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Tropical forests in the context of climate change: From drivers, policies to REDD+ actions and intensity analysis – A review

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Abstract: Accurate forest reference and emission level (FRL, FREL) with related policies and regulations are the key determinants in establishing sustainable forest ecosystem management programmes (e.g. REDD+). This fundamental is for promoting and sustaining climate smart agricultural practices in a changing climate. With the aim to deliver better knowledge to the scientific community and policy makers on regulations and existing tools for more rigorous scientific communication when it comes to FRL and FREL accountability and policies. Thus, this review investigates forest in the changing climate and policies and underlines the performance of land use transition and intensity analysis towards deforestation with some key examples and achievements (e.g. Togo). Simply put, (i) forest as break of greenhouse gas (GHGs) and ecosystem regulator, (ii) policies and REDD+ actions, (iii) potential drivers and (iv) transition and intensity analysis approach for their accountability are discussed. In sum, impressive studies, policies and regulations are under initiations and implementations regarding the role, place and evaluation of forest losses and its ecosystem functions and services. However, there are still some gaps when it comes to: the choice of the evaluation methods in the real context of a specific ecosystem as well as the firm implementations of formulating policies in developing countries. This paper concludes with some policy measures for forest sustainability, carbon enhancement and accountability.

Keywords: Deforestation; Forest degradation; Forest reference level; Forest reference emission level; REDD+, Intensity analysis, GHG, Togo.

1. Introduction

Climate change is the main impediment to food security, sustainability of natural resources and population well-being. Increasing carbon dioxide emissions in the late 1960s and early 1970s [1, 2] continues to outpace global warming and climate change effects, highlighted as the core bottleneck concerns of United Nations climate talks. The first UN's conference on Human Environment is also

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known as Stockholm conference led in Sweden in June 1972, which addressed the relationships between environment and development at the global level, and pinpointed the total implications of human in maintaining its environment, and it has been considered as the genesis of climate change [3]. The main outcome was the establishment of the United Nations Environment Programme (UNEP) which was the first international body to deal with environment protection, study, understand and halt human actions on natural ecosystems in order to guaranty present and future needs of generations. Thereafter, the United Nations Conference on Environment and Development (UNCED, Rio de Janeiro, 1992) also known as Earth Summit, initiated the ratification of three international entities to handle : the loss of biodiversity (UNCBD: United Nations Convention on Biological Diversity); roll back land degradation and desertification (UNCCD : United Nations Convention to Combat Desertification) and climate change (UNFCCC: United Nations Framework Convention on Climate Change) which entered into force on 21st March 1994 [4, 5]. It was committed to stabilize greenhouse gas (GHG) concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system, within a time-frame that is sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner (UNFCCC, Art. 2). In 1997, to strengthen the global response to climate change, countries that were part of this Convention also adopted the Montreal protocol on substances that deplete the Ozone Layer in London (1990), Copenhagen (1992), Vienna (1995), Montreal (1997) and Beijing (1999); and Kyoto protocol to the UNFCCC [6, 7]. The Kyoto Protocol legally binds developed countries to meet emission reduction targets. The Protocol's first commitment period began in 2008 and ended in 2012. The second commitment period began on 1st January 2013 and will end in 2020 [4]. Annual meetings named Conference of Parties (COP) are organized to bring each signatory party head to meet for climate change negotiations. The recent COP: COP 21 in Paris (France), COP 22 (Marrakech: Morocco) and COP 23 in Germany (Bonn) called for capping global warming at well below 2.0°C and 1.5°C if possible, compared to pre-industrial levels.

The above state of affairs illustrates the need for the establishment of the scientific committee to give the real facts, evidence and policy measures to combat climate change and global warming through sustainable adaptation and mitigation actions. In this light, the Inter-governmental Panel on Climate Change was ratified jointly by the World Meteorological Organization (WMO) and United Nations Environment Programme (UNEP) in 1988 on these concerns and gave credible information regarding to related climate change science, effects and policy actions of land use changes interactions (e.g. transition forest to non-forest land use types) and climate change [8 – 10]. Referring to the fifth assessment report [10], it is extremely likely that, increasing greenhouse gas emissions causes climate change and global warming are 95% anthropogenic sources since mid-industrial era to a recent past. Human activities are creating disturbances in soil, plants and atmosphere relationships leading to tremendous impacts on the carbon cycle concomitant to earth temperature rise. The global average temperature increased by 0.85°C from the period of 1880 to 2012 compared to 0.4 degree Celsius in 1850.

