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RESEARCH ARTICLE

Policy Responses to Illegal Logging in Ghana: Insights from Goaso and Nkawie Forest Districts

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Abstract

Forests provide a range of essential ecosystem services, goods, and benefits to both humans and the environment. In Ghana, the forest sector is governed by numerous laws aimed at managing forest resources. Despite these regulations, political and institutional challenges hinder effective enforcement, leading to widespread illegal forest activities. These activities cause environmental degradation, financial losses, and disrupt the livelihoods of communities living near forests. Furthermore, detailed information on the types and frequencies of illegal activities in various forest reserves in Ghana is lacking. This study aimed to investigate the various illegal forest activities in the Nkawie and Goaso forest districts. Secondary data from the forest district offices, including records of confiscated timber from 2019 to 2021, reported forest offences, and actions taken, were collected and analyzed. The analysis was conducted using ANOVA and descriptive statistics, such as mean and frequency, in Microsoft Excel. Findings were presented through graphs and frequency tables, with tree species star-ratings categorized according to the system by Hawthorne and Abu-Juam. The most common illegal activities were transporting illegally sawn timber in Goaso and illegal farming in forest reserves in Nkawie. Twenty-two tree species were exploited, with Wawa, Onyina (Ceiba), Dahoma, and Mansonia being the most frequently targeted from 2019 to 2021. Among the star-rated species, those in the scarlet category (eight species) were the most exploited. Common deterrent actions included impounding timber at the district office in Goaso and reporting offenders to the police in Nkawie. The study recommends enhancing the involvement of environmental NGOs to collaborate actively with law enforcement agencies, aiming to reduce illegal forest activities through joint efforts.

Keywords: Biodiversity, Climate Change, Deforestation, Forest Degradation, Illegal Logging, Timber Exploitation.

1. Introduction

Tropical deforestation has emerged as a significant environmental challenge in recent decades, posing a major global concern due to the crucial role tropical forests play in biodiversity conservation and climate regulation *(Culas, 2007; Kanninen et al., 2007)*. Ghana is experiencing substantial deforestation and forest degradation, with deforestation rates escalating at 3% annually. This is primarily driven by illegal logging, unsustainable agricultural expansion, illicit mining, and fuel wood collection *(Gyamfi et al., 2021; Mpanga et al., 2021; Adjei et al., 2023)*. Globally, forests provide a wide array of direct and indirect ecosystem

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services, goods, and benefits. They harbor over three-quarters of the world's terrestrial biodiversity and are fundamental to ecosystem services *(Kyere-Boateng and Marek, 2021).*

In Ghana, the forest sector is regulated by a comprehensive set of laws designed to manage forest resources. However, political and institutional challenges hinder the effective enforcement of these regulations, leading to widespread illegal activities that cause environmental degradation, financial losses, and disrupt the livelihoods of communities living near forests *(Derkyi and Dietz, 2014)***.** Despite initiatives like the Forest Law Enforcement, Governance and Trade – Voluntary Partnership Agreement (FLEGT-VPA), which aims to ensure only legally sourced timber is traded with the European Union, illegal forest activities persist.

Effective forest governance relies on policies and instruments that regulate forest management to protect environmental values, particularly in an era where environmental crimes have severe impacts on ecosystems, livelihoods, and the global economy *(McDermott et al., 2010; Sander et al., 2014)***.** Ghana's forest sector is governed by numerous laws, but enforcement is weakened by political and institutional issues, leading to illegal activities that harm the environment, reduce revenue, and threaten community livelihoods *(Nutakor* ***et*** *al., 2011; Oduro et al., 2011).*

Three key issues undermine the regulatory framework in Ghana's forest sector: non-compliance with regulations, excessive regulations, and low penalties for violators *(Derkyi and Dietz, 2014).* Additionally, weak law enforcement is exacerbated by the remoteness of forested areas, inadequate road networks, and dense canopies that obscure illegal activities *(Christy, 2007).* In 2008, Ghana committed to the Non-Legally Binding Instrument on All Types of Forests (NLBI), which includes strengthening law enforcement as a key policy objective, in line with the United Nations Forestry Forum (UNFF) NLBI resolution 6(n). This resolution calls for the review and improvement of forest-related legislation, enhanced law enforcement, and good governance to support sustainable forest management and combat illegal practices.

To achieve these objectives, one strategy is to document forest offences within the NLBI monitoring and evaluation framework, establishing a baseline for tracking illegal activities and assessing the effectiveness of existing measures *(Gondo, 2015)***.** Ghana's Voluntary Partnership Agreement (VPA) with the European Union also supports this goal through the enforcement of legality assurance and compliance systems *(Hansen et al., 2018).*

However, detailed information on the types and frequencies of illegal forest activities and the most exploited species in Ghana's forest reserves is limited. This study aims to address this gap by analyzing the types, prevalence, and trends of forest offences and identifying institutional challenges in the Nkawie and Goaso forest districts. The findings are intended to support national efforts to strengthen law enforcement and inform policy considerations.

