over these years thus showing a bit of stability in the overall wood consumption while showing no big changes in the fuelwood consumption.

EKC for Fuelwood to GDP

The figure below represents the EKC for fuelwood to GDP for the global north data.

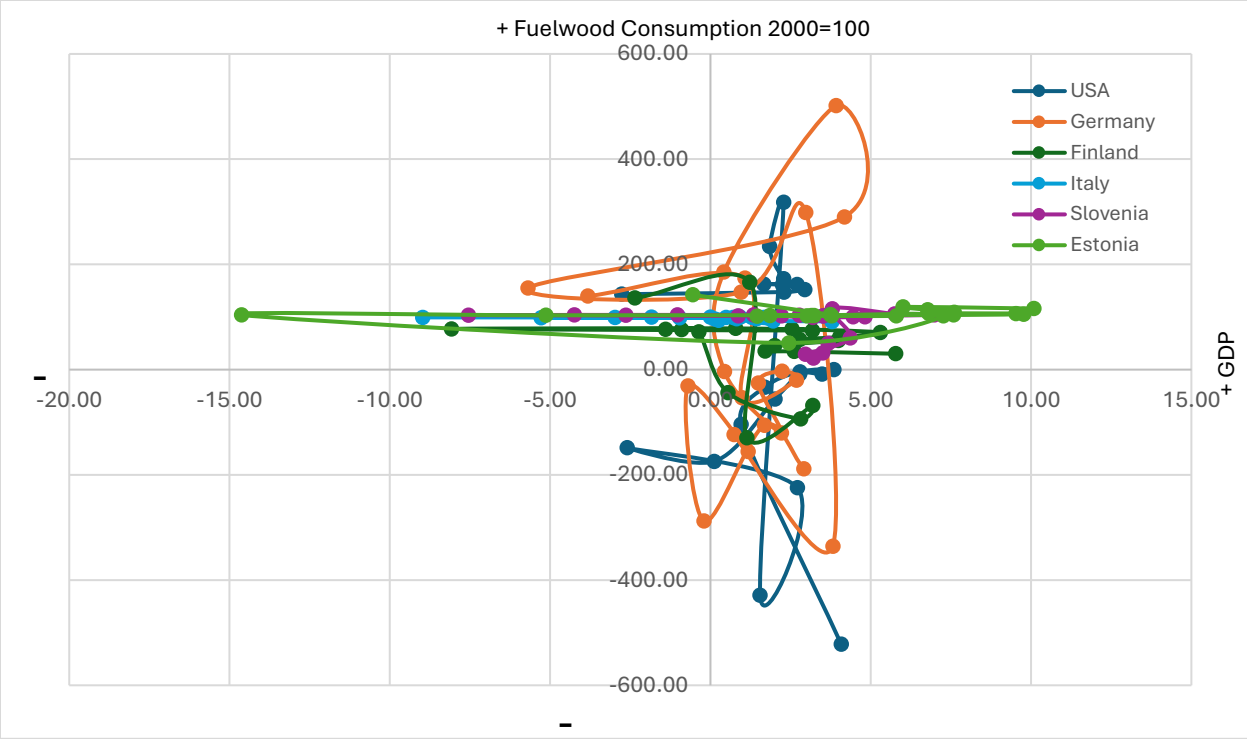

Figure 19 EKC – Fuelwood to GDP Global North - A

Now focusing on the EKC to find the changes in the fuelwood consumption on the basis of changes in the economic growth of the country, for USA, the graph clearly shows that there were sufficiently great fluctuations in the fuelwood consumption when the economy of the USA change (sharp decrease in the fuelwood consumption due to increase in GPD) which were relatively very high in the beginning years whereas the level of fluctuations decreased in the late years. Moreover, for Germany, the figure above shows that there were sufficiently great fluctuations thus representing substantial peak points especially in 2007 and 2011 where increase in GPD resulted in boosting the fuelwood consumption. Likewise, for countries like Finland, it can be seen that there was a decreasing trend in the late years in the consumption of fuelwood when the economic growth of the country was decreasing whereas for Italy there were no big changes in the fuelwood consumption being quite stable during the years when GDP of the country was continuously changing. Also for Slovenia, there were certain ups and downs in the fuelwood consumption of the country when the GDP was changing but in comparison to the other countries the ratios of changes were relatively very less. Finally, for Estonia, there was been a quite stability in the

consumption of fuelwood over these years while showing no big changes in the fuelwood consumption when the GDP changed.

