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A REVIEW OF CARBON EMISSION ESTIMATION USING REDD+

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ABSTRACT

Forest degradation and carbon emission stock estimation are becoming important components of fighting global warming. By increasing afforestation as well as plantation, carbon Dioxide in the atmosphere gas could be saved in solid-state in the trees and shrubs, which can be estimated through evaluation & quantify forest biomass analysis. The most difficult task is assessing forest carbon stock transformation and analyzing forest degradation, as degradation entails changes in forest structure that do not include impacts on land use, which are difficult to detect with remote sensing techniques. There seems to be no particular method for monitoring forest degradation in the particular instance of the REDD+ policy, as per the IPCC guideline under UNFCCC. This paper on forest degradation & carbon stock assessment changed that depended on the many parameters such as availability of historical data, resources, capacity, the limitation & potential of various measurement & monitoring approaches. Through the field data recent degradation can be measured (i.e., various types of forest inventory, commercial data sets of the forest, permanently plot data, and from the domestic market's proxy dataset). The ideal opinion is generated by combining these techniques as well as remote sensing data i.e., instantly mapping canopy length and vegetation structure changes or indirectly mapping by modeling approaches. For assessment of past forest degradation mostly the developing country are lack consistently collect historical field data sets and mostly depend on the remote sensing technology and recent field survey approaches to the assessment of changes in the current carbon stock. The historical assessment of forest carbon stock and forest degradation has low accuracy and large uncertainty. However, recent geospatial technology improved the monitoring capacity of forest degradation estimation systematically which will support today to reduce the uncertainty through even historical estimation. Furthermore, it describes the useability of geospatial technology to estimate terrestrial carbon sequestration, and finally, limitations, gaps & needs to further study are underlined.

KEYWORDS: Forest Biomass, Carbon emission & sequestration, GIS & Remote Sensing, REDD+.

INTRODUCTION

From the perspective of the United Nation Framework Conversion on Climate Change (UNFCCC) the Reduced emission from degradation and forest deforestation (REDD+) refers to the forest-covered loss with accordingly loss of carbon stock. Vegetation regions are covered by forest fires, over-harvesting, pests, and also climatic events including snow, air, frozen, drought, river flooding, and other events that affect roughly 100 million hectares worldwide each year. [1,2]. Almost 10 times these values represent globally i.e., affected through deforestation (i.e., 13 million $hayr^{-1}$ in 2000-2005) [3,4]. The tropical region is the most well-known largest scale forest disturbance & degradation region [5-8]. But in the case of large forest-covered areas, the reduction of forest carbon stock is not well characterized by time & space.

The UNFCCC's mitigation action of climate change is agreed on 5 different components in the forest sector under negotiation for REDD+. This includes reducing forest degradation, reducing deforestation, sustainable management of forests, forest enhancement, and forest conservation. Identify, monitoring & established national forest cover area are the main need of negotiations by using an appropriate combination of ground base forest carbon inventory and remote sensing (RS) approach to estimate anthropogenic greenhouse gas emissions related to the forest by sources and sink, which also need to established emission levels by using historical reference data and maintain for national circumstance [9].

There is international debate on the technical & political level on the issues related to monitoring & assessing forest degradation concerning carbon stock changes [10,11]. In recent times, there has been a lot of interest in REDD+ implementation in its early stages, to underestimate those activities that have contributed to forest degradation and define carbon emissions as a result of this operation of source emission standards. Due to deforestation, their degradation is increased i.e., necessary to prove that it has a positive impact on the REDD+ implication[12].

About historical moments, an overview of methods and techniques for carbon emission measurement from forest degradation. The following are some of the most critical issues and hypotheses addressed in this review:

- REDD+ consists of specific measurements, such as national-level monitoring which use IPCC guidance over the need to demonstrate a reference CO_2 emission and analyze how REDD+ guidelines address the real causes of forest carbon loss.
- The IPCC guidance referred to using the changes in the activity area and emission factors for estimations national level & mostly focused on emission sources region & different ways to manage the uncertainty.
- Their need to be very consistent with carbon emission estimates from recent and historical perspectives, also for correlation to reduced impact of actual uncertainty.
- Different methods such as field measurement & RS are needed for derived activity data and also required emission factors of the different degradation processes. The availability of data are varying concerning the region and historical periods.