2. Materials and Methods

2.1 Study Area

The study was conducted in Goaso and Nkawie forest districts *(Figures 1 and 2)*. The Goaso Forest District (GFD) is largely in the Asunafo District, with a smaller piece in the Asutifi District. As shown in the map *(Figure 1),* eight forest reserves make up the forest district. These are; Bia Shelterbelt, Bia-Tano, Goa Shelterbelt, Bonkoni, Subim, Ayum, Bonsambepo and Aboniyere. Because of the comparatively greater quality of the soil in this district, it is well known for its enormous amounts of cocoa and food crops such as plantain, cassava, maize, and vegetables.

The Nkawie Forest District (NFD) is one of the several forest districts in Ghana under the jurisdiction of the Forest Services Division of the Forestry Commission. The Forest District headquarters is at Nkawie, which as well serves as the municipal capital of the Atwima Nwabiagya administrative district in the Ashanti Region. The Nkawie Forest District, has six forest reserves covering a total area of 1,019.72 km2. These are Asenayo, Desiri, Jimira, Offin Shelter, Tano-Offin, and Tinte Bepo forest reserves *(Figure 2)*.

2.2 Data Collection and Analysis

2.2.1 Data Type for the Study

Secondary data was gathered from the two study forest district offices of the Forestry Services Division of the Forestry Commission of Ghana.

2.2.2 Sample Size and Sampling Technique

The research aimed to identify incidents of forest offences in the selected districts, determine the tree species exploited by offenders along with their species guild and star-ratings, and evaluate the actions taken to address these offences. Purposive sampling was employed to select the two forest districts due to the availability of data and the cost-effective accessibility to these districts.

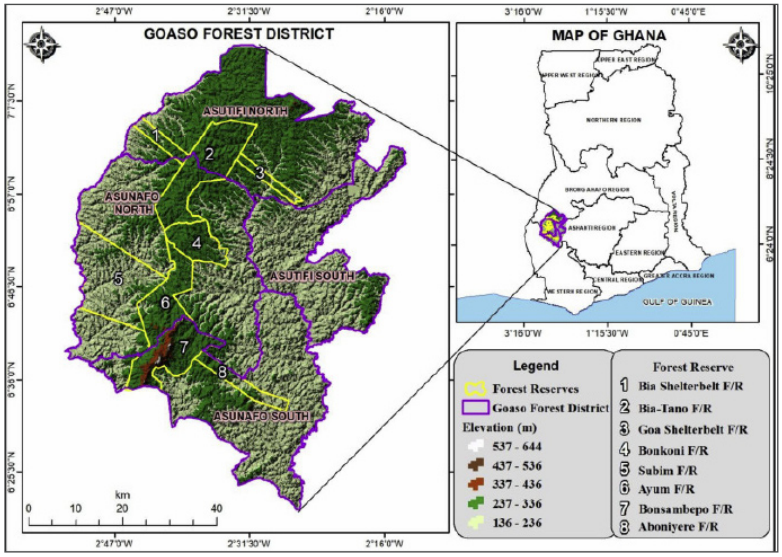

Figure 1. *Map of Goaso Forest District*

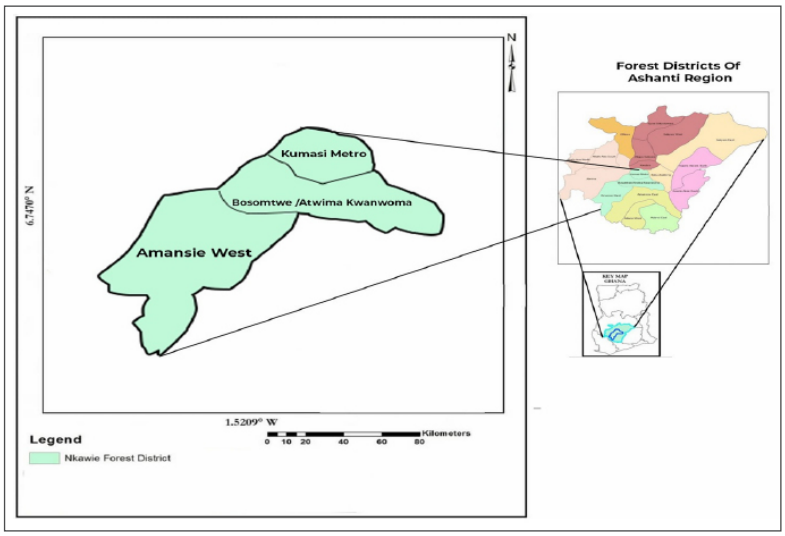

Figure 2. *Map of Nkawie Forest District*

2.2.3 Data collection

The data were collected in two stages: the planning and preparatory phase and the data collection phase. The planning and preparing phase included a review of the literature as well as consultations with Forestry Commission personnel. Secondary data was collected in the two forest district offices of the Forestry Services Division of the Forestry Commission of Ghana. The information collected in their offences files included:

i) the confiscated timber in each district from 2019 to 2021 and the reported cases of the different forest offences found in these offences' files. In these files, the information picked was the quantity of timber (in terms of pieces of lumber, beams, boards, billets, etc.) by timber species for the months within the target years of 2019, 2020, 2021;

ii) reported cases of various forest offences in the days and months in these years, and

iii) corresponding actions taken by the forestry officials to deal with these offences. These years were chosen because of the availability of the required data.

