African Forest Forum

A platform for stakeholders in African forestry

Carbon Markets and Trade

A COMPENDIUM FOR TECHNICAL TRAINING IN AFRICAN FORESTRY 05

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Correct citation: African Forest Forum. 2019. Training modules on climate change and forests: adaptation, mitigation, carbon market and payments for environmental services: A compendium on carbon market and trade for technical training on forestry in Africa. 72 pp.

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ISBN 978-9966-7465-5-9

9 789966 746559

Front cover photos: Ecosysem servives in the Lokoly forest in Benin: gallery forest in Lokoly, Benin (left), deforestation in Benin (middle), water falls in Tanougou, Benin (right). Credit: Enoch G. Achigan-Dako

Back cover photo. Standing carbon sink in the Lokoly forest in Benin. Credit: Enoch G. Achigan-Dako

Design & Layout: Conrad Mudibo, Ecomedia

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Abbreviations and Acronyms

AFOLU	Agriculture, Forestry and Other Land Uses
DNA	Designated National Authority
UAQ	Units of Assigned Quantity
CCX	Chicago Climate Exchange
CDM	Clean Development Mechanism
CERs	Certified Emission Reduction Units
COP	Conference of the Parties
DFID	Department for International Development
DOE	Designated Operational Entity
ERUs	Emission Reduction Units
ETS	Emission Trading System
EU ETS	European Union Emission Trading System
FCPF	Forest Carbon Partnership Fund
GHG	Greenhouse Gases
IPCC	Intergovernmental Panel on Climate Change
IDRC	International Development Research Center
JIM	Joint Implementation Mechanism
JVETS	Japan's Voluntary Emission Trading Scheme
KP	Kyoto Protocol
LULUCF	Land Use, Land Use Change and Forestry
MRV	Monitoring, Reporting and Verification
VCM	Voluntary Carbon Market
OECD	Organization for Economic Co-operation and Development
PDD	Project Design Document
PED	Developing Countries
PES	Payment for Ecosystem Services
PIN	Project Idea Note
REDD+	Reduction of Emissions from Deforestation and Forest Degradation
RGGI	Regional Greenhouse Gas Initiative
SFM	Sustainable Forest Management
SOC	Soil Organic Carbon
UNFCCC	United Nations Framework Convention on Climate Change
VER	Voluntary or Verified Emission Reduction

Acknowledgements

This compendium has been developed through an organic process that initially led to the development of "Training modules on forest-based climate change adaptation, mitigation, carbon trading, and payment for other environmental services". These were developed for professional and technical training, and for short courses in sub-Saharan African countries. The compendium provides the text required for effective delivery of the training envisaged in the training modules; in other words, it is structured based on the training modules. In this context many people and institutions, including those from government, civil society, academia, research, business, private sector, and other communities, have contributed in various ways in the process that culminated in the development of the compendium. We wish to collectively thank all these individuals and institutions for their invaluable contributions, given that it is difficult in such a short text to mention them individually.

We also appreciate the kind financial support received from the Government of Switzerland through the Swiss Agency for Development and Cooperation (SDC) to implement an AFF project on "African forests, people and climate change" that generated much of the information that formed the basis for writing this compendium. AFF is also indebted to the Swedish International Development Cooperation Agency (Sida) for its support of another AFF project on "Strengthening sustainable forest management in Africa" that also provided inputs into the compendium, in addition to helping facilitate various contributors in developing it. The issues addressed by the two projects demonstrate the interest of the people of Switzerland and Sweden in African forestry and climate change.

We are also grateful to the lead authors, the contributors mentioned in this compendium and the pedagogical expert, as well as reviewers of various drafts.

We hope that the compendium will contribute to a more organized and systematic way of delivering training in this area, and eventually towards better management of African forests and trees outside forests.

Preface

African forests and trees support the key sectors of the economies of many African countries, including crop and livestock agriculture, energy, wildlife and tourism, water resources and livelihoods. They are central to maintaining the quality of the environment throughout the continent, while providing international public goods and services. Forests and trees provide the bulk of the energy used in Africa. Forests and trees are therefore at the centre of socio-economic development and environmental protection of the continent.

Forests and trees outside forests in Africa are in many ways impacted by climate change, and they in turn influence climate. Hence, African forests and trees are increasingly becoming very strategic in addressing climate change. The great diversity of forest types and conditions in Africa is at the same time the strength and the weakness of the continent in devising optimal forest-based responses to climate change. In this regard, given the role of forests and trees to socio-economic development and environmental protection, actions employed to address climate change in Africa must simultaneously enhance livelihoods of forest dependent populations and improve the quality of the environment. It is therefore necessary for Africa to understand how climate change affect the inter-relationships between food, agriculture, energy use and sources, natural resources (including forests and woodlands) and people in Africa, and in the context of the macro-economic policies and political systems that define the environment in which they all operate. Much as this is extremely complex, the understanding of how climate change affect these inter-relationships is paramount in influencing the process, pace, magnitude and direction of development necessary for enhancing people's welfare and the environment in which they live.

At the forestry sector level, climate affects forests but forests also affect climate. For example, carbon sequestration increases in growing forests, a process that positively influences the level of greenhouse gases in the atmosphere, which, in turn, may reduce global warming. In other words, the forests, by regulating the carbon cycle, play vital roles in climatic change and variability. For example, the Intergovernmental Panel on Climate Change (IPCC) special report of 2018 on the impacts of global warming of 1.5 ^{o}C above pre-industrial levels underscores the significance of afforestation and reforestation, land restoration and soil carbon sequestration in carbon dioxide removal. Specifically, in pathways limiting global warming to 1.5 ^{o}C, agriculture, forestry and land-use (AFOLU) are projected with medium confidence to remove 0-5, 1-11 and 1-5 $GtCO_2\ yr^{-1}$ in 2030, 2050 and 2100, respectively. There are also co-benefits associated with AFOLU-related carbon dioxide removal measures such as improved biodiversity, soil quality and local food security. Climate, on the other hand, affects the function and structure of forests. It is important to understand adequately the dynamics of this interaction to be able to design and implement appropriate mitigation and adaptation strategies for the forest sector.

In the period between 2009 and 2011, the African Forest Forum sought to understand these relationships by putting together the scientific information it could gather in the form of a book that addressed climate change in the context of African forests, trees, and wildlife resources. This work, which was financed by the Swedish International Development Cooperation Agency (Sida), unearthed considerable gaps on Africa's understanding of climate change in forestry, how to handle the challenges and opportunities presented by it and the capacity to do so.

The most glaring constraint for Africa to respond to climate change was identified as the lack of capacity to do so. AFF recognizes that establishment and operationalization of human capacities are essential for an effective approach to various issues related to climate change, as well as to improve the quality of knowledge transfer. For example, civil society organisations, extension agents and local communities are stakeholders in implementing adaptation and mitigation activities implicit in many climate change strategies. In addition, civil society organisations and extension agents are more likely to widely disseminate relevant research results to local communities, who are and will be affected by the adverse effects of climate change. It is therefore crucial that all levels of society are aware of mechanisms to reduce poverty through their contribution to solving environmental problems. Training and updating knowledge of civil society organisations, extension service agents and local communities is one of the logical approaches to this. Also professional and technical staff in forestry and related areas would require knowledge and skills in these relatively new areas of work.

It was on this basis that AFF organized a workshop on capacity building and skills development in forest-based climate change adaptation and mitigation in Nairobi, Kenya, in November 2012 that drew participants from selected academic, research and civil society institutions, as well as from the private sector. The workshop identified the training needs on climate change for forestry related educational and research institutions at professional and technical levels, as well as the training needs for civil society groups and extension agents that interact with local communities and also private sector on these issues. The training needs identified through the workshop focused on four main areas, namely: Science of Climate Change, Forests and Climate Change Adaptation, Forests and Climate Change Mitigation, and Carbon Markets and Trade. This formed the basis for the workshop participants to develop training modules for professional and technical training, and for short courses for extension agents and civil society groups. The development of the training modules involved 115 scientists from across Africa. The training modules provide guidance on how training could be organized but do not include the text for training; a need that was presented to AFF by the training institutions and relevant agents.

Between 2015 and 2018, AFF brought together 50 African scientists to develop the required text, in the form of compendiums, and in a pedagogical manner. This work was largely financed by the Swiss Agency for Development and Cooperation (SDC) and with some contribution from the Swedish International Development Cooperation Agency (Sida). In this period eight compendiums were developed, namely:

1. Basic science of climate change: a compendium for professional training in African forestry
2. Basic science of climate change: a compendium for technical training in African forestry
3. Basic science of climate change: a compendium for short courses in African forestry
4. Carbon markets and trade: a compendium for technical training in African forestry
5. Carbon markets and trade: a compendium for professional training in African forestry

6. Carbon markets and trade: a compendium for short courses in African forestry
7. International dialogues, processes and mechanisms on climate change: compendium for professional and technical training in African forestry
8. Climate modelling and scenario development: a compendium for professional training in African forestry

Another notable contribution during the period 2011-2018 was the use of the training module on "Carbon markets and trade" in building the capacity of 574 trainers from 16 African countries on rapid forest carbon assessment (RaCSA), development of a Project Idea Note (PIN) and a Project Design Document (PDD), exposure to trade and markets for forest carbon, and carbon financing, among others. The countries that benefited from the training are: Ethiopia (35), Zambia (21), Niger (34), Tanzania (29), Sudan (34), Zimbabwe (30), Kenya (54), Burkina Faso (35), Togo (33), Nigeria (52), Madagascar (42), Swaziland (30), Guinea Conakry (40), Côte d'Ivoire (31), Sierra Leone (35) and Liberia (39). In addition, the same module has been used to equip African forest-based small-medium enterprises (SMEs) with skills and knowledge on how to develop and engage on forest carbon business. In this regard, 63 trainers of trainers were trained on RaCSA from the following African countries: South Africa, Lesotho, Swaziland, Malawi, Angola, Zambia, Zimbabwe, Mozambique, Tanzania, Uganda, Kenya, Ethiopia, Sudan, Ghana, Liberia, Niger, Nigeria, Gambia, Madagascar, Democratic Republic of Congo, Cameroon, Côte d'Ivoire, Burkina Faso, Gabon, Republic of Congo, Tchad, Guinea Conakry, Senegal, Mali, Mauritania, Togo and Benin .

An evaluation undertaken by AFF has confirmed that many trainees on RaCSA are already making good use of the knowledge and skills gained in various ways, including in developing bankable forest carbon projects. Also many stakeholders have already made use of the training modules and the compendiums to improve the curricula at their institutions and the way climate change education and training is delivered.

The development of the compendiums is therefore an evolutionary process that has seen the gradual building of the capacity of many African scientists in developing teaching and training materials for their institutions and the public at large. In a way this has cultivated interest within the African forestry fraternity to gradually build the capacity to develop such texts and eventually books in areas of interest to the continent, as a way of supplementing information otherwise available from various sources, with the ultimate objective of improving the understanding of such issues as well as to better prepare present and future generations in addressing the same.

We therefore encourage the wide use of these compendiums, not only for educational and training purposes but also to increase the understanding of climate change aspects in African forestry by the general public.

Macarthy Oyebo
Chair, Governing Council of AFF

Godwin Kowero
Executive Secretary-AFF

Executive Summary

Overview of the module

The carbon market mechanisms (emission exchange, Clean Development Mechanisms (CDM), Reduction of Emissions from Deforestation and Forest Degradation (REDD+) and voluntary markets) are considered as one of the means to reduce climate change and other environmental issues. The carbon (C) market is conducted through the captions of cap-and-trade or credit schemes that finance or offset Greenhouse Gas (GHG) reductions. This module introduces the principles and concepts of C stock estimation, C trading, payments for environmental services, C trading processes and agreements, C stock estimation methods, methodological questions about C market and trading, C market risks and opportunities, global, regional and national marketing.

Module objective

The objective of this module is to improve learners' knowledge of C stock assessment, the C market and financing mechanisms for related forestry activities.

Expected learning outcomes

At the end of this module, leaners will be able to:

- outline the principles and concepts of C market;
- determine the institutional and legal frameworks of carbon market;
- explain the risks and opportunities of C market;
- describe the C trading processes and agreements; and
- evaluate C stocks.