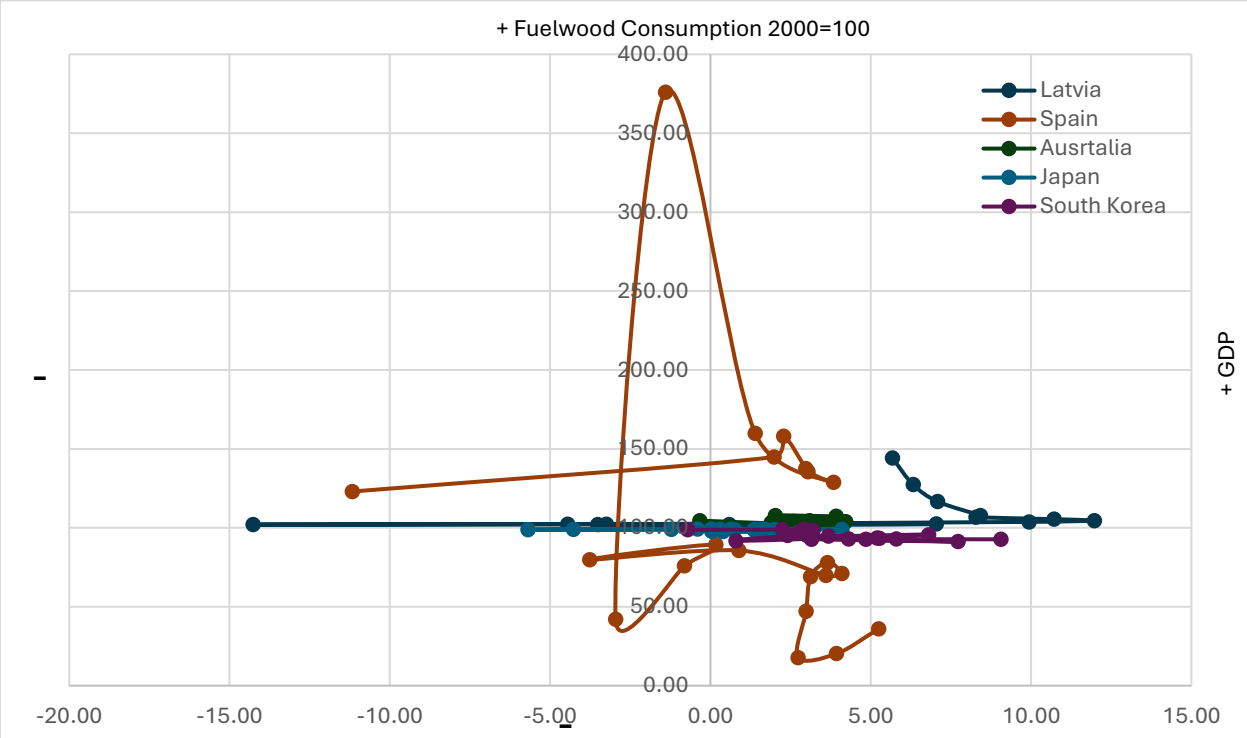

Figure 20 EKC – Fuelwood to GDP Global North - B

Now, for Latvia, the figure above shows that there was a decreasing trend in the fuelwood consumption when the GDP of the country increased over these years and there were no big changes in the fuelwood consumption especially when the economic condition of Latvia eventually decreased. The figure above shows that in comparison to this, Spain has seen sufficiently great increase in its fuelwood consumption overtime with increase in the economic growth of the country as of 2013 but also faced decrease in the fuelwood consumption as the economic growth improved in the late years. Moreover, Australia has seen no big changes in the fuelwood consumption over these years when the economic growth of the country fluctuated over time and the same goes for Japan and South Korea which also shows no big changes in the fuelwood consumption with changes in economic growth of the country.

The figure below represents the EKC for fuelwood to GDP for the global south data.

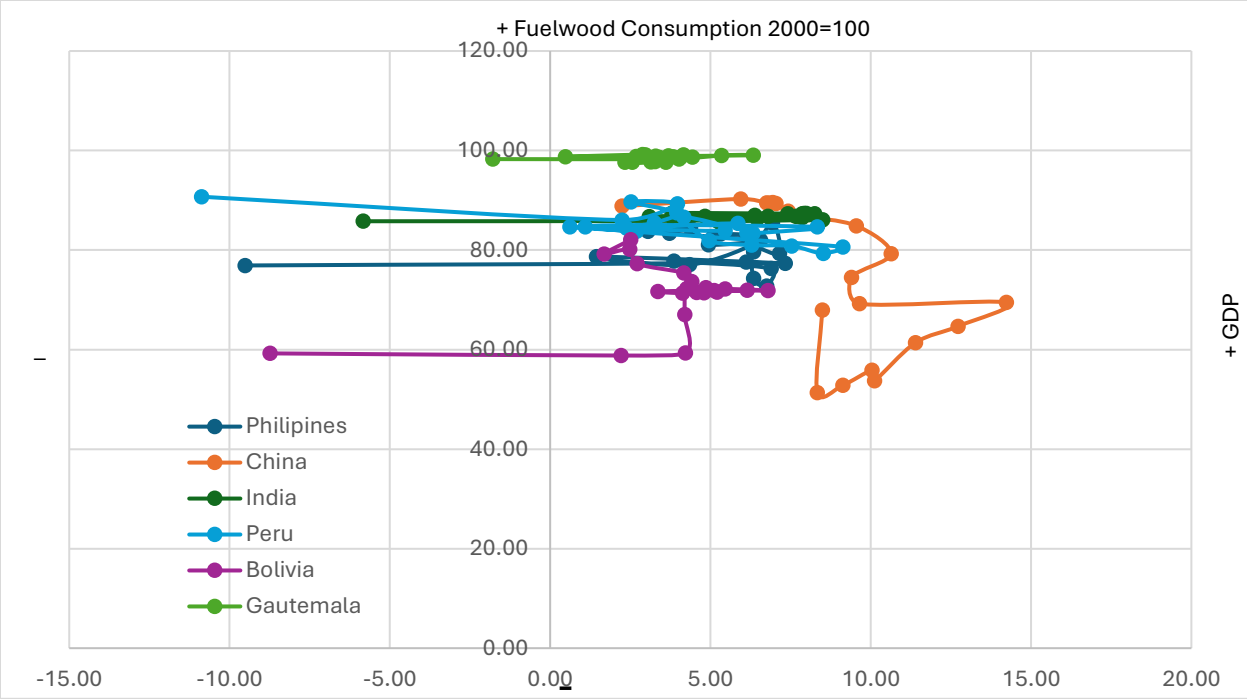

Figure 21 EKC – Fuelwood to GDP Global South - A

Now coming to the global south, as we can see in the figure above, with changes in the economic condition of the country, there has been no big changes in fuelwood consumption of Philippines especially when the economic growth of the country was increasing and the same goes for Peru and India whereas China has seen substantial decrease in the fuelwood consumption due to increase in the economic performance of the country. Moreover, Bolivia has seen a bit increase in the fuelwood consumption over time with increase in the GDP in the starting years whereas no big changes in the late years. Moreover, Guatemala has also seen very slight ups and downs in the fuelwood consumption but with increase in the GPD of the country, there were no big changes in the fuelwood consumption by the people of the country.

