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Implications of the Association Between Forest Cover and the Central Bank Rate of Return on Sustainable Forest Management in Kenya

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Abstract: Forests play an important role in human well-being and sustainable development. However, in the wake of the rising deforestation and climate change, information on how monetary policy factors, especially the Central Bank Rate of Return (CBRR) affect sustainable forest management in developing countries is scarce. This study examined the relationship between CBRR and forest cover in Kenya for the period of 2006–2022, with the aim of contributing to a better understanding of the factors influencing sustainable forest conservation and management. A literature review and quantitative data analysis using pearson's correlation, multiple regression and ANOVA showed a weak, negative correlation between the CBRR and forest cover ($r = -0.36$, $p<0.05$), indicating that a higher CBRR is generally associated with lower forest cover value in Kenya. This result indicates that there could be some relationship, but the data points remained scattered such that the correlation is closer to zero (R-squared = 0.130). Moreover, the correlation coefficient also suggests that the relationship between the two variables is weak. Analysis of variance (ANOVA) found a statistically significant difference between the means of the CBRR and forest cover groups ($F(1,32) = 21.93$, $p< 0.000$), supporting the idea that the CBRR could have an impact on the forest cover percentage in Kenya. However, this impact could be weak and influenced by other factors not captured in the model. This paper recommends that forest management stakeholders in Kenya consider the potential influence of changes in the CBRR on forest cover and the need for a coordinated effort from policymakers, researchers, and local communities to address the complex issues driving forest cover change in the country.

Keywords: ANOVA, Correlation Coefficient, Deforestation, Regression Analysis, Sustainable Forest Management

1. Introduction

Forests are natural ecosystems characterized by their biodiversity, which includes a wide variety of flora and fauna. In contrast, forest cover refers to the total land area covered by forests, including both natural and planted forests. Forests provide numerous ecological, economic, and social benefits. Ecologically, forests serve as habitats for a vast array of animal species, support biodiversity, and contribute to carbon sequestration by absorbing carbon dioxide from the atmosphere. Sustainable forest

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management involves the responsible use and conservation of forests to meet the socio-economic and environmental needs of current and future generations. In the recent past, due to the changing socio-economic conditions, especially population growth, limited fiscal space for governments, and the growing demand for forest goods and services, which appears to be driving deforestation, biodiversity loss, and ecosystem fragmentation, there is the growing need for studies that explore the connection between forest cover changes and monetary policies across the globe. The Central Bank Rate of Return (CBRR), which refers to the interest rate at which the central bank lends money to commercial banks and other financial institutions, is emerging as a critical monetary policy factor affecting sustainable forest management. The central bank rate of return is speculated to indirectly affect sustainable forest management by influencing investment decisions, government policies, funding availability, and land use choices. Thus, forest management stakeholders must consider these interconnections when designing and implementing strategies for the conservation and sustainable management of forests[1].

In Kenya, forests are important strategic national assets because of their ecological and socio-economic value. Kenya's forest sector contributes to the livelihood base for over 82% of the nation's households, including direct employment for over 750,000 Kenyans and indirect benefits for over four million citizens. Trees and forests comprise approximately US $365 million (3.5%) of gross domestic product (GDP), excluding ecological services, non-wood forest products, contributions to other sectors, and household wood energy. Ecological services, such as watershed protection and carbon sequestration, also contribute more than US $20 billion worth of goods annually to other productive sectors of the economy, such as agriculture, fisheries, livestock, energy, wildlife, water, tourism, trade, and industry[1]. The annual contribution of these sectors to GDP is estimated at 33–39%[2].

Consequently, Kenya has ratified various national, regional, and international conventions and agreements to protect its tree resources. The country is committed to the United Nations (UN) Sustainable Development Goals (SDGs), the African Forest Landscape Restoration Initiative (AFRI100), and the Nationally Determined Contribution (NDC) as part of the UN Framework Convention on Climate Change (UNFCCC), in line with the requirements of the Paris Climate Change Agreement, which aims to lower Kenya's greenhouse gas (GHG) emissions by 30% by 2030. Besides implementing the constitutional requirements of maintaining a minimum of 10% tree cover in the country, Kenya has also rolled out an ambitious greening project aimed at attaining 30% tree cover by 2032, up from the current 12.13%. Beyond these resources, the nation has undertaken significant political and economic reforms that have contributed to sustained economic growth, social development, and political stability over the past decade[3][4].

However, Kenya is still a low forest cover country, with less than the recommended minimum global standard of 10%. There are also limited studies that address the relationship between factors that drive forest cover changes, such as CBRR. If the status quo remains, with the rapidly expanding human population, deforestation is likely to escalate. Whereas the other factors that drive deforestation, such as agriculture expansion, have been widely discussed in the scientific literature in the country, the correlation between monetary policy factors, especially the central bank rate and forest cover change, remains understudied. For the first time, this article examines this relationship for Kenya from 2006-2022 to generate lessons for sustainable forest management and sustainable development. This study will explore the theoretical linkages between the two variables and review empirical studies that have explored this relationship. This study will then conclude by discussing the implications of our findings for policymakers and suggesting directions for future research. To achieve the study aims of this paper, one key question was asked: What are the implications of the relationship between central bank interest rates and changes in forest cover and sustainable forest management in Kenya? Forests play a crucial role in providing ecological, economic, and social benefits, making their preservation and sustainable management imperative. By examining the connection between the central bank rate of return and forest-related changes, such as deforestation or afforestation, this research seeks to shed light on the potential impacts on Kenya's forestry sector. Understanding these implications will inform policymakers and stakeholders in developing effective strategies to promote sustainable forest management and balance economic growth with environmental conservation. The implications of this study could reveal how financial policies indirectly influence conservation efforts. Understanding this link can guide policymakers in formulating strategies that promote sustainable forest practices while considering economic interests and long-term environmental resilience. Balancing financial incentives and ecological preservation is crucial for achieving effective and lasting solutions in forest management and biodiversity conservation.