2.2.4 Data Analysis

This study employed quantitative data analysis using Excel, presenting results in graphs and frequency tables. The main objective was to investigate illegal forest activities in the Nkawie and Goaso forest districts, which was divided into three specific objectives. Descriptive statistics and frequency tables were used to report incidents of forest offenses in both districts. In determining exploited tree species, graphs were used to illustrate the species exploited. One-way ANOVA was conducted to analyze timber quantities exploited from 2019-2021 to identify significant differences. The species guild and star-ratings were presented in a table based on *Hawthorne and Abu-Juam (1995)*. In evaluating measures taken to address

offenses, a table was used to tally forest offenses and the corresponding actions taken in each district.

3. Results

3.1 Incidents of Forest Offences Reported in Nkawie and Goaso Study Forest Districts

Table 1 provides a detailed breakdown of offenses recorded in the Nkawie and Goaso forest districts, along with their frequencies and percentages of the total offenses. In the Nkawie District, the most prevalent offenses are illegal farming and illegal felling and sawing of trees, with both offenses recorded 7 and 6 times respectively, each accounting for 12.9% of the total offenses. Illegal felling of trees occurred 4 times (8.06%), followed by a variety of other offenses occurring once each (1.61%). In the Goaso District, the most frequent offense is the conveying of illegally sawn lumber with dimensions 2/6/14 of assorted species, recorded 9 times (14.52%). This is followed by the conveying of pieces of Wawa boards (6 times, 9.68%) and various dimensions of species being evacuated (5 times, 8.06%). Illegal felling and sawing of trees occurred twice (3.23%), while the remaining offenses were recorded once each (1.61%). Overall, the combined data from both districts shows the conveying of illegally sawn lumber with dimensions 2/6/14 of assorted species as the most frequent offense (9 times, 14.52%), followed by illegal farming and illegal felling and sawing of trees (both 8 times, 12.9%). Other notable offenses include the conveying of pieces of Wawa boards (6 times, 9.68%) and illegal felling of trees (5 times, 8.06%).

Table 1. *Incidents of forest offences reported in Nkawie and Goaso District, 2019-2021*

Offences	Nkawie District	Goaso District	Total	Total
	Freq.	Freq.	Freq.	(%)
Illegal felling of trees	4	1	5	8.06
Tractor intercepted	0	1	1	1.61
Assault on YEA beneficiary	0	1	1	1.61
Conveying illegally sawn lumber with dimensions; 1/12/14 of assorted species	0	2	2	3.23
Conveying illegally sawn lumber with dimensions; 2/6/14 of assorted species	0	9	9	14.52
Conveying illegally sawn lumber with dimensions; 4/12/8 of assorted species	0	4	4	6.45
Conveying pieces of Wawa boards	0	6	6	9.68
Illegal clearing of land	0	1	1	1.61
Illegal farming	7	1	8	12.9
Illegal felling and hauling of restricted species in compartment 11	0	1	1	1.61
Illegal felling and sawing of trees	6	2	8	12.9
Illegal felling of trees and trespass in compartment 23	1	0	1	1.61
Illegal felling of trees in compartment 11	0	1	1	1.61
Illegal mining	1	0	1	1.61
Illegal sawing of trees in a compartment	0	1	1	1.61
Illegal spraying of weedicide on teak seedlings in 2019 plantation coup	1	0	1	1.61
Squatting of Fulani herdsmen and their cattle destroyed planted teak seedlings in 2019	1	1	1	1.61
Tractors illegally entered the forest	0	1	1	1.61
Tree felled and sawn	1	0	1	1.61
Trees felled, sawn, and evacuated near FRBP2 of Dome River	1	0	1	1.61
Tricycle laden with chainsaw lumber	1	0	1	1.61
Various dimensions of species were evacuated	0	5	5	8.06
Wildfire	1	0	1	1.61

3.2 Tree Species Exploited by Forest Offenders in the Nkwaie Forest District (2019 - 2021)

Figure 3 illustrates the exploitation of timber species in the Nkwaie Forest District over the years 2019, 2020, and 2021. Throughout these three years, a total of 16 different tree species were exploited. Notably, nine species were consistently targeted each year, including Ofram, Emire, Onyina, Otie, Cebrella, Watapuo, and Nyamedua. In 2019 and 2020, Onyina was the most exploited species. However, in 2021, its exploitation rate decreased, making Ofram the most

exploited species for that year, with Onyina falling to second place. Conversely, the exploitation rate of Wawa showed a consistent increase over the three-year period. Among all species, Emire and Cebrella were also significantly exploited, following Onyina in terms of overall exploitation during the study period. On the other hand, Konkroma and Hyedua were the least exploited species across the three years.