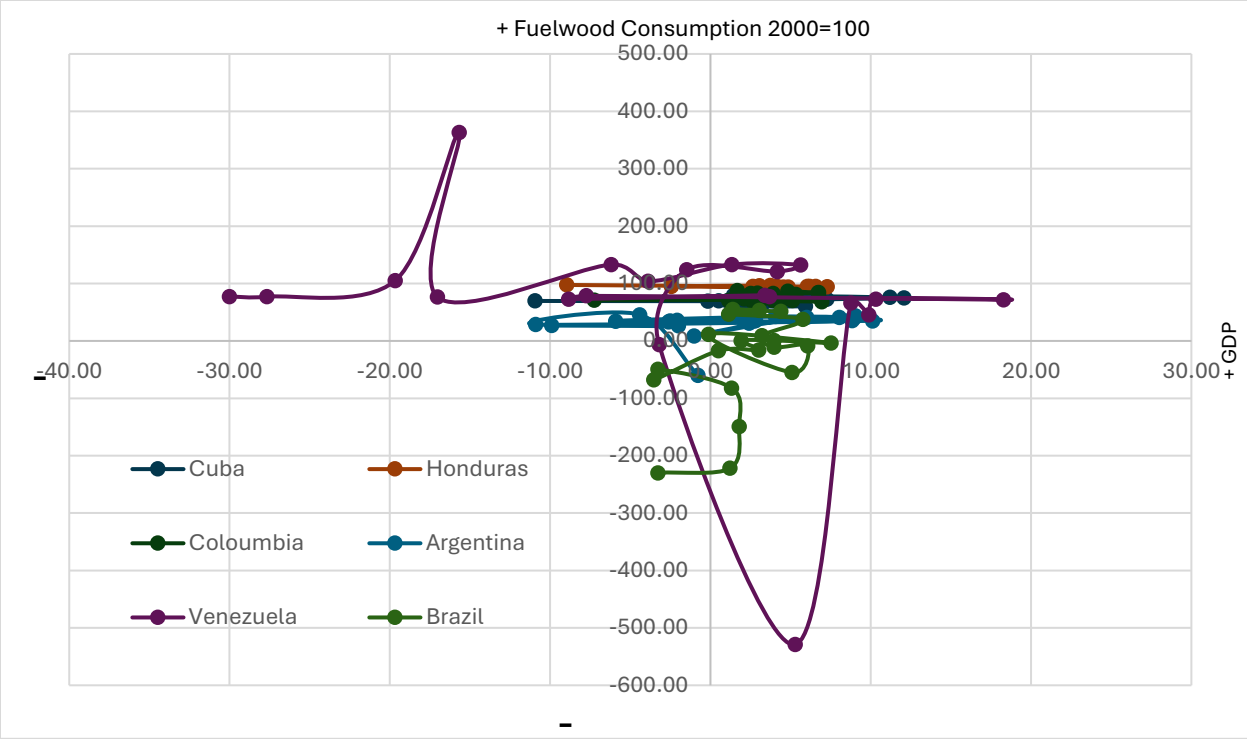

Figure 22 EKC – Fuelwood to GDP Global South - B

The figure above shows that the fuelwood consumption for Cuba has no big changes over the period of 20 years when the GDP of the country increased and so did that for Columbia, Argentina and Honduras which also have quite close to stable fuelwood consumption when the economy of the countries was growing. In comparison to this, Venezuela has seen sufficiently great increase in the starting years when the economy improved in 2003 but decreased later on after which there was big decrease in the fuel consumption seen with improvement in the economic condition of the country. Also, for Brazil, it can be seen that there was a decreasing trend in the fuel consumption as the economy of the country increased in the beginning years and decreased in the late years.

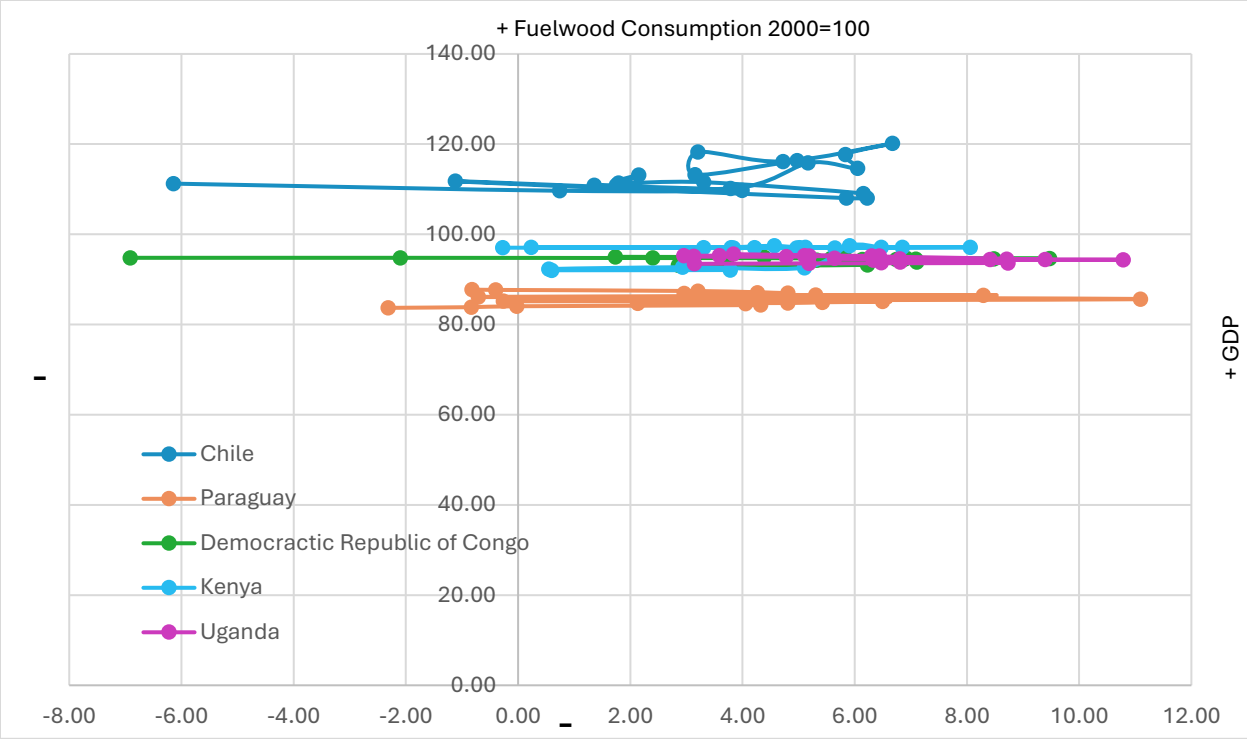

Figure 23 EKC – Fuelwood to GDP Global South - C

Now, for Chile we can see there was an increasing trend in the late years when the economic performance of country increased resulting in increase in the fuelwood consumption whereas for Paraguay, Congo, Kenya, and Uganda, with increase in GDP, there were no big changes in the fuelwood consumption by the people of the country.