Chapter 1. Types of Environmental Services

1.0 Chapter overview

Ecosystems are crucially important to human societies for their many and varied services upon which life is based. They provide products of direct value to people - food, fiber, and fuel - and an array of indirect benefits, including water filtration, climate regulation, nutrient cycling, pollination, pest control, and disease regulation. Healthy ecosystems are particularly important for people living in the developing world, who often live in very close connection to their natural surroundings. Despite the fundamental importance of ecosystem services to human well-being, ecosystems and their constituent goods and services continue to decline at alarming rates (Millenium Ecosystem Assessment, 2005).

Since 1961, tropical countries have lost more than 500 million ha of forest cover and the consumption of wood products has exploded by 50 % worldwide. This results in loss of important environmental services to the livelihood, economic development and health of people around the world.

A major reason for the systemic decline of these ecosystems is that many ecosystem services are not priced or assigned a value by the prevailing systems of production, exchange and regulation. Although there are markets for many of the “provisioning” eco-system services, markets tend to be incomplete or lacking for the “regulating”, “supporting” and “cultural” services. Reasons for market failure are well known: cultural services tend to have public good characteristics (non-rivalry in consumption and non-excludability), while regulatory services are highly influenced by production externalities (Swallow et al., 2009).

These services are generally little known, little understood or simply taken for granted by decision-makers, private companies or local authorities. As a result, they are rarely considered on markets due to inadequate access to information, poor awareness of consu-mers about them, or lack of effective incentive measures that would encourage land users to adopt sustainable or environment-friendly practices. Payment for Ecosystems/Environ-mental Services (PES) systems attempt to bridge the gaps by internalizing benefits. This creates the need for appropriate incentive measures, to encourage adoption of environ-ment-friendly approaches to ecosystem use. The first step is to define the environmental services and to determine which services can be internalized in market transactions.

Societies have devised a number of public policy instruments to cope with these market failures. Some instruments, particularly regulations, property rights, and financial instru-ments, have been used for environmental governance for many years. Regulatory instru-ments tend to be implemented in a top-down and rigid manner, earning them the name “hard policy” or “command-and-control” instruments. Over the last 20 to 30 years, a variety of new “soft” environmental policy instruments have been devised and implemented. These tend to be more flexible and subject to negotiation and multi-stakeholder dialog, and consistent with market approaches to efficiency (Swallow, 2009).

This chapter provides definitions of basic terminologies and concepts related to environmental services and proposes a classification and/or typology of these services. The chapter also equips the learner with knowledwge and skills about economic opportunities related to environmental services and mechanisms of carbon (C) markets.

1.1 Definitions and concepts

Objectives

At the end of this chapter, the learner will be able to:

- define Payment for Ecosystem Services (PES) as well as the associated concepts ; and,
- explain the principles of forest C financing and trading mechanisms including Clean Development Mechanism (CDM), Reduction of Emissions from Deforestation and Forest Degradation (REDD+) and Voluntary markets.

Activity 1.1: Brainstorming

Share your views on the concept of "environmental services".

1.1.1. Definitions

Forest ecosystem

An ecosystem is a unit of nature comprising a community of living things (plants, animals and microorganisms) together with the non-living factors of the environment (soil, water and climate) with which they interact. A forest ecosystem is one in which the community is a forest. The Congo basin rain forest is an example of a forest ecosystem. It is home to a wide variety of plant and animal species, which include producers, consumers and decomposers. These organisms are interdependent on each other for survival. Plants are the producers of this ecosystem. The herbivores that depend on green plants for food are the consumers. The decomposers break down dead plants and animals, returning the nutrients to the soil to be made usable by the producers. Bacteria, ants and termites, among others, are important decomposers in the ecosystem.

Ecosystem services

Ecosystem services are the many and varied benefits that humans freely gain from the natural environment and from properly functioning ecosystems. They include, for example, agroecosystems, forest , grassland and aquatic ecosystems. Collectively, these benefits are becoming known as "ecosystem services", and are often integral to the provisioning of clean drinking water, decomposition of wastes, and natural pollination of crops and other plants.

Environmental service

Environmental service is defined as an intentional activity to maintain or improve a natural resource asset, the purpose of which is to improve the quality of the asset. Four criteria help to qualify an environmental service (Aznar, 2002):

- the support property on which the environmental service is produced: this property is part of the natural space;

- the technical act, i.e. the modification of the support property;
- service as a voluntary act, i.e. intentional act; and,
- the collective aim of the service: the environmental service is a public good in the economic sense; for the provider, there is compensation for the rendered service, usually in monetary form, but this is not always the same thing when the providers are volunteers, grouped or not in association.

"Environmental" and "Ecosystem" services are often used interchangeably in the literature (Muradian et al., 2010).

1.1.2. Concepts

Economic value of environmental services

Ecosystem services are material or immaterial benefits that produce wellbeing for the society, either in economic or non-economic terms. Forests, peatlands, agricultural lands, and inland waters all together provide many ecosystem services for the society. While some, such as wheat, timber and peat, have a market value, others, such as beautiful scenery, can be enjoyed without charge, or they contribute to the supply of other services, for instance, pollination. The economic value of these is not directly seen. For instance, the actions that deteriorate nature are not reflected in the market price of the products. Therefore, it is very difficult, if not impossible, to give a monetary, market value to the services provided by ecosystems (i.e. a price for nature).

Any monetarization made is based partly on subjective criteria, especially because these services are intertwined within an ecosystem, which is itself dependent on other ecosystems and ultimately on the state of the biosphere. An economic value (value for the economy) is often quoted and is the subject of much research. One of the difficulties in measuring the value of biodiversity and provided services by ecosystems is that much of this value is not directly marketable, but is related to ecological resilience and ecological potential. This value is thus largely unknown, because it is hidden in the living things (from the genomic scale to the large ecological networks). It is also expressed only under certain conditions (climate warming or cooling, epidemics, major environmental changes etc.), which are inconceivable conditions in the laboratory.

Payment for Environmental Services (PES)

PES is an economic tool by which an unconstrained producer of environmental services is paid, to implement practices to ensure the maintenance of these services. It differs from approaches that are based on a constraint, whether regulatory or requiring producers to pay themselves to compensate for the negative effects of their activity. Although the scope of the tool, PES varies from one study to another, the most commonly accepted definition is: payment made in a voluntary transaction where a clearly defined environmental service is purchased by one or more "users" from one or more "suppliers"; the payment takes place if and only if the supplier actually provides the service.

Activity 1.2: Group discussion (30 minutes)

1. Why is it important to study of the concept of environmental services?
2. Evaluate the the economic value of environmental services

Exercise (15 minutes)

1. Identify and define terminologies commonly associated with environmental services?
2. Describe any five environmental services
3. What is the economic value of the five environmental services described in (2) above?

1.2. Economic opportunities related to environmental services

Today, four types of environmental services are targeted by the PES system: preservation of biodiversity, protection of water resources, C sequestration and preservation of land-scapes:

- PES to protect biodiversity is still rare. The relationships between biodiversity, eco-systems and human well-being remain less perceived than those related to water. Here, the scale to be favored is that of the protected area or, more precisely, of the territory where intermediaries able to implement the management plans are present and active.
- PES for hydrological services remains the most widespread. Protection of water quality, regulation of flows, including, in particular, flood prevention, and preservation of aquatic habitats.
- PES for C, already boosted by the CDM set up under the Kyoto Protocol (KP) should continue to develop. Its scale must necessarily be broad, with beneficiaries all over the world.
- PES linked to landscapes is by far the least developed: based on an aesthetic or cultural value given to certain natural sites. With the development of ecotourism, this could evolve rapidly throughout the world.

In practice, environmental services refer to the services provided by forests and forest plantations that have an impact on the protection and improvement of the environment. These include greenhouse gas (GHG) mitigation (fixing, reduction, sequestration, storage and absorption); protection of water for urban, rural or hydroelectric exploitation; protection of biodiversity with a view to its sustainable use for scientific and pharmaceutical purposes, the genetic resources and their valuation, the preservation of ecosystems and life forms; and the beauty of natural landscapes for tourism and for scientific purposes.

Apart from these types of services, we distinguish bundled services (different services considered together from the same territory).

Exercise: Group discussion (25 minutes)

1) Describe the environmental services targeted by PES?
2) Assess the main strengths and weaknesses of PES systems?

1.3. Environmental services markets

Objective

At the end of this session, the learner will be able to:

- define different markets for environmental services and their characteristics.

1.3.1. Practical challenges for operational implementation of PES

The geographic scope, strength and structure of demand, competition, nature and price of goods sold and the number of transactions vary according to the PES systems. One of the challenges in creating PES systems is to transform the services provided by ecosystems into "products" that can be sold to beneficiaries. This requires precise data on the nature of the market, the structure of demand and the value of services for the beneficiaries. Generally, the more a product is specific (and the more complex the service contract), the higher the transaction cost of the system is - and the prices obtained are raised. Less precise products will be cheaper to generate, but they will get lower prices. As a result, an optimal situation must be found that reconciles product accuracy with transaction costs. In all cases, the success of a PES system requires a good knowledge of the markets for the environmental services to be sold.

1.3.2. Watershed-related services contracts

Markets for hydrographic services are generally of local scale, and most transactions occur at the watershed level. Traditionally, markets for watershed protection services do not involve the exchange of "products" such as quantity or quality of water. Instead, they focus on the financing of land uses that generate hydrographic benefits. Watershed services are usually funded through the application of user fees that help to improve the management of upstream protected areas.

1.3.3. Carbon sequestration markets

C sequestration markets are global scale and most transactions involve international purchasers. These markets are well structured and extremely competitive. This forces service providers to reduce their transaction costs to minimize the risk associated with the reliability of C credits. The deployment of a global C market is hampered by the uncertainty surrounding the ratification of the KP and the precise rules that will govern its implementation. This situation influences the definition of C credits and their prices.

1.3.4. Markets for biodiversity conservation services

With respect to biodiversity conservation services, markets are local, national and international. The diversity of biodiversity conservation services brings about a multitude of requirements that increase the complexity of payment mechanisms. Biodiversity conser-vation services are not sold directly; rather, they are specific uses of land aiming to protect species, ecosystems or natural/ biological diversity that are sold. International organizations, foundations and NGOs devoted to conservation are the main buyers of biodiversity conservation services. Some services, especially those resulting from bioprospecting, sometimes rely on the potential value of future discoveries. In this context, it is difficult to determine the value of services and to balance supply and demand.

1.3.5. Service markets for preserving the beauty of landscapes

These are the least developed. These services are the subject of national and international demand. The ecotourism industry is perhaps one of the main beneficiaries and, therefore, requesters of services to preserve the beauty of landscapes. For the time being, govern-ments are the main providers of services related to landscape beauty, through the creation of protected areas or the protection of natural or cultural heritage sites. However, there is an increase in the provision of services for the preservation of the beauty of landscapes by local authorities, since this concept may also include cultural practices, traditional land uses or architectural features.

1.3.6. Bundled services markets

These markets have elements in common with the environmental services markets included in the group. Services can be sold as unified groups (where services cannot be separated) or “baskets” (specific services can be purchased and land users sell different services to buyers). Unified groups are easier to manage and enable the reduction of transaction costs. However, they are less effective because it is impossible to target payments on individual services due to regrouping. The “basket” approach therefore helps to maximize returns, but is more complex to manage and more costly.

Group exercise (25 minutes)

1. What factors influence the operational implementation of PES?
2. Describe the different markets for environmental services that you know? Describe their characteristics.

1.4. Payment for environmental services

This session addresses the payment of environmental services. This involves defining them and determining which services can be internalized in market transactions.

Objectives

At the end of this session, the learner will be able to:

- identify the environmental services targeted by PES;
- describe the conditions for the implementation of the PES; and
- determine the strengths and weaknesses of PES systems.

Activity 1.3. Brainstorming (25 minutes)

Share your views on the environmental services payment system.

1.4.1. PES Systems

PES systems focus basically on environmental services provided by forest conservation, reforestation and SFM, and some agroforestry or agropastoral farming practices. Many PES systems target hydrographic services. The following is a list of services provided by forest ecosystems and covered by existing PES systems:

- regulation of water flow: maintenance of water flows in dry weather and regularization of floods;
- water quality management: regulation of solid load, nutrient load (e.g. phosphorus and nitrogen), chemical load and salinity;
- control of erosion and sedimentation;
- reduction of soil salinization and regulation of groundwater or water table; and
- management of aquatic habitats (eg, maintaining water temperature, shading rivers/ streams, ensuring sufficient woody debris in the water).

