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Review

Analysis of the Social-Ecological Causes of Deforestation and Forest Degradation in Ghana: Application of the DPSIR Framework

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Abstract: Globally, forests provide several functions and services to support humans' well-being and the mitigation of greenhouse gases (GHGs). The services that forests provide enable the forest-dependent people and communities to meet their livelihood needs and well-being. Nevertheless, the world's forests face a twin environmental problem of deforestation and forest degradation (D&FD), resulting in ubiquitous depletion of forest biodiversity and ecosystem services and eventual loss of forest cover. Ghana, like any tropical forest developing country, is not immune to these human-caused D&FD. This paper reviews Ghana's D&FD driven by a plethora of pressures, despite many forest policies and interventions to ensure sustainable management and forest use. The review is important as Ghana is experiencing an annual D&FD rate of 2%, equivalent to 135,000 hectares loss of forest cover. Although some studies have focused on the causes of D&FD on Ghana' forests, they failed to show the chain of causal links of drivers that cause D&FD. This review fills the knowledge and practice gap by adopting the Driver-Pressures-State-Impacts-Responses (DPSIR) analytical framework to analyse the literature-based sources of causes D&FD in Ghana. Specifically, the analysis identified agriculture expansion, cocoa farming expansion, illegal logging, illegal mining, population growth and policy failures and lapses as the key drivers of Ghana's D&FD. The study uses the DPSIR analytical framework to show the chain of causal links that lead to the country's D&FD and highlights the numerous interventions required to reverse and halt the ubiquitous perpetual trend of D&FD in Ghana. Similar tropical forest countries experiencing D&FD will find the review most useful to curtail the menace.

Keywords: social-ecological; Ghana; high forest zones (HFZs); deforestation & forest degradation (D&FD); DPSIR framework

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1. Introduction

The world's forests biodiversity and ecosystem services face alarming depletion and loss due to deforestation and forest degradation (D&FD) [1,2]. The D&FD has become a twin global environmental problem that humanity is battling with no apparent solutions in sight. While it is accepted that D&FD is ubiquitous, it is regrettably evident that it is much more widespread in developing countries within the tropical regions where forests serve as a means of livelihoods and well-being. Deforestation, forest degradation, and other global environmental change issues have caught the global leaders' attention, wherein several fora and conferences have been discussed and debated to find lasting approaches to address them. These discussions and debates on finding the appropriate measures and approaches to addressing D&FD have resulted in several global conventions, protocols, and interventions to achieve sustainable forest management [3–5]. For instance, the recent

global intervention of reducing deforestation and forest degradation, forest conservation, and carbon stocks enhancement (REDD+) is currently in operation in many developing tropical countries worldwide [6]. The Food and Agricultural Organization (FAO) refers to deforestation as involving converting forests into other land uses over the long-term, reducing tree canopy cover below the 10 percent minimum threshold [7]. Equally, forest degradation involves changes occurring within the forest, affecting forest structures and functions and its capacity to provide services, benefits, and goods [7]. The UNFCCC describes deforestation as human-caused activities that render forestlands non-forested [6]. From the above definitions, deforestation signifies forest cover loss due to anthropogenic or human actions and activities. In contrast, forest degradation denotes human-caused activities or actions that render forests' potentials and capacity to be low-quality, incapable of producing common goods and services.

Globally, forests provide a significant number of direct and indirect ecosystem services, goods, and benefits to humankind and the environment. Forests contain over three-quarters of the global terrestrial biodiversity [8], which serve as a critical bedrock for ecosystem services [9]. Forests constitute the primary sources of food, timber, fiber, fuelwood, and medicines to over a billion people [8] and intangible services for regulating climate, water and soil conservation [10]. Simultaneously, the forest can sequester carbon, act as a habitat for biodiversity, and serve tourism and recreational purposes [11] and flood regulation, disease regulation, water purification, and shelter and habitat for billions of flora fauna species [12]. Other supporting services help in soil nutrient cycling, soil formation, and photosynthesis for primary production [9,12–16]. Forests are expected to provide livelihoods and food security to the world's rural poor, out of which about 250 million of them are described as extremely rural poor who dwell in forests and savannah areas, especially in the tropical regions [8]. Forest role in carbon cycle processes, mainly [17,18], has caught global attention as a powerful avenue to mitigate global carbon emissions [10].

These notwithstanding, the world's forest is depleting alarmingly [1] as Global Forest Resources Assessment (FRA), an affiliate to FAO, discovered that the world's forest area reduced significantly by 31.6% to 30.6% between 1990 and 2015. However, the pace of forest cover loss has been declining [8]. Global deforestation has increased since the 1990s leading to some 420 million hectares of forestland conversion into other land uses [19]. The global deforestation rate was expected to reach 10 million hectares per year between 2015 to 2020, lower than the 1990s rate of 16 million hectares per year, although the global primary forest has declined by over 80 million hectares since 1990 [19]. Globally, the causes of D&FD are varied and diverse with the local, country, and regional specifics. Deforestation is due to anthropogenic and natural factors, including pests and diseases infestation, forest fires, invasive species, droughts, and extreme weather conditions and events claiming over 100 million hectares of forests [19]. Deforestation and forest degradation pose significant threats to tropical forests [20]. Deforestation and forest degradation also occur in some countries in Europe, although it is one region with the least degraded land areas [19]. For example, illegal logging drives D&FD in Ukraine [15]. Europe's forest area saw expansion at 70,000 ha annually, though at slower rates of 900,000 ha per year during the 1990s [7]. Thus, while some countries in Europe are experiencing forest degradation, the deforestation and forest degradation rate may not be as high as in the tropical regions for several reasons. In Europe, forest lands cannot be used for agriculture production through shifting cultivation practices as in most tropical forest countries. The practice of land-intensive, the use of modern farm tools and fertilizers are mostly used to increase agricultural production on the same farmlands in seasons within the year because it is the only region in the world with the highest proportion of forest area (96%) with long-term management plans [19]. However, forests in European countries suffer from insect pests and pathogens that destroy large forest areas; for instance, *Noediprion sertifer* destroy Belarus, Georgia, Latvia, Norway, Turkey, and Ukraine European pine [7]. This notwithstanding, Europe is the only region with the least percentage (<5%) of forest area in protected areas [7]. Diseases, insect pests, and fires are the key drivers of forest cover lost in most of Europe's forests [7].

Although tropical forests constitute only 12% of the global land area, they are responsible for providing 40% of the global net primary production (NPP) with a global biomass carbon of 25% [21]. Despite the crucial social and ecological contributions that tropical forests provide, they face substantial threats and dangers of D&FD, loss of flora and fauna species due to rising global population, urbanization, unsustainable agricultural expansion, illegal and legal logging, mining, fires, and changes in climate [18]. Hence, D&FD's pervasive ecological and social issues will require applying social-ecological networks that link the community-led approach to managing natural resources such as forests [22].

Ghana's forest governance has revolved around several policies, laws, and regulations. Until the state-led forest governance and management in Ghana, forestlands were under the customary law administration. During those periods, chiefs were the key custodians of the forestlands under their respective jurisdiction held on behalf and in trust of people who had the user rights [1,19]. The chiefs ensured the conservation and preservation of forests biodiversity and ecosystem services through the traditional system and indigenous knowledge [23]. In 1927 the British colonial administration, through the "Forest Ordinance 1927", converted some stool lands under the care of the traditional chiefs into "forest reserve" under the control of the colonial authority to save the forests from excessive exploitation of timber resources [1]. Later, the state enacted major forest polices and key legislations to ensure proper conservation and forest resources preservation. Notable among them include the 1948 Forest Policy, which had the key objectives of protecting forests, creating permanent forest estates, and protecting the environment to maintain ecological balance [24]. Then, the 1951 Forests Ordinance was promulgated to protect forests, including the forest reserves [24]. The top-down forest management structure operated even after independence from the British on 6 March 1957 [25]. These include the 1960 Forest Improvement Act enacted to embark on forest plantation development and timber plantation and management. After that, the Forest Commission Act of 1960, the forest Concessions Act of 1962 [25] were promulgated. The Concessions Act, (Act 124, 1962) in particular was remarkable as it sought to vest timber resources and naturally occurring timber trees in the President of the Republic in the trust of the people of Ghana [26]. Thus, the 1962 Concession Act marks the first-time farmers lost their rights to forest resources in Ghana [27]. The communities owning timber resources saw the shift as losing their ownership rights to the state [26]. The Act also demarcated Ghana's forests and protected areas into different concessions for timber exploitation purposes and determining forest fees, licenses, and timber decrees [26]. Under the Concessions Act 1962, the Forestry Commission was tasked with the sole responsibility to have the management rights and harvest timber resources on behalf of the state [26].

The 1974 Forest Protection Decree was to protect the forest and define offences, provide guidelines for the timber logging industry, specifying sanctions for non-compliance, and promoting processed timber export [24]. After that, the 1983 Trees and Timber Regulations that sought to regulate chainsaw operation for logging, tree felling, and forest protection regulations were established [24]. Following that, the Land Administration Act of 1984 and the Forest Protection [Amendment] Law 1986, which specifically defined forest offences and penalties, were enacted. The 1990 Control and Prevention of Bushfires Law and the 1994 Forest and Wildlife Policy were promulgated specifically to ensure forest protection and the conservation of forests resources, among others [25]. Additionally, the Forest and Wildlife Policy of 1994 constituted a crucial milestone in advancing Ghana's forests and wildlife protection and conservation with the significant involvement of communities, and the restoration of degraded forests coupled with the introduction of market-driven mechanisms to enhance forest resources use [1,24,28]. The Timber Resources Management Act, 1997—Act 547 dealt with timber utilization contracts, applications for timber rights, granting of timber rights, terms of the contract, timber operation management, payment of royalties, charges and other fees, and all other relevant issues concerning timber resources [25].

