Chapter 2

From Forest Biomass to Carbon Trading

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Additional information is available at the end of the chapter

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Abstract

The role of forest biomass is now greater due to its ability to cope with global warming. Facts prove that forest cover decreases have caused climate change and various disasters such as flood, landslide, drought, extreme weather, and others. Efforts to address climate change have been made by the international community through greenhouse gas (GHG) emission reduction programs with avoided deforestation and forest degradation through the afforestation/reforestation clean development mechanism (A/R CDM), reducing emission from deforestation and degradation (REDD+), joint implementation (JI), and voluntary carbon market (VCM) schemes. These programs are closely related with carbon trading. Carbon markets need a unit of trade. For carbon, this is one ton of greenhouse gas emissions expressed as carbon dioxide equivalents (tCO_2e). That is why measurement of forest biomass is very important. Methods to estimate forest biomass from models, inventory, remote sensing data, and geographical information system are being developed, evaluated, and demonstrated at several pilot regions in the world. Carbon markets are believed to be effective and efficient mechanisms in providing these financing sources. In carbon markets, prices are decisive in generating carbon credits. Higher carbon prices will cause more carbon credits to be generated. Nevertheless, carbon trading from REDD+ is found to be a concern especially for developing countries that is the risk of leakage and non-permanence. This chapter aims to inform the importance of measuring forest biomass as it is used as the basis for carbon accounting on carbon trading.

Keywords: forest biomass, carbon trading, leakage, permanence, additionality

1. Introduction

The role of forest biomass is now greater due to its ability to cope with global warming. Facts prove that forest cover decreases have caused climate change and various disasters such as flood, landslide, drought, extreme weather, and others. Global climate change is widely

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seen as one of the greatest environmental problems facing the twenty-first century [1–3]. The impacts resulting from this period of great change begin to take place, are felt and will affect the whole world, every ecosystem, every nation, and every human endeavor [4]. Scientific consensus points to emissions of greenhouse gases, largely from the burning of fossil fuels, as the primary culprit behind this problem [5]. In this regard, one important effort to reduce greenhouse gases in the atmosphere is to immediately replace fossil fuels with renewable energy sources.

In general, biomass is the total weight or volume of organisms in a given area or volume. Biomass is defined as the total amount of living matter above the surface of a tree and is expressed by tons of dry weight per unit area [6]. For forest, biomass itself is defined as the overall volume of living things of all species at a given time and can be divided into three main groups, viz. trees, shrubs, and other vegetation [7]. Forest biomass is highly relevant to climate change issues. Forest biomass plays an important role in the biogeochemical cycle, especially in the carbon cycle. From the total forest carbon, about 50% is stored in forest vegetation. As a consequence, forest damage, fire, logging or illegal logging, and so on will increase the amount of carbon in the atmosphere. In general, the dynamics of carbon in nature can be explained simply by the carbon cycle. The carbon cycle is a biogeochemical cycle that includes the exchange/transfer of carbon between the biosphere, the pedosphere, the geosphere, the hydrosphere, and the earth's atmosphere. The carbon cycle is actually a complex process and every process interacts with other processes. Plants will reduce the carbon in the atmosphere (CO_2) through the process of photosynthesis and store it in plant tissue. Until the time carbon is refluxed into the atmosphere, the carbon will occupy one of a number of carbon pools. All the components of the vegetation of trees, shrubs, lianas, and epiphytes are part of above biomass. Below the soil surface, plant roots are also carbon stores other than the soil itself. For example, in peat soils, the amount of carbon stores may be greater than the carbon deposits on the surface. Carbon is also stored in dead organic materials and biomass-based products such as wood products both when used or already in the landfill. Carbon can be stored in carbon pools for long periods or only briefly. Increasing the amount of carbon stored in this carbon pool represents the amount of carbon absorbed from the atmosphere [8]. The role of forest biomass is greater after having financial value in mechanism of carbon trading. Carbon markets need a unit of trade. For carbon, this is one ton of greenhouse gas emissions expressed as carbon dioxide equivalents (tCO_2e). Besides that, each greenhouse gas can be converted to a ton of CO_2e through multiplication by the global warming potential of the gas. This is the physics of the gas in the atmosphere that results in energy being absorbed rather than radiated out to space.

That is why there is much research on the measurement of forest biomass from all forest components. In its development, forest biomass measurements include all living biomass above- and below ground, such as trees, shrubs, palms, saplings, and other undersea plants, creeping plants, lianas, epiphytes, etc., and, in addition, biomass from dead plants such as dead wood and litter. Since carbon in the forest can be traded in the carbon market, an accurate mechanism for measuring forest biomass is required. Therefore, the purpose of this chapter is to inform the importance of measuring forest biomass as it forms the basis for carbon accounting on carbon trading.

2. Forest biomass

In general, forest biomass is the mass of the above-ground portion of live trees per unit area. It is a basic forest property linked to the productivity and processes of the forest ecosystem, and is an important indicator of the carbon stock that will help determine the contribution of forests to the global carbon cycle. Methods for estimating forest biomass have been largely undertaken from models or using allometric methods, forest inventory, applications of remote sensing data and geographical information system (GIS). The method has been widely practiced in various pilot areas in almost all countries in the world.