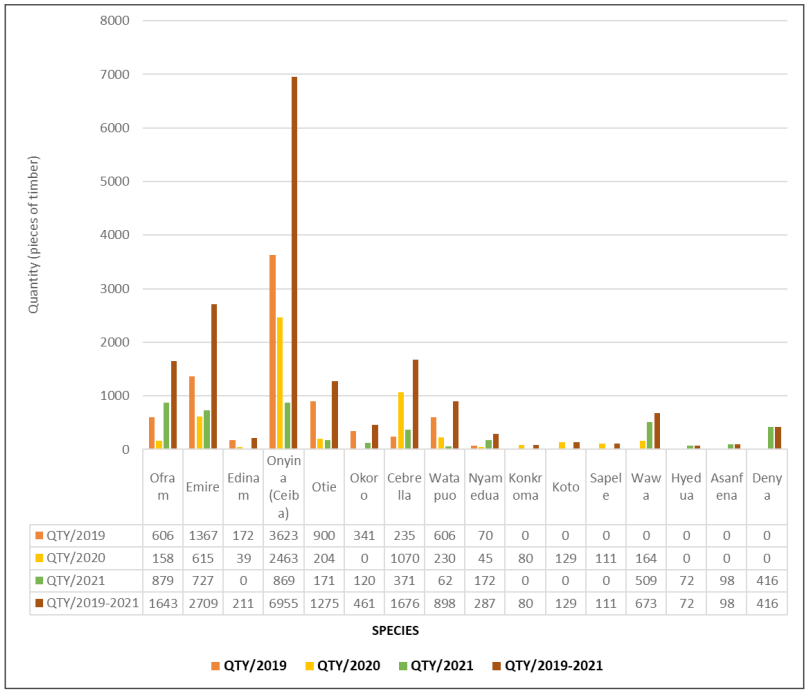

Figure 3. *Timber Species Exploited From Nkawie forest District, 2019-2021 (Source: Author's construct)*

From *Table 2,* the p-value is greater than the chosen alpha of 0.05, it means that there is no statistically significant difference in the quantity of timber species exploited between the years 2019, 2020, and 2021. The variation in quantities of exploited timber species can therefore be attributed to random fluctuations rather than systematic differences between the years.

Table 2. *Comparison of Mean Quantities of Exploited Timber Species Across Years (2019, 2020, 2021) in Nkawie Forest District*

SUMMARY						
Groups	**Count**	**Sum**	**Average**	**Variance**		
2019	16	7920	495	854992		
2020	16	5308	331.75	400923.3		
2021	16	4466	279.13	98092.92		
ANOVA						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F crit**
Between Groups	405450.5	2	202725.25	0.45	0.64	3.21
Within Groups	20310122.75	45	451336.06			
Total	20715573.25	47				

Source: *Author's construct*

Figure 4 provides insight into the exploitation of various tree species in the Goaso forest district over the years 2019, 2020, and 2021. Throughout this period, a total of 13 different tree species were exploited. Among these species, Wawa, Mansonia, and Dahoma were consistently exploited each year. However, their rates of exploitation fluctuated over the study period. Wawa was the most exploited species in 2019 and 2020, but its exploitation decreased in 2021, falling behind Mansonia and Dahoma. Papao and Nyamedua, on the other hand, saw exploitation only in 2019, with no recorded exploitation in 2020 and 2021. Over the three-year period, Wawa emerged as the most exploited species, followed by Mansonia and Dahoma. In contrast, Papao was the least exploited species. Interestingly, Onyina, despite being exploited only in 2020, ranked as the fourth most exploited species over the three years, indicating a significant level of exploitation during that single year compared to the other species

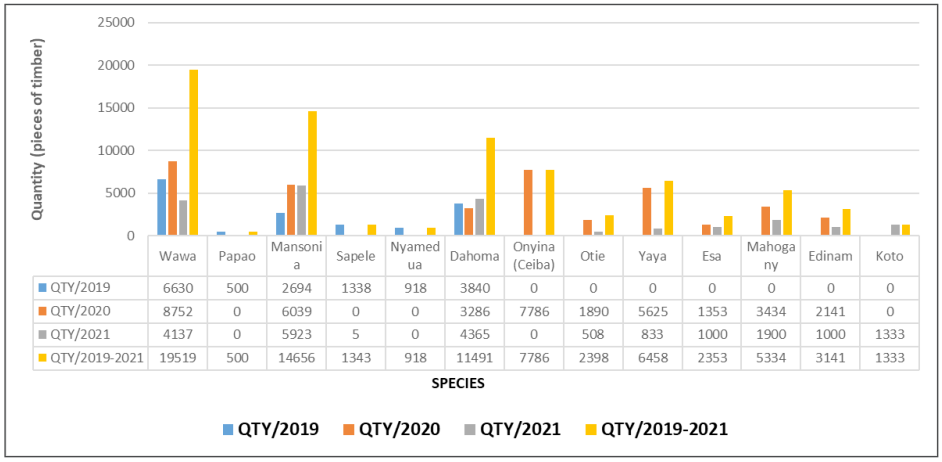

Figure 4. *Timber Species Exploited From Goaso, 2019-2021*

According to Table 3, the p-value is 0.13, which is greater than the significance level of 0.05. This indicates that the study does not have sufficient evidence to conclude that there are significant differences in the quantities harvested between the years.