Kenya has been chosen because it is a developing country that has experienced rapid economic growth in recent years. This growth has been accompanied by an increase in the demand for natural resources, including timber and agricultural land, which has put pressure on the nation's forests. Moreover, Kenya has a fairly well-developed financial sector with a central bank that sets interest rates to influence macroeconomic variables such as inflation, exchange rates, and economic growth. Changes in interest rates can affect the cost of borrowing and investment, which in turn can influence land-use decisions and deforestation rates. Kenya has a diverse range of forest ecosystems, including montane, coastal, and dryland forests, and is home to a wide range of plant and animal species. Deforestation in these areas can significantly impact biodiversity conservation and ecosystem services, hence the suitability of Kenya as a study site.

2. Literature Review

2.1 Sustainable Forest Management and the Central Bank Rate of Return

The role of sustainable forest management is to ensure the responsible use and conservation of forests to meet the needs of present and future generations. It involves a comprehensive approach that considers the environmental, social, and economic aspects of forests, aiming to achieve a balance between conservation and utilization. It promotes the sustainable use of forest resources, ensures their conservation for future generations, and contributes to global efforts to address environmental challenges such as climate change and biodiversity loss[5]. However, sustainable forest management is increasingly being undermined globally by multiple direct, indirect, and proximate causes that drive deforestation, forest fragmentation, and degradation. According to the World Resources Institute (WRI)[6], deforestation due to agriculture, logging, and mining continues to drive global tree cover loss. Many tropical rainforests have been destroyed by agriculture and other land-use types. The Food and Agriculture Organization (FAO)[7] reported that the global forest area decreased by 178 million hectares between 1990 and 2020, with most of the loss occurring in tropical regions. Deforestation is largely driven by a range of factors, including agriculture, mining, logging, infrastructure development, and urbanization. However, in light of the emerging socio-economic changes and complexities around the world necessitated by policy shifts, population growth, climate change, and biodiversity loss, there is a need to explore other possible causes, such as the CBRR, which appears to be driving current forest cover loss, fragmentation, and degradation.

The theoretical linkages between central bank interest rates, deforestation, and sustainable forest management can be understood from two primary perspectives: (1) the impact of monetary policy on economic growth and (2) the influence of economic growth on deforestation and sustainable forest management. As a macroeconomic variable, the central bank interest rate has a significant impact on land investments, including forestry. When a central bank increases its interest rates, it becomes more expensive for investors to borrow money, leading to decreased demand for land investments because higher interest rates can increase the cost of borrowing money to finance land purchases, making land less attractive to investors[8-10]. This interest rate behavior also extends to land-based forestry investments

Conversely, when the central bank decreases its interest rates, it becomes cheaper for investors to borrow money, which can lead to an increase in the demand for land investments, such as forestry. This interest rate behavior is because lower interest rates decrease the cost of borrowing money to finance land purchases, making them more attractive to investors. Additionally, the central bank interest rate can affect the overall economy and housing market, which can indirectly impact land investments. For example, a decrease in interest rates can lead to an increase in home buying and construction, thereby leading to urbanization, which can produce an increase in demand for land to build new homes or commercial properties[11-13].

Empirical studies exploring the relationship between central bank interest rates and deforestation rates and, by extension, forest cover are scarce, but the few existing have produced mixed results. Some studies have found a positive correlation between these two variables, whereas others have found no significant relationship. In Indonesia, Wehkamp[14] found that lower interest rates led to increased economic growth, which in turn generated increased deforestation rates. Karsenty[15] found that lower interest rates were associated with increased deforestation rates in the Democratic Republic of Congo (DRC). Merganič et al.[16] found that a higher interest rate reduces the duration of forest cutting, whereas lowering rates increase it. Leite-Filho et al.[17] found no significant correlation between the two variables. Ávila-García et al.[18] indicated no significant relationship between the two variables in the case of Mexico. Furumo and Lambin[19] found that in some parts of the world, such as the Amazon Basin, deforestation is mostly driven by factors such as land-use policies, market demand for commodities, and weak governance structures. The mixed results of these studies suggest the need for more research and, hence, the need to explore the case of Kenya.

2.2 The Context for Forest Management in Kenya

Trees and forests are important strategic national assets in Kenya because of their ecological and socio-economic value. Kenya's forest sector contributes to a livelihood base for over 82% of Kenya's households. Direct employment for over 750,000 Kenyans and indirect benefit to over 4 million citizens. About USD 365 million (3.5%) to GDP[20].

Whereas Kenya is a low forest cover country (8.83%) which is less than the recommended minimum global standard of 10%, the rapidly expanding population and conversion of forest lands to agriculture were the major drivers of forest cover loss over the years. From 1990 to 2015, about 311,000 Ha of forest land was converted to other land uses[21]. Weak governance, unsustainable exploitation, overreliance on forest products, forest fires, and increasing adverse effects of climate change have further exacerbated deforestation and degradation of forests in Kenya[21].

The Kenyan Constitution 2010 recognizes the need to maintain the national tree cover to at least a minimum of 10% by the year 2030. This development aspiration is also in line with Kenya's commitment to restore 5.1 million hectares of forest and degraded landscapes, which formed part of the African Forest Landscape Restoration Initiative (AFRI100) target, and the NDC target of reducing greenhouse gasses emissions by 32% by 2030 relative to a business-as-usual scenario.

Kenya has made significant political and economic reforms that have contributed to sustained economic growth, social development, and political stability over the past decade. From 2015 to 2019, Kenya's economy achieved broad-based growth averaging 4.8% per year, significantly reducing poverty to 34.4% in 2019[22]. Kenya's economy is highly dependent on the natural resource base, and with over 84% of its land area classified as arid and semi-arid, Kenya is exposed and highly vulnerable to increasing extreme weather conditions. An average drought results in a food deficit of 20–30%, slashes GDP growth by 3–5%, and affects the livelihoods of over 80% of the population[23]. According to the Global Climate Change Risk Index (GCRI) of 2021, Kenya is ranked as the 25th most affected country by extreme weather conditions and weather-related losses[24]. Youth unemployment and a high poverty rate are also key challenges to Kenya's economic growth and development. The youth unemployment rate is estimated at 38.9%, with an estimated 800,000 young people getting into the labor market every year and over 8.9 million people in Kenya living below the poverty line[25]. With a population growth rate of 2.7%, the Kenyan population is projected to rise to 66.3 million by 2030. The increasing population presents a challenge to the sustainable utilization of forest resources but also an opportunity for the expansion of farm forests. According to a study by GATSBY Charitable Fund in 2014, Kenya's national wood deficit was estimated at 12 million M3 in 2014 and is predicted to rise to as high as 34.4 million M3 by 2030. It is against this background that the new Kenya Kwanza administration's bottom-up economic model has prioritized accelerating the achievement of 30% national tree cover by 2032 for increased employment opportunities, improved livelihoods, climate change reliance, and enhancing Kenya's economic growth within the context of the Vision 2030.