PES systems often involve services related to biodiversity. Thus, biodiversity can be measured by ecosystems, species and genetic diversity. The biological services provided under PES systems include the protection of ecosystems, natural habitats, species, genetic resources or other resources of particular importance.

C sequestration services are also included in multiple commercial transactions around the world and in several PES systems. C sequestration occurs when trees or other plants absorb C from the atmosphere as they grow. Conversely, the destruction of forests results in the release of C into the atmosphere. C sequestration therefore involves two types of services: active absorption through reforestation or reduction of emissions through forest cover conservation.

Services related to the beauty of landscapes are mainly associated with aesthetic or cultural values attributed to certain natural sites. These include protection of natural patrimony sites, coral reefs, cultural sanctuaries or even traditional livelihoods in order to adopt a unified approach to protect cultural and environmental sites. However, few PES systems use these services because they are difficult to quantify and evaluate because of their cultural bases.

1.4.2. Conditions for the implementation of PES

Principles that support PES

The notion of PES covers many things, but it can be said that the desire to solve environmental problems outside the coercive contribution of the state has urged many actors - particularly NGOs – to promote alternative actions. They suggest the negotiation between several agents who interact through what is called "environmental services": some agents benefit from certain services (water quality, soil erosion control, maintenance of bio-diversity, etc.), while other agents have the capacity to maintain, produce or alter these services. In addition to this "voluntary" and "negotiating" aspect, there is the reversal of the well-established principle of "polluter pays": it is no longer a question of fines when environmental degradation occurs but rather of paying an Agent so that he/she improves on the quality of the environment beyond what regulation provides. This leads to one last founding principle of PES: it is based on the incentives, as opposed to coercive payments.

Issues of Payments for Ecosystem Services (PES)

A distinction is often made between issues related to water and forestry cycles, agriculture that are more broadly linked to biodiversity, and finally those of the more gentle functions created by landscapes, around the notion of ecosystem function of which the unifying and coherent virtues were identified in the 1980s (a first classification was made by the *Millenium Ecosystem Assessment*).

Environmental effectiveness and economic efficiency of PES

Several characteristics of PES systems can influence their effectiveness (capacity to achieve the environmental objective) or their efficiency (cost of achieving the goal). The main strengths and weaknesses of PES systems include:

- **identify the beneficiaries and generate a request**: it is possible to create a PES system only if there is a request for an environmental service; the first task is therefore to identify the beneficiaries of the environmental services and those who are willing to pay for these services; it is easier to convince beneficiaries to participate in a PES system when the costs and benefits are perceptible and quantifiable;
- **generate incomes for service providers**: PES systems must provide sufficient and sustainable income to land users so that they adopt and maintain land management practices that will generate the desired ecological services; the payment must therefore be continuous - not punctual - and not limited in order to be sustainable; in addition, the level of payment must be high enough to cover the cost of adopting new land-use practices and the cost of certain practices desertion;

- **create scientific knowledge and assess ecosystem services**: ecosystems provide multiple services that are sometimes poorly understood, difficult to quantify or link to specific land uses; in addition, various types of conservation or productive land use approaches are compatible with the application of these same environmental services; in this perspective, to create PES systems, it is important to understand how environmental services are delivered by ecosystems; PES systems therefore require reliable scientific knowledge on the natural sites and the linkage between land uses and the application of environmental services;
- **understand the legal and strategic environment**: this concerns assessing and understanding issues related to financial regulation and policies, property rights, establishing and operating of institutional structures, financing of PES system; and,
- **manage transaction costs**: transaction costs related to the establishment and management of PES systems are essential to the profitability of these systems; considering that PES systems involve the creation of new markets with legal, financial and institutional support, transaction costs are likely to outweigh the potential benefits of such systems; overall, if transaction costs are too high, PES systems may not be the most cost-effective strategy for delivering environmental services. In this context, managing these costs becomes a priority.

1.5. Reviews on PES systems

Objective

By the end of this session, the learner will be able to critically analyse PES systems as applied in African countries.

Activity 1.4: Group discussion (25 minutes)

Critically analyse the role of PES systems inenabling sustainable flows of ES for the benefit of the ecosystem.

The PES approach focuses on the immediate utility that economics and society derive from the functioning of preserved ecosystems, while its preservation has a cost (restoration, maintenance, etc.) that is generally not assumed by the beneficiaries of the services. Remunerating those who, through their practices, participate in this preservation therefore seems right. PES systems are considered as often effective tools and provide pragmatic responses to challenges faced by traditional environmental policies, but:

- They usually only partially tackle problems. According to Ostrom and Cole (2010) and Muradian et al. (2012), they are politically negotiated economic tools to make them acceptable, and do not seek "to grasp the true price of ecosystem services (and) are rather political instruments that are part of complex institutional and ecological contexts; it follows that the choice of recipients of payments, resulting from a negotiation process, responds to political considerations that determine both the legitimacy and the accepta-bility of the mechanism and therefore, retroactively, its effectiveness through lowering of the likelihood of occurrence of opportunistic behavior";
- After a first group of experimentation, they are questioned about their effectiveness and the fact that they often appear to be sources of ambiguous messages or even perverse effects (real or potential), e.g: remuneration for the cessation of certain illegal practices, but authors believe that in some contexts that favor these effects, remuneration sometimes seems more effective than law enforcement when it is too weak or seems too "unfair" for a coercive action to be possible.
- In addition, there are changes in motivation induced by PES. In theory, payment should encourage people to engage in virtuous behavior (crowding in effect). But sometimes, paying people to conduct environmental activities can cause them to get rid of any other environmental action: do nothing until you get paid; consider that we are doing enough. This crowding out effect would lead local populations to adopt principles of action contrary to what economic theory assumes. This is all the more relevant as the relation to environment and money is not the same in all parts of the world and PES are supposed to be fixed-term contracts. And the issue of behavior after the PES program is only rarely addressed.

- Equitable access to PES is also controversial because of land tenure issues. Indeed, the PES receiver is supposed to hold property rights on the spaces providing the ES. However, many ES producers do not always hold title to the land. This situation excludes those who do not have land. In addition, access to PES requires resources to cover transaction costs (knowledge of systems, prior technical studies, etc.), which creates barriers to entry for small producers. Finally, payments received depend on the land area and ES produced (often based on a land use area). PES then reinforces the economic power of those already well endowed in the land to the detriment of the poor.

Summary

This chapter has addressed the definitions of environmental services as well as related concepts. It focused on the systems of payment for environmental services, enabling the learner to know the types of services that are targeted by PES, the conditions for PES implementation and the strengths and weaknesses of PES systems. It also focused on the different markets for environmental services and their characteristic, and allows us to know the factors that influence the operational implementation of PES and critiques on PES systems.

Chapter 2. Climate Change and Carbon Trade

2.0 Chapter overview

This chapter focuses on the Clean Development Mechanism (CDM) and Reduction of Emissions from Deforestation and Forest Degradation (REDD+) as forest-based mechan-isms to mitigate climate change. It facilitates the understanding of CDM and REDD processes, implementation processes, the difference between RED, REDD and REDD+, and project development cycle.

Regulated C markets are based on systems of emission quotas allocation and trading of CO_2 equivalents of GHGs, deriving their legitimacy from international treaties such as the KP for EU, UK, Japan or regional agreements such as the Regional Greenhouse Gas Initiative (RGGI) for some States in the US. The regulated market includes the transactions generated by the UN Framework Convention on Climate Change (UNFCCC), including the C market (ETS) established by EU, and a growing number of national or regional markets.

Accordingly, this chapter introduces technicians to notions related to REDD+ and CDM mechanisms and related project cycles. It also emphasises the understanding of principles and practices of C financing and trade on emission reduction from CDM and REDD+ projects.

2.1 Flexibility mechanisms of the Kyoto Protocol

Objective

At the end of this session, the learner will be able to:

- explain the flexibility mechanisms of the Kyoto Protocol;
- define the objectives of the CDM; and
- describe the principles of implementation and the general operating conditions of the CDM.

2.1.1. Clean Development Mechanism

CDM definition and objectives

The objective of the CDM is two-fold:

- reduce the cost of industrialised countries (Annex I) in implementing their reduction commitments by financing or undertaking low-cost emission reduction projects in developing countries; and,
- support developing countries (non-Annex I) to host projects that contribute to their sustainable development; in this manner, a transfer of environmentally sound technologies is expected to take place; the CDM is thus a way to attract foreign investment.

Principles of implementation

A country, state or enterprise in an Annex I country invests in a project to reduce GHG emissions in a developing country. In exchange of the recorded reductions, an equivalent volume of Certified Emission Reduction Units (CERs) is issued. This investor may sell these Units on the market or deduct them from its international reduction obligations.

Nature of projects

The sectors covered by CDM projects are: energy, waste treatment, industry, residential and tertiary sector, transport, agriculture and the forestry sector. CDM projects can be energy saving, fuel change, renewable energy projects or “carbon sink” projects (for the forestry sector).

General operating conditions of the CDM

- **Eligibility criteria**: the KP imposes 4 conditions for CDM projects:
    - ratification of the KP by both States (investor and host);
    - the project must contribute to the sustainable development of the host country: this implies that it is up to each developing country to define and establish its own criteria for sustainable development; some NGOs have developed sustainable development assessment tools;
    - the project must be approved by the host country; and,
    - the CDM project must be additional that is, the project allows emission reductions that would not have been achieved without the creation of an emission reduction obligation.

- **Restrictions**: the restrictions contained in the Marrakesh Accords are related to the prohibition of nuclear power and the limitation of the use of C sinks under the CDM, to 1% of the GHG emissions of 1990, of the industrialized countries, each year between 2008 and 2012; and,
- **Institutional actors of the CDM**: three bodies are absolutely necessary for the functioning of the CDM:
    - the **Executive Board**: oversees the implementation of the CDM and records CDM projects; it is also responsible for issuing CERS;
    - the **Designated National Authority (DNA)**: established by the host country, having ratified the Protocol, it determines country-specific criteria for sustainable develop-ment and controls the project approval process; and,
    - the **Designated Operational Entities (DOEs)** are in charge of validating, auditing CDM projects and informing the public.

2.1.2. Joint Implementation

Joint Implementation (JI) is a particular form of international trading of emission rights or emission permits defined in the KP. In practical terms, it is one of the so-called "flexibility" mechanisms under the KP, which allows developed countries to reduce their GHG emissions by trading C quotas. Companies (public or private) invest in "clean projects" within industrialized countries or outside the national territory, enabling them to obtain emission credits. These C credits are measured in Emission Reduction Units (ERUs). The Joint Implementation Mechanism (JI) operates in the same way as the CDM, except that these projects are carried out in industrialized countries and generate Kyoto units called ERUs. What about developing countries in Africa?

2.1.3. Negotiable emissions permits mechanisms

This is a trade system of emission permit. As the principal mechanism under the KP, the negotiable emission permits mechanism aims at encouraging the improvement of the most polluting and less efficient production systems as quick as possible. Any effort to reduce emissions in such systems will indeed have a low cost compared to a reduction effort in an already efficient system. The profit margin, resulting from the resale of permits, will therefore primarily be reverted to those that will improve the structures that are less efficient and polluting. It is therefore rational that several countries agree to control CO_2 emissions at the best efficiency/price ratio, where the emission reductions are the least expensive. Several emission permit markets have been established at companies, groups of companies, or States' level.

Exercise: Group discussion (25 minutes)

1) What are the flexibility mechanisms of the Kyoto Protocol?
2) Describe the main features of the Clean Development Mechanism (CDM)

2.2 Regulated markets

Objectives

At the end of this session, participants will be able to:

- define the characteristics of a regulated carbon market; and,
- describe the mechanisms, functioning and limitations of regulated markets.

2.2.1 Structure of regulated markets

These regulated markets are often referred to as "cap-and-trade" or "allowance trading" mechanisms. Under the KP, States and industries that are forced to reduce GHG emissions exchange Assigned Quantity Units (AQUs) at the government level and EU Allowances (EU ETS) at the industry level via a market. Under certain treaties (KP, RGGI), participants in a regulated market also have the opportunity to acquire C credits from projects in order to achieve their objectives by offsetting their emissions. An emission ceiling is set and actors reduce their emissions according to their reduction costs and the value of the emission permit. Regulated markets comply with regulations and policies issued by the government, allowing organizations to meet annual requirements for the emissions cap. International agreements or national policies oblige countries or economic actors to reduce their GHG emissions and give them the opportunity to exchange emissions rights. For example, an actor who must reduce his emissions to 100 t CO_2e but only manages to reduce to 105 t CO_2e can buy 5 emission permits from an actor who has been able to reduce more than his objective.