Additionally, the Timber Resources Management Act 1997 LI 1649 [as amended] mandates holders of Timber Utilization Contracts [TUCs] to pay at least a 5% stumpage fee as

part of their Social Responsibility Agreements [SRAs] to timber-producing communities. The 5% stumpage fee was supposed to provide social amenities, services and other benefits to beneficiary communities where TUCs operate. The Forest Protection [Amendment] Act 2002 was aimed at upscaling forest protection through the revision of forest fines as the 1986 Forest Protection [Amendment] Law which was to deal with forest offences, sanctions, and penalties, had developed loopholes and relaxations [24]. Particularly, the 1986 Forest Protection Amendment Law could not adequately deal with the key objectives it was intended to achieve as stated above; hence the 2002 Forest Protection Act sought to upscale the offences and the fines as contained in the 1986 Forest Protection [Amendment] Law [24]. In 2008, Ghana adopted the REDD+ strategy to reduce emissions from deforestation and forest degradation, sustainable management and conservation of forest biodiversity, and enhanced carbon stocks. However, the implementation of REDD+ has met several challenges, including a lack of appropriate carbon benefit-sharing mechanisms, weak tree and land tenure arrangements and non-fulfilment of safeguards strategies [25,29–32]. The Forest Carbon Partnership Facility [FCPF] provides grant assistance for supporting Ghana REDD+ intervention [33]; currently, REDD+ actions and activities operate in the high forest zones [HFZs] of the southern part of Ghana, considered to be the biodiversity hotspots [34]. The REDD+ strategy primarily uses Ghana's HFZs for carbon stocks enhancement and emission mitigation [25]. The Modified Taungya System, established in 2002, is a community-level intervention aimed at achieving the dual purpose of allowing local farmers to grow food crops while caring for trees in the farms [25]. The MTS scheme is supposed to serve as a win-win opportunity for farmers and local people to engage in tree planting and nurturing in degraded forestlands while growing food and cash crops to provide income and employment. However, [31] finds inadequate income to be generated from growing food crops under the MTS as a major factor demotivating the farmers in investing their time and resources in the restoration and afforestation processes. This situation threatens the sustainability of the MTS scheme.

The Community Resources Management Areas [CREMAs] intervention was tasked with engaging in actions and activities to achieve a reduction in the D&FD, and promoting sustainable farming practices [35]. The CREMAs were also tasked to ensure the curtailment of illegal logging, enhancing conservation and management of protected areas and forest reserves [34]. Like the MTS, the CREMA members also lack the appropriate tangible benefits and incentives, which could motivate them to actively participate in the sustainable management of forest and forest restoration projects [35,36]. At the lower levels, CREMAs are faced with numerous challenges, including inadequate funding and weak governance structures [35]. Hence many of the CREMA members develop apathetic attitudes towards CREMA activities [25,35].

In 2001, the National Forest Plantation Development Programme [NFPDP] was launched to embark on national forest plantation acceleration [37,38]. The programme comprises the government, private organizations and local communities. The key objectives of the NFPDP include the restoration of degraded forest lands by increasing the forest cover, ensuring increased wood supply for domestic use and market. The rest are to generate employment to significantly reduce rural poverty, enhance environmental quality, and enable beneficiaries to benefit from the carbon market and payment for environmental services and improve food security [39]. The NFPDP developed a Large Scale Private Commercial Plantations Development [LSPCPD] to implement the above objectives [38].

In 2012 the Ghana Forestry Commission [GFC] promulgated the Ghana Forest and Wildlife Policy 2012. This policy document contains the laws, institutions, systems and organizations that should be integrated to promote sustainable management and conservation of forest landscapes and wildlife in Ghana [40]. These Acts, policies, schemes and interventions constitute Ghana's forest governance journey over several decades. However, despite all these, Ghana's forest governance is characterized by problems and challenges that have partly resulted in ubiquitous D&FD.

Ghana's tropical forest continues to face dangers and severe threats of deforestation and degradation. Ghana is currently experiencing alarming deforestation and forest degradation with an annual rate of 2% (about 135,000 hectares/year) of forest cover loss through anthropogenic causes [34]. There is the need to tackle the underlying factors that drive direct causes of Ghana's D&FD. Therefore, this review aims to analyse the causes of D&FD in Ghana through a social-ecological perspective to understand how drivers-pressure-state-impact-response (DPSIR) reinforces D&FD. There is a paucity in the DPSIR literature regarding the causes of D&FD in Ghana. This necessitated our aim to use the DPSIR to present to forest policy and management planners to understand the chain of causal links in D&FD, as the use of DPSIR to analyse D&FD from the social-ecological lens is underexplored.

2. Materials and Methods

2.1. Study Area

Ghana is an English-speaking developing country situated on the West Coast of Africa, positioned between the latitudes 4.5–11.5° N and longitude 3.50° W–1.30° E. Broadly, Ghana's climate is characterized by the Inter-Tropical Convergence Zone (ITCZ) and the West African Monsoon, which modulate the dry and wet seasons [41]. The precipitation gradient influences Ghana's vegetation, resulting in the highest precipitation in the south-western region, whereas it becomes low along the northern and eastern portions of Ghana [41]. Ghana covers a total land size/area of approximately 238,540 km^2. Ghana's forests vegetations are primarily classified as the tropical high forest zones (THFZs) and the savannah zones (SZs). The THFZs comprise a high canopy, thick tall, close forest, while the SZs constitute trees and shrubs of different canopy open forest. However, the land area has been classified into six key ecological zones: deciduous forest, the transitional zone, the Guinea Savannah, the Sudan Savannah, and the Coastal savannah and Wet Evergreen [42,43]. Ghana is characterized by a tropical climate with a mean temperature ranging between 25 °C and 27 °C annually, while it also experiences 2000 mm annual rainfall in the south-western part of Ghana, where it declines steadily across the northeast, dipping to 1000 mm towards its northern border area [44].

Ghana's first Landsat satellites imagery captured in 1972 showed 82,000 km^2 of forest zone area (approximately 34%) of the country's total land area, where both forest reserve and wildlife reserve comprised about 18,000 km^2 representing some 22% of the entire forest zone [45]. However, Ghana's closed natural forest has experienced a persistent decline from 1990–2020. Table 1 below shows the mean volume (m^3/ha) of closed natural forest, open natural forest, close plantation forest and open plantation forest in Ghana from 1990–2020. It also shows close natural forest had declined from 3,108,508 ha in 1990 to 1,204,372 ha in 2020. It means that within 30 years, Ghana lost 1,904,136 ha of closed natural forest. Similarly, there was a loss in an open natural forest of 281,512 ha, from 6,765,748 ha in 1990 to 6,484,236 ha in 2020. However, there was a gain in the closed plantation forest from 50,000 ha in 1990 to 276,618 ha in 2020. Open plantation forest experienced a decline from 59,197 ha in 2015 to 20,477 in 2020.

Table 1. Mean volume m^3/ha estimates for four key forest types in Ghana 1990–2020.

		Area (Ha)								
Designation	**Mean Volume m^3/ha**	**1990**	**2000**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Closed Natural Forest	136	3,108,508	2,207,166	1,305,824	1,021,838	1,113,105	1,204,372	1,204,372	1,204,372	1,204,372
Open Natural Forest	28	6,765,748	6,591,441	6,417,134	6,598,149	6,541,193	6,484,236	6,484,236	6,484,236	6,484,236
Close Plantations	175	50,000	50,000	219,977	201,250	228,101	254,952	262,174	269,396	276,618
Open Plantations	31	0	0	0	59,197	39,837	20,477	20,477	20,477	20,477
Total		9,924,256	8,848,607	7,942,935	7,880,434	7,922,236	7,964,037	7,971,259	7,978,481	7,985,703

Source: Global Forest Resources Assessment, 2020 [46].

Figure 1 depicts Ghana's forest cover map from the years 2000–2010, 2010–2013, and 2013–2015. The map shows deforestation related activities and their main crops responsible for the forest cover changes over the periods specified above. For details of these activities, see Table 2 under agriculture expansion.

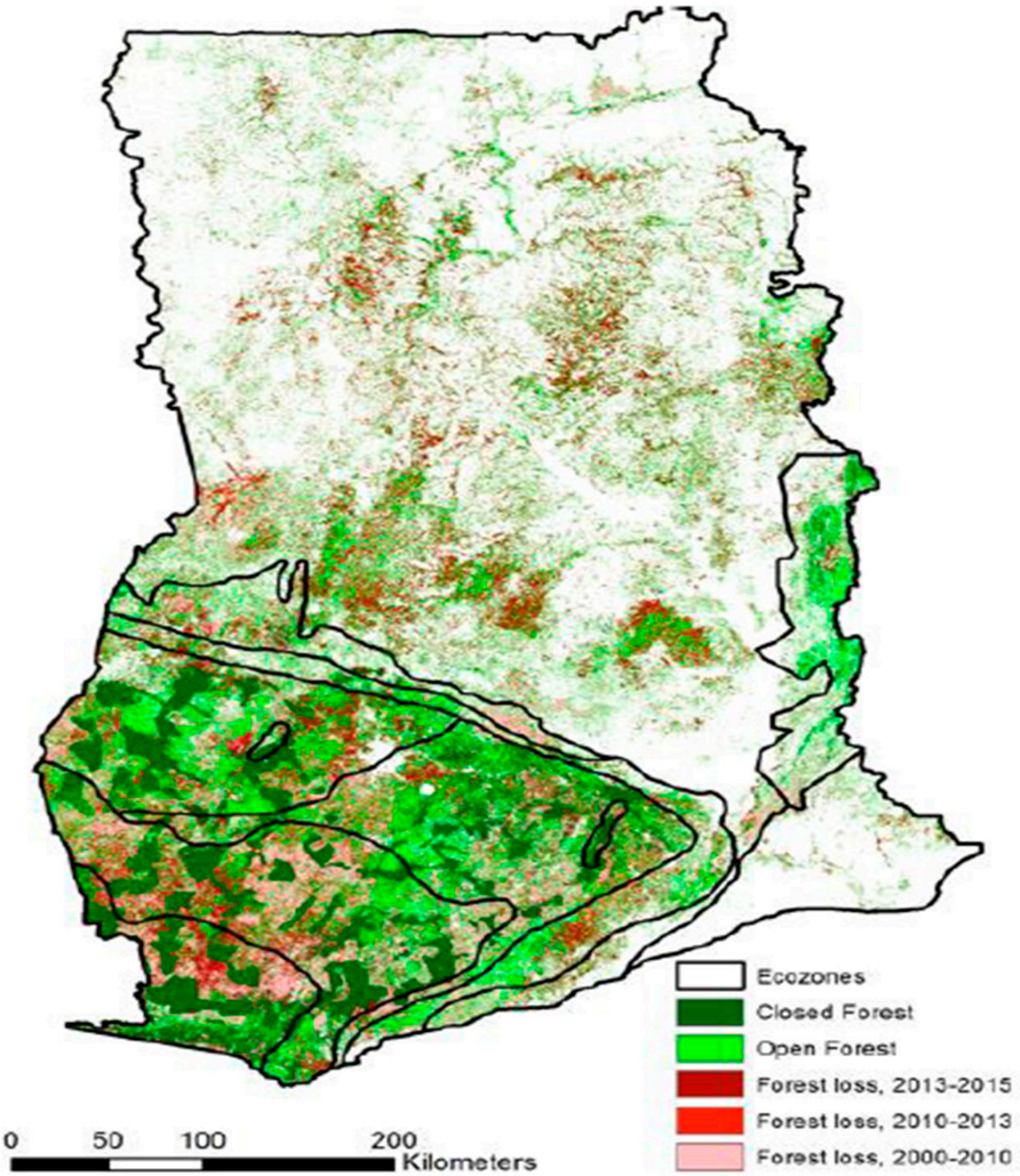


Figure 1. Forest cover map of Ghana (Adapted from Ghana Forestry Commission, 2017) [47].

