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The Importance of Forests Production in Rwandan Trade Environment

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ABSTRACT
Many developing countries, including Rwanda, are currently seeking to integrate into the international trading system, leading to a significant increase in exports through the exploration and sale of natural resources. However, the actual consequences of this expansion on cross-border trade are still largely unknown. To address this, the study aims to assess the production of forests, specifically wood exports, in Rwanda and its contribution to the country's GDP. Time-series data on Rwandan wood exports from 2011 to 2020 were collected from the World Bank database and analyzed using SPSS v26. The study tested two hypotheses: 1) that wood exports do not significantly contribute to goods and services exports and 2) that the production of forest, especially wood exports, significantly contributes to the Rwandan GDP. Regression analysis results rejected the null hypothesis and retained the alternate hypothesis, indicating that wood exports do contribute to the country's GDP. Additionally, both the values of wood exports and goods and services exports increased during the study period. The study found that there is a relationship between the forest plantation area and the export value of woods, which in turn affects the export of goods and services as well as the national GDP, based on the analysis of data from 2011 to 2020. The null hypothesis, which stated that the woods' export value does not significantly contribute to the goods and services export, was rejected.

Keywords: Forest, Wood, Export, Trade, Environment.

I. INTRODUCTION

The quest to comprehend the world requires establishing an order, even if none exists naturally. This philosophy emphasizes individual freedom to connect with the majestic reality of the world (Michael, 2000).The ecosystem refers to all the living and non-living things in a specific location that interact with each other, including humans. Humans rely on ecosystems, such as agricultural zones and production woodlands, for food and raw materials. The goods produced are a result of both natural and human factors (Pohjanmies, 2018).

Forests are the dominant ecosystem on Earth, containing 80% of the planet's plant biomass and producing 75% of the biosphere's gross primary production. Different types of forests are influenced by various factors like temperature, rainfall, soil composition, altitude, and latitude (Pranav& Usha, 2018).Despite our limited understanding of changing demands, we continue to rely heavily on forest resources, such as wood for fuel (Singh, 2006).These areas reveal how the planet's flows, such as migration and atmospheric circulation, interact with its surface (Corey, 2002).

The exploitation of forests for a wide range of products such as wood fuel, industrial round wood, veneer sheets, and hardboard, plays a critical role in many nations' economies, particularly in Africa, Asia, and Latin America, which have abundant forested land (Pohjanmies, 2018).Regional projects that offer business opportunities can benefit underprivileged forest producers, dealers, and employees(Sophie et al., 2015).Rwanda has political measures and laws from the colonial era that regulate the cutting and selling of wood, such as the Decree of December 18, 1930. This decree requires authorization and payment of taxes before cutting or purchasing wood, and imposes fines for violations(MINILENA, 2018).Wood is used by over 96% of households for energy and by 31.4% for lighting. Charcoal is also widely used in cities, and wood is commonly used in construction(MINILENA, 2018).

Rwanda trades wood with other countries and regions globally, including North America, the United States, Europe & Central Asia, and African nations(WTS, 2015). Charcoal production

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generates 61.8% of jobs, while wood production generates 19.2% of employment in forest areas. Distribution and sales employ a smaller percentage, 6% and 12.8%, respectively (Jeffrey &Joseph, 2003).

The trading market welcomes diverse products, and environmental and economic scientists can analyze the movement of trade activities to help policy makers set rules for this environment. However, lack of reliable and complete data is a challenge in this field. The study proposes to assess the impact of forest resources, particularly wood, in Rwanda's trade environment, with the aim of maximizing gains from forestry production and guiding policy makers to set favorable policies. The study seeks to answer questions about factors that explain forest production in Rwanda, the relationship between wood exports and GDP, and how to forecast future wood exports. The study uses scientific methods for data treatment and analysis to achieve its objectives.

II. RELATED WORKS

This article reviews works on the use of statistical data analysis techniques in environmental economics, particularly in forest production approaches.

A research study conducted between 2011 and 2020 found that forest plantation areas have an impact on the export value of wood, as well as the export of services and goods and the national GDP. It is recommended that the Rwandan Ministry of Environment increase the area of forest plantations to ensure economic growth. The study also suggests further research on other factors that may influence economic growth in Rwanda, such as social, economic, and environmental factors(Stella& Richard, 2015).

