African Forest Forum

A platform for stakeholders in African forestry

Carbon Markets and Trade

A COMPENDIUM FOR PROFESSIONAL TRAINING IN AFRICAN FORESTRY

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Front cover photos: An affluent of the river Zio in Northen Togo (left), Land clearing for agriculture in Benin Front cover photos: Land clearing for agriculture expansion, Ghana (left), Logging, Ghana (middle), Land degradation in northern Ghana (right). Credit: Enoch Achigan-Dako & N'Danikou Sognigbe

Back cover photo: Mining in forest area, Ghana. Credit: Enoch Achigan-Dako & N'Danikou Sognigbe

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Abbreviations and Acronyms

AAU	Assigned Amount Unit
AFOLU	Agriculture, Forestry and Other Land Uses
CBD	Convention on Biological Diversity
CDM	Clean Development Mechanism
CER	Certified Emission Reduction
CH4	Methane
CMP	Conference Meeting of Parties of the Kyoto Protocol
C	Carbon
CO2	Carbon dioxide
CO2e	Carbon dioxide-equivalent
COP	Conference of the Parties
DOE	Designated Operational Entity
EUA	European Union Allowance
FAO	Food and Agriculture Organization
GHG	Greenhouse Gas
GWP	Global Warming Potential
IPCC	Intergovernmental Panel on Climate Change
JI	Joint Implementation
KP	Kyoto Protocol
MRV	Measurement, Reporting and Verification
NFPF	National Forest Programme Facility
NGO	Non-Governmental Organization
NWFP	Non-Wood Forest Product
ODA	Official Development Assistance
OECD	Organisation for Economic Co-operation and Development
PDD	Project Design Document
PES	Payment for Environmental Services
PIN	Project Idea Note
REDD+	Reduction of Emissions from Deforestation and Forest Degradation
UNCED	United Nations Conference on Environment and Development
UNFCCC	United Nations Framework Convention on Climate Change
VCM	Voluntary Carbon Market
VER	Voluntary 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.

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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 of the compendium.

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

Carbon market mechanisms, including emissions trading, Clean Development Mechanism (CDM), Reduction of Emissions from Deforestation and Forest Degradation (REDD+) and voluntary markets are seen as means of addressing climate change and other environ-mental degradation issues. The carbon market is driven by the cap and trade regimes or credits that fund or offset Greenhouse Gas (GHG) reductions. This compendium introduces learners to the principles and concepts of carbon stock assessment, carbon trading, payments for environmental services, trade processes and agreements related to carbon trading. It allows for the understanding and control of carbon stock estimation methods, methodological issues in the market and carbon trading, risks and opportunities in carbon market at global, regional and national levels.

Objectives of the compendium

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

(i). Assess forest carbon stocks;

(ii). Analyse opportunities for environmental services;

(iii). Describe carbon market and trading mechanisms;

(iv). Evaluate the institutional and legal frameworks of the carbon market; and,

(v). Determine the technical aspects of carbon projects.

Chapter 1. Principles and Concepts of Carbon Trading

1.0 Chapter overview

This chapter is intended to build learners' competence on the concepts and principles of carbon (C) trade and marketing, and introduce learners to the concept of Payment for Environmental Services (PES), the basic principles for preparation of a Project Idea Note (PIN) and a Project Design Document (PDD) for forest C projects, concepts and principles of economics and markets, and principles/practices of C markets and trading mechanisms.

Objectives

By the end of this chapter, the learner should be able to:

- describe the concepts and principles of Payment for Environmental Services (PES);
- describe concepts and components of PIN and PDD;
- explain the concepts and basic principles of economics and relate them to carbon markets and trade; and
- evaluate the principles and practices of carbon markets and trading mechanisms.

This chapter consists of four sessions. Each session may be presented in several training sub-sessions lasting an hour each. The number of sub-sessions per chapter depends on the nature, weight and type of content developed, vis-à-vis the nature of participants involved. The sessions are as follows:

- payment for environmental services (PES);
- basic principles of forest carbon Project Idea Note (PIN) and Project Design Document (PDD);
- concepts and principles of economics and markets; and,
- principles and practices of carbon markets and trading mechanisms.

1.1 Payment for environmental services (PES)

1.1.1 Introduction to PES

Activity 1 (Brainstorming) (10 minutes)

Share your views on:

- The concepts and terminologies: tangible and intangible ecosystem services
- Traditional sources of funds for ecosystem management: revenues collection, government budgets, Official Development Assistance (ODA) through bilateral and multilateral organizations, etc.

Forest ecosystems offer both direct tangible benefits and indirect benefits of which some are perceived as ecosystem services. The direct benefits include wood products for: firewood, charcoal, round wood and sawn wood. The Non-Wood Forest Products (NWFPs) consist of game meat, medicinal plants, fodder, latex, beverages, dyes, fibres, gums, resins, oils, beeswax and honey, tannins and toxins. Several of these are subsistence products providing nutrition to forest dwellers, critical in situations of drought and famine. Traditional medicines are the most common products to most rural and urban populations in Africa.

Ecosystem services include protection of watersheds that are sources of water for domestic use, power generation and irrigation, conservation of biodiversity, landscape beauty, climate change amelioration through carbon dioxide (CO_2) sequestration and storage.

The traditional sources of funds for forest management have, in most cases, focused on revenues from tangible forest products. Some governments also set aside budgets for conservation. UN has set a target of 0.7% of Gross National Income (GNI) of developed countries as Official Development Assistance (ODA) to developing countries. ODA can comprise loans, grants or technical assistance, in the form of bilateral or multilateral agreements, for the purpose of supporting infrastructure development, technology improve-ment, capacity building, environment conservation or removing structural barriers in the economy. ODA is short of the commitment of the developed countries as the average ODA/GNI ratio is only 0.22% for the Organization for Economic Co-operation and Develop-ment (OECD) countries (FAO, 2004).

At the 1992 United Nations Conference on Environment and Development (UNCED), in Rio de Janeiro, world leaders agreed on a comprehensive strategy for sustainable develop-ment: meeting our needs while ensuring that we leave a healthy and viable world for future generations. Some of the key agreements adopted at Rio were the Convention on Biological Diversity (CBD) and the United Nations Framework Convention on Climate Change (UNFCCC). This pact among the vast majority of the world's governments sets out commitments for climate change control and maintaining the world's ecological systems as we go about the business of economic development. While the Kyoto Protocol (KP) of the UNFCCC provides carbon-trading mechanisms, the CBD establishes three main goals: the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of the benefits from the use of genetic resources (UNEP, 1994).

In line with policies and priorities of the UNCED, many international development agencies and financial mechanisms provide funds for conservation. In developing countries, experience shows that the international conservation community mostly finances investment for conservation (Winrock International, 2004). These are mostly development banks and foundations from the United

States and Europe that solicit funds from developed countries and, through international agencies, implement conservation projects in developing countries. The Food and Agriculture Organization (FAO) of the United Nations through participation of the Collaborative Partnership on Forests (CPF) and the National Forest Programme Facility (NFPF) has established an online sourcebook on funding for sustainable forest management (SFM) (CPF, 2005). The major component of the source-book is the database of funding sources that provides different ways to locate global funding sources for SFM. Developing countries that have ratified the CBD treaty are eligible to propose biodiversity conservation projects. The private sector, NGOs and other civil society organizations that are doing conservation activities are also eligible to some fund sources.

With all these existing sources of funds for ecosystem management, most ecosystems in developing countries are still degraded or disappearing. It is proposed by neo-market natural resources economists that, new ways and institutional set-ups to generate funds for forest management have to be developed (Winrock International, 2004). These required funds for environmental services generation are referred to as *Payments for Environmental Services* or *Payments for Ecosystem Services* (PES).

Sound forest management practices generate a number of environmental benefits that their consumers may be willing to pay for. The services are, for example, C sequestration, biodiversity conservation, watershed protection and landscape beauty. These benefits can excite far-reaching effects at a global scale or have immediate effects at national/regional as well as at a local level. For example, a molecule of CO_2, regardless of where it is emitted, can be anywhere on the planet in little more than a week (Trexler, 2003). Similarly, reduction of greenhouse gas (GHG) emissions has the same effect on the atmosphere no matter where the reduction occurs. On the other hand, sound management of water catchments in upland areas can reduce soil erosion, landslides, sedimentation and flooding and provide clean water for downstream users at national/regional and local levels (Winrock International, 2004). Market opportunities for environmental services are therefore expected to be at international, national/regional and local levels. Empirical examples of these markets under these different levels will be given.

The term payments for environmental services or PES emerged in the 2000s when a number of disparate practices were conceptualized under a single term. PES is commonly presented as an innovative and particularly promising instrument for environmental conservation, particularly in the context of REDD+, which is supposed to provide solutions to the shortcomings of traditional tools. PESs no longer concern all services rendered to humans by ecosystems (definition of the MEA) but *the services that men make to each other through the use they make of nature* (Karsenty, 2013). PES is a concept that already guides resource management and development policies (Hassan et al., 2005). According to Wunder (2005), five criteria characterize the principle of PES: (1) a voluntary transaction, in which (2) a well-defined environmental service or a use that secures the service (3) is proposed for purchase by (4) a minimum of suppliers to a minimum of buyers (5) if and only if the supplier ensures the sustainability of the service (the necessary condition).

PESs are voluntary and contractual transactions between at least one buyer and one seller of a well-defined environmental service (or well-defined agricultural or land use practice) that results in payment (monetary or otherwise) conditioned by the respect of the terms of the contract over a defined period (Wunder, 2005).

Types of environmental services

In practice, the services that are the subject of PES are generally of four types: C-related services (storage or reduction of emissions), biodiversity services, water services (water quality and erosion avoided), and aesthetic services (beauty of the landscape for example). Other services provided by ecosystems are, according to the Millennium Ecosystems Assessment (MEA, 2005) classification, support services (processes internal to ecosystems) and supply services such as wood and fiber, food or soft water.

Economic opportunities for environmental services

PES can be defined as: "a voluntary transaction in which a well-defined environmental service or land management guaranteeing the performance of that service is purchased by the beneficiary if and only if the performance of the service is actually provided by the service provider" (Prokofieva et al., 2012). These are economic incentive tools and are increasingly used. Nowadays, these tools are used to broaden and diversify the financial base for SFM and to maintain the protective functions of forests. For example, many economic opportunities related to payments for environmental services are emerging in several sectors. But all of these economic opportunities involve increasing the efficiency of our resource use, limiting our environmental impact and accessing an environmentally-friendly service offered at attractive rates. Its economic opportunities may concern the textile, agri-food, building materials, and other sectors. The establishment of all its components can thus attract financial resources from the private sector.

In text question (10 minutes)
Describe the concepts of Payment for Environmental Services (PES).

1.1.2 Types of ecosystem/environmental services

Activity 2 (Brainstorming) (10 minutes)
What are your views on existing examples of PES and challenges facing PES establishment?

Biodiversity conservation payments

Conservation concession agreement: governments or local resource users agree to protect natural ecosystems in exchange for structured compensation.

- The opportunity cost of foregoing natural resource exploitation, including lost employ-ment and government revenue from taxes, may serve as a basis for determining the amount of the payment.
- This may apply, for example, in timber harvesting after a timber concession, whereby a logging company pays the government for the right to extract timber from public forests.
- Rather than log the concession area, the conservation investor would pay the govern-ment for the right to preserve the forest intact.

Purchase of nature: This provides financial support to local NGOs for strategic purchase of nature areas in tropical countries. In principle, nature areas should not be for sale, because these areas belong to everyone. In practice, however, purchase appears to be a strong instrument in saving highly threatened nature areas from destruction.

Forest carbon trading

Carbon trading is possible through the Clean Development Mechanism (CDM) of the KP of UNFCCC. Under CDM, developed countries will meet their GHG reduction commitments and get Certified Emission Reduction (CER) credits, by investing in certain kinds of tropical forestry. It had been agreed that in the first CDM commitment period (2008-2012), activities involving land use, land-use changes and forestry would be limited to afforestation and reforestation projects only. Avoided deforestation projects were not included.

- Being ratified, KP member countries are eligible to benefit from C trading under CDM.
- However, the requirements are very demanding.
- There is a possibility to benefit from non-compliance/voluntary markets.
- In the future, more opportunities such as REDD+ are also expected since the C market is still developing.

Watershed/Ecotourism

It is long accepted that sound natural resources management in upstream areas provides environmental benefits to beneficiaries downstream, such as hydroelectric facilities, clean irrigation and domestic water. The beneficiaries of these services can be asked to compensate the upland landowners for the services they are receiving. This mechanism provides self-sustaining markets for environmental services at the local level. Similarly, the recreational use of forests and their contribution to scenic beauty are effectively and widely sold through ecotourism enterprises. The revenues, whether collected by the government or landowners themselves, can be used as direct incentives for forest conservation.

People in urban areas are in most cases the main beneficiaries of water services and can compensate for watershed management through their municipal or town councils in order to avoid negative consequences of bad land management in upland areas.

Private and public hydroelectricity companies are also beneficiaries of water services. Empirical examples show that there are voluntary agreements between some hydro-electricity companies that compensate for watershed management by direct payments to the upland landowners. Other than these direct payments some electricity companies support conservation activities like tree planting.

Apart from domestic water in urban areas and hydroelectricity, bottled drinking water supply companies are also potential buyers of watershed services.

All these examples suggest that agreements for payments for water services provision include a whole watershed area, with improved land uses such as agricultural fields, forests and general lands. A legal framework is needed to institutionalize such agreements, as most of them are voluntary and locally made initiatives with little government intervention, though sometimes a government may act as an intermediary. For the voluntary mechanism to work there should be consumers' willingness to pay for the services. This is driven by increased awareness of the economic importance of environmental services, growing awareness of threats to supply of environmental services, and the availability of improved methods for monitoring status, impact and consumption of environmental services.

In text question (10 minutes)

Explain the factors hindering PES in your country.

Case study

Existing examples of PES Describe what the activities the learner is expected to do in developing the case. Thus, give the instructions to be followed.

1.2 Climate change and carbon trading

Activity 3 (Brainstorming) (10 minutes)
Views on the reasons why forest ecosystems are considered important on climate change regulation and on how forest carbon trading is possible. Brainstorming is always better after a brief introcudtion of the topic.

1.2.1 Background

The C market comprises all the mechanisms for exchanging and trading credits to reduce GHG emissions. C credits are credits earned for each ton of CO_2 that is not emitted into the atmosphere through measures that have been taken. For companies that do not manage to meet their quota, they have the opportunity to buy polluting rights - thanks to the C market they can increase their emission quota. The C market foundations emerged from the KP on 11 September 1997. At that time, the reduction in GHG emissions was quantified and dated. It was therefore decided that the overall reduction to achieve between 2008 and 2012 should be 5.2% compared to the 1990 level. It was set up in 2005 by the KP to encourage countries to reduce their CO_2 emissions and invest in cleaner technologies to combat global warming.

1.2.2 The role of forests in climate regulation

C trading emerged as a reaction to the alarming rate of increase of levels of CO_2 in the atmosphere contributing to climate change. This persuaded policy makers to look into ways of slowing down or even reversing CO_2 accumulation in the atmosphere. A leading approach thought of was to limit the amount of CO_2 emitted into the atmosphere, primarily by curbing fossil fuel use. The other alternatives were to identify ways of reducing the concentration of CO_2 in the atmosphere through natural processes. It was in this regard that forestry was considered as a possible way of reducing the build up of CO_2 in the atmo-sphere, because trees and other vegetation naturally draw CO_2 from the atmosphere for photosynthesis, and store (sequester) the carbon in their body - leaves, bark, branches, roots, and storage organs. To promote tree planting and sustainable forestry practices, including rehabilitation of degraded areas, various policy directions have been initiated across the globe, with the overall aim of enhancing C sinks. This has remained politically and environmentally attractive.

On the other hand, forest biomass acts as a source of C when burned or when it decays. Also when soil is disturbed it releases CO_2 and other GHGs into the atmosphere. The Intergovernmental Panel on Climate Change (IPCC) estimated that 20-25% of current global annual carbon emissions are the result of loss of tropical forest (IPCC, 2000). Mechanisms are, therefore, underway to slow down the loss of tropical forest and thereby reduce the amount of CO_2 that is emitted to the atmosphere.

1.2.3 Operational terms used in climate change and carbon trading

In order to understand the concepts of climate change and C trading, it is important to get acquainted with the meaning of the following key terms.

Climate change/global warming: This is a change in global climate which results directly or indirectly from human activity that changes the composition of the global atmosphere, in addition to natural climate variability. Global warming is a more popular term that recognizes that global temperatures overall have been increasing since the industrial revolution.

Carbon (C) is an element found in many GHGs, though not all. CO_2, the most significant component in the GHG mix, accounts for about 80 % of the total; methane (also a carbon-based GHG) is another important component.

Carbon dioxide (CO_2) is a naturally occurring gas, also a by-product of burning fossil fuels such as oil, gas and coal, of burning biomass, and of land use changes and other industrial processes. It is the principal anthropogenic GHG and thus the reference gas against which other GHGs are measured. It is described as having a global warming potential of one.

Kyoto Protocol (KP) is an international agreement linked to UNFCCC. The Protocol sets binding targets for industrialised countries which are signatories to the protocol as listed in Annex 1, for reducing GHG emissions amounting to an average of a five % reduction against 1990 levels over the five-year period 2008-2013. UNFCCC 'encourages' industrialised countries to stabilise GHG emissions, KP 'commits' them to do so. KP established C trading to facilitate this.

Carbon trading is the sale and purchase of GHG (or C) accounting tokens (permits and credits) including transactions and securities based on these accounting tokens. It also means that C trading is the process of buying and selling of quotas that allow the holder of the quota to emit the equivalent of one tonne of CO_2 per unit. This implies that if a company's or a country's emissions are lower than its quota, it can sell its surplus. If it exceeds its limits, on the other hand, it will have to buy additional quota on the market or cut its production. It enables polluters to meet their reduction targets over the crucial next decade without the structural changes that will be needed for the longer-term reduction targets and the transition to a low carbon economy.

Carbon credits: a unit of offset credit represents the right to emit one tonne of CO_2. Credits can be exchanged between the offset project owner and a company or individual requiring such a credit to offset their emission or can be bought and sold on the international market at the current market price.

Carbon dioxide equivalence (CO_2e): There are several gases other than CO_2 that have global warming effect and half-lives in the atmosphere that differ from that of CO_2. In order to be able to compare the dangers of each of the gases, their global warming potential (GWPs) is measured against a metric tonne of CO_2 over a fixed period, so as to know what mass of the gas would have the same global warming effect. This is known as its *carbon dioxide equivalence*. KP measures CO_2 equivalence using a time horizon of 100 years.

Carbon financing are financial resources provided to projects generating or expected to generate GHG emission reductions in the form of purchase of such emission reductions. Its also defined as a purchase contracts whereby one party pays another party in exchange of a given quantity of GHG emission reductions.

Climate finance refers to local, national or transnational financing - drawn from public, private and alternative sources of financing - that seeks to support mitigation and adaptation actions that will address climate change. The Convention, KP and the Paris Agreement call for financial assistance from Parties with more financial resources to those that are less endowed and more vulnerable. This recognizes that the contribution of countries to climate change and their capacity to prevent it and cope with its consequences vary enormously. Climate finance is needed for mitigation, because large-scale investments are required to significantly reduce emissions. Climate finance is equally important for adaptation, as significant financial resources are needed to adapt to the adverse effects and reduce the impacts of a changing climate.

In accordance with the principle of “common but differentiated responsibility and respective capabilities” set out in the Convention, developed country Parties are to provide financial resources to assist developing country Parties in implementing the objectives of UNFCCC. The Paris Agreement reaffirms the obligations of developed countries, while for the first time also encouraging voluntary contributions by other Parties. Developed country Parties should also continue to take the lead in mobilizing climate finance from a wide variety of sources, instruments and channels, noting the significant role of public funds, through a variety of actions, including supporting country-driven strategies, and taking into account the needs and priorities of developing country Parties. Such mobilization of climate finance should represent a progression beyond previous efforts.

Carbon offsets is an instrument that aims to allow C to continue being released in one place in return for reducing C emission in another place. They are measured and given credits for each metric tonne of CO_2e they reduce. One C credit represents the reduction of one metric tonne of CO_2, or its equivalent in other GHGs. They are issued by various bodies, with some only accepted in voluntary markets. Only those issued by KP are accepted in the EU ETS.

Certified Emission Reduction (CER) is a unit of GHG emission reduction issued pursuant to CDM-KP, and measured in metric tonnes of CO_2e. One CER represents a reduction of GHG emission of one tCO_2e.

Clean Development Mechanism (CDM) is an arrangement under KP that allows industrialised countries with a GHG reduction commitment to invest in projects that reduce emissions in developing countries as an alternative to more expensive emission reductions in their own countries.

Credit is what is issued to project owners who prove they have reduced emissions from their baseline level in an industry or country that sits outside of a cap and trade system.

Derivative contract is the contract between two parties to carry out a transaction in the future based on an ‘underlying’ quantity such as an asset (e.g. C permits) or a financial variable (e.g. interest rate). This has four basic types: the forward, future, option and swap.

Emissions Reduction Purchase Agreement (ERPA) is a contract between a buyer and a seller of project based offset credits under KP stipulating the firm intent and method of purchase of credits eventually awarded to the project owners. The contract will also cover such events as failure to deliver. A pro-forma has been developed by the International Emissions Trading Association (IETA), and as such reflects the needs of its members, being mostly on the purchasing side of the contract. However, the terms are free to be set according to each project’s needs. Emissions trading the sale and purchase of airborne pollution accounting tokens (permits and credits) include transactions and securities based on these accounting tokens.

Global Warming Potential (GWP) is an index measuring the climate changing effect of a quantity of GHG relative to the climate changing effect of the same quantity of CO_2 over a specific time-span (assuming that there is a uniform mix of gases in the atmosphere). The GWP of CO_2 is thus always one. The GWP of other GHGs depends on the timeframe considered, as their decay rates vary. The value also depends on initial concentration, as the relationship for some gases is non-linear, i.e. there is a concentration at which their effect is suddenly magnified.

Joint Implementation (JI) under KP allows an Annex B country with an emission reduction or limitation commitment to earn emission reduction units (ERUs) from an emission reduction or emission removal project in another Annex B country, each equivalent to one metric tonne of CO_2. This can be counted towards meeting its Kyoto target. ERUs are created by converting an equal number of the host countries AAUs into ERUs and transferring them to the implementing countries registry account.

Linking Directive is a directive allowing GHG emission credits earned through the Kyoto flexible mechanisms (JI and CDM) to be used for compliance by operators of installations covered by the EU ETS.

Voluntary Emissions Reduction (VER) is a form of offset produced primarily for sale in voluntary offset markets.

Carbon market consists of exchanging carbon permits or offset credits for cash: this is known as spot trading because the agreed exchange takes place ‘on the spot’ (in fact usually between one and three days of the price being agreed); spot trading is relatively risk-free for those involved in the transaction, as parties are unlikely to default on payments over such a short period of time; in this method, spot prices vary with each transaction in the market and can change rapidly and unexpectedly with changes in information about supply and demand; this is where dealers and brokers enter the picture with various buying and selling instruments, creating a derivatives market; it is here, in the complex world of swaps, options and futures (all explained below), that the overwhelming majority of C permits and credits are traded; and,

Derivatives is a contract for the sale of future goods that is used wherever product process are volatile. It is also sometimes referred as **forward trade**. How does this work? consider a case where a farmer selling apples to a shop at an agreed price before the apples are ready to be harvested; this holds both pros and cons for the farmer; protection against future drops in price is set against the risk of missing out on future increases in price; the date that the contract is entered into is known as the trade date, and the date that the apples are harvested and delivered is known as the maturity date.

In an example of a forward trade, the shop pays the farmer what is known as a premium in exchange for taking on the exposure to any movement in the price of apples. This premium usually takes the form of a slightly inflated price for the product rather than an up-front fee. The farmer hopes that if the price of apples rises between the trade date and maturity, any loss encountered from having agreed to sell at a lower price will be at least covered by the premium paid by the shop. If the price of apples drops between the two dates, then the farmer will have made extra profit.

As well as the forward, there are three other building-blocks of the derivatives market: the **future,** the **option** and the **swap**.

Futures are closely related to forwards in that the buyer and seller agree to exchange the assets for cash on the maturity date. The difference is that futures are traded through an exchange, meaning that terms and conditions are set by whichever futures contract is offered by that exchange. Although a future is a bilateral agreement between two parties, as long as they are registered to trade on the exchange, parties do not need to know anything about each other. By contrast, forwards are traded between parties known to each other but where little information is made public about the trade. Typically, forwards have longer maturity dates than futures, which tend to be limited to the short to medium term. In the C market, futures are bought (Kill et al., 2010)

Options allow one of the parties to pay an up-front fee for the inclusion of a get-out clause in the C trading contract. In an option there is a fee-payer and a fee-taker. The fee-taker is obliged to fulfil the contract; the fee-payer is not. Options are popular because they allow the fee-payer to drop the contract if there is the opportunity of a better deal by buying or selling at the spot price available on the maturity date. All the fee-payer would lose is the up-front fee. In the C market, options are traded between emitters or speculators and dealers such as investment banks.

A swap is an agreement between two parties to exchange the difference between two prices of a fixed quantity of a commodity at periodic intervals. Typically, the exchange is the difference between a fixed price (determined at the trade date) and the spot price of the commodity at periodic intervals. Who pays and who receives depends on whether the fixed price is higher than the spot price. Swaps are used as a way to fix future prices. Swaps are a purely financial transaction that allow traders to hedge or speculate against future prices without the need to hold the underlying asset.

These basic derivatives are often mixed and matched according to desires of individual clients. Because the carbon market is relatively new, most trading is limited to these four basic derivative instruments – although new and more complex types of derivatives are being developed. In contrast to other commodities, no goods are ever exchanged when trading carbon.

Overall, the carbon trade works as illustrated in figure 1.