The living organic matter that is total presence in the trees calculated as oven-dry tons/unit area is called forest biomass. It is not an easy way to measure forest biomass in the areas of various and complex environmental conditions. Though in the arid region were very much lower vegetation density covered areas these approaches are also applicable and they only required consistent and accurate measurement methods. The process is when the atmospheric CO_2 is stored & captured as a solid and liquid state i.e., called carbon sequestration. Naturally, this process occurred through live trees, organic matter, soils, & oceans, etc. [13]. Any storage or reserve of carbon is called a carbon pool. The storage of CO_2 is three-way such as terrestrial sequestration in plants and soil, Geological sequestration underground, and in the deep oceans' sequestration. Biologic or terrestrial carbon sequestration is the process of storing CO_2 from the atmosphere to the root, soil, stems, and plants. In this way, the forest and soil made a large amount of carbon storage pool. Through the photosynthesis processing atmospheric CO_2 is converted as the biomass in the forest. Annually 2-4 gigatons of estimated carbon are sequestered in the forest [14]. In the atmosphere, almost 60% of carbon sequestrations are returned through the deforestation process [15].

The issues of carbon sources and sinking the forest play major contributors to global climate change [16,17]. In the global & regional carbon cycle, estimation of carbon from the forest ecology system is much significant to understanding the impact of land-use change on carbon flux, budgeting & nutrient cycle. Likewise, forest biomass monitoring for estimation of carbon stock i.e., not only environmental issues actually >190 countries committed to implementation & support the sustainable management of the forest also increase forest carton stock by the Paris agreement on climate change[18]. Through the afforestation processing, carbon sequestration is increased and helps to reduce the carbon footprint & reducing greenhouse gases[19] as a result, policymakers' and government officials' interests are intrigued[20]. The UN program for REDD+ is an international program to help nations to earn a financial incentive for that country are implemented climate policies and reduce CO2 emissions [21].

The main goal of this review is to look at different types of geospatial technology-based methods for estimating carbon emissions with the REDD+ contribution.

METHODOLOGY AND DISCUSSIONS

Geospatial methods

For estimation of forest above-ground biomass (AGB) & carbon stock, their required plots, the survey, the forest inventories & used allometric equations to measure using in-situ data [22] & their need to collect data more accurately. In another way, RS & GIS techniques provided more advanced data collection in the inaccessible region by traditional field measurement with less time & cost-effectively. With various resolutions & sensors, RS data has been obtained from different sources covering local to global levels on a large to small scale. There are a variety of sensors and specifications available, including passive sensor data such as thermal and optical, as well as active sensor data such as LiDAR and Radar sensors. Another option GIS is a spatial information platform capable of analyzing and simulating georeferenced data, as well as establishing spatial models of various scenarios and allowing for real-time forest management.

Forest biomass data and other vegetation structural variables have recently been collected using GIS and RS methods. These methods are very efficient for mapping & monitoring forest distribution at large scales & quantify

Gross carbon emissions — Deforestation — Degradation

$$C_{gr\_em} = \left(\sum_{i=1}^{m} A_{loss(i)} \cdot C_{loss(i)} \right) + \left(\sum_{i,j=1}^{n,m} A_{dgr(ij)} \cdot C_{dgr(ij)} \right) \tag{1}$$

A_{loss} = Area of deforestation (ha)
C_{loss} = Carbon emission from deforestation (t/ha) } for forest types i … m

A_{dgr} = Area affected by degradation (ha)
C_{dgr} = Carbon emission from degradation (t/ha) } for degradation types j … n, for forest types i … m

productivity [23,24-27]. There are several methods for mapping vegetation using geospatial technology, including the first, which uses image processing techniques to improve image quality. Second, categorize the trees and shrubs on a species and individual level. Third, establish a link between vegetation type and RS imaginary spectral properties. Finally, categorized spectral signatures or classes into vegetation types by grouping each similar pixel in one class or type of vegetation land. The most accurate classification method is based on the object-oriented base classification (OOC) approaches and the pixel-based classification (PBC) approaches. It depends on the data and their area of application whereas both classification approaches have some advantages and disadvantages [28].