The second study analyzes the impact of timber exports on economic growth in Cameroon. Previous research on primary exports and growth has primarily focused on cocoa, coffee, bananas, rubber, and oil, neglecting the importance of timber exports. However, many economies have grown through wood exports, with round wood shipments to France alone earning an average of $252 million in yearly export earnings between 1970 and 2012 (Njimanted& Nkwetta, 2015). This study analyzes the market trends of Ghanaian wood product exports, specifically lumber, furniture components, plywood, and glulam. The focus is on the impact of forest loss on wooden furniture production and exports. The study examines the trends in unit price and volume fluctuations of lumber and furniture exports over time, as well as the average value/m3 of kiln-dried lumber and garden furniture across wood species and importing countries. The study also explores the influence of product type and direction of trade on the value/m3 of lumber and garden furniture (Dadzie, P. K. et al., 2016).

Previous studies have mainly focused on the impact of total exports on national economic development, with limited attention given to the contribution of wood exports to the GDP. Literature on this topic has been conducted in countries such as Cameroon and Ghana, which have different forest policies and climates than Rwanda. As such, this study aims to assess the productivity of forests in Rwanda, particularly the contribution of wood exports to the country's economy.

III. RESEARCH METHODOLOGY

3.1Description of the study area

This research focuses on forestry production, specifically the case of wood production in Rwanda. Rwanda has a high population density and agriculture is the primary economic activity, contributing to a third of the country's GDP. However, woody perennial plant cultivation was not traditionally a part of Rwandan culture and more than 90% of the country's natural climatic conditions have been lost due to various human activities. This includes settlements, agropastoral practices, forest product consumption, bushfires, and urbanization(EPR, 2006).

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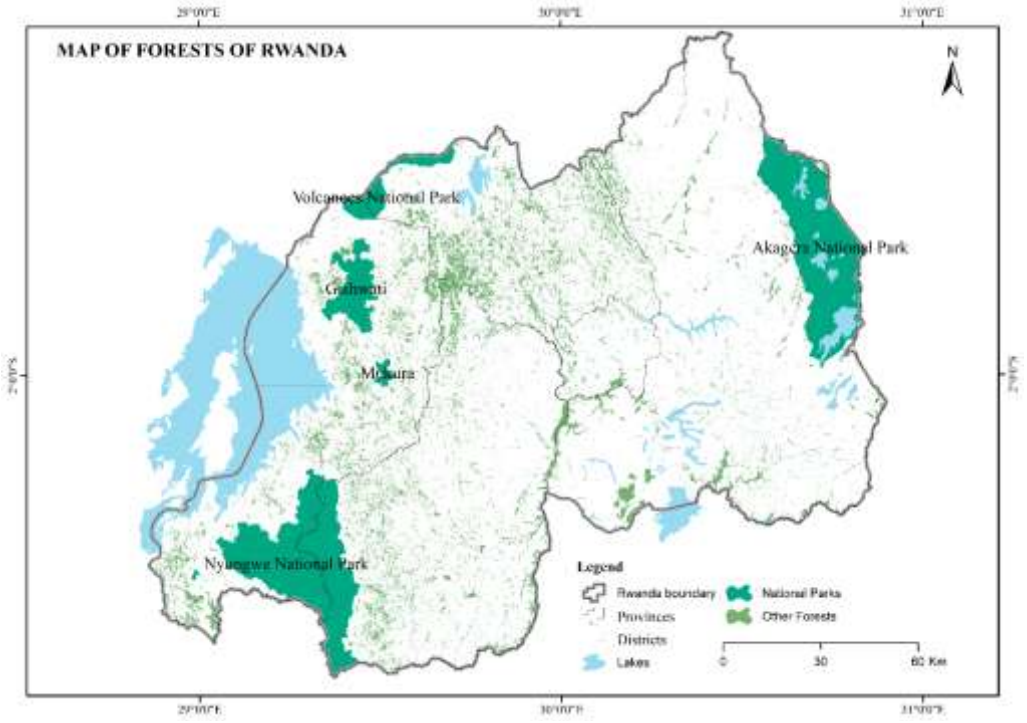

Figure 3.1- Rwanda forests map

Despite attempts to decrease it, over 85% of the nation is still dependent on fuel, with 95% of rural populations relying on wood. Rwandan households consume roughly 2.7 million tons of fuelwood annually, and nearly half of it comes from charcoal production. According to projections, there will be a significant deficit in wood supply and demand, with a 4.3 million ton deficit in 2017 and a 7.5 million ton deficit by 2026 under the "Business as Usual" scenario(FIP - Rwanda, 2017).