Table 3. *Analysis of Variance (ANOVA) for the Comparison of Mean Quantities of Exploited Timber Species Across Years (2019, 2020, 2021) in Goaso Forest District*

SUMMARY						
Groups	**Count**	**Sum**	**Average**	**Variance**		
2019	13	15920	1224.62	4112269		
2020	13	40306	3100.46	9411582		
2021	13	21004	1615.7	3804399		
ANOVA						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F crit**
Between Groups	25463878.36	2	12731939.18	2.2	0.13	3.26
Within Groups	207939001.1	36	5776083.36			
Total	233402879.4	38				

Source: *Author's construct*

Table 4 offers insight into the exploitation of various tree species in the Nkawie and Goaso forest districts. Wawa stands out as the most heavily exploited species, with a combined total of 20,202 pieces, predominantly from Goaso (19,529 pieces) compared to Nkawie (673 pieces). Onyina (Ceiba) is the second most exploited species with a total of 14,741 pieces, with Goaso contributing slightly more (7,786 pieces) than Nkawie (6,955 pieces). Mansonia and Dahoma are significant in Goaso, with 14,656 and 11,491 pieces harvested respectively. In contrast, these species were not exploited in Nkawie. Several species, including Yaya (6,458 pieces), Mahogany (5,334 pieces), and Esa (2,353 pieces), were exclusively harvested in Goaso. Nkawie has notable exploitation of Emire (2,709 pieces), Cebrella (1,676 pieces), Ofram (1,643 pieces), Watapuo (898 pieces), and several other species in smaller quantities, which were not harvested in Goaso. Otie, Edinam, Koto, Sapele, and Nyamedua were exploited in both districts, with higher quantities generally harvested in Goaso.

Table 4. *Timber Species Exploited in Nkawie and Goaso forest districts from 2019-2021*

	QUANTITY		Total
	Nkawie	**Goaso**	
Wawa	673	19529	20202
Onyina (Ceiba)	6955	7786	14741
Mansonia	0	14656	14656
Dahoma	0	11491	11491
Yaya	0	6458	6458
Mahogany	0	5334	5334

Otie	1275	2398	3673
Edinam	211	3141	3352
Emire	2709	0	2709
Esa	0	2353	2353
Cebrella	1676	0	1676
Ofram	1643	0	1643
Koto	129	1333	1462
Sapele	111	1343	1454
Nyamedua	287	918	1205
Watapuo	898	0	898
Papao	0	500	500
Okoro	461	0	461
Denya	416	0	416
Asanfena	98	0	98
Konkroma	80	0	80
Hyedua	72	0	72

Source: *Authour's construct*

3.3 Species Guild and Star-Ratings

Table 5 shows that seeds of non-pioneer light demanders (NPLD) species germinate in forest shade and respond to growth when exposed to light. Pioneer species have varying levels of sunshine requirements throughout their life histories. Their seedlings are rarely detected beneath the canopy and only appear when an opening has been created. They do not regenerate in-situ under shade. Shade-bearing plants' seeds can sprout in the shade, but they are unlikely to germinate in direct sunshine. There were nine NPLD species, which included Edinam, Otie, and Okoro. The pioneer species were ten, including Ofram, Emire, and Onyina. There were three shade bearer species: Esa, Hyedua, and Denya. The categorization of tree species by star rating was based on *Hawthorne and Abu-Juam (1995)*. The star ranking highlights timber species' conservation priorities. In Ghana, green represents no threat of extinction; pink represents significant exploitation but no threats to their economic future; red indicates that current rates of exploitation pose a significant risk of economic extinction; blue are widespread internationally but rare in Ghana; and scarlet indicate an imminent threat of economic extinction. Among the 4 Green star rating exploited species were Okoro and Cedrella; among the 3 exploited Pink star rating species are Watapuo and Esa; among the 7 red star rating exploited species are Ofram, Onyina and Otie; among the 8 scarlet star rating exploited species were Emire, Edinam and Wawa; Blue star rating species had no exploitation.