Between 2006 and 2022, the trend of the central bank rate of return in Kenya was characterized by fluctuations. In 2006, the rate stood at 8.50% before gradually increasing to a peak of 18.00% in 2012, reflecting efforts to combat inflation. However, from 2013 onwards, the rate began to decline, reaching a low of 7.00% in 2016. Subsequently, there were intermittent adjustments, with the rate fluctuating between 7.00% and 10.00% until 2022. The central bank aimed to strike a balance between stimulating economic growth and maintaining price stability amidst changing domestic and global economic conditions during this period. However, specific studies that directly examine the relationship between the central bank rate of return and forest cover change in Kenya between 2006 and 2022 appear to be limited or non-existent, hence the need for this pioneering study.

3. Methodology

3.1 Research Design

The case study research design was adopted to investigate the impact of the central bank rate of return on sustainable forest management. In this design, the researcher selected Kenya, which has experienced variations in central bank rate of return over time between 2006 and 2022. The focus was on understanding the specific context, processes, and outcomes related to sustainable forest management in relation to changes in the central bank's rate of return. The case study design was chosen because it allows for an in-depth examination of the specific case and provides a comprehensive understanding of the complexities and contextual factors that influence the impact of the central bank rate of return on sustainable forest management.

3.2 Study Area

Kenya is located in East Africa and is known for its immense natural resources, especially diverse wildlife resources, magnificent landscapes, and vibrant traditions. Kenya has famous wildlife reserves, including the Masai Mara National Reserve, known for its annual wildebeest migration, and Amboseli National Park, renowned for its large elephant herds. Kenya has a population of approximately 50 million and over 40 ethnic groups, each with a unique language, customs, and traditions. Kenya's capital, Nairobi, serves as an economic and cultural hub. Kenya's geography is diverse, ranging from savannas to forests, mountain ranges, and coastal plains. The country's coastline is dotted with pristine beaches, coral reefs, and marine parks, making it a popular destination for beach holidays and sports. In terms of its economy, Kenya is one of the most developed states in East Africa, with a GDP of approximately US $100 billion[26].

Kenya offers unique and diverse study sites for scholars from numerous fields. The nation's rich biodiversity, coupled with its diverse ethnic groups and cultural heritage, provides a wealth of opportunities for research in the fields of anthropology, ecology, and conservation. Kenya's myriad landscapes, ranging from arid savannas to tropical forests, provide ideal sites for researchers interested in studying the impacts of climate change on ecosystems and wildlife. Kenya's position as a regional economic and political hub provides opportunities for research in fields such as international relations, economics, and political science. The nation's history of political instability, coupled with its current status as a relatively stable democracy, makes it an ideal place to explore the connection between sustainable forest management and central bank interest rates in developing countries.

3.3 Data Sources and Collection Process

This paper used secondary data to demonstrate the association between CBRR and forest cover changes in Kenya using document content analysis. The process of document content analysis entailed identifying relevant documents, selecting a sample for analysis, developing coding schemes or categories to organize the data, and systematically analyzing the content of the documents to draw conclusions about the research question.

Data on forest cover changes was obtained from the existing literature using desktop search engines, especially Google, as well as official records. During the desktop search, appropriate keywords related to the topic, such as "forest cover," "forest loss," "forest management," "deforestation," and any other relevant terms were chosen. In some cases, advanced search techniques such as quotation marks ("”) to search for exact phrases or the minus sign (-) to exclude certain keywords were used. Notes were taken to keep track of the reference sources. Collected information was later synthesized and used to develop insights and support the arguments presented in this study. Data on the central bank's interest rate was obtained from the official website of the Central Bank of Kenya, which usually provides information on its policy or interest rates. Central bank interest rate data, released on a monthly basis, were averaged to obtain a single annual interest rate. This average rate figure was correlated with the forest cover percentage data for the period of 2006–2022. Additional secondary data was gathered by reviewing key policy documents (listed in [Table 1]), which provided more context for this study.

[Table 1] Key Policy Documents

No.	Document	Key information sought	Source
	Constitution of Kenya (2010) [27]	Contextual information for forest management and interest rates in Kenya	Kenya law reporting website at http://kenyalaw.org/kl/index.php?id=398
	Draft Forest Policy (2015) [28]	Contextual information for forest management and interest rates in Kenya	Kenya Forest Service website at http://kenyaforestservice.org/
	Forest Conservation and Management Act (2016) [29]	Institutions established to promote forest management and interest rates in Kenya	Kenya law reporting website at http://kenyalaw.org/kl/fileadmin/pdfdownloads/Acts/2016/No._34_of_2016.pdf
	Vision (2030) [30]	Contextual information for forest management and interest rates	Vision 2030 website at https://vision2030.go.ke/
	County Government Act (2012) [31]	Contextual information for forest management	Parliament website website at http://www.parliament.go.ke/sites/default/files/2017-05/CountyGovernmentsAct_No17of2012_1.pdf
	Agriculture (Farm Forestry) Rules (2009) [32]	Contextual information for forest management and interest rates	FAO website at https://faolex.fao.org/docs/pdf/ken101360.pdf
	Kenya Agroforestry Strategy (2021–2032) [33]	Contextual information for forest management and interest rates	Internet search at https://www.ctc-n.org/system/files/dossier/3b/KENYA%20AGROFORESTRY%20STRATEGY%20DRAFT%20February%202021_.pdf

Document content analysis was the preferred research method because it is less expensive than other research techniques, such as surveys or experiments, as the data are readily available and do not require researchers to collect new data. Unlike surveys or experiments, document analysis does not require direct contact with participants, which can be useful when studying sensitive topics or when the researcher wants to avoid influencing participants' behavior. Document content analysis is more objective than other research approaches because it relies on the content of documents rather than the researcher's interpretation of the data. Lastly, historical data on forest cover and the central bank's rate of interest was explored.