2.2.2 Normative framework for the regulated market

Markets for CO_2 quotas have seen an explosion in volume since 2000, and they are more and more comparable to financial markets. Not only professionals but also individuals are investing in these markets, whose underlying assets are increasingly considered as financial assets like stocks or bonds. In this context, and taking into account the primary mission of protecting savings of financial markets, it has become crucial to apply to the CO_2 market rules that are inspired by the rules of the financial markets. Therefore, the best practices of regulation of the financial world: fight against abuses, the regulation of intermediaries, etc. should also be applied.

2.2.3 Mechanisms and functioning of the regulated market

Regulated markets are created and governed by compulsory national or international climate provisions. They allocate or auction GHG emission targets (quotas or ceilings) to countries, subnational entities or companies and allow them to purchase C credits to reach their ceilings, or to sell if their emissions are lower than those ceilings (there is exchange, that is why it is also referred to as "cap and trade").

2.2.4 Limitations of regulated markets

- **Cap and cumbersome regulation**: initially, the setting of a ceiling imposed to economic operators is based on statistical data on the volume of emissions that are fluctuating both as a result of economic conditions and because of the disparity of the methods of analysis. In addition, the limitations imposed are based on economic forecasts that may prove to be false. The cap-and-trade system also imposes a heavy burden in its application: define the companies subject to it, allocate quotas to them, and manage registers and transactions, make the system an *administrated* program and hence rigid.
- **Sectors that cannot be reached by regulation**: if the large emitters in the industrial and energy sectors are easily identifiable, this is not the case for small emitters and even transmitters especially when they are outside the industry. Yet, non-industry and energy emissions, particularly those related to buildings, account for 30% of total GHG emissions and consume 40% of all energy used.
- **Political uncertainty**: Both at international and local levels, political uncertainty affects the development of the regulated market and even its existence (e.g.: the United States, the world's second largest emitter of GHGs after China has not ratified the KP; Canada, after ratification, has withdrawn); in these conditions, how can a stable market with conditions that reassure the economic players in the long term be created? The same applies to the national level where changes in the political majority call into question cap-and-trade legislation, as in Australia.

Exercise: Group discussion (25 minutes)

1) What are the differences between the market for environmental services and the regulated carbon market?
2) What are the mechanisms, opération and limitations of the regulated carbon market?

2.3 Voluntary carbon market

Objectives

At the end of this session, the learner will be able to:

- Explain the characteristics of voluntary C markets;
- describe the structure and organization of voluntaryC markets; and,
- determine the mechanisms and operation of the voluntary C markets.

2.3.1 Origin and issues

The voluntary exchange market is a mechanism for trading C credits not linked to inter-national regulation (unlike a C exchange). The voluntary market allows entities (companies, municipalities, individuals or NGOs) to acquire C credits to offset their GHG emissions, outside the regulatory framework and any legal obligation. The players in this market can buy either C credits from a regulated market, such as the KP, i.e CERs, or C credits from the voluntary market (VER) that are certified, mainly by NGOs. Therefore, the VERs are not issued by a State or administrative authority. As a result, their issuance is not subject to the bureaucratic cumbersome rules related to the CERs.

2.3.2 Structure/organization of voluntary markets

A major hub in the voluntary exchange market is the Chicago Climate Exchange (CCX), whose exchange volume has exceeded 11 million tons of emission reduction since it began operations in 2003. It includes among its members some States, municipal governments and private companies having voluntarily committed to reducing their GHG emissions (average 4% over the period 1998-2001 for the first phase in 2006 and 6% for the second phase). In addition to exchanging credits, CCX also facilitated the creation of 3.6 million tons of emission reductions at the end of 2006. Other voluntary exchange markets exist and the best known are: Montreal Climate Exchange, European Climate Exchange, Regional Greenhouse Gas Initiative, and Midwestern Greenhouse Gas Reduction Accord.

2.3.3 Normative framework of the voluntary market (Standards)

Although the voluntary market is very open, it is not devoid of any organization or any benchmark. National and international public bodies and NGOs have developed standards to be applied to this market, which is not regulated, but standards have been developed to ensure a credible (real and verifiable) GHG emission reduction. These include *Voluntary Gold Standard* and *Voluntary Carbon Standard*. In addition, the ISO 14064 standard also demonstrates a rigorous approach to the development of an emission reduction project. The value VER units will depend on the quality and integrity of the project.

2.3.4 Mechanisms and functioning of the voluntary carbon market: concept of voluntary credit

In voluntary markets, organizations or individuals seek to buy C credits to offset their emissions for ethical or public image reasons. These markets are characterized by a wide variety of actors, processes and types of C certificates. Voluntary markets can sometimes be linked to other markets. For example, some companies offering emissions offsets, purchase CDM project credits and cancel them so as to prevent their issuance elsewhere. Credits purchased by individuals will reduce the amount of total emissions permitted for businesses on the regulated market.

Exercise: Group discussion (25 minutes)

1) What are the differences between the regulated C market and the voluntary C market?

2) Analyse the mechanisms and operation of the voluntary carbon market.

2.4 Voluntary and regulated markets project procedures

Objectives

By the end of this session, learners will be able to:

Explain the main standards adapted to the voluntary C market, and,

Describe the different players who can intervene in the voluntary and regulated C markets.

2.4.1 Market standards

Based on the limitations of voluntary markets (market credibility in the absence of control, transparency of suppliers), a number of organizations and NGOs have developed standards adapted to the voluntary market. These standards include:

- **Main traditional standards**: Clean Development Mechanism, Verified C Standard, Gold Standard, REDD+, ISO 14064, Climate Action Reserve, etc; and
- **Additional Standards**: Social C Standard, W+ Standard, Water Benefits Standards, Climate, Community & Biodiversity Standards, Vivo Plan, etc.

2.4.2. Main market players

C funds are partnerships between buyers and private or public institutions. They centralize a demand for credits from buyers and prospect projects. The credits generated by the projects are then distributed to the various funders in proportion to their participation. In C markets in general, supply is offered by projects, countries or companies. Projects produce and sell credits from reduction or absorption actions. Countries or companies sell permits in excess of their emission quotas. The demand is made up of countries, companies or individuals looking to buy licenses or credits to fulfill commitments or for ethical or image reasons. Transactions can be made directly between a buyer and a seller or through intermediaries. We therefore find the following players in these markets:

- **project developers**: develop projects to reduce GHG emissions and sell VER;
- **wholesalers**: sell offsets only in large quantities and often have a portfolio of credits;
- **retail sellers**: sell small amounts of credit to individuals or organizations often online, and may have a portfolio of credits; and,
- **brokers**: do not have credits, but facilitate transactions between sellers and buyers.

Exercise: Group discussion (15 minutes)

- Identify the players in the C markets.
- Cirtically examine the roles of these players.

2.5 Carbon trading

Objectives

At the end of this session, learners will be able to:

- Determine the flexibility mechanisms of the C market.;
- Describe the rules and operations of these markets.
- Explain the mechanism of C offset and legal entity accreditation; and,
- Describe the structure of the contracts of purchase and price of C and the terms of sale and payment.

Activity 1.5: Group discussion in (25 minutes)

Analyse the different aspects of C trade.

2.5.1 Origin and flexibility of carbon markets

The response to the challenge of climate change is the reduction of GHG emissions and sequestration of C from human activities. That reduction will be integrated into all economic activities of the planet through pricing anthropogenic GHG emissions. Toward this end, there was a wide range of available means at political level, but the main response chosen by the international community, both by the UN and by various States, was the establish-ment of *carbon markets* under the KP.

However, in an innovative approach, these commitments were accompanied by flexibility mechanisms based on the principle that combating "*climate change requires cost-effective-ness so as to ensure overall benefits at the lowest possible cost*". These flexibility mechan-isms included:

- exchange of emission rights or quotas between States (a *cap-and-trade* system); and,
- development of C-reducing projects allowing to generate offset credits with emissions rights; these projects came under two categories, viz.: Joint Implementation (JI), which allowed the development of these projects among developed countries, generating ERUs; CDM allows projects to be set up in developing countries, giving rise to CERs.

2.5.2 International law and carbon markets

The regulated market comprises the transactions derived from the UNFCCC, including the carbon market (ETS) established by EU, and a growing number of national or regional markets. The objective of UNFCCC was to stabilize GHG emissions "*at a level that would prevent dangerous anthropogenic interference with the climate system*". KP strengthened this obligation through quantified GHG emission reduction commitments (to reduce GHG emissions by at least 5 % over the period 2008 to 2012, with reference to 1990 emission levels). Technically, this commitment resulted in a right to emit a certain amount of GHGs during this period, each State having a ceiling of which amount of emissions is fixed in *Assigned Quantity Units* (AQUs) for the 2008-2012 commitment period. The exchange of these units between States has been a *prima facie* case for the C market resulting from the KP. This interstate market has become a business-to-business market through the establishment of an exchange system set up by EU under the KP.

2.5.3 Compensation

Voluntary C offset is a financing mechanism whereby an entity (government, business, individual) substitutes, in whole or in part, a reduction at source of its own GHG emissions, an equivalent amount of C credits by purchasing them from third parties. In practical terms, offset consists of measuring the GHG emissions generated by an activity (transport, heating, etc.) and then, after having sought to reduce these emissions, to fund a project to reduce GHG emissions or C sequestration: renewable energy, energy efficiency or reforestation, which will reduce the amount of GHG in another location. The underlying principle is that a given amount of CO_2 emitted in one location can be compensated by the reduction or sequestration of an equivalent amount of CO_2 at another location. This concept of "geographical neutrality" is at the heart of the mechanisms set up by KP. It is important to emphasize that voluntary compensation must be C neutral: it must always go along with or follow the implementation of alternative energy solutions or efforts to reduce emissions.

The compensation or flexibility offered to companies subject to EU quotas through the CDM allows them to offset their quotas with CERs. Let's note that this flexibility is primarily based on voluntary work, as the development of a CDM project is the result of an initiative by these same companies. Other cap-and-trade schemes accept, in accordance with widely varying rules, offset for emissions rights or quotas as well as the type of offset credits eligible for their system: Australia, California, India, Japan, Kazakhstan, New Zealand, Norway, South Korea, Quebec and Switzerland. South Africa recognizes its C tax offset through CERs.

2.5.4 Rules and markets functioning

A C market (or GHG emission allowance trading system) is a public policy tool to reduce GHG emissions (mainly CO_2) in the atmosphere, which are responsible for global warming. This policy consists of making the emitters pay the cost for the climate disruption caused by their emissions according to the *polluter pays* principle. This additional cost for emitters should encourage them to reduce their emissions, for example by reducing their energy consumption or by using renewable energies rather than fossil fuels. On a C market, a public entity (for example, the UN, the EU, or the State...) sets emission ceilings lower than their current emission levels for GHG emitters and distributes emission quotas corre-sponding to this ceiling. At the end of a certain period, emitters must prove that they have complied with their obligations by providing that public authority with the volume of allowances equivalent to their volume of emissions over the period. Those who have emitted more GHGs than the authorized level must buy the quotas they lack, unless they receive a large, generally non-discharged fine. Conversely, those who have emitted less than their allocated allowances can sell the quotas they do not need on the market or, if the market allows them to be kept for use in the next period.

2.5.5 Legal entity accreditation

Accreditation is the phase that precedes the generation of C credits. After verification, an independent auditor will certify that the project has been successful in avoiding GHG emissions. Under the CDM, it is the Designated Operating Entity (DOE) that certifies GHG reductions. A DOE is an independent entity accredited by UNFCCC to validate offset projects in the framework of the CDM.

2.5.6 Structure of purchase contracts and carbon prices

The legal relationship between the seller and the buyer of the CERs is materialized by a contract under which the objective is to define the conditions of delivery and payment of CERs between the two parties. Like any contract, the CER purchase contract covers the legal aspects of ownership of C credits, delivery and payment terms and risks associated with the transaction. Contracts are generally designed taking into account the specificities of the project and the parties involved (seller and buyers). While the majority of purchase contracts of emission credits derived from projects have common characteristics (*forward* purchases with payment on delivery), there is no standard contract yet. The purchase timeframe varies with the project, from a few years to ten years. The nature of the under-lying projects varies widely, and the risks of project non-performance are therefore very different. Depending on the contracts, risks - particularly the risk of non-validation of credits under the KP - are distributed very differently between the buyer and the seller. Some buyers, such as the Japanese Carbon Fund, bear a large part of the non-validation risk by acquiring the emission credits as soon as they are validated by an operating entity before they are certified by the CDM Executive Board.