3.2Population sampling framework

The article describes a research study that utilized data from the World Bank online database. The study focused on the wood trade industry and its impact on Rwanda's economic development from 2011 to 2020. The research involved a survey of the entire target population and the collection of secondary data on forest production. The study aimed to provide insights into the wood trade sector's contribution to Rwanda's economic growth.

3.3Research Instruments

Research tools refer to various techniques, methods, and software used to collect and analyze data to achieve research objectives. As mentioned in the "Theoretical Framework" section, data collection and analysis are crucial steps in research. One such tool that is proposed for statistical data analysis is the Statistical Package for the Social Sciences (SPSS). The Data Editor in SPSS displays the contents of the active data file, which includes cases and variables that hold relevant information.

3.4 Data analysis

This section discusses the analytical model and diagnostic tests used in data analysis using SPSS version 26. Descriptive statistics are used to summarize the dataset, while inferential statistics, such as correlation and multiple regressions, are used to analyze the relationship between forest production and national trade environment as well as the association of independent and dependent variables. The correlation analysis evaluates the strength and kind of two-variable linear relationships, while the regression model includes all explanatory variables to focus on the long-term relationship between both types of variables. The research objectives and hypotheses guide the selection of pertinent data used in the analysis. The empirical model and thus econometric model is specified as follows:

$Yit = \beta_0 + \beta_1 X1\ it + \beta_2 X2it + \beta_3 X3it + \beta_4 X4it + \varepsilon it$

Where;

Y_i: Dependent variable, X_i: Independent variable, β: Unknown parameter, and ε: Error terms

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IV. PRESENTATION OF FINDINGS AND DISCUSSION

4.1Analysis of wood production trend in Rwandan

The study focuses on Rwanda's economic growth, using GDP as the dependent variable and forest production as the independent variable. Data was collected from various sources and statistical tools were used to analyze the information. The research aims to answer questions about the mean, standard deviation, minimum, and maximum values of the data.

Table 4.1 - Descriptive statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Forest Area (sq.km)	10	2660	2760	2710.00	34.960
Exports of GS (US$)	10	871553114.95	2258510232.38	1461862573.7889	521079924.20969
Wood Export	10	487840.00	12663020.00	5181719.0000	4187071.21606
GDP (US$)	10	6494395409.37	11182411389.07	8798507992.6398	1615003503.03334
Valid N (listwise)	10				

The table shows a summary of data, including the minimum and maximum values for forest area and export of goods and services. The mean values for export of services and goods and export of woods are $1.46 billion and $5.18 million, respectively. The standard deviation for GDP is $1.6 billion. The data covers ten instances from 2011 to 2020.

4.2 Data analysis and inferential statistics

The study uses inferential statistical tests to analyze data and determine the relationships between dependent and independent variables in order to achieve its objectives. These objectives include studying the correlation between forest area and wood export value, the correlation between wood export value and export of services and goods value, and assessing the influence of wood export value on Rwanda's GDP between 2011 and 2020.

Table 4.2– Correlations of variables

		Forest Area (sq.km)	Exports of GS (US$)	Wood Export	GDP (US$)
Forest Area (sq.km)	Pearson Correlation	1			
	Sig. (2-tailed)				
Exports of GS (US$)	Pearson Correlation	.945**	1		
	Sig. (2-tailed)	.000	.001		
Wood Export	Pearson Correlation	.884**	.858**	1	
	Sig. (2-tailed)	.001	.001		
GDP (US$)	Pearson Correlation	.988**	.955**	.864**	1
	Sig. (2-tailed)	.000	.000	.001	

**. Correlation is significant at the 0.01 level (2-tailed).

The table above represents the correlation matrix table to present the relationship between the variables for the current research, below is the interpretation of the correlations.

4.2.1 Forest plantation area on Woods' Export value correlation

A correlation test was conducted to fulfill the first objective, which revealed a highly positive correlation of 0.884 between forest plantation area and woods' export value. The significance value of 0.001 indicates that this is not just a result of random sampling error. Therefore, an increase in plantation area is likely to lead to an increase in income from woods' exports.

