Food and Agriculture Organization of the United Nations

EX-ACT Training - Exercises

Training Booklet for the EX-Ante Carbon-balance Tool

EX-ACT Exercises booklet

Targeting climate change mitigation in agriculture, forestry and other land uses with EX-ACT

The **Ex-Ante Carbon-balance Tool** (EX-ACT) is an appraisal system developed by FAO providing estimates of the impact of agriculture and forestry development projects, programmes and policies on the carbon balance. The carbon balance is defined as the net balance from all GHGs expressed in CO_2 equivalents that were emitted or sequestered due to project implementation as compared to a business-as-usual scenario. EX-ACT is a land-based accounting system, estimating carbon stock changes (i.e. emissions or sinks of CO_2) as well as GHG emissions per unit of land, expressed in equivalent tonnes of CO_2 per hectare and year. The tool can be used by project and policy designers to estimate and prioritize project activities with high benefits in economic and climate change mitigation terms. This way, GHG mitigation benefits can be quantified. The amount of GHG mitigation might also be used as part of economic analyses as well as for requesting additional project funds.

KEY MESSAGES

- The EX-ACT tool directly contributes to the following FAO Strategic Programmes: make agriculture, forestry and fisheries more productive and sustainable (SP2); reduce rural poverty (SP3) and enable inclusive and efficient agricultural and food systems (SP4).
- It focuses on enabling frameworks for economically, socially and environmentally sound food production systems that embody resource use efficiency, diversification, climate change adaptation and mitigation, ecosystem services and accessibility.
- In addition to the main EX-ACT Tool, two new tools have been developed: EX-ACT Value Chain and EX-ACT Monitoring, Reporting and Verifying.

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EX-ACT Exercises

Abstract

The *EX-ACT Training Exercises* provides users with a comprehensive set of exemplary project situations in order to develop their capacity to independently use the Ex-Ante Carbon-balance Tool (EX-ACT).

New tool users are provided with strictly simplified problem sets of management situations at the farm and at the landscape levels. The problem sets become progressively more complex and comprehensively cover different aspects, ranging from Land Use Changes (AFOLU), Crop Production (Annual & Perennial Crops), Grasslands and Livestock to Land Degradation and Inputs and Investments (Agrochemicals, Energy, Infrastructure).

At the end, one exercise is proposed that allow to get an understanding of EX-ACT VC, i.e. the new tool elaborated by FAO that allows to perform an environmental and socio-economic analysis of the value chain, in terms of climate mitigation, resilience, income and employment generation.

The *Training Exercises* complement the EX-ACT *User Manual* that provides all the key information on the methodology, the application and the utilisation of EX-ACT.

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Resources

- EX-ACT Website
  www.fao.org/tc/exact
- Free Tool Access
  www.fao.org/tc/exact/carbon-balance-tool-ex-act
- EX-ACT User Manual & EX-ACT Quick Guidance
  www.fao.org/tc/exact/user-guidelines

Exercise 1 Forestry Reserve in Brazil

Objectives:
This simulated situation aims at providing a good understanding of how to use EX-ACT for deforestation and afforestation activities as part of the "*Land Use Change*" module.


@FAO/Alberto Conti/FAO


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Indicative time to carry out the exercise: 30 minutes
Description of the Brazilian context:
Simulations of deforestation suggest that, over the coming decades, the Amazon rainforests will suffer from a rapid increase in forest loss due to the pressure by farmers, loggers as well as due to other externalities from economic development. In 2006 the Government of the State of Amazonas decided therefore to create the JUMA reserve. The reserve aims at reducing deforestation, protecting forests with a high biodiversity value as well as enhancing the livelihoods of the 322 families living within the boundaries of the reserve. The reserve lies along one main highway and is crossed by another, which attracts illegal logging. The main dominant soils are LAC soils.

Proposed activities:

- *Reducing the expected deforestation*

If no preventing measures are taken 350 000 ha of tropical rainforest will be deforested using fire and converted to set aside land between 2008 and 2050. With the implementation of the reserve, we assume that 80 percent of this area will remain primary forest.

- *Reforestation*

The reserve will moreover lead to the reforestation of 100 ha of tropical rainforest each year (from 2008 to 2050) on land that is currently set aside land. Without the implementation of the reserve, no area will be reforested.

Additional help:
You can use the table below to identify the surface areas concerned by the project. Insert the amount of hectares for each situation.

	Initial Situation	Without Project	With Project
Existing Forested Area			
Afforestation/Reforestation			

Main outputs:
This simulation focuses on project components aiming at conserving natural resources and encouraging sustainable forest management by controlling and monitoring reduced deforestation. Though not accounted for in EX-ACT, the simulation should also guarantee an improvement in the region's living standards, in order to develop sustainable economic activities as well as to fund research and conservation projects within and outside the JUMA reserve.