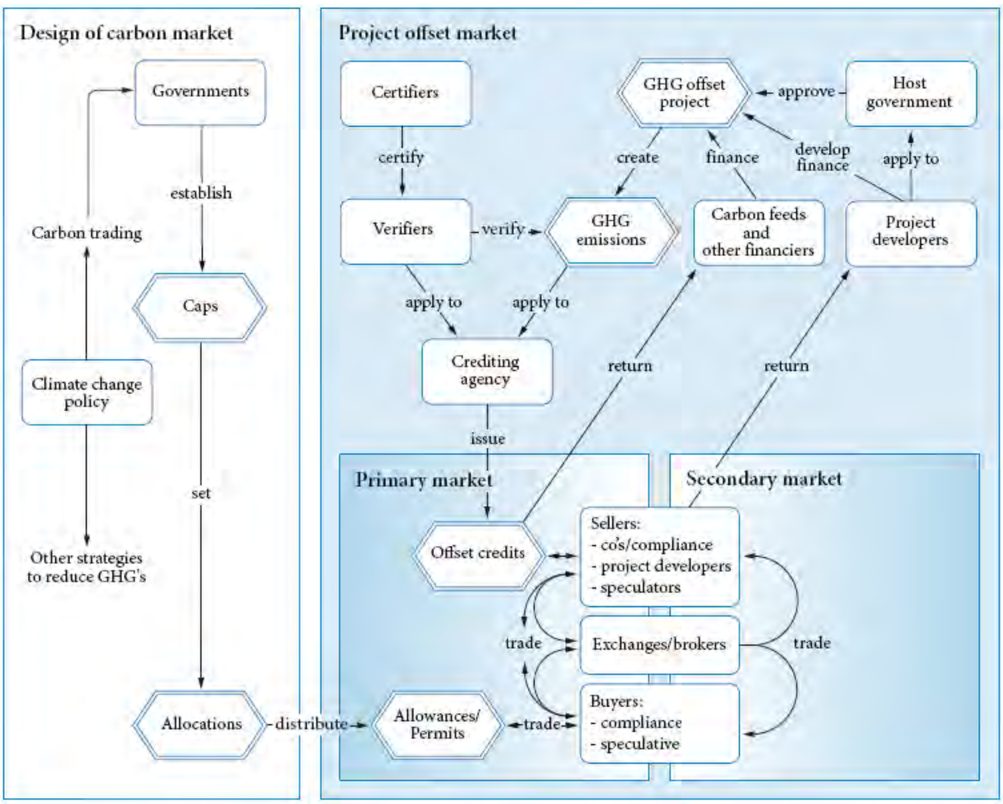

Figure 1. Carbon trade.
Source: Kill et al., (2010)

1.2.4 Clean Development Mechanism (CDM)

What is the Clean Development Mechanism (CDM)? Under Article 12 of the KP, an economic operator from an industrialized country (Annex B country) can purchase "emission reductions" in the context of a project in a country (Host country), according to a well-defined formal process. These reductions can be credited to the buying country, helping it to meet its GHG reduction commitments.

What is a CDM project? Any project that reduces or avoids GHG emissions or increases C sinks in a measurable and sustainable manner can potentially be considered a CDM project.

What are the eligibility requirements for the CDM? A CDM project must meet the following conditions:

- be mounted on a voluntary basis;
- contribute to the sustainable development of the host country;
- be "additional" in environmental and financial terms; and
- does not divert official development assistance.

Why set up a CDM project? By selling GHG emission reductions from a CDM project, the developer can improve the project's profitability. At the same time, it can strengthen its competitive position in the market by introducing new technologies, thus contributing to the sustainable development of its country.

In assessing a project's contribution to emissions reduction, a comparative element is needed. ***The baseline*** is this comparator. It can be defined as the future trajectory of GHG emissions that would normally and probably have been observed in the absence of the CDM project. In other words, the baseline is the most likely scenario of a company, sector, or even a country emissions evolution that would occur in the future if the project was not realized. The baseline (or reference level) is essential to any CDM project because it is used as a basis for calculating the emission reductions that would be achieved. Hence, the crucial importance of the care to be taken in its determination, in a transparent and prudent way.

Additionality is an essential core concept in the CDM philosophy. It will be argued that an additional CDM project is required if it meets the following two conditions:

- The project GHG emissions are lower than those that would have occurred without the project. Emissions reductions must be real, measurable and additional to those that would occur in the absence of the project activity; and,
- The project could not be carried out without the contribution of the CDM (financial, technological, regulatory, business-as-usual barriers, etc.).

By way of illustration, in order to demonstrate the first condition of additionality, it is necessary to:

- Determine the most likely reference scenario for the evolution of emissions, i.e the baseline.
- Estimate the emissions that the project itself should generate; and,
- Calculate the difference between baseline emissions and project emissions. The CDM Executive Board has developed an additionality test to be used to carry out this demonstration. The latest version of the test should be downloaded from the Convention website (www.unfcccc.int/cdm).

The ***accounting period*** is the length of time a given CDM project will generate C credits (CERs), which may result in a C transaction. According to the Marrakesh Accords, project promoters have a choice between two options:

- a period of 7 years, renewable no more than twice (i.e. 21 years in total), and,
- a fixed period of not more than 10 years, not renewable.

In the case of the first option, the baseline (reference scenario) must be redefined for each new period of 7 years. This option is more advantageous since it allows the generation of emission credits for 21 years. Nevertheless, it may be “risky” since it involves updating the baseline, which may be lower if the circumstances of the country have changed, which means a reduction in the C credits generated, calling into question the eligibility of the project. The 10-year option generates less CDM income because it is non-renewable, but it does not require any baseline discounting and therefore guarantees the initial estimated C credits. The accounting period is chosen by the project proponent itself as soon as the PDD is drawn up. In principle, the choice is made according to the context of the project and that of the country. Where there is a risk that the country context will change significantly, to the point where it would call into question the additionality of the project, it would be preferable to opt for a period of 10 years. For example, the promulgation of regulations requiring flaring of CH_4 at landfill sites during the first 7-year period challenges the additionality arguments of a CDM project for recovery and flaring of landfill gas. The project would run until the end of the 7^{th} year of the first period, but it would no longer be eligible for a second period.

Evaluation of emission reductions. The net emission reductions generated by a CDM project are calculated by subtracting the emissions from the baseline scenario (LB) from those of the project, to which leaks must be added. Project emissions are those directly related to the project on-site and off-site.

The scope of the project should be defined to identify project emissions and leaks. It must reflect both the physical or geographical boundaries of the project, and in particular the emission sources taken into account in the calculation of project emissions.

All GHG emission sources of the CDM project activity, which are “under control” of the project developer, which are “significant” and “reasonably attributable” to the project, must be included within the project boundaries. It is recommended that the boundaries of the project be shown in a diagram as well as the emission sources included and excluded from these limits.

Follow-up plan. The monitoring plan, which must be based on the approved monitoring methodology and set out in the CDM project document (PDD), defines the monitoring modalities of the project during its implementation. During this monitoring, project participants should:

- collect data to estimate GHG emissions within the project boundaries and to determine the “baseline”;
- identify all potential sources and data on the GHG emissions attributable to the project activity;
- periodically calculate GHG emission reductions and leakage in accordance with the approach specified in the PDD; and,
- set up quality control and quality assurance procedures.

The quality assurance and control procedures, the calibration of the measuring instruments and the uncertainty levels of the different variables to be measured must be specified in the project document. At the time of the verification, the Designated Operating Entity shall verify the authenticity of the uncertainty levels of the instruments used to do the measurements.

The project proponent should be aware that CERs will be generated from the implementation of the monitoring plan. It is therefore in its best interest to take the utmost care in developing and implementing the Monitoring Plan, which is its sole responsibility.

Concept of "cap and trade" refers to a policy where a regulatory or international body sets a limit (i.e. the cap) on the amount of pollution (e.g. GHGs) that can be emitted in a certain period by certain entities (depending on the body, these entities might represent industrial sectors or a group of nations). The cap is divided into permits for the right to a small part of the capped pollution. The permits have transferable title (ownership) which allows for exchange of permits. Not to be confused with offsetting.

In any cap and trade scheme, it is the cap which determines the scheme's level of ambition, while the trading component is intended to make compliance with the cap more cost-effective for the participating entities. In addition to the setting of the cap, the distribution of the permits and the monitoring of compliance all determine whether the 'cap and trade' scheme will achieve what it was developed for.

The "trade" component of any cap and trade scheme is a cost-management tool. It allows at least some of the entities affected by the cap to achieve their reduction commitment more cheaply. While it will not be possible for the trade component to make up for a cap set at an inappropriate level, the structure of the trading component is important to many participants for economic reasons. Those who advocate that trading is able to trigger structural low-carbon investment incentives point out that the structure of the trading component will determine investment incentives, and will thus influence the kind of energy infrastructure that companies and governments will invest in, as well as how soon the transition to low-carbon economies can take place.

The main structural aspects that determine the costs and incentives provided by the "trade" component are:

- how the pollution allowances are distributed?
- have the allowances had a use-by date?
- can extra allowances be imported from outside the scheme without breaching the cap? and,
- who is allowed to trade?

In a cap and trade scheme, a government or intergovernmental body sets an overall legal limit on emissions (the cap) over a specific period of time, and grants a fixed number of permits to those releasing the emissions. The polluting entity must hold enough permits to cover the emissions it releases. If one polluter does not use all its permits, it can trade them with another entity that has already used up all its permits and needs more to continue emitting without exceeding the legal limit. In the case of C trading, the entities that are being capped at present are the large industrial producers of the six GHGs: industrialised countries (in the case of KP) or companies (in the case of EU's or other regional emissions trading schemes). Each permit in a C trading scheme is considered equivalent to one tonne of CO_2e. Such permits presuppose that the global warming potential of the other GHGs can be calculated and converted to a multiple of the value assigned to CO_2, which is one.

Climate change and the cap. C trading is currently the central pillar of international climate change policy. In such cap and trade schemes, it is the level of the cap which determines how much emission is allowed. It also determines what contribution those countries whose emissions have been capped will make towards UNFCCC's stated aim of avoiding dangerous climate change and keeping global warming below 2ºC. The level of the cap within countries or regions determines how much the largest polluting industries contribute to achieving these national or regional emission targets.

IPCC predicted that GHG concentrations in the atmosphere would peak by 2015 before being reduced by up to 85 % by 2050 to stabilise at 445-490 ppm CO_2e. Even then, their estimation is that we will have a small chance of not overshooting 2º of warming. Many low-lying island states and countries most vulnerable to climate change are calling for a return as quickly as possible from the current 380 ppm CO_2 (430 ppm CO_2e) to a maximum concentration of 350 ppm CO_2, to limit average temperature rises to 1-1.5ºC. Beyond these levels, climate change will pose a threat to their existence. It is clear that the caps pledged as of January 2010 by industrialised countries in the post-2012 UN climate treaty negotiations are insufficient to bring concentrations to anywhere near the 450 ppm mark, let alone the lower levels called for.

Setting the level of the cap. The objective of UNFCCC (confirmed at the UN climate conference in Copenhagen in December 2009) is to avoid dangerous climate change. While there is still some debate about what the maximum temperature rise can be if this objective is to be achieved, the UN climate conferences have agreed to limit the average global rise to a maximum of 2ºC. Many analysts argue that to achieve such a drastic turnaround in emissions, governments need to focus on making structural changes to energy production, power grids and transport systems. Many governments have, however, decided to use C trading as the key instrument to halt climate change, often claiming that trading itself will help reduce emissions. This disregards the fact that the reduction is set by the cap, while the trade is only a cost-management tool, which does not itself reduce emissions. Setting a global C cap is complex. It involves governments assessing the costs and risks of not reducing emissions, and weighing these against the costs and risks of implementing the cap, in both the short and long term.

The straightforward theoretical approach to setting the cap would be to:

(i). decide on the policy objective, e.g. keeping global warming below 2ºC (and capping GHG concentrations at a maximum of 450 parts per million CO_2e) or keeping global warming below 1.5ºC (capping emissions at a much lower level); and,

(ii). determine how much can still be emitted before concentrations pass that policy objective.

In the context of the KP, the cap was set by industrialized countries collectively allocating themselves permits for 95% of the emissions they had been releasing before any limits were in place. In other words, the setting of the cap was not connected to the policy objective, for which a much lower cap would have had to be set.

Distribution of permits. Once a cap has been set, it must be decided who will be covered, and how to distribute the permits. This is one of the most contentious aspects of any programme that limits the release of a polluting substance. It is particularly so when the substance being limited is the key motor of economies, as is the case with fossil fuels, the main source of GHG emissions.

In cap and trade schemes, two main questions arise: *who* will be covered by the cap? and *how* to decide on the number of permits. Two further issues are *whether* to provide all permits up front or in instalments, and at *what* price to issue them. The decision of who will be covered has far-reaching implications which are not always immediately obvious. Should the scheme cover economic units, or should participants be chosen on the basis of their geographical location?

Under the KP, geographical location was chosen as the deciding factor: but now China and other exporting countries in the global South are arguing that a large proportion of their emissions comes from the manufacture of products that will be consumed in other countries covered by the KP cap, and that emissions ought to be accounted for by the consumer rather than the producer.

Permits and credits. *Permits* are pollution units given to emitters under a cap and trade scheme. They are issued by a relevant authority, usually a governmental body. In the case of C permits, they are effectively a licence to emit a certain amount of GHGs. UNFCCC issues Assigned Amount Units (AAUs), and the EU issues European Union Allowances (EUAs). There is often confusion around the term "permit"; some call them allowances, while others use "permit" to describe both allowances and offset credits (see below). In this guide we make a distinction between permits and credits.

Credits are the units which describe claimed emission reductions generated by C offset projects. In the regulated C market they are issued by a relevant authority (such as the board of the KP's CDM). In the voluntary market they are issued by the offset companies themselves. Under KP CDM, credits are known as *certified emissions reductions* (CERs), in the voluntary offset market they are known as *verified emissions reductions* (VERs). All existing regulated cap and trade schemes include trading of both permits and offset credits, and they currently command different prices.

Carbon Co-benefits. C trading fits well as an incentive provision mechanism for forest management while generating other different environmental services. Primarily C projects are managed for C sequestration and generate these multiple services all at a go. This is due to the fact that when the objective of the management is to generate some of the benefits, others are automatically generated. The logical PES payment scheme for forest should therefore aim at selling the services all together. The "*bundling*" of different forest services and 'selling' them together as a single product result in more value added to forest C projects and provide more tangible incentives to the forest owners.

In text question (10 minutes)

Explain how forest ecosystems regulate climate change and how forest carbon trading is possible.

1.3 Carbon offset markets

Activity 1 (Brainstorming) (10 minutes)
Share your views on existing markets for carbon and Carbon trade?

The C offset scheme is based on the following types of markets:

(i). compliance market; and,

(ii). voluntary offset market.

The compliance market is based on the KP because it created both the demand for offsets and the mechanism to fill this demand. It provides two instruments that generate carbon offsets. The Clean Development Mechanism (CDM) regulates offset projects located in countries that do not have emission targets – generally speaking, the global South – while Joint Implementation (JI) is the offset mechanism that allows for offset projects in countries with emissions targets (Kill et al., 2010).

Basically, the trade in credits generated by C offset projects under the Kyoto Protocol is often referred to as the "compliance market", because countries with a target under the protocol can count offset credits towards compliance with this target. All existing and planned C trading schemes related to the Kyoto Protocol, as well as regional cap and trade schemes in the USA, allow companies to use offset credits to achieve compliance with their emissions targets.

Outside this compliance market, C offset credits are also traded in the "voluntary offset market". In this market, offset credits are available for nearly any imaginable activity that generates GHG emissions. Individuals, companies or governments can purchase C offsets to compensate for the emissions caused by such things as air travel, car rentals, a band's CD or concert, conferences, births, weddings and funerals. Compared with the compliance offset market, trading volume in the voluntary offset market is relatively small, about one per cent of the regulated market (Kill et al., 2010).

Both the compliance and the voluntary offset markets have many elements in common. They are based on the same concept and projects in both markets use many of the same tools, mechanisms and procedures to calculate the volume of offset credits a project will generate or can sell.

There are also important differences, the crucial one being the overall lack of scrutiny and transparency in the voluntary offset market which makes it likely that a significantly higher percentage of projects selling offset credits in that market is not leading to additional emissions cuts. In fact, some projects that have been rejected by the CDM, because they could not substantiate their claims that the reductions would not have occurred in the absence of the C offset funding, have subsequently sold their credits in the voluntary offset market.

Overall the offset concept is illustrated below in Figure 2.

Offset credits allow the company buying the credits to continue emitting greenhouse gases that it would otherwise have had to avoid. Thus offsets do not reduce emissions. The net effect of a carbon offset on greenhouse gas concentrations in the atmosphere is at best zero, because what is claimed to be reduced in one place allows continuation of emissions elsewhere. In many cases, where the claimed emissions cuts are not additional reductions and where offset credits are thus issued for business-as-usual reductions, the net effect is an increase of greenhouse gas emissions in the atmosphere as the additional emission the offset credit justifies, is not met with an additional reduction.

Figure 2. Offset concepts.
Source: Kill et al., 2010.

The offset mechanisms in the Kyoto Protocol

The main difference between the two offset mechanisms – the CDM and JI – is that the CDM generates offset credits in a country without an emissions target under the KP, while with JI the offset-generating projects are located in a country that has a Kyoto target. The conceptual problem of verifying the generated offset credits applies in both mechanisms, but many proponents of JI projects argue that additionality is less of an issue for them, because they take place in a capped country. Thus, any credit it generates and sells is deducted from the capped country's pool of emission permits that it was issued under KP. This is important, as without such a conversion, the reduction would be counted twice: once by the C offset project that sells the offset credit, and once by the country in which the reduction takes place, where the project contributes to reducing the overall emissions in that capped country.

To avoid this risk of double counting, every JI project requires approval from the country in which it is located. Once issued, the JI project's offset credits are exchanged for an equivalent portion of that country's allocation of AAUs, with the AAUs being converted into a new unit, Emissions Reduction Units (ERUs), to identify their origin as JI offset credits. With this conversion, the country that gives up some of its emissions permits for JI offset credits accepts an exchange between an emission permit with a clearly verifiable value (the AAU) with an offset credit whose reduction value is not verifiable to the same extent (because it is a credit generated from comparing an actual reduction with an estimate of how high emissions would otherwise have been).

Because JI credits can only be sold if the country in which the project takes place is willing to exchange the offset credits for emission permits, few JI projects currently exist.

The approval process in the offset markets

Kill et al. (2010) states that the main difference between the CDM and voluntary C offsets is the absence of oversight, transparency and a uniform set of standards by which projects in the voluntary offset market are assessed. In this market there are several standards (Gold Standard, Chicago Climate Exchange, Voluntary Carbon Standard etc.) against which 'additionality' and other factors affecting the volume of reductions an offset project can claim are judged. Voluntary offset providers have often been criticised on the grounds that C reduction claims are exaggerated, unsubstantiated or misleading. The most commonly cited shortcomings are the virtual absence of verification and long-term monitoring of compliance with emission reduction projections made in the PDD, and the potential for the double selling of credits in the absence of some form of comprehensive register for voluntary offset projects. Many also argue that this makes it difficult for buyers to assess the true value of offset credits. Because of this lack of transparency, it is not possible to assess with any certainty the level of demonstrably non-additional offset credits traded in the voluntary market. It can be assumed, however, that due to the absence of scrutiny, the percentage is higher than that in the CDM.

The approval in the offset compliance has to pass through some processes before a C offset project can sell offset credits in order to establish the number that can eventually be sold. The voluntary market uses a less structured procedure with fewer independent assessments of the claims and calculations, and has no single agreed set of standards. It also lacks a central database comparable to the CDM's database that the UNFCCC Secretariat maintains to try and prevent the double selling of offset credits.

In text question (10 minutes)
Explain the difference between voluntary and compliance carbon markets.

1.3.1 Types of carbon markets

A C market is a market for the negotiation and trading of GHG emission allowances (not just CO_2). There are two C markets, voluntary compensation and compulsory compensation.

Voluntary compensation markets

The voluntary offset market is a C credit exchange mechanism not linked to international regulation. It allows exchanging C credits voluntarily. The voluntary offset market plays a very important role in agriculture and forestry projects. Voluntary C credits, or Verified Emissions Reduction units (VER), are mainly purchased by the private sector. Corporate social responsibility (CSR) and public relations are the most common motivations for buying this carbon credit.

Other incentives to purchase VERs are certification, reputation, as well as environmental and social benefits. The private sector can either purchase its C credits directly from projects or specialized companies (e.g. Ecosecurities) or purchase them from C funds (e.g. the World Bank BioCarbon Fund).

Examples of voluntary markets:

- Montreal Climate Market.
- Chicago Climate Exchange.
- European Climate Market.
- Regional Greenhouse Gas Initiative.
- Midwestern Greenhouse Gas Reduction Agreement.

Compulsory compensation markets

This type of market is used by companies and governments that, according to the law, must comply with GHG emission quotas. It is regulated by national, regional or international mandatory emission reduction schemes. The three mechanisms set up by the KP are very important for the compulsory compensation market: the Clean Development Mechanism (CDM), Joint Implementation (JI) and the Community Trade Emission Quotas (ETS).

1.3.2 Carbon offset standards

Activity 2 (Brainstorming) (10 minutes)
What are your views on existing carbon offset standards?

The management of forest C projects and the methodology used to determine the credits should meet national and international standards. Basically, all C markets use similar criteria to evaluate the C credits. However, there are strict criteria in the formal UNFCCC market compared to the voluntary market.

Projects under the voluntary C market (VCM) can be realized in a variety of ways. What is most appropriate depends chiefly on the buyer criteria. There are many critics of ventures developed under this market, given that it is not well regulated. Therefore, most project developers choose to implement ventures following the guidelines of some set of third party standards that have been developed to assure transparency and provide accountability to credit buyers.

The aim of C standards is to provide assurance for buyers that projects' emission reductions are real, additional and permanent. There are a number of C standards that can be applied to forestry projects globally:

- CDM;
- Agriculture, Forestry and Land Use Voluntary Carbon Standard (AFOLU VCS);
- Community Carbon and Biodiversity Standard (CCBS);
- American Carbon Registry (ACR);
- CarbonFix Standard (CFS);

- Climate Action Reserve (CAR);
- Plan Vivo Systems and Standard;
- ISO 14064; and
- Social Carbon Standard.

C standards, such as the CDM and VCS, focus on accounting C stocks and emissions in the project area under these different scenarios. CCB Standards require assessing analogous sites or aspects for determining net community and biodiversity impacts. Thus, CCBS does not issue certified credits but certifies that a project contributes positively to communities and biodiversity protection.

Depending on the project's characteristics, projected scale of C benefits, location, and fit with available methodologies, project proponents can choose between available standards. These standards have very strict requirements, such as project start date, proving additionality, and setting a project baseline. If these requirements are not met, or if the criteria do not meet the conditions on the ground, the project can fail to achieve registration/ accreditation.

Given the complexity of standards' rules and requirements, it is not an easy task to identify the best standard for a specific project. However, one can conclude that for rural forest-dependent communities in Africa, the most suitable standard is a combination of Plan Vivo and CCBS, as they were designed specifically to be applied in community settings.

CCBS, when combined with a recognized C accounting standard, is highly accepted in the market and ensures that environmental and social benefits will also be delivered to the communities. Plan Vivo provides good guidelines and tools on how to work with communities and implement projects on the ground. However, it has serious reservations towards projects that promote plantations using naturalized (i.e. non-invasive) species.

In text question (10 minutes)

Explain the difference between voluntary carbon standards and compliance carbon standards.

Summary

This session has covered voluntary and compliance C standards. Their similarities and differences are also explained. Although all C standards use basically similar criteria to evaluate the C credits, there are strict criteria in the formal UNFCCC market.

The session also covered the concept of PES and distinguished it from traditional sources of funds available for ecosystem management. Such sources of funds range from ecosystem management own sources such as revenues from sale of timber but also there can be government budget allocations and funds from development partners. All these are not enough which is why our ecosystems are still degraded. PES suggests market based opportunities to trade ecosystem/environmental services, e.g. C sequestration, biodiversity conservation, watershed protection and landscape bea uty.

Ecosystem management generates a number of environmental benefits such as C sequestration, biodiversity conservation, watershed protection and landscape beauty. The consumers of these services may be willing to pay for their sustainable generation. PES agreements can be made at local level for the case of, for example, watershed services but also at international level for the case of biodiversity and C sinks. These are opportunities that can be explored. However, there are also a lot of hindrances. That is why there are few successful cases in Africa.

The role of forests in climate change mitigation is also explained in this session, which also covered the important terminologies used in C trading. The session also covered principles and concepts of C trade.

Finally the session covered the two types of C markets, i.e. compliance and voluntary markets. While compliance market is the official UNFCCC regulated market, voluntary markets involve individuals, companies or governments who want to offset their C footprint.

1.4 Basic principles of forest carbon project preparation: Project Idea Note (PIN) and Project Design Document (PDD)

1.4.1 Elements of PIN

Activity 3 (Brainstorming) (10 minutes)

Share your views on:

- the context of preliminary project ideas;
- how to come up with initial idea; and
- the need to consult experts.

Components and format of PIN in relation to forestry

The project idea note is the shortest expression of the project given on paper to a donor. This highlights key areas that the project will focus on. Upon the approval of the PIN, the developers will be required to develop a Project Design Document or a Proposal for consideration in funding.

The main components of PIN include the following;

- the type and size of the project;
- its location;
- the anticipated total amount of GHGs considering CO_2, CH_4 and N_2O reduction compared to the "business-as-usual" scenario (which will be elaborated in the baseline later on at Project Design Document [PDD] level);
- the suggested crediting life time;
- the estimated Emission Reductions (expressed in CO_2e);
- project institutionalization, C revenue distribution and incentive systems;
- the financial structuring (indicating which parties are expected to provide the project's financing); and,
- the project's other socio-economic or environmental effects/benefits.

Usually, the PIN will consist of approximately 7 pages providing *indicative* information on the above components.

PIN structure for CDM standard

A. Project description, type, location and schedule

Objective of the project	Describe in less than 5 lines
Project description and proposed activities (including a technical description of the project)	About ½ page
Technology to be employed	Describe in less than 5 lines. Please note that support can only be provided to projects that employ commercially available technology. It would be useful to provide a few examples of where the proposed technology has been employed.