The allometric method for biomass assessment was first discovered by Kittredge [9] in the form of a logarithmic formulation as follows:

$$Y = aX^b \tag{1}$$

where Y = dependent variable (in this case, biomass content); X = independent variable (in this case, may be the trunk diameter or height of tree, root, wide tree canopy, etc.); and a, b = constants. Allometric method is a method of measuring plant growth expressed in terms of exponential relationships or logarithms between plant organs that occur harmoniously and changes proportionally [10]. The methods used to measure carbon content in forest biomass can be done in three ways as follows:

1. Total harvesting method: This method is commonly done to measure the content of biomass or carbon in vegetation of relatively small size, that is, for the level of shrubs and herbs, for example, the types of agricultural crops as a mixture of agroforestry, such as peanuts, corn, rice, soybeans, under plants, shrubs, grasses, and others.
2. Stratified clip method/allometric method: This method is usually done to measure the content of biomass or carbon in vegetation of relatively large size, such as poles and trees. Implementation of this method in the field is usually done by destruction of sample trees, then separating each section of plant organs that generally include roots, stems, branches, and leaves. Parts of the plant organs are weighed for wet weight (if possible) and sampled for drying (oven) to get biomass value. The biomass content or carbon content of each tree is associated with easily measurable growth variables, such as tree diameter and/or tree height. With the number of samples of varying sizes, the allometric equations can be obtained.
3. Estimation method: This method is done using commonly used assumptions to estimate the carbon content of forest vegetation. Some commonly used assumptions for estimating carbon content are as follows:
    a. carbon content of vegetation trees = 0.5 × biomass weight [11]
    b. forest carbon content = 80% × charcoal weight [12]
    c. stem biomass = stem volume × wood density
    d. total above-ground biomass (tree biomass above ground) = biomass stem × BEF (Biomass Expansion Factor).

4. The types of allometric equations formulated include allometric equations based on types of forest, types of tree, and the parts of trees. For example: *Swietenia mahogany*, $Y = 0.9029 (D^2.H)^{0.6840}$; *Dalbergia latifolia*, $Y = 0.7458 (D^2.H)^{0.6394}$; and Tectona grandis, $Y = 0.0149 (D^2.H)^{1.0835}$ where Y is the total biomass of trunk, branch, and leaf; D is the diameter at breast height; and H the total height. The total biomass of five combined tree species (*Swietenia mahogany, Dalbergia latifolia, Tectona grandis, Paraserianthes falcataria, and Acacia auriculiformis*) $Y = 0.0219(D^2.H)^{1.0102}$ [13]; Y = 0.262 + 1.934 D where Y is the total liana biomass in tropical primary and secondary forests and D is the liana diameter; Y = 2.55 + 0.416 L, where Y is the stem biomass and L is the liana length [14]; for young rain tree or *Albizia saman,* Y = −10,31 0.50 + $1820.89X_1 + 10.89X_2$ where X_1 = Diameter and X_2 = Height [15]. Besides that, there are also the relationships between above-ground dry plant biomass and stem diameter of liana [16] and bamboo [17–19]. Generally, several generalized allometric equations for tropical forests have been established and also widely used. Unfortunately, application of such generalized equations to individual sites may lead to large errors in biomass estimates especially when the species concerned is poorly represented by the generalized models. In this case, local allometric models are needed to give an accurate estimation [20].

In a forest carbon inventory, a calculated carbon pool contains at least four pools of carbon. The pools of carbon are above- and below-ground biomass, dead organic matter, and soil organic carbon.

1. The above-ground biomass is all living material above the ground, including stems, stumps, branches, bark, seeds, and leaves from the vegetation either from the strata of the tree or from the strata of the lower plants on the forest floor.
2. The below-ground biomass is all biomass of plant roots that is alive. This root meaning is valid up to a certain diameter set. This is done because plant roots with diameters smaller than the provisions tend to be difficult to distinguish from soil organic matter and also litter.
3. Dead organic materials include dead wood and litter. Litter declared as all organic materials die with a diameter smaller than the diameter that has been established with various levels of decomposition located at the ground surface. Dead wood is all dead organic matter that is not covered in litter either standing or falling on the ground, dead roots, and stumps with a diameter greater than the specified diameter.
4. Soil organic carbon contains carbon in mineral soil and soils organic including peat.

Remote sensing satellites have been used in many studies on forest biomass successfully. The use of remote sensing is increasingly widespread after supported by the use of spatial analysis in the geographical information system (GIS). That is why the making of forest biomass maps and other thematic maps has been done for many purposes. Remote sensing applications have been able to estimate forest structure and biophysical parameters such as land cover, crown closure, stand height, leaf area index, biomass, volume, etc. The advantages of remote sensing applications include systematic repetition scope with spectral and spatial consistency, the ability to monitor areas of interest over time, suitability for large area coverage, and a digital representation conducive to image processing. This is supported by satellite sensors capable of recording the reflectance spectra of the stands which is a combination of soil reflection spectrum, trees and ground vegetation. Stand reflectance depends on the relative amounts of these components within a ground resolution cell.

In relation to the search for renewable energy sources for the future, actual forest biomass such as felled and low-value trees can be an alternative in determining renewable energy sources or bioenergy. Thriving markets for these materials will add value to the working forests and provide an important tool for addressing a number of natural conservation goals, including hazardous fuel reduction, degraded forest restoration, habitat management, etc.