Table 2. Activity data for deforestation in Ghana between 2000 and 2015.

2001–2010	Cropland	Oil Palm	Citrus	Rubber	Cocoa	Total
Open Forest	852,565	14,568	2428	7284	99,562	976,407
Closed Forest	153,624	19,244	3207	9622	122,065	307,762
Total	1,006,189	33,812	5635	16,906	221,627	1,284,169
2010–2013						
Open Forest	348,161	5325	887	2662	38,185	395,220
Closed Forest	56,282	7938	1323	3969	51,040	120,552
Total	404,443	13,263	2210	6631	89,226	515,773
2013–2015						
Open Forest	487,743	8185	1364	4092	61,874	563,258
Closed Forest	76,686	9231	1539	4616	71,446	163,518
Total	564,429	17,416	2903	8708	133,320	726,776

Source: Ghana Forestry Commission, 2017 [47].

2.2. Data Sources

The study was conducted using a literature search in several web-based databases and sources. Key of the web-based databases include Google Scholar, Science Direct, and Scopus. Broadly, the search focused on deforestation and forest degradation in Ghana. The key terms used were "Forest" OR "Deforestation" OR Forest degradation" OR "Social-ecological" OR "DPSIR" OR "Ghana". The search string was broadened to include an extensive array of key studies on deforestation and forest degradation in Ghana, focusing mostly on social-ecological drivers, pressures, state, impact, and responses of D&FD in Ghana. Figure 2 below depicts the search processes using the key terms as indicated above to show which search engines were used, results obtained and the final output on the key driving factors of deforestation and forest degradation in Ghana. Furthermore, forest policy documents, documentary reviews on deforestation, and forest degradation from book chapters, and Ghana Forestry Commission published and unpublished articles as well as technical reports were reviewed for the study. Additionally, the search string was widened to aid a comprehensive understanding of the dynamics and contours of D&FD in the Ghanaian context.



Figure 2. Methodological processes of deforestation and forest degradation using the keywords to various web-based databases.

However, we restricted the results to cover the year 2012 to 2020, when many of the key forest governance and policy interventions were in operation arguably intended to govern and manage Ghana's forest sustainably. Significant among them including the Ghana Forest and Wildlife Policy 2012 and the REDD+ intervention. These interventions aimed to reduce D&FD in Ghana's forests to increase forest biodiversity and ecosystem services. This approach allowed us to refine the results to include only literature that focused mainly on the DPSIR perspectives of a social-ecological system (SES) of D&FD in Ghana. To meet our set research objectives, we initially read all abstracts, then read the selected papers thoroughly, while the subsequent reading mostly focused on the analysis and the narrative to comprehensively understand the application of DPSIR through the SES approach.

2.3. DPSIR Analytical Framework

Although the DPSIR framework was developed and applied in varied forms by reputable agencies, institutions, and organizations such as Statistics Canada during the 1970s, and in the 1990s by the OECD and the United Nations, its current form of application can be traced to European Environmental Agency (EEA) [48]. The DPSIR (Drivers-Pressure-State-Impact-Response) framework espoused by the European Environment Agency [49] became a strategic tool for assessing, analyasing and reporting global, regional, national and local environmental problems [50] in an integrated and interdisciplinary perspective [51]. The framework helps structure and organize indicators from an interdisciplinary perspective to foster effective decision making to bring desirable social-ecological changes [52]. It fosters the understanding and connectedness of the origins of environmental problems and consequences [53]. Following its adoption and usage by the EEA, the DPSIR framework had gained worldwide recognition and acceptance as a robust integrated reporting framework [51]. The DPSIR framework presents the opportunity to identify and analyze the state and causal drivers of environmental challenges, including the key challenge of D&FD [48]. Thus, the DPSIR framework integrates ecological and social information on D&FD (drivers and pressures) [51,54].

However, critics argue that DPSIR tends to show that the causes and effects are merely linear processes [48]. Additionally, critics argue the DPSIR framework does not foster a sufficient understanding of the driving forces regarded as external factors which cause social and ecological problems rather than perceiving them as an aggregation of multiple factors, including social, economic, cultural, and political, among others [48]. Also, the framework does not show the levels of complex, diverse indicators that may be linked or associated with components [55]. While the framework illustrates the significance of causality of factors leading to different states and conditions, it simplifies the issues as linear uni-directional processes that elude an understanding of complex interactions and interlinkages of causal elements [50]. Although the framework is challenged for not fostering perfect communication among researchers, stakeholders and actors, and policymakers, it shows the critical relationships between and among components of the environment and society [48]. Primarily, the framework seeks to connect causes (drivers and pressures) to determine their outcomes (state and impacts) and based on that, responses are offered to curtail those causes and pressures. It helps to describe the linkages between the origins and consequences of a particular problem. It is useful in understanding dynamics linkages when the chain of causal links is clearly illustrated (Figure 3).

For instance, a chain of causal links beginning with 'driving forces' (agriculture expansion) though 'pressures' (shifting cultivation) to 'state' (biodiversity and ecosystem depletion and loss) and 'impacts' on (wildlife habitat destruction) leading to political responses (land-use intensification and crop rotation).

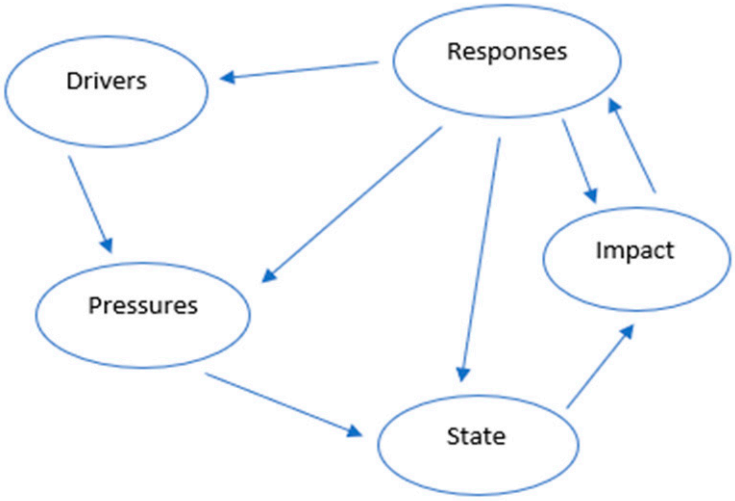


Figure 3. The drivers-pressure-state-impact-response (DPSIR) assessment framework [51].

3. Results

Even though Ghana has embarked on several forest governance approaches to reduce by 45% of all emissions that emanate from the cocoa landscape [56], it is still fraught with widespread D&FD challenges in the high forest zones, including the forests reserves [57–60]. This review study applies the DPSIR framework to provide information, discuss and analyse the multiple direct and underlying causes of D&FD in Ghana.

3.1. Drivers (D) of D&FD

3.1.1. Agriculture Expansion

The massive expansion in food crops production, including cocoyam, plantain, yam, maize, and other trees/cash crops such as cocoa, palm oil, among others, have been identified as the key direct driving force of Ghana's forest LULCC, leading to D&FD especially in the high forest zones [61,62]. For example, the expansion in cocoa and palm oil production was directly associated with the land cover transition in Ghana's eastern region [61]. Agricultural expansion and activities are associated with shifting cultivation, slashing and burning, inorganic chemicals, including weedicides and insecticides, are causing widespread D&FD in Ghana [58,63–69]. The chemicals, pesticides, and weedicides applied to control crop insects, pests, diseases, and weeds are powerful substances that eventually kill many useful bacteria and insects that contribute to natural soil restoration [70]. These ultimately render farmlands degraded incapable of producing higher crop yields leading to the annual clearing of virgin forests, including the destruction of naturally occurring economic forests trees including Mahogany, rosewood, dawadawa, and shea trees [71].

Moreover, slashing and burning have accelerated D&FD in Ghana [56,58,72] as often fires spread into other forestlands causing massive destruction of forest trees and vegetation [73]. The use of tractors and modern machinery for clearing forest for farming purposes equally destroy a large tract of the virgin forest [71]. Table 2 above illustrates agricultural activity and key crop data within Ghana's open forest and closed forest from 2001–2010, 2010–2013, and 2013–2015 as drivers of deforestation. Different food crops were aggregated into cropland, while key cash crops that drive deforestation are cocoa, oil palm, rubber, and citrus. Between 2001 and 2010, an area of 852,565 ha of open forest was used as cropland to cultivate food crops, with 99,562 ha for cocoa production and 14,565 for oil palm production. During the same period, 153,624 ha of closed forest was used for cropland. Also, 122,065 ha, 33,812 ha, and 16,906 ha were used to cultivate cocoa, oil palm, and rubber. Between 2010 and 2013, open forest land of 348,161 ha went into cropland purposes and 38,185 ha for cocoa production. This indicated a decline in the use of the open forest for deforestation related activities—similarly, this trend was observed in the closed

forest during the same period. The decline could be attributed to the REDD+ campaign against D&FD, which started gaining roots.