Project developer	
Name of the project developer	
Organizational category	Government / Government agency / Municipality / Private company / Non Governmental Organization (mention what is applicable)
Other function(s) of the project developer in the project	Sponsor / Operational entity / Intermediary / Technical advisor / (mention what is applicable)
Summary of the relevant experience of the project developer	Describe in less than 5 lines
Address	Address, PO Box, City, Country
Contact person	Name of the Project Development Manager
Telephone/Fax; E-mail and web address, if any	
Project sponsors *(List and provide the following information for all project sponsors)*	
Name of the project sponsor	
Organizational category	Government / Government agency / Municipality / Private company / Non Governmental Organization / (mention what is applicable)
Address (include web address, if any)	Address, PO Box, City, Country
Main activities	Not more than 5 lines
Summary of the financials	Summarize the financials (total assets, revenues, profit, etc.) in less than 5 lines.
Type of the project	

Greenhouse gases targeted	CO_2 / CH_4 / N_2O / HFCs / PCFs / SF_6 (mention what is applicable)
Type of activities	Abatement / CO_2 Sequestration
Field of activities:	
a) Energy supply	Renewable energy, excluding biomass / biomass / cogeneration / improving energy efficiency by replacing existing equipment / minimization of transport and distribution / fuel switch (e.g., switch coal to biomass) (mention what is applicable)
b) Energy demand	Replacement of existing "household equipment" / improvement of energy efficiency of existing production equipment (mention what is applicable)
c) Transport	More efficient engines for transport / modal shift / fuel switch (e.g. public transport buses fuelled by natural gas) (mention what is applicable)
d) Waste management	Capture of landfill methane emissions / utilization of waste and wastewater emissions (mention what is applicable)
e) Land Use Change and Forestry	Afforestation/ reforestation/ forest management/ wetlands management/ watershed management/ improved agriculture / land degradation prevention (mention what is applicable)
Location of the project	
Region	East Asia & Pacific / South Asia / Central Asia / Middle East / North Africa / Subsaharan Africa / Southern Africa / Central America & the Caribbean / South America/Central & Eastern Europe (mention what is applicable)
Country	
City	
Brief description of the location of the plant	No more than 3 - 5 lines
Expected schedule	
Earliest project start date	Year in which the plant will be operational

Estimate of time required before becoming operational after approval of the PIN	Time required for financial commitments: xx months Time required for legal matters: xx months Time required for negotiations: xx months Time required for construction: xx months
Expected first year of CER delivery	Year
Project lifetime	Number of years
Current status or phase of the project	Identification and pre-selection phase / opportunity study finished / pre-feasibility study finished / feasibility study finished / negotiations phase / contracting phase / etc. (mention what is applicable and indicate the documentation [e.g., the feasibility study] available)
Current status of the acceptance of the Host Country	Letter of No Objection available / Letter of Endorsement under discussion or available / Letter of Approval under discussion or available / Host Country Agreement under discussion or signed / MoU under discussion or available (mention what is applicable)
The position of the host country with regard to the Kyoto Protocol	The host country a) signed, signed and ratified, accepted, approved or acceded to the Kyoto Protocol or b) signed and has demonstrated a clear interest in becoming a party in due time (e.g., countries which have already started or are on the verge of starting the national ratification, acceptance or approval process) or c) has already started or is on the verge of starting the national accession process d) other. (mention what is applicable)

B. Expected environmental and social benefits

Estimate of GHGs abated / CO_2 Sequestered (in metric tons of CO_2-equivalent)	Annual: Up to and including 2012: xx tCO_2-equivalent Up to a period of 10 years: xx tCO_2-equivalent Up to a period of 7 years: xx tCO_2-equivalent Up to a period of 14 years: xx tCO_2-equivalent
Baseline scenario	CDM projects must result in GHG emissions being lower than "business-as-usual" in the Host Country. At the PIN stage questions to be answered are at least: • What is the proposed Clean Development Mechanism (CDM) project displacing? • What would the future look like without the proposed CDM project? • What would the estimated total GHG reduction be? (About ¼ - ½ page)
Specific global & local environmental benefits	(In total about ¼ page)
Which guidelines will be applied?	Name and, if possible, the website location
Local benefits	
Global benefits	
Socio-economic aspects What social and economic effects can be attributed to the project and which would not have occurred in a comparable situation without that project?	(In total about ¼ page)
Which guidelines will be applied?	Name and, if possible, the website location
What are the possible direct effects (e.g., employment creation, capital required, foreign exchange effects)?	
What are the possible other effects? For example: • training/education associated with the introduction of new processes, technologies and products and/or • the effects of a project on other industries	

Environmental strategy/ priorities of the host country	A brief description of the relationship or the consistency of the project with environmental strategy and priorities of the Host Country (Not more than ¼ page)

C. Finance

Total project cost estimate	
Development costs	xx US$ million
Installed costs	xx US$ million
Other costs	xx US$ million
Total project costs	xx US$ million
Sources of finance to be sought or already identified	
Equity	Name of the organizations and finance (in xx US$-million)
Debt – Long-term	Name of the organizations and finance (in xx US$-million)
Debt - Short term	Name of the organizations and finance (in xx US$-million)
Not identified	xx US$million
CDM contribution sought	xx US$million
CDM contribution in advance payments. (The quantum of upfront payment will depend on the assessed risk of the project by the World Bank, and will not exceed 25% of the total ER value purchased by the World Bank for the project. Any upfront payment will be discounted by a factor considered appropriate by the World Bank for the project).	xx US$ million and a brief clarification (not more than 5 lines)
Sources of carbon finance	
Indicative CER Price (subject to negotiation and financial due diligence)	
Total Emission Reduction Purchase Agreement (ERPA) Value	
A period until 2012 (end of the first budget period)	xxUS$
A period of 10 years	xxUS$
A period of 7 years	xxUS$

A period of 14 years (2 * 7 years)	xxUS$
If financial analysis is available for the proposed CDM activity, provide the forecast financial internal rate of return for the project with and without the CER revenues. Provide the financial rate of return at the expected CER price above and US$3/ tCO_2e. DO NOT assume any up-front payment from the PCF in the financial analysis that includes PCF revenue stream. Please provide a spreadsheet to support these calculations.	

Eligible Land Use, Land Use Change and Forestry project under CDM

Code	Afforestation and reforestation
1	Rehabilitation of degraded lands (e.g. Imperata grasslands) to
1a	Forest
1b	Agroforestry (shade trees, boundary planting)
2	Reforestation of degraded temperate grasslands or arid lands by tree planting
3	Establishing tree/shade crops over existing crops (e.g. coffee)
4	Plantations for wood products
4a	Small scale landholder driven
4b	Commercial scale
5	Landscape rehabilitation through planting corridors etc
6	Fuel wood plantings at a commercial scale
	Forest management
7	Improved forest management via fertilizer, in-plantings etc
8	Improved fire management
9	Reduced impact logging
10	Alternatives to fuel wood for forest/environmental protection
	Crop land management
11	Reduced till agriculture
12	Other sustainable agriculture
	Grazing land management
13	Revegetation of semi-arid and arid lands with shrubs or grasses
14	Improved livestock management leading to vegetation and soil recovery
15	Bio-fuels: Use of biological residue to produce energy
16	Other

PIN structure for BioCarbon Fund standard

A. Project description, type, location and schedule

General description	
A.1 Project description and proposed activities Provide information on the i) objectives of the project, ii) size of the project in ha and if the project is sub-divided in smaller areas, iii) innovations involved and iv) economic drivers of the project apart from carbon finance opportunities	
A.2 Project category adopted and description of introduced technologies Select code(s) of project category(ies) from the list above and describe the current and alternative land use practices with reference to existing pilot activities	
Project proponent submitting the PIN	
A.3 Name	
A.4 Organizational category (choose one or more)	a) Government b) Government agency c) Municipality d) Private company e) Non Governmental Organization
A.5 Other function(s) of the project developer in the project (choose one or more)	a) Sponsor b) Operational Entity under the CDM c) Intermediary d) Technical advisor
A.6 Summary of relevant experience	
A.7 Address	
A.8 Contact person	
A.9 Telephone / fax	
A.10 E-mail and web address	

Project sponsor(s) financing the project *(List and provide the following information for all project sponsors)*	
A.11 Name	
A.12 Organizational category (choose one or more)	a) Government b) Government agency c) Municipality d) Private company e) Non Governmental Organization
A.13 Address (include web address)	
A.14 Main activities	
A.15 Summary of the financials (total assets, revenues, profit, etc.)	
Type of project	
A.16 Greenhouse gases targeted Mention gases that will be monitored CO_2 / CH_4 / N_2O	
Location of the project	
A.17 Country	
A.18 Nearest city	
A.19 Precise location Please provide GPS coordinates from project boundary and sub- project area boundaries	
Expected schedule	
A.20 Estimate of time required before becoming operational after approval of the PIN	Time required for financial commitments: xx months Time required for legal matters: xx months Time required for negotiations: xx months Time required for establishment: xx months
A.21 Earliest project start date (Year in which the project will be operational)	

A.22 Current status or phase of the project	a) Identification and pre-selection phase b) Opportunity study finished c) Pre-feasibility study finished d) Feasibility study finished e) Negotiations phase f) Contracting phase
A.23 Current status of the acceptance of the project by the Host Country (choose one)	a) Letter of No Objection is available b) Letter of Endorsement is under discussion or available c) Letter of Approval is under discussion or available

B. Expected environmental and social benefits

Environmental benefits	
B.1 Estimate of carbon sequestered or conserved (in metric tones of CO_2 equivalent – t CO_2e). Please attach spreadsheet if available. If information is not available please provide information on: i) site conditions, annual rainfall, altitude, soil type ii) tree species planted per ha, iii) tree harvesting intervals iv) above ground biomass (e.g. trees and mulch) and below ground biomass accumulation (roots and composted organic material) in tones dry matter/ha.	Up to and including 2012: x t CO_2e Up to and including 2017: x t CO_2e
B.2 Baseline scenario (What would the future look like without the proposed project? What would the estimated total carbon sequestration / conservation be without the proposed project? Explain why the project is additional, i.e. without the carbon finance project component the project would not take place.)	
B.3 Existing vegetation and land use (What is the current land cover and land use? Is the tree cover more or less than 30%?)	

B.4 Environmental benefits	
B.4.a Local benefits	
B.4.b Global benefits	
B.5 Consistency between the project and the environmental priorities of the Host Country	
Socio-economic benefits	
B.6 How will the project improve the welfare of the community involved in it or surrounding it? What are the direct effects which can be attributed to the project and which would not have occurred in a comparable situation without that project? (e.g., employment creation, poverty alleviation, foreign exchange savings). Indicate the number of communities and the number of people that will benefit from this project.	
B.7 Are there other effects? (e.g., training/education due to introducing new techno-logies and products, replication in country or region)	

C. Finance

Project costs	
C.1 Preparation costs (e.g. baseline survey, development and documentation costs of carbon finance component)	US$ million
C.2 Establishment costs (e.g. extension costs to introduce new management practices, tree planting, mulching etc costs)	US$ million
C.3 Other costs (explain) (e.g. organic or ISO certification)	US$ million
C.4 Total project costs	US$ million
Sources of finance to be sought or already identified	
C.5 Equity (Name of the organizations and US$ million)	
C.6 Debt - Long-term (Name of the organizations and US$ million)	
C.7 Debt – Short term (Name of the organizations and US$ million)	
C.8 Grants	
C.9 Not identified (US$ million) Projects with a big financing gap will not be considered by the C Fund	
C.11 Sources of carbon finance (Has this project been submitted to other C buyers? If so, say which ones)	

C.12 Indicative price for the emission reductions in US$ per t/CO_2e for the first 10 years of the project Subject to negotiation and financial due diligence	
C.13 Emission Reductions Value offered to the BioCarbon Fund (= price per t CO_2e * number of tCO_2e) Leave this field empty if you have not calculated the estimated emission reductions in section B1	
Until 2012	US$
Until 2017	US$
C.14 Financial analysis Provide the expected financial internal rate of return (FIRR) for the project with and without the C finance component (Please attach financial spreadsheet if available.). If you can not estimate impact of the C finance component on the FIRR list, rank and qualify important decision making parameter for your enterprise to develop a C finance project, e.g. C component should be at least cost covering, partly covering the introduction costs of new activities or within the corporate social responsibility budget ceiling (Please attach financial spreadsheet if available).	FIRR without C component: FIRR with C component:

D. Institutionalization and carbon revenue distribution

Institutionalization
D.1 In-house capacity to develop, implement and monitor project activities. Provide information on: i) extension system, number of extension workers and project area covered by extension workers, ii) number of mapping, inventory and monitoring specialists
D.2 Internal Control System (ICS) Describe your ICS system and mention which national and international quality standards are achieved or will be achieved in the future (ISO, organic certification etc).
D.3 Project participants, institutional structures and partnerships List project participants, describe existing or envisaged institutional structures and partnerships to develop, implement and monitor C finance project component. Please indicate sustainable financing mechanisms in place covering respective costs.
Carbon revenue distribution and incentive systems
D.4 Carbon revenue distribution Please explain what you intend to do with the C revenues and in particular how small-scale farmers will benefit from the C revenues.
D.5 Incentive systems Please list existing and future incentives of the project that will ensure a high adoption rate of new management practices. Please also indicate the expected level of adoption in %.

In text question (10 minutes)

Use hypothetical project details to write up a PIN for any forest of your choice and at the end of the exercise answer the following:

- What lessons have you learnt from the development of PIN?
- What recommendations do you propose in line with development of the PIN?

Case study

Examples of filled in PIN

1.4.2 Elements of Project Design Document (PDD)

Activity 4 (Brainstorming) (10 minutes)

What are your views on the context of detailed project proposal?

The project design document (PDD) provides the flow of the proposal in relation to PIN to seek financial aid from C finance institutions responsible for disbursement of funds to support mitigation and adaptation to climate change. Key components of the PDD are:

a) general description of the proposed project activity;

b) duration of the project activity / crediting period;

c) application of an approved baseline and monitoring methodology;

d) estimation of *ex ante* net anthropogenic GHG removals by sinks and estimated amount of net;

e) anthropogenic GHG removals by sinks over the chosen crediting period;

f) monitoring plan;

g) environmental impacts of the proposed project activity;

h) socio-economic impacts of the proposed project activity; and

i) stakeholders' comments.

Annexes

j) Annex 1: Contact information on participants in the proposed A/R CDM project activity

k) Annex 2: Information regarding public funding

l) Annex 3: Baseline information

m) Annex 4: Monitoring plan

These components constitute key areas to be addressed on carbon projects as prescribed in the following formats http://cdm.unfccc.int/Reference/PDDs_Forms/index.html.

Project design document form for CDM project activities (Version 06.0)	
Complete this form in accordance with the Attachment "Instructions for filling out the project design document form for CDM project activities" at the end of this form.	
Title of the project activity	
Version number of the PDD	
Completion date of the PDD	
Project participant(s)	
Host party	
Sectoral scope and selected methodology(ies), and where applicable, selected standardized baseline(s)	
Estimated amount of annual average GHG emission reductions	

SECTION A. Description of project activity

A.1. Purpose and general description of project activity

A.2. Location of project activity

- A.2.1. Host party
- A.2.2. Region/State/Province etc.
- A.2.3. City/Town/Community etc.
- A.2.4. Physical/Geographical location

A.3. Technologies and/or measures

A.4. Parties and project participants

Party involved (Host) indicate host Party	Private and/or public entity(ies) project participants (as applicable)	Indicate if the Party involved wishes to be considered as project participant (Yes/No)
Party A (host)	Private entity A Public entity A	
Party B	Private entity B Public entity B	
Etc.	...	

A.5. Public funding of project activity

SECTION B. Application of selected approved baseline and monitoring methodology and standardized baseline

B.1. Reference of methodology and standardized baseline

B.2. Applicability of methodology and standardized baseline

B.3. Project boundary

Source	GHGs	Included?	Justification/Explanation
Baseline scenario			
Source 1	CO_2		
	CH_4		
	N_2O		
	…		
Source 2	CO_2		
	CH_4		
	N_2O		
	…		
Etc.	…		
Project scenario			
Source 1	CO_2		
	CH_4		
	N_2O		
	…		
Source 2	CO_2		
	CH_4		
	N_2O		
	…		
Etc.….	…		

B4. Establishment and description of baseline scenario

B.5. Demonstration of additionality

B.6. Emission reductions

- B.6.1. Explanation of methodological choices
- B.6.2. Data and parameters fixed ex ante

(Copy this table for each piece of data and parameter.)

Data / Parameters	
Unit	
Description	
Source of data	
Value(s) applied	
Choice of data or Measurement methods and procedures	
Purpose of data	
Additional comment	

- B.6.3. Ex ante calculation of emission reductions
- B.6.4. Summary of ex ante estimates of emission reductions

Year	Baseline emissions (t CO_2e)	Project emissions (t CO_2e)	Leakage (t CO_2e)	Emission reductions (t CO_2e)
Year A				
Year B				
Year C				
Year …				
Total				
Total number of				
Annual average				

B.7. Monitoring plan

- B.7.1. Data and parameters to be monitored

(Copy this table for each piece of data and parameter.)

Data / Parameters	
Unit	
Description	
Source of data	
Value(s) applied	
Measurement methods and procedures	
Monitoring frequency	
QA/QC procedures	
Purpose of data	
Additional comment	

- B.7.2. Sampling plan
- B.7.3. Other elements of monitoring plan

B.8. Date of completion of application of methodology and standardized baseline and contact information of responsible persons/ entities

SECTION C. Duration and crediting period

C.1. Duration of project activity

- C.1.1. Start date of project activity
- C.1.2. Expected operational lifetime of project activity

C.2. Crediting period of project activity

- C.2.1. Type of crediting period
- C.2.2. Start date of crediting period
- C.2.3. Length of crediting period

SECTION D. Environmental impacts

D.1. Analysis of environmental impacts

D.2. Environmental impact assessment

SECTION E. Local stakeholder consultation

E.1. Solicitation of comments from local stakeholders

E.2. Summary of comments received

E.3. Report on consideration of comments received

SECTION F. Approval and authorization

Appendix 1.Contact information of project participants and responsible persons/ entities

Project participant and/ or responsible person/ entity	Project participant Responsible person/ entity for application of the selected methodology (ies) and, where applicable, the selected standardized baselines to the project activity
Organization name	
Street/P.O. Box	
Building	
City	
State/Region	
Postcode	
Country	
Telephone	
Fax	
E-mail; Website	
Contact person	
Title	
Salutation	
Last name	
Middle name	
First name	
Department	
Mobile	
Direct fax	
Direct tel.	
Personal e-mail	

Appendix 2. Affirmation regarding public funding

Appendix 3. Applicability of methodology and standardized baseline

Appendix 4. Further background information on ex ante calculation of emission reductions

Appendix 5. Further background information on monitoring plan

Appendix 6. Summary of post registration changes

Attachment. Instructions for filling out the project design document form for CDM project activities

1. When designing a project activity and completing the CDM PDD-FORM, in addition to applying the “CDM project standard” (Project standard), the selected approved baseline and monitoring methodology(ies) (hereinafter referred to as the selected method-logy(ies)) and, where applicable, the selected approved standardized baseline(s) (hereinafter referred to as the selected standardized baseline(s)), consult the “Rules and Reference” section of the UNFCCC CDM website. This section contains all regulatory documents for CDM, such as standards (including methodologies, tools and standar-dized baselines), procedures, guidelines, clarifications, forms and the “Glossary: CDM terms”.
2. When documenting changes occurred in the project activity after its registration in accordance with applicable provisions relating to the post registration changes process, prepare two versions of the PDDs using the CDM-PDD-FORM, one in clean version and the other indicating the changes in track-change.
3. In addition to the provisions in paragraph 2 above, provide a summary of the changes, including the reasons for thm and any additional information relating to the changes, in Appendix 6 below.
4. Where a PDD contains information that the project participants wish to be treated as confidential/proprietary, submit documentation in two versions:

a. one version where all parts containing confidential/proprietary information are made illegible (e.g. by covering those parts with black ink) so that the version can be made publicly available without displaying confidential/proprietary information; and,

b. a version containing all information that is to be treated as strictly confidential/ proprietary by all parties handling this documentation (designated operational entities (DOEs) and applicant entities (AEs). Board members and alternate members; panel/ committee and working group members; external experts requested to consider such documents in support of work for the Board; the secretariat).

5. Information used to: (a) demonstrate additionality; (b) describe the application of the selected methodology(ies) and, where applicable, the selected standardized baseline(s); and, (c) support the environmental impact assessment; is not considered proprietary or confidential. Make any data, values and formulae included in electronic spreadsheets provided accessible and verifiable.
6. Complete the CDM PDD-form and all attached documents in English, or containing a full translation of relevant sections in English.
7. Complete the CDM PDD-FORM using the same format without modifying its font, headings or logo, and without any other alteration to the form.
8. Do not modify or delete tables and their columns in the CDM PDD-FORM. Add rows of the tables as needed. Add additional appendices as needed.

9. If a section of the CDM PDD-FORM is not applicable, explicitly state that the section is left blank intentionally.
10. Use an internationally recognized format for presentation of values in the CDM PDD-FORM, for example use digits grouping in thousands and mark a decimal point with a dot (.), not with a comma (,).
11. Complete the CDM-PDD-FORM deleting this Attachment “Instructions for filling out the project design document form for CDM project activities”.

In text question (10 minutes)

Use hypothetical project details to write up a PDD for any forest of your choice and at the end of the excise answer the following:

- what lessons have you learnt from the development of PDD?
- what recommendations dol you propose in line with development of the PDD?

Case study

Examples of filled in PDD.

1.4.3 Processing of PIN and PDD for carbon markets

Activity 1 (Brainstorming) (10 minutes)

Share your views on how the project document can be submitted to possible competitive sources of funds including the review process.

Project validation for compliance CDM Market

A CDM project can consist of one activity at a single location, or be made up of the same activity in several locations. To calculate the amount of emissions they can sell, projects must either use a previously approved methodology or propose a new one (Kill et al., 2010). Each project wishing to be considered must submit a Project Design Document (PDD) to show how it will produce emission reductions that would not otherwise have happened. The PDD should also explain how the project ensures that emissions reduced at the project location are really reduced and not simply emitted at another location (a process known as “leakage”). To establish both the volume of credits that result from these additional emissions savings and the potential emissions that arise elsewhere as a result of the project, the PDD also has to describe the hypothetical ‘baseline’ of the project. This describes how many emissions would have been released without the CDM project.

Since the PDD documentation is highly complex, this task tends to be carried out by specialist “project design consultants”. A project must then receive approval from the host country’s Designated National Authority (DNA), which is usually the country’s environment or energy ministry. If there are other entities directly involved in the project that are registered outside the host country, letters of approval must also be submitted from the country in which these project partners are registered before the PDD can be submitted for validation.

The validation process entails the following steps as illustrated below (Figure 3).

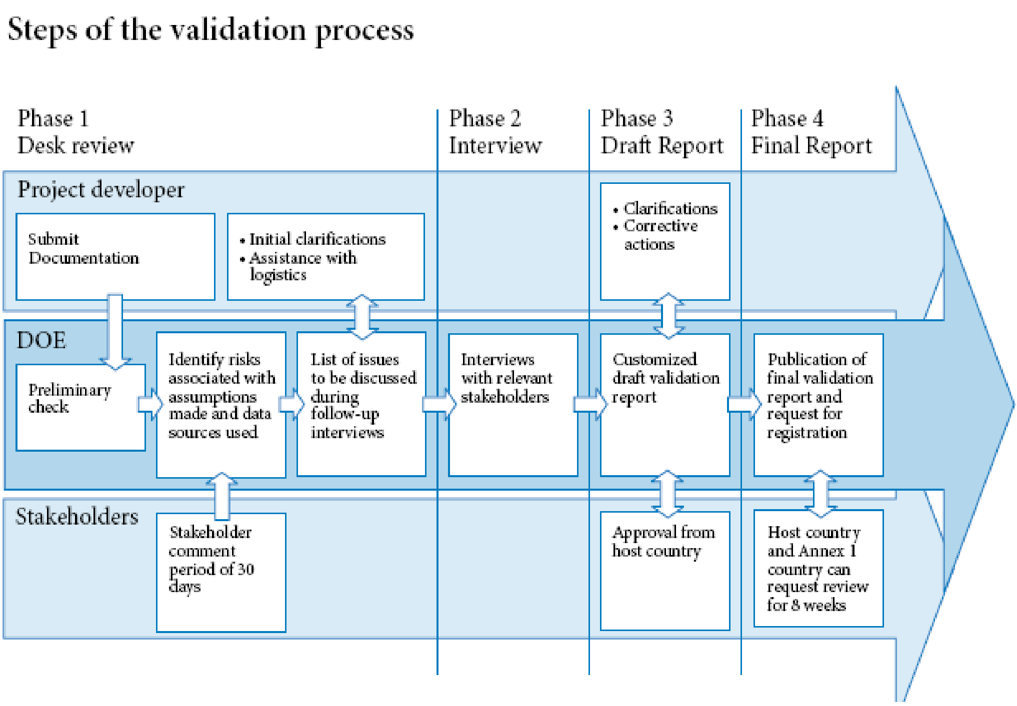

Figure 3. Validation process for compliance CDM Market.
Source: Kill et al., (2010)

The validation process starts with the PDD being sent to a Designated Operational Entity (DOE) or validator, whose task it is to assess the project, and who has to be accredited by the CDM Executive Board. Once the validator has assessed the project and recommended registration as a CDM project, a formal request for registration is made. The PDD and validation report are submitted to the CDM secretariat (the administrative body attached to the UNFCCC that is responsible for the implementation of the CDM). The documents are then passed to the UNFCCC registration and issuance team, which reviews both the PDD and validation report. The team can request revisions or reject the project outright. Projects recommended by the registration and issuance team are then passed to the CDM Executive Board, which has the final say on registration. Once a project is registered, it must submit monitoring reports to the CDM secretariat. These are reviewed by the UNFCCC registration and issuance team, with the subsequent report sent to the CDM Executive Board for approval.

When this process is completed, the CDM Executive Board announces the number of certified emissions reductions (CERs) that have been issued to the project. In practice, many of these CERs will have been traded in advance on a future market. Information made public on the CDM database (http://cdm.unfccc.int/Projects/projsearch.html) includes the PDD, any comments made on the project and responses to them, the validation report, the monitoring reports and information about the volume of CERs issued to each project. The UN Risoe Centre (http://www.cdmpipeline.org) has an up-to-date and searchable database called CDM Pipeline which includes information on the project participants, and often the buyers too.

Approval in the voluntary offset market

The main difference between the CDM and voluntary carbon offsets is the absence of oversight, transparency and a uniform set of standards by which projects in the voluntary offset market are assessed (Kill et al., 2010). In the voluntary offset market there are several standards (Gold Standard, Chicago Climate Exchange, Voluntary Carbon Standard etc.) against which 'additionality' and other factors affecting the volume of reductions an offset project can claim are judged. Voluntary offset providers have often been criticised on the grounds that C reduction claims are exaggerated, unsubstantiated or misleading. The most commonly cited shortcomings are the virtual absence of verification and long-term monitoring of compliance with emission reduction projections made in the PDD, and the potential for the double selling of credits in the absence of some form of comprehensive register for voluntary offset projects. Many also argue that this makes it difficult for buyers to assess the true value of offset credits. Because of this lack of transparency, it is not possible to assess with any certainty the level of demonstrably non-additional offset credits traded in the voluntary market. It can be assumed, however, that due to the absence of scrutiny, the percentage is higher than that in the CDM.