A Statistical Analysis of Variables of the Research

Figures above clearly represent the patterns of variation in the total wood and the fuelwood consumption in the selected countries. To explore the factors behind the drastic variations, the present study has focused on performing a statistical analysis that includes correlation and regression analysis to identify the factors that influence these trends from 2000 to 2020.

Descriptive statistics

The table below represents the statistical representation of the data for global north for the present research.

Table 3 Descriptive Statistics Global North					
	Fuelwood /total (%)	**Total Consumption (2000=100)**	**Population**	**Forest Area**	**GDP**
Mean	78.00	204.21	6.40E+7	48.03	2.02
Standard Deviation	100.24	737.89	~~8.63E+7~~	~~17.86~~	3.59

The descriptive statistics table for the data gathered from global north countries above indicates that the average proportion of fuelwood in total wood consumption is approximately 78%, with a significant standard deviation of 100.24%. This suggests a large amount of variation in this proportion within the dataset. Similarly, the average total wood consumption is 204.21, with a deviation of 737.89, which reveals that there have been significant changes in total wood consumption, as revealed in the figures above. The population sizes demonstrate significant variation, with an average population size of 6.40E+7 and a huge deviation from the mean of 8.63E+7.

In addition, the average forest area is calculated to be 48.03, with a standard deviation of 17.86, representing sufficient differences in forest coverage within different countries. The data s*et al*so represents variety in economic activity, as indicated by the GDP growth, whose average is 2.02%, whereas the deviation from the mean is 3.59%. This indicates that there have been significant changes in the GDP growth of countries and so in the population and forest areas in all these countries.

The table below represents the statistical representation of the data for global south for the present research.

Table 4 Descriptive Statistics Global South					
	Fuelwood /total (%)	**Total Consumption (2000=100)**	**Population**	**Forest Area**	**GDP**
Mean	75.97	113.55	1.89E+08	37.10	3.62
Standard Deviation	52.55	89.33	~~4.06E+08~~	~~18.90~~	5.08

The descriptive statistics table for the data gathered from global south countries above indicates that the average proportion of fuelwood in total wood consumption is approximately 75.97%, with a significant standard deviation of 52.55%. This suggests a large amount of variation in this proportion within the dataset. Similarly, the average total wood consumption is 113.55, with a

deviation of 89.33, which reveals that there have been significant changes in total wood consumption, as revealed in the figures above. The population sizes demonstrate significant variation, with an average population size of 1.89E+8 and a huge deviation from the mean of 4.06E+8.

In addition, the average forest area is calculated to be 37.10, with a standard deviation of 18.90, representing sufficient differences in forest coverage within different countries. The data set also represents variety in economic activity, as indicated by the GDP growth, whose average is 3.62%, whereas the deviation from the mean is 5.08%. This indicates that there have been significant changes in the GDP growth of countries and so in the population and forest areas in all these countries.

The study then performed a correction analysis to identify whether there was a relationship between the independent and dependent factors selected.

Correlation Analysis

The table below represents the statistics of the correlation analysis performed for global north.

Table 5 Correlation in Global North					
	Fuelwood/total (%)	**Total consumption**	**Population**	**Forest Area**	**GDP**
Fuelwood/total (%)	1.00				
Total consumption	-0.06	1.00			
Population	-0.23	-0.19	1.00		
Forest Area	0.05	-0.03	-0.25	1.00	
GDP	0.00	0.00	-0.11	0.06	1.00

As Table 5 indicates, the value of correlation statistics for data from global north for population and fuelwood to total consumption is -0.23, whereas that for total consumption is -0.19, which represents that there is a negatively weak connection of population with fuelwood to total consumption and total wood consumption where increase in population brings decrease in fuelwood as well as total wood consumption.

Furthermore, the value of the correlation statistics for the forest area and the fuelwood to the total consumption is 0.05 while that for the total removals is -0.03, which represents that there is a

positively weak connection of the forest area with the fuelwood to the total consumption and negatively weak connection with the total wood consumption.

Finally, the value of correlation statistics for GDP and fuelwood to total consumption is 0.00 whereas that for total consumption is 0.00, which represents there is no connection of GDP with fuelwood to total consumption and total wood consumption.

The table below represents the statistics of the correlation analysis performed for global south.

Table 6 Correlations in Global South					
	Fuelwood/total (%)	**Total consumption**	**Population**	**Forest Area**	**GDP**
Fuelwood/total (%)	1.00				
Total consumption	-0.07	1.00			
Population	-0.02	0.12	1.00		
Forest Area	-0.13	-0.40	-0.26	1.00	
GDP	0.02	0.17	0.26	-0.16	1.00

As Table 6 indicates, the value of correlation statistics for data from global south for population and fuelwood to total consumption is -0.02, whereas that for total consumption is 0.19, which represents that there is a negatively weak connection of population with fuelwood to total consumption and positively weak connection with total wood consumption.

Furthermore, the value of the correlation statistics for the forest area and the fuelwood to the total consumption is -0.13 while that for the total removals is -0.40, which represents that there is a negatively weak connection of the forest area with the fuelwood to the total consumption and negatively moderate connection with the total wood consumption.

Finally, the value of correlation statistics for GDP and fuelwood to total consumption is 0.02 whereas that for total consumption is 0.17, which represents there is a positive but very weak connection of GDP with fuelwood to total consumption and weak connection with total wood consumption.

Based on these results, now the study proceeds towards the influence of these factors on the total wood consumption and fuelwood to total consumption in both global north and global south, respectively.

Regression analysis

The multiple regression method has been adopted to identify the influence of three independent variables (Population, Forest Area, and GDP) on the dependent variables (total consumption and fuelwood to total consumption) while considering countries from global north and global south separately.

Total Wood Consumption

Global North

The table below shows the model summary statistics for the regression analysis performed for the total wood consumption while considering the countries from global north.

Table 7 Regression Statistics – Model Summary Global North	
Multiple R	0.21
R square	0.04
Adjusted R-square	0.03
Standard error	726.86
Observations	231

First of all, table 7 shows that the value of multiple R is 0.21, which reveals that the joint or altogether influence of three independent variables, population, forest area, and GDP, on total wood consumption, is 21 percent. Likewise, the value of R-square is 0.05 which depicts that from 100%change in the total consumption, 4% of change is due to population, forest area, and GDP. Along with this, the standard error value is 726.86, which reveals the variation around the regression line.