Monitoring is required – meaning, operators, and IPCC guidelines.

Equation 1 gave a general overview of how to calculate and assess gross carbon emissions(Cgr_em) from the forest land due to the deforestation & loss of carbon stock in the forest land which is the remaining forest land from the level of a national perspective [29].

The forest degradation methods assess the carbon stock change in the forest land remaining the same land, using the combination of activity data & emission factors. While carbon stock is removed by deforestation permanently i.e., depends on the frequency and type of the human disturbance. The equation shows that there needs to be a clear distinction between degradation and deforestation with various types of existing degradation.

Given the fact that many definitions exist, no clear standard of forest degradation has been approved on the international stage [30-32]. Forest degradation, as defined by the UNFCC in the context of REDD+, refers to the reduction of carbon stock in forested areas that is still forest land[11], as well as caused by human activity sources of pollution & removals. Though it is well established that human-caused degradation has a negative effect on the carbon stock about a specific threshold value of tree crown coverage, these values can vary by nation.

In the approaches of REDD+, their necessary & need to be understood activities that cause forest degradation. This information is also needed for the definition of suitable methods of forest monitoring & measurement purpose for formulating apricate REDD+ strategies & policies. Various types of degradation, including canopy damage and tree removal, have different effects on the forest carbon stock. that are useful for forest degradation monitoring using remote & in situ methods. Normally within one country, various types of degradation processes exist, with interaction among the process & recurrent events to leads more carbon emissions. Forest degradation has not equally distributed over the country's territories & it's may or may not effected large areas.

The main way of direct forest degradation includes –

The local household people are privately or communally extracting the forest for sales in the local market or useful purposes such as a collection of fruits, fuelwood, roots & other parts of trees for medicinal purposes, harvesting of timber & thatch for construction. With enhanced forest degradation, the newly developing country quickly urbanized, generating consumer needs for forest-based products (i.e., charcoal). Industrialization or commercial extraction of the forest on large scale makes the loss of carbon stock. Also, uncontrolled anthropogenic and accidental wildfires were the major source of forest degradation & loss of carbon stock.

There are two components to measure CO_2 emission from forest degradation such as -

At the national level forest area remain a forest area that is affected by degradation & how much forest area & where degradation occurred such information is calculated through RS & forest inventory. Another way, How much carbon is released into the atmosphere due to forest degradation per unit area that's has measured to find changes in forest carbon stock. Such statistics have been measured through field surveyed sampling & repeated forest inventories such as forest carbon emission factors (EF). Five types of forest carbon pools should be measured such as aboveground biomass, soil organic matter, belowground biomass, litter & deadwood [33]. The three tires for estimation of emission are provided by the IPCC [33]. IPCC default value used in tire 1 and country-specific data use in tire 2 and tire 3 used with repeated measurement actual inventories or combination with plot data used to measure changes of biomass directly.

Field observation & expert survey to assess degradation -

As well design to estimate forest degradation a field sampling scheme has required to collect the carbon stock data from the ground. With period to assess carbon stock change field served has required. Such type of field methods for evaluating carbon stock changes includes – commercial forestry data, proxy data from the domestic markets, and inventory-based approaches. To estimate changes of forest carbon stock with low uncertainty (i.e., tire 3 level) assumes that continually measure with a different point of time i.e., before degradation to afterward to identify emission factors at different points throughout the period. Long-term forest information is now almost non-existent in most developing countries or is restricted to specific regions or field assessments in a small region of the country. So, permanent sampling plots are used to monitor changes in forest resources with temporal dynamics. In so many countries, forest stock data is taken regularly from forest organizations and is generally not able to focus on the effect of degradation on carbon stocks.