However, this decline could not be sustained as between 2013 and 2015, land use activities for cropland, cocoa, oil palm, rubber, and citrus increased in both open and closed forests compared to the previous years of 2010–2013.

3.1.2. Cocoa Farming

Cocoa (*Theobroma cacao* L.) serves as the main cash crop that contributes 25% of earnings in foreign exchange to Ghana's economy [74], as well as providing livelihood needs and well-being to over 800,000 rural Ghanaian families [75,76] and over six million Ghanaians representing about 25% of the population involved in the value chain processes of cocoa production [77]. As a second major cocoa producer, Ghana globally supports its economy through a foreign exchange that boosts Ghana's economy. Several benefits derived from cocoa have made its production widespread in almost all the HFZs in Ghana. The Ghana Cocoa Board (COCOBOD) and the Produce Buying Company Ltd., and the Cocoa Research Institute of Ghana (CRIG) are the three key organizations that oversee the cocoa purchase and other related issues regarding its production. The crop primarily thrives well in the forestlands; hence, cocoa farming characterized by slashing and burning has caused excessive D&FD in Ghana's high forest zones (HFZs) [56,78–80].

During its production stages, the farmers cut the shade trees from their cocoa farms to enable the cocoa to attract much sunlight to aid increased yields [56]. This practice of cutting shade trees constitute the significant drivers of D&FD, which is detrimental to biodiversity, productivity and carbon stocks [56,78]. According to [79], cocoa production is responsible for converting 54.6% in the closed forest and 77.8% in the open forest. Broadly, Ghana's high forest landscape zones have been experiencing ubiquitous D&FD due to massive cocoa production [78]. From Table 2 above, cocoa production accounted for 221,627 ha in both open forest and closed forest between 2001 and 2010. Also, between 2010 and 2013, 89,226 ha of open forest and the closed forest was used for cocoa production. Similarly, in 2013–2015, 133,320 ha was lost to cocoa production.

3.1.3. Legal and Illegal Logging

The widespread legal and illegal logging occurring in Ghana's high forest zones are directly driving D&FD. Legally, some forests and reserves are earmarked for large timber companies for timber production concessions [81]. As far as D&FD is concerned, illegal logging through illegal chainsaw activities occurring in the high forest zones and reserves had been identified as constituting the key D&FD [60,65,79,81–87]. All previous forest policies had forest protection spelt out in them but failed to criminalize illegal logging and the sanctions thereof. However, the Timber Resources Management Act, 1997—Act 547 and the subsequent Timber Resources Management (Amendment) Act of 2002 abhor illegal logging in the forests and spell out offences. Similarly, CREMAs were tasked with the responsibility to curtail illegal logging in the forests in Ghana. What made these three major forest policy interventions unique was that they had provisions that criminalize illegal logging in all its forms in the forests, yet the practice goes unabated. These attest to the weaknesses and lapses in forest governance and management regarding logging activities in the forests.

These illegal loggers use diverse illegal and unapproved tactics and methods, including using chain saws to operate very deep in the forests during the nights, public holidays and weekends, during which times the forest guards and officials are off duty [84]. Additionally, a study by [70] indicates that despite the existing bylaws prohibiting illegal chainsaw operation in the country, most youth still engage in illegal logging in the middle of the reserves during deep nights. These illegal operations are carried out at nights and in the middle of the forests and forest reserves, ostensibly to hide from the forest guards. It is also worth mentioning that the above two Acts explicitly state the Timber Utilisation Contract, which authorizes legal logging in the off-reserves and the production sides of

on-reserves. These give TUCs the legal power and authority to log as much as they operate within the TUC legal framework. Legal logging activities drive forest degradation in Ghana [85]. Table 3 presents the foreign exchange earned from timber and other wood products exports from 2010 to 2017 with the volume and the value in euros.

Table 3. Earned foreign exchange from the export of timber and other wood products.

No	Year	Volume (m^3)	Value (€)
1	2010	403,254.00	137,850,000.00
2	2011	319,842.00	107,400,000.00
3	2012	251,245.00	99,836,393.79
4	2013	275,470.23	121,793,697.76
5	2014	356,036.00	138,215,618.00
6	2015	367,060.72	187,624,643.02
7	2016	396,991.53	224,958,215.86
8	2017	339,226.61	189,892,298.57
Total		2,709,126.09	1,207,570,867.00

Source: Timber Industry Development Division, Forestry Commission of Ghana [39].

Thus, between 2010 and 2017, Ghana has exported 2,709,126.09 (m^3) of timber and wood related products with total earnings of over 1 billion euros. Due to the high foreign exchange that Ghana derives from the export of timber and other wood products, legislative laws would be impossible to curtail logging from the production reserves and other forest types. Although, Table 3 represents the official statistics of timber harvested and exported annually, the volume may be higher, as those harvested illegally, may not be captured.

3.1.4. Illegal Mining

The widespread illegal mining occurring in most parts of Ghana's high forest zones and the forest reserves are characterized by open-surface mining, which involves scooping off the forests cover and vegetation leading to high D&FD [58,88,89]. The key minerals mined in Ghana include Gold, Bauxite, Diamond, and Manganese. Two major laws regulate mining for minerals in Ghana: The Minerals and Mining Act, 2006 (Act 703) (as amended by the Minerals and Mining (Amendment) Act, 2015 (Act 900) and the Minerals Commission Act, 1993 (Act 450). These Acts stipulates that all minerals in their natural forms are owned by the state and spell out the licensing procedures for minerals explorations in Ghana. Section 82 (1) of The Minerals and Mining Act, 2006 (Act 703) stipulates the procedure for acquiring a license for small-scale mining and the granting authority. These illegal forest mining activities persist despite the Minerals Commission, the Forestry Commission and the Environmental Protection Agency (EPA) that are government agencies primarily mandated to manage and regulate forest mining [90]. Although large-scale mining activities occur in the forest, they are involved with deep-underground mining, which has limited impact on forest cover and vegetation degradation.

On the contrary, the small-scale illegal mining activities in the forests are characterized by an open-cast or surface mining which cause massive D&FD [58,88]. The less punitive sanctions meted out by the judiciary to small-scale miners demotivate officials to arrest the illegal miners, while government officials are reluctant to engage the miners on the proper ways of regulating and formalizing their mining activities [90]. Studies had shown that large parts of Ghana's high forest zones and reserves had suffered massive and widespread D&FD due to illegal forest mining [58,88–90]. For instance, illegal mining activities along the Offin shelterbelt of forest reserve have driven irreparable habitat and biodiversity loss [89], while similar D&FD has also occurred along the Pra River Basin, further leading to water pollution [91]. In the Offin Shelterbelt reserve, factors such as increased income, employment opportunities, and increased market activities constituted drivers of illegal mining activities [89]. Also, small scale mining operations grew and were mostly responsible for the Ankobra riverbanks' degradation [58].

Similarly, the Bibiani Forest District, located in Ghana's western region, has equally suffered widespread D&FD owing to illegal mining operations in the forests [88]. Notwithstanding the official processes for formalizing Artisanal Small-Scale mining operations in the country, since the 1980s, currently, 85% of unregistered small-scale miners popularly referred to as 'galamsey', translating as 'gather and sell' operating illegally in the forests [92]. Although illegal mining operations can reduce rural poverty and enhance youth employment, the operations pose adverse consequences on forest biodiversity and ecosystems, water pollution, and not paying taxes from the minerals they prospect from the state's land resources to enhance national revenue. Ghana's government has embarked on several measures to end the menace of galamsey operations, particularly in the forest dubbed 'anti-galamsey crusade. However, the crusade has failed to curb the menace. The crusade included the deployment of a joint police-military team to arrest illegal miners on site. However, until the political drivers that propel the galamsey operations are dealt with, the crusade will not succeed [92]. This is because the network of powerful nationals and foreign nationals used unapproved mining activities with the connivance of top political actors, landowners, and the chiefs to mine illegally for gold and other precious minerals in the forests [90]. The persistent illegal mining activities are fueled by political leniency and corruption associated with law enforcement [92]. There is a need for stronger political will to promote sustainable mechanisms to regularize the illegal miners' activities and sanction offenders for non-compliance to deter others.

3.1.5. Population Growth

One of the key underlying drivers of D&FD in Ghana's high forest zones and the reserves is population growth. The growth in the rural population, in particular, is indirectly pushing more people to depend on forest resources for their well-being and sustenance. Ghana's population growth has led to massive farm expansion, increased shelters, and land fragmentation [71] which constitute the significant drivers of forests' biodiversity loss and extinction [93]. Apart from the natural population increase by inhabitants living around the forest areas, people migrating towards forestland areas has also soared, leading to high dependence on forestlands for farming and other livelihood activities to meet their socio-economic needs [84]. Although Ghana has experienced an increased urban population in recent times, it had not resulted in rural areas' depopulation [37]. This implies that there will be continuous demand and dependence on forestlands and resources for livelihood activities. If the trend continues, it will not foster forest regeneration to the forest transition agenda [37]. The increased rural population has massive pressure on scarce forestlands, causing severe degradation in the natural environment [94] and indirectly accelerating D&FD in Ghana [58]. Table 4 below shows Ghana's population from 2010–2019 with their urban, rural dimension. It also depicts the growth rate and change rate. The table shows that both urban and rural population increased over the years. For instance, the rural population increased from 2,213,131 in 2010 to 13,168,802 in 2019, while that of the urban population also increased from 12,566,488 in 2010 to 17,249,054 in 2019.

Table 4. Total population with urban and rural dimension.

Year	Total Population	Growth Rate	Population Urban	% of Total	Change	Population Rural	% of Total	Change
2019	30,417,856	2.19%	17,249,054	56.71	3.31%	13,168,802	43.29	0.68%
2018	29,767,102	2.22%	16,687,441	56.06	3.36%	13,079,667	43.94	0.72%
2017	29,121,465	2.25%	16,135,333	55.41	3.42%	12,986,138	44.59	0.76%
2016	28,481,945	2.27%	15,593,581	54.75	3.47%	12,888,365	45.25	0.79%
2015	27,849,205	2.29%	15,062,521	54.09	3.51%	12,786,684	45.91	0.83%
2014	27,224,473	2.32%	14,543,041	53.42	3.56%	12,681,431	46.58	0.86%
2013	26,607,645	2.35%	14,034,999	52.75	3.61%	12,572,643	47.25	0.91%
2012	25,996,450	2.35%	13,537,131	52.07	3.68%	12,459,318	47.93	0.96%
2011	25,387,712	2.45%	13,047,760	51.39	3.76%	12,339,950	48.61	1.03%
2010	24,779,619	2.52%	12,566,488	50.71	3.84%	2,213,131	49.29	1.11%

Source: Macrotrends, 2021 [95].