Table 8 Regression Statistics – Anova Global North					
	df	**SS**	**MS**	**F**	**Significance F**
Regression	3	5.30E+06	1766915.44	3.34	0.02
Residual	227	1.20E+08	528323.37		
Total	230	1.25E+08			

Next, the ANOVA table reveals the fitness of the model where the value of F is 3.34 with a significance value of 0.01, which is less than 0.05, thus showing that the model of the present research is fit for independent variables, population, forest area, and GDP and dependent variable, total wood consumption. Based on this, we now proceed to the coefficient statistics.

Table 9 Regression Statistics – Coefficient Global North				
	Coefficients	**Standard Error**	**t Stat**	**P-value**
Intercept	498.57	156.66	3.18	0.00
Population	0.00	0.00	-3.12	0.00
Forest Area	-3.61	2.78	-1.30	0.20
GDP	-2.90	13.42	-0.22	0.83

The value of significance for the population to total wood consumption is 0.00 with a t value of -3.12, which confirms there is a negatively significant impact of changes in population on the total wood consumption however, the value of coefficient is 0.00 which represents that the role is very less. Likewise, the value of significance for forest area to total wood consumption is 0.20>0.05 with a t value -1.30, which confirms no significant impact of changes in forest area on the total wood consumption. Finally, the value of significance for GDP to total wood consumption is 0.83>0.01 with a t value of -0.22, which confirms no significant impact of changes in GDP on the total wood consumption.

Global South

The table below shows the model summary statistics for the regression analysis performed for the total wood consumption while considering the countries from global north.

Table 10 Regression Statistics – Model Summary Global South	
Multiple R	0.41
R square	0.17
Adjusted R-square	0.16
Standard error	81.84
Observations	357

First of all, table 10 shows that the value of multiple R is 0.41, which reveals that the joint or altogether influence of three independent variables, population, forest area, and GDP, on total wood consumption, is 41 percent. Likewise, the value of R-square is 0.17 which depicts that from 100%change in the total consumption, 17% of change is due to population, forest area, and GDP. Along with this, the standard error value is 81.84, which reveals the variation around the regression line.

Table 11 Regression Statistics – Anova Global South					
	Df	**SS**	**MS**	**F**	**Significance F**
Regression	3	476699.60	158899.87	23.73	0.00
Residual	353	2364047.08	6697.02		

Total	356	2840746.68			

Next, the ANOVA table shows that the value of F is 23.73 with a significance value of 0.00, which is less than 0.01, thus showing that the model of the present research is fit for independent variables, population, forest area, and GDP, and dependent variable, total wood consumption. Based on this, we now proceed to the coefficient statistics.

Table 12 Regression Statistics – Coefficient Global South				
	Coefficients	**Standard Error**	**t Stat**	**P-value**
Intercept	91.56	7.11	12.87	2.32E-31
Population	-7.28E-09	7.27E-09	-1.00	0.32
Forest Area	-0.39	0.15	-2.56	0.01
GDP	0.09	0.57	0.15	0.88

The value of significance for the population to total wood consumption is 0.86 with a t value of -0.17, which confirms no significant impact of changes in population on the total wood consumption. Whereas the value of significance for forest area to total wood consumption is 4.15E-13<0.01 with a t value -7.53, which confirms a negatively significant impact of changes in forest area on the total wood consumption. The forest area coefficient is -1.80, signifying that a one-unit increase in forest area results in a drop of 1.80 units in total wood consumption globally. Finally, the value of significance for GDP to total wood consumption is 0.04<0.05 with a t value of 2.11, which confirms a positively significant impact of changes in GDP on the total wood consumption. The GDP coefficient is 1.87, signifying that a one-unit increase in GDP results in an increase of 1.87 units in total wood consumption globally.

Overall, the regression analysis indicates that population brings substantially decrease in the total wood consumption in global north with no role played by forest area and GDP whereas in the global south, increase in forest area brings decrease in the total wood consumption in these countries.

Fuelwood to Total Wood Consumption

Global North

The table below shows the model summary statistics for the regression analysis performed for the fuelwood to total wood consumption while considering the countries from global north.

Table 13 Regression Statistics – Model Summary Global North

Multiple R	0.23
R Square	0.05
Adjusted R Square	0.04
Standard Error	98.25
Observations	231

For the fuelwood to total wood consumption, first of all, table 13 shows that the value of multiple R is 0.23, which reveals that the joint or altogether influence of three independent variables, population, forest area, and GDP on fuelwood to total wood consumption is 23 percent. Similarly, the R-square value, as shown in table 13, is 0.05, which depicts that from 100% change in the fuelwood to total wood consumption, 5% of change is due to population, forest area, and GDP. Along with this, the standard error value is 98.25, which reveals the variation around the regression line.

Table 14 Regression Statistics – Anova Global North					
	df	**SS**	**MS**	**F**	**Significance F**
Regression	3	119897.0848	39965.69	4.14	0.01
Residual	227	2191232.053	9653.00		
Total	230	2311129.138			

Next, the ANOVA table shows that the value of F is 4.14 with a significance value of 0.01, which is less than 0.05, thus showing that the model of the present research is a fit for independent variables, population, forest area, and GDP, and dependent variable, fuelwood to total wood consumption.

Table 15 Regression Statistics – Coefficient Global North				
	Coefficients	**Standard Error**	**t Stat**	**P-value**
Intercept	98.10	21.18	4.63	6.08E-06
Population	-2.68E-07	7.80E-08	-3.44	0.00
Forest Area	-0.04	0.38	-0.10	0.92
GDP	-0.61	1.81	-0.33	0.74

The value of significance for population to fuelwood to total wood consumption is 0.00 with a t value of -3.44 which confirms a negatively significant impact of changes in population on the fuelwood to total wood consumption. The population coefficient is -2.68E-07, indicating that the fuelwood to total wood consumption declines by a very small amount for each unit increase in population as the connection is indirect. Likewise, the value of significance for forest area to fuelwood to total wood consumption is 0.92>0.01 with a t value –0.10, which confirms no

significant impact of changes in forest area on the fuelwood to total wood consumption. Finally, the value of significance for GDP to fuelwood to total wood consumption is 0.74>0.01 with a t value of -0.33 which confirms no significant impact of changes in GDP on the fuelwood to total wood consumption.