4.2.2 Woods' Export on Export of Services and Goods values correlation

"Export of Services and Goods" refers to transactions between residents and non-residents involving products and services, and a correlation test was conducted to determine the impact of Woods' sales on these transactions. The Pearson correlation coefficient was found to be 0.858, indicating a strong positive correlation between variables. The p-value of 0.001 is less than the

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standard alpha value of 0.05, indicating that the relationship is statistically significant, but not linear.

4.2.3 Woods' Export on GDP values

The GDP measures a country's value added through the production of goods and services, and accounts for revenue and spending on final products (excluding imports). This study examines the impact of wood exports on national GDP. Results show a strong positive correlation (r=0.864, p=0.001) between forest plantation area and wood exports, which in turn affect both the export of goods and services and national GDP from 2011 to 2020.

4.3 Regression analysis

4.3.1 Hypothesis Testing

Hypothesis one, which is "The woods' export value does not contribute importantly to the Services and Goods export." To test the hypothesis, a test is run and the findings are as follow:

Table 1.3 - Model summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.858[a]	.736	.703	283909800.63379

a. Predictors: (Constant), Wood Export

The summary shows a strong correlation (R value of 0.858) between the predicted and actual values in the study, indicating a high degree of association. Additionally, the R square value of 73.6% suggests that the independent variable explains a significant portion of the variation in the dependent variable. These findings are key information for the research paper.

Table 4.4 - Regression analysis (ANOVA) – Export of Goods & Wood Export

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1798880387561995780.000	1	1798880387561995780.000	22.317	.001[b]
	Residual	644838199167351940.000	8	80604774895918992.000		
	Total	2443718586729347600.000	9			

a. Dependent Variable: Exports of GS (US$)

b. Predictors: (Constant), Wood Export

The ANOVA table shows how well the regression equation fits the data and predicts variables. The p value for this study is 0.001, indicating that the regression model significantly predicts the outcome variable, specifically that wood export can predict the export of services and goods. This result is good as it is less than the alpha level of 0.05 or 5%.

Table 4.5 - Regression Coefficients - Exports of Goods & Services and Wood Export

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	908584577.317	147570457.042		6.157	.000
	Wood Export	106.775	22.602	.858	4.724	.001

a. Dependent Variable: Exports of GS (US$)

The coefficients table helps to understand how exports of services and goods are predicted from wood exports and its contribution to the model's significance. The null hypothesis is tested using the t-value and 2 tailed p-value. The p-value is compared to α=0.05, and since it is less than α, the null hypothesis is rejected, concluding that the model is statistically significant and different from 0. This allows us to conclude that wood exports have a significant impact on the prediction of exports of services and goods.

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Table 4.6 - Model summary - Woods' export and GDP

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.864[a]	.746	.714	863183512.63783

a. Predictors: (Constant), Wood Export

The model summary table provides two key pieces of information, the R and R square values, which indicate the correlation between the predicting and predicted values, and the amount of variance in the dependent variable explained by the independent variable. The R value of 0.746 and R square value of 71.4% are both high, indicating a strong correlation between the variables and a high amount of explained variance.

Table 4.7 - Regression analysis (ANOVA) - Woods' Export & GDP

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	17513440621371417000.000	1	17513440621371417000.000	23.505	.001[b]
	Residual	5960686211918245900.000	8	745085776489780740.000		
	Total	23474126833289662000.000	9			

a. Dependent Variable: GDP (US$)
b. Predictors: (Constant), Wood Export

Table 4.7 shows the relationship between variables in predicting outcomes. The p value of 0.001 under the Sig. column is significant as it is less than α=0.05, suggesting that the regression model predicts the outcome variable and wood export can impact Rwanda's GDP.

Table 4.8 - Regression coefficients - Woods' Export & GDP

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	7072161397.320	448664981.578		15.763	.000
	Wood Export	333.161	68.718	.864	4.848	.001

a. Dependent Variable: GDP (US$)

When validating a hypothesis using the coefficients table analysis, a p-value is used to determine whether to retain or reject the hypothesis. A p-value of 0.001 was found in this study, which is less than the significance level of 0.05, indicating that the model is statistically significant and different from 0. This allows for the retention of the alternative hypothesis. Using SPSS for data analysis, the null hypothesis was rejected and the alternate hypothesis was retained.