Remote sensing methods for measuring degradation -

To monitor and measurement of the areas affected by degradation through remote sensing methods there are various advantages such as i) it represents coherent, consistent, fairly & transparent accurately reported in the areas and helps real-time monitoring and land use land cover (LULC) changes. ii) in the case of the logistically or remote complected region it provided spatially in detail national datasets. iii) it provides long historical trend data & objective information in an area where data don't exist today. However, also it has several disadvantages such as – i) its data can be disturbed by cloud cover in some areas (for optical data). ii) technical capacity has limited to sense, capture & record of changes of canopy-covered (for fine-scale changes). iii) interpretation of images sometimes difficult & labor-intensive especially in the case of the national estimate are derived. Aircraft data provide so much details information & resolved most of the inherent limitations to providing data about forest mapping purposes [34-36].

Rather than mapping deforestation, it's more difficult to map forest degradation using RS techniques [37]. So, the degradation forest is surrounded by a multifaceted and mixed of various land cover types such as grasses, leaf litter, dead trees, and shade, and the degradation region's thumbprint has altered within 1-2 years. [38, 39, 40]. Various types of medium resolution satellites are used for forest degradation mapping purposes such as Landsat, SPOT, and ASTER, etc., and very high-resolution satellites are used such as Quickbire or Ikonos, also aerial digital imagery is acquired to generate maps & monitoring forest cover regions.

The use of remote sensing to monitor forest degradation can be done in a variety of ways-

Directly observe forest canopy height and damage or health condition & changed areas of the forest-covered region for assessments, mapping & monitoring of forest degradation region [39, 41, 42]. They're frequently mapping with this approach because the spatial signature of the degraded forest area always changed due to canopy gap change (i.e., low biomass secondary species covered the canopy gaps).

Indirect approaches are used when low degradation intensity or when infrequent coverage & little spectral evidence remains of the canopy gaps. The RS method focused on spatial disturbance & evaluation of human infrastructure (i.e., population center, roads, etc.) which are used to measure newly degraded areas [43, 44]. So, this method works on the newly developed areas for the best mapping of forest degradation areas but is less effective on the repeated degradation.

To monitor carbon emission due to biomass burning there are three primary categories are included in this approach such as post-fire burned area mapping, identifying of active fires, and fire characterization. For the emission estimation purpose, these categories are described in GOFC-GOLD (2010). However, for historical periods these approaches are less suitable.

Forest biophysical parameters -

The different biophysical parameters of the vegetation growth can be detected & measured by RS tools based on the assumption that their body parts or branches grow at different degrees [45]. Due to measuring different spectral signatures differently from different forest biophysical parameters RS techniques are capable to measure it. Though the spectral signature is mainly affected by chlorophyll content but the vegetation density is also affected in this signature generation and also shadow, texture, roughness, and soil moisture has affected [46, 47]. In this way using the RS tool can be generated forest biomass. Also, other biophysical parameters are used to make forest biomass such as chlorophyll content, leaf area index (LAI), Leafe nutrient concentration, DBH, height, crown area & diameter, stand basal area & canopy's greenness. Traditionally all these parameters are used to estimate forest biomass. There is a positive relationship between LAI and NDVI during the initial growth stage but after full canopy cover, there is no significant increase recorded [48]. The hyperspectral RS can extract and record reflectance with a large number of narrow bands, which has many benefits for extracting forest parameters like chlorophyll content and Leafe nutrient concentration. [49].

Aerial photography is extensively used to measure different forest parameters such as crown closure, tree height, etc. [50, 51]. For indirect estimation of forest biomass, the canopy reflectance model and multiple regression analysis were used [52]. Medium to more detailed spatial resolution data could be used to estimate crown coverage [53]. To detect and delineate of crown projection area (CPA) the object-based image analysis could be used where the canopy is covered by the trees [54, 45]. The IKONOS with 4 m spatial resolution data could be used to estimate CPA, DBH & stem density [55].

The active RS LiDAR & Radar were used to measure the tree height which is the potential indicator for the measurement age of trees & also used to estimate forest biomass [45]. The P and L band of Radar backscattering is not only used for tree height & age measurement but also used for forest biophysical measurements such as DBH, total AGB, and basal areas measurement [56]. The LiDAR data are used for both tree volume (3D) and height and also estimate forest biomass. The SOPT & IKONOS could be generated stereo viewing of the forest to develop forest canopy height.