Table 5. *Exploited tree species from Nkawie and Goaso forest districts, species guild and star-rating, 2019-2021*

Species Trade/Local Name	Species Guild	Star-Rating
Ofram	Pioneer	Red
Emire	Pioneer	Scarlet
Edinam	NPLD	Scarlet
Onyina (Ceiba)	Pioneer	Red
Otie	NPLD	Red
Okoro	NPLD	Green
Cedrela	Pioneer	Green
Watapuo	Pioneer	Pink
Nyamedua	Pioneer	Green
Wawa	Pioneer	Scarlet
Papao	Pioneer	Red
Mansonia	Pioneer	Red
Sapele	NPLD	Scarlet
Dahoma	NPLD	Red
Konkroma	Pioneer	Green
Koto	NPLD	Scarlet

Yaya	NPLD	Red
Mahogany	NPLD	Scarlet
Esa	Shade bearer	Pink
Asanfena	NPLD	Scarlet
Hyedua	Shade bearer	Scarlet
Denya	Shade bearer	Pink

Source: *Author's construct*

3.4 Action taken by authorities in response to the offences

From Table 6, ten (10) different actions were taken in Nkawie forest district. Reported to the police is the action with the highest frequency in 2019 (N= 4) and 2020 (N=4) accumulating to (N=8) from 2019 to 2021. Among the least actions with single frequency of happening in the district were suspects fined and suspect for planned farm destruction. In 2020, 5 different actions were taken where suspects fined and suspects arraigned before court were among the ones with least frequency of one (1). Though Nkawie forest district reported of illegal occurrences in 2021, there was no data on actions taken within that year. Over all, suspects arraigned before court followed reported to police in highest frequency while suspect for planned farm destruction was among the ones with least frequency.

Table 6: *Frequency of Actions Taken to Address Offences in the Nkawie Forest District from 2019 to 2021*

Actions taken in Nkawie	2019 Freq.	2020 Freq.	2021 Freq.	2019-2021 Freq.
Tricycle impounded and rider to help in investigations	2	0	0	2
Suspects fined	1	1	0	2
Suspects arraigned before court	2	1	0	3
Suspect for planned farm destruction	1	0	0	1
Suspect fined 10 times the value of product removed	1	0	0	1
Reported to the police and the suspect arrested	0	2	0	2
Reported to police	4	4	0	8
Reported to police and 153 Ofram conveyed to district office	0	1	0	1
Perpetuators confiscated at district office	1	0	0	1
Intensified surveillance	1	0	0	1
Forest guard cautioned	1	0	0	1
Culprits were fined and excavator confiscated to the state	1	0	0	1

Source: *Author's construct*

From *Table 7*, the Goaso frorest district recorded no action on forest offenders in 2019, only one (1) action in 2020 but 11 different actions in 2021. Lumber impounded at the district office was the only action taken in 2020 which also was the action with the second highest frequency in 2021 after impounded at the district office (illegally sawn lumber of assorted species). In 2021, actions taken which had single frequency included suspects arraigned before Goaso circuit court and culprits arrested and arraigned before Goaso circuit court. Over all, impounded at the district office had the highest frequency, while arrested and are in police custody and arrested and brought to police station were among the ones with least frequency.

Table 7. *Frequency of Actions Taken to Address Offences in the Goaso Forest District from 2019 to 2021*

Actions taken in Goaso	2019 Freq.	2020 Freq.	2021 Freq.	2019-2021 Freq.
Suspects arrested	0	0	2	2
Suspects arraigned before Goaso circuit court	0	0	1	1
Monitoring team managed and brought the tractors to the district office	0	0	2	2
Lumber impounded at the district office	0	3	4	7
Impounded at the district office (illegally sawn lumber of assorted species)	0	0	19	19
Culprits arrested and arraigned before Goaso circuit court	0	0	1	1

Arrested, police visited scene, culprits granted bail	0	0	1	1
Arrested and brought to police station	0	0	2	2
Arrested and arraigned before court	0	0	1	1
Arrested and arraigned before Goaso circuit court	0	0	1	1
Arrested and are in Police custody at Goaso police station	0	0	1	1

4. Discussion

4.1 Incidents of Forest Offences in Nkawie and Goaso Forest Districts, 2019-2021

Forests constitute 31% of the Earth's land area and are crucial for the livelihoods of over a billion people globally, as well as being a significant source of tax revenue for many states *(Lundgren & Morrison-Metois, 2016)***.** However, forest crimes, such as illegal logging and farming, pose serious threats to these resources. The current study's findings that illegal farming, logging, chainsaw lumbering, and illicit mining are prevalent align with earlier research by *Derkyi and Dietz (2014).*

This study recorded 62 forest offences in the Goaso and Nkawie Forest Districts from 2019 to 2021, with a higher incidence in on-reserve areas compared to off-reserve areas. This contrasts with findings by *Abugre and Kazaare (2010),* who reported more offences outside forest reserves. However, the current results are consistent with *Derkyi and Dietz (2014),* who also found higher illegal activity in on-reserve areas in the Nkawie District. These differences may be due to the varying locations and specific needs of local inhabitants, as well as the accessibility of on-reserve versus off-reserve forests. Illegal logging is particularly concerning as it not only depletes forest resources but also contributes to the extinction of wildlife species and exacerbates climate change by releasing stored carbon as greenhouse gases. In this study, illegal felling and sawing of trees accounted for approximately 13% of total offences in the Goaso and Nkawie districts. The removal of trees can lead to soil erosion, as the replacement agricultural crops, such as cotton, wheat, coffee, palm oil, and soybean, do not hold the soil as effectively, perpetuating a cycle of soil degradation and further deforestation.