Global South

The table below shows the model summary statistics for the regression analysis performed for the fuelwood to total wood consumption while considering the countries from global south.

Table 16 Regression Statistics – Model Summary Global South	
Multiple R	0.14
R Square	0.02
Adjusted R Square	0.01
Standard Error	52.27
Observations	357

For the fuelwood to total wood consumption, first of all, table 16 shows that the value of multiple R is 0.14, which reveals that the joint or altogether influence of three independent variables, population, forest area, and GDP on fuelwood to total wood consumption is 14 percent. Similarly, the R-square value, as shown in table 16, is 0.02, which depicts that from 100 percent change in the fuelwood to total wood consumption, 2 percent of change is due to population, forest area, and GDP. Along with this, the standard error value is 52.27, which reveals the variation around the regression line.

Table 17 Regression Statistics – Anova Global South					
	df	**SS**	**MS**	**F**	**Significance F**
Regression	3	18718.56	6239.52	2.28	0.08
Residual	353	964289.79	2731.70		
Total	356	983008.35			

Next, the ANOVA table shows that the value of F is 2.28 with a significance value of 0.08, which is greater than 0.05, thus showing that the model of the present research is unfit for independent variables, population, forest area, and GDP, and dependent variable, fuelwood to total wood consumption.

Table 18 Regression Statistics – Coefficient Global South				
	Coefficients	**Standard Error**	**t Stat**	**P-value**
Intercept	91.56	7.11	12.87	2.32E-31

Population	-7.28E-09	7.27E-09	-1.00	0.32
Forest Area	-0.39	0.15	-2.56	0.01
GDP	0.09	0.57	0.15	0.88

The value of significance for population to fuelwood to total wood consumption is 0.32 with a t value of -1.00 which confirms no significant impact of changes in population on the fuelwood to total wood consumption. Whereas the value of significance for forest area to fuelwood to total wood consumption is 0.01<0.05 with a t value -2.56, which confirms a negatively significant impact of changes in forest area on the fuelwood to total wood consumption. The forest area coefficient is -0.39, signifying that a one-unit increase in forest area results in a drop of 0.39 units in fuelwood to total wood consumption globally. Finally, the value of significance for GDP to fuelwood to total wood consumption is 0.88>0.015 with a t value of 0.15 which confirms no significant impact of changes in GDP on the fuelwood to total wood consumption.

Overall, the regression analysis indicates that population brings substantially decrease in the fuelwood to total wood consumption in global north with no role played by population and GDP whereas in the global south, increase in forest area brings decrease in the fuelwood to total wood consumption in these countries.

5. Discussion

This chapter focuses on the implications of the findings presented above while discussing them in detail to understand the influence of identified factors (population, forest area, and GDP) on the total wood consumption and fuelwood to total wood consumption in both global north and south. Moreover, while aligning with the findings of the present study with the past literature this section discusses in detail the overall contribution of these findings..

Wood Consumption Trends

Increasing Total Consumption Trends:

In the global north, different countries including Latvia, Italy, Estonia, and South Korea have shown sufficient increase in the overall wood consumption in the last two decades where Latvia has shown the highest increase while reaching a peak value of 3492.85 as of 2020 from a low of 276.4 m3 in 2003. This increasing trend clearly represents that there has been increasing reliance on the overall wood resources which is possibly driven by the increasing demand for renewable

energy sources or utilization of roundwood for different economic activities. This trend is in line with the finding of Shafron (2019) and Ajanaku and Collins (2021) who in their studies have highlighted the increasing demand for renewable energy sources as well as the role of economic growth in increasing the demand for the wood consumption.

Along with this, countries like Italy and Estonia have also followed a quite similar trend where Italy reached the peak value of 1150.97 cubic meters in 2018 from 94.54 m3 in 2001 before slightly decreasing to 990.16 in 2020 which represents stability as well as improvement in their wood industries. Likewise, Estonia has also peaked to 715.56 m3 in 2017 from 50.8 m3 in 2010 and South Korea peaked to 529.71 m3 in 2020 from 86.37 m3 in 2002 which represents quite stable increase in South Korea as compared to other countries.

In comparison to this, in the global south, there has been more variation in the trends as Argentina and China have shown sufficiently great changes in the total wood consumption where Argentina's consumption reached to 376.54 m3 from 8.67 m3 in 2012 whereas China increase to 193.76 m3 in 2020 from 51.36 m3 in 2001 which represents their expanding economies along with growth in the industrial sector. This is in line with the findings of Hung (2022) and Global Wood (2023) which forecasted that increasing economic condition and population rate results in increasing wood consumption. Along with this, there was steady increase in different countries like Bolivia, Guatemala, India, Paraguay, and Peru which represents that in these countries there was relatively very stable demand for wood resources specifically due to increase in population or due to growth of economies of these countries as supported by Nabavi *et al.* (2020).

Decreasing Total Consumption Trends:

In the global north, several countries such as Slovenia, USA and Germany have shown decrease in the overall wood consumption in their markets where Slovenia decease from 103.79 m3 in 2007 to 41.00 m3 in 2020 whereas USA decreased from 621.54 m3 in 2004 to -1265.66 m3 in 2020 and Germany decreased from 204.21 m3 in 2003 to -786.51 m3 in 2020. This decline can be possibly related to different factors such as the environmental regulations, the increasing shift of these countries towards more sustainable practices or the continuously changing industrial demand as discussed earlier in their studies by Adila *et al.* (2021) and McCallister *et al.* (2022).

Moreover, from the global south, there was only one country with decreasing trend, i.e., Venezuela whose wood consumption decreased significantly from 130.27 m3 in 2007 to 21.33 m3 in 2020 while clearly being related to the economic instability as well as the political instability in the country as the prime reason for decrease in wood consumption as represented in the research by Nguyen *et al.* (2023).