3.4 Data Analysis

Quantitative time series data on forest cover percentage changes and the central bank's rate of interest was analyzed using an Excel spreadsheet to generate visualizations. To test the statistical significance of a relationship, this study used the dependent variable based on multiple regression analysis of the independent variable, which involved building a regression model using an Excel spreadsheet. The Excel spreadsheet outputs (model coefficients) were interpreted. The statistical significance was determined by examining the p-values of the coefficients. The statistical significance was set at $p<0.05$. The model fit was assessed by examining the R2 value, which represents the proportion of variance in the dependent variable explained by the independent variables. The model assumptions were tested, which included testing for the normality of residuals, the homoscedasticity of residuals, and the absence of autocorrelation of residuals. Finally, predictions were made based on the model. The results of the multiple regression analysis included the strength and direction of the relationships, the statistical significance of the results, and the study's limitations. Regression analysis was used because similar studies, such as Hansen[34], employed a similar approach. Later, the researchers synthesized and interpreted emerging themes from the document content analysis, as well as the visualizations from the quantitative time series data on the variables, to generate lessons for this study. [Table 2] defines the regression variables used in this study.

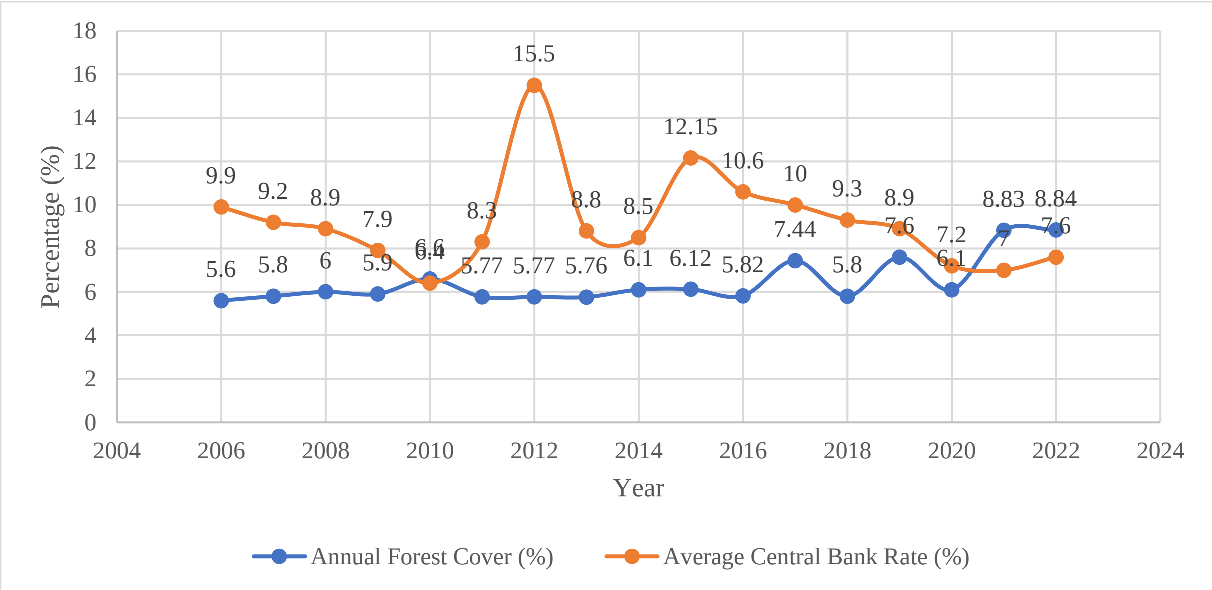
[Table 2] Key Regression Variable Used

Code	Variable Name	Short Description	Data Type	Domain
DV	Forest Cover Change	The extent of change in forest cover	Numeric	Continuous
		over a specified time period		
IV	Central Bank Rate of	The annual rate of return on investments	Numeric	Continuous
	Return	managed by the central bank		
CV	Economic Indicators	Variables capturing economic conditions	Numeric	Continuous
		and potential confounders		
CV	Policy Variables	Variables representing forest conservation	Categorical	Coded categories or indicator
		policies, regulations, or interventions		variables
CV	Geographic Variables	Variables capturing geographical	Categorical	Coded categories or indicator
		characteristics influencing forest cover		

4. Results

4.1 Description of the Central Bank Rate of Return and Forest Cover for the Period of 2006–2022

The lowest CBRR was recorded in 2010 when the rate was 6.6%; thereafter, the CBRR continued to rise [Fig. 1]. The highest CBRR at 15.5% was recorded in 2012. This figure indicates high volatility in the CBRR between 2011 and 2012. The lowest forest cover was recorded in 2006 at a rate of 5.6%; thereafter, forest cover continued to rise. The highest forest cover, at 8.84 %, was recorded in 2022. This figure shows a relatively steady increase in forest cover during the study period.



[Fig. 1] Trends in Forest Cover and the CBRR for the period of 2006–2022

4.2 Descriptive Statistics for the Central Bank Rate of Return and Forest Cover in Kenya

[Table 3] provides statistics on the average CBRR and forest cover (%), along with descriptive statistics for the period of 2006–2022. The average CBRR during the study period is 9.18%, with a standard error of 0.52. The median value is 8.9%; the mode is also 8.9%. The range of central bank rate values spans from 6.4–15.5%, with a standard deviation of 2.15. The sample variance is 4.63, and the kurtosis is 3.91, suggesting that the data on the CBRR are moderately leptokurtic (i.e., more peaked than a normal distribution). The skewness is 1.67, which implies a positive skew and that the distribution is skewed toward higher values.