Available forest areas are limited by a number of non-market factors, such as environmental regulations, conservation efforts, the value of non-timber forest, and the behavior of landowners. In addition, economic factors will determine where biomass is available and its quantities. National policies of developed countries and global market mechanisms can improve the demand for woody biomass; then, the prices for these materials will tend to increase as well. The given high biomass prices will certainly benefit forest landowners and increase the bottom line for sustainable forest management. In terms of biomass, buyers will increase the cost for existing biomass users. In terms of the pricing process through supply and demand mechanisms in the market, increasing demand will lead energy producers into competition with forest products for timber and residues, or encourage timber harvesting to unsustainable levels. On the other hand, the forest products industry can afford higher prices for wood fibers than most energy producers can meet, due to the high value of wood, pulp/paper, and other wood products relative to energy values. Thus, the availability of biomass at low costs will limit where and to what extent bioenergy is seen as cost-effective. This is especially true as other renewable energy costs (such as wind, geothermal, solar, and water technology) continue to decline.Actually, the economic feasibility of bioenergy will depend on the supply of reliable and affordable raw materials. In this case, bioenergy has more in common with oil, natural gas, or coal than any other form of renewable energy, such as wind, geothermal, and solar. However, unlike fossil fuels, forest biomass is a living resource, subject to biological forces, climates, and natural disasters. Also, unlike fossil fuels, forests are much appreciated, more than just their energy content. People depend on forests for clean water, biodiversity, timber products, recreational opportunities, essential ecosystem services, and for their esthetic and spiritual appeal. The challenge is to build an infrastructure for cost-effective harvesting of reliable biomass supplies without negatively impacting these other values. The following recommendations address the need to develop infrastructure and an atmospheric biomass market that prioritizes conservation goals, ecosystem restoration, and other forest stewardship objectives.

3. Handling climate change

Efforts to address climate change have been made by the international community through greenhouse gas (GHG) emission reduction programs with avoided deforestation and forest degradation through the afforestation/reforestation clean development mechanism (A/R CDM), reducing emission from deforestation and degradation (REDD+), Joint Implementation (JI), and voluntary carbon market (VCM) schemes.

3.1. Afforestation/reforestation clean development mechanism (A/R CDM) scheme

The forestry CDM is a partnership between the developed and developing countries to reduce greenhouse gas (GHG) emission through the forestry activity: afforestation and reforestation. Principally, carbon trading will assist in reconstruction of forest ecology and forest protection in Indonesia. The actor of the forestry CDM is called the developer of the afforestation and reforestation project under the CDM. This developer is a union of two institutions between investor from developed country (Annex I of the United Nations Framework Convention on Climate Change/UNFCCC) and business sector by state or private company, cooperation, or personnel from the developing country. The Kyoto Protocol is a 1997 international treaty that came into force in 2005; it binds most developed nations to a cap-and-trade system for the six major green house gases. Emission quotas were agreed by each participating country, with the intention of reducing their overall emissions by 5.2% of their 1990 levels by the end of 2012. Under the treaty, for the five-year compliance period from 2008 until 2012, nations that emit less than their quota will be able to sell emissions credits to nations that exceed their quota. It is also possible for developed countries within the trading scheme to sponsor carbon projects that provide a reduction in green house gas emissions in other countries, as a way of generating trade-able carbon credits. The protocol allows this through CDM, in order to provide flexible mechanisms to aid regulated entities in meeting their compliance with their caps. The UNFCCC validates all CDM projects to ensure they create genuine additional savings and that there is no carbon leakage. The developer of the afforestation and reforestation project under the CDM can obtain Certificate of Emission Reductions (CERs) if they make: (1) project proposal of the afforestation and reforestation project under the CDM and (2) project design document for project activities under the CDM.

CDM projects labeled by the Gold Standard (GS CDM Project) must be verified by an independent auditor authorized by the United Nations and must meet more stringent requirements than regular CDM projects. This unique quality standard is chosen to demonstrate a broader CSR commitment and it is likely that the credits from the Gold Standard project will remain eligible in the future compliance regime. These high-quality carbon credits are often used by international banks, insurance companies, public authorities, or individuals [21].

In our opinion, the afforestation and reforestation project under the CDM is very flexible because it can be done at forest area, forest community area, state forest area, and private land. Land use change that can be done in the afforestation and reforestation project under the CDM is conversion from agriculture, wetland, settlement area, ranch area, or prairie to forest. The types of forestry activity for implementation of the afforestation and reforestation project under the CDM include agroforestry, silvofishery, rubber estate, monoculture and mixed species plantation, multipurpose species plantation, etc.

3.2. Reducing emission from deforestation and degradation (REDD+)

The Parties to the United Nations Framework Convention on Climate Change created an ambitious plan—the Paris Agreement—for global action on climate change mitigation and adaptation at the 21 Conference of the Parties in Paris in 2015. As part of the plan, the Paris Agreement promotes the adoption of policy approaches and positive incentives to reduce emissions from deforestation and forest degradation, the role of nature conservation, enhancement of forest carbon stocks, and sustainable forest management known as REDD+. The aim is to enable stakeholders to contribute to climate change mitigation. Countries in Africa, Latin America, and the Asia-Pacific region are working on their REDD+ strategy and developing an architecture to monitor, report, and verify emissions reductions [22].