Fuelwood to Total Wood Consumption Increasing Trends

In the global north, it can be seen that there has been mixed trends in the fuelwood consumption when the overall consumption was increasing just as in the Finland and Estonia, there was increase in the proportion of the fuelwood to total consumption as the fuelwood proportion for Finland increase to 136.11 percent in 2020 from 30.16 percent in 2010 while showing sufficient ups and downs. In the similar manner, Estonia has also shown an increased to 142.11 percent in 2020 from 50.8 percent in 2010 which indicates that there was pretty much reliance of the countries on the utilization of fuelwood in their energy consumption mixture which aligns with the findings of Chen *et al.* (2019). In contrast, other countries such as Italy and Lativa have shown stable fuelwood consumption over these years where Italy's consumption was 91.56 percent in 2000 and 99.26 percent in 2020 with no big change and that of Lativa was 144.20 percent in 2000 which decreased to 107.70 in 2003 and then to 102.11 in 2020 with no big changes. This represents that overall, there was balanced approach in terms of utilization of wood resources.

In the global south, there has been great decrease in the fuelwood consumption in Brazil which decreased from 123.86 m3 in 2010 to -229.85 m3 in 2020 thus showing that there was a great shift from the traditional fuelwood utilization when the total wood consumption was increasing. In the similar way, for Argentina, there was an increase from 34.25 m3 in 2009 to 77.39 m3 in 2020 when the total wood consumption was increasing thus showing that there were sufficiently great changes in the preferences related to utilization of energy in these countries as discussed by Atinga *et al.* (2023) in their research. Majority of the other countries form the global south had maintained quite stable consumption levels related to fuelwood when the total wood consumption was increasing thus showing that the countries had relatively diverse approaches related to energy and resource management as indicated by Amoah and Korle (2020).

Fuelwood to Total Wood Consumption Decreasing Trends

Now coming to the changes in fuelwood consumption when the total wood consumption was decreasing where countries like USA and Germany have faced sufficiently great ups and downs in their fuelwood consumption where USA improved from -521.76 m3 in 2000 to 143.31 m3 in 2020 thus representing sufficiently great shift in the economy of the country as well as its industries. In the similar way, Germany has also seen sufficiently great fluctuations such as peak point of 501.92 m3 in 2011 increased from a trough in 2002 of -287.90 m3 which shows that even when the overall wood consumption decreased, there was sufficient reliance on the fuelwood for different consumption reasons especially due to its accessibility or its cost effectiveness as reported by Lau *et al.* (2018).

In the similar way, Spain has also shown increasing trend in fuelwood consumption especially when the overall wood consumption was decreasing where fuelwood consumption increase to 123.02 m3 in 2020 from 69.10 m3 in 2004 which represents sufficient reliance of people on fuelwood as an energy source. In comparison to this, when the total wood consumption was decreasing in global south, Venezuela has seen changed in the fuelwood consumption changing from -529.12 m3 in 2008 to -229.85 m3 in 2020 which is probably due to ups and downs in the economic and political condition of the country thus resulting in changes in the reliance of the population on different energy sources as stated by Shabbir *et al.* (2020).

Environmental Kuznets Curve Analysis

This study has found that the in terms of EKC for the fuelwood to overall consumption, there were sufficiently great fluctuations in the global north where sufficient increase has been seen in USA and Germany where initially the fuelwood consumption increased and then decreased in the late years which is in line with the theory presented by Can and Gozgor (2017). Germany has reached the peak point when the overall wood consumption was increasing, where peak point was 501.92 m3 in 2011 which eventually decreased to 139.73 m3 in 2020 whereas Finland has increased from 30.16 m3 in 2000 to 136.11 m3 in 2020 whereas Italy and Slovenia were having stable utilization of fuelwood when the overall wood consumption in these countries were growing.

In the similar way, for EKC to see changes in fuelwood consumption due to changes in the economic condition, in both global north and south there has been very interesting patterns changing over time. The countries in the global north like USA and Germany have shown that with

increase in GDP the fuelwood consumption initially increased and then decreased in the later years where the turning point represents that the countries have adopted more efficient and sustainable energy mediums. Just as the fuelwood consumption of USA increase from 4.08 percent in 2000 to 7.33 percent in 2010 and decreased to -2.77 percent in 2020 when GDP was increasing. Similarly, in the global south, this change has been more complex where Brazil and Argentina shows that w(ith increase in the economic growth of the country there has been a decreasing trend in the country, where Brazil has seen decrease from 5.76 percent in 2004 to -3/28 percent in 2020. Overall, this represents that as the GDP of the countries increased, they focused on adopting more useful mediums related to energy.

Factors influencing Wood Consumption

Our study focused on finding the role of three different factors, i.e. population, forest area, and GDP, on both types of consumption.

Total Wood Consumption

The regression analysis for the total wood consumption while focusing on the countries from the global north represent that 21 percent of changes in the total wood consumption is explained by three variables including population, forest area, and GDP. It has been found that population brings negative influences on the total wood consumption with a coefficient value of 0.00 and the significance value of 0.00 which represents that increase in population results in decrease in reliance on total wood consumption which is due to diverse and sustainable energy source (Nguyen *et al.,* 2023). Similarly, in the global north, forest area and GDP are found to have no significant influence on the total wood consumption as the value of significance are great than 0.05 (0.20 and 0.83) which was also found in the study by Can and Gozgar (2017) who reported that in the developed regions, there is no significant influence of macroeconomic factors.

Similarly, in the global south, it has been found that the value of R is 0.41 which shows that 41 percent of change in total wood consumption is due to changes in population, forest area, and GDP where the population has a significance value of 0.86 with coefficient value of -2.03E-09 thus showing no significant role of population in the overall wood consumption. Whereas, the value of significance for forest area is 4.15E-13 which is less than 0.05 and for GDP the value of significance is 0.04, less than 0.05, where coefficient for forest area -1.80 shows that increasing

forest area decreases wood consumption whereas GDP value of 1.87 shows that increase in GDP brings increase in the overall wood consumption in the global south. This represents that in the developing regions both forest resources and economic conditions play a sufficiently great role in bringing changes in the overall wood consumption.