However, most of the other buyers require the delivery of certified credits. In case of default, penalties are often introduced into the contract, for example in the form of fines or obligations on the seller to acquire CERs on the secondary market. Under these conditions, it is difficult to compare C prices between contracts for the following reasons:

- The price of C is very sensitive to the nature of the underlying asset. For example, emissions reductions not intended to be introduced into the Kyoto regime were purchased between \$ 0.65 and \$ 2.65/t CO_2e between January 2004 and April 2005, with a volume weighted average of \$ 1.20. Conversely, credits to be validated under the KP were purchased between \$ 3 and \$ 8; and,
- Prices vary considerably depending on whether the risk of non-validation rests primarily with the seller or buyer. When the buyer takes the risk of non-validation, prices range from \$ 3.60 to \$ 5/tCO_2e (weighted average \$ 4.23).

2.5.7 Terms of sale and payment

In practice, contracts can be designed according to different options, depending on the type of project and its progress, profitability, the nature and level of the risks involved, the quality and soundness of the project participants, etc. There are three main options for contracts:

- **Tolling agreement**: this type of contract involves two options, namely sale with payment in advance, or advance sale (when the project holder establishes a contract with a buyer before the implementation of the project) and the sale with payment on delivery (pay-ment is made when the buyer enters the CERs, i.e. when the CERs are transferred to the buyer's account in the national registry by the administrator of the International Registry on instructions from the EC);
- **The option contract:** the buyer pays an option premium to the project developer; the validity of the option is conditioned by special requirements that are the subject of a contract; and,
- **Direct resort to the carbon market**: after the project developer enters into the CERs, he can either call on a broker or find a buyer.

2.6 Benefits sharing

In the context of C trade, a benefit may be pecuniary or not, and be shared among indivi-duals, groups, communities and organizations. In the context of REDD+, benefits can be derived from the forest rent associated with the management of forest resources and from both monetary and non-monetary incentives. Financial incentives include cash payments, loans, wages, or tax reduction. Non-monetary incentives can be formal land titles, property and equipment, capacity building, price guarantee, cost-sharing arrangements, better enforcement of laws, improved market access, etc. These benefits can be shared with forest-dependent communities at the sub-national or local level, in a way that is either the contribution of the beneficiaries or the incentive to stimulate a particular set of activities. In some cases, the benefits may be more a form of compensation given to beneficiaries for not performing certain activities or to meet social obligations required by law.

In-text questions (15 minutes)

- Describe the existing C markets in Africa.
- What are the flexibility mechanisms of these C markets?
- What factors need to be considered in C trade?
- Describe how the profit from C sales is shared among actors.

2.7 Background on reduction of emissions from deforestation and forest degradation (REDD+) and clean development mechanism (CDM)

Objectives

At the end of this session, learners will be able to:

- define the origin of REDD+ and CDM projects
- describe of REDD+ and CDM mechanisms

Brainstorming (20 minutes)

- Describe the REDD+ and CDM mechanisms.
- Explain how these mechanisms contribute to the issue of climate change.

2.7.1 Origins and definitions

Origin of CDM projects

With the KP (1997), industrialized countries, the so-called Annex I countries (OECD and Eastern European countries) agreed on limiting their GHG emissions. These countries pledged to reduce their overall emissions by 5.2% over the period 2008-2012, compared to 1990 levels. This capping is reflected in emission reduction obligations specific to each industrialized country to which the Protocol allocates an annual quota of GHG emissions. In exchange for these obligations, pushed by the countries of the umbrella (composed of the US, Japan, Australia, New Zealand (which has since left), Norway, Russia, Ukraine and Iceland), three market mechanisms, known as "flexibility mechanisms" have been introduced to reduce the implementation costs of these commitments: joint implementation (Article 6), the clean development mechanism (Article 12) and the international emissions trading market (Article 17). These three mechanisms have a dual advantage for the industrialized countries: they will make it possible to fulfill the Kyoto obligations at a lower cost and they include the idea of a flexibility of the cost linked to their implementation, depending on the place of issue. The Marrakesh Accords, which were adopted in 2001, laid down the rules for the functioning of the CDM.

Interactive quizzes (15 minutes)

1) Describe the origins of the CDM.
2) What is the main objective of the CDM mechanism?
3) What activities are eligible in CDM?
4) Analyse the place of the REDD+ among the mechanisms to reduce GHG emissions.

Origin of REDD+ projects

The "avoided deforestation" mechanism, whose acronym has been successively RED, REDD and REDD+, originated from the debate on CDM eligibility for land use and forestry projects, which was one of the most controversial issues at the 6th Conference of the Parties on Climate Change (COP) in November 2000. One of the main reasons for a majority of delegates to reject "avoided deforestation" projects in the CDM was the risk of emissions "leakage": not tackling the structural causes of deforestation, conservation projects risk moving it from one location to another, either directly (through diversion of human pressures) or through price changes of agricultural products and land (a constraint on cropping new land can increase the prices of agricultural products and thus make deforestation more profitable in other forests). Following this rejection, a proposal on "compensated reductions" (financially) was formulated in 2003 (Santilli et al., 2003). It was designed as a response to the objection of the risk of leakage which had hampered the inclusion of conservation projects in the CDM. The proposal was that emission reductions of deforestation be calculated at the national level, reducing the risk of leakage related to project-based activities.

Since 2005 and with the proposal of the *Coalition for Rainforest Nations*, the REDD mechanism (which would become REDD+) has been the subject of intensive discussions as a remuneration principle for developing countries that would reduce their rate of defore-station. As negotiation progressed, the scope of eligible activities expanded under pressure from various public and private interest groups. First, combating forest degradation, followed by SFM, tree planting and C stock conservation were declared as "eligible activities" under REDD+.

Interactive quiz (10 minutes)

Analyse the relationship between REDD+ and CDM mecha.

2.7.2 Concept of CDM project

CDM is one of the means by which the developed countries signatories to the KP will fulfill their commitments. It aims to help developing countries achieve sustainable development by promoting "green" investment in their economies by the governments of industrialized countries and their enterprises. This mechanism allows an industrialized country to finance projects that reduce GHG emissions in a country of the South. In return, the investor obtains emission credits. The purpose of the CDM of the KP is to:

- help developed countries (or their companies) meet their quantified emission limitation and reduction commitments; for example, if a developed country is helping a developing country to set up a mechanism that allows the developing country to develop more sustainably, the developed country can deduct such aid from these emissions; and,
- assist developing countries in achieving sustainable development by contributing to the stabilization of GHGs.

Signatory and non-signatory countries

The protocol was signed on December 11th 1997 at the Third Annual Conference of the Parties ("COP3") in Kyoto, Japan. In order to enter into force, it had to be ratified by 55 developed countries that had consolidated at least 55% of the world's GHG emissions in 1990. It entered into force on 16 February 2005. To date, 196 "Parties" (195 States and the EU) have deposited their instruments of ratification, accession, approval or acceptance, with the notable exception of the US. Only 37 industrialized countries were really committed to the objectives of this mechanism during the first period. Developing countries, including Brazil, China, India and Indonesia, are also parties to the Protocol but are not involved in the commitment to reduce GHG emissions. In practice, sanctions resulting from non-compliance with the KP have never been clearly defined. In practice, the agreement is not legally binding to date. COP 21 in Paris (30 November -11 December 2015) was intended to lead to a legally binding agreement involving all 196 Parties. The objective is to limit the temperature increase of the globe to 2°C compared to the beginning of the industrial era.

Group discussion (25 minutes)

- Identify the signatory and non-signatory countries of the KP.
- Evaluate the position of China, Brazil and Indonesia and the success of the mechanism and show how this impacts on forestry in Africa.

Chronology of CDM and challenges in Africa

In 1992, at the Rio Earth Summit, the countries present adopted the UN Framework Convention on Climate Change (UNFCCC) and thus recognized the influence of human activities on global warming. In the UNFCCC, the signatory industrialized countries (listed in Annex 1 of the Convention) were to reduce their GHG emissions to 1990 levels by the year 2000. This commitment soon proved insufficient to avoid the inevitable warming of the climate. That was why, during the COP 1 in 1995, following the entry into force of the Con-vention, the Contracting Parties decided to begin negotiations to adopt the Protocol of Kyoto. In order to reduce the costs associated with the implementation of these reduction commitments, the three "flexibility mechanisms", including CDM were put in place.

One of the intentions in the creation of CDM was to bolster Africa through technology transfer, community-level development benefits, enhanced private-sector investment and market development. However, projects in Africa that had successfully journeyed through the formal procedures for developing and registering a CDM project were very few (3% of the projects) (Desanker, 2005).

The nature of the development benefits from a CDM project is left to the developing country to define, while the contribution towards offsetting a developed country's emissions is assessed and verified at the international level. This has several implications important to the success of the project. Projects need to be developed with the close collaboration and cooperation of the hosting government to ensure that CDM activities have broad national support. Neglecting the role and interests of a national government has led in some cases to difficulties in registering CDM projects. The international oversight of the actual emission reductions raises the need for elaborate systems for approving, verifying and validating projects and accruing emission reductions. This process is widely seen as too complex and costly for many developing countries to navigate, or in the case of small projects (which have simplified rules) simply too costly. In addition, CDM projects are supposed to be developed by the private sector, often in domains – including forestry – that have traditionally not been managed through private investment in Africa.

Given the high degree of land degradation in many African countries and the heavy depen-dence on wood resources for energy, afforestation and reforestation projects (sink projects) make intuitive sense. The low technology requirements to grow trees should make this type of project very accessible even to rural communities. Yet the trends in African CDM participation for this type of project are especially grim. The challenges are many, and vary by country, but in general include (Desanker, 2005):

- prohibitive costs and lack of investment capital to develop forest projects over the many years before income from emission trading starts to accrue;
- lack of private investors for afforestation and reforestation, since these activities have typically been carried out through government or donor-supported development projects in most of Africa;
- uncertain markets for emission reductions, especially the reluctance by many buyers in developed countries to consider credits from forestry activities;
- the complexity of the processes for developing projects to completion, especially the preparation of methodologies, and the lack of national technical capacity to develop methodologies without reliance on expensive international technical support;
- lack of adequate international institutional capacity for the various steps in a CDM project from mobilization of resources to certification and validation for the diversity of situations in the many countries of Africa;
- lack of institutional capacity in Africa for implementing all the requirements of CDM participation, such as the establishment of a Designated National Authority (DNA) which role is to define sustainable development criteria and facilitate private investment in CDM activities; and,
- difficulties in identifying eligible projects.

Mechanisms and principles

A State or an enterprise in an Annex I country invests in a project to reduce GHG emissions in a developing country. In exchange for the reductions noted, an equivalent volume of Certified Emission Reduction Units (CERs) is issued. This investor may sell these Units on the market or deduct them from its international reduction obligations. The objective of the CDM is two fold:

- for industrialized countries (Annex I): to reduce the cost of implementing their reduction commitments by financing or carrying out low-cost emission reduction projects in developing countries; nevertheless, the Protocol requires that significant reductions can be made within the industrialized countries; and,
- for developing countries (Non-Annex I), it is a question of hosting projects that contribute to their sustainable development; technology transfer is supposed to take place.

The main stakeholders involved in a CDM project are:

- The ***Project proponent***: the entity that develops the project and submits it to the CDM Executive Council for adoption; this body can be a government body, a municipality, a foundation, a financial institution, a private operator or an NGO;
- ***CDM Designated Operational Entities*** (DOEs) are national or international entities (auditing firms) accredited by the CDM Executive Council and invested with various operational missions: validation of the PDD; public submission of the PDD; incorporation of stakeholder input into project documents; verification and certification of reduced emissions during project operation;
- The ***CDM investor of the project*** is generally a public institution or a private operator from an industrialized country with a binding commitment to reduce GHG emissions;
- The ***host country of the project*** is a non-Annex I country, having met the conditions for eligibility for participation in CDM projects (ratification of the KP and establishment of a CDM Designated National Authority (DNA); and,
- The ***CDM Executive Council (CDM-EC)***: an institution operating under the authority of the COP with several responsibilities: formulation of recommendations on modalities and procedures for CDM projects; approval of methodologies, base and project monitoring plans; accreditation of Designated Operational Entities; public submission of CDM projects for stakeholder comment; maintaining a CDM project registry; and, issuing Emissions Reduction Certificates.