3.1.6. Policy Failures and Lapses

Forest policy lapses have indirectly fostered different kinds of forest illegalities in Ghana's high forest zones and forest reserves [96]. For example, to date, Ghana's forest policy has failed to adequately reform and address benefits and rights that would allow land occupants to harvest or access on-farm and fallow land trees culminating in widespread illegal logging [97]. Similarly, the Modified Taungya System (MTS) lacks timely timber income rights for its beneficiaries, coupled with the non-signing of MTS agreements, lack of clear benefit-sharing from 40% timber share are all challenges that deter farmers from tree planting and nurturing [31]. The current forest policy has lapses regarding timber tree tenure and ownership, where farmers realize limited benefits from the existing forest policy [96]. Ghana's forest policy has not entirely made apparent the tree and land issues and the right to forest carbon benefits, and the lack of a precise framework on the benefit-sharing of forest resources. These have resulted in policy incoherence in the forestry sector, thereby exacerbating ubiquitous D&FD in many parts of Ghana's forest zones [98], leading to conflicts and competing forest resources claims [57]. Lack of significant policy collaboration between the Forest Law Environmental Governance and Trade (FLEGT) and REDD+ is hampering forest policy reforms [99,100]. For instance, the poor enforcement of the national forest policy caused inadequate community forest protection in the Sissala West District in the northern region, leading to poor forest resources management [71]. Forest policies must provide an opportunity to increase farmers' rights and capacity to manage and use timber trees [96] to curtail the widespread illegal logging in Ghana's high forest zones [81]. A study by [101] indicates that Ghana's forest governance is challenged by several factors: weak structures for detection and sanctioning, inadequate and unrealistic laws, corruption in which forestry officials, police, and the judiciary accept bribes to avoid stringent sanctions. The absence of stringent penalty and sanctions to offenders of forest illegalities have perpetuated D&FD [86]. The lapses and loopholes within the forestry sector have driven illegal chainsaw milling, illegal logging, and illegal farming, as those who engage in these illegalities hardly got arrested and punished.

3.1.7. Poverty

Poverty is the critical underlying force that is driving high D&FD in Ghana. For instance, [25,71] identify the underlying local level poverty issues as factors compelling the rural people to heavily depend on forests for most of their livelihoods and survival needs which put heavy pressure on the forests leading to massive and widespread D&FD. Unfortunately, there is a lack of clarity in analyzing poverty-environment effects on D&FD [60]. For example, the massive D&FD occurring along the Lake Bosomtwe was primarily caused by poverty dynamics of the local rural communities [72] as rural poverty, in particular, is associated with natural resources degradation by people living in many rural forest areas in Ghana [70,102]. However, the rich in the Ashanti region of Ghana, other than the poor, were the major drivers of forest degradation as most of their activities were forest degrading [72]. Accordingly, the rich in the area financed and sponsored most forest illegalities, including acquiring machinery and chainsaws for illegal mining and logging, respectively [60]. The rural poor use the environment for almost all their livelihood needs and purposes, leading to high depletion of forestlands and their resources [70]. Poverty dynamics of the local forest actors and stakeholders constitute some of the major underlying factors that necessitate their involvement in the illegal chainsaw operations as a means to supplement livelihood needs and income [60,84]. Forest governance policies should consider local indigenous knowledge and underlying poverty issues at the local level [25] and that reducing poverty alone will not solve the indiscriminate D&FD in Ghana [60]. Table 5 below indicates that the country's poor people reside in rural areas. Although the number of rural poor dropped from 6,050,606 in 2006 to 4,981,967 in 2013, one can still argue that the rural poor number was high compared to the urban poor within the same period. The urban, rural percentage was higher for the rural at 85.3% in 2006 and 78% in 2013, whereas the urban was 14.7% in 2006 and 22% in 2013.

Similarly, the poverty estimates on people living in urban and rural forests based on GLSS V and VI show that the poverty headcount is higher in rural forest areas than in urban areas. The second part of the table below illustrates rural forest poverty headcount of 33.1 with the urban been 8.7. In both the GLSS V and GLSS VI, people living in rural areas are poor compared to their urban forest counterparts. Although Ghana experienced a downward trend in the poverty rate from 56.5% to 24.2% between 1992 and 2013, this has not trickled down to reduce the rural poverty rate, which stands at 37.9% compared to the 10.6% urban poverty rate. Thus, the reduction in poverty from 55% in 2011 to nearly 46% in 2017 indicates that close to half of Ghana's 31 million population, translating into 14 million, are estimated to be multidimensionally poor [103].

Table 5. Distribution of the poor and the population (2006 and 2013) and poverty estimates for Ghana.

	Distribution of the Poor		**Distribution of the Poor (%)**			**Distribution of the Population**		
	2006	**2013**	**2006**	**2013**	**Change**	**2006**	**2013**	**Change**
Urban	1,041,086	1,402,091	14.7	22	7.3	37.7	50.1	12.4
Rural	6,050,606	4,981,967	85.3	78	−7.3	62.3	49.9	−12.4
Total	7,091,692	6,384,058	100	100	0	100	100	0
Poverty Estimates for Ghana								
			Upper Poverty Line = 1314			**Lower Poverty Line = 792.05**		
Poverty Estimates Based onGLSS V			**Headcount**	**Depth**	**Severity**	**Headcount**	**Depth**	**Severity**
All Ghana			31.9	11.0	5.4	16.5	5.0	2.3
Urban Forest			8.7	2.2	0.9	2.8	0.8	0.3
Rural Forest			33.1	8.4	3.1	12.6	2.1	0.6
			Upper Poverty Line = 1314			**Lower Poverty Line = 792.05**		
Poverty Estimates Based onGLSS VI			**Headcount**	**Depth**	**Severity**	**Headcount**	**Depth**	**Severity**
All Ghana			24.2	7.8	3.6	8.4	2.3	0.9
Urban Forest			9.9	2.0	0.7	1.8	0.2	0.0
Rural Forest			27.9	7.9	3.3	7.8	1.8	0.7

Sources: Ghana Living standard survey [104].

3.1.8. Climate Change Impacts

In addition to the anthropogenic drivers of D&FD, natural climatic factors have been associated with D&FD directly and indirectly [70,105]. Since tropical rainforests are located in areas with water ecosystem resources, any hydrological changes that occur will significantly affect ecological patterns, processes and functions [106]. Also, decreasing precipitation trends can cause frequent drought and frequent fires leading to D&FD [107]. The climatic and natural factors result in droughts, long dry spell, high temperature, and low rainfall, which cause a significant reduction in farmers' crop yields [70,71,105]. Drought associated wildfires caused significant forest reserve destruction in Ghana's forest reserve areas, especially in 2016, where the estimated fire was 2137 km [41]. Drought related forest fires can also emanate from D&FD. Thus, while drought influences tropical forest to fire, forest degradation fuels the fire to cover large spatial extent burned forests [41]. These climatic factors resulting in low crop production yields push farmers to clear virgin forests annually in anticipation of increasing their crop yields instead of putting the old farms into highly intensive use [71]. The farmers perceived virgin forests to produce more yields, but forestland cover's conversion reduces forest ecosystem structures and functions and accounts for 10% of global carbon loss stock, leading to increasing climate change and change in water and rivers balance and degradation [58]. However, farmers inability to access timely weather information [71], such as rainfall and drought forecast [108], constitute the critical vulnerability factors that result in low crop production and yields, a situation that compels farmers to clear a large tract of virgin forest for increased crop yields. Hydrological conditions and factors result in poor land fertility and unfavorable

climates, which often propel forest-fringe communities to clear new forest for food, income, and other forest resources [71]. For example, a study by [62] on climate variability and climate change responses by smallholder farmers in rural southern Ghana indicates that climate variability and climate change cause high-temperature rise, and erratic rainfall patterns driving farmers to clear virgin forests to increase food crop production. Climate variability and change (CVC) reduces farmers' crops yields pushing them to clear new and virgin forest to increase crop production yields [105]. Thus, the hydrological factors that fuel drought drive forest fires, reducing forest capacity to sequester and store carbon and providing other provisioning ecosystem services. In 2015, insects, diseases, and severe weather events destroyed nearly 40 million ha of the global forest, with temperate and boreal forests being the hardest hit [19].

3.1.9. Land and Tree Tenure

Land and tree tenure structures and dynamics still create impediments for forest-dependent people and communities to have access and rights to benefit from forestland and forest resources [32,56,108,109]. Contextually, all forests, including naturally occurring trees existing in both reserves and off-reserves in Ghana, are owned by the state for the stools, and the state has all the user rights [30]. Currently, Ghana lacks an appropriate legal definition for formal and customary rights of tree and land tenure arrangements, resulting in conflicts [25]. Also, Ghana's tenure structures are complex and lack precision, leading to unfair and inequitable forest resources distribution [43]. The lack of tree and land tenure security pose several constraints and threats promoting unsustainable forestland and forest resources use [56,90,109]. The current forest policies (e.g., Ghana Forest and Wildlife Policy 2012) contain lapses regarding timber tree tenure and ownership, where farmers realize limited benefits from the existing forest policy [96]. This situation leads to illegal logging and destruction of naturally occurring trees on farmers' and landowners' land, and this demotivate them from getting involved in local/community tree planting projects [56]. Moreover, the lack of clarity in the tree and land tenure arrangement also denies local people the carbon rights that militate against key REDD+ objective of forest conservation and carbon stocks [98]. Damnyag et al. [63] emphatically attributed the fundamental cause of D&FD in Ghana's high forest zones to land tenure insecurity which demotivates farmers and community people from engaging and investing in tree planting and nurturing activities in their farms.