In addition, the average forest cover percentage over the study period is 6.46%, with a standard error of 0.26. The median value is 6%, and the mode is 5.8%. The range of forest cover values spans from 5.6–8.84%, with a standard deviation of 1.06. The sample variance is 1.12, and the kurtosis is 1.28, suggesting that the forest cover data are moderately platykurtic (i.e., less peaked than the normal distribution). The skewness is 1.56, denoting a positive skew, meaning that the distribution is skewed toward higher values.

[Table 3] Descriptive Statistics

Parameter	Average CBRR	Forest Cover (%)
Mean	9.185294118	6.461764706
Standard Error	0.521799853	0.256700265
Median	8.9	6
Mode	8.9	5.8
Standard Deviation	2.151435909	1.058402306
Sample Variance	4.628676471	1.120215441
Kurtosis	3.911190725	1.280689543
Skewness	1.668023618	1.56795722
Range	9.1	3.24
Minimum	6.4	5.6
Maximum	15.5	8.84
Sum	156.15	109.85
Count	17	17
Largest (1)	15.5	8.84
Smallest (1)	6.4	5.6
Confidence Level (95.0%)	1.106166273	0.544180252

CBRR = central bank rate of return

4.3 Correlation between the Central Bank Rate of Return and Forest Cover Percentage

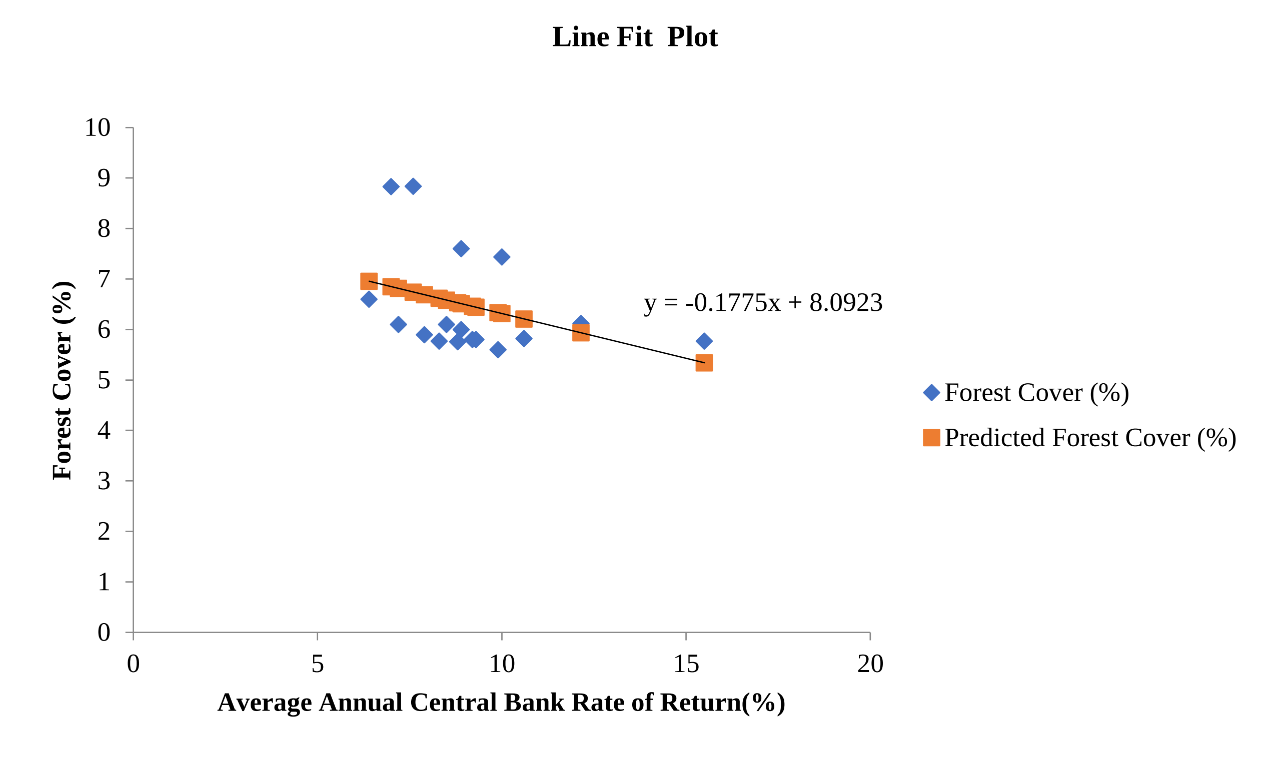
[Table 4] presents the correlation coefficients between the average CBRR (%) and forest cover (%) using Pearson's correlation coefficient. The value of -0.36 shows the correlation between the average CBRR and forest cover. A negative sign indicates an inverse correlation, which means that as the CBRR increases, forest cover declines. However, the correlation coefficient suggests a weak, negative correlation between the two variables, implying that the relationship between the CBRR and forest cover is weak.

[Table 4] Correlation Analysis

Parameter	Average CBRR (%)	Forest Cover (%)
Average CBRR	1	
Forest cover (%)	-0.360838539	1

CBRR = central bank rate of return

[Fig. 2] outlines the results of the regression analysis of the average CBRR and forest cover from 2006–2022. There appears to be a negative linear relationship between the CBRR and forest cover during the study period. The regression line provides a reasonable fit to the data, with an intercept of 8.09% and a slope of -0.18%. These outcomes imply that a higher CBRR is likely to result in lower forest cover value in Kenya. However, other factors not captured in this model could affect Kenya's forest cover percentage. The accuracy of the predictions made using this regression line could also depend on the range of the CBRR values in the dataset.