Interactive quizzes (20 minutes)

1) What are the consequences of the lack of binding legal provisions on CDM for forestry in Africa?
2) In what ways can the refractory countries be encouraged to join this mechanism?

Incentives measures

Objectives

At the end of this session, learners will be able to:

- Describe the CDM incentives for developed countries.
- Assess the CDM incentives for developing countries

The CDM provides developed countries with the means to obtain emission reduction credits, access to new markets, an opportunity to prove the viability of a voluntary financial and environmental approach. For developing countries, new financial resources are needed for their development, employment and income creation, and increased investment in priority sectors (infrastructure improvements, etc.). The CDM should provide green technology transfer, improved energy efficiency (lower costs, reduced reliance on fossil fuels) and the local environment (improved quality of life). Through this climate policy, the countries of the South must therefore make their contribution by facilitating the implementation of projects in the frame of a rational and sustainable development.

The attractiveness of this new mechanism for host countries has resulted in the establishment of structures in a growing number of developing countries to promote, support and validate these projects. The CDM can thus serve as a complementary instrument of support for the competitive positioning of the company. It is precisely the incentive and stimulating nature of this instrument which is of interest to many companies, with effects on innovation as well as on the transfer of technology to developing countries, the main beneficiaries, in fine, of these mechanisms.

Interactive discussions (30 minutes)

- To what extent are the incentives for developed countries sufficient to get them to join the CDM process?
- How are incentives to host countries sufficiently equipped to ensure the sustainable, clean and rational development of these countries?

Measures and incentives for carbon producers

Objective

At the end of this session, learners will be able to:

Determine the measures and incentives to C producers that enable continuity in playing their role as C sinks.

Brainstorming (20 minutes)

- What is the meaning of the term C producer?
- Describe the measures and incentives for C producers under CDM.

The attractiveness of the CDM lies in the fact that it combines an incentive mechanism, particularly with operators in the North who have undertaken commitments to reduce or limit their emissions, and an interest for host countries that can thus promote environmentally friendly development projects. Taking into account the fact that the investments under the CDM will take place in developing countries and will generally be financed by "Party" countries or the enterprises that fall under them, this mechanism can be considered innovative as a new source of development finance. The CDM will support projects that can:

- make positive contributions to the local environment (waste, urban pollution, etc);
- provide positive contributions to the economy and generate positive social impacts (access to decentralized energy, forestry development, etc.);
- encourage foreign direct investment in new clean technologies and technology transfer: energy efficiency, industrial processes, sustainable forestry, land restoration, etc.
- provide an additional financial contribution to make a project financially viable by lowering the cost of its realization and exploitation;
- an additional source of revenue for the project, linked to the generation and sale of certified emission reduction units (CERs), more commonly referred to as "carbon credits";

- an option to reduce and diversify risks likely to be of interest to companies or groups with domestic targets for reducing GHG emissions under the European trading system; and,
- the CDM is also likely to provide additional benefits to project developers, particularly in terms of image and social and environmental responsibility.

Interactive quiz (20 minutes)

1) To what extent is the country approach appropriate in the current climate change conjecture?
2) Determine the status of countries, such as Russia, China, India and Brazil, as sinks or sources of C.
3) C credits is a solution to the GHG increase. Critically assess this statement.

CDM project cycle

Objective

At the end of this session, learners will be able to:

Describe the CDM project cycle from the development of project briefing notes to the registration of CERs.

Brainstorming (20 minutes)

- What are the main steps in the development of CDM projects?
- Describe Certified Emission Reduction Units (CERs).

a) Preparation of the Project Idea Note

The Project Idea Note (PIN) is an optional document that can be developed by the project proponent in order to have a first approval of its idea of a CDM project before embarking on costly procedures of a CDM project cycle (PDDs and next steps). The PIN is an abbreviated form of the PDD and includes the following:

- project participants: summary information about the promoter(s) and sponsor(s) of the project;
- project description: title, geographic location, type of activity and a brief description of the technical consistency of the basic project including the implementation planning;
- financial aspects of the project: project cost (core and CDM component) and expected sources of funding;
- avoided GHG emissions: GHGs covered by the emissions reductions, description of the baseline, crediting period, CDM calculations of expected reductions and financial revenue of the CDM;
- contribution of the project to sustainable development; and,
- other relevant information.

b) Development of Project Design Document (PDD)

The Project Design Document (PDD) is the CDM project document on the basis of which the project is registered by the Executive Council and which will enable the project to sell avoided emissions. The developer of a CDM project (State, private company or NGO) must fill in a standard form ("Project Design Document") and submit it to the Executive Council for approval. This form should contain the following key information:

- the baseline emissions scenario (business as usual scenario): is the scenario of the host country's future emissions within the project's sphere of activity, most likely in the absence of any CDM project; it is established on the basis of methodologies approved by the Executive Board;
- a plan for monitoring emissions (i.e. reductions) of the project based on methodologies to be approved by the Executive Board;
- an environmental impact study of the project; and,
- comments received during consultation with local stakeholders organized by the project developer.

Interactive quiz (15 minutes)

1) Describe the entities that can submit a CDM project.
2) Differentaite the Project Information Note (PIN) from the Project Document Design (PDD).
3) What are the disadvantages and/or advantages of skipping the PIN step?

c) Validation and registration of the project

Validation: After approval by the DNA, all projects must be validated by a Designated Operating Entity (DOE). Project Participants must select and establish a contract with a DOE for the validation of their project, previously approved by the DNA. The DOE will review the PDD and post it on its website to make it available to the public for a period of 30 calendar days. The public, including local project stakeholders and NGOs, can comment on the project. These comments are recorded by the DOE and sent to Project Participants (PP) to respond. During this public consultation period, the DOE examines the PDD and gives the PP the opportunity to make the necessary changes to the PDD in order to bring it into line with the requirements of the CDM "Modalities and Procedures". The DOE must follow a procedure established by the EC to conclude the validation of the project.

Registration: The registration corresponds to the formal acceptance by the EC of the project validated as a CDM project activity. This is a prerequisite for verification and subsequent certification of CERs. With the validation report, the DOE transmits to the EC an application for registration of the project. Registration fees and administrative fees must then be paid by the PPs. Upon receipt of these documents by the EC, a period of eight weeks (four weeks in the case of small projects) is granted to the Parties involved and the members of the EC to request the revision of the project in case of objection. The CER Registration and Issue Team (RIT) assists the EC in the process of evaluating projects submitted for registration and possible revision. The official response of the Executive Council on the registration of the project is transmitted to the DOE who informs the project holder. If positive, the project is officially recognized as a CDM project and can then be implemented. Otherwise, the PPs still have to respond to EC requests for clarification. The choice of a DOE and the costs of the services related to the validation services and the registration are the responsibility of the project holder.

Interactive quiz (15 minutes)

1) Describe how a CDM project is funded after the validation and registration stages have been completed.

2) To what extent is it possible to monitor the effectiveness of the actions proposed in the project?

d) Funding and implementation of the project

Project funding must be defined in the context of the project's feasibility studies upstream of the PDD. The financial package may include public, national or foreign funds, private funds and own funds of the Participants in the project. They can use a portion of the revenue from the sale of CERs that would be prepaid (if there is an advance) to complete project financing. This stage of the CDM project cycle is the same as in any other non-CDM project.

e) Implementation of monitoring plan of the project

In order to be able to produce CERs, the first essential step that the project proponent must undertake after the physical realization of the project is to rigorously implement the monitor-ing plan described in the Registered DP (Monitoring plan). This is prerequisite for subse-quent verification and certification of CERs. The proponent must prepare a follow-up report for the period after which he wants to obtain the CERs. This period, usually one year, may vary depending on the interest of the project holder from two months to four years. The follow-up report should cover all the elements contained in the project monitoring plan (e.g. data collection and archiving, quality assurance and quality control procedures, periodic calculation procedures, etc.). If the PP (or project proponent) does not have the capacity to carry out this specific work, they must recruit a competent technical entity to do so.

f) Verification/certification of emissions reduction

At the first deadline, the DOE recruited by the PPs verifies the emission reductions on the basis of the monitoring report provided by the PPs. This DOE must be different from the one that carried out the project validation, except for small projects where the same DOE may be authorized to carry out both operations.

Verification: Upon receipt of the monitoring report prepared by the PPs, the DOE shall review and determine the emission reductions that result from the implementation of the project during the period covered by the report. During this process, the DOE must perform a number of tasks, including a control on the project site. PPs must be prepared to answer all questions of the DOE and facilitate the task on the site. The DOE may propose changes to the monitoring methodology and comment on the implementation of the registered project. The DOE provides a verification report to the PPs, the Parties involved and the EC.

Certification: After verification, the DOE must certify in writing that the project activity has achieved the verified emission reductions. It must inform the PPs, the Parties involved and the EC in writing of its decision on certification immediately after the certification process. It must also post the certification report on its website to make it available to the public. The certification report is usually transmitted with a letter from the PP to the EC specifying the distribution of CERs between the PPs.

g) CERs registration

The certification report submitted to the EC by the DOE constitutes an application for the issuance of verified CERs. However, the issuance of CERs is effective only 15 days after receipt of the request. This period allows Parties involved in the project or at least three EC members to request a review of the number of CERs proposed for issuance. After this 15-day period, if there is no request for revision, the EC instructs the Registry Administrator to enter the specified amount of CERs on the EC “Transition Account” and then transfer to PP accounts according to their “distribution declaration”, after deduction of 2% of the CERs issued which will feed into the account of the Adaptation Fund. However, CERs are not entered in the PP accounts of the register until they have paid the administrative costs.

Interactive quiz (15 minutes)

1) Explain the extent to which the CDM project cycle is achieved.
2) What are the weaknesses and strengths of CDM projects?
3) Analyse the adaptation fund and its allocation mechanisms.

Steps in the development and implementation of CDM projects

Table 1. Steps in the development and implementation of CDM projects

Activity	Actors	Tasks	Expected result	Duration
Project design	Project sponsors (public or private companies, States)	Identifying partners, seeking funding, developing the project design document using the methods approved by the CDM Executive Board	Project design document	1 to 3 months
Project approval	Designated National Authority of the host country and of Annex 1 country project partner	Evaluation of the project’s compliance with the Marrakesh agreements and national rules	Approval letter	1 to 2 months
Project validation	Designated Operational Entity	Assessment and approval of project feasibility and GHG quantities to be reduced through the project	Validation report	3 months
Acceptance and registration of the project	Executive Board of the CDM	Evaluation of project integrity, submission of project to public comments	Decision of the CDM Executive Board	1 to 3 months

Activity	Actors	Tasks	Expected result	Duration
Project monitoring	Project leaders	Performance tests, demonstration of feasibility, implementation and follow-up of the project	Follow-up report	annual
Project verification and certification	Designated Operational Entity	Monitoring, evaluation and approval of reduced GHG reality and quantity	Audit and Certification Report	15 days
Issuance of carbon credits	Executive Board of the CDM	Assignment of Certified Emission Reduction Units (CERs)	Recording and account-ting for CERs	15 days

Note: The duration of each step includes the estimates of the CDM Executive Board

Costs related to the cycle of a CDM project

Objectives

At the end of this session, learners will be able to:

- Determine the costs of a CDM project from its drafting stage to its finalization;
- Assess the contribution of a CDM project to the development of the host country

Brainstorming (20 minutes)

Critically assess the costs associated with CDM projects.

There are two types of costs associated with the preparation and implementation of a CDM project:

- the first type is the development cost of the project which is the same for the develop-ment of any commercial project (feasibility studies, initial cost of construction and equip-ment, operating and maintenance costs, cost of capital, etc.); and,
- the second type of costs corresponds to the specific requirements of the CDM process, also known as “transaction costs”, which occur at different stages of the process. In this type of costs, there are still two categories of costs:
    - the costs to be paid to the Secretariat of the Convention and decided by the COP/ MOP or the CDM; they can therefore be calculated according to the requirements of the decisions;
    - service charges, ordered by the PPs, depend on the specific circumstances of the project and the service providers; some of these services can be carried out by the PPs themselves to reduce costs (e.g. development of the PDD by their own staff).