In text question (10 minutes)
Explain the difference between validation process in the voluntary carbon market and compliance carbon market.

1.4.4 Steps for setting up a REDD+ project

Project idea and preliminary assessment

- Define at the outset what are the objectives of the project, what actions will achieve those objectives and where the project will take place. They must also identify the participants and partners essential to the implementation of the actions and the achievement of the objectives.
- Define project interventions to increase or maintain forest cover and biomass.
- Remember that a C project goes beyond quantifying C benefits.
- Conceptualization.
- Project objectives: the main objective of increasing C stocks or reducing losses (objectives related to rural development, poverty reduction, biodiversity protection, or income generation commercial).
- Activities related to REDD+: linking the causes of deforestation/degradation of forests to the actors involved.
- Project scale, area and boundary: first elements on project scales and locations.
- Identification of key participants: groups involved in the implementation of project activities.
- Landowners, surrounding local populations, etc.
- Drafting of the Project Idea Note (PIN): a brief description of a proposed project;
- Feasibility study.

- Document required to obtain the approval of the government during the exchanges with the potential financial partners.
- Containing, in addition to the aforementioned elements:
- the characterization of the reference level (trend of deforestation, change in land use, etc.);
- assessment of forest carbon stocks or sequestration potential;
- preliminary assessment of carbon benefits;
- additionality; and,
- social and environmental benefits.

Project development and planning

- Define the standard to be used, and therefore the target market sector (notably VCS and CCB for the most part).
- Ensuring engagement of stakeholders, especially local communities.
- Define roles and responsibilities for project design and implementation.
- Preparation of the work plan and budgeting.
- Verification of the regulations and legislation in force governing the setting up and implementation of the project.
- Assessment of the social and biodiversity impacts of the project (especially if CCB certification is targeted).
- Identification of risks and risk mitigation strategies.

Development of the Project Design Document (PDD)

The PDD should highlight information vital to the design and calculation of emission reductions and focus on essential information that can be monitored and verified throughout the life of the project:

- Establish a drafting team;
- Indicate the standard to be respected;
- Demonstrate the additionality of the project;
- Starting conditions: the draft reference level and the reference scenario;
- Quantification of carbon benefits; and
- Aspects of leakage and risks of non-permanence.

Review of project activities and development of the implementation strategy

- Adjust the information following the updated data obtained.
- Develop a financial model beyond the more basic tools used for the feasibility study to reflect cost categories, revenue streams, funding agreements, and organizational structures unique to the project.

- Clearly define the roles, responsibilities, and management structures for project implementation (sometimes requiring stakeholder capacity building).

Finalization of financing and investment arrangements

- Conclusion of financing agreements (with investors and others): may require legal advice.
- Establishing the ERPA contract.

Box 1. How will REDD+ funds be spent?

Before examining the national authorities implementing REDD+, we will present the main areas that can benefit from its funding. They include:

1) **capacity building and preparedness**; these include funding for consultations, developing a national REDD+ strategy and developing MRV capacity; this also includes funds for the implementation of demonstration activities that build capacity and contribute to education, while reducing and eliminating emissions;
2) **general policies to address the factors of forest C evolution**; these are funds allocated to policies and measures (PAM) to address the underlying drivers of forest C changes, including the regulation of demand for agricultural and forest products, land reforms, better governance, and authoritarian measures; and,
3) **performance**; these funds to reward performance or results, which requires measuring one way or another performance, e.g. through indicators, indirect indicators or quantified evolution of forest C, depending on the level of MRV capacity. Payments for services related to forest C are the most direct type of payment based on performance, but other intermediate solutions between them and PAM are possible.

Agreements, validation and registration

- No need for government agreement for the voluntary market, but this can be a strong signal on the stability of the situation;
- Consultation with stakeholders to obtain their consent;
- Validation: a process whereby an independent accredited auditor reviews the documentation and the design of the project to ensure that it meets the applicable standards and methodology criteria and rules;
- Period of full study, public inquiry, site inspection, preparation of draft validation report, requests for additional information (clarification request) or design adjustment, description, or analysis of the project (request for corrective action) before the final report of the auditor;
- 6 months to deal with and remedy problems before the auditor prepares a final report that will be made available to the public prior to certification;
- Validator charged to the project holder;
- List of validators;
- VCS: list of validators and verifiers for different project sizes available on: http://www.v-c-s.org/verification-validation/find-vvb;

- CCB: approved verifiers for the application of the CCB Standards available at: https://s3.amazonaws.com/CCBA/Approved_CCBS_Auditors.pdf; and
- Registration: on the websites of the standards (to be entered in the records).

Implementation and follow-up

This step requires the vast majority of the project's efforts, resources, and commitments for many years requiring:

- Performance to be consistent with the content of the PDD;
- Monitoring to develop verifiable evidence that the project generates GHG benefits; and,
- Continuous monitoring of data, calculations and results to be rigorously documented and presented to third party verifiers during the verification process.

Verification and issuance of credits

- An external auditor reviews and certifies the volume of GHG benefits achieved and monitored by the project. This audit is based on the monitoring results gathered by the project developer, based on the monitoring plan validated as part of the PDD.
- Verification elaboration of the report the project initiator then submits an application for registration and granting including the verification statement and other documents to the VCS registry administrator review of the documents by the registry administrator granting of the Verified Carbon Units (VCU) to the account of the promoter.
- Verification interval: 5 years max for VCS.
- Potential funders of REDD+:
  - local or international banks, able to finance projects by debt or equity;
  - private investors (debt or equity);
  - environmental patrons (donations, preferential debt, etc.);
  - purchasers of credits financing the project by prepayment of the credits purchased (this may be assimilated to a form of debt); and,
  - public actors.

Box 2. The three REDD+ implementation phases

(1) Preparation phase

The objective of this phase is to develop a national strategy on REDD + and capacity building. On the basis of the analysis of the causes of deforestation and forest degradation, the country will have to define an implementation framework that specifies the national legislation applying to REDD + and C credits, the institutions responsible, Intersectoral coordination, or REDD + revenue management mechanisms. This framework should also specify the technical tools best suited to national circumstances to establish a reference scenario and an MRV system for GHG emissions related to the forest sector. It is estimated that this preparatory phase will require funding in the region of EUR 200-250 million (IWG-IFR, 2009). More than 40 countries have already begun this phase of preparation through multilateral or bilateral initiatives.

(2) Intermediate phase

This phase can be divided in two with:

- 2a. capacity building of key institutions and policy reforms; and
- 2b. payments based on the performance of REDD+ activities, estimated using indicators to approximate the emission reductions achieved.

It will therefore make it possible to implement the first measures included in the national REDD+ strategy and which are considered as prerequisites for participation in a mechanism based on payments to the result (political or governance reforms concerning land rights and forest C law, land use planning, elimination of perverse incentives for deforestation and unsustainable use of forests, improvement and enforcement of forest sector laws, but also institutional reforms in the broad sense, etc.). In addition, pilot projects and programs would be developed in the areas most affected by deforestation, in order to test new technologies and incentives to actors in the field. This phase would also allow for the gradual establishment and strengthening of the GHG emission MRV system, increasing the accuracy and reliability of monitoring changes in land use. Finally, the country will have to have tangible elements enabling it to adopt a reference scenario on which to engage. It is estimated that this inter-mediate phase will require funding in the range of EUR 1.2-2.2 billion (IWG-IFR, 2009).

(3) Final phase

Based on payment to measured, reported and verified results, the country would then collect payments based on emission reductions compared to a baseline scenario, using a reliable and transparent MRV system. REDD+ projects could then be linked to this accounting. Kindermann et al. (2008) estimated that a 50% reduction in deforestation between 2005 and 2030 would generate 1,500-2,700 MtCO_2/year and would require funding of 11.5 to 18.5 bn EUR per year. The work carried out by Eliasch (2008) concludes at a cost of between EUR 11.5 and EUR 22 billion per year to reduce deforestation by 50% by 2030.

Source: NFB International

Summary

This session covers the definition of project idea note (PIN) and its contents. The project PIN is the shortest expression of the project given on paper to a donor. This highlights key areas that the project will focus. Two examples of voluntary and CDM PIN forms are given.

The session also covers the definition of project design document (PDD) and its contents. The PDD provides the flow of the proposal in relation to PIN to seek for financial aid from C finance or institutions responsible for disbursement of funds to support mitigation and adaptation to climate change. An example of a CDM PIN forms is given.

Finally the session covers validation process in voluntary and compliance C standards. Their similarities and differences are also explained. The main difference between the CDM and voluntary C offsets is the absence of a uniform set of standards by which projects in the voluntary offset market are assessed. In the voluntary offset market there are several standards.

1.5 Concepts and principles of economics and markets

1.5.1 Demand, supply, prices and markets

Activity 1 (Brainstorming) (10 minutes)
What are your views on the law of demand and supply.

What is demand?

The quantity of goods or services that the consumer is willing to buy at given market conditions.

What is supply?

The quantity of goods or services that the supplier is willing to sell at given market conditions

Supply and demand curves

- At *low prices*, people are willing to buy *more goods or services*. At *high prices*, people will buy *less*.
- With *low prices* producers reduce supply and *high prices* they *increase supply*.

Where the curves cross, is where the price and quantity are determined. This point is called equilibrium price (Figure 4).

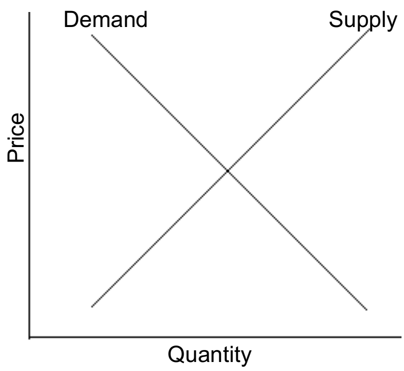

Figure 4. Graphical determination of equilibrium price

Like any other goods or services, prices of C credits are determined by the demand and supply forces. In the compliance C market the supply and demand of C credit are regulated through complex regulations, whereas in the voluntary C market, supply and demand of credits respond to free market transactions.

The supply in the voluntary carbon market

The supply in the voluntary C market is controlled by standards that checks the legitimacy of the credits based on the verification of the reductions, the additionality, the registration of the credits and avoidance of double credits. The number of projects certified under internationally known standards is increasing steadily but are still limited in quantity since the costs of registering and verifying a project under these standards impose strictness which guarantees quality.

The demand

The demand in the voluntary C market is mostly motivated by a voluntary decision to act for the preservation of the environment. The motivation is derived by the desire to meet corporate social responsibility, demonstrating climate leadership, pre-compliance and climate driven mission.

In text question (10 minutes)
Explain the relationships between demand and supply.

1.5.2 Concepts of economic value and valuation

Activity 1 (Brainstorming) (10 minutes)
What are your views on how the value and valuation of different commodities are determined?

Basics of economic valuation

Economic value is one of many possible ways to define and measure value. Although other types of value are often important, economic values are useful to consider when making economic choices - choices that involve tradeoffs in allocating resources.

Measures of economic value are based on what people want - their preferences. Economists generally assume that individuals, not the government, are the best judges of what they want. Thus, the theory of economic valuation is based on individual preferences and choices. People express their preferences through the choices and tradeoffs that they make, given certain constraints, such as those of income or available time.

The economic value of a particular item, or good, for example a loaf of bread, is measured by the maximum amount of other things that a person is willing to give up to have that loaf of bread. If we simplify our example "economy" so that the person only has two goods to choose from, bread and pasta, the value of a loaf of bread would be measured by the most pasta that the person is willing to give up to have one more loaf of bread.

Thus, economic value is measured by the most someone is willing to give up in other goods and services in order to obtain a good, service, or state of the world. In a market economy, dollars (or some other currency) are a universally accepted measure of economic value, because the number of dollars that a person is willing to pay for something tells how much of all other goods and services they are willing to give up to get that item. This is often referred to as "willingness to pay".

It is often incorrectly assumed that a good's market price measures its economic value. However, the market price only tells us the *minimum* amount that people who buy the good are willing to pay for it. When people purchase a marketed good, they compare the amount they would be willing to pay for that good with its market price. They will only purchase the good if their willingness to pay is equal to or greater than the price. Many people are actually willing to pay more than the market price for a good, and thus their values exceed the market price.

In order to make resource allocation decisions based on economic values, what we really want to measure is the net economic benefit from a good or service. For individuals, this is measured by the amount that people are willing to pay, *beyond* what they actually pay. Thus, two goods that sell for the same price may have different net benefits. For example, I may have a choice between wheat and multi-grain bread, which both sell for $2.00 per loaf. Because I prefer multi-grain, I am willing to pay up to $3.00 for a loaf. However, I would only pay $2.50 at the most for the wheat bread. Therefore, the net economic benefit I receive for the multi-grain bread is $1.00, and for the wheat bread is only $.50.

The economic benefit to individuals, or consumer surplus, received from a good will change if its price or quality changes. For example, if the price of a good increases, but people's willingness to pay remains the same, the benefit received (maximum willingness to pay minus price) will be less than before. If the quality of a good increases, but price remains the same, people's willingness to pay may increase and thus the benefit received will also increase.

Economic values are also affected by the changes in price or quality of substitute goods or complementary goods. If the price of a substitute good changes, the economic value for the good in question will change in the same direction. For example, wheat bread is a close substitute for multi-grain bread. So, if the price of multi-grain bread goes up, while the price of wheat bread remains the same, some people will switch, or substitute, from multi-grain to wheat bread. Therefore, more wheat bread is demanded and its demand function shifts upward, making the area under it, the consumer surplus, greater.

Similarly, if the price of a complementary good, one that is purchased in conjunction with the good in question, changes, the economic benefit from the good will change in the opposite direction. For example, if the price of butter increases, people may buy less of both bread and butter. If less bread is demanded, then the demand function shifts downward, and the area under it, the consumer surplus, decreases.

Producers of goods also receive economic benefits, based on the profits they make when selling the good. Economic benefits to producers are measured by producer surplus, the area above the supply curve and below the market price. The supply function tells how many units of a good producers are willing to produce and sell at a given price. The supply curve is the graphical representation of the supply function. Because producers would like to sell more at higher prices, the supply curve slopes upward.

If producers receive a higher price than the minimum price they would sell their output for, they receive a benefit from the sale – the producer surplus. Thus, benefits to producers are similar to benefits to consumers, because they measure the gains to the producer from receiving a price higher than the price they would have been willing to sell the good for.

When measuring economic benefits of a policy or initiative that affects an ecosystem, economists measure the total net economic benefit. This is the sum of consumer surplus plus producer surplus, less any costs associated with the policy or initiative.

Ecosystem valuation approach

Ecosystem valuation can be a difficult and controversial task, and economists have often been criticized for trying to put a “price tag” on nature. However, agencies in charge of protecting and managing natural resources must often make difficult spending decisions that involve tradeoffs in allocating resources. These types of decisions are economic decisions, and thus are based, either explicitly or implicitly, on society’s values. Therefore, economic valuation can be useful, by providing a way to justify and set priorities for programs, policies, or actions that protect or restore ecosystems and their services.

In order to understand how economists approach ecosystem valuation, it is useful to review some important definitions and concepts.

Ecosystem functions and services

Ecosystem functions are the physical, chemical, and biological processes or attributes that contribute to the self-maintenance of an ecosystem; in other words, what the ecosystem does. Some examples of ecosystem functions are provision of wildlife habitat, C cycling, or the trapping of nutrients. Thus, ecosystems, such as wetlands, forests, or estuaries, can be characterized by the processes, or functions, that occur within them.

Ecosystem services are the beneficial outcomes, for the natural environment or people, that result from ecosystem functions. Some examples of ecosystem services are support of the food chain, harvesting of animals or plants, and the provision of clean water or scenic views. In order for an ecosystem to provide services to humans, some interaction with, or at least some appreciation by, humans is required. Thus, functions of ecosystems are value-neutral, while their services have value to society.

Some factors that complicate ecosystem management decisions

Decisions about ecosystem management are complicated by the fact that various types of market failure are associated with natural resources and the environment. *Market failures* occur when markets do not reflect the full social costs or benefits of a good. For example, the price of gasoline does not fully reflect the costs, in terms of pollution, that are imposed on society by burning gasoline. Market failures related to ecosystems include the facts that: (i) many ecosystems provide services that are public goods; (ii) many ecosystem services are affected by externalities; and (iii) property rights related to ecosystems and their services are often not clearly defined.

Ecosystem services are often public goods, which means that they may be enjoyed by any number of people without affecting other peoples’ enjoyment. For example, an aesthetic view is a pure public good. No matter how many people enjoy the view, others can also enjoy it. Other services may be quasi-public goods, where at a certain level of use, others’ enjoyment may be diminished. For example, a public recreation area may be open to everyone. However, crowding can decrease peoples’ enjoyment of the area. The problem with public goods is that, although people value them, no one person has an incentive to pay to maintain the good. Thus, collective action is required in order to produce the most beneficial quantity.

Ecosystem services may be affected by externalities, or uncompensated side effects of human actions. For example, if a stream is polluted by runoff from agricultural land, the people downstream experience a negative externality. The problem with negative externalities is that the people (or ecosystems) they are imposed upon are generally not compensated for the damages they suffer.

Finally, if property rights for natural resources are not clearly defined, they may be overused, because there is no incentive to conserve them. For example, unregulated fisheries are an open-access resource – anyone who wants to harvest fish can do so. Because no one person or group “owns” the resource, open access can lead to severe over-harvesting and potentially severe declines in fish abundance over time.

Ecosystem valuation can help resource managers to deal with the effects of market failures, by measuring their costs to society, in terms of lost *economic benefits*. The costs to society can then be imposed, in various ways, on those who are responsible, or can be used to determine the value of actions to reduce or eliminate environmental impacts. For example, in the case of the crowded public recreation area, benefits to the public could be increased by reducing the crowding. This might be done by expanding the area or by limiting the number of visitors. The costs of implementing different options can be compared to the increased economic benefits of reduced crowding.

In the case of a stream polluted by agricultural runoff, the benefits from eliminating the pollution can be compared to costs of actions to reduce the runoff, or can be used to determine the appropriate fines or taxes to be levied on those who are responsible. In the case of open-access fisheries, the benefits from reducing overfishing can be compared to regulatory costs or costs to the commercial fishing industry if access is restricted.

Ecosystem values

Ecosystem values are measures of how important ecosystem services are to people – what they are worth. Economists measure the value of ecosystem services to people by estimating the amount people are willing to pay to preserve or enhance the services (see **Concept of Economic Value** for more detailed information). However, this is not always straightforward, for a variety of reasons.

Most importantly, while some services of ecosystems, like fish or lumber, are bought and sold in markets, many ecosystem services, like a day of wildlife viewing or a view of the ocean, are not traded in markets. Thus, people do not pay directly for many ecosystem services. Additionally, because people are not familiar with purchasing such goods, their willingness to pay may not be clearly defined. However, this does not mean that eco-systems or their services have no value, or cannot be valued in dollar terms.

It is not necessary for ecosystem services to be bought and sold in markets in order to measure their value in dollars. What is required is a measure of how much purchasing power (dollars) people are willing to give up to get the service of the ecosystem, or how much people would need to be paid in order to give it up, if they were asked to make a choice similar to one they would make in a market (*Overview of Methods to Estimate Dollar Values* gives an overview of, and *Dollar-Based Ecosystem Valuation Methods* describes in more detail, the methods that economists use to estimate dollar values for ecosystems and their services).

Types of values

Economists classify ecosystem values into several types. The two main categories are use values and non-use, or “passive use” values. Whereas use values are based on actual use of the environment, non-use values are values that are not associated with actual use, or even an option to use, an ecosystem or its services.

Thus, use value is defined as the value derived from the actual use of a good or service, such as hunting, fishing, bird watching, or hiking. Use values may also include indirect uses. For example, African national parks, games reserves and recreational centres provides direct use values to the people who visit the area. Other people might enjoy watching a television show about the area and its wildlife, thus receiving indirect use values. People may also receive indirect use values from an input that helps to produce something else that people use directly. For example, the lower organisms on the aquatic food chain provide indirect use values to recreational anglers who catch the fish that eat them.

Option value is the value that people place on having the option to enjoy something in the future, although they may not currently use it. Thus, it is a type of use value. For example, a person may hope to visit the African national parks such as Serengeti in Tanzania or Aberdare Ranges in Kenya sometime in the future, and thus would be willing to pay something to preserve the area in order to maintain that option.

Similarly, bequest value is the value that people place on knowing that future generations will have the option to enjoy something. Thus, bequest value is measured by peoples' willingness to pay to preserve the natural environment for future generations. For example, a person may be willing to pay to protect the Aberdare Ranges area so that future generations will have the opportunity to enjoy it.

Non-use values, also referred to as "passive use" values, are values that are not associated with actual use, or even the option to use a good or service. Existence value is the non-use value that people place on simply knowing that something exists, even if they will never see it or use it. For example, a person might be willing to pay to protect the Aberdare Ranges wilderness area, even though he or she never expects or even wants to go there, but simply because he or she values the fact that it exists.

It is clear that a single person may benefit in more than one way from the same ecosystem. Thus, total economic value is the sum of all the relevant use and non-use values for a good or service.

In text question (10 minutes)

Explain how you can determine the value of an ecosystem.

Summary

This session covered the concepts of demand and supply. The relationships among them and how they determine price is also explained.

It also introduces the concepts of economic value and valuation. Economic value is one way to define and measure value which is useful to consider when making economic choices that involve tradeoffs in allocating resources. The concepts can also be applied for ecosystem valuation by providing a way to justify and set priorities for programs, policies, or actions that protect or restore ecosystems and their services.

1.6 Other considerations in carbon trading

1.6.1 Carbon pricing

Activity 1 (Brainstorming) (10 minutes)
Views on how and why carbon market and prices change over type.

Cpricing refers to initiatives that put an explicit price on GHG emissions. These initiatives include not only emissions trading scheme (ETSs), C taxes, offset mechanisms, and results-based finance (RBF), but also internal instruments set by companies. According to Kossoy et al. (2015) the C prices observed in these instruments vary significantly, from less than US\$1/tCO_2e to \$US130/tCO_2e, 85% of them priced at less than US\$10/tCO_2e. As C pricing is not implemented uniformly around the world, one of the key issues facing the affected industries is C leakage - the situation where production and associated emissions shift to jurisdictions that do not have equivalent policies in place.

The choice of C pricing instruments is based on national circumstances and political realities. What is the most suitable instrument depends on the specific circumstances and context of a given jurisdiction, and the instrument's policy objectives should be aligned with the broader national economic priorities and institutional capacities.

An ETS and a C tax are increasingly being used in complementary ways, features of both instruments often being combined to form hybrid approaches. C pricing is only one instrument in a range of approaches that need to be mobilized for emissions mitigation. Other policy instruments, such as the removal of fossil fuel subsidies, infrastructure investments in transport and energy, renewable energy portfolio standards, and energy efficiency standards, also have an important role to play in achieving emission reductions. C pricing and these complementary policy instruments need to operate in tandem to address the urgency and scale of the climate change mitigation challenge.

In spite of the available C markets that may provide revenues from the sale of forest C, there are risks that presence of C projects will result in restricted access and displacement of local communities. There are also risks associated with market challenges such as price fluctuations, imperfection and lack of insurance. It is also likely that technology may change so that current knowledge on the role of forest on climate mitigation may become absolute.

In text question (10 minutes)
Explain how carbon market and prices may change over time.

1.6.2 Property rights in carbon trade

Activity 1 (Brainstorming) (10 minutes)
Views on property rights.

The concept of ownership has been described as a `container' of a number of rights in relation to property,e.g. the right to possess it, to use it, to enjoy its fruits, and to dispose of it. The owner may transfer particular rights to other parties for a period on agreed terms (rent a tract of land for grazing for three years, for example) but the container of ownership remains with the owner. Even if all rights have been transferred for the time being, ultimately they will revert to the owner. ***Land tenure*** on the other hand is the name given to the legal regime in which land is owned by an individual, who is said to "hold" the land (the French verb "tenir" means "to hold"; "tenant" is the present participle of "tenir").

Property rights are created and enforced by society for particular purposes. They define the relationship between a person (an individual or a legal entity such as a company) and a thing (which may be physical or intangible). Legal systems typically distinguish between types of ownership by reference to both the subject (i.e. the owner) and the object of the right. The categories vary between legal systems but many legal systems incorporate distinctions between:

- things that cannot be owned, for example, air or the sea which are common to everyone (*res communes*) and property such as the seashore which is held by the state for the benefit of the public (*res publicae*);
- things that are unowned but can be owned (such as wildlife before capture), although wildlife and fisheries are generally regulated by the state, and licensing is required in order to take these resources; and,
- things in respect of which full ownership rights exist and that may be freely bought and sold (this "alienable property" is often referred to as "private property" but in fact it may be owned by the state as well as by private individuals or corporations).

Discussions of property regimes often focus on the various categories of persons who hold the rights. They thus sometimes lose sight of the fact that the characteristics of the property regime are determined both by the category of person holding the right (e.g. the state, a group with common rights, or a private individual or legal entity) and by the nature of the property (or thing) in question.

- Open-access property is not 'owned' by anyone. It is non-excludable (no one can exclude anyone else from using it) but may be rival (one person's use of it reduces the quantity available to other users). Open-access property is not managed by anyone, and access to it is not controlled. There is no constraint on anyone using open-access property (excluding people is either impossible or prohibitively costly). Examples of open-access property are the upper atmosphere (navigable airspace) or ocean fisheries (navigable waterways).

  Open-access property may exist because ownership has never been established, granted by laws within a particular country, or because no effective controls are in place, or feasible, i.e., the cost of exclusion outweighs the benefits. The government can sometimes effectively convert open access property into private, common or public property through the land grant process, by legislating to define public/private rights previously not granted.

- Public property (also known as state property) is property that is owned by all, but its access and use are controlled by the state or community. An example is a national park or a state-owned enterprise.
- Common or collective property is property that is owned by a group of individuals. Access, use, and exclusion are controlled by the joint owners. True commons can break down, but, unlike open-access property, common property owners have greater ability to manage conflicts through shared benefits and enforcement.
- Private property is both excludable and rival. Private property access, use, exclusion and management are controlled by the private owner or a group of legal owners.