Reference:
http://www.climate-standards.org/projects/files/pdd_juma_project_v_3_0.pdf

Exercise 2 Palm Trees in Indonesia

Objectives:

This simulated situation guides EX-ACT users to analyse deforestation and perennial crop systems as part of the *"Land Use Change"* and *"Crop Production"* modules.

Indicative time to carry out the exercise: 45 minutes


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Description of the Indonesian context:

Palm oil comes from the fruit of the palm tree, a tropical species native to West Africa, which is presently produced as a hybrid in many parts of the world. The world demand for palm oil has soared in the last two decades, primary for food and consumer products, and more recently as raw material for the use of biofuel. Indonesia and Malaysia are the two main producers of palm oil, accounting in 2007 for 87 percent of the world production.

Palm plantations are seen in both countries as causing a high rate of deforestation. The comparably high oil yields per hectare and the favourable price development attracts many smallholders to adopt the crop. High deforestation rates are thereby associated to a wide range of negative impacts including biodiversity loss, reduced pest and disaster resilience and negative socio-economic impacts on forest resource users without property rights.

Description of the Indonesian context:

The following activities will be proposed in Indonesia (Asia insular, tropical wet) during an implementation phase of 3 years, with an assumed capitalization phase of 17 years.

- *Deforesting natural forests*

Initially, there are 10 000 ha of natural forest on LAC soils that would be preserved in the absence of the establishment of the palm tree plantation. With the palm plantation, the totality of the forest will be deforested, using fire.

- *Developing perennial crops*

10 000 ha of palm trees will be planted in the future to meet the demand for biofuels and vegetable oils. Without the project intervention, no perennials will be planted.

Additional help:

You can use the table below to identify the surface areas concerned by the project. Insert the amount of hectares for each situation. The total surface area must be the same in the 3 situations (initial, without and with).

EX-ACT Module	Type of Land Use	Initial Situation	Without Project	With Project
Land Use Change (LUC)	Forest			
LUC/Crop Production	Palm Tree (Perennial)			

Rethinking the project formulation:

You are a project manager and your technical team has recently presented the total carbon results. What is your conclusion? How would you improve the project? What is the potential gain?

Main outputs:

In terms of climate change mitigation, the plantation of palm trees is not a suitable action in this context. The induced deforestation severely worsens the final carbon balance, which is not compensated by the positive aspects of planting (palm) trees. The results will be even worse once accounting for the emission impacts of inputs, such as fertilizers.

References:

http://www.rfi.fr/contenu/20100223-conference-le-palmier-huile-bali
http://www.pecad.fas.usda.gov/highlights/2007/12/Indonesia_palmoil/

Exercise 3 Agricultural Project in Benin

Objectives:

This simulated situation aims at providing a good understanding of the "*Land Use Change*", "*Crop Production*" and "*Inputs and Investment*" modules. It focuses on the aspects of annual and perennial crop cultivation as well as on the utilisation of fertilizers.

Indicative time to carry out the exercise: 1h15

Description of the Benin context:

Food security is a priority issue for the Government of Benin. 87 percent of the population lives in rural areas and depends essentially on agriculture as an income source. Cotton is the main cash crop, but due to low prices and unbalanced markets, the smallholders' income has decreased, thus greatly increasing the vulnerability of millions of people, especially in the north of the country. Thereby, water management and infrastructure, food crops intensification, diversification of production systems towards small livestock or aquaculture are the main activities considered in order to sustainably guarantee food security.

Proposed activities:

The following activities are proposed that affect 10 000 households. They concern about 7 500 ha of lands. The project will implement activities over a period of five years, while further benefits will manifest during a consecutive period of 15 additional years.

- *Developing perennial crops*

With the proposed project, 1 000 ha of set aside land are expected to be planted with perennial crops (cashew), whose biomass will not be burnt during the cultivation period. However, fire will be used during the conversion.

- *Decreasing the cotton area*

The project seeks to improve the cultivation of cotton. 3000 ha of the initial 5000 ha of cotton will be managed using improved varieties, increasing the duration of crop rotation, applying manure and stopping the residue burning (for the sake of simplicity, livestock is not accounted for in the simulation). 1 000 ha will be converted into rainfed rice (use of improved varieties), while the remaining 1 000 ha will still be cultivated with non-improved conventional practices. Without the project, no improvements will occur.

- *Improving the cassava crops*

1 500 ha of cassava will be improved by adopting no tillage practices and other improved agronomic practices. Residues are retained in the current situation.