Despite threats and intimidation, some local communities remain motivated to combat illegal activities. Local engagement in environmental conservation is often driven by the belief that they are best equipped to address their environmental challenges *(Goodwin, 1998; Savan et al., 2003)***.** Enforcement plays a crucial role in deterring unlawful practices, but it is particularly challenging in developing countries where forestry sector violations are common. *Boakye (2020)* notes that the enforcement of logging regulations in Ghana is weak, with the Forestry Commission struggling to catch violators and impose effective sanctions. This weak enforcement is compounded by the lack of essential state law enforcement agencies in rural areas *(Marfo et al., 2006).* Additionally, the reluctance to report illegal activities may be due to the involvement of higher authorities in these crimes and a lack of trust in the monitoring network. This issue is mirrored in a rural Australian study, which found that land managers were less likely to report noncompliance with weed control if they did not trust the authorities *(Graham, 2014)***.** The inadequate record-keeping and documentation further hinder the management of natural resources. *Oso et al. (2017)* emphasize that the lack of data on forest violations hampers sustainable forest management in Nigeria. *Contreras (2005)* advocates for accurate and up-to-date information as essential for the prevention, detection, monitoring, and suppression of forest crimes.

4.2 Tree Species Exploited by Forest Offenders: Species Guild and Star-Rating Analysis

In response to overexploitation, the export of 14 major tree species was banned in 1979, with an additional four species added to the list in 1987. This prohibition led to increased use of secondary species *(Friar, 1987)***.** The rising demand for wood products, coupled with a shortage of legally sourced timber, has contributed to the heightened exploitation of timber. Most of the species targeted by illegal loggers have significant market value. The economically valuable tree species that were least exploited are now nearly extinct, with low relative abundance in both reserves and non-reserve forests. Among the findings, *Triplochiton scleroxylon* (Wawa) emerged as the most illegally felled tree species. This species, classified as scarlet star-rated, is under imminent economic threat. Other frequently targeted species include *Ceiba pentandra* (Onyina) and Mansonia. Conversely, less targeted species include Hyedua, also scarlet star-rated, and Konkroma, which has a green star rating, indicating lower economic value.

Species guilds and star-rating categorizations are essential for determining ecological and conservation

measures as well as the economic values of timber species. Illegal logging complicates natural regeneration and may lead to species extinction, particularly for shade-bearers like Esa, Hyedua, and Denya, which were minimally exploited. Illegal logging not only causes biodiversity loss *(Curan et al., 2004***)** but also poses a significant threat to global forest cover. In Ghana, illegal logging threatens the country's forest resources, especially targeting the most valuable species within the permanent forest estate *(Hansen and Treue, 2008).* Scarlet star-rated species, which are in imminent danger of extinction in Ghana, require protection from illegal felling and processing. Despite this, these species, such as Wawa, remain the most exploited. Studies in Sunyani, Bechem, Goaso, and Nkawie Forest Districts have confirmed that *Triplochiton scleroxylon* (Wawa) is the most illegally exploited species *(Abugre & Kazaare, 2010; Derkyi & Dietz, 2014)***.** According to *ITTO (2006),* the most commercially significant wood species with scarlet ratings have been overharvested at rates exceeding 200% of the sustainable yield, threatening their extinction.

Twenty-two tree species were identified as being exploited, with star ratings distributed as follows: eight scarlets, seven red, three pink, and four green. No blue star-rated species were recorded, likely due to their rarity in Ghana's forest reserves. Blue star-rated species are more common internationally but rare in Ghana *(Hawthorne and Abu-Juam, 1995)***.** This finding aligns with previous studies *(Akoto et al., 2015)* which found no blue star-rated species in mixed plantations within the Anwhiaso North Forest Reserve, except in natural forests. Despite the star-rating system's lack of revision for over two decades, an official from the Forestry Commission indicated that the Commission internally adjusts the star ratings of species based on economic value, availability, or extinction risk during tree sales to timber firms *(Derkyi, 2012)***.** This practice highlights the need for an updated and standardized star-rating system to better reflect current conservation and economic realities.