3.1.10. Benefit-Sharing Issues

Similar to land and tree tenure, is the contentious issue of benefit-sharing. It is expected that financial benefits that accrue from the forest intervention schemes will trickle down to benefit the average farmers or communities. Nonetheless, these benefits do not reach their intended beneficiaries. For instance, the non-receiving of the 40% share from timber benefits deters farmers from tree planting and tree nurturing [31]. There is a lack of an appropriate benefit-sharing framework and policy [98] in the forestry sector, which hampers sustainable forest resources use. In addition, the inequitable carbon benefits-sharing [90] demotivates local community participation in voluntary tree planting exercises to boost forest restoration and conservation [110]. Also, inadequate and untimely reforms in the forestry sector to promote appropriate forest-related benefit-sharing schemes will hinder sustainable forest resources use and conservation [63].

3.1.11. Institutional Lapses

Forest institutions and other forest-related agencies and ministries are weak, lack appropriate coordination and capacity, and are characterized by lapses and failures [72,73]. The weak institutional lapses and coordination by forest institutions and agencies [73,111] have fueled illegal logging and overexploitation of forest resources due partly to weak forest monitoring [83]. The Ghana Forestry Commission (GFC) and Ministry of Lands Natural Resources (MLNR), expected to play a critical role in coordination and integration

for monitoring in all forests in Ghana, are relatively passive [25] and lack of bottom-up inclusion at the community-level for engagement, participation and decision-making in forest governance [111]. Likewise, Ghana's forest institutions lack adequate accountability and transparency elements in forest governance processes [35,90,112], driving forest competing claims and conflicts [57].

3.1.12. Non-Compliance of Forest Rules

Forest policy and institutional lapses and failures are primarily the products of non-compliance with the forest laws and rules [96], leading to all forms of forest illegalities, including illegal logging, illegal mining, among others [84]. The excessive illegal chainsaw operations occurring in both off-forest and on-forest reserves indicate severe lapses in the current and existing forest laws [84,96,101]. Inadequate sanctions or punishment against the perpetrators of forest illegalities have driven massive D&FD [84]. It became evident that persons who engage in forest illegalities when arraigned before the court are fined as low as (Ghc200 or $60) a fine not deterrent enough to deter illegal chainsaw operations in the forests, including the reserves [84]. These processes have gained social acceptance in many communities [84]. The promotion of active local community participation in forest resources governance and management [73] coupled with modern forest law compliance and enforcement regimes other than the traditional command methods and controls will achieve significant social and environmental outcomes in Ghana [96].

3.1.13. Corruption

Forest corruption in Ghana is ubiquitous, driving illegal activities leading to D&FD. Corruption drives illegal logging in high forest zones and forest reserves as the illegal chainsaw operators use corrupt networks with forests guards to log illegally [83]. The unfair benefit-sharing arrangement of forest resources has also bled corruption compelling the disadvantaged and marginalized local forest and farming communities to engage in illegal logging activities perceived as their forest resources share [25]. Furthermore, the allocation of timber harvest rights is characterized by bureaucratic and political corruption [113]. In the Ashanti Region of Ghana, some respondents alleged that some forestry officials receive payment as bribes to allow illegal chainsaw operators to continue their nefarious forest activities [84]. Also, the lack of timber harvest rights and the fact that political leaders and politicians grant timber rights to firms and individuals who belong to their political organizations to satisfy their political, personal and material wishes have bled corruption in the forestry sector driving illegal forests logging [113].

Additionally, the influential personalities such as Traditional leaders, District Chief Executives (DCEs), and Member of Parliament (MP) often intercede to quash or reduce and sometimes avoid the sanctions meted out to the illegal loggers where in return they also support and campaign for them during constituency, the parliamentary and national elections [84]. In most cases, these influential personalities and financiers acquire the chainsaw machines for the teeming unemployed youth to engage in illegal logging operations. Simultaneously, these influential people arrange to get bail for illegal loggers due to their connectedness with the higher forestry and regulatory officials [84]. Some key Ghanaian actors, including chiefs, landowners, and powerful political authorities, illegally engage in mining in the forest reserves [90]. Similarly, forestry officials' corrupt practices have also persisted the illegal mining activities in the forests and forest reserves [101].

3.2. Pressures (P) on Forests in Ghana

3.2.1. Unemployment and Livelihood Activities

The high rate of youth unemployment that had characterized Ghana's economy has pressured many youths to engage in illegal logging and illegal surface mining, which has caused widespread D&FD in many high forest zones in Ghana. Although generally, the unemployment rate in Ghana has been falling from 10.1% in 1999 to 4.33% in 2019 [114], many rural communities are faced with high youth unemployment due to a high rate of

high school dropouts and lack of alternative employment avenues pushing the youth into illegal logging and mining in the forests [84].

Furthermore, livelihood activities such as charcoal production, illegal forest surface gold mining and illegal logging being practiced by unemployed youth are driving D&FD in Ghana's high forest zones [71] coupled with excessive game meat and hunting, palm-wine tapping, sand winning activities, charcoal burning and the outmoded slashing and burning farming practices have accelerated Ghana's D&FD [34,70]. For instance, the traditional slashing and burning for farming purposes destroy forests' resources, foodstuffs and even human lives during the harmattan seasons [70].

Table 6 illustrates the employment-to-population ratio, where it currently stands at 75.4 percent. In the urban areas, the rate is 69.9%, while that of the rural areas is 81.6%. It indicates a relatively large proportion of the urban population lack jobs, whereas the male's proportion compared to the female is relatively higher. However, the absence of alternative livelihoods options by people living along the fringes of forest reserves compels them to over-depend on forest reserves [71,115,116]. Although the economy has moved from predominantly agriculture to services, workers' share in the agriculture sector remains the highest. The population employed in agriculture, forestry and fishing account for 44.7%, with the service sector 40.9% and manufacturing employing 9.1% [115]. Males account for 48.2% compared to females, who account for 41.4% of the people employed in agriculture and 71.1% of rural dwellers are employed compared to16.8% urban dwellers [115]. Table 7 below shows the unemployment rate and annual change from the year 2010 to 2019. The downward trend from 5.32% in 2010 to 4.33% in 2019 indicates that Ghana is making efforts to reduce its unemployment rate.

Table 6. Number of currently employed persons and employment-to-population ratios. (persons 15 years and older) by locality type and sex.

	Number Employed (Thousands)			Employment-to-Population Ratio (Percentage)		
Locality Type	**Total**	**Male**	**Female**	**Total**	**Male**	**Female**
Ghana	12,039.7	5783.0	6256.7	75.4	78.4	73.0
Urban	5861.4	2773.2	3088.2	69.9	73.2	67.1
Rural	6178.4	3009.8	3168.5	81.6	83.7	79.8

Source: Ghana Living Standard Survey, GLSS6 [115].

Table 7. Unemployment rate and annual change in Ghana 2010–2019.

Year	Unemployment Rate	Annual Change
2019	4.33%	0.17%
2018	4.16%	−0.07%
2017	4.22%	−1.23%
2016	5.45%	−1.36%
2015	6.81%	0.28%
2014	6.53%	0.26%
2013	6.27%	0.33%
2012	5.94%	0.32%
2011	5.62%	0.30%
2010	5.32%	0.20%

Source: Macrotrends, 2021 [95].

3.2.2. Market Demand

The high market demand for timber for domestic use and the foreign market has put much pressure on Ghana's high forests zones leading to their D&FD. The persistent and rampant illegal logging activities in the high forest zones and the reserves have been attributed to the excessive market demand for lumber for domestic purposes [23,79,81,84,90]. The reason for the lack or inadequate lumber supply to the domestic and local market is that the big timber firms and companies with legal concessions only target foreign export of

lumber where they could earn foreign exchange, leading to a substantial domestic supply-demand gap [81,84]. Therefore, to meet the huge local and domestic market demands for lumber, illegal chainsaw operators use illegal and unapproved means to log illegally in the high forest zones and reserves to fill this demand-supply gap leading to widespread D&FD [81,117]. For instance, lumber's vast market demand leads to overexploitation of mangrove forest in Ghana's Volta estuary areas [118].

3.2.3. Overexploitation of NTFPs

The overexploitation of non-timber forest products (NTFPs) by local communities significantly drives massive D&FD in Ghana's forests and forest reserves, which leads to a sharp decline in forest biodiversity and ecosystem services [119]. The overexploitation of forest resources is due to the weak institutional framework and inadequate forest monitoring, which have driven D&FD in many parts of Ghana's forest zones [83]. Similarly, the overexploitation of wildlife and plant protein consumed by 14% to 60% of Ghanaian households also drive unsustainable farm-forest landscape conservation management [120]. In the same vein, the unsustainable overexploitation and illegal forests resources extraction are degrading the Atewa forests flora and fauna, driving its resources into fast depletion and loss [70].

3.2.4. Shifting Cultivation

Ghana's food and cash crops farming are characterized by a shifting cultivation system wherein each farming season farmers clears new or virgin forest and burn the vegetation cover for farming purposes without intensifying the old, cleared lands for future production. For instance, the slashing and burning farming have caused significant forest degradation along the basin of Lake Bosomtwe [72]. In addition to destroying the naturally occurring trees in the farms during slashing and burning activities, the fires often inadvertently spread to other forests areas to cause severe forests fires leading to D&FD [96]. For instance, in the Tamale Forest District, Walewale Forest District and Yendi Forest Districts of the northern region in Ghana, forest fires occurred in the forest reserves due to farming activities and other factors causing 46, 51 and 55 forest fires between 2012–2017 respectively [121].

3.2.5. Unsustainable Charcoal and Shea Production

Charcoal is produced for both domestic or household energy supply and commercial purposes. According to [71], charcoal production remains the key livelihood activity of both the old and the youth. However, unsustainable charcoal production puts much pressure on forests as the practice has been identified as responsible for rampant D&FD in Ghana [60,70,71]. Also, charcoal burning has led to wild forests fires in the High Forest Zones and reserves [60,70,71,84]. Moreover, shea production and processing, which constitute the significant livelihood activity in the northern part of Ghana, is leading to the loss of carbon stocks and sequestration potentials in the forest [122], hence, alternative energy sources to meet the high domestic and household energy needs to safe the forests from further D&FD are urgently needed.