- *Changes in inputs use*

Currently, farmers use an average of 15 kg of urea per hectare per year on cotton crops. The simulation aims to help farmers to buy 50 kg per hectare per year on the whole area planted with cotton. Although a reduction in the consumption of pesticides is recommended, it is expected that farmers will still apply 6 L of pesticides (half herbicides and half insecticides) per hectare per year on the cotton crops.

Additional help:

You can use the table below to identify the surface areas concerned by the project. Insert the amount of hectares for each situation. The total surface area must be the same in the 3 situations (initial, without and with).

EX-ACT Module	Type of Land Use	Initial Situation	Without Project	With Project
Other LUC	Set Aside			
Other LUC/Perennial	Cashew (Perennial)			
Annual	Conventional Cotton			
	Improved Cotton			
	Conventional Cassava			
	Improved Cassava			
	Upland Rainfed Rice			
Total				

Main outputs:
Climate change mitigation can be carried out in synergy with food security and poverty reduction. The sole reliance on cotton cultivation will be replaced by a diversification into rice production, which should contribute to household food security and risk management. Further, perennial crops are established on a selected area that will store carbon and serve as a further income source to smallholders.

Carbon footprint:
The cotton lint is used by a textile manufacturer to produce shirts. The company would like to put a carbon label on its product. The label will inform consumers of the environmental impact of the shirt that they are purchasing.

The two chosen indicators are:

1. The GHG emissions of one shirt in tCO_2-eq/shirt
2. The emissions' reduction due to the project's improvements

The yield of the conventional cotton was 800 kg/ha, while the improved cotton reaches a yield of 1200 kg/ha. To produce one shirt, 270 g of cotton are needed. The industrial process of transforming cotton into shirts emits 3375 gCO_2-eq/shirt.

You can use the table below to do the calculations. Do not forget that even with the project, the firm is still using a small percentage of conventional cotton. Emissions from fertilizers have to be included as well. You also need to divide the EX-ACT results by the total duration of the project, to obtain an annual average of emissions. Please fill in the logos (from a Korean Carbon Label) with the right numbers!

Carbon Footprint Label

Carbon Reduction Label

	Without Project	With Project	
	Conventional Cotton	Improved Cotton	Conventional Cotton
Yield in kg/ha/year			
Ha			
Total production in t/year			
GHG emissions in t CO_2-eq/year from cotton production (see in the annual module)			
GHG emissions in t CO_2-eq/year from inputs use (see in the inputs module)			
Total GHG emissions in t $C0_2$-eq/year			
Carbon footprint (CFP) in t $C0_2$-eq/t cotton/year			
Amount of cotton to produce one shirt in g			
GHG emissions from cotton production for 1 shirt in g CO_2-eq/shirt/year			
GHG from industrial process in g CO_2-eq/shirt			
CFP of one shirt in g CO_2-eq/shirt			
Emissions per shirt reduced as a result of the project in g CO_2-eq/shirt			

References:

FAO Country Brief Reports. 2010.

Available at: http://countrybriefs.fao.org/TO/default.asp

http://www.crdc.com.au/uploaded/file/E-Library/Climate%20Change%20July%2009/Grace%20LCA%20Climate%20Change%20Cotton.pdf

Exercise 4Livestock Project in Mongolia

Objectives:
This simulated situation aims at providing a good understanding of how to use EX-ACT for the "*Grassland and Livestock"* as well as the "*Inputs and Investments"* modules.

Indicative time to carry out the exercise: 45 minutes


@FAO/Sean Gallagher/FAO


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Description of the Mongolian context:
The Mongolian pastoral livestock sector has already suffered from climate variability, particularly due to severe winters (dzud) and summer droughts. The sector is highly sensitive to climate change. Moreover, the Mongolian economy is mainly based on livestock and almost half of the population is engaged in that sector. Therefore, mitigation and adaptation options are vital to achieve sustainable development in the country. Furthermore, the country experiences high rates of natural resource degradation.

During the past 60 years the plant composition within pastures has changed significantly in Mongolia. High-nutrient plants have decreased by 1.5–2 times and are expected to decline further because of increased temperatures and decreased precipitation. Instead, low nutrient plants like *Carex Duriuscula-Artemisia* became dominant in pasturelands, while pastures became furthermore less diverse as a consequence. In continuation of today's trends, it is expected that by 2050 11 per cent of the steppe pasture in Mongolia will be replaced by desert.

Livestock depends to a great extent on the availability of pasture resources. About 70 per cent of the national pasture area is degraded. In spite of this situation, the number of animals has sharply increased, which emphasis the pressure on grasslands, making it increasingly difficult to provide the necessary amount of feed for the livestock (overgrazing).