REDD+ in international climate change policies is often championed as an important mechanism in response to the accepted fact that deforestation and forest degradation account for about 20% of global greenhouse emissions. Deforestation and forest degradation are the main causes of climate change. In this regard, REDD+ is understood as a multifaceted response mechanism, with targets including the protection and conservation of forest areas, reforestation, forest restoration, and sustainable forest management. Ultimately, REDD+ seeks to increase or conserve carbon stocks contained in forests, but the associated benefits of better forest conditions also provide lower ecosystem services. In addition, it also seeks to improve soil stability, provide livelihoods, maintain biodiversity, supply raw materials, and reduce flood risk [23].

Through this REDD+ program, carbon trading is possible in many countries. In the development of REDD+, implementation is still facing many obstacles, especially in developing countries such as in some countries of Asia and Africa. One of the obstacles to REDD+ implementation is the adoption of Forest Reference Emissions Level (FREL) used as a benchmark/country/territory reference to measure GHG emission reduction performance. This FREL needs to be prepared by meeting the requirements of the COP, in accordance with the technical assessment guidance, the application of the principles of transparency, accuracy, completeness, and consistency of data, as well as practicality and cost-effectiveness of its measurable, reportable, and variable (MRV) aspects. Through this national FREL, it is expected that the status and level of future GHG emission reduction will be measurable and monitored, and can be reported periodically. In the implementation of MRV aspects on REDD+, it is necessary to carefully measure forest biomass among others by the use of local allometric equations. Therefore, for a country with high biodiversity, it will certainly require many local allometric equations, and developing countries will have their own constraints in implementing it. Implementation of REDD+ requires long-term financial certainty and this will be realized if there is certainty in the carbon market.

3.3. Joint implementation

The definition of a joint implementation of Article 6 of the Kyoto Protocol provides the possibility for a country to reduce GHG emissions or a limiting commitment under the Kyoto Protocol (Annex B Party) to obtain emission reduction units (ERUs) from emission reductions or other Annex B party emission removal projects, with each unit equivalent to one ton of CO_2, which can be calculated to meet its Kyoto targets. JI provides the parties with a flexible and cost-effective way of fulfilling some of their Kyoto commitments, while the host party benefits from foreign investment and technology transfer. This project should provide for emission reductions by sources, or increased absorption by sinks, which is additional to what should have happened. The project shall have the consent of the host party and the participant shall be authorized to participate by the party involved in the project [24].

3.4. Voluntary carbon market (VCM) scheme

The voluntary carbon market (VCM) scheme is slightly different from CDM, REDD+, and JI. As part of the global carbon market, the voluntary CO_2 market differs from the compliance schemes under the Kyoto Protocol and the EU-ETS. Rather than undergoing the national approval of project participants and the registration and verification process of the United Nations Framework Convention on Climate Change (UNFCCC), the calculation and certification of emissions reductions are carried out in accordance with a number of industry-made standards. The advantage of lower development or transaction costs makes the voluntary market particularly attractive to small and sustainable projects where the UN certification process is too expensive.

Compared with compliance markets such as EU-ETS, the total size of the voluntary CO_2 market is much smaller. The credits coming from the voluntary CO_2 market are called voluntary emission reductions (VERs). Currently, VER is mostly used by companies that want to voluntarily offset the emissions generated during their business activities to demonstrate social responsibility and build a healthy and green corporate image. More companies are investing in VER projects to reduce their carbon footprint and to achieve "zero emission" status.

4. Carbon trading

Carbon trading is a market-based mechanism for helping mitigate the increase of CO_2 in the atmosphere. Carbon trading markets are developed to bring buyers and sellers of carbon credits together with standardized rules of trade. Any entity, typically a business, that emits CO_2 to the atmosphere may have an interest or may be required by law to balance their emissions through the mechanism of carbon sequestration. These businesses may include power-generating facilities or many kinds of manufacturers. Entities that manage forest or agricultural land might sell carbon credits based on the accumulation of carbon in their forest trees or agricultural soils. Similarly, business entities that reduce their carbon emission may be able to sell their reductions to other emitters. The legal aspect of carbon trading is CERs. In other words, carbon trading is a market mechanism for reducing GHG emissions. The idea is to price the carbon so that the activities that emit GHG become expensive. The carbon trading section allows companies to buy and sell carbon credits on the carbon market. Therefore, companies can continue to produce GHG as long as they can buy enough credit to cover their emissions. In addition, the credit market also allows the government to ramp prices by controlling credit supply, thus accelerating the transition away from activities that release GHG [25].

Like other goods or services, the price of carbon credits in carbon trading is established by the intersection of supply and demand. Contrary to regulated markets where supply and demand for carbon credits are regulated through complex regulation, supply and demand for carbon credits respond to free market transactions.

One of the factors that support the determination of carbon trading is the rise in energy prices in the world. This encourages people to reduce their consumption and lower their personal share of global emissions. But beyond that, there is actually a growing framework of economic solutions to this problem. Two major market-based options exist, and politicians around the world have largely settled on carbon trading over their rivals, the carbon tax, as the method chosen to regulate GHG emissions. In carbon trading is not separated by the carbon tax. The alternative to markets for carbon prices is to impose a carbon tax. It has never been a popular choice with voters and is government-dependent to act reasonably both in how they impose the tax and what they do with revenues. Therefore, for taxes to have a mitigating effect on global warming, governments need to spend on revenues for schemes that reduce emissions or buy carbon credits so that net emissions are reduced. Carbon trading takes pressure from governments to source and fund emissions reductions because price pressures make activity change. Emitter must buy permission or credit in the market to balance (offset) the equivalent carbon dioxide that they directly or indirectly release into the atmosphere.