A well-defined or efficient property right has the following characteristics:

- **exclusivity**: all benefits and costs accrued as a result of owning and using the resource should accrue to the owner, and only to the owner, either directly or indirectly by sale to owner;
- **transferability**: all property right should be transferable, e.g. can be sold, exchanged or rented, or can be gifted from one owner to another in a voluntary exchange;
- **enforceability**: property right should be secured from involuntary seizure or encroach-ment by others.

In text question (10 minutes)
Explain the meaning of property rights and their characteristics.

Summary
This session introduced concepts of C markets dynamics. C can be traded through initiatives such as emissions trading, C taxes, offset mechanisms, and results-based finance (RBF), but also internal instruments set by companies. Prices in these schemes differ significantly.

This session also introduced concepts of property rights and their charac-teristics. The concept of ownership has been described as a `number of rights a person has in relation to the property, e.g. the right to possess it, to use it, to enjoy its fruits, and to dispose of it. A well-defined or efficient property right has the characteristic of exclusivity, transferability and enforceability.

Chapter 2. Carbon Trading Processes and Agreements

2.0 Chapter overview

This module is designed to build learners' competence on concepts and principles of C trade and marketing. It introduces learners to the different C trading agreements such as the Kyoto Protocol (KP) of the UNFCCC, processes on C trading and marketing, international C standards and C trading, obligations of Annex I and Non-Annex I Parties, rules governing C trading, myths and the realities of marketing and trading in C, roles of professionals in C trading and the mechanisms for C benefit sharing at community (sub-national), national and international levels. Country experiences on benefit sharing schemes in Africa are given.

Objectives

By the end of this chapter, the learner should be able to:

- describe the agreements and processes on C trading and marketing;
- describe the international carbon standards and C trading;
- explain the obligations of Annex I and Non-Annex I Parties;
- explain the rules governing C trading;
- analyse the myths and the realities of marketing and trading in C;
- highlight the roles of technical officers in support of C trading; and,
- evaluate the mechanisms for C benefit sharing at community (sub-national), national and international levels.

The chapter consists of two sessions. Each session may be presented in several training sub-sessions lasting an hour each. The number of sub-sessions per chapter depends on the nature, weight and type of content developed, vis-à-vis the nature of participants involved. The sessions are as follows:

- agreements and processes on C trading and marketing; and,
- other agreement and processes issues relevant to the C trading including:
    - ✓ international C standards C trading;
    - ✓ obligations of Annex I and Non-Annex I Parties;
    - ✓ views on the rules governing international trading of forest products;
    - ✓ myths and the realities of marketing and trading in C;
    - ✓ roles of technical officers in support of C trading;
    - ✓ mechanisms for C benefit sharing at community (sub-national), national and international levels; and,
    - ✓ country experiences on benefit sharing schemes in Africa.

2.1 Agreements and processes on carbon trading and marketing

2.1.1 Agreements on carbon trading and marketing

Activity 1 (Brainstorming) (10 minutes)
What are your views on trading agreements at national, regional and inter-national levels?

There are several C trading agreements ranging from national and regional to international.

National agreements

These are in most cases statutory in nature, where investors are obliged to use clean-energy technologies that create green jobs and reduce dependence on imported oil. These are efforts to reduce GHG pollution.

Regional agreements

Multinational companies from across the emissions trading cycle: regulated emitters, solution providers, brokers, financial services firms, verifiers and law firms: may also be pulled together to formulate C trading agreements. For example, the International Emissions Trading Association (IETA) is a non-profit organization created in 1999 to establish a functional regional framework for trading GHG emissions. It creates Emission Reduction Purchase Agreements, i.e a type of transaction that has its standards set forth by the IETA whereby a purchaser will pay a seller an amount of cash in return for C credits. This exchange will thus allow the buyer to emit additional units of CO_2 into the air. Under IETA, a number of agreements were created. These include:

- ***Emissions Trading Master Agreement for the EU Scheme*** of 2008 has been developed by the IETA to facilitate trading under the EU emissions trading scheme;
- ***The Western Climate Initiative (WCI)*** is a collaboration of independent jurisdictions working together to identify, evaluate, and implement emissions trading policies to tackle climate change at a regional level. In this scheme, British Columbia, California, Ontario, Quebec and Manitoba are continuing to work together through the WCI to develop and harmonize their emissions trading program policies. This is a comprehensive effort to reduce GHG pollution, spur investment in clean-energy technologies that create green jobs and reduce dependence on imported oil; and
- ***California Emission Trading Master Agreement*** developed by the International Emissions Trading Association (IETA) to facilitate emissions trading in California.

International agreements

In 1992, countries joined an international treaty, the United Nations Framework Convention on Climate Change (UNFCCC) as a framework for international cooperation to combat climate change by limiting average global temperature increases and the resulting climate change, and coping with impacts that were, by then, inevitable. By 1995, countries launched negotiations to strengthen the global response to climate change, and, two years later, adopted the Kyoto Protocol (KP). KP legally binds developed country Parties to emission reduction targets. The Protocol's first commitment period started in 2008 and ended in 2012. The second commitment period began on 1 January 2013 and will end in 2020. There are now 196 Parties to the Convention and 192 Parties to the KP.

This time line detailing the international response to climate change provides a contextual entry point to the essential background:

- **1979** - the first World Climate Conference (WCC) takes place;
- **1988** - the Intergovernmental Panel on Climate Change (IPCC) is set up;
- **1990** - IPCC's first assessment report released. IPCC and second World Climate Conference call for a global treaty on climate change; UN General Assembly negotiations on a framework convention begin;
- **1991** - the first meeting of the Intergovernmental Negotiating Committee (INC);
- **1992** - the INC adopts UNFCCC text. At the Earth Summit in Rio, UNFCCC is opened for signature along with its sister Rio Conventions, UNCBD and UNCCD;
- **1994** - UNFCCC enters into force;
- **1995** - the first Conference of the Parties (COP 1) takes place in Berlin;
- **1996** - the UNFCCC Secretariat is set up to support action under the Convention;
- **1997** - Kyoto Protocol formally adopted in December at COP 3;
- **2001** - release of IPCC's Third Assessment Report; Bonn Agreements adopted, based on the Buenos Aires Plan of Action of 1998. Marrakesh Accords adopted at COP 7, detailing rules for implementation of KP, setting up new funding and planning instruments for adaptation, and establishing a technology transfer framework;
- **2005** - entry into force of the KP; the first Meeting of the Parties to the KP (MOP 1) takes place in Montreal; in accordance with KP requirements, Parties launched negotiations on the next phase of the KP under the Ad Hoc Working Group on Further Commitments for Annex I Parties under the KP (AWG-KP); what was to become the Nairobi Work Programme on Adaptation (it would receive its name in 2006, one year later) is accepted and agreed on;
- **2007** - IPCC's Fourth Assessment Report released; climate science entered into popular consciousness; at COP 13, Parties agreed on the Bali Road Map, which charted the way towards a post-2012 outcome in two work streams: the AWG-KP, and another under the Convention, known as the Ad-Hoc Working Group on Long-Term Cooperative Action Under the Convention;
- **2009** - Copenhagen Accord drafted at COP 15 in Copenhagen; this was taken note of by the COP; countries later submitted emission reductions pledges or mitigation action pledges, all non-binding;
- **2010** - Cancun Agreements drafted and largely accepted by the COP, at COP 16;
- **2011** - the Durban Platform for Enhanced Action drafted and accepted at COP17;
- **2012** - the Doha Amendment to the KP is adopted by the CMP at CMP 8;

- **2013** - key decisions adopted at COP 19/CMP 9 include decisions on further advancing the Durban Platform, the Green Climate Fund and Long-Term Finance, the Warsaw Framework for REDD+ and the Warsaw International Mechanism for Loss and Damage. Under the Durban Platform, Parties agreed to submit "intended nationally determined contributions", known as INDCs, well before the Paris conference;
- **2014** - at COP 20 in Lima in 2014, Parties adopted the 'Lima Call for Action', which elaborated key elements of the forthcoming agreement in Paris; and
- **2015** - intensive negotiations took place under the Ad Hoc Group on the Durban Platform for Enhanced Action (ADP) throughout 2012-2015 and culminated in the adoption of the Paris Agreement (PA) by the COP on 12 December 2015. The PA aims at strengthening the global response to the threat of climate change by keeping a global temperature rise this century well below 2 ºC above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 ºC. Additionally, the agreement aims to increase the ability of countries to deal with the impacts of climate change, and at making finance flows consistent with a low GHG emissions and climate-resilient pathway.This is expected to be achieved through nationally determined contributions (NDCs).
- **2016 -** at COP 22 in Marrakech, Morocco tha focused on preparation for the entry into force of the PA and the first session of the conference of Parties serving at the meeting of the Parties to the PA.
- **2017** - COP-23/CMP 13/Second Meeting of Parties to PA was held in Bonn, Germany where subsidiary bodies called parties to collaborate with relevant inter-governmental and international organizations to raise awareness and enhance capacity-building on the impacts of implementation of response measures in line with PA.
- **2018** - at COP 24 in Katowice, Poland reviewed functions, work programme and adoption of PA rule book that contained climate pledge guidance, market mechanisms, climate financing, transparency, loss and damage and Talanoa dialogue

The Kyoto Protocol

KP is an international agreement linked to UNFCCC, which commits its Parties by setting internationally binding emission reduction targets. Recognizing that developed countries are principally responsible for the current high levels of GHG emissions in the atmosphere as a result of more than 150 years of industrial activity, the Protocol places a heavier burden on developed nations under the principle of "common but differentiated responsibilities". The KP was adopted in Kyoto, Japan, on 11/12 1997 and entered into force on 16/2 2005. The detailed rules for the implementation of the Protocol were adopted at COP 7 in Marrakesh, Morocco, in 2001, and are referred to as the "Marrakesh Accords." Its first commitment period started in 2008 and ended in 2012.

In text question (10 minutes)
Describe examples of C trading agreements at national/regional/global levels.

2.1.2 Processes in carbon trading and marketing

Activity 1 (Brainstorming) (10 minutes)
Views on existing UNFCCC processes.

UNFCCC bodies

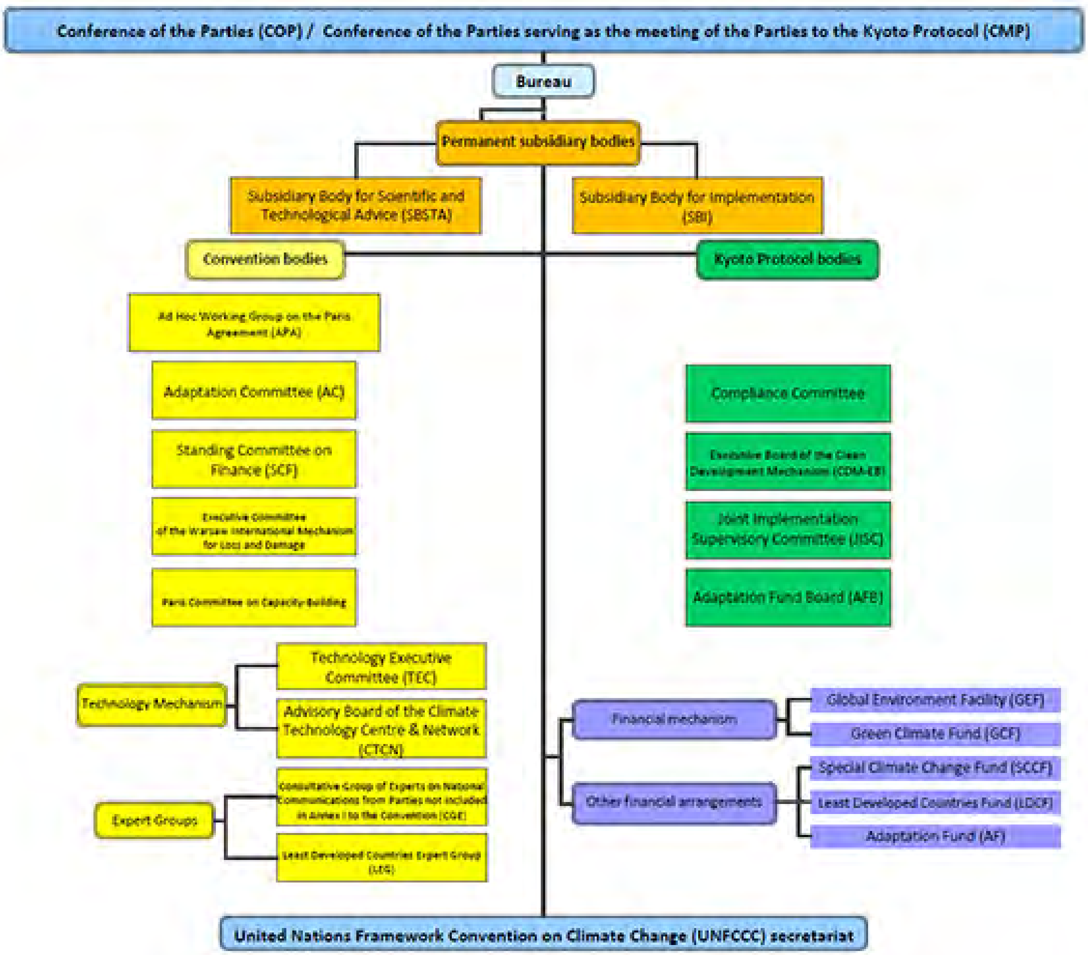

Figure 5. Structure of the UNFCCC process and bodies therein. (UNFCCC, 2014)

Conference of Parties (COP)

The COP is the supreme decision-making body of the Convention. All States that are Parties to the Convention are represented at the COP, at which they review the implementation of the Convention and any other legal instruments that the COP adopts and take decisions necessary to promote the effective implementation of the Convention, including institutional and administrative arrangements.

Conference of Parties serving as the meeting of the Parties to the KP (CMP)

The Conference of the Parties, the supreme body of the Convention, shall serve as the meeting of the Parties to the KP. All States that are Parties to the KP are represented at the COP serving as the meeting of the Parties to the KP (CMP), while States that are not Parties participate as observers. The CMP reviews the implementation of the KP and takes decisions to promote its effective implementation.

Subsidiary Body for Scientific and Technological Advice (SBSTA)

The SBSTA supports the work of the COP and the CMP through the provision of timely information and advice on scientific and technological matters as they relate to the Convention or its Kyoto Protocol.

Subsidiary Body for Implementation (SBI)

The SBI supports the work of the COP and the CMP through the assessment and review of the effective implementation of the Convention and its Kyoto Protocol.

Bureau of the COP and the CMP

The Bureau supports the COP and the CMP through the provision of advice and guidance regarding the ongoing work under the Convention and its Kyoto Protocol, the organization of their sessions and the operation of the secretariat, especially at times when the COP and the CMP are not in session. The Bureau is elected from representatives of Parties nominated by each of the five UN regional groups and small island developing States.

In text question (10 minutes)
Explain existing UNFCCC processes in relation to carbon trading agreements at global level.

2.1.3 Scenarios of carbon trade agreements

Activity 1 (Brainstorming) (10 minutes)
Views on carbon trade agreements.

Scenarios of carbon trade agreements are:

(i). no agreement;

(ii). weak agreement; and

(iii). ideal/ambitious agreement

2.1.4 Implementation procedures

Stakeholders in CDM process

The three governance bodies established under the CDM are:

- The Conference of Parties serving as the Meeting of the Parties to the KP (COP/MOP);
- The CDM Executive Board (EB), appointed and elected by the COP/MOP; and
- Designated Operating Entities (DOE), composed of private organizations accredited by the Executive Board.

These bodies are responsible for the administration and application of CDM rules, modalities, procedures and guidelines.

The Designated National Authority (DNA) acting as national level and constituting the focal point of all stakeholders in the CDM project is added to the above listed three bodies which intervene at the international level.

Conference of Parties / Meeting of Parties

COP calls countries that have ratified UNFCCC to negotiate decisions on the Convention for annual meeting. COP serving as the Meeting of the Parties to the Protocol (COP/MOP) also calls countries that have ratified the KP for meeting at the same time and place as the COP. It is the supreme body that oversees the implementation of the Protocol.

The MOP mainly takes decisions, makes recommendations and provides guidance on all matters relating to the CDM. Thus, for example, it:

- appoints the members of the Executive Board of the CDM;
- provides general orientations for the implementation of the CDM;
- takes decisions on the basis of the recommendations of the Executive Board of the CDM;
- accredits the Designated Operational Entities;
- examines the annual reports of the Executive Board;and
- reviews the regional distribution of DOEs and CDM projects.

CDM Executive Board

The Executive Board oversees the CDM under the authority and direction of the COP/MOP, and according to the rules established and adopted by the COP/MOP. The Executive Board is mainly responsible for the following activities:

- make recommendations to the COP/MOP on CDM modalities and procedures;
- approve the new methodologies, monitoring, etc;
- review the provisions for the definition of small-scale project activities and the corre-sponding simplified modalities and procedures;
- accredit Operational Entities and make recommendations to the COP/MOP for their designa-tion (DOE);

- make available all documents and technical reports to the public for comments during defined periods;
- develop and maintain the CDM registry;
- record validated CDM projects; and
- instruct the CDM registry administrator to issue CERs generated by CDM project activities.

The Executive Board is composed of 10 members and 10 alternates, nominated by the region or group of countries to which they belong and elected by the COP/MOP. The composition must reflect the balance between the regions of the world and between countries of the North and the South.

Panels and Working Groups

The CDM Executive Board may establish committees, panels and working groups to have their assistance in the performance of its technical tasks. For this purpose, it must call on the experts, including those listed in the Convention, and observe the regional balance in their nomination. In June 2007, the Executive Board established the following panels and working groups:

a) ***Methodology Panel*** (Meth Panel) is responsible for reviewing proposals on new methodologies and for making recommendations to the EB on baseline methodologies and monitoring of normal-sized CDM projects as well as on revisions of project design documents (PDD);

b) ***Small-Scale Projects Working Group*** (SSC WG) is responsible for reviewing the proposals and making recommendations to the EB on simplified baseline methodologies and follow-up of small scale project activities;

c) ***Working Group on Afforestation/Reforestation Projects*** (ARWG) is in charge of reviewing proposals and making recommendations to the EB on afforestation/ reforestation methodologies, related project documents, etc;

d) ***Executive Board-Registration and Insurance Team*** (EBRIT) is responsible for assessing whether applications for the registration of CERs and the issuance of CERs by Designated Operational Entities meet the requirements before they are considered by the EB;

e) ***Accreditation Panel*** (CDM-AP) is responsible for making recommendations to the EB on the accreditation of candidate entities; the panel is also in charge of the selection of the members of the assessment team for accreditation; and,

f) ***CDM accreditation assessment team*** (CDM-AT) is made up of a team leader and at least two member experts selected to carry out the evaluation of a given entity.

Designated Operational Entities

A Designated Operating Entity (DOE) is a legal entity, accredited and designated by the EB on an interim basis until it is confirmed by the COP/MOP. DOE can have two functions:

- the validation of CDM projects for registration by the EB; and,
- verification - certification of emission reductions of registered projects.

In the case of normal-sized projects, the DOE “validator” must be different from the one responsible for verification. For small projects, the same DOE can perform both functions for the same project. Accreditation of DOEs must follow a procedure approved by the COP/MOP and involving the accreditation panel (CDM-AP), Accreditation Assessment Team (CDM-AT), the EB, and COP/MOP. Accreditation is granted for one or more areas (sectorial scope) and for a period of three years. The EC exercised regular supervision during these three years. The Executive Board may recommend to the COP/MOP the suspension or withdrawal of accreditation to a DOE if the requirements are no longer met. An updated list of DOEs can be found on the Convention website: http://cdm.unfcc.int/DOE.

Designated National Authority of the CDM

Parties to the KP desiring to participate in the CDM should establish a Designated National Authority (DNA) of the CDM (see Marrakesh Accords and decision CMP / 2005/8 / Ad1). The countries are sovereign to choose the institutional form to give to this new structure (Committee, Council, Institute, etc.). They must, however, designate a contact point whose contact details are posted on the Convention's website.

The regulatory role of the DNA is to examine CDM projects submitted to it by the national economic operators, to ensure that they contribute to sustainable development and, if accepted, to issue an official "letter of Approval". Details of the project approval process are established by the DNA. The DNA may also undertake to promote the CDM to national economic operators and potential buyers of CERs in the Annex B countries of the Protocol, which are empowered to use the flexibility mechanisms.

Summary

This session introduces C trading agreements. There is a number of C trading agreements ranging from national, regional to international agreements.

This session also introduces carbon trading processes at global level. Different bodies - COP, CMP, SBSTA, SBI and Bureau of COP and CMP - are defined.

2.2 Other issues in carbon processes and agreements relevant for carbon trading

2.2.1 International carbon standards and carbon trading

Activity 1 (Brainstorming) (10 minutes)
Views on criteria used in the international markets and trading of different commodities.

The management of forest C projects and the methodology used to determine the credits should meet national and international standards. Basically, all C markets use similar criteria to evaluate the C credits. However, there are strict criteria in the formal UNFCCC market compared to the voluntary market.

Projects under the voluntary C market (VCM) can be realized in a variety of ways. What is most appropriate depends chiefly on the buyer criteria. There are many critics of ventures developed under this market, given that it is not well regulated. Therefore, most project developers choose to implement ventures following the guidelines of some set of third party standards that have been developed to assure transparency and provide accountability to credit buyers.

The aim of C standards is to provide assurance for buyers that projects' emission reductions are real, additional and permanent (refer 1.3.2).

2.2.2 Obligations of Annex I and Non-Annex I Parties

Activity 1 (Brainstorming) (10 minutes)
Views on the difference between developed nations, countries with economy in transition, and least developed countries and their known international obligations.

Distinction between Annex I and non-Annex I Parties

The Convention divides countries into three main groups with differing commit-ments:

Annex I Parties include the industrialized countries that were members of the OECD (Organisation for Economic Co-operation and Development) in 1992, plus countries with economies in transition (the EIT Parties), including the Russian Federation, the Baltic States, and several Central and Eastern European States.

Annex II Parties consist of the OECD members of Annex I, but not the EIT Parties. They are required to provide financial resources to enable developing countries to undertake emission reduction activities under the Convention and to help them adapt to adverse effects of climate change. In addition, they have to "take all practicable steps" to promote the development and transfer of environmentally friendly technologies to EIT Parties and developing countries. Funding provided by Annex II Parties is channelled mostly through the Convention's financial mechanism.

Non-Annex I Parties are mostly developing countries. Certain groups of developing countries are recognized by the Convention as being especially vulnerable to the adverse impacts of climate change, including countries with low-lying coastal areas and those prone to desertification and drought. Others (such as countries that rely heavily on income from fossil fuel production and commerce) feel more vulnerable to the potential economic impacts of climate change response measures. The Convention emphasizes activities that promise to answer the special needs and concerns of these vulnerable countries, such as investment, insurance and technology transfer.

The 49 Parties classified as **least developed countries** (LDCs) by UN are given special consideration under the Convention on account of their limited capacity to respond to climate change and adapt to its adverse effects. Parties are urged to take full account of the special situation of LDCs when considering funding and technology-transfer activities.

Observer organizations

Several categories of observer organizations also attend sessions of the COP and its subsidiary bodies. These include representatives of UN secretariat units and bodies, such as UNDP, UNEP and UNCTAD, as well as its specialized agencies and related organizations, such as GEF and IPCC. Observer organizations include intergovernmental organizations (IGOs), such as OECD and International Energy Agency (IEA), along with non-governmental organizations (NGOs).

Over 1880 NGOs and 100 IGOs are admitted as observers. The NGOs represent a broad spectrum of interests, and embrace representatives from business and industry, environ-mental groups, farming and agriculture, indigenous populations, local governments and municipal authorities, research and academic institutes, labour unions, women and gender and youth groups. Constituency groupings have emerged from the above groups to facilitate interaction.

In text question (10 minutes)
Explain the memberships of the Annex I, Annex II, Non-Annex I and Least Developed Countries (LDCs) parties.

2.2.3 Views on the rules governing international trading of forest products

Activity 1 (Brainstorming) (10 minutes)
Views on the rules governing international trading of forest products.

General project eligibility requirements are framed in the modalities and procedures as requirements for validation. These requirements are as follows:

- the Party hosting the project has met the participation requirements;
- stakeholders have been consulted with;
- the environmental impacts of the project have been considered;
- emission reductions are additional;
- baseline and monitoring methodologies comply with requirements; and,
- the project complies with all other relevant requirements.

These requirements are set out in full in 3/CMP.1, Annex, paragraph 37:

1) the participation requirements as set out in paragraphs 28 - 30 above are satisfied;
2) comments by local stakeholders have been invited, a summary of the comments received has been provided, and a report to the designated operational entity on how due account was taken of any comments has been received;
3) project participants have submitted to the designated operational entity documentation on the analysis of the environmental impacts of the project activity, including trans-boundary impacts and, if those impacts are considered significant by the project partici-pants or the host Party, have undertaken an environmental impact assessment in accordance with procedures as required by the host Party;
4) the project activity is expected to result in a reduction in anthropogenic emissions by sources of GHGs that are additional to any that would occur in the absence of the proposed project activity, in accordance with paragraphs 43 - 52 below;
5) the baseline and monitoring methodologies comply with requirements pertaining to:
    - methodologies previously approved by the Executive Board; or,
    - modalities and procedures for establishing a new methodology (para 38 below);
6) Provisions for monitoring, verification and reporting are in accordance with decision 17/CP.7, the present annex and relevant decisions of the COP/MOP; and,
7) The project activity conforms to all other requirements for CDM project activities in decision 17/CP.7, the present annex and relevant decisions by the COP/MOP and the Executive Board (3/CMP.1, Annex, paragraph 37).

2.2.4 What is additionality?

Additionality refers to C emission reductions that are additional to what would have occurred without the REDD+ project. To be additional, the project must demonstrate that it would not have happened in the absence of C finance.

2.2.5 Baselines (Business as Usual)

C benefit of any forest project = C changes to known levels of precision. Determination of C changes requires beselines REL/RL. REL/RL benchmark against which additional C benefits as a result of C projects (individual, sub-national or national) can be determined. Requires reliable data on forest extent and stocking.