There is also clear evidence that, this three decade have been the hottest due to significant changes in land use systems, causing a net release of carbon dioxide up to 10% of total greenhouse gases from terrestrial ecosystems. It was also revealed that, the deliberate conversion of tropical forests to agriculture lands, intensive deforestation, forest degradation and inappropriate land management practices, limit the role of forests and soil in acting as main carbon pools [11 – 16]. Valentine et al. [17] asserted that, forests have a remarkable ability to store carbon in both plants and soils and they are valuable natural break and sinkers of atmospheric carbon dioxide. It is likely that, the largest source of GHGs emissions in most tropical countries is from deforestation and forest degradation. [18, 19] investigation on tropical deforestation revealed that, 1 to 2 billion tonnes of carbon is been lost per year since 1990's which, equates roughly 15 to 25% annual global greenhouse. Lasco [20] also posited that, land use change and forest conversion are a significant sources of CO2 contributing to around 1.7 ± 0.6 Pg C per year. Similarly, several studies have emphasised on the role of tropical forests in

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net carbon dioxide emissions reduction through photosynthesis activities and carbon stock in plants [21 – 25].

It is against this background that, scientific communities and policy makers have been given credit to driven forces of deforestation and forest degradations projects and researchers to limit forest depletion and degradation. The role of forests in storing carbon, mitigating climate change and increasing biodiversity is of utmost importance to meet the requirements of sustainable development goals. Reducing emissions from deforestation and forest degradation; conservation of forest carbon stocks; sustainable management of forests and enhancement of forest carbon stocks (REDD+), has become the main topic of climate change discussions. REDD+ not only rolls back climate change, but also proffers additional co-benefits in response to food security, conservation of nature and improvement of socio-economic livelihoods of rural and the poorer communities are likely to experience the adverse effects of the changes. Accordingly, the main questions to ask is how much forest changes and at which rates of forest changes?, what is the role of agriculture activities on forests carbon loss or gain?, Do we have strong and tangible policies to curb forest extensions?.

Several studies have been carried out on land use land cover changes from one period to another [26 – 28]. Literature is also rich in materials related to land use change intensity analysis and its implications on carbon cycle with emphasis on perennial and agroforestry systems e.g. [29 - 33]. However, linkage forests, climate changes and existing policies are overlooked. The methods developed to assess forest losses and its ecosystems functions and services fail to account for socioeconomic and political interactions. The policies that enable an emission reduction from REDD+ project implementations are not effective. From this front line, this paper aims to discuss forest in the environmental and socio-economic changing in terms of: (i) Greenhouse gas and ecosystem regulator, (ii) policies and REDD+ actions, (iii) potential drivers and (iv) transition and intensity analysis approach for accurate carbon balance assessment in relation with multi-facet forest transitions.