Once a carbon market is formed, buyers and sellers can bargain prices and volumes. In fact, carbon trading becomes complicated because buyers, who recall being forced to buy credits to offset the reported emissions, look for the best prices. Soon, all sorts of financial mechanisms emerge to protect themselves from risks, minimize costs, and make deals. Secondary markets in on-selling, bundling, and derivative credits will emerge that outstrip the volume and market value for primary credits. Sellers are those who have generated carbon credits from emission reduction projects, reductions or sequestration that generate carbon offsets, or have allocated credit.

In the free market, supply and demand will determine the price. However, the carbon market is not a free market because the reason for carbon trading is to reduce GHG emissions. One of the problems in carbon trading is the declining carbon price. To ensure the increase in the carbon price, the number of permits and credits allowed in the limited system is the cap. Supply cannot meet demand and the price goes up. This is what is known as the cap-and-trade system. Initially, demand will continue to increase along with rising emissions. This emission will occur only as a result of economic growth which is the foundation of the capitalist economic system and a necessity when the human population grows at 8,000 per hour. Limits on credit supply can be achieved by limiting the issuance of faux credits (emissions allowances or permits) and real credits resulting from mitigation, reduction, and reimbursement projects. Thus, there will be a balance. In this case, there should be enough credit to meet the demand because the issuer is forced to pay. In addition, carbon markets should also create opportunities for cost savings, but the price per credit also needs to rise [25].

Sometimes, carbon trading is called emissions trading, as it is a market-based tool for limiting GHG. The carbon market trades emissions under a cap-and-trade scheme or with credits that pay or offset the reduction of GHG [26]. The cap-and-trade scheme is the most popular way to regulate carbon dioxide (CO_2) and other emissions. The scheme's governing body begins by setting a cap on allowable emissions. It then distributes or auctions off emissions allowances that total the cap. Member companies or firms that do not have enough allowances to cover their emissions must either deduct or purchase another company's reserve credit. Members with extra allowances may sell it or give it to the bank for future use. In practice, the cap-and-trade scheme can be either mandatory or voluntary.

Success of the cap-and-trade scheme relies heavily on strict but feasible constraints that reduce emissions over time. If the cap is too high, excess emissions will enter the atmosphere and the scheme will not affect the environment. A high cap can also decrease the value of benefits, causing losses to firms that have reduced their emissions and banked credit. If the cap is too low, its allowances are scarce and too expensive. Some cap-and-trade schemes have a safety valve to keep the value of allowance within a certain range. If the allowance price is too high, the scheme's governing body will release additional credits to stabilize the price. The price of allowances is usually a supply-and-demand function. Credits are similar to carbon offsets except that they are often used in conjunction with a cap-and-trade scheme. Firms wishing to reduce the targets can fund pre-approved emission reduction projects on other sites or even in other countries.

From the above description, carbon trading is actually a clever set of ideas that utilize market mechanisms that have been sharpened from generation to generation in capitalist economy. Of course, this will allow some investors to make serious money, and it fits with the adverse risks in the midst of current politics. Furthermore, these ideas will change our greenhouse gas emissions because, in time, it will be too expensive to release greenhouse gases. Unfortunately, no one is really sure if carbon trading will be able to change it fast enough [25].

5. Implementation of REDD+ in relation to risk, financing, and implementation strategies

The occurrence of deforestation and forest degradation, especially in developing countries, has accounted for nearly 20% of global GHG emissions. From various literatures, it can be used to limit the impacts of climate change in which the global community is able to cope with stabilizing the average of 20°C. REDD is an attempt to evaluate the value of carbon stored in forests and offer incentives for developing countries that have managed to reduce emissions from forest land and invest in low-carbon paths for sustainable development. The scope of REDD is then expanded by incorporating conservation roles, and increasing forest carbon stocks (REDD+). Implementation of REDD+ related to the Principles of National Approach and Sub-national implementation can be effectively applied to reduce the emissions if each stakeholder can make efforts to reduction of carbon emissions.

For the development of REDD+ activities, the commitment itself is highly dependent on the management of applied management in order to overcome the uncertainties in the field leading to the termination of commitment or non-permanence. This is due to the high competitiveness of land-based commodities around REDD+ sites. Competitiveness itself is influenced by the cost borne by the developer. Of course for developers to keep that commitment very closely related to how to get certainty to get REDD+ financing. As to the certainty of financing, the strategies that can be applied to maintain the commitment can be divided into two, viz. the institutional and distribution funding aspects. Institutional aspects include the strategy of enacting REDD+ sites as protected areas, implementing adaptive payment schemes that are a combination of input and performance-based mechanisms and buffer provision as a guarantee, and optimization of co-benefits. The funding distribution aspect includes the use of an existing funding channel, through government channels or fiscal transfers, the establishment of a new and verifiable government funding agency REDD+ and verification by a third party. With regard to transaction costs, the first and second strategies are believed to be lower than the third strategy.