2.2.6 Leakage

Tranfer of forest use to other forest: *A C project must identity and determine the extent of all forest utilization levels before the start of the project and make sure that the uses are not transferred elsewhere (leakage) in the presence of the project.*

? **In text question (10 minutes)**
Explain the basic eligibility criteria governing carbon trading.

2.2.7 Myths and the realities of marketing and trading in carbon

Activity 1 (Brainstorming) (10 minutes)
Views on the realities of marketing and trading in C.

Realities of marketing and trading in C include:

- the over-expectation;
- a revenue from C credits being lower than expected;
- the possibility for C credits to solve climate change problem; and,
- the volatility of C markets.

2.2.8 Role of technical officers in support of carbon trading

Activity 1 (Brainstorming) (10 minutes)
Role of technical officers in forest C credits

The technical officers in C project are expected to support the C related programmes through the following:

- multi-disciplinary teams are needed to provide technical support in developing C projects by preparing:
  - Project Identification Note (PIN);
  - Project Design Document (PDD);
- independent expert validators, e.g. consultants, are required for:
  - sensitization of policy makers;
  - awareness creation and capacity building of stakeholders;
  - measurement, Reporting and Verification of C projects;
  - monitoring of C projects;
  - guiding interpretation and implementation of C agreements;
  - identification and engagement of stakeholders that would be carefully consultated;
  - enhancement of decision making on the amount of incentive payments to stake-holders, the timing and the form in which this payment takes place and linked directly to actions agreed with stakeholders;
  - monitoring to ensure mechanisms in place can be trusted and have the necessary accountability provisions to disburse timely payments to stakeholders;

- monitoring to ensure that information about all transactions is available in the public domain for scrutiny by civil society, government and private sector;
- monitoring so that benefit sharing agreements are flexible and allow for necessary changes based on learning and have clear dispute settlement mechanisms;
- building local capacity of the stakeholders to meaningful engage in C markets;
- estimation of costs of people's sacrifices; to determine level, form and timing of benefit distribution, in relation to stakeholders' productive engagement on C benefit activities;
- follow-up of procedures for reporting, auditing, and monitoring of benefit streams to effectively safeguard against corruption;
- harnessing internal and external forces for increased transparency; and,
- preparedness for changes in agreements; prompt adoption of dispute settlement mechanisms to avoid costly conflicts & reduction of uncertainty.

In text question (10 minutes)
Explain why is it necessary to consult and involve different technical officials in the carbon project.

2.2.9 Mechanisms for carbon benefit sharing at sub-national, national and international levels

Activity 1 (Brainstorming) (10 minutes)
Views on the mechanism for benefit sharing at community, national and international levels for any known trading regimes.

Overview of mechanisms of carbon benefit sharing

C benefit sharing entails the following attributes:

- benefit sharing systems that should provide effective incentives for actions and build support for C credit mechanisms;
- benefits should be shared more widely than a strict focus on effective incentives allows;
- clear reasons for benefit sharing e.g.:
  - o to create effective incentives by rewarding individuals, communities, organizations and businesses for actions that change land-use and reduce emissions; and,
  - o to build wider national (and international) legitimacy and support behind the C credits mechanism.

Caution

- Avoid scenarios where many people benefit who do not directly contribute to the reduction of emissions. This is likely to dilute the incentives and make it more expensive. It will also lower the C emissions.
- Be careful in giving rewards only to certain groups, actions or geographical areas. This may make others feel unfairly treated and turn against the whole mechanism as illegitimate.
- The sharing mechanism that is necessary to ensure support and legitimacy would also depend on the specific type of C credit policy (e.g REDD+ policy) and measures, and the stakeholders involved.

Overall, the mechanisms of C benefit sharing depend on:

- national input-based arrangements;
- sub-national input-based arrangements;
- national performance based arrangements; and,
- sub-national performance based arrangements.

At the national input-based arrangement level, carbon benefit sharing entails:

- national level benefit sharing mechanisms distribute benefits from national to sub-national or local levels; and
- benefits distributed either directly to the end recipient (e.g. community groups) or via a sub-national organization (e.g., local government institutions).

At the sub-national level, the carbon benefit sharing involves the following:

- sub-national benefit sharing mechanisms distribute benefits from sub-national to local levels (e.g., from a provincial government institution to community groups) or between sub-national actors (e.g., benefits disbursed from provincial to municipal government); and,
- sub-national benefit sharing mechanism types that are applicable to sub-national or nested approaches.

With the national performance based arrangement, the C benefit sharing involves the following:

- performance based arrangements distribute benefits on the condition that the partners receiving the benefits (e.g. community groups) have achieved a predefined, measurable and verifiable standard of performance against a baseline (e.g. have restored or protected X ha of forest); and,
- this mechanism is generally linked to market-based payments.

At the sub-national input performance based arrangement, carbon benefit sharing involves the following:

- in input based arrangements, beneficiaries agree with the benefit-sharing mechanism management body to carry out specified actions, or refrain from certain actions, in return for up-front monetary or non-monetary inputs; and,
- no link is provided between the distribution of benefits and future measurable performance in forest management.

How to identify what benefits to share?

This needs the following:

- consultation and participation of stakeholders (building on what was done to identify beneficiaries);
- analytical work on costs, returns, opportunity costs, institutional constraints, etc;
- negotiation over benefits and the principles and standards that underpin the agreement; and,
- a capacity assessment to ensure that the key institutions have the needed capacity to make management decisions and enforce them (e.g. in areas such as negotiation, site specific technical areas and knowledge sharing, transparent financial systems, monitor-ing, legal frameworks, and organizational, management and general business skills).

Who are central block and beneficiaries to C benefits?

- People involved in reduction of GHG emissions?
- Stakeholders?
- Government?
- International partners?
- NGOs?
- Investors?

Highlights of C trading benefits

C trading benefits vary from one level to the other. The major types of C benefits include the following:

- direct benefits e.g financial gains;
- indirect benefits e.g non-financial; and,
- intermediate benefits.

These would broadly be categorized as Economic, Social and Environment at national and local levels e.g.:

- at National level, economic benefits are:
  - contribution of REDD+ finance to national GDP and profits from sale of REDD+ credits;
  - multiplier effects of REDD+ investments, such as spending of income in local markets or;
  - creation of jobs elsewhere in the economy;
  - physical (e.g. roads; monitoring systems) and institutional (e.g. better resourced forest management institutions) infrastructure improvements; and,
  - reduced spending, for example on flood management due to improved forest environmental services.

- at local level, economic benefits are:
  - employment in C credit schemes;
  - income from direct incentive payments;
  - income from sale of products linked to Carbon credit schemes e.g REDD+;
  - increased net income due to local infrastructure improvements; and,
  - increased land and forest assets.
- the social benefits at local level
  - local institutions more inclusive of poorer community members interests in decision making processes;
  - reduced conflict and acknowledgement of cultural traditions; and,
  - improved health.

Experiences on mechanisms of C benefit sharing under REDD+ programme

The REDD+ C benefit sharing experiences focus on the following:

- governance;
- transparency;
- accountability; and,
- the involvement of the poor in decision-making processes.

Benefits are delivered either as payments to individuals or communities or as contributions to development projects, or social services. The Clean Development Mechanism (CDM), voluntary C projects, integrated conservation and development projects all struggle with delivering both environmental services and livelihood contributions. The taxing of C credits has been suggested in order to strengthen the poverty dimension of projects, and enable the funding of dedicated livelihood programs. The design and development of benefit sharing mechanisms under REDD+ should build on these existing experiences.

Below is a summary review of REDD+ experiences across the globe (Table 1).

Table 1. Summary of global of REDD+ benefit sharing experiences

Benefit sharing areas reviewed	Lessons for benefit sharing under REDD-plus
Forest conservation and management types	
Integrated Conservation and Development Projects (ICDPs)	• Key stakeholders for benefit sharing need to be more carefully identified; • Links between incentives, benefits and actions are often too loose; • Criteria for benefit sharing could include cost, compliance, need and residency; • Embezzlement and elite capture are often major problems; • ICDPs take on too many things – lessons for REDD+?
Payment for forest Environmental services (PES)	• Links between incentives, benefits and actions stonger than for ICDPs • PES is usually not targeting the poor, one reason is high transaction costs • Flexible tenure arrangements and up-front payments may improve benefit sharing
CDM & voluntary carbon markets	• Sustainable development concerns under CDM are left to countries. • Standards in voluntary markets for social issues may be useful. • Front-loaded payment schedule is important for poor participants. • Taxation of C credits can be redistributed for benefit sharing purposes.
Community Forest Management (CFM)	• Vertical benefit sharing is often specified in regulations, horizontal benefit sharing is often decided locally. • Government procedures for CDM are often cumbersome and benefits are low. • Clear and stable government rules on benefit sharing are important for incentives. • The inclusion of marginal groups makes benefit sharing more fair and transparent.
Production forestry	• Sensitization and training is needed before receiving monetary benefits; • Transparency and accountability problems at different levels.
Other areas and sectors	
Extractive industries	• Appropriate benefit sharing can induce cooperation also in difficult situations. • Dedicated benefit sharing systems are needed if existing systems are dysfunctional.
Infrastructure project safeguards	• Available guidelines may be useful for benefit sharing under REDD+. • Monetary compensation systems may create local problems.

Based on the lessons learnt, there are five features that are critical for well-functioning mechanisms of C benefit sharing under REDD+ programmes. These are:

a) stakeholders need to be carefully identified and engaged, and not just consulted;

b) the amount of incentive payments to these stakeholders, the timing and the form in which this payment takes place need to be decided and linked directly to actions agreed with them;

c) a mechanism which is trusted and has the necessary accountability provisions should be in place to disburse timely payments to stakeholders;

d) information about all transactions should be available in the public domain for scrutiny by civil society, government and private sector; and,

e) benefit sharing agreements should be flexible and allow for necessary changes based on learning and have clear dispute settlement mechanisms.

These five critical areas are as summarized in table 2.

Table 2. Critical areas associated to REDD+

Key areas	Features of benefit sharing mechanism	Results
1. Stakeholder engagement	Identifies stakeholders, consults with them, and builds local capacity for them to engage	Basis for determining incentives, builds ownership, trust and legitimacy
2. Incentive design	Estimates costs of people's sacrifices, determines level, form and timing	Clear and direct incentives for stakeholders to engage in REDD+ activities
3. Delivery mechanism	Ensures proper procedures for reporting, auditing and monitoring of benefit streams	General trust and legitimacy and effective safeguards against corruption
4. Transparency provisions	Harnesses internal and external forces for increased transparency	Cost-effective, meaningful levels of accountability
5. Dispute settlement	Prepares for changes in agreements adopts dispute settlement mechanisms	Avoids costly conflict, disciplines actors and reduces uncertainty

Source: Maginnis and Espinosa (2009)

In text question (10 minutes)
Explain the problems facing benefit sharing, citing some examples from Africa.

Case study of Wildlife works – Kasigau Corridor in Kenya on C benefits

- Of the 25% C credits sold in 2011, 50,000 USD were received by Marungu conservancy on behalf of the community, of which 20% is used for bursaries and 80% for water projects.
- In total, the company has C emission reduction portfolio of 1.002 million tonnes of C per year covering 22,000 ha.
- More importantly, the company is involved in innovative livelihood alternatives to forest products namely the EPZ eco-factory, Greenhouse and Eco-Charcoal.
- The wildlife works company buys seedlings from the community at 5, 10, or 15 shillings depending on species type, grows the seedlings in green houses in polythene bags and later distributes them to institutions and individual farmers free of charge for restoration of degraded areas.
- The communities on their part collect seeds and grow seedlings to 6 cm before selling to the company.
- A monitoring team follows up the planted seedlings in the field for survival count and incentives are provided for the students whose trees survive by issuing them with T-shirts.
- Also fruit trees are raised in greenhouses and sold for a token to the community. The Bio– enterprises in the area include the Tsavo Soap Company and Aloe.
- Eco-charcoal was initiated in September of 2010 where carbonized charcoal briquets are produced using starch and charcoal dust: One drum of charcoal is said to generate 90 kg of charcoal briquets ideal for energy conservation which are sold to the community for 5 shillings per briquet and to outsiders for 10 shillings per briquet.

Mode of benefit sharing

- The money received from international buyers - shared equally with the community (1/3), shareholders of the land (1/3) and WWC (1/3).
- The 1/3 belonging to the community - given to a group (e.g. women's or youth groups) for the implementation of an activity which will generate new incomes.

NB: For every new project that was approved for the community, a new bank account was opened for that project to enhance transparency in benefit sharing.

Summary

This session has covered voluntary and compliance C standards. Their similarities and differences are also explained. Although all C standards use basically similar criteria to evaluate the C credits, there are strict criteria in the formal UNFCCC market.

This session also defined the Annex I, Annex II, Non-Annex I and Least Developed Countries (LDCs). This is in accordance with the UNFCCC classification of member countries. The Convention divides countries into three main groups according to differing commitments.

The session also covered general project eligibility requirements for C trading under the official market. It is required that the country where the project is implemented has ratified the KP; stakeholders have been consulted with; environmental impacts of the project have been considered; emission reductions are additional; baseline and monitoring methodologies comply with requirements; and the project complies with all other relevant requirements.

This session shows that technical officers in C projects are expected to support the C related programmes by providing needed technical inputs.

Benefit sharing in C trading forms a key component that will help realize the efforts towards mitigation and adaptation to climate change. Different C trading schemes need to define mechanisms of C benefit sharing. In this section highlights on the experiences on C benefit sharing approaches used by various approved projects are provided. The description of each benefit varies.

Chapter 3. Forest Carbon Stock Estimation

3.0 Chapter overview

This chapter is designed to build learners' competence on forest C stock estimation. It introduces learners to the Measurement, Reporting and Verification (MRV) for baseline determination: components of MRV, concept of biomass, C stock and C fluxes, C pools, verification and reporting; and approaches to forest C estimation.

Obligations of Annex I and Non-Annex I Parties

Parties to the Convention are obliged to reduce GHG emissions, to cooperate on research and technology and to encourage protection of sinks. The Convention lays emphasis on "common but differentiated responsibilities" of countries, taking into account their respective development priorities, goals and special circumstances, in order to reduce GHG emissions. "Common but differentiated responsibilities" principle rests on the fact that some countries need to take more responsibility in reducing GHG emissions, since they have been emitting more GHG than others since the industrial revolution. In this respect, the Convention allots the Parties to three categories:

Annex I countries: These are mostly developed nations that are considered to have historically contributed most to C emissions. These countries have agreed to either cut or cap their emissions, relative to their base year. The Convention obliges them to reduce GHG emissions, to protect and to develop sinks and to report the measures they take to prevent climate change and their data on GHG emissions. This category has two types of countries in it. The first group includes OECD countries as at 1992; the second those whose economies are in transition. The Annex I category comprises 42 countries and the European Community (EC).

Annex II countries: This category includes OECD countries at the year of 1992 and the EC. These countries are obliged to transfer environment-friendly technologies to specially developing countries and to take all necessary steps to encourage, facilitate and finance access to these technologies on top of other responsibilities they have as being Annex I countries. This category comprises 23 countries and EC.

Non-Annex countries: These are mostly low income developing nations that claim that a cap on emissions could make things difficult in becoming developed nations. These countries have no obligation to reduce/cap their emissions. However, they can participate in emission reduction Clean Development Mechanism (CDM) projects where green projects in their countries are funded from Annex I countries. These countries are encouraged to reduce GHG emissions, to cooperate on research and technology and to protect sinks, but are not bound by other obligations like the Annex I and II countries. This category currently includes 153 countries.

Objectives

By the end of this chapter, the learner should be able to:

- describe the components of the MRV system;
- describe the concept of biomass, C stock and C fluxes;
- describe the C pools; and
- demonstrate approaches to forest C estimation.

This chapter consists of two sessions. Each session may be presented in several training sub-sessions lasting an hour each. The number of sub-sessions per chapter depends on the nature, weight and type of content developed, and the nature of participants involved. The sessions are as follows:

- Measurement, Reporting and Verification (MRV) for baseline determination; and,
- Approaches to forest rapid C stock estimation.

Carbon storage mechanisms

Green plants absorb CO_2 from the atmosphere by photosynthesis. C is stored in foliage, stems, root systems and, more importantly, in the woody tissue of the main stems of trees. Due to the long life of most trees and their relatively large dimensions, trees and forests are real C reserves.

Carbon emission

C emission is the discharge of CO_2 over a certain area and period of time. C emissions in the atmosphere are either related to natural phenomena or related to human activities. However, those linked to anthropogenic activities are fairly regular and have been growing strongly in recent decades.

Notions of carbon flux

C is present in oceans, soils, fossil C reserves, bedrock, atmosphere, and plant biomass and these represent Earth's pools or reservoirs. C flux is the rate of C exchange between different C reservoirs.

3.1 Biomass estimation

Techniques of above ground biomass measurements

Biomass can be estimated using two approaches: direct, also known as destructive methods and indirect methods. Direct methods generally involve field harvesting of samples and sometimes even whole plants (see Figures 6, 7, 8 & 9). They achieve a higher level of accuracy but have considerable costs (Simiane, 2007; Mbow, 2009). Although highly appropriate, direct methods are destructive, time-consuming, financially and humanly. Indirect methods, on the other hand, involve the establishment of biomass prediction equations based on visual estimates and measurements of physical parameters without breaching the physical integrity of the plant (Bognounou et al., 2008).

Destructive methods: approach. The various operations followed in estimating the biomass of trees are:

1) take various measurements (diameter at 1.3 m, height of individual, diameter of crown);
2) cut down the tree and proceed to its dissection by categories of diameters;
3) separate the various components (trunk, branches, twigs, leaves, etc.);
4) collect data on dimensions (lengths, diameters, etc.);
5) weigh the green components (before drying);
6) take green samples (discs on stem and branch wood, portions of the leaves);
7) weigh the green samples;
8) dry the samples in an oven to a constant weight;

For trunks and large branches, one should

9) weigh the wet mass in the field after cutting the stem, taking into account the size;
10) take and weigh the samples in-situ; and,
11) weigh the samples after drying.

Figure 6. Measuring the diameter of *Acacia nilotica* stand at 20 cm height above ground (left); Measuring the diameter of a stand of *Lannea microcarpa* at breast height (right).
Source: Bayen, 2016.

Figure 7. Removal of a stand of *Anogeissus leiocarpa* (left); Separation of *Acacia gourmaensis'* branches (right). Source: Bayen, 2016.

Figure 8. Measurement of the length of a stand of *Anogeissus leiocarpa* (left); Trunk samples of *Acacia tortilis* (right).
Source: Bayen, 2016.

**Figure 9. Sample weighing at field (left); Samples oven-drying (right).
Source: Bayen, 2016.**

Choice/development of allometric models

Statistical tests make it possible to better select a model from parameters such as p-value, regression coefficient (R^2), standard residual error (RSE), Akaike's information criterion (AIC) and the difference between observed and predicted values. While the higher values of R^2 show a better fit, the least squares approximation minimizes the RSE. Similarly, the model with the lowest AIC indicates the best model, that is, the model that offers the best fit while taking into account the number of parameters (Akaike, 1974).

Non-destructive methods: use of allometric models. They involve the use of biomass prediction equations from pre-established allometric equations. In this case the biomass is estimated from visual estimates and measurements of physical parameters without breaching the physical integrity of the plant. These methods of estimating biomass are cost effective but less precise. Data mining and analyses for establishing GHG inventory is as demonstrated in Fig 10 below.

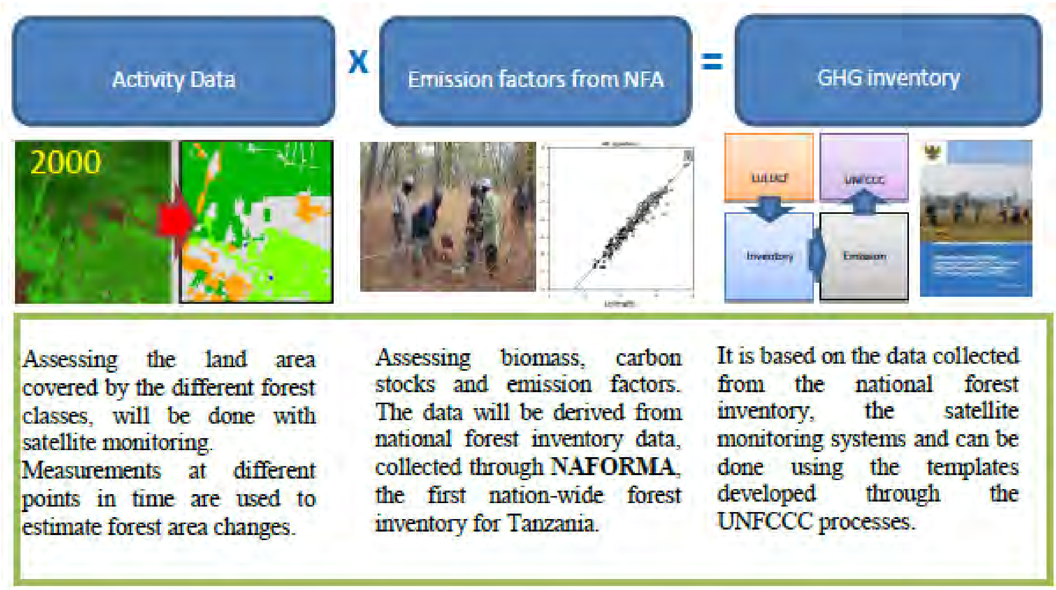

Figure 10. Data input for the estimation of emissions and removals of GHGs.

Emission factors are emissions/removals of GHGs per unit area, e.g. CO_2 emitted or sequestered per ha. The C changes are determined in the five IPCC pools namely (Figure 11):

- above ground biomass,
- below ground biomass,
- litter,
- dead wood; and
- soil organic carbon.

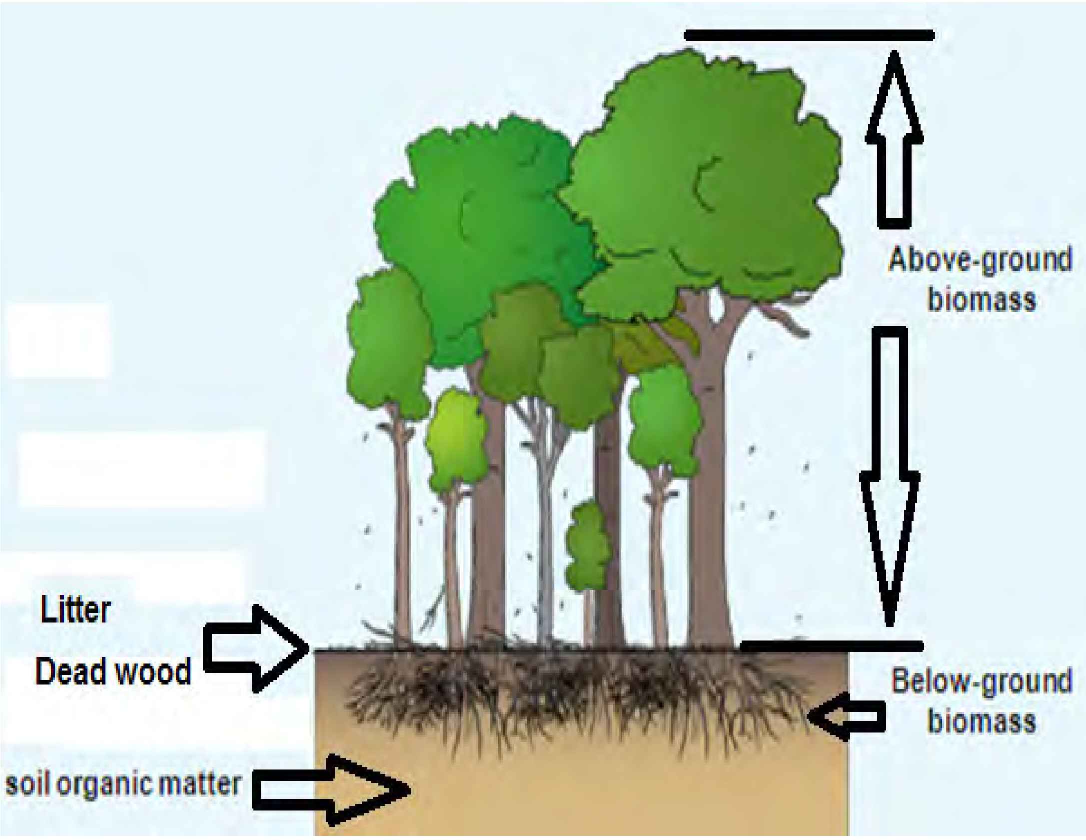

Figure 11. The five IPCC carbon pools.

There are three Tiers of data for emission factors in the IPCC GPG that are derived from ground measurements:

- **Tier 1**: the use of IPCC default values such as above ground biomass in six ecological zones in Africa, Asia and Latin America (IPCC Emission Factors Data Base – EFDB). This provides crude estimates of ±70% of the mean;
- **Tier 2**: this is the improvement of Tier 1 where country specific data collected within the national boundary are used. More detailed strata may also be delineated to improve the precision of estimations; and
- **Tier 3**: uses actual inventory with repeated measurements from permanent sample plots for the direct determination of forest biomass changes; this is the most rigorous approach associated with highest level of efforts.

Moving from Tier 1 to Tier 3 increases the accuracy and precision of the estimates, but also increases the complexity and the cost of monitoring. Before moving to Tier 3, Approach 2 for activity data and a combination of Tier 1 and 2 for emission factors could be used. This information can be provided though National Forest Inventories (NFI).