2. Forest, climate change, climate talks and policies

2.1 Forest and climate change

The carbon cycle is a regulatory system of carbon equilibrium within the soil, plants, ocean and atmosphere systems, and any perturbation inducing harm to the climate system through significant fluxes of carbon, are the main driver of climate change and global warming. It is a scientific consensus that soils and forests are an innate stock of carbon, which can also lead to carbon losses due to anthropogenic activities mainly through land use changes. Overall, 10% of net carbon dioxide is driven by land use change [10]. Every loss of 1 tonnes of soil carbon equates to 3.67 tonnes of carbon dioxide and for 1 tonne of forest cleared is an equivalent of 0.5 tonnes of carbon released into the atmosphere. These small statistics give light and understanding of the relevance of the forest sector in adapting and mitigating climate change. Tropical forests are net sinks of soil carbon and repository of 195Pg of above ground biomass carbon [34 – 37]. However, the role of forests, especially tropical forests, which cover only 6% of the global land surface in climate change mitigation through the highly dense carbon stock has been compromising by humankind activities mainly through deforestation and forest degradation. Pertinent studies on tropical ecosystem carbon cycling are highly cited in the literature e.g. [38 - 41]. Meanwhile, the magnitude of sequestration is a function of multiple factors, notably: climate management, social barriers, and the period of monitoring. This particular passage has come to throw more lights on the role of Land Use, Land Use Change and Forestry (LULUCF) sector in the abatement of atmospheric greenhouse gas, most importantly carbon dioxide. In its special report on LULUCF, the Intergovernmental Panel on Climate Change (IPCC), cited by Watson et al. [42] underlined the potential removal of 87PgC by LULUCF at the global level by 2050. This role of climate cooler and regulator and stabilizer of atmospheric carbon dioxide has been emphasized by [43]. Simply put, forests can play a decisive

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role to meet the goal of Intended Nationally Determined Contributions (INDCs) of all the parties signatories of the UNFCCC agreements. To recall, parties of the UNFCCC have been asked to disclose their demarches to attenuate greenhouse gas emissions from their different sectors of activities in relation to UNFCCC post-visions 2020 to curb global warming and climate change. This recent study conducted by the authors above, given the credible evidence of LULUCF contributions in reducing carbon removal from terrestrial forest ecosystems considerably. Results have revealed a net LULUCF emissions increase with time up to 0.6GtCO2e/yr in 2020 and 1.3GtCO2e/yr in 2030 with a significantly depletion through the implementation of INDC's policies compared to the [44] benchmark emission (3GtCO2e/yr). The significant reductions in net LULUCF emissions are likely to come from Indonesia, Brazil and Ethiopia, respectively under climate change policies. Previous and current statistics estimated that the implementation of INDCs would decrease worldwide LULUCF net emissions by 1.1 while others vowed for 11 GtCO2e/yr by 2030 [45, 46].

Forests have the ability to mitigate climate changes, if well managed through enforced policy actions as previously mentioned. Forests have been given credit and privilege in climate talks and mitigation actions for their capability to absorb billions of tonnes of carbon dioxide at the global scale annually and for their remarkable co-benefits (social, economic and ecological). For example, studies have posited that forests nearly sink 3PgC/yr of anthropogenic carbon and absorb about 30% of carbon dioxide fluxes from fossil fuel burning and net deforestations [47 – 49]. The mainstream of forest contributions to climate change mitigation must emanate from activities dedicated not to jeopardize either its extension or ability to fight back carbon removal and sink in both soils and plants. Sustainable forests management practices to guarantee this eternal role are vividly required in the following ways: (i) increase forested land area through reforestation with new carbon dense species to avoid and reduce respiration from old growth plantations; (ii) increase carbon density of existing forests at both stand and landscape scales; (iii) expand the use of forest products that sustainably replace fossil-fuel CO2 emissions; (iv) tackle main drivers of forest degradation and deforestation through diversification of source of income for the rural communities and promotion of clean energy sources for domestic needs and (v) enforce policies to reduce emissions from deforestation and degradation. Accordingly, the United Nations Framework Convention on Climate Change (UNFCCC) jointly with Food and Agricultural Organization (FAO) and United Nations Environment Programme (UNEP) established a climate-friendly and socio-economic worthy international programme (REDD+), which aims to guarantee forest conservation, carbon stock, biodiversity with additional co-benefits.

2.2 Landmarks REDD+ and UNFCCC

Forests have great potential to mitigate both anthropogenic and natural greenhouse gases, and tropical forests in developing countries who on their parts, have significant roles to play. As such, international negotiations and efforts to provide positive incentives for these countries to contribute to climate change mitigation through sustainable management of forests and land use activities sectors is paramount. Reducing emissions from deforestation and forest degradation and the role of sustainable forests management, conservation and enhancement of forest carbon stock, in acronym REDD+, was negotiated and ratified by all parties of the United Nations Framework Convention on Climate Change (UNFCCC) during a conference of parties (COPs) [50 – 52]. The genesis of REDD+ commenced with UN-REDD, which stands for United Nations collaborative programme on reducing emissions from deforestation and forest degradation in developing countries established in September 2008 for preparedness to the REDD+ mechanism and build these countries capacities to slow down and stabilize atmospheric greenhouse gas. It is a global partnership commitment which brings on board, the developing and developed countries to promote low carbon emissions and climate resilient activities, assist and provide predictable and significant funding as incentive measures to reduced forest-based carbon emissions [52 - 55]. The concept and understanding of UN-REDDs differ from one school of thought to another. While others stand for REDD+, we can also distinguish an additional plus (+) meanwhile, mechanisms and policies gathering them do not vary