4.4 Discussion of the findings

This section analyzes and discusses the results of a study using statistical methods, organized by research questions and objectives. The findings suggest that expanding forest plantations positively impacts the export value of wood, goods, and services, and increases the country's GDP. Previous research also supports these findings.The research analyzed Iran's commercial forests and their contribution to the country's economy, as well as their correlation with macroeconomic variables such as population, GDP, world oil price, exchange rate, unemployment rate, and inflation. The study revealed that wood export is a significant factor in Iran's economy(Sotoudeh, B. et al., 2016).The second paper shows that with careful management, forests can greatly contribute to economic growth and generate job opportunities for local communities. The study examined the economic benefits of forestry, including revenue from wood, non-timber forest products, medicinal and aromatic plants, and protected areas. The analysis found that revenue from fuelwood and timber was higher than revenue from protected areas and non-timber forest products/medicinal and aromatic plants over the previous 15 years(Bharat, P. B. et al., 2021).

V. CONCLUSION

The study aimed to fulfill its objectives by analyzing the wood production trend, assessing the GDP progress, and analyzing the impact of wood production on national GDP in Rwanda from 2011 to 2020. The forest area ranged from 2660 km2 to 2760 km2, and the export of goods and services ranged from $871,553,114.95 to $2,258,510,232.38. The mean export of woods and services was $1,461,862,573.7889 and $5,181,719 for the export of woods. The GDP of Rwanda varied non-linearly between 2011 and 2020, and the null hypothesis was rejected as the wood export value significantly contributed to the export of goods and services and the national GDP.

VI. RECOMMENDATION

The research showed that the area of forest plantations has an impact on the export value of woods, as well as on the Export of Services and Goods and the national GDP of Rwanda between 2011 and 2020. The study recommends that the Ministry of Environment in Rwanda should focus on developing forests by increasing the area of forest plantations in order to promote economic growth in the country. Additionally, further research is suggested on other factors that could influence economic growth in Rwanda, including social, economic, and environmental factors.

REFERENCES

[1]. Bharat, P. B. et al. (2021). Economic Contribution of Forestry Sector to National Economy in Nepal. Journal of Resources and Ecology, 620-627.

[2]. Collins Dictionary. (2023). Wood. Retrieved from Collins Dictionary: https://www.collinsdictionary.com/dictionary/english/wood

[3]. Dictionary. (2023). Trade Definition & Meaning. Retrieved from Dictionary.com: https://www.dictionary.com/browse/trade

[4]. Merriam-Webster. (2023, March 30). Environment Definition & Meaning. Retrieved from Merriam-Webster: https://www.merriam-webster.com/dictionary/environment

[5]. Segal, T. (2022, December 18). What Are Exports? Definition, Benefits, and Examples. Retrieved from Investopedia: https://www.investopedia.com/terms/e/export.asp

[6]. Sotoudeh, B. et al. (2016). Investigation of wood production and trading in Iran. JOURNAL OF FOREST SCIENCE, 407 - 412.

[7]. Pohjanmies, T. (2018); Trade-Offs Among Intensive Forestry, Ecosystem Services and Biodiversity in Boreal Forests. The Faculty of Mathematics and Science of the University of Jyväskylä, in building Ambiotica, hall YAA303, on February 9, 2018 at 12 o'clock noon.

[8]. Singh, K. Y. (2006); Environmental science. Department of Education – Mahatma Gandhi Chitrakoot Rural University. Chitrakoot (Satna) Madhya Pradesh.

[9]. Michael, A. (2000); Basics of Environmental Science 2nd Edition. British Library Cataloguing in Publication Data. ISBN 0-203-13752-3 Master e-book ISBN.

[10]. Pranav, K. and Usha, M. (2018); Fundamentals of Ecology and Environment - Second edition. Pathfinder Publication New Delhi, India

[11]. Corey L. L. (2002); Environmental impacts of globalization and trade: A systems study. Library of Congress Cataloging-in-Publication Data. ISBN 0-262-12245-6 (hc.: alk. paper)

[12]. Jeffrey P. P. and Joseph, B. (2003); International Trade in Forest Products. USDA Forest Service, University of Wisconsin-Madison, USDA Forest Service, and University of Georgia

[13]. Sophie H. et al. (2005); The Sustainable Forestry Handbook. A practical guide for tropical forest managers on implementing new standards - Second edition. Typesetting by Mapset Ltd, Gateshead, UK. Printed and bound in the UK by Cromwell Press, Trowbridge. ISBN: 1-84407-118-9 hardback.