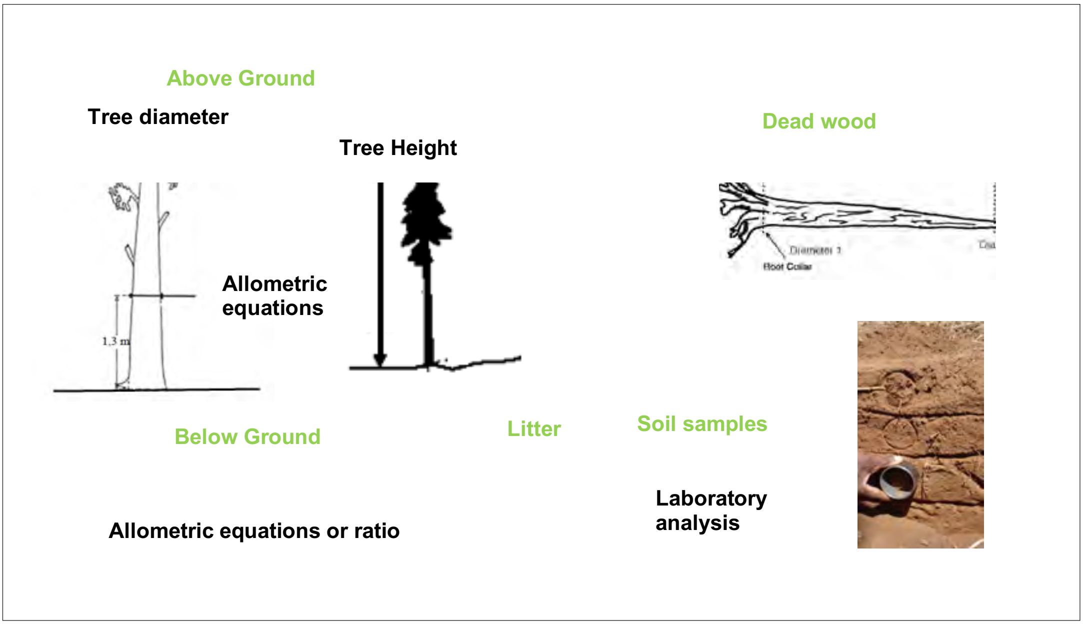

Figure 12. How to measure carbon in the five IPCC pools.

Figure 12 illustrates how to measure biomass in the five IPCC pools of above ground biomass, below ground biomass, litter, deadwood and soil organic carbon.

Measurement of above and below ground biomass

There are two main approaches in estimating tree biomass. The first approach is to obtain biomass as a product of tree volume and wood basic density. Since most of the volume equations consider only the above ground merchantable part of the tree, an expansion factor is usually incorporated in the equation to account for un-merchantable parts and below ground biomass of the tree. The second approach is the direct use of biomass models.

The development of both biomass- and volume models have been based on relating easily measurable tree variables, such as *diameter at breast height* (dbh) and *total tree height* (ht), to biomass or volume. These tree variables are considered to be the most efficient explanatory variables for tree level volume and biomass prediction (Brown, 1997; IPCC, 2003; Chave et al., 2014).

Global models have the advantage of being, in principle, applicable anywhere. However, due to great variation in climatic and edaphic factors, such models can yield large errors locally. Thus, a model developed on data from a smaller region will, within that region, give more accurate estimates. Similarly, a model developed generally for a large number of species is more versatile in the application phase, but will yield estimates with large errors for those species that are atypical relative to the mean relationship between the response and the explanatory variables. Species specific models have a more narrow range of application, but will give better estimates for the particular species. A recent review of bio-mass and volume models for sub-Saharan African forests (Henry et al., 2011) revealed that for tropical forests, a large number of species-specific and fewer general models existed.

In highly diverse ecosystems such as tropical forests, global models (Brown, 1997; Chave et al., 2005; Chave et al., 2014) have been applied in the absence of general- or species-specific local models. Species-specific models are generally more desirable. However, in a tropical forest with a large number of different species, developing species-specific models is almost impossible and, thus, general models for specific ecotypes are most appropriate.

The development of biomass and volume models requires that the biomass or volume of each sample tree be measured accurately. Destructive sampling, where sample trees are felled and separated into different components (stem, branches, twigs and leaves), and further into billets, have so far been the most common way of establishing the accurate biomass or volume. The obtained individual tree biomass or volume is then related to easily measurable tree variables, i.e dbh and ht, to constitute a model. This work is done by researchers. Users in a specific country or region should consult researchers, forest officials or the literature to get the models to use in their areas.

Dbh is defined as the stem diameter, at a point 1.3 m above ground, usually measured from the uphill side of the stem. Dbh is measured using calipers or tapes while height is measured using hypsometers or poles (Figure 13).

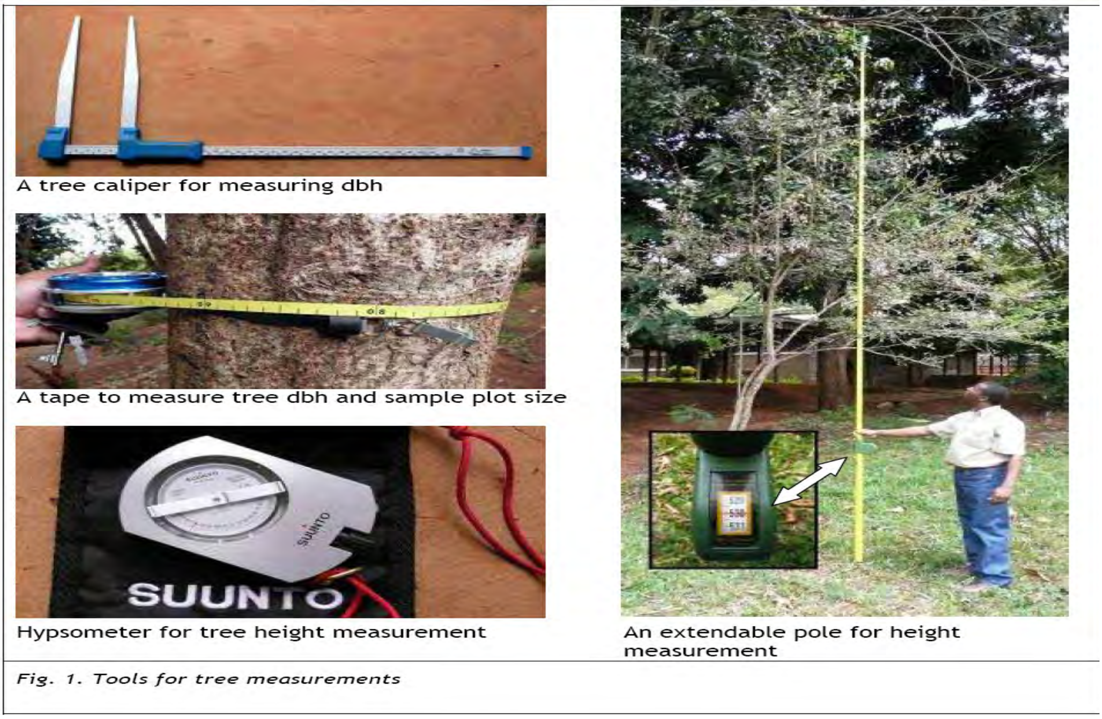

Figure 13. Tools for tree measurements.

Calipers are normally made of wood, steel or aluminium. Aluminium calipers are more convenient because they are light and durable. Often a single caliper measurement is adequate. However for an elliptical cross section of a stem, two caliper readings at right angles should be made and the average recorded. To obtain reliable measurements, operators must be trained to ensure that:

- the point of measurement is located correctly (it is recommended to use a stick of 1.3m consistently whenever dbh is measured);
- the place of the calipers is at right angles to the longitudinal axis of the tree;
- the correct pressure is applied at the moment of measurement; and,
- the bar of the caliper is pressed against the stem.

The diameter tape measures the circumference of the stem. However, for specially made diameter tape the diameter graduations are based on the relationship between diameter and circumference. Often diameter measurements with the tape are more consistent than using a caliper provided the tape is level and pulled tightly at the time of measurement.

Calipers are convenient for measuring trees up to 50 cm diameter. Diameter tapes are preferred for larger trees because large calipers are bulky and inconvenient to handle. Measuring elliptical stems with the tape however tends to overestimate diameter in which case a caliper is preferable.

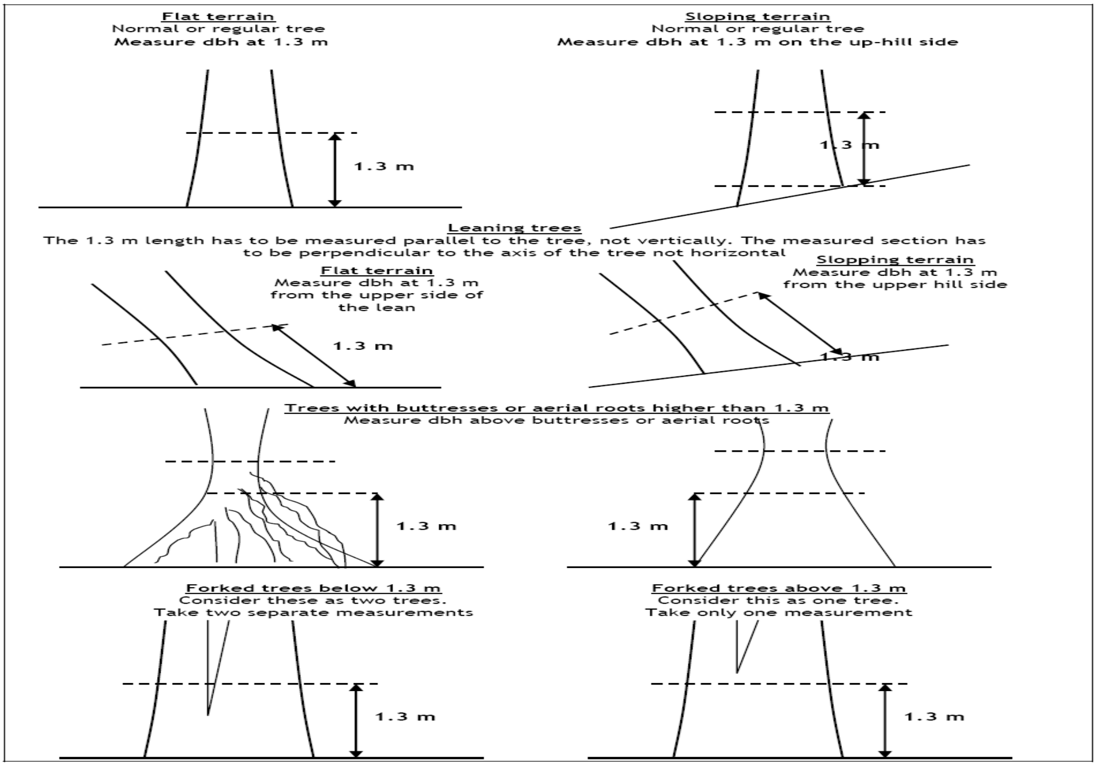

Figure 14. Standard dbh measurement techniques for normal and abnormal trees

Figure 14 provides standard techniques on what to do with trees of abnormal shapes. As far as possible these techniques should be followed in order to maintain consistency in consecutive measurements of dbh.

Instruments for measuring height are known as hypsometers. Common hypsometers include the trigonometric instruments based on angles such as Suunto hypsometer and Haga altimeter. Poles can also be used to measure tree heights (Figure 13).

Height is normally measured from ground level including the stump. Height is important since it is a variable in most biomass determination equations (allometry). For this purpose total height of the tree should be measured. If hypsometers are not available; tree height may also be measured using direct methods usually for relatively small trees by climbing with a tape or by using a graduated pole. A graduated pole, especially the extendable one, is very useful in measuring small trees in experimental plots and in dry woodlands where trees are relatively short.

Errors in height measurement are common and should be avoided as much as possible. Often the causes are:

(i). incorrect identification of top and bottom of the tree; erroneous top identification is particularly common due to wind sway or nature of the tree crown;

(ii). incorrect estimation of the horizontal distance or mismatch of hypsometer scale chosen and actual distance used - shorter distance than that of the scale will result in height overestimation and vice-versa; and,

(iii). a leaning tree towards the observer will cause an overestimate and vice versa.

Measurement of dead wood

Dead wood are tree parts that are lying on the ground. Usually the field crew determines dead wood parts which are inside the plot area. The *length* and *diameter of both ends* of all pieces of fallen wood are measured and their species identified (Figure 14). With these measurements it is possible to compute volume and thereafter biomass.

Measurement of litter

Fixed size quadrats or circles (metal, they usually fold up) are used. These are placed on the ground. They are usually one square meter whether round or square. Quadrats do not have to be randomly located within the main plot. However, certain amount of randomization is essential to avoid human bias. Four subplots are recommended to be sampled for each plot as shown in Figure 15.

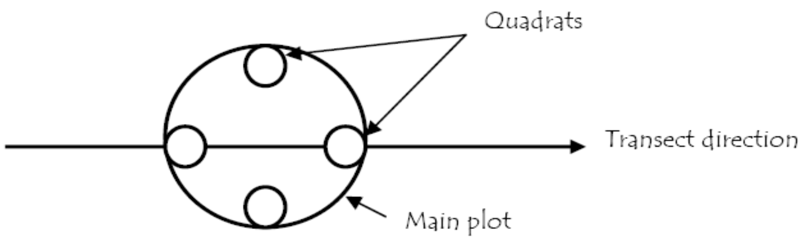

Figure 15. Fixed size quadrats or circles.

In practice:

- in the quadrats, sample first for herbs and grasses, then for standing litter and lastly for soil; include only vegetation that originates within the quadrat, but include branches that originate within the quadrat and hang over to the outside;

- clip all the vegetation down to ground level, place in a sample weighing bag, weigh, and record weight; take a small sub sample of this vegetation and put in a bag, label, weigh and take to laboratory for dry weight determination; and,
- collect all biomass litter on the ground, put in a large bag and weigh, record. Take a small sub sample in a small bag, label, weigh and take it to the laboratory for dry weight determination.

Measurement of soil organic carbon

Within the quadrat used for litter data collection, excavate a soil mini-pit to 30 cm depth with at least one vertical surface. On the vertical wall of the pit, mark the locations in the middle of each 10 cm depth of the mineral soil layers 0-10, 10-20 and 20-30 cm, where volumetric soil samples will be taken. For each sample plot place the soil samples taken from the same sampling depth into a clearly labelled plastic bag to form a composite soil sample. Therefore there will be 3 composite soil samples for 0-10, 10-20 and 20-30 cm layers. Place these samples into another similar plastic bag for laboratory analysis.

The laboratory analysis approaches to determine SOC are of two categories i.e. “intensive” and “non-intensive” (McCarty et al., 2002). The intensive approaches include dry combustion for total C, calcimeter method for inorganic C and wet oxidation for SOC (Walkley and Black, 1934). These methods are conventional and standard procedures but are time-consuming, laborious and expensive. In recent years, several radiation based methods are used as alternative because of their multiple advantages. These methods include diffuse reflectance infrared spectroscopy (IR) like mid-infrared (MIR) (Cecillon et al., 2009). These methods are rapid, simple, reproducible, and some times more accurate than conventional analytical methods. Therefore, the study needs to compare the amount of SOC analyzed by two methods of SOC analysis in miombo woodland ecosystems.

Literature shows that the Walkley-Black method estimates higher amount of SOC than the Mid Infrared method (Stevens et al. 2006; Bulenga, 2016). The Walkley-Black method was found to provide an accurate estimate of SOC with 100% recovery for most soil samples as the elemental analysis (Lettens et al., 2007; Wang et al., 2012). Owing to its low cost and minimal requirements in laboratory equipment, the Walkley-Black procedure is still used widely throughout the world to measure SOC content (Chatterjee et al., 2009). But if the sources of laboratory error can be identified, the infrared method may in fact be a better tool for interpretation than the chemical analysis (Janik et al., 1998).

In text question (10 minutes)
Explain the two basic sets of data needed for forest C determination and how to measure them.

Practical exercise
Get practice on the different tools used in measuring C.

3.2 Measurement, Reporting and Verification (MRV) for baseline determination

Activity 1 (Brainstorming) (10 minutes)
Views on what is tree carbon and how it can be measured.

Introduction

The most commonly debated subject under forest C monitoring is *Measurement, Reporting and Verification (MRV)* of C. That is, how the amount of forest C, including changes over time can be reliably accounted for. This is the core monitoring challenge in C projects. In any C project it is important to establish MRV system in order to generate data needed for Baseline or Reference level determination.

The **baseline/reference level** is a benchmark against which the achievements on imple-mentation of a C project will be credited. It entails historical trends and projected business as usual scenario against which additional C benefits as a result of a C project can be determined. In the construction of baseline/reference level the following terminologies are used: *Reference Emission Level (REL)* and *Reference Level (RL)*.

Forest Reference Emission Level (REL) is the amount of gross emissions from a geogra-phical area estimated within a reference time period. It covers only emissions from defore-station and forest degradation (Angelsen et al., 2011).

Forest Reference Level (RL) is the amount of emissions/removal from a geographical area estimated within a reference time period (Angelsen et al., 2011). In addition to emissions from deforestation and forest degradation, RL also cover removals through sustainable management of forests and enhancement of forest C stocks.

Data for setting up REL/RL usually come from Forest Inventories that utilise remote sensing technologies combined with ground measurements to provide activity data and emission factors. Remote sensing is used for the estimation of historical emissions while degradation is assessed using ground measurements.

3.2.1 Measurement: the "M" in Measurement, Reporting, Verification (MRV)

Measurement for REDD+ refers to collection of data and information for the estimation of emissions and removals of GHGs from deforestation and forest degradation. It involves determination of changes in C stocks and GHGs emissions from changes in forest cover, and the enhancement of forest C stocks.

In the IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry (GPG-LULUCF) (IPCC, 2003), forestry activities are grouped into three categories:

(i) "forest land converted to other land" - deforestation;

(ii) "forest remaining as forests" - degradation, forest conservation, SFM, and enhancement of C stocks; and,

(iii) "other land converted to forest" - afforestation/reforestation of non-forest land.

IPCC GPG-LULUCF is at present a widely accepted official document that provides metho-dologies for the estimation of emissions and removals of GHGs. It refers to two basic data inputs (Figure 10):

(i) Activity data i.e. extent of emission/removal category: in case of deforestation refers to area of deforestation presented in ha over known time period. This can be determined using the following approaches:

- ***approach 1*** identifies the total area for each land category and provides net area changes i.e. deforestation minus afforestation;
- ***approach 2*** involves tracking of land conversions between categories, resulting in a non-spatially explicit land-use conversion matrix; and,
- ***approach 3*** extends Approach 2 by using spatially explicit land conversion information derived from sampling or wall to wall mapping techniques.

3.2.2 Reporting and verification the "R" and "V" in Measurement, Reporting and Verification (MRV)

Activity 1 (Brainstorming) (10 minutes)
What are your views on how different reports are written and the process of financial audit is done.

Reporting

Reporting implies the compilation and availability of forest data and statistics for information in the format requirements for a particular standard. Reporting requirements to UNFCCC (National Communications), for example, may cover issues other than just those subject to measurement. The core elements of the national communications are information on emissions and removals of GHGs and details of the activities a country has undertaken to fulfil its commitments under UNFCCC.

Experience has shown that using appropriate plot sizes, the C stocks in natural forest can be estimated to precision levels within ±10% of the mean, with 90% probability level. The first of these means is that if you carry out measurement in the forest, your average estimate will be within plus or minus 10% of the real value of the C stock. The second means that such incidence is likely to happen 90 times out of 100 (i.e. one in ten times, you may be more than 10% above or below the real value).

Since C credits will be issued on the basis of statistical probability of your estimates being precise, it is important to report these statistics. You can calculate them as follows:

1) calculate the standard error of the mean from your C inventory; this is a standard operation that can be done on the computer from the data base;
2) Select the confidence level at which you wish to work (we recommend 90%)

   $CI = X \pm tsX$; where:

   X = mean value of estimate

   t = is the expression of confidence that the true average is within the estimated range

   sX = the standard error of the mean from the C inventory

It is also important to show the attained precision levels of estimates (percentage confidence).

It is not certain whether the payment of C will be based on average or minimum estimate. It is more likely that minimum estimate will be used which is why it is important to show the average values with their lower and upper limits. The proper inventory planning with stratification is highly important for the generation of high quality reports, i.e. C estimates with very high precision.

Table 3. An example for the carbon data reporting.

Forest Name	KSUATFR
Vegetation type	Miombo woodland
Year	2005
Stems ha^{-1}	694.9 ± 82 (12%)
Volume per ha (m^3 ha^{-1})	68.12 ± 16.92 (14%)
Biomass (t ha^{-3})	42.19 ± 8.65 (9%)
Carbon (t ha^{-3})	20.39 ± 4.24 (9%)
Mean CO_2 t/ha	74.83
Upper limit CO_2 t/ha	90.39
Lower limit CO_2 t/ha	59.27

The figures in brackets indicate precision levels of estimates i.e. percentage confidence intervals to average value of estimate.

Verification

Verification refers to the process of independently checking the accuracy and reliability of reported information or the procedures used to generate information. This verification is done by a totally independent and external reviewer. The UNFCCC Secretariat, through its experts, will verify the data reported. The verification of countries' actions depends on 3 factors: 1) the degree to which reported data is capable of being verified; 2) the actors conducting the verification; and, 3) the way in which verification is performed.

The data are stored and harmonized into a REDD+ database. The data on forest land area are used to develop matrices representing the changes between land uses and within the forest land area. The data on C stocks and C stock changes will be used to develop emission factors. The data on land use changes and changes in forest uses are integrated with their respective emission factors to establish the GHGs inventory. The data are used to report to UNFCCC.

The verification process concerns all the variables that are reported under a given standard. The verification can be done by several institutions, including civil society. All data, including the satellite and national forest inventory data will have to be made available in order to allow the verification of the GHGs inventory. The different means of verification are: through interviews with key government officials and national NGOs, reports, media reports, training materials, etc.

In text question (10 minutes)
Explain how the reporting and verification of forest C can be done.

Summary

There are two basic sets of data needed for forest C estimation: activity data and emission factors. Activity data provide the forest extent while the emission factors provide the stocking. Mapping techniques are used to generate activity data while emission factors are obtained from ground forest inventory. In this session basic techniques of how to measure C in the five IPCC pools are explained.

Reporting implies the compilation and availability of forest data and statistics for information in the format requirements for a particular standard. Verification refers to the process of independently checking the accuracy and reliability of reported information or the procedures used to generate information. This verification is done by a totally independent and external reviewer.

3.3 Approaches to rapid forest carbon stock estimation

3.3.1 Mapping and forest stratification

Activity 1 (Brainstorming) (10 minutes)
What are your views on how mapping of the piece of land can be done and the importance of stratification?

Divide the forest area into strata if necessary: strata being areas of forest which are distinctly different from each other in type and which, from simple observation, would appear to have different amounts of C stored, e.g.: heavily degraded forest area, normal forest, area of plantation within forest, age class within a plantation. In some cases this will relate to topography or soil or species types (Figure 16).

This exercise should ideally be done by either the technical staff or the forest owners themselves. Both boundary tracking and forest stratification is to be done by means of a GPS and the team should already have previously trained to become familiar with its use.

The nature of stratification should first be explained to the community team, who, though they may easily think of areas of forest that have very different species present, may not be so quick to see that a degraded patch of forest should be a separate stratum. Discussion on what constitutes 'different strata' (in terms of quantity of standing woody biomass or C) should be followed by walking first around the forest boundaries and then if necessary inside the forest (supporting organization together with the community team) to identify strata (typical tree species and typical condition of trees (stunted, harvested etc). These should then be mapped on the same basemap as was used for the boundary identification.

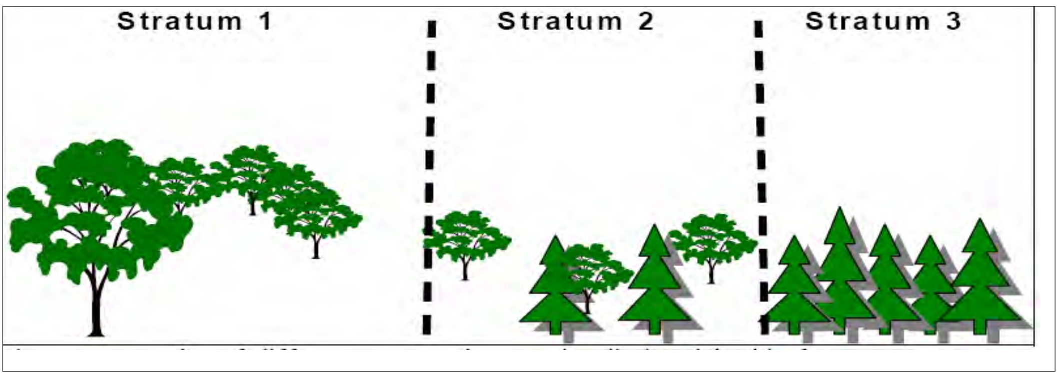

Figure 16. Examples of different Strata that can be distinguished in forests.

Typical problems that will be encountered include the fact that the GPS may not work well in dense forest due to difficulties in receiving the signals. With these circumstances, natural land marks such as hills or valleys that could be easily identified on a map can be used instead.

In text question (10 minutes)
Explain how you can quickly generate a map of a particular piece of land.

Practical exercise
Use of GPS

3.3.2 Pilot survey to calculate variance

Activity 1 (Brainstorming) (10 minutes)
What are your views on the possible procedures for the determination of a sample.

In each stratum, make a pilot survey to estimate the variance in tree stocking. For this purpose, tree data should be taken from at least 15 sample plots distributed all over each stratum to cover all possible variations. This will allow an estimation of the number of sample plots needed for each stratum based on the observed tree population variation.

The plots used for the initial training could be used also for the pilot, to save time and efforts. Steps to be followed:

Step 1. For estimation of variation of tree stocking at least 15 randomly laid out sample plots distributed to cover all possible variation should be established in each stratum; and

Step 2. Use nested sample plots (a larger circle containing smaller sub-units) and measure small trees in small sub-plots and large trees in the whole area (larger circle); this is a strategy to save time as it is expected that, a naturally grown forest has many small size trees and fewer large size trees.

The size of the large outer circle of the plot is decided based on the area per tree as described by MacDicken (1997) and presented in Table 4. From the table, depending on the density of the trees (column 3) or the nature of vegetation (column 4), you pick your plot size (columns 1 and 2). The rule of thumb is that the plot size should accommodate at least 7 large trees.

- All trees greater than 10 cm dbh will be measured all over the larger circle. Experience shows that most community managed forests in old degraded forests have many small size trees of < 10 cm dbh and few large trees of > 10 cm Dbh. Therefore, in general, sample plots of at least 15 m radius will be suitable. For very dense tropical rain forest such as those in Papua New Guinea and other rain forests, plots with the outer circle of 12.62 m, would be large enough to capture sufficient numbers of large trees.

Table 4. Plot radii for carbon inventory plots.