Fuelwood to Total Wood Consumption

Now coming to the role of population, forest area, and GDP in the fuelwood to total wood consumption where in global north the overall influence on basis of multiple R is 23 percent change where the value of coefficient for population is -2.68E-07 with a significance value of 0.00 which shows that increasing population results in decrease in the fuelwood to total wood consumption as reported in their study by Shabbir *et al.* (2020). Whereas for the forest area and GDP the study failed to find any significant influence where the value of significance is greater than 0.05 (0.92 and 0.74) in line with the findings of Lau *et al.* (2018) which stated that economic growth in developed nations result in adoption of efficient mediums which can bring decrease in reliance on traditional sources.

When coming to the global south, the scenario is different as forest area has sufficiently great influence on the fuelwood to total wood consumption while having a coefficient value of -0.39 where the negative sign represent that increase in forest area represent decrease in the fuelwood to total wood consumption. This aligns with the findings of Amoah and Krole (2020) who stated that countries which are having more forest areas have very less exploitation of the resources while resulting in having sufficiently greater fuelwood to overall wood consumption. In the similar way there has been found no significant influence of population and GDP on fuelwood to overall consumption as the value of significance is greater than 0.05 (0.32 and 0.88) which is in line with the finding of Rahman (2020) who revealed that there are several other factors like forest management policies and market dynamics which also influence the overall consumption level of fuelwood as well as other wood types.

Research Implications

This research has both theoretical and practical implications, as discussed below.

Theoretical Implications

The findings of this study highlight that there has been sufficient trends in the overall influence of population, forest area and GDP on the wood consumption including both fuelwood and overall wood consumption. The regression analysis has confirmed that GDP and forest are the key role players in the wood consumption while showing sufficient variations in both global north and south. These findings support the EKC hypothesis which suggests that better economic growth results in initial degradation of the environment but later eventually brings improvement in the environment when the economies become mature and focus on more sustainable practices.

The negative connection between forest area and wood consumption clearly represents that in the global south the findings align with the resource scarcity model which represents that resources become scare resulting in increasing its costs and focusing on more solutions. Findings of this study are the empirical evidence contribution to the existing studies especially related to the developing regions where forest resources are highly exploited.

Practical Implications

The findings of this research are very important insights for the policymakers who want to develop effective strategies for sustainable wood consumption where the influence of GDP and forest area indicates that there is need for better policies which can result in promoting economic development while also making sure that forest resources are conserved. Moreover, the forest managers and the stakeholders and also use findings of this study in order to promote more sustainable wood consumption practices where reforestation and afforestation can help in bringing decrease in negative influences of wood consumption especially in the global south region.

Along with this, findings of this study imply that there is need for more investment in technological solutions which can help in bringing efficiency in the wood utilization while improving the yield as well as quality of wood products as it will bring decrease in the pressure on the forest resources. Also, increasing public awareness and education related to sustainable consumption of wood resources can help in bringing decrease in the wood consumption while bringing decrease in deforestation.

Recommendations

Based on the findings of the present research following are the recommendations:

I. There is a need for integrated policies that consider the changes in population, economy, and forest areas to plan better strategies and solutions for sustainable wood consumption.

II. There is a need for the adoption of renewable energy options with a vision to increase the utilization of sustainable wood consumption.

III. There is a need to invest in technological solutions which can help in boosting the efficient utilization of wood while promising increased outcomes from the same wood amount while decreasing the pressure levels on the forests and environment.

IV. There is a need for the development of forest-related strategies that can create a balance between the demand and supply of wood products while considering strategies like increased reforestation to continuously fill the gaps and not harm the environment.

V. There is a need for public awareness at a higher level related to the sustainable management of forests and understanding the role of wood in all renewable energy policies.

Limitations and Future Research

While performing this research, there were several limitations identified, which can be used as a basis for future research to understand the influence effectively.

I. The study selected 28 countries (11 from global north and 17 from global south) due to the lack of complete information available related to all the factors of the present research. Incomplete data can result in variations in results. However, future research after gathering complete data can be performed to better understand the impacts.

II. The study had a limited time frame to be completed within, due to which all the incomplete data or the time-taking data was removed. Research in the future can be performed while gathering data in more timeframes.

III. The study found that the present research variables have a 6-8 percent role in a 100 percent change in total wood consumption and total wood consumption and fuelwood

to total wood consumption, but future research can be performed on other variables to identify other factors that have influenced wood consumption.

Conclusion

Fuelwood and roundwood consumption altogether and the proportion of fuelwood consumption in total wood consumption has changed in the past 20 years from 2000 to 2020, where 7 countries from global north and 16 countries from global south have been found to have an increasing and dynamic trend, whereas 4 countries from global north and 1 country from global south have a dynamic and decreasing trend. The research further found that there has been a highly dynamic fuelwood to total wood consumption proportion in these years for the countries with increasing and decreasing total wood consumption, where some countries had upwards, some had downwards, and many had close to stable fluctuations. Moreover, the study also found that there was a delicate balance among the population, forest area, GDP, and the consumption of wood, including total (fuelwood and roundwood) and the proportion of fuelwood in the total wood consumption. As the world is increasingly focusing on climate change and sustainable growth, the findings of the present research provide valuable insights of the factors that are directly and indirectly contributing to the dynamics of wood consumption. Overall, the study concludes that there has been a significant change in wood consumption in different countries around the world, where several factors contributed to the changes.

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7. Annex

Definitions

Fuelwood consumption is the amount of wood that is used as a fuel source for different things, like cooking, heating, or making electricity, over a certain amount of time. Branches, leaves, and logs are the most popular types of fuelwoods used by an increasing number of people around the globe (Gioda, 2019).

Industrial Roundwood Consumption is the amount of Roundwood, also called natural wood, that is used for industrial purposes by companies, just like making buildings, making furniture as well as making paper for daily usage (Lundback *et al*., 2021).

Gross domestic product (GDP) represents the total value of all the goods and services that are produced in a country in a certain time period while representing the overall working of the economy as a whole (Kuboniwa *et al*., 2019).

Deforestation is the process in which trees or wood is cut or removed wood on purpose, which eventually results in lowering the frequency of land that is covered by trees (Balboni *et al*., 2023).

Sustainable development means meeting all the goals set to grow where the needs of present and future both generations are fulfilled, which in terms of forest means that there are enough trees for people to use presently and have enough resources for the future as well (Jeronen, 2020).

Renewable energy is a kind of energy that can be used again and again at a rate equal to or greater than their own use without harming society and playing a positive role in the environment (Harjanne and Korhonen, 2019).