2.7.3 Voluntary Carbon Market and Clean Financing Mechanism

Objective

At the end of this session, learners will be able to:

Explain the difference between the Voluntary C Market (VCM) and the Clean Funding Mechanism (CFM)

Brainstorming (20 minutes)

- Explain the strengths and weaknesses of the CDM.
- What do we mean by voluntary C market?

The comparison of these two mechanisms is as follows in Table 2.

Table 2. Comparison of the Voluntary Carbon Market and the Clean Financing Mechanism

Elements of comparison	Clean Funding Mechanism (CFM)	Voluntary Carbon Market (VCM)
Commitments	The market for C credits generated by CFM projects (CERs) is part of the binding contract markets.	The voluntary market, or compensa-tion market is non-binding.
Credit buyers	The buyer is any organization offering to purchase CERs and may include a government or public body, a private company or an NGO from an Annex I country, a region-nal or international organization manda-ted by governmental organizations and/or private companies in Annex I countries, commercial intermediaries (commercial banks, insurance companies, etc.).	Buyers are companies or individuals who want to offset or neutralize the impact of their activities on the climate (to become "carbon neutral"), for reasons of ethics or environmental marketing.
Sellers of credits	On this market, the seller is the project leader (legal owner of CERs).	Any country in the North or the South with GHG emission reduction or carbon sequestration projects. Small-scale projects and community projects, including forestry projects.
Transactions	Transactions with a regulatory body.	Transactions are subject to over-the-counter agreements between buyers and sellers, without a regulatory body

Elements of comparison	Clean Funding Mechanism (CFM)	Voluntary Carbon Market (VCM)
Emission reduction arrangements	Emission reductions are subject to more flexible and less expensive independent modalities and procedures than those of the CDM.	Emission reductions are governed by more stringent and costly modalities and procedures
Types of eligible projets	CDM projects cover the sectors of energy, waste treatment, industry, transport, agriculture and forestry	The voluntary market accepts a wide range of projects, including projects to combat deforestation, which are not yet eligible for CDM

Interactive discussions (30 minutes)

1) what can you learn from VCM?
2) What are strengths and weaknesses of the VCM?
3) What guidance would you give to the CDM to make it more attractive and effective?

Summary

This chapter addressed the various mechanisms of the KP. It introduced REDD+ and put more emphasis on the CDM mechanism The mechanism of negotiable permits and the regulated C markets was presented. It addressed the voluntary C market with an emphasis on its origin, stakes, mechanisms and operation. The adapted standards (standards developed by certain NGOs) to the voluntary market and various players in the C markets were presented. It developed the parameters that must be taken into account or that are relevant in the context of C trading, such us terms of sale and payment, C purchase and price contracts, rules and markets functioning, inter-national law and C markets, flexibility of C markets. In addition, it addressed the concepts of offset, legal entity accreditation and profit sharing.

The chapter also described some basic notions of CDM projects, namely their principles and mechanisms of operation. It set out the main incentives to developed countries and host countries so that both parties fully adhere to CDM. It discussed the preliminary stages of the drafting of the project until the registration of the CERs on the PP account.

Then the chapter outlined the main measures for the effective reduction of GHG emissions. It went through the generation and sale of certified GHG emission reduction units.

Chapter 3. Assessment of Carbon Stocks

3.0 Introduction

This chapter provides the learner with basic concepts of payment for ecosystem services (PES), methods for calculating and estimating C stocks and changes in C stocks in different pools. It introduces learners to transparent and verifiable methods of the C market, quanti-fication of uncertainties and appropriate monitoring systems.

The objective is to enable learners to acquire skills to help measure and quantify C stocks. At the end of this chapter, learners are able to:

- understand the concepts of C sinks, biomass, C stock and C fluxes;
- know the methodology of biomass assessment; and,
- apply appropriate protocols and methods for estimating C stocks in different C sinks.

3.1 Definitions and concepts

This section defines the main concepts adopted in the disciplines related to carbon stock assessment.

Objective

At the end of this session, learners will be able to:

Explain the different terminologies used in C stock assessment.

Activity 3.1: Brainstorming (15 minutes)

Analyse the concept of “Carbon Stock”

Carbon: Carbon is a chemical element of the family of crystallogenes. Its symbol is C, its atomic number 6 and its atomic mass 12.0107. It is one of the main elements of the organic matter constituting living beings. Plants fix it during their growth from the CO_2 in the atmosphere or the dissolved CO_2 present in oceans.

Carbon cycle: This is the displacement of C in its various forms among the Earth’s surface, its interior and the atmosphere. The main C exchange mechanisms are photosynthesis, respiration and oxidation.

Carbon flux: The rate of C exchange between the reservoirs is called *flux*. These sinks are either C *sources* or C *sinks*. C sinks absorb C from another part of the C cycle while C sources release C. For example, green plants absorb C from the atmosphere and are considered a C sink. A plant that releases C into the atmosphere when it decomposes or is burnt is considered a source of C.

Carbon source: From an ecological point of view, a source of C or CO_2 source is an element (or process on it) that releases CO_2 into the atmosphere. For example, human activity produces GHGs through the use of fossil C sources (coal, gas, oil). Similarly, decomposition of dead vegetation releases large amounts of C.

Carbon sinks: This refers to places in the environment where C is present in one form or another. The C cycle is represented as four interconnected reservoirs or basins - the atmosphere, the terrestrial biosphere (including freshwater systems), oceans and sediments (including fossil fuels). Therefore there are natural C reservoirs that absorb C from the atmosphere and thus help reduce the amount of atmospheric CO_2.

There are processes that extract GHGs from the atmosphere either by destroying them through chemical processes or by storing them under another form (e.g. CO_2 is often stored in ocean water, plants or subsoils). Forests and oceans absorb about half of the emitted into the atmo-sphere. The oceans even constitute a durable storage for this C: indeed, any excess CO_2 dissolved in them is carried from the surface to the deep waters.

In-text questions (15 minutes)

1) Define terminologies commonly used for C stock assessment.
2) Describe the sources of C?

Carbon storage (or carbon sequestration) mechanism: is the process of long-term storage of CO_2 out from the atmosphere. It occurs naturally or artificially:

- naturally: in a C sink such as the oceans (dissolved CO_2), and fixed CO_2 in photo-synthetic organisms, planktonic algae, photosynthetic bacteria, grasslands, forests, vegetation cover and biological cultures, and in soils (mainly humus); and,
- artificially: through sequestration by reactor-raised microorganisms and storage or recovery of the biomass produced (as biomaterials, fuels, chemicals, bio-plastics, insulators, etc.). It can also be done artificially by sequestration and storage of CO_2 in an appropriate geological environment.

Carbon emission: This is the discharge of CO_2 regardless of the means. There are several types of emissions: anthropogenic emissions (those related to human activities: heating, vehicles, incineration units and various types of combustion or fermentation), natural emissions (may be of volcanic origin or related to forest fires, and more generally due to animal and plant respiration and to soil organisms (bacteria, protozoa, etc.)) and transport-related emissions.

Carbon Stock: is the amount of C in a “basin”, i.e. a reservoir or system that can accumulate or release C.

Carbon density : This is the distribution of the amount of C stock in a pool relatively to the whole of a system (example of C pools: dead wood C pool, soil organic C (SOC) pool).

Activity 3.2: Group discussion (25 minutes)

Discuss the importance of the following terminologies

- Main C sinks
- C fluxes
- Deforestation and afforestation balance.

3.2. Forest inventories

Planning for forest management and exploitation is based on knowledge of its potential and available resources. Some data collected on these forests can be used to estimate the forest resource availability. Forest inventories are a very important step in the collection of qualitative and quantitative information for the knowledge of the forest to be managed.

Objective

At the end of this session, learners will be able to:

- explain the methodologies and instructions for carrying out forest inventories.

Activity 3.3: Brainstorming (15 minutes)

What is the importance of forest inventories?

3.2.1 Objectives of forest inventories

Inventorying a forest stand allows us to quantify it, to define an initial state of standing capital. Monitoring over time allows us to better know the changes in this capital. This can be done from two perspectives:

- from a management perspective, enabling management to have guidelines and to plan harvests; and,
- from a silvicultural perspective, allowing the implementation of sustainable silviculture throughout time (e.g. knowing how to intervene in a stand according to the cuts realized, optimizing sampling intensities).

3.2.2 Inventory methods

Sampling

Sampling consists essentially of acquiring information from a fraction of a large group or population, in order to draw conclusions about the population as a whole. Its objective is therefore to provide a sample that will represent the population and reproduce as closely as possible the main characteristics of the population studied. In a forest inventory, it is not possible to undertake detailed study of all the stations in a given region, so we are led to determine a set of plots, which will be the only ones studied to represent all the others. The sample thus constitutes the set of individuals of observation and must be distributed in space according to certain logic. The results will be extrapolated to the forest, which requires statistical inference (mean estimate, error of the estimate).

Types of sampling

There are basically three types of sampling:

- **random sampling**: in which each point in the study area has a probability of being chosen at each placement of a sampling unit; each point is chosen independently of another point; increasing the efficiency of the design may lead to the subdivision of the population or the vegetation: this is called sampling at two degrees (two levels of subdivision), three degrees (three levels of subdivision), ..., n degrees (n subdivision levels);
- **systematic sampling**: the sampling units in the studied area are arranged at regular intervals in a rigid direction such that each unit is linked to its neighbors and the selection of a given unit systematically leads to the choice of the others; it is then carried out according to a network of points, lines or evenly spaced surfaces; for this type of sampling to remain random, the first point of the mesh must be designated at random; and,
- **stratified sampling**: non-homogeneous or multi-mosaic area (strata); thus, the region studied is first subdivided into strata according to criteria already known in order to minimize the variability within each stratum.

In-text question (15 minutes)

Describe the different types of sampling adopted for a forest inventory.

Sampling rate

The sampling rate is defined according to the objectives pursued by the study, but the generally proposed minimum sampling rate is 0.01 %. The higher the sampling rate, the more accurate the data collected.

Size and shape of observation sites (plots)

Plots vary in size and shape depending on the type of vegetation, but may be circular, rectangular or square. For the dominant tree formations, for the tree stratum, minimum surfaces areas are recommended.

Data to be collected

The data to be collected during forest inventories include:

- dendrometric information, woody species, palm trees, stem density, diameters, total height, drum height, basal area, volume of timber, total volume);
- non-woody biomass (leaves, grasses and soil carbon);
- qualitative observations on other uses (grazing, agriculture, NTFP, etc.);
- factors of environmental disturbance: grazing pressure, bush fires, etc.; and,
- stationary factors: soil type, texture, topography, type of formation and overall strata overlap.

Activity 3.4: Group discussion (25 minutes)

Identify the types of information to be collected during forest inventories and determine their contribution to the analysis of the dynamics of forest ecosystems.

1.2 Biomass assessment

Environmental changes involve a redefinition and expansion of ecosystem services provided by forests, while at the same time aiming at the sustainability of their management. Quantification of productivity and C storage function requires the development of methods for assessing forest volume and biomass. To this end, the use of a relationship linking the volume or biomass of one or more trees to one or more easily measurable parameters is a widely adopted approach.

Objective

At the end of this session, learners will be able to:

- describe the methodologies and instructions for the evaluation of plant biomass in different compartments of ecosystems.

Activity 3.5: Brainstorming (15 minutes)

Describe the steps followed in processing forest inventory data.

1.2.1 Above-ground biomass

Definition

This is the total biomass of living aerial, woody and herbaceous vegetation including stem, stump, branch, bark, seed and foliage above ground level. Note: Where forest understory is a relatively minor component of the above-ground biomass C pool, it may not be included in the associated methods and data used for certain levels, provided consistency is main-tained in the time series of the inventory.

The two main C pools are biomass and soil C. Biomass is defined as the total quantity of living and inert or dead organic matter, above and below the ground, expressed in tonnes of dry matter per unit area, such as a hectare. Soil C is C held in soil as organic matter, humified material and in stable structures such as charcoal

Total C = biomass C + soil C

Biomass C = above-ground biomass C + below-ground biomass C + dead organic matter C.

In Africa, for example, C in living biomass is dominant in a forest stand, accounting for about 60%, followed by soil C (approximately 34%). The share of deadwood and litter together is less than 11% in all regions. C in the litter pool is less than 5% in all regions, while soil C is the dominant pool in grassland and cropland systems (IPCC, 2006).