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across countries. Each activity has its objective, benefits, and covers three main principles to tackle climate change, viz: reduction of emissions, enhancement of the rate of sequestration and repository of native carbon stock.

The first discussion on UN-REDD activities came out during the Montreal meeting, the eleventh conference of parties (COP 11) in 2005. During that meeting, focuses was on substances that deplete the ozone layer, pioneer countries such as Papua (New Guinea) and Costa Rica asked for new agenda or approach for low carbon activities in developing countries. Consequently, before late 2007 and early 2008, the concept encompassed only Reducing Emissions from Deforestation and Forest Degradation known as REDD. This lays a roadmap to further UNFCCC discussions to define the mechanisms of assessment of the efficacy of the programme and criteria and means of financial support from developed countries. To such, in 2007 during the thirteenth conference of the parties (COP 13) in Bali, the action was provided in which the REDD concept was broadened to REDD+ (evolved from paragraph 70 of the Cancun Agreement; COP16). The additional (+) stands for (i) conservation of forest carbon stocks; (ii) sustainable management of forests and (iii) enhancement of forest carbon stocks. In some books, we can find a second (+) which means (iv) low carbon losses and high biodiversity lands. Later all, the methodological guidance for REDD+ activities was adopted in 2009 during COP15 at Copenhagen [52, 56, 57]. In 2010, COP16 at Cancun, Cancun agreements were established, including policy approaches and positive incentives on issues relating to REDD+. In simple words, the vision defined for REDD+ during the conference can be summarized in two main points, notably: (i) Reducing GHG emissions produced by the forestry sector and (ii) enhancing the capacity of the forestry sector to act as a carbon sinkers, by storing and enhancing carbon in the five pools. In November 2013, COP19 at Warsaw, finalized and established REDD+ rulebook, comprising modalities and guidance (COP16, Cancun) for establishing national strategy/action plan (NS/AP); national forest monitoring systems (NFMS); measuring, reporting, and verification (MRV); forest reference level (FRL); forest reference emissions level (FREL) and addressing safeguards and drivers for deforestation and forest degradation (DDFD). REDD+ is quite easy to understand, but complicated to implement due to the interactive complexities of the components that is involved. In the light of this, parties came to a consensus and defined REDD+ implementation in three core phases (Figure 1), notably: Readiness, Implementation and Results-based actions (RBaA) with a specific objective and involved actions [58, 59].

In sum, climate concerns are worldwide with likelihood significant impacts in developing countries due to their low and inadequate adaptation capabilities. Besides, West Africa is the most vulnerable to climate change due to its fragile ecology, extreme poverty and poor governance. For instance, in Togo, climate change manifests through variations in precipitation and temperature regimes causing fluctuations on the agricultural calendar from one year to another. Effects related to extremes, notably floods and droughts spells have been recorded in southern and northern parts of the country, respectively [60 – 64]. Simulations of future temperature and precipitation regimes in the year 2025 and 2100 are very drastic. The temperature is likely to increase from 0.6 to 4.5 degree Celsius with increase in precipitation from 3.26 to 39.7 mm. Using different IPCC representative concentration pathways scenarios (RCP2.6 and 8.5), temperatures are projected to fluctuate between 0.63 and 0.71oC under RCP2.6 and 0.78 and 0.88 degree Celsius under RCP8.5. Precipitation is likely to fluctuate between 3.26 and 7.6 mm, which equates to an increase from 0.36 to 0.47% [64]. For horizon 2100, the temperature will increase from 0.88 to 4.5 degree Celsius, while we will experience precipitation increase from 3.6 to 26.9 mm. This credible evidence on the likely future climate scenarios are some of the statistics to alert the population and policymakers to take a position to attenuate atmospheric greenhouse gas buildup through positive incentive measures and implementation of climate-friendly mitigation actions. Review of available national communications on climate change and adaptation and mitigation documents clearly the land use land use change and forestry (LULUCF) sector on top of emissions and carbon removal. Also it can be used as carbon dioxide removal and carbon sinker.