Actually, REDD+ can be an effective incentive mechanism and efficient in reducing emissions. The incentives in question are benefits derived from REDD activities in the form of financial support and/or technology transfer and/or enforcement. Thus, the incentive scope may be in the form of monetary or non-monetary incentives. The success of running REDD+ is very much in line with the policy used for the expenses incurred. In other words, the scope of activities in REDD+ implementation for the purpose of reducing carbon emissions will definitely bring other benefits such as co-benefits, environmental services, forest sustainability, biodiversity, etc. However, the performance of REDD+ implementation is measured by looking at the ability of developers in reducing carbon emissions. This problem is related to the amount of carbon emission reductions generated through the measurable, reportable, and variable (MRV) system.

In addition, REDD+ also has negative impacts such as reduced public access to forest resources, reduced forest industry investment, and reduced forest sector economic contribution. The pressure on the existence of forests takes place in various forms of activities such as encroachment, illegal logging that occurs as a result of low socioeconomic conditions of people or below the poverty line. Pressure on REDD+ sustainability will certainly increase as commodity prices increase and as lands are used for agriculture, plantation, mining, etc. These pressures need to be considered as they relate to lower REDD+ competitiveness compared to other land-based commodities such as palm oil, coconut, and mining. This is indicated by the price per ton of carbon that must be applied to compensate the costs of other businesses such as oil palm and rubber plantations. The competitiveness of REDD+ can also be low again due to the high transaction costs that must be incurred. The high cost of such transactions is usually due to the lengthy process of issuing and trading certificates of reducing forest carbon emissions. Transaction costs in the production process are undesirable costs because the existence of these transaction costs makes commodity prices inefficient as prices become more expensive and tradable goods become less.

It should be emphasized, however, that transaction costs in REDD+ implementation are costs that must be taken into account. This is related to institutional costs inherent in REDD+ implementation, at least cost for contracting, searching and disseminating information, handling conflicts of interest that occur between stakeholders, validation and verification activities, and certification of emission reduction and credit buffer in case of leakage and non-permanence. The transaction costs will also increase in line with the intensive coordination between stakeholders involved as an effort to avoid conflict between stakeholders [27]. The effect of transaction costs on the price and quantity of carbon is presented in **Figure 1.**

5.1. Types of risks facing REDD+ and project financing

The key to successful implementation of REDD+ is the implementation of carbon conservation activities properly and correctly. Carbon conservation activities will have a major impact on the economy and the environment. The carbon conservation effort will have an

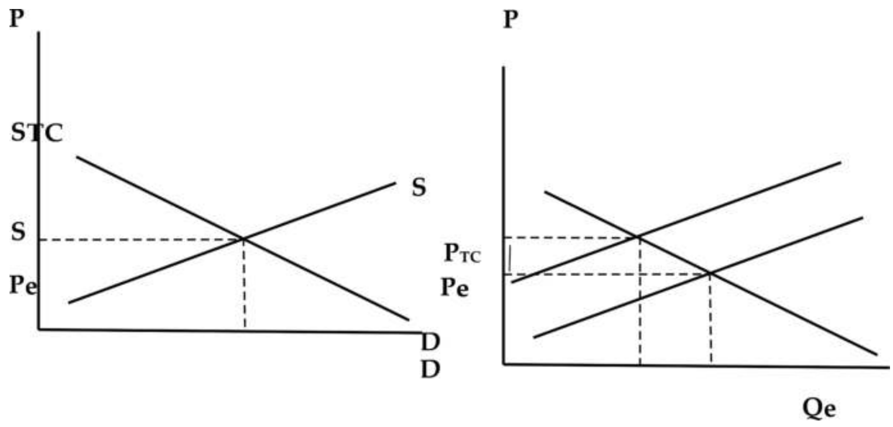

Figure 1. The effect of transaction costs on the price and quantity of carbon.

impact on the presence of carbon co-benefits such as biodiversity, community empowerment, employment creation, and other livelihood creation. However, there are also negative impacts such as "reducing access" of the community or the private sector in the management of forest resources. In general, the risks faced in implementing REDD+ are leakage and non-permanence. Leakage illustrates the occurrence of emissions that occur outside the project site. Leakage that occurs will reduce the amount of carbon credits generated. The opposite of leakage is additionality, which means increasing the amount of carbon produced. To facilitate the understanding of leakage and additionality, illustrations are presented in **Figure 2.**

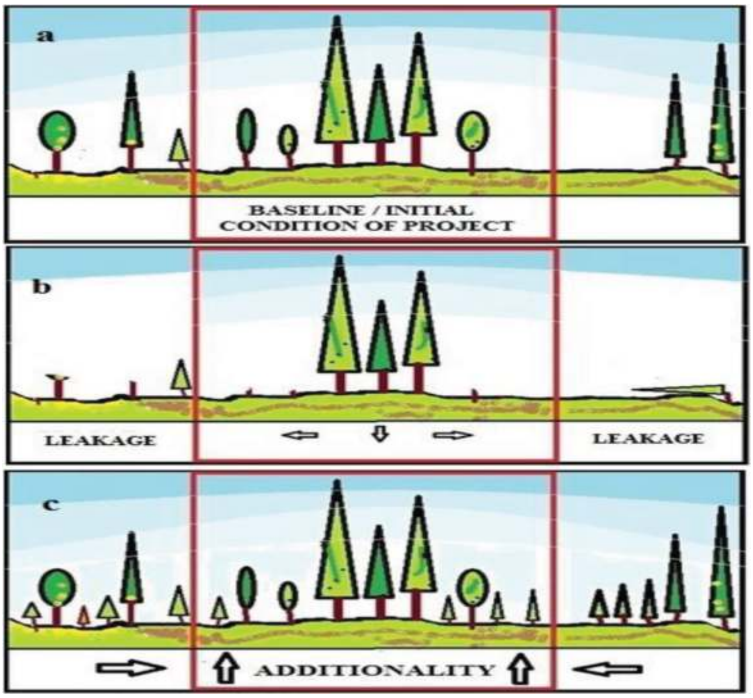

Figure 2. (a) Baseline, (b) Leakage, and (c) Additionality.