GAPS AND LIMITATIONS:

Though RS and GIS technology help to saving of money and time, without additional field surveying for data collection this technology may not achieve their goal [21,57,58]. Although the amount of field data collection with RS are reduced recently. But using the traditional method and data collation to measure the AGB is not rejected today and using the help of the geospatial technology applied advanced modeling and methods to accelerate existing knowledge [59]. So, the geospatial technology can measure AGB but it may not come without its limitation & drawbacks [60]. That is all extremely costly in the RS technology, the instrument is used such as satellites, computers, sensors, aerial photography devices like drones, etc. In addition, the cost of maintaining this technology is very high, especially when it comes to security and trained professionals, to the person in these fields all are very much costly. Likewise, using the computer analysis of RS and GIS data required a trained and skilled person who can understand and make sense of RS & GIS data. In the case use of RS technology in ecological study to estimate AGB & carbon more uncertainty increases because of various landscape, vegetation structure variance, species composition, soil properties, seasonality, and climate variability also disproportionately data and human activities which significantly impacted on the biomass distribution and change assessment [61,62,63]. Also, without ground base data collection only the RS sensor may not able to measure the forest carbon stock [21,57,58]. At any time, the forest biomass and carbon stock could be affected by disturbance likewise forest structure is also influenced by environmental conditions, and the ecological process of tree growth, decomposition, and mortality [27,64]. All these issues are considered when RS-based change detection is studied and time-series records of vegetation are required when monitored forest change in a dynamic system.

RECOMMENDATION AND CONCLUSION

This review paper made with supporting so much scientific references over the last five decades. The geospatial technology (RS & GIS) provides an adequate validation for the assessment & monitoring of AGB also the management and modeling of forest carbon sequestration. This technology provided a tool in the developing country for monitoring, modeling, generate a map, of carbon stock, biomass, and soil.

The majority of developing countries lack the past data needed to estimate carbon emissions from across all different kinds of forest degradation[65]. In many countries unlikely based on the past data the historical forest degradation and estimation of the forest carbon change are measured though there are little or no field/ground data available. Remote sensing is the only source of recent past data of carbon source measurement that provide the assessment of past trends. By using archive satellite data historical emission data from the forest products can be collected.

There are so many methods available for estimating forest biomass and carbon stock with varying advantages. The most accurate method is the filled-based measurement method, though they are destructive, expensive, time-consuming, and labor-intensive. But using allometric equations can help alleviate these disadvantages. Unfortunately, these equations apply to mixed species-area with specific sites and ecosystems and in the arid region, it is less applicable. Thus, the recommendation that to build an allometric equation for biomass and carbon stock estimation with RS technology. In the plant species, the carbon sequestration rate that has economic values can be determined by building a spatial database. In this way, it should field the gap & improved the ability to estimate the potential of the plant ecosystem for carbon sequestration.

Only RS-based carbon stock and biomass assessment may not always be possible without ground measurements such as soil sampling and field validation. This procedure goes through three steps such as in the pre-field work identifies the area of interest for sampling, fieldwork which includes the collection of sampling data and plant characteristic measurement, and finally, a post fieldwork activity that includes analyzing and processing of the field data and their validation. Due to long time observation to assessment and monitoring of forest carbon stock there most problem is that the various type of instruments and platforms are used that are so difficult for this variation. The high-resolution RS data are most costly but provide accurate information however moderate resolution data such as Landsat data provide to effectively estimation of AGB with good accuracy & calculate carbon stock consequently. Its most important that the effect of vegetation structure, seasonality, and heterogeneity of landscape are affected on the AGB and forest carbon stock. In addition, this provided good knowledge to the policy mackerel to identify where and what the essential action to

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be taken. The UN program for the REDD+ is an international program to help the country to gain financial support if they use their policy and reduced carbon emission. The geospatial technology is the poutful tool that helps to implement the REDD+ strategy and agenda through continuous monitoring and assessment of all nations' efforts to support the long-term management of carbon stocks in all ecosyst

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