4.3 Measures Taken to Address Forest Offences in Each District

To promote sustainable forest management, several policies are being implemented. These policies aim to support the production of wood and wood-derived products from existing forest reserves and off-reserve regions. The 1994 Forest and Wildlife Policy laid the foundation for sustainable forest resource management, implemented under the Timber Resources Management Act (Act 547) of 1997, the primary legislation governing forest resource use *(Anonymous, 2003)*. The Forestry Commission, responsible for forest management and the forest industry, allocates Concessions through Timber Utilization Contracts. The Forestry Services Division sets the total annual allowable cut for timber within the country *(SGS, 2002)***.** The recent Ghana Forest and Wildlife Policy *(Anonymous, 2012)* highlighted a significant biodiversity loss, noting that about 10 prime indigenous species, including *Milicia excelsa* and *Khaya spp*., may become extinct within a decade. Before the 1980s, the government primarily managed forests, employing highly skilled professionals *(Contreras-Hermosilla, 2011)***.** However, due to policy failures leading to deforestation and forest degradation, especially in developing countries, this hierarchical model lost favor *(Ahenkan and Boon, 2010; Agyarko, 2001).* Since the 1980s, there has been a shift toward interactive multi-actor forest governance *(Contreras-Hermosilla***,** *2011).*

Active participation from local leaders and communities is essential to deter illegal logging. Despite efforts to curb it, illegal logging remains prevalent. According to Act 547 (amended 617), LI.1649, and NRCD (amended 642), accessing, processing, and transporting forest resources without a permit is illegal. The International Criminal Police Organization defines forestry crime as encompassing illegal activities throughout the forestry supply chain, including document fraud, corruption, and money laundering. Illegal logging not only harms biodiversity but also endangers the lives of those who depend on forests. Criminal land clearing can cause landslides and deny forest-dependent communities access to food, medicine, and fuel. Therefore, understanding strategies to mitigate forest crimes and their implications is crucial. The Forest Service Division (FSD) resolves many cases by levying penalties and releasing the vehicles involved. For unlawful farming offences within forest reserves, illegal farms are often destroyed, and offenders may be dealt with by the police, regional or district FSD officials, or through fines and charges. *Boakye (2020)* identifies two main reasons for weak deterrence by state regulators: limited resources reduce proactive detection capacity, and political, sociocultural, and administrative interferences, along with corruption, hinder the imposition of severe fines. Empirical studies in Ghana also point to weak enforcement as a critical factor in persistent logging violations *(Marfo, 2010; Hansen, 2011; Boakye, 2015).*

Derkyi (2012) examined how the Forestry Commission enforces regulations, noting that low detection rates are due to inadequate proactive capacity. Additionally, discrepancies in record-keeping and undisclosed outcomes of offences complicate the evaluation of enforcement effectiveness. Building the capacity of Forestry Commission officials, including field officers and those with university training, is essential *(Derkyi, 2012)*. Combating forest crimes requires a combination of strategies reported by Forestry Commission officials, including governance initiatives like FLEGT-VPA and REDD+, monitoring taskforces, routine operational checks, and the use of drones for remote detection. Other studies support these mechanisms, advocating for accurate and current information on forest violations, streamlined forest policies, and the elimination of policies that incentivize illegal activities *(Contreras-Hermosilla, 1997; Contreras-Hermosilla, 2005; Azizan et al., 2017)*. Effective enforcement should focus on the discovery, prevention, and repression of illegal behavior.

5. Conclusion

This study emphasizes the integration of science and policy to achieve sustainable forest management, which is crucial for attaining Sustainable Development Goals (SDGs). It provides insights for restoring fragile forest zones and informs policy frameworks at various levels. The primary objective was to investigate illegal forest activities in the Nkawie and Goaso forest districts. Descriptive statistics revealed frequent offences such as transporting improperly sawn lumber, illegal farming, tree felling, and sawing. To improve regulation, the Forestry Commission of Ghana needs to enhance training and logistics for frontline staff for better resource monitoring and data management. Between 2019 and 2021, significant exploitation of economically valuable scarlet timber species was noted, causing environmental harm and revenue loss. Twenty-two tree species were exploited, classified by star ratings (scarlet, red, pink, and green), with higher exploitation rates for valuable species. Actions taken included reporting to police and impounding timber, but gaps were found in recording criminal case outcomes. The study recommends:

- Investing in logistics, technology, and human resources by the Forestry Commission to improve monitoring and collaborating with forest communities.
- Developing a robust information management system for accurate forest crime data.
- Supporting forest-based organizations and involving environmental NGOs to reduce illegal logging, with stronger judicial penalties for offenders.
- Reviewing and updating the star-rating categorizations to reflect current trends.

Author contributions

Isaac Adu Poku, Lawrence Damnyag, Adjei Eric, Enock Mensah Frimpong, Alexander Danson-Anokye, and Amankwaah Frederick conceptualized the research. Isaac Adu Poku, Adjei Eric, Enock Mensah Frimpong, Alexander Danson-Anokye and Amankwaah Frederick designed the methodology. Formal data analysis was done by Isaac Adu Poku, Adjei Eric, and Enock Mensah Frimpong. They also managed resources and data curation. Isaac Adu Poku and Adjei Eric drafted the manuscript, which all authors reviewed and edited. Visualization was done by Isaac Adu Poku, Adjei Eric, and Enock Mensah Frimpong, while Lawrence Damnyag supervised the research.

Conflict of Interest

All authors approved the manuscript and declared no conflicts of interest.

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Data Availability

Data is available upon formal written request to the corresponding author.

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