Sufficient knowledge of the source of leakage is important to develop a clear strategy for dealing with leakage issues. The risk of this leak may increase in line with: (1) opening of new business land for agricultural purposes and offsite plantations. Such encroachment activities may occur in other locations, and (2) the occurrence of encroachment or illegal logging activities tend to occur outside of the locations devoted to REDD+. The risk of non-permanence is associated with increased carbon emissions resulting from reduced management commitments to maintain REDD+ activities during the project or post-project completion. This can happen as a result of the project manager's ability to reduce carbon emissions. One of the factors driving irresponsibility is the absence of long-term financing planning. This leads to uncertainty in financing activities. This inadequacy increases in line with the increased cost of logging or the value of land for agriculture or plantation or other higher land use. In addition, this lack of permanence is also driven by the lack of clarity on incentive mechanisms and the benefits of REDD+ activities. This condition is usually exacerbated by the weakness of law enforcement. Increased dependence on increased forest resources is a result of declining public purchasing power due to the absence of alternative livelihoods among the project-related communities. Successful implementation of REDD+ is highly dependent on developer access to capital or financing sources. In addition, the seriousness of the developers also depends on how the implementation of REDD+ is able to compete with other uses, especially plantations and agriculture. This problem is related to the risk of failure of REDD+ implementation by leakage of non-permanence.

As with other land-based carbon business activities such as the forestry CDM, REDD+ implementation faces long-term financing issues. Given that REDD+ is a long-term program and requires huge financing. The availability of long-term financing is an indicator of developer commitment in REDD+ implementation. This is related to the risks faced by the developer of leakage and non-permanence. With regard to financial flow, there are currently two alternative incentive mechanisms, namely input-based mechanism (IBM) and result-based mechanism. Both are donors funding flows to REDD+ implementers or developers. IBM is a stream of funds tailored to the needs of REDD+ implementation. The amount of funds is not related to the emission reduction performance achieved. While RBM is a stream of funds whose amount depends on the amount of emission reductions achieved. The amount of carbon credits generated in this RBM is highly dependent on the additionality obtained. If project financing occurs through RBM, then the receipt of the developer will depend on the applicable price or the deal price of the buyer. In this situation, the developer must be a company that has strong capital and has a strong commitment to conservation activities so that the company is able to generate verified carbon credits [27].

5.2. Strategy to overcome leakage and non-permanent risk

The REDD+ and socioeconomic conditions around the project site define the developer strategy in addressing the risks in order to ensure that it. Increasing public demand on land due to decreasing public purchasing power as a result of rising food prices. In addition, higher competitiveness of other land-based enterprises such as plantations, mining, and agriculture is the driving force behind non-permanence. Considering that REDD+ is an activity with national and subnational approach and is related to national commitment to reduce GHG emission, financing certainty is required. Based on stakeholder perception, the first strategy applied is through the implementation of disincentives for developers who cannot guarantee permanence of activities. This is related to the commitment of REDD+ developers. Efforts are needed to facilitate the implementation of the strategy, then the government can issue a policy that regulates the status of REDD+ project location as a protected area. Implementation of this strategy encourages developers to ensure certainty of performance reduction of carbon emissions achieved. The next strategy is to implement an adaptive payment scheme, in which payments received by the developer are in line with the dynamics that occur. This strategy is linked to REDD+ financing mechanisms. This adaptive payment is a combination between IBM and RBM. Developers are eligible to receive early or periodic or annual payments as per performance results for REDD+ activities. Other strategies that can be pursued are to optimize the management and utilization of existing co-benefits within the site and set up the reserve area to cover potential losses [27]. The commitment of developers of REDD+ activities will be maintained if REDD+ funding distribution is acceptable to developers effectively and efficiently. Funding certainty for REDD+ activities will work effectively if it has a clear institutional funding distribution. The effectiveness of the channeling can be achieved if using existing government channels in the form of fiscal transfers. Donors can channel their funds through government agencies (national and subnational), then the government agencies channel them to developers. The second strategy is the transfer of funding through a REDD+ agency verified by the national government. The involvement of government agencies is believed to minimize transaction costs faced by developers. This transfer mechanism requires the establishment of a REDD+ financial institution first. The third strategy is the same as the second strategy, but incoming and transferred funds must be verified first by an independent third party. Nevertheless, this strategy will have the opportunity to bring in high transaction costs.

Carbon markets are believed to be effective and efficient mechanisms in providing these financing sources. In carbon markets, prices are decisive in generating carbon credits. Higher carbon prices will cause more carbon credits to be generated. Nevertheless, carbon trading from REDD+ is found to be a concern especially for developing countries that is the risk of leakage and non-permanence. Transactions that occur in the carbon market are based on the amount of carbon credits traded. In fact, the resulting forest carbon credits are difficult to verify because a strong measurement methodology is required. Thus, the amount of carbon credits generated depends largely on: baseline and measurement methodology, additionality, sustainability or permanence, and leakage rates.