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To exemplify this, in 2001, the benchmark emission from the forestry sector mainly, through land use change was 22132 Gg CO_2 in 1995. For the second National Communication on Climate Change [62], the benchmark emission level was 2000 with 10 260. 36Gg and 9010Gg of carbon dioxide (CO_2). Finally, the recent communication revealed a significant increase from LULUCF sector. Considering 2005 as baseline data, which was 17,743.42 Gg (72.93% progression compared to 2000 with 10, 260.36 Gg and 12, 569.42 Gg CO_2), LULUCF sector has emitted 11, 559.70 GgCO_2e. It is against the above background that, policies and actions have been put in place to reinforce, halt forest shrinking and improve the ability of forest in mitigating climate change in Togo, where forests are defined in terms of minimum tree heights of 5 m with at least 10% crown cover within minimal area of 0.5 ha. These forests are experiencing rampant degradation and deforestation, and the rate of vegetation recovery is 24.24% referencing to the national forest inventory conducted for the starting of reducing emission from deforestation and forest degradation (REDD+) project. Based on the statistics of 2011, forest occupies 6.8 % (386,000 hectares) of the total land mass with an annual deforestation rate of 4.5% [65]. To date, up to 50% of these assets are lost due to human-induced activities. In terms of additional policies, promulgation of decree dated on 5th February 1938 related to forest sector (forest protection and reforestation) in Togo. This act aims to define rules and regulations to protect and monitor forests and natural resources utilizations and establishment of national tree celebration day (1st Jun., 1977) and environment by the Ministry of Environment and Forest Resources.

These measures were followed by the elaboration and adoption of the National Action Plan for Environment. Moreover, valuable actions are taken towards (i) reforestation (5000 ha/yr) and promotion of agroforestry onto cultivated lands and (ii) sustainable management of remaining forestlands through enforcement of laws against deforestation and forests degradation. Unlike neighboring and some of West African countries (e.g., Ghana, Nigeria) which are more advanced in REDD+ project and its mechanisms. Togo had commenced its readiness proposal plan in 2015 with ProREDD project. REDD+ readiness and rehabilitation of forests (ProREDD) project was launched to meet these objectives (https://www.giz.de/en/worldwide/31415.html). With financial support of donors (World Bank, BMBF) and with strong political will of the government, national strategies and actions plans have been established to facilitate the start of the project. This step is very crucial to define forest monitoring and information systems as well as reference levels in terms of emissions and species distributions. It is in light of these achievements that, the national forest inventory was organized for qualitative and quantitative estimations of our national forests resources, as benchmark for monitoring and to mitigate climate change and deliver non-forest benefits (social, cultural and economic). This step also underlines proximate and underlying causes of deforestation and forest degradation through inclusive discussions of key stakeholders in order to develop, experience and implement incentive measures to surmount emissions from LULUCF sector in Togo. Moreover, it also focused on the timely and accurate evaluation of emissions resulted from forest conversion to other land use changes (e.g. agriculture, building, road, etc.) via remote sensing techniques combined with transition and intensity analysis.