Methods of assessment of above-ground biomass

Destructive method consists of cutting down the tree and subdividing it first into two compartments: the trunk and the crown. The branches are then pruned along the trunk before the complete trenching of the tree with a chainsaw, from the base circumference at the large end of the shaft, to the small end circumference through the branches (Cassart, 2011). Trunks are afterwards weighed (piece by piece) using a dynamometer or digital load cell with an accuracy of 100 g to have the total weight of the trunk (trunk biomass). Then all leaves and small branches of the tree are put in a large bag to determine the weight of the leaves (leaf biomass). All branches of the tree are also weighed to obtain the total biomass of the branches. Finally, the total weight of the aerial part of the tree (above-ground biomass) is obtained by summing the different biomasses measured separately. It is important to note: (1) that the weights in reference are dry weights obtained by weighing in an oven to a constant value, and, (2) that because of the bulk of trees and forest compo-nents, all weights are derived from manageable fractions (samples) of each component, taking green weights first, subsampling the green weighed material to determine dry weights, and then by relating the dry weights to the green samples, deriving, finally, the dry weights for the components.

Non-destructive methods are based on the use of forest inventory data combined, in general or as far as possible, with local allometric equations (Gibbs et al., 2007). If destructive biomass data are needed to establish an allometric local biomass equation, scientists today agree to use a general allometric equation, and to adjust the allometry height:diameter with local non-destructive data (Chave et al., 2014). Thus, the above-ground biomass estimate is based on the allometric method proposed by Chave et al. (2004, 2005 and 2014) and which involves forest inventory data, thus :

$$AGB = \rho \times Exp(-0{,}667 + 1{,}784*Ln(D) + 0{,}207*(LN(D))^2 - 0{,}0281*(Ln(D))^3)$$

Where ρ = specific wood density (g / cm^3); D = diameter at breast height (cm); AGB (Above-ground Biomass) in kg).

Activity 3.6: Group discussion (15 minutes)

Analyse the different methods for assessing above-ground biomass.

1.2.2 Below ground biomass

Definition

This is the total biomass of living roots. Thin roots less than 2 mm in diameter (suggestion) are sometimes excluded because they can, often, not be distinguished empirically from soil organic matter or litter.

Assessment Methods of below ground biomass

- **Soil sampling method:** Soil samples are taken at different horizons (0 - 10 cm, 10-20 cm, 20 - 30 cm, etc.) with cylinders of different diameters. These soil samples are washed and the roots are recovered progressively using 5 mm, 2 mm and 1 mm diameter sieves . These roots are dried in an oven for 24 h to 60°C and weighed.

- **Excavation method:** Around a previously identified tree, delineate a polygon in which the excavation will be carried out. The hypothesis is that all the roots of the sampled tree that grow outside the polygon are compensated by those of the neighboring trees that penetrate the polygon. Excavation is carried out over a depth of 150 cm subdivided into layers (the first layer is 10 cm deep, all the others are 20 cm, up to 150 cm, i.e. 8 layers). The excavated soil is sorted on site with sieves and the large, medium and fine roots are recovered and bagged per layer. The roots are washed and sorted within 48 h in the laboratory. They are cleaned with running water, bagged, dried for 48 h at 60°C. in an oven and then weighed.

The total below ground biomass is determined by the weighing per area unit and the weights are converted to the respective areas of each land-use unit.

In-text questions (15 minutes)

- Explain the main methods for assessing below ground biomass.
- Describe the composition of the below ground biomass.

1.2.3 Litter

This is the totality of the dead biomass exceeding the size limit defined for soil organic matter (suggestion: 2 mm) and less than the minimum diameter chosen for dead wood (10 cm, for example), dead on the ground, at various stages of decomposition, and located above or within the mineral or organic soil. This includes the litter layer as usually defined in soil typologies. Thin living roots above mineral or organic soil (below the minimum diameter adopted for below ground biomass) are included in litter when it is not possible to distin-guish them empirically from litter.

Activity 3.7: Group discussion (25 minutes)

Analyse the evolution of above-ground to below-ground biomass ratio.

1.2.4 Soil organic matter

Definition

This includes organic C from mineral soils at a specified depth selected by the country and used consistently in the time series (C stocks in organic soils are not explicitly calculated using Tier 1 or 2 methods, which estimates only annual C fluxes from organic soils, but can be estimated using the Tier 3 method). Thin live and dead roots and DOM within the soil below the minimum diameter (suggestion: 2 mm) for roots and DOM are included in soil organic matter when it is not possible to distinguish them empirically. The default soil depth is 30 cm and recommendations for determining country-specific depths are given.

Method for evaluating soil organic matter

The assessment of organic matter must include other likely related parameters, since it can directly or indirectly affect their presence in soils. There are several methods of dosage out of which the most commonly used, the Anne Method, weight loss and Walkley & Black methods. Before evaluation based on each method, soil samples are dried in open air and then sieved to 2 mm.

- **Using the Anne method,** the organic matter is determined by:
    - the hot extraction of potassium bichromate in sulfuric medium;
    - dosing the excess of dichromate by a Mohr salt solution; and,
    - determining the volume difference that reacted with soil C (Naânaâ and Susini, 1988).
- **Based on the weight loss method,** the organic matter is determined by:
    - incinerating at 375°C, 5 g of soil for 16 hours (Moreno et al., 2001); and,
    - obtaining the organic matter content by doing the ratio of the difference between the weight of the dry soil and the weight of the soil incinerated (*100) on the dry soil weight; the weight of the dry soil is obtained by oven-drying for 24 h at 105°C.
- **With the Walkley & Black method**, the organic matter is determined through:
    - C extraction that is carried out as the Anne method with potassium bichromate in sulfuric but in cold medium; and,
    - the dosage of the extracted C by colorimetry (green color of trivalent Cr ions) at 590-600 nm.
- **To determine the cathodic exchange capacity (CEC):** you extract 10 g of soil with a normal solution of ammonium acetate at pH = 8.2 and afterwads you wash with alcohol and then a second percolation with a 10% NaCl solution. You carry out by steam the displaced NH_4^+ ions and collect them in a 2% boric acid solution and then titrate with 0.01 N HCl. The quantity of NH_4^+ expressed in meq/100 g represents the CEC.
- **To determine the exchangeable potassium**, you realize an assay by flame photometry in 1 N ammonium acetate extract at pH = 8.2. This assay requires range points prepared with a KCl solution.
- **To determine the assimilable phosphorus**, you extract with a 0.5 N $NaHCO_3$ solution adjusted to a pH = 8.5 by soda and you realize a colorimetric assay at 660 nm of the blue color developed by the phosphomolybdic complex reduced by ascorbic acid.

Activity 8: Group discussion (25 minutes)

What are the advantages and disadvantages of Tier 1, Tier 2 and Tier 3 methods for assessing soil organic matter

1.2.5 Carbon assessment

The carbon stock estimate is based on the different components of the ecosystems: quantity of carbon in the soil, amount of carbon in litter, amount of carbon in understorey vegetation, and amount of carbon in tree vegetation.

Activity 3.9: Group discussion (25 minutes)

Figure 1. Measurement of carbon stocks. Source: Delpierre, 2014

- In figure 1, identify the different corresponding compartments for carbon stock measurement.
- At the level of each compartment, briefly describe the method (s) that can be used for the assessment of the carbon stock.

Carbon of living matter (above ground and below ground biomass)

The amount of carbon contained in the total biomass (above and below ground) is calcula-ted as follows:

Carbon stock = CF. (AGB + BGB)

with CF being the C fraction by default (0.47) for all species, with interspecific and intra-specific variability being low (IPCC, 2006).

Soil carbon

The determination of the soil C may be carried out by dry method or combustion by deter-mining the CO_2 originating from the organic matter, but also by wet method, by provoking an interaction of the soil with a well-known amount of an oxidizing body.

- **Organic C dosing using dry combustion after automated decarbonation of soils**: The determination of the total organic C (TOC) based on the Dumas method requires, on the one hand, the total C (CT) determination through dry combustion and, on the other hand, the determination of total inorganic C (CIT) by calcimetry. Organic C is then obtained by calculating the difference between total C and mineral C (TOC = CT - CIT). However, this method is poorly adapted to high carbonate and low organic matter samples due to the inherent uncertainties associated with high values (CT, CIT) which accumulate on low differences (TOC). For this reason, the direct determination of organic C by the sulfochromic oxidation method remains possible for highly carbonated soils, but poses hygiene and safety problems due to the necessity to handle highly allergenic products.

- **Direct dosing using the wet method or sulfochromic oxidation:** This allows the direct dosage of organic C but presents risks of hygiene and safety due to the handling of dichotomous and very allergenic pollutants. The principle of the process is that the organic C present in the soil sample is oxidized by excess potassium dichromate in a sulfuric medium and at 135°C. Chromium VI (orange) is reduced by the organic matter in chromium III (green). Then, the chromium III formed is dosed by colorimetry. Indeed, the amount of chromium III is proportional to the organic C content present in the soil. The wet method adapts almost to all types of soils, requires low cost materials and reagents, allows the possible analysis of a large number of samples (one hundred) during the day and the glassware is reusable after cleaning.

Activity 3.10: Group discussion (10 minutes)

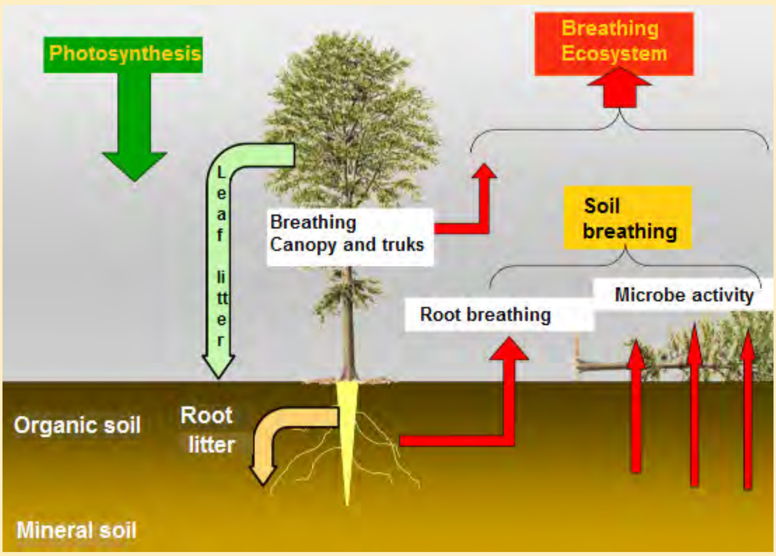

Figure 2. Carbon footprint in a forest ecosystem.
Source : Delpierre, 2014

3.3.6 Community engagement in carbon stock assessment

Because field sampling activities lead to direct interactions with community members, local communities should be informed about the ***Carbon stock assessment*** approach and process before the forest inventory begins. Ideally this should take part during the initial engagement with communities through the early stages of the process and toolkit should be made available to them. Communities will also need to give consent to any sampling activities being carried out on their lands.

Participatory mapping and community engagement should have indicated areas that communities identify as important to maintain for their current and future livelihoods and socio-cultural needs. These can include both High Carbon Stock (HCS) forest areas, for instance those used for gathering non-timber forest products or hunting, as well as non-HCS areas such as small farms, gardens or agroforestry plots. Note that if these non-HCS areas are identified during the image based classification or during the field sampling, but were not identified during the participatory mapping process, this could be an indicator that the participatory mapping process was not sufficiently completed and that it needs to be revised before the HCS process can be finalised (www.highcarbonstock.org).

Summary

This chapter has highlighted the key concepts and definition of terms on payment of ecosystem services. It has laid emphasis on forest ecosystem services taking into account the importance of forest inventories and methods used in forest inventory to quantity available biomass and C stock in the forest ecosystem. The chapter has demon-strated that quantification of productivity and C storage function requires the development of methods for assessing forest volume and biomass. The use of a relationship linking the volume or biomass of one or more trees to one or more easily measurable parameters has been highlighted as one of the widely adopted method of biomass assessment. In this chapter, also different types of biomass and C pools have been defined according to IPCC standards. Both destruct-tive and non-destructive methods of biomass assessment have been explained and demonstrated.

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A platform for stakeholders in African forestry

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ISBN 978-9966-7465-5-9