This condition is particularly difficult for developing countries because there is still a need for development in the country that still requires forest conversion for other uses, for example, urban development, expansion of infrastructure, transportation, expansion of agricultural land and plantations, settlements, and others. Seen from the demand side of the carbon market, the success of REDD+ implementation is also highly dependent on the commitment of developed countries that are obliged to reduce greenhouse gases. In its development, demand for carbon credits is dominated by carbon credits from non-land-based sectors. It turns out that carbon credits in the market globally are dominated by the energy sector. This will lead to an oversupply of carbon credits in the European carbon market. As a result, there is a tendency to decrease the value of carbon credit transactions not only in the European carbon market but in all carbon markets. It is feared that increasing carbon credits from REDD+ to existing carbon markets will lead to over carbon credits in the carbon market, resulting in lower carbon prices. The amount of carbon credits from REDD+ is equivalent to a decrease in deforestation and forest degradation rates. Of course, it will be burdensome for developing countries. It is not worth the sacrifice of a developing country if the carbon credits generated by nobody pay primarily from developed countries. In our opinion, the implementation of REDD+ still involves a lot of harm, especially for developing countries associated with leakage, permanence, and additionality. Even Conservation bytes [28] calls these three things "Unholy trinity of leakage, permanence and additionality."

5.3. Unholy trinity of leakage, permanence, and additionality

The problem with REDD is that it is a wonderful thing to be given on some niggly issues that basically revolve around trust. Ah yes, bugbear from every business transaction. As "buyers" of carbon credits (companies or nations or individuals who want to offset their carbon output by "buying" carbon uptake provided by intact forests), we definitely want to make sure that all the money we spend to offset our carbon is actually just that, not just ending up in the hands of some corrupt officials, or even worse, are used to produce an industry that produces higher emissions! Of course, as a buyer we want to attract investors to give us a lot of money. If we interrupt the transaction, we will not have any more investors who come knocking on our door. Enter an unholy trinity of leaks, permanence, and additions. Imagine we are legislators and must make sure that buyers and sellers do not do anything clever and fall into one or all of the leak, eternal, or additional traps. Sounds like a terrible job, and probably not possible. How do we manage it and how long is "permanent"? How do we prove "what will happen"? So, basically we can imagine this unholy trinity has dropped many proposed REDD projects, and even kill that has been going on for some time. Like communism, that's a good idea, but REDD is almost impossible to make a job in the real world for many of the same reasons that communism fails—human greed and pettiness. Efforts to force such obstacles in the sky to avoid leaks and ensure timelessness and addition are actually more dangerous than good because so many programs fail even to get started. Further REDD+ implementation needs to be improved by including an insurance policy element called iREDD [28].

iREDD basically functions as follows: Before changing hands, the buyer and seller request an insurance brokerage service to assign premiums based on a priori assessment of any issues that may be related to leakage, immortality, and additions. Here, the Likert scale is used to rate proposals based on five criteria: (1) government structure—are the institutions reputable? Do they have a good business history?; (2) management plan—is the plan for managing REDD forests detailed enough to account for unforeseen events?; (3) project liquidity—do the institutions involved have sufficient cash flow to ensure they can meet the objectives of the management plan?; (4) acceptance—is the project acceptable to the community in the region? Do other groups support it?; and (5) purchase-politics—is the project included in the long-term plan of the relevant government agency? Is that against anything?

Once a rating is made, certain components of the money invested are used to purchase a scaled insurance policy against the identified (and approved) risks. If the seller (i.e., the recipient of funds and forest managers) fails to keep the forest intact, or it is subject to a destructive forest fire or political unrest, the buyer receives at least part of the premium as an out-of-pocket insurance payment. However, if the seller is true to their word (contractual obligations), the premiums and the interest are paid to them other than the money originally invested. In other words, everyone wins. If the seller fails, the buyer is compensated and can invest elsewhere. If the seller is good, they get more money. Most importantly, it increases the likelihood that atmospheric carbon will decrease and forest-related biodiversity will remain [29].

6. Conclusion

The role of forest biomass is now greater due to its ability to cope with global warming. The facts prove that forest cover decreases have caused climate change and various disasters such as flood, landslide, drought, extreme weather, and others. Efforts to address climate change have been made by the international community through GHG emission reduction programs with avoided deforestation and forest degradation through the forestry CDM, REDD+, Joint Implementation, and Voluntary Carbon Market schemes. This is closely related to carbon trading.

Since forest carbon has become a tradable commodity in the carbon market, forest biomass measurements are essential. Although there have been various programs to reduce GHG emission such as REDD+, there are still weaknesses such as the tendency of carbon prices to fall. This is certainly very detrimental, especially for developing countries that generally act as a seller of carbon. Therefore, much effort is needed to improve REDD+ so that the carbon trading mechanism can provide a satisfactory price for both sellers and buyers of carbon. One of the efforts undertaken, among others, is incorporating an element of insurance policy named after iREDD. With the insurance policy, concerns about the implementation of REDD+ related to leakage, permanence, and additionality can be reduced.

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