[Fig. 2] Line of Fit

[Table 5] Regression Statistics

Regression Statistics								
Multiple R	0.360838539							
R^2	0.130204451							
Adjusted R^2	0.072218081							
Standard Error	1.019468308							
Observations	17							
ANOVA								
	df	*SS*	*MS*	*F*	*Significance F*			
Regression	1	2.333713	2.333713	2.245432	0.154758			
Residual	15	15.58973	1.039316					
Total	16	17.92345						
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	8.09229303	1.115863	7.252049	2.82E-06	5.713888	10.4707	5.713888	10.4707
Average CBRR	-0.177515091	0.118464	-1.49848	0.154758	-0.43001	0.074984	-0.43001	0.074984

ANOVA = analysis of variance, CBRR = central bank rate of return

[Table 5] depicts the regression statistics for a linear regression model that relates the average CBRR and forest cover. The multiple R-value is 0.36; it represents the correlation coefficient between the two variables. The value of R2 is 0.1302, which indicates that the average CBRR can explain 13.02% of the variance in forest cover. The adjusted value of R2 is 0.07; it considers the number of predictor variables in the model and provides a more accurate measure of how well the model fits the data. The standard error is 1.02, which denotes the average distance between the observed values and the regression line.

The ANOVA table provides information on the regression and residual sum of squares, degrees of freedom, mean square values, F-statistics, and significance level of the F-statistics. The F-statistic is 2.24, and the significance level is 0.15. It implies that the regression model is not statistically significant at the 5% level, and this study cannot reject the null hypothesis that the regression coefficient is equal to zero. The coefficient table provides estimates for the intercept and average CBRR regression coefficients along with their standard errors, t-statistics, and p-values. The intercept estimate is 8.09%, indicating that the model predicts a forest cover value of 8.09% when the average CBRR value is zero. The average CBRR regression coefficient estimate is 0.18, indicating that the model predicts a decrease of 0.18% in the forest cover value for every unit increase in the average CBRR. However, the p-value for this coefficient is 0.15, implying that this coefficient is not statistically significant at the 5% level, and this study cannot reject the null hypothesis that the regression coefficient is equal to zero.

[Table 6] presents the results of the single-factor ANOVA for the CBRR and forest cover. The summary section provides the count, sum, average, and variance of the two variables. The ANOVA table includes three sources of variation: between groups, within groups, and in total. The between-group source of variation represents the variation in the means of the two groups (CBRR and forest cover). The sum of squares (SS) for this source of variation is 63.04, and the degree of freedom (df) is 1, resulting in a mean square (MS) value of 63.04. The within-group source of variation represents the variation within each group. The SS for this source of variation is 91.98, and the df is 32, resulting in an MS value of 2.87. The total SS is 155.03, which is the sum of the between-group and within-group SS. The F-statistic is 21.93, with a p-value of 4.98E-05, indicating a statistically significant difference between the means of the CBR and forest cover groups. The critical F-value for this ANOVA, with 1 and 32 degrees of freedom at a 5% level of significance, is 4.15. As the calculated F-value is greater than the critical F-value, this study rejected the null hypothesis that the means of the two groups are equal.

[Table 6] ANOVA Results

ANOVA: Single-Factor						
Summary						
Groups	***Count***	***Sum***	***Average***	***Variance***		
CBR	17	156.15	9.185294	4.628676		
Forest Cover	17	109.85	6.461765	1.120215		
ANOVA						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Groups	63.04971	1	63.04971	21.93456	4.98E-05	4.149097
Within Groups	91.98227	32	2.874446			
Total	155.032	33				

5. Discussion

Deforestation and climate change, partly driven by limited studies on specific factors that exacerbate them, continue to threaten sustainable forest management with implications on achieving Sustainable Development Goals and global commitments on forest conservation and climate change mitigation. This study explores the impact of CBRR on forest cover changes. Results from Kenya from 2006–2022 indicate that the relationship between the central bank's interest rate and sustainable forest management is more multifaceted and complex than previously thought. The findings show a weak, negative correlation between the two variables [Table 4, Fig. 2, and Table 5], suggesting that as the CBRR increases, forest cover decreases. However, the correlation coefficient implies that the relationship between the CBRR and forest cover is weak. These study outcomes denote that higher CBRR values are likely to result in lower forest cover values in Kenya. This relationship could be due to the fact that a higher CBRR leads to increased borrowing costs for businesses, which could result in reduced investment in activities that promote forest conservation. However, the weak correlation coefficient suggests that other factors not included in the model affected the percentage of forest cover in Kenya. This finding agrees with the results of Furumo and Lambin[19] and Liapun[10], who established that forest loss could also be linked to other factors such as land-use policies, market demand for commodities, and weak governance structures.

Moreover, this study found an F-statistic of 2.24 and a p-value of 0.15 [Table 5], indicating that the regression model is not statistically significant at the 5% level. This result means that this study cannot reject the null hypothesis that the regression coefficient is equal to zero, indicating no significant relationship between the CBRR and forest cover percentage. In addition, the p-value for the coefficient is not statistically significant at the 5% level, further supporting the conclusion that the relationship between the CBRR and forest cover percentage in Kenya is weak. These study outcomes imply that the accuracy of the predictions made using the regression line could be limited and should be interpreted with caution.

Additionally, this study conducted an ANOVA, which revealed a statistically significant difference between the means of the CBRR and forest cover groups, with an F-statistic of 21.93 and a p-value of 4.98E-05 [Table 6; Annex 1]. This result rejects the null hypothesis that the means of the two groups are equal. The critical F-value for this ANOVA, with 1 and 32 degrees of freedom at the 5% level of significance, is 4.15. Because the calculated F-value is greater than the critical F-value, the null hypothesis is rejected, indicating that the difference between the means of the two groups is statistically significant. These study outcomes hint that the CBRR is likely to have an impact on forest cover percentage in Kenya, although this impact could be weak and influenced by other factors. Our findings also highlight the importance of considering other variables that affect forest cover percentages, such as climate patterns, agricultural practices, and population growth.