Plot size (m^2)	Plot radius (m)	Area per tree (m^2 $arbre^{-1}$)	Nature of vegetation
100	5.64	0 – 15	Very dense vegetation with large number of small diameter stems. uniform distribution of larger stems
250	8.92	15 – 40	Moderately dense woody vegetation
500	12.62	40 – 70	Moderately sparse woody vegetation
666.7	14.56	70 – 100	Sparse woody vegetation
1000	17.84	> 100	Very sparse woody vegetation

Source: MacDicken (1997)

- Saplings (i.e. all woody stems longer than 1.3 m high but with 1 ≥ dbh ≤ 5 cm) will be measured in a small circular plot (of 2 m to 5 m radius) at the centre of the large circle. A count of regenerating tree species (i.e. very small saplings less than 1cm diameter) will also be made in this subplot. Data on each tree will be recorded in pre-prepared field forms.
- The size of the sample (number of sample plots needed for any given forest) will depend on a number of factors, but particularly on the variability of the forest (the more variable, the more plots needed in order to get an accurate estimate of overall biomass level). A monoculture of even-aged trees for example will have little variability and require few plots. A mixed natural forest with many different species will have much greater variability. Use of strata (see above) is one of the ways of reducing the effects of variability. The pilot survey provides an initial picture of the variability (the co-efficient of variability or CV), which is then used to calculate how many plots are needed.
- The calculation of sample size required will be based on the variability of trees and saplings as measured in the pilot survey; so, in the pilot survey it is not necessary to sample the herb and grasses layers (although, if the pilot survey is being used as a training exercise, herbs, grasses and soil could also be sampled).

Step 3. While walking inside the forest and at a particular plot, try as far as possible to record tree/shrub names. These will be used to finalize a compilation of species checklist to be used for the main inventory.

Step 4. With data from the 15 plots, the number of sampling units (n) is calculated using the formula:

Where:

- CV is the coefficient of variation which is the measure of variability of tree cross-sectional areas at breast height;
- t is the expression of confidence that the true average is within the estimated range. For 15 plots this always has a value of 1.76;
- E is the error that you are willing to accept in the final estimation of the mean. We have decided on 10% error rather than 5% as this considerably reduces the number of plots required.

Given CV of basal area = 40%, t value for the 15 plots = 1.761 and E = 10%. Then the number of plots n= (0.4^2 x 1.761^2)/0.1^2 = 50 plots.

In text question (10 minutes)

In a pilot inventory a class established 12 sample plots. From the computations the CV of basal area was 20%. Determine the number of plots needed for a major forest inventory if the allowable error is 10%.

3.3.3 Locating permanent sample plots

Activity 1 (Brainstorming) (10 minutes)

Use the plan to execute forest inventory for the purpose of determining forest parameters such as volume, number of stems, biomass etc.

The required number of permanent plots then needs to be laid out in each stratum. Plots of the same size as for pilot surveys should be used. Systematic layout of plots with a random start should be used. First, the plots are systematically laid out on the map and, secondly, on the ground.

Locating permanent plots on the map

Use the map developed earlier in your stratification. Within each stratum, we need to establish transects at right angles to the longest side of the stratum (or from the side with maximum accessibility) - this results in transects that are short and easy to work with.

(i). Decide how many transects you need on the basis of a reasonable spread of the plots over the whole area. Hints:

If you have a forest/stratum of size a ha;

Each plot with represent an area a_1= *Area of the stratum/number of plots*

The square root of a1 represents the distance between plots.

Concentrate the plots in transects whereby the rule of thumb is that twice the distance in a square plot grid gives the interval between transects. Then get the total transects length.

(i). Randomly locate the starting points of the transects along the chosen boundary line. Hint:

In order to have a random start, the first transect should be established at a distance determined by a randomly drawn number between 0 and the total length of the side of the forest from which you have chosen to approach;

(ii). Draw the transects parallel to one another to the far side of the forest;

(iii). Carefully note the compass bearing on these transects;

(iv). Calculate the total length of the transects when these are all added together;

(v). The distance between plots = total transect length/number of plots;

(vi). Allocate the plots systematically along this total length, the first plot being placed at half the inter-plot distance from the start point on the forest boundary; and

(vii). Mark the locations on the map.

The result of this process is a combined random and systematic sampling frame, with the advantage that the plots can always be found again if the start points along the chosen boundary are known, as well as the bearings and distances along the transects to each plot.

(a) Sighting the direction of the transect using a compass,

(b) Measuring distance between plots using a tape measure,

(c) Demarcating a plot using a tape measure

(d) Recording details of the description of the plot to the handheld computer database,

Figure 17. a-d: Illustrations to show the sequence of activities while locating permanent sample plots on ground.

Locating the permanent plots on the ground

Actual forest C measurement begins when the group meets at the starting point of the first transect. Then a sequence of activities takes place. At first a description of the starting point of a transect and associated landmarks is made and recorded. A foreman in a group then sights the direction using the compass and walks forward along the transect. The other members of the group follow and measure the appropriate inter-plot distance using measuring tape or a stand alone GPS.

Upon arriving at the plot centre, mark the plot on the ground by using measuring tape and mark the center with a brightly painted pole. Measure out the circle of selected radius from this point using length of rope. Trees which are on the border are 'in' if more than 50% of the basal area falls within the circle and 'out' if less than 50%. Overhanging trees are not 'in' but trees with trunk in and branches out, are 'in'. If the slope in the plot is more than 10%, it is necessary to correct for this.

Measurements taken from permanent sample plots

We are including in the measurements the C pools for trees/shrubs (above ground biomass only; below ground biomass will be estimated mathematically as a proportion of above ground), litter, dead wood and soil organic C. However, not all projects will be looking at all the pools: particularly for the case of soil C, it is up to the project team whether they want to include this or not.

To determine above ground biomass, herbs, grass, litter and soil organic C, the following should be done:

- measure the dbh of all trees greater than the minimum dbh within the sample plot areas and record this information on pre-prepared field forms; larger trees will be measured over the whole plot and small trees only in the smaller central plot, as described above;
- set out the quadrats for the shrub and herb layer, cut all vegetation from each quadrat, weigh it, take a small sample of this in a small bag and label with plot and subplot identification code and record this in pre-prepared forms;
- collect all litter from the subplot: bag, label, weigh and record;
- take soil samples randomly within the plot; bag and label.

Trees

The simple way to do this is as we did in the pilot survey, that is to measure all trees over dbh of 1 cm within the small central plot (or 1m radius), and all trees over 5 cm dbh in the whole plot. For this calipers or a diameter tape can be used (Figure 18), start measuring trees clockwise from the direction of transect and from the plot centre, marking each tree as it is done to prevent accidental double counting and recording data on the pre-prepared field forms. A staff of 1.3 m should be used to ensure that readings are taken at exactly the correct height. Each tree is recorded individually with its local name and botanical name. A checklist of the area/forest should be used for consistency in tree naming.

Figure 18. Measuring of tree parameters.

It is very important that the same trees are measured every year in each plot (with some recruitment expected). For consistency of measurements in the successive years, the field forms in the database are set up so that measurements in successive years can be compared. One possibility is to unobtrusively mark all the trees in each plot so that they can easily be identified every year. Any markings on trees must however be very discrete, because there is a risk that community members deliberately avoid them, e.g. in their normal search for firewood or poles, but instead harvest trees which are not in the sample plot. This would of course bias the sample considerably.

From the point of view of C storage, it is the large trees, which contribute the most to C stock, that are of most interest, so special care should be taken to make accurate assessments of trees greater than 10 cm dbh. Trees which are already as tall as 1.3m but which are less than 1 cm dbh can hardly be measured, but they can be counted and recorded, and this count will be important especially if comparisons are made from year to year. It could act as an indicator of rate of forest growth (also of sustainability). For what to do with trees of 'unusual' shape, please refer to the subsequent section on measurements.

Most allometric equations and tables are based on dbh and height variables. Usually only a few trees are measured for height in the sample plots and the height of other trees obtained by comparison. In order to get good representative trees it is suggested to take height measure for largest, medium and smallest trees in each plot.

Record the time taken, and number of people involved to:

- find and reach the plot;
- record all information related to trees;
- do the herb and shrub sampling;
- do the litter sampling;
- do the soil sampling; and
- enter data into the computer

In text question (10 minutes)
Explain how you can lay out plots on a map and on the ground in the forest. Also explain the different measurements that are taken from the plot.

Practical exercise
Layout of plots and taking measurements from the forest.

Activity 1 (Brainstorming) (10 minutes)
Learners to explain how data analysis is carried out.

3.3.4 Estimation of carbon from biomass

From the collected data, forest stand biomass is computed using locally available allometric equations. The most reliable results will be associated with allometric equations which have been locally developed. So it is well worth contacting forest departments or forest colleges to enquire what equations are available and which ones are most used. In the absence of local allometric equations, a common procedure is to compute stand volume and convert it to biomass. The volume-biomass conversion factor ranges from 0.5 to 0.6. The biomass is then converted to C. The biomass-carbon ratio varies slightly by species and biomass components (trunk, branches etc), but 0.5 (MacDicken, 1997) is recommended if no local value is available. To get the equivalent atmospheric CO_2 multiply the C by 3.67 since a gram of C is about 3.67 grams of CO_2.

Example: Assuming tree volume/ha is 68 m^3 and the biomass is 42 t/ha, the carbon is 42 x 0.5 = 21 t/ha. The equivalent CO_2 is 21 x 3.67 = 77 tCO_2/ha.

Data analysis for the trees

As pointed out above stand biomass is computed from the collected data from plots using available local allometric equations as average sums of trees biomass in the plots. Ideally it is required to check the allometric equations by destructive sampling but if they are used locally, this is not necessary.

Also, an allometric equation may not include branches, twigs and foliage parts of the trees. As such, biomass expansion factors should be included to estimate the biomass constituted by these tree parts. Similarly, though below ground estimate of roots biomass represent about 10 to 40% of total tree biomass, it is expensive to determine. It is recommended to include instead an estimate based on the locally available above ground-roots ratio or equations. The best available literature values relating to a comparable area may be used.

Experience shows that tropical natural mixed forests are complex ecosystems characterised by a high number of different species of different ages and sizes. In order to determine forest stocking (volume, biomass and carbon), tree species composition and structures, and even diversity of these complex forest ecosystems, it is logical to express their stand parameters by sizes for each species. Normally this data analysis is done by the use of computer spreadsheets, but this is very cumbersome and liable to errors. For consistency, accuracy and ease of computations, a Tropical Forest Inventory Data Analysis (TROFIDA) package was developed for this purpose (Box 3).

Box 3. Tropical Forest Inventory Data Analysis (TROFIDA) package

TROFIDA consists of computation procedures fitted on Microsoft Access database file to enable computations as fast as data are placed in the database. This database can be used for the computation of important forest stand parameters such as stem, basal area, volume, biomass and C cycle by species and size class. The data inputs required are:

Tree species checklist is prepared for each forest by compiling a list of all local names of all different tree species encountered in all the measured plots. This is then followed by matching the local name to their botanical names using locally available tree species checklists. The two columns of names are then sorted alphabetically by either local names or botanical names, and assigned species identification codes.

Tree species data from plot. The species identification code for each tree in the sample plot is entered in the data base together with data for dbh and height etc. The data are saved to the computer ready for analysis.

Development of height/diameter equation. If allometric functions for estimation of trees biomass, volume or C require height variable, few trees (sample trees) in each plot are measured for height. Using the sampled trees whose heights were measured, a height = f(diameter) equation is developed for each forest (vegetation type). Such an equation is used to estimate the height of trees that were measured for dbh only.

The Pre-designed Access Database. For simplicity of use, the database is designed in such a way that the user need to replace default tree species checklist and tree data tables only. All other computation procedures are already included. The moment when the data for a particular forest are loaded to the database, the forest stand parameters are outright obtained. The stand parameters are separated for each species into diameter classes for convenience. The default diameter classes used in this case are:

Dbh classes	Dbh range(cm)
1	<10
2	11-20
3	21-30
4	31-40
5	41-50
6	51-60
7	61-70
8	>70

This database was designed to be used for data analysis by staff from local supporting organiza-tions, and immediate sharing of the results with the communities. Its applicability that requires the replacement of appropriate allometric equations for the area was tested widely and recommended to be used elsewhere. The database is provided on a separate CD.

Data analysis for non-tree vegetation, litter and soils

Herbaceous vegetation, grasses and shrubs can be measured by simple destructive sampling techniques in up to four small subplots per plot as explained above. The samples from each plot are then oven dried to determine dry-to-wet matter ratios. The results are averaged for all the samples taken, giving a per m^2 estimate of non-woody biomass.

For soil and litter samples required for laboratory analysis, it is recommended to discuss sample needs thoroughly with laboratory technicians beforehand, to ensure that samples are properly prepared.

In text question (10 minutes)

Explain the analysis procedure for forest carbon data generated from forest inventory.

Practical exercise

Demonstration on how forest carbon data is generated

3.4 Carbon stock modeling

3.4.1 CO_2 Fix Model

As part of the development of forest strategies to manage and accurately assess C stocks and fluxes, many simulation tools have been developed. It seemed to us that the CO_2Fix, in particular due to its flexibility during parameterization and its relative ease of use, was the best adapted to our simulation needs. The presentation of the software and its general operating principle are covered in the two points of this paragraph.

CO_2Fix was developed under the "Carbon Sequestration in Afforestation and Sustainable Forest Management" program (CASFOR), funded by the INCO-DC program of EU. The teams involved in the development of the software are made up of members of ALTERRA (Netherlands), the "Instituo de Ecologia" of the National University of Mexico, the "Centro Agronomico Tropical de Investigacion y Ensenanza" (CATIE) in Costa Rica, and the European Forest Institute based in Finland (Masera et al., 2003). The first developments of CO_2Fix date back to 1999. The first version allowed monitoring the C stock dynamics of mono-specific stands from plantations. Version 2 has been improved allowing for the analysis of more complex forests. For example, it can be used to assess the impact of selective harvesting in tropical or natural forests, in agroforestry systems, or in mixed stands. In both versions, it is also possible to measure C stocks in wood products and their changes. The major contributions of the third version are the creation of a financial module enabling the evaluation of the economic profitability of management options, and a module "carbon credits" allowing the evaluation of the number of C credits generated by a project.

CO_2FIX therefore makes it possible to calculate the C fluxes and stocks generated by forestry activities and to simulate their long-term evolution according to different manage-ment scenarios for several cohorts of population. Six modules formed the backbone of CO_2Fix. The first describes the evolution of biomass (for different types of forest plots) and converts wood volumes into C stocks and annual increases in C fluxes. Rotation para-meters and thinning and cutting hypotheses transfer C stocks from biomass to soil C stocks and products C stocks. The second module concerns the soil. Soil C emissions are a function of climate data and the nature of the grass cover. The C emitted is also determined by the wood-based module using parameters that describe the efficiency of the manufacturing process, product lifetime and recycling. With regard to the bioenergy module, waste from the wood products module as well as usual products can be used to produce energy using different technologies. A financial module that takes into account the costs of forest management activities, and analyzes the economic profitability of the various scenarios. CO_2Fix also allows the accounting of C credits generated in forest management scenarios depending on whether Article 3-3 of the KP (planting of new forests) or Article 3-4 (forest management activities) are considered, or whether we simply assess the quantities of C sequestered in the project. The application of CO_2Fix is reported in a number of studies (Masera et al., 2003; Oeba et al., 2016, 2017 & 2018) that are very useful in demonstrating the use of the modelling framework for C estimation at different landscapes.

C stocks increase scenario, through modification of stand management and simultaneously taking into account of wood products, will be based on the assessment of stocks of standing C and products resulting from the exploitation of the Massif Landais (Malfait et al., 2003). CO_2Fix uses negative exponential degradation functions. If the lifespan of a product is N, then 1/N% of the initial stock degrades each year.

3.4.2 CASS (Model Roxburgh, 2004)

The ability to model C fluxes in ecosystems is central to the study of climate change. The CASS model makes it possible to simulate C fluxes in major terrestrial ecosystems. Savannas present a good opportunity to define the characteristics of particular ecosystems and subtle variations that result in a change in the C balance. The model takes into account the litter, the C dynamics in the soil, and the remaining C from harvested wood products (paper, firewood, construction, etc.). In this model, atmospheric C is fixed through photo-synthesis and redistributed to leaves, twigs and roots, a part of which is restored as autotrophic respiration. The different portions of the absorbed C are gradually transferred to the ground from where they can reach the atmosphere through heterotrophic respiration. Plant growth depends on how much C they can absorb from the atmosphere to photo-synthesize. This rate of CO_2 absorption varies depending on the amount of available CO_2, nutrients, temperature, water, atmospheric nitrogen, types of formation, etc. Decomposition follows a simple exponential function in relation to temperature and the availability of water resources. The effect of disruptions caused by bushfire and timber harvesting can be factored into the model in the same way as land use change.

It is also very important that models for establishing C balances be based on physiological processes, rather than on a presumption of homogeneity of plant formations. Indeed, in the coming decades, trees will be exposed to changes not only in the atmospheric concen-tration of CO_2 but also perhaps to extreme changes in temperature or rainfall. Although short-term studies have examined the effects of increasing CO_2 on the growth of forest formations, the response of trees and forests to high CO_2 concentrations and potentially associated climate change remains to be defined.

The principle of the CASS model is that terrestrial ecosystems can be distributed roughly in three separate reservoirs: 1) the C pool of living vegetation, 2) the C pool of dead vegeta-tion (litter), and, 3) the reservoir of C in the soil. The model also takes into account a reservoir 4, made up of C in the atmosphere, but just to see its fertilizing effect in the process of photosynthesis. Sub-reservoirs can be associated with each of these major groups.

The main input of the model is the atmospheric C fixed by plants (PPN, $gC/m^2/year$) and the main outputs are the C stock of the different blocks and sub-blocks and the CO_2 released into the atmosphere. The parameters (af, ab, ar) are the portions of C distributed among leaves, branches and roots: af + ab + ar = 1. The rate through which the C of living vegeta-tion is transferred to the litter is defined by the average duration of C at the leaves, branches and roots (Lf, Lb, lr). For example, if Lf is 5 years old, then 1/5th of the total leaf C is lost to the leaf litter for the same time period.

3.4.3 Graphical data mining

Graphical data mining is the first step in data analysis. It consists of visually studying the relations between variables in order to get an idea of the type of model to be adjusted. Concretely, we generate scatterplots whose coordinates correspond to two variables: explanatory variable on the x-axis and variables to be explained on the y-axis. We now suppose that we have a variable to be explained, noted Y (volume, biomass ...) and p explanatory variables denoted X_1, X_2,..., X_p (the diameter, the height, etc.).

The aim of the graphical mining is not to select from the p explanatory variables those which will be effectively retained for the model: the selection of variables assumes that one knows how to test the significance character of a variable, which refers to the next phase of fitting the model. The p explanatory variables are therefore considered as fixed, and we seek the shape of the model which best links the variable Y to the variables X_p (Picard et al., 2012).

3.4.4 Choice of variables

In order to choose the variables that will be used to develop the model, the correlation between each explanatory variable and biomass is studied using either the Pearson correlation coefficient or the variance inflation factor (VIF). Only the variables with an inflation factor of the variance less than 5 and those most correlated to the biomass will be retained in the development of the model. Once the variables are determined, the model is generated.

3.4.5 Model adjustment

The adjustment of a model consists of estimating the parameters of this model based on data. This assumes on the one hand that the data are already available and formatted, and on the other hand that the mathematical expression of the model to be adjusted is known (Picard et al., 2012). Adjusting a model consists of finding coefficients such that the sum of the squared deviations between the measured values and the predicted values is the smallest possible. In other words, it is a question of finding the value of the coefficients of the model such that these values are as close as possible to the regression line. A key concept of fitting models is the residue. The residue, or residual error, is the difference between the observed value of the response variable and its prediction. The lower the residue, the better the model adjustment.

3.4.6 The model selection

Several criteria can be used to select the best predictive model: the Residual Standard Error (CSR), the Akaike Information Criterion (AIC), and the Variance Influence Factor (VIF). These indices are criteria for judging the good quality of the model fit. The lower the residual standard error and the information criterion, the better the model (Chave et al., 2005).

$AIC = -2 \ln(L) + 2p$ with p the parameter number of the model and L the maximized likelihood

3.4.7 The model validation

The validation of a model consists of comparing its predictions with observations that are independent of those used for fitting the model (Rykiel, 1996). For being validated, multiple linear models must satisfy the following conditions: residual normality, homogeneity of variance, non-linearity and finally the independence of observations (Eisenlohr, 2014). The Shapiro-Wilk normality tests, the Breusch Pagan heteroscedasticity test, the Durbin and Watson residual autocorrelation test and the non-linearity RESET test were applied to the residues for this purpose. The intercept and the overall significance of the model were also tested at the 5% probability threshold.

Several criteria, which are the criteria used to evaluate the fitting quality of a model can be used to compare predictions to observations (Parresol, 1999; Tedeschi, 2006) including: residual variance, adjusted residual error, the adjusted R^2, the Akaike information criterion (AIC), the sum of the squares of the residual deviations, etc.

3.5 Dynamics of carbon stocks

Plant biomass is an important C stock in many ecosystems. Biomass is found in the above and the belowground parts of annual and perennial plants. The biomass associated with annual herbaceous (v.i.z non-woody) plants is relatively ephemeral: it decomposes and regenerates annually or over a few years. As a result, emissions from decomposition are offset by removals due to regrowth. Thus, the global net C stocks of biomass remain rather stable over time. As a result, the methods are based on changes in biomass stocks associated with woody plants and trees that can accumulate large amounts of C (up to hundreds of tons/ha) throughout their life span (Aalde et al., 2006). C stock changes can be estimated using direct inventory methods or process models. All C stocks or pools may exist in all land use categories. Two methods are provided to estimate changes in C stocks in biomass.

3.5.1 Gain-loss methods

Gains include the growth of biomass in its above and below ground components. Losses are classified as logging or harvesting of timber, collection of firewood and losses due to natural disturbances on managed lands, such as fire, insect infestations and extreme weather events (e.g .hurricanes or flooding) (IPCC, 2006).

This method requires subtraction of the biomass C losses from the biomass C gains. Annual changes in C stocks of remaining land biomass in the same land-use category (gain-loss method) are given by the following equation proposed by IPCC (2006):

$\Delta C_B = \Delta C_G - \Delta C_L$ where:

ΔC_B = Annual change in biomass C stocks (sum of terms representing above and below ground biomass) for each land subcategory, taking into account total area, tonnes C yr^{-1}.

ΔC_G = Annual increase in C stocks due to biomass gains for each land subcategory, taking into account the total area, C yr^{-1}.

ΔC_L = Annual decrease in C stocks due to biomass losses for each sub-category of land, taking into account the total area, C yr^{-1}.

Changes in C stocks in biomass for land remaining in the same land use category (e.g., forest land remaining forest land) are based on estimates of annual gains and losses in biomass stocks. This method is valid for all countries regardless of the level chosen. It can be used by countries that do not have a national inventory system for woody biomass stocks.

3.5.2 Stock difference methods

This method requires inventories of biomass C stocks for a particular area at two different time points. Annual changes in biomass are represented by the difference recorded in the biomass stock between time t_2 and time t_1, divided by the number of years between inventories. Annual changes in C stocks of the remaining land biomass in the same land-use category (stock difference method) are given by the following equation proposed by IPCC (2006):

where:

ΔCB = Annual change in biomass C stocks (sum of terms representing above and below ground biomass) for land remaining in the same category (e.g. forest land remaining forest land), tons C yr^{-1}.

C_{t2} = Total biomass C for each sub-category of land at time point t_2, tons C.

C_{t1} = Total biomass C for each land sub-category at time point t_1, tons C.

The method of stock difference will apply in countries with national inventory systems for forests and other land-use categories, and where stocks of different biomass pools are measured at periodic intervals (IPCC, 2006). The method of stock difference requires greater resources and many countries do not have inventory systems for forests and other land use categories.

Additionality

It is a principle according to which the reduction of emissions or sequestration of C must be complementary to the reduction or sequestration obtained in the absence of the project. GHG emissions after project implementation must be less than the status quo scenarios.

To be additional, an activity carried out within the framework of a project must provide emission reductions higher than those that would have occurred in the absence of the project (Article 12 of the KP). Demonstrating additionality involves defining a “no project scenario”, comparing it to a “scenario with project” and deducing the “net effect” of the project, which is the additional component.

Box 4. Models of forest carbon dynamics

Such models are grouped into two families: **functional (or mechanistic)** and **empirical**

Functional models, EFISCEN (Nabuurs et al., 2002), CO_2FIX (Masera et al., 2003), and TRIPLEX (Peng et al., 2002) require data input such as the leaf area index (LAI) as well as certain climate and soil variables at very short time intervals. These models are well suited to assess the impact of climate change on forest C stocks in the same way that they are useful when there are no empirical data on the growth of forest species.

Models constructed from empirical growth data such as CBM-FS3 (Kurz et al., 2009), CENTURY 4.0 (Price et al., 1999), FORCARB (Heath et al., 1999) and TEM (Titan et al., 1999) are built with the same type of data used by forest managers in their analysis of forests possibility: the marketable standing volume according to age and forest type and the distribution of forest classes for each of the forest types. These models are therefore particularly well adapted to simulate the effect of human activities and natural disturbances on the C dynamics of a given area at the operational level (Kurz et al., 2009). It is for these reasons that we have chosen to use an empirical model for this project, more specifically the CBM-CFS3 model developed by the Canadian Forest Service.

Leakage

Leakages are defined as GHG emissions that occur outside the project boundary, which are measurable and directly attributable to the CDM project activity. It is a principle that refers to unplanned and indirect GHG emissions from project activities. For example, when affore-station of an agricultural land causes the migration of the people who cultivated this land, and who will therefore deforest elsewhere. Leakage refers to a geographic shift in emissions resulting from emission reductions at a specific location. In the case of deforestation, a project to conserve an endangered forest may have the effect of increasing deforestation pressures in another forest. Leakage also has an economic dimension: forest conservation can reduce the availability of timber and agricultural land on the market, which increases their price and makes profitable the deforestation of landlocked areas previously protected by the high cost of their conversion to other uses.

Summary

This session has covered how to rapidly use a GPS to generate maps. The importance of forest stratification has also been explained. Pilot survey is required in order to determine the variation of forest stock for the determina-tion of adequate number of samples. Usually, tree basal area in 15 plots is taken to cover as much as possible the existing variation in a forest. From the 15 values of basal area, coefficient of variation (CV) is computed and then the number of plots determined.

This session also outlined the procedure for the laying out plots on the map and on the ground. It has also explained how different measurements are taken from the forest for the different pools.

The session has provided key highlights on how to estimate C, undertake C modelling and the various dynamics on C stock that are essential in overall C assessment at different forest types and tree level C assessment.

Finally, the session outlined the procedure for the analysis of C data from a forest inventory. This is given for trees and non-tree vegetation, litter and soil.

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