[14]. Andrew, A. (2016); How to Day Trade for a Living. Day Trader at Vancouver Traders.

[15]. Alexander, E. (2014); The New Trading for a Living. Psychology • Discipline • Trading Tools and Systems Risk Control • Trade Management. Published by John Wiley & Sons, Inc., Hoboken, New Jersey. ISBN 978-1-118-44392-7 (Hardcover).

[16]. EPR (2006); Environmental Profile of Rwanda. This report is financed by the European Commission and is presented by Dr. Fabien TWAGIRAMUNGU for the National Authorizing Officer of FED and the European Commission.

[17]. FIP - Rwanda (2017); Forest Investment Program for Rwanda, Ministry of Lands and Forestry – Rwanda.
[18]. Liu, C. et al. (2016); Online ARIMA Algorithms for Time Series Prediction. School of Computer Science and Technology, Zhejiang University, China. Proceedings of the Thirtieth AAAI Conference on Artificial Intelligence (AAAI-16).
[19]. Stella, B. A. and Richard, K. A. (2015); Impact of Trade Policies on Wood Products Export in Ghana. CSIR-Forestry Research Institute of Ghana, KNUST, Kumasi, Ghana. Department of Mathematics, Kwame Nkrumah University of Science and Technology Kumasi, Ghana.
[20]. Njimanted, G. F. and Nkwetta, A. A. (2015); The impact of timber exports on economic growth in Cameroon: An econometric investigation. Associate Professor of Economics, Department of Economics and Management, University of Buea, S.W.R, Cameroon.
[21]. Dadzie, P. K. et al. (2016); Some Market Trends of Wood Products Exports in Ghana and Their Implications for Stakeholders: The Case of Furniture and Kiln-Dried Lumber. Interior Architecture and Furniture Production Department, Faculty of Built and Natural Environment, Kumasi Polytechnic, Kumasi, Ghana. Department of Wood Science and Technology, Faculty of Renewable Natural Resources, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.
[22]. Pranav, K. & Usha, M. (2018). Fundamentals of ecology and environment. Pathfinder Research and Training Foundation, India and Pathfinder Academy, India
[23]. Turner, I. M. (2004). The ecology of the trees in the tropical rain forest. Singapore Botanic Gardens
[24]. Rwanda National Forestry Policy (2018). Ministry of lands and forestry, Republic of Rwanda.
[25]. GEF (2009). Global Ecological Forest Classification and Forest Protected Area Gap Analysis. United Nations Environment Program World Conservation Monitoring Centre. 2nd revised edition, January 2009
[26]. Motivans, E. (n.d.). The different types of forests: everything you need to know. ZME Science. Retrieved April 11, 2023, from https://www.zmescience.com/other/did-you-know/different-types-forests/
[27]. Rwanda National Forest Policy (2017). Ministry of Natural Resources.
[28]. Jim, S. & Jonathan, R. (2008). The Handbook of International Trade - A Guide to the Principles and Practice of Export. Second Edition. ISBN 978-1-84673-034-4; E-book ISBN 978-1-84673-035-1.
[29]. ITC (2011). The International Trade Centre (ITC) is the joint agency of the World Trade Organization and the United Nations. ISBN 978-92-9137-402-1. United Nations Sales No. E.12.III.T.3
[30]. NES (2011). Rwanda National Export Strategy. Ministry of Trade and Industry.
[31]. Creating markets in Rwanda (2019). Creating Markets in Rwanda; Transforming for the Jobs of Tomorrow. Country private sector diagnostic. World Bank Group – The International Finance Cooperation
[32]. NFP (2018). Rwanda National Forestry Policy 2018; Ministry of Lands and Forestry.
[33]. Forests and Tree - based Systems Sector Working Paper (2011). Appendix B. Smith School of Enterprise and the Environment. University of Oxford.
[34]. FIP (2017). Forest investment program for Rwanda. Ministry of Lands and Forestry.
[35]. Jean, N. (2011). Forest Plantations and Woodlots in Rwanda. Forest plantations and woodlots in Rwanda. A Platform for stake holders in African forestry.