Although results from Kenya point to a weak relationship between the two variables, the findings from the reviewed literature show that central bank interest rates can influence land-based investments, including forestry development. Lower interest rates tend to stimulate economic activity by making borrowing cheaper and encouraging investments. In contrast, higher interest rates tend to constrain economic activity by making borrowing more expensive and investment less attractive, which in turn affects deforestation rates[8][11]. Moreover, the literature demonstrates that as countries develop and become more affluent, their demand for forest products (such as timber) decreases. At the same time, the demand for agricultural products (such as beef and soy) increases[12][13]. This shift in demand can lead to increased deforestation rates as forests are cleared to make way for agricultural activities. Empirical studies conducted across the country on the topic have yielded mixed outcomes, showing that the relationship between the central bank's interest rate and sustainable forest management is multifaceted, complex, and context-based; thus, it is important to carry out more studies on the subject. Lambin and Meyfroidt[13], Wehkamp[14], and Karsenty[15] linked increased central bank rates to increased forest cover losses. Leite-Filho et al.[17] and Ávila-García, et al.[18] found no significant correlation between these two variables.

This study encourages the need to conduct more studies on this topic because forests are important strategic assets for human well-being and sustainable development[2][3][7][20][21]. Studies are needed because changing socio-economic matrices around the globe—especially due to population growth, urbanization, and agricultural expansion— exacerbate deforestation and forest cover loss, thereby affecting the actualization of sustainable forest management and the achievement of the 17 UN SDGs, as well as many global treaties and agreements that seek to promote sustainable forest management, such as the UN Decade on Ecosystem Restoration, and global commitments such as the New York Declaration on Forests and the Paris Agreement on Climate Change. Overall, this study provides insight into the potential impact of the CBRR on the forest cover percentage in Kenya. However, the weak correlation and lack of statistical significance in the regression analysis suggest that further research is required to understand the complex factors influencing forest conservation in Kenya.

6. Conclusion and Recommendations

This study contributes to the understanding of the relationship between the central bank rate and forest cover percentage in Kenya. These study findings suggest that a higher CBRR is generally associated with lower forest cover value in Kenya; however, the correlation coefficient denotes a weak relationship between the two variables. The ANOVA revealed a statistically significant difference between the means of the CBRR and forest cover groups, supporting the idea that the CBRR is likely to have an impact on forest cover percentage in Kenya, although this impact is weak and could be influenced by other factors. It is important to note that other factors not captured in the model could also affect the forest cover percentage in Kenya, and further research is needed to understand the complex interplay between these study factors.

Based on these study findings, the study recommends that policymakers in Kenya consider the potential impact of changes in the CBRR on forest cover percentage. A higher CBRR could lead to increased borrowing costs for businesses, resulting in reduced investment in activities that promote forest conservation. Therefore, it is necessary to explore alternative funding mechanisms to support forest conservation efforts in Kenya. For example, policymakers could consider creating incentives for businesses and individuals to invest in sustainable forestry and conservation projects or explore public-private partnerships to support forest conservation efforts. Furthermore, it is crucial to consider other variables that affect the percentage of forest cover in Kenya, such as climatic patterns, agricultural practices, and population growth. Addressing these complex issues requires the coordinated efforts of policymakers, researchers, and local communities. Future studies should consider these additional study factors to better understand the drivers of change in forest cover in Kenya. Future studies should investigate whether there is an intermediary variable that influenced the current observed weak relationship. Furthermore, policy suggestions should focus on exploring more significant variables to derive a strong relationship.

Finally, it is essential to note that the accuracy of predictions made using the regression line in this study could be limited, and caution should be taken when interpreting the results. As such, it is necessary to conduct further research to validate the findings and understand the study's limitations. It is necessary to gather additional data on other factors that could influence forest cover percentage and to employ more sophisticated statistical techniques to better understand the complex relationships between these study factors.

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References

[1] M. Odongo, R. N. Misati, C. Kageha, P. S. Wamalwa, Sustainable financing, climate change risks and bank stability in Kenya, KBA Centre for Research on Financial Markets and Policy Working Paper Series, (2023)
Available from: http://hdl.handle.net/10419/271532

[2] KFS Kenya Forest Service Strategic Plan 2014-2017, KFS, Nairobi Kenya, (2014)
Available from: http://www.kenyaforestservice.org/

[3] Ministry of Environment and Forestry, Taskforce Report on Forest Resources Management and Logging Activities in Kenya (April 2018)
Available from: https://dc.sourceafrica.net/documents/119054-Taskforce-Report-on-Forest-Resources-Management.html

[4] Kenya's Economic Outlook and the World Bank's supports the government's Vision 2030 development strategy, World Bank, (2022)
Available from: https://www.worldbank.org/en/country/kenya/overview

[5] J. Mantilla Contreras, D. Schüßler, S. Zerbe, Current challenges in forest restoration and sustainable forest management, Frontiers in Forests and Global Change, (2023), Vol.6, 1172760.
DOI: https://doi.org/10.3389/ffgc.2023.1172760

[6] https://www.wri.org/insights/global-tree-cover-loss-rose-51-percent-2016, Apr 25 (2023)

[7] Food and Agriculture Organization (FAO), State of the World's Forests 2020, Rome, (2020)
Available from: https://www.fao.org/3/ca8642en/ca8642en.pdf

[8] O. Ralarala, T. Ncanywa, (2020). Effects of Some Monetary Variables on Fixed Investment in Selected Sub-Saharan African Countries, Linear and Non-Linear Financial Econometrics, (2020)
DOI: https://doi.org/10.5772/intechopen.93656

[9] P. Krugman, Four observations on secular stagnation, Secular stagnation: Facts, causes and cures, pp.61-68, (2014)

[10] T. Liapun, Forest management and development of forest sector.: A case study from Ukraine, University of Oslo, Master Thesis, (2009)

[11] A. Muthaura, The Relationship Between Interest Rates and Real Estate Investments in kenya, University of Nairobi, Master Thesis, (2012)

[12] A. Angelsen, D. Kaimowitz, Introduction: the role of agricultural technologies in tropical deforestation, Agricultural technologies and tropical deforestation, Wallingford UK: CAB International, pp.1-17, (2001)
DOI: https://doi.org/10.1079/9780851994512.0001

[13] E. F. Lambin, P. Meyfroidt, Global land use change, economic globalization, and the looming land scarcity, Proceedings of the national academy of sciences, (2011), Vol.108, No.9, pp.3465-3472.
DOI: https://doi.org/10.1073/pnas.1100480108