3.2.6. Excessive Fuelwood Use

The use of fuelwood for domestic and household energy purposes in Ghana is alarming as virtually every rural home currently uses fuelwood or charcoal as domestic and household energy sources, putting much pressure on Ghana's forests, leading to D&FD [70]. However, the government, through the Tema Oil Refinery (TOR)'s campaign to encourage Ghanaians to shift from using fuelwood and charcoal as domestic and household energy sources to LPG, is yet to be fully materialized [38]. This advocacy by TOR to make Ghanaian homes substitute LPG as an alternative energy source has not been very successful due to constant LPG shortages, irregular supply, and high prices [123].

3.2.7. Poaching/Hunting

Indiscriminate hunting as a means of livelihood by both the youth and old is an everyday activity in the high forest zones [70,71]. Some poachers and hunters use fires to trap the animals, which often cause forest fires, especially during the harmattan seasons destroying large tracts of forestlands [34,70].

3.2.8. Rural Settlement and Urbanization

Many Ghanaian farmers dwell in the forest communities with settlements within the high forest zones and the reserves. Establishing forest rural and urban settlements have put undue pressure on the forestlands [79] and settlement expansion are pressuring and accelerating D&FD [123]. For instance, [124] identify the unregulated peri-urbanization as putting a lot of pressure on many rural landscapes causing irreversible D&FD. In particular, the urbanization expansion led to over 95% of degradation in the Sekondi-Takoradi forest zones from 1986–1991 [80] while generally, urban developmental activities (e.g., buildings) [125] and the expansion in the built-up areas [66] are putting massive pressure on Ghana's forest and the reserves driving D&FD.

3.3. State (S) of Ghana's Forest

The combined effects of direct and indirect anthropogenic and natural climatic factors have put the state of Ghana's forests into severe D&FD. These factors have driven forest biodiversity and ecosystem services into depletion and loss. Forests resources in Ghana are nearing depletion and loss owing to rampant D&FD [71]. The rivers and water bodies in the forests are being polluted and dried up due to surface forest mining in all forests and the reserves. A study carried out by [91] showed illegal mining along the Pra River Basin, having degraded forests and polluted rivers and water bodies. Illegal mining activities have caused severe habitat and biodiversity loss in the Offin shelterbelt of the forest reserve [89], while overexploitation and unsustainable and illegal forests resources extraction have caused flora fauna depletion, loss and habitat destruction in the Atewa forest [70]. The Atewa Forest which, is home to a high diversity of species, including more than 860 plant species, and over 570 butterfly species and other threatened and endangered species, has begun experiencing D&FD due to anthropogenic activities [70].

3.4. Impacts (I) of D&FD

Diverse drivers and pressures that emanate from D&FD impact significantly and negatively on the forest biodiversity and ecosystem services. The D&FD have caused widespread wildlife habitat destruction [126]. D&FD has also resulted in flora and fauna loss in many parts of Ghana's high forests zones, including the Atewa forest reserve. Most rivers and water bodies are being polluted due to illegal open-surface mining occurring in the forests. Rural people living in forest areas whose only sources of water are from rivers, streams and other water bodies are faced with pollution as a result of illegal forest mining. Using polluted streams and rivers for drinking and domestic purposes have profound health implications for the forest-dwelling communities.

Moreover, the forest vegetation cover changes emanating from D&FD affect biodiversity and ecosystem health and functions and reduce ecosystem services and functions. Besides, forest cover conversion through D&FD reduces forest carbon stocks [59]. Furthermore, D&FD resulting from illegal and legal logging severely destroy the understory vegetation and habits for birds and other mammals [85]. The ubiquitous and persistent D&FD caused climatic changes, resulting in prolonged droughts and high temperatures impacting forest biodiversity and ecosystem services [41]. Also, D&FD induced climate variability is causing high-temperature rise leading to erratic rainfall patterns [62]. The variations in high temperature and low rainfall patterns affect the biodiversity and ecosystem functions [71], while climate variability similarly degrades forests resources [127]. For instance, D&FD was responsible for the disappearance of key economic species such as

Afzelia Africana and *Khaya senegalensis* (IUCN classified threatened species), driving severe biodiversity loss [65].

Figure 4 below follows [51] DPSIR analytical framework used to illustrate Ghana's D&FD. It shows the chain of a causal link from Drivers-Pressures-State-Impacts-Responses to affect a desirable outcome. For instance, a chain of causal links starting with '*driving forces*' (agricultural expansion) through '*pressures*' (shifting cultivation) to '*states*' (biodiversity and ecosystem depletion and loss) and '*impacts*' (wildlife habitat destruction) requiring prioritizing political, policy, interventions, and governance '*responses*' to deal with the state, pressures and drivers in a causal manner. The '*responses'* should be setting Specific, Measurable, Achievable, Relevant, and Time-bound (SMART) targets and indicators to curtail the drivers that propel other processes. Although, in some cases identifying the precise causal chain from driving factors to impacts and responses entails a complex exercise, demanding a careful and diligent assessment of the situation holistically from the social-ecological and interdisciplinary perspective.

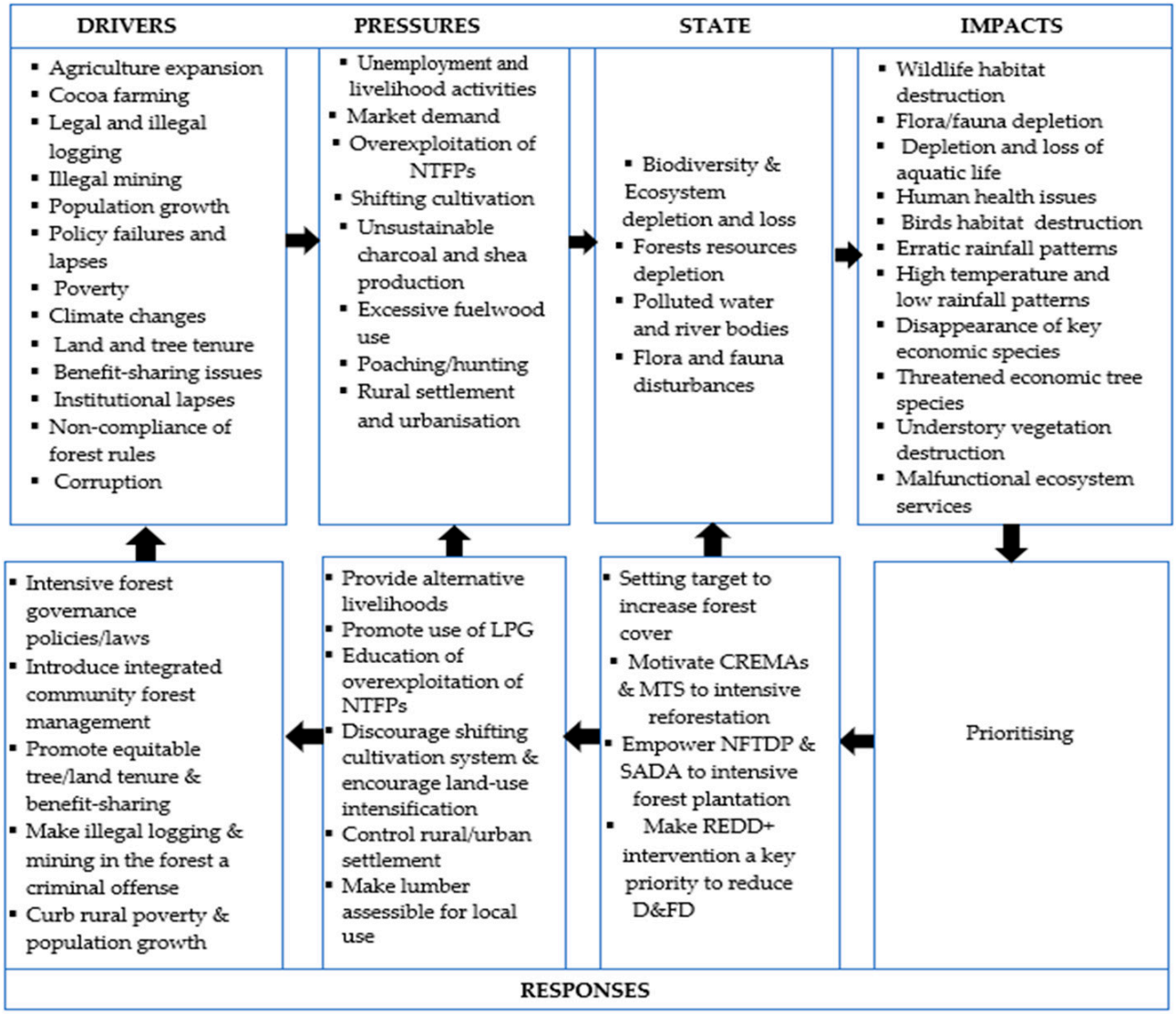


Figure 4. DPSIR Analytical framework on the causes of deforestation and forest degradation (D&FD) in Ghana.

3.5. Responses (R) to D&FD

Over the years, Ghana has embarked on several policies, laws, and regulatory mechanisms and interventions as immediate practical responses to curb the wanton D&FD in the Ghanaian forests and the reserves. The Forest and Wildlife Policy 1994, which was subsequently revised as the Ghana Forest and Wildlife Policy 2012, constitutes key forest policy and other numerous laws and regulations that guide forest governance and management strategies in Ghana. The Ghana Forestry Commission (GFC), working through the REDD+ intervention, targets hotspots where D&FD drives Ghana's forests into extinction by strengthening and reforming forests laws and policies to achieve sustainable forest management and governance. To address sustainable forest management challenges, including the key one of D&FD, Ghana, through the international bilateral and multilateral bodies, namely World Bank, FAO, IUCN, and EU, have received financial and technical support assistance to salvage Ghana's forests from further D&FD. It is envisaged that these supports would reverse the D&FD trend and enhance ecosystem services, including carbon emission. A local community-level intervention called the Community Resource Management Areas (CREMAs) was established to restore the degraded lands and forests and manage lands and trees [30,35]. The Modified Taungya System (MTS) was also designed to allow local farmers to grow their food and non-tree cash crops while planting and caring for trees on the farms [25,31]. These interventions were expected to serve the dual purposes of enhancing participating members livelihoods and boosting reforestation and afforestation potentials.