3. Drivers of deforestation and forest degradation

Deforestation and forest degradation is driven by a couple of forces which can be environmental (climate change), socioeconomic (poverty) and political (government interventions). These determinants can jeopardize the successful implementation of REDD+ projects and this must not be overlooked. The successive story of REDD+ is tightly correlated to how best we can identify, solve and draw valuable policies to mitigate these driving forces on forest resources in playing their essential role, notably carbon sequestration, mitigation of climate change and conservation and diversity of biodiversity. The intensity of deforestation and forest degradation driving forces varies across the globe with significant imprints in developing countries. Meanwhile, determinants, agents and institutions are quite similar. For instance, in Togo, deliberate expansion of croplands entails significant degradation of native forestlands in association with total conversion of forest areas to croplands meanly for cash (cocoa agroforestry, coffee, tea, palm oil production) and food crops (rice,

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maize and cassava cropping). Available statistics showed that forest occupies 24.24% of the total land mass with an annual deforestation rate of 4.5% will loss of up to 50% of vegetation cover [65, 66]. Among the causes mentioned above, agriculture and population growth are the frontline determinants endangering deforestation and forest degradation mainly in sub-Sahara African regions and other developing countries. Existing extensive literature and policies on this matter give clear evidence of the level of a hindrance; draw and propose analytic frameworks to comprehend and analyse them [56, 57]. According to [54], drivers in REDD+ context are actions and processes direct or indirect factors that jeopardize deforestation and forest degradation surmountable, through their accurate identification, understanding and analysis of their relevance and layout of frameworks on how to analyse them.

These measures are keys to deepen the understanding of main DDFD, critical for readiness phase [67]. Besides, it helps in the development of national REDD+ strategies/action, plans and the formulation of policies and measures. Drivers of deforestation and forest degradation (DDFD) can be separated into direct and indirect. Direct drivers also called proximate causes are anthropogenic or immediate actions with impacts on forest cover and carbon losses, while indirect drivers, underlying causes, or driving forces are complex interactions of fundamental social, economic, political, cultural and technological factors. For, agriculture expansion, infrastructure, legal or illegal mining, logging etc. and population growth, international markets and national policies and measures are some of frontline direct and indirect drivers of forest depletion [68, 69], respectively. A synthesis report on drivers of deforestation and forest degradation for REDD+ policymakers published by Kissinger et al.[70] disclosed the contribution and areas affected of five main drivers (urban expansion, infrastructure, mining, local/subsistence and commercial agriculture) of deforestation and three key drivers of degradation (Commercial timber extraction, fuelwood collection and charcoal production) from 2000 to 2010 across three continents viz: Africa, Latin America, sub and tropical Asia. Results revealed that, in terms of the proportion of deforestation, agriculture is driving 80% of worldwide deforestation with one third in Africa, sub and tropical Asia while large-scale commercial takes two third in Latin America. In the meantime, subsistence agriculture accounts for a similar proportion in each continent. On the other hand, degradation statistics show that fuelwood extractions and charcoal productions are critical drivers in Africa while commercial timber harvesting accounts for 70% of forest degradation in the sub and Tropical Asia and Latin America. The context of deforestation and forest degradation in Bolivia also informed that, mechanized agriculture, cattle ranching and small-scale agriculture are the three vital direct drivers of deforestation up to 30%, 50% and 20% between 2000 and 2010, respectively [71] while, forest fires, selective logging (legal and illegal), grazing and fuelwood collection have been identified as frontline to forest degradation at different intensity [71, 72].

Additional studies in relation to drivers of deforestation and forest degradation span across various countries e.g. [28, 73, 74, 75]. For instance, Geist and Lambin [76] analytical framework on DDFD identified ancillary factors (physical, climatic and land characteristics) as external to proximate and driving forces related to the forest depletion. These external factors serve as mediators between the indirect and direct forces and this can jeopardize the effectiveness of REDD+ scheme. On the other hand, Sulaiman et al. [77] investigated the effect of poor institutions and bad governance as well as fuel consumption on forest degradation using cluster data from 2005 to 2013 of 45 sub-Saharan African countries. Results were impressive and gave a valuable answer to this empirical question. In fact, wood fuel consumption, corruption and poor governance lead to forest degradation in the region. This suggests that effective control of corruption and poor governance, as well as instauration of policies and measures to promote domestic gas consumptions, can significantly curb forest degradation in sub-Saharan Africa.

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In sum, the factors of DD are complex and dynamic and they need to be well scrutinized. Besides, proper identification of drivers is vital for effective implementation of policies targeting carbon sequestration and greenhouse gas removal. To such, linkage of spatial analyses of socioeconomic data as well as policies and measures can make drivers identification strong and accurate to establish reliable frameworks to analyze halt or combat them though, deforestation and forest degradation are growing at an alarming rate.