[14] J. Wehkamp, Institutional and Fiscal Policies for Forest Conservation, Technische Universität Berlin, Doctoral dissertation, (2017)

[15] A. Karsenty, The World Bank's endeavours to reform the forest concessions' regime in Central Africa: Lessons from 25 years of efforts, International Forestry Review, (2017), Vol.19, No.4, pp.64-79.
DOI: https://doi.org/10.1505/146554817822295948

[16] J. Merganič, K. Merganičová, J. Výbošťok, P. Valent, J. Bahýľ, Impact of interest rates on forest management planning based on multi-criteria decision analysis, Central European Forestry Journal, (2022) Vol.68, No.1, pp.23-35.
DOI: https://doi.org/10.2478/forj-2021-0019

[17] A. T. Leite-Filho, B. S. Soares-Filho, J. L. Davis, G. M. Abrahão, J. Börner, Deforestation reduces rainfall and agricultural revenues in the Brazilian Amazon, Nature Communications, (2021), Vol.12, No.1, 2591.
Available from: https://www.nature.com/articles/s41467-021-22840-7

[18] D. Ávila-García, J. Morató, A. I. Pérez-Maussán, P. Santillán-Carvantes, J. Alvarado, F. A. Comín, Impacts of

alternative land-use policies on water ecosystem services in the Río Grande de Comitán-Lagos de Montebello watershed, Mexico, Ecosystem Services, (2020), Vol.45, 101179.
DOI: https://doi.org/10.1016/j.ecoser.2020.101179

[19] P. R. Furumo, E. F. Lambin,Policy sequencing to reduce tropical deforestation, Global Sustainability, (2021), Vol.4, e24.
Available from: https://www.cambridge.org/core/journals/global-sustainability/article/policy-sequencing-to-reduce-tropical-deforestation/E6DBD1514B7F500D7D5C9512152E5443

[20] FAO, The State of the World's Forests (SOFO) 2022 Report, Forest Pathways for Green Recovery and Building Inclusive, Resilient and Sustainable Economies, (2022)
Available from: https://www.fao.org/3/cb9360en/cb9360en.pdf

[21] FAO, Current Status of Forestry Sector and the Vision for the Year 2020, (2015)
Available from: http://www.fao.org/docrep/003/ab569e/AB569E04.htm

[22] Africa Development Bank, Africa Economic Outlook; Kenya Economic Outlook, Recent macroeconomic and financial developments, (2022)
Available from: https://www.afdb.org/en/countries-east-africa-kenya/kenya-economic-outlook

[23] Kenya's Economic Outlook and the World Bank's supports the government's Vision 2030 development strategy, World Bank, (2023)
Available from: https://www.worldbank.org/en/country/kenya/overview

[24] Africa Economic Outlook; Kenya Economic Outlook, Recent macroeconomic and financial developments, Africa Development Bank, (2022)
Available from: https://www.afdb.org/en/countries-east-africa-kenya/kenya-economic-outlook

[25] Statista, People living in extreme poverty in Kenya 2016-20221, by area, (2022)
Available from: https://www.statista.com/statistics/1229720/number-of-people-living-in-extreme-poverty-in-kenya-by-area/

[26] J. Macheru, Outward Foreign Direct Investments and Economic Growth: An Investigation of Kenya, International Journal of Poverty, Investment and Development, (2023), Vol.3, No.1, pp.1-11.

[27] http://www.parliament.go.ke/sites/default/files/2017-05/The_Constitution_of_Kenya_2010.pdf, Apr 16 (2023)

[28] https://eawildlife.org/resources/reports/Forests_Conservation_and_Management_Policy-2015.pdf, Mar 23 (2015)

[29] http://kenyalaw.org/kl/fileadmin/pdfdownloads/Acts/2016/No._34_of_2016.pdf, Sept 7 (2016)

[30] https://vision2030.go.ke/publication/kenya-vision-2030-popular-version/, Apr 16 (2023)

[31] http://www.parliament.go.ke/sites/default/files/2017-05/CountyGovernmentsAct_No17of2012_1.pdf, Apr 16 (2023)

[32] https://faolex.fao.org/docs/pdf/ken101360.pdf, Apr 16 (2023)

[33]https://www.ctcn.org/system/files/dossier/3b/KENYA%20AGROFORESTRY%20STRATEGY%20DRAFT%20February%202021_.pdf, Apr 16 (2023)

[34] B. G. Hansen, Selecting a tax rate for use in analyzing forest industry capital investment, Northern Journal of Applied Forestry, (1986), Vol.3, No.3, pp.101-103.
DOI: https://doi.org/10.1093/njaf/3.3.101

Appendix

Annex 1: Residual Output and Probability Output of the Regression Analysis

Residual Output **Probability output**

Observation	*Predicted Forest Cover (%)*	*Residuals*	*Standard Residuals*	*Percentile*	*Forest Cover (%)*
1	6.334893626	-0.73489	-0.7445	2.941176	5.6
2	6.45915419	-0.65915	-0.66777	8.823529	5.76
3	6.512408717	-0.51241	-0.51911	14.70588	5.77
4	6.689923809	-0.78992	-0.80025	20.58824	5.77
5	6.956196446	-0.3562	-0.36085	26.47059	5.8
6	6.618917772	-0.84892	-0.86002	32.35294	5.8
7	5.340809114	0.429191	0.434802	38.23529	5.82
8	6.530160226	-0.77016	-0.78023	44.11765	5.9
9	6.583414754	-0.48341	-0.48973	50	6
10	5.93548467	0.184515	0.186927	55.88235	6.1
11	6.210633062	-0.39063	-0.39574	61.76471	6.1
12	6.317142117	1.122858	1.137537	67.64706	6.12
13	6.441402681	-0.6414	-0.64979	73.52941	6.6
14	6.512408717	1.087591	1.101809	79.41176	7.44
15	6.814184373	-0.71418	-0.72352	85.29412	7.6
16	6.849687391	1.980313	2.006201	91.17647	8.83
17	6.743178336	2.096822	2.124233	97.05882	8.84