Another response to combat the rampant D&FD was introducing commercial plantation development strategies that engaged farmers to restore degraded forest reserves [30]. Likewise, the National Forest Plantation and Development Programme (NFPDP) has been established to achieve multiple aims of lessening rural poverty, increasing food production, and job creation through agroforestry schemes to enhance local economic opportunities [117]. Similarly, the Savanna Accelerated Development Authority (SADA), established in 2010 by MLNR and GFC, was charged to primarily restore degraded lands in Ghana's savanna areas through afforestation and reforestation [117]. In its efforts to reduce domestic and commercial use of fuelwood and charcoal as energy sources, Ghana's government devised a strategy to encourage LPG use as substitutes to safe Ghana's forests from incessant D&FD [38,117]. However, its implementation has met several challenges, including shortage, irregular supply, and LPG prices in the Ghanaian market [38]. Broadly, these interventions' main aim was to address the ubiquitous D&FD and restore forest biodiversity to enhance ecosystem resilience to provide numerable services, goods and benefits to human well-being and enhanced forest carbon stocks and sequestration potentials.

4. Discussion

This review has primarily focused on understanding and describing forest challenges that governance needs to address and the problems the governance system faces in addressing the key drivers of D&FD. The review adopts DPSIR to understand Drivers-Pressures-State-Impact-Responses from the social-ecological causes of D&FD in Ghana. We were motivated to use the DPSIR approach as studies most conducted in Ghana on D&FD fail to use DPSIR, which provides causal links in the processes. The findings from the review indicate both direct and underlying socio-economic and policy issues, institutions and actors' issues, and natural and climatic factors constitute the major problems that the governance system is confronted with to curtail D&FD. The review found direct factors such as agricultural expansion, coca farming, legal and illegal logging, illegal mining as driving forces of Ghana's high rate of D&FD. Illegal logging, in particular, is a major driving force of D&FD. This is consistent with a finding by [15] in remote mountain areas in the Ukrainian Carpathians, while in Nepal, illegal logging is a major driving force of D&FD [128]. Equally, agricultural expansion constitutes the key driving force of D&FD, leading to forest habitat loss in the tropical landscapes in Zambia, Burkina Faso, Cameroon, Ethiopia, Indonesia and Bangladesh [129]. The FAO 2020 studies find agricultural expansion remaining the

biggest driver of D&FD [19]. This implies that direct driving forces that propel D&FD are ubiquitous and not peculiar to forest governance challenges in Ghana.

Illegal small-scale mining should, as a matter of urgency, be curtailed and make those involved go through proper registration and be assigned with proper legal concessions for monitoring purposes. Formalizing their activities and giving them training can equip them to practice sustainable mining, which involves limited open land surface destruction and land reclamation. The government and the banks can help small-scale miners procure equipment that can mine sustainably with less or no open land surface scooping or destruction. Findings indicate that the existing forest policy and governance in Ghana have failed to tackle these direct factors of D&FD. We contend that forest policymakers and interventions often focus on direct factors that propel D&FD without tackling the underlying socio-economic driving forces such as population growth, policy failures and lapses, poverty, land and tree tenure, and benefit-sharing issues. Others include institutional lapses, non-compliance of forest rules, and corruption and climate change impacts. The lack of forest policy and law reforms have perpetuated forest illegalities in Ghana [31], and our findings indicate the need to improve forest institutions to promote policy coherence and enhance forest compliance, accountability and transparency. For instance, a growing rural population who depend on forests for livelihood opportunities leads to forests resources depletion and loss [71], while increased population and the consequent high demand for timber result in massive forests resources and timber depletion [117]. Similarly, studies buttress that high population growth leads to increased consumption, increased resource use, natural resources extraction [130], and [131] postulates growing population outstrips common resources. The [132] associate increase fuelwood use with population growth in Ghana. This is buttressed by a finding, as presented in Table 4 above. It indicates an increased population from 24,779,619 in 2010 to 30,417,856 in 2019. Also, there was an increase in the rural population from 2,213,131 in 2010 to 13,168,802 in 2019. The increased rural population implies increased forest resources use, including fuelwood and timber. Studies show that Ghana's rural dwellers use fuelwood the most while also producing charcoal for sale to urban areas [38]. This necessitated the policy intervention to encourage LPG use by rural forest dwellers to reduce fuelwood use [38,117]. However, irregular supply and high prices of LPG made the policy intervention unstainable [38].

Therefore, there is a need to curtail increased population, especially rural populations, to reduce forest dependence. Moreover, the poverty levels in Ghana's rural areas leave the rural forest communities no option than to depend on the forest resources for livelihood and survival needs. The government should roll out policy strategies and interventions such as alternative off-farm activities to reduce excessive forest resources use. However, the challenge is that many people find forest-related income, such as illegal logging and mining, much quicker and faster and provide higher returns than engaging in soap making, beekeeping, and gari processing. Previous alternative livelihood interventions have been providing small income facilities to engage in the off-farm activities stated above. Because these interventions have not reduced illegal activities in forest areas, they are not the best alternative livelihood options to reduce forest dependence. The policy intervention that seeks to reduce poverty and the subsequent reduction in forest resources extraction and use should yield more income and economic benefits returns than they would have gained from the forests. For instance, in Nepal, a study showed that forest income contributes 14.5% average rural household income [133]. A similar study in Ghana can inform government and economic policy planners to initiate measures to provide other income sources while tightening forest laws and rules. Extracting forest resources that degrade forest biodiversity and ecosystem should attract greater sanctions. Thus, protecting forest through sustainable forest management achieves win-win benefits such as carbon sequestration to increase carbon stocks and enhance the collection of NTFPs that do not deplete or degrade forests. Sustainable forest management can enhance Ghana's carbon stocks and storage potentials to combat climate change impacts that propel hydrological drivers such as droughts that increase forest fire tendencies. Because sustainably managing Ghana's forest will reduce

natural and climatic drivers that bring the high temperature and low rainfall patterns, and changes in the climate system. Land/tree tenure and benefit-sharing issues regarding naturally occurring trees in farms and forests belonging to families and communities should be shared equitably to curtail illegal logging and other forest illegalities. Some studies claim that unfair and inequitable land/tree benefit-sharing constitute factors that encourage forest-fringe communities to engage in forest illegalities [108]. The inequitable carbon benefit-sharing and lack of tenure security are major factors that drive D&FD in Ghana [90].

We are of the strong view that until the drivers that propel Ghana's D&FD are identified and categorized into the direct and underlying drivers through the social-ecological lens, the pressures on Ghana's forest will rage to affect the state of the forest and have negative impacts and consequences. The detailed analysis and presentation of data from interdisciplinary perspectives and sectors show that no one ministry, for example, the MLNR through its agency FC can wage the fight on Ghana's D&FD and win unless it involves other ministries and sectors. For instance, the appropriate sector coordination and collaboration among the Ministry of Finance (MoF), the Ministry of Employment and Labour Relations and the Ministry of Energy and Petroleum can reduce rural poverty, provide alternative livelihoods and promote LPG use. However, this lack of coordination and cohesion among responsible ministries and sectors has perpetuated the long-standing battle of D&FD despite Ghana having enacted a plethora of forest decrees, policy, interventions, governance and management schemes since 1948. Also, there is one thing having numerous polices and other, ensuring their proper implementation and monitoring. We, therefore, believe that the MLNR through its agency FC solely responsible and mandated for forest policy cannot do it alone. There is a need for greater inter-ministerial coordination and collaboration to tackle the drivers of D&FD from the social-ecological dimensions. The analysis and presentation of data from different sectors through the social-ecological lens using the DPSIR will go a long way to eradicate activities that drastically propel D&FD in Ghana.

5. Conclusions and Recommendations

Following a comprehensive and critical review of relevant literature that focuses on the causes of deforestation and forest degradation in Ghana, our analysis reveals that Ghana is faced with multifaceted drivers and pressures leading to massive and ubiquitous D&FD. Direct and underlying factors that drive high and massive D&FD in Ghana's forests include agriculture expansion, cocoa farming activities, legal and illegal logging and mining, increased rural population and poverty, policy failures and lapses, and the lack of appropriate benefit-sharing and tenure issues, among others. Despite the numerous forest policies, laws, legislations, and interventions aimed at governing and managing Ghana's forest sustainably, the country continues to face the D&FD challenges. To address Ghana's D&FD challenges in a holistic manner, forest planners, managers, and policymakers should focus on the underlying problems the forest governance system faces in addressing D&FD, such as socio-economic, policy, and institutional issues, which serve as catalysts to direct forest challenges governance needs to address D&FD.

Additionally, the review's findings indicated the plethora of forest policies, laws, legislation and interventions, implementation and enforcement failures, and lapses due to the absence of appropriate harmonization and coherence forest governance institutions. The review recommends using modern technology systems to monitor high forest zones to detect illegalities continuously. Also, offenders and perpetrators of forest illegalities should be made to face the law without any political, social, or economic considerations and maneuvering. Forest policy intervention responses should intensify agroforestry and plantation schemes to achieve co-benefits to promote rural and forest-dependent people's livelihoods and enhance biodiversity and ecosystem services to promote carbon stocks for climate mitigation. It is also critical to ensure adequate sectoral collaboration to provide alternative livelihood opportunities for the teeming forest-dependent people to reduce

excessive pressures on the natural forests. There is a need to find alternative energy sources to reduce high and excessive fuelwood and charcoal use, which puts massive pressure on Ghana's forests. At the same time, however, the communities should actively involve and participate in forest governance and management processes to enhance sustainable forest resources use. Forest communities should be allowed to have equal legal access to forest benefits and the right to land and tree tenure security. Farmers should be given the right to benefit from naturally occurring trees in their farms through access to carbon credits under the REDD-plus scheme. Ghana should take appropriate measures to modernize its agriculture to reduce excessive land use through shifting cultivation characterized by slashing and burning and practice land-use intensification. Ghana's forestland use policies and plans should consider mechanisms to promote sustainable agriculture to promote food security to meet its growing population's food needs while ensuring environmental sustainability. While we acknowledge the study could have been focused on a particular forest area or reserve to present a clear picture of the social-ecological DPSIR analysis, we believe that this exploratory review will set the platform to apply the methodology in future in specific regions or forest reserve in Ghana. However, this study can be applied in similar tropical forest countries that are experiencing high D&FD rates. Finally, there is a critical need to approach the issues from the social-ecological perspectives through the comprehensive analysis of the drivers, pressures, state, impacts and the responses from various sectoral agencies and ministries to address challenges holistically.

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