4. Land use land cover change transition and intensity analysis

Land Use Land Cover Change (LULCC) analyses are vital processes to identify drivers of degradation of natural land cover and explore possible policies and measures to curb their destructions. It refers to the change in the natural aspect of the land cover between at least two times-period over the same spatial extent and geographic location. It can be in terms of size (quantity of change) where only the percentage of overall annual change in LULC types are exposed based on the contingency tables or Markov Chan Analysis e.g. [26, 27, 32, 78, 79]; or in terms of size and intensity known as unify analysis (Interval, Category and Transition: ICT) introduced by [29, 31]. The first approach is based on a separate contingency tables of considered periods without accounting for the speed of the changes, the behaviours and transition levels of categories for the simultaneous periods. Moreover, it is also regardless of the uniformity of the annual rate of change that can occur. Besides, the quantity of changes in LULC types is less informative and explanatory of possible actions to limit the damage on a specific land use type. The proportion of changes does not expose how and which of land use types. However, the intensity of conversion may vary from one point to the other, which generates information on the status of the land category. The size and intensity analysis are carried out through three main phases, notably: interval, category and transition, which give valuable information about the speed (slow or fast) of change; categories regarding active or dormant and their gains and losses compared to the uniform annual rate changes, respectively.

This method has been applied and tested across the globe in comparison with existing classical methods. It comes from the assumptions that: (i) annual rate of change in land use land cover types is not similar (increase or decrease) over the time.; (ii) gains and losses may vary across each land category for each time interval and (iii) some categories may be targeted or avoided and vice versa over each time interval [29, 30, 80, 81]. In the simple manner, this approach aims to answer three main questions: (i) during whom time interval is the overall annual change rate relatively slow versus fast? (ii) Which land use categories are relatively dormant versus active? Also, (iii) which transitions are targeting versus avoiding for each time interval? With regard to the uniform change (stationarity). According to [30], reports based only on the net land use land cover change category are not accurate but misleading because, gross gains and losses in the land use category are overlooked. In the following, land use intensity analysis across various agroecology are duly summarized (Table 1). Land use intensity analysis and land classification go hand in hand in giving detailed information regarding the characteristics of the transition. Net land use changes do not only expose or give information on how the transition behaves, and the type land use categories are targeted or avoided and active or dormant. It comes to reinforce the quantitative analysis, which gives information about the overall net change, categories that are persistent and those that are lost and/or gained. Many land use land cover change methods fail to account for these details. e.g., Markov Chain analysis is one of the most powerful land use algebra analysis but does not gives information about the behaviours of the categories. Unlike intensity analysis, which is performed at three levels: interval, transition and category to assess the speed of change, dormant or active as well as these targeted to lose and to be avoided; Markov chain just gives the net change of each interval, but its ability to explain the changes is limited. Also, it is hard for a Markov approach to reveal information regarding the interval, category and transition level for the investigated periods. Moreover, the Markov approach compares the entries within each row of the transition matrix, since the Markov approach divides the area of each transition by the area of the losing category at the initial time. Thus, the Markov matrix is not adequate to scrutinize the process in terms of gains, while the process of gains is the primary focus in many analyses.

5. Conclusions

Forests play a decisive role in adapting, mitigating and enhancing biodiversity in tropical regions and worldwide. This paper emphasizes on the extensive literature of forests as sink and source of carbon dioxide and relevance projects for carbon stock and enhancements, notably REDD+ (reducing emission from deforestation and forest degradation). From the history of the methodology, we also scrutinize the existing methods for land use change analyses with emphasis on land use land cover change based on cross-tabulation and Markov Chain Analysis as well as the size and intensity analysis, for their strengths and weaknesses in giving tangible land use information. Knowing the speed of the transition, the category of land use systems involved in terms of dormant or active and avoided or targeted. This approach is vital for forest ecosystem conservation through carbon sinks and forest conservation and projection project is dedicated by the United Nations Reducing Emission from deforestation and forest degradation, forest conservation; conservation and Enhancement of Forest Carbon Stock (UN-REDD+). Accordingly, both scientific, political and communal attributions and law enforcement, must serve as robust commitments to the attainment of these visions. Simply put, these actions must be following three main components:

- Politics must enhance decisions and actions to promote scientific research targeting forest ecosystems and climate change mitigation through valorization of incentives, notably technical (capacity building); political (enforcement of protection laws) and economic (tax withdrawal or deduction on domestic clean energy usage and promotion of climate-smart actions);

- Research must be accurate and policy-oriented and must serve as a valuable instrument to bridge the gap of knowledge between theories and actions. Instruments and tools used must be accurate;

- Promotion of green economy actions and sustainable food productions techniques, viz: sustainable agricultural and land management and agroforestry practices must go hand in hand with carbon plantations (forest conservation and enhancement) must be underlined, promoted through communities as climate change policy and options to slow down the build-up of atmospheric greenhouse gas especially carbon dioxide (CO_2) concentrations.

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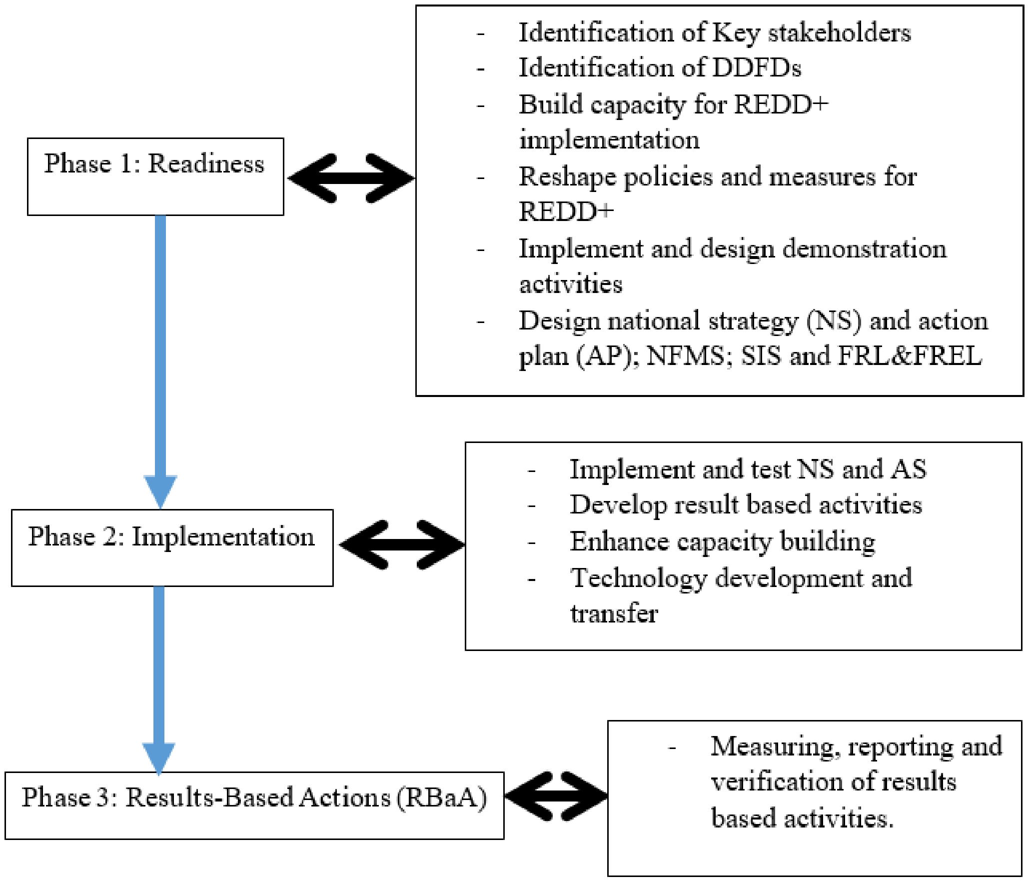

Figure 1. Steps of REDD+ Implementation
Source: Adapted from [53, 54, 55].