Proposed activities:
The following activities will be proposed, affecting 10 000 beneficiary households that currently own an average of 200 animals, including sheep (70 per cent), cattle (10 per cent) and goats (20 per cent). Without the project, livestock numbers are expected to further increase in the next 20 years (by 50 per cent for sheep, by 30 per cent for cattle and by 80 per cent for goats). The implementation of this project should instead allow farmers to keep the same livestock numbers as at the present time.

- *Increasing livestock productivity*

Measures will be taken to increase sheep and cattle productivity through the use of different kinds of supplementary feed, increasing livestock weight. The project will promote the use of concentrates, targeting a daily norm of 300 grams per sheep and 1 500 grams per cattle, reaching 90 per cent of the livestock. It is assumed that currently only 3 per cent of livestock receives improved feeding practices. In the future, without the implementation of the project, it is expected that only 10 per cent of livestock will be better fed. Goats will be kept within extensive management systems (no improved feeding practices).

- *Maintenance of pastures*

The proposed project focuses on improving pasture yields, including the reintroduction of traditional pasture

management, which involves limiting the pasture area that is grazed during any given season, the restoration of degraded pasture with increased vegetation cover, the expansion/rehabilitation of water supply, the development and maintenance of irrigated pasture and the modification of the grazing schedule.
For the sake of simplicity, it is assumed that these improvements will not be carried out with chemical fertilizers. The user should not take into account the reduction in total available pasture areas due to their conversion into protected areas, settlement, mining and roads.

With the implementation of the project, which concerns 2 million ha of grassland, it is expected that:

- ¼ of the total grazed surface will be improved, without inputs, through decreasing grazing intensity
- 5 000 ha of grasslands will be newly irrigated, with the installation of a solid roll sprinkle irrigation system
- The remaining pastures will stay moderately degraded

Without the project implementation, the surface area that would have been improved by the project will remain moderately degraded, while the rest will become severely degraded in the future due to an increased grazing pressure.

The following table sums up the different pasture degradation trends:

Initial State	Final State Without Project	Final State with Project	Area
Moderately Degraded	Moderately Degraded	Improved without Inputs	
	Moderately Degraded	Improved with Inputs	
	Severely Degraded	Moderately Degraded	

- *Project management*

To implement the project, a team of experts will carry out regular field visits. One international expert will fly to Mongolia twice a year, during the implementation phase. One round-trip flight Rome-Oulan Bator consumes 546L of kerosene per passenger, with an emission factor of 2.5 kg CO_2-e/L.

Locally, two cars will be purchased to enable local experts to monitor the progress of the project. Gasoil consumption is about 5 000L per car and per year throughout the implementation phase.

The project is foreseen to be characterized by 5 years of implementation and 15 years of capitalisation.

Main outputs:
Implementing such activities should allow (i) preventing natural resource degradation, (ii) enhancing capacities and livelihood opportunities of rural communities, (iii) increasing food security and supply, and (iv) improving the understanding of climate extreme events and forecasting.

References:
http://www.aiaccproject.org/working_papers/Working%20Papers/AIACC_WP41_Batima.pdf

Exercise 5 Milk Production in Kenya

Objectives:
This simulated situation aims at providing a good understanding of how to use the EX-ACT modules "Land Use Change", "Crop Production", "Grassland and Livestock" as well as "Inputs and Investments".

Indicative time to carry out the exercise: 1h


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Description of the context:
The example situation is presently taking place in Western Kenya, close to the Victoria Lake. Western Kenya has a tropical moist climate, with HAC soils. The region is dominated by small scale dairy farms that combine milk production and mixed farming systems. The 20 000 famers in the area own 2.65 ha of land on average. The total area under analysis accounts for 53 000 ha.

Households are characterised by livelihoods under pressure. Farmers experience problems in accessing markets, especially for milk products. Increased productivity per cow would thereby greatly boost the interest of milk distributors and processors in small producers. Such productivity increases require better feeding, breeding and management practices. Thereby, the associated agricultural land is moderately degraded and needs improvements via sustainable land management practices in order to produce better feed.

The estimated time for the implementation phase is 5 years, whilst the capitalisation phase amounts to 15 years. The different activities of the project scenario are listed below.

Proposed activities:

- *Deforestation*

Currently, 10 per cent of the initial forested area, which is 15 000 ha, is deforested each year, during the implementation phase. With the project, it is expected that only 2 per cent of the initial forested area will be converted every year into tea plantations.

EX-ACT Module	Type of Vegetation	Start (ha)	Area Forested Without Project (ha)	Area Forested With Project (ha)
Deforestation	Tropical Moist			

- *Land use changes*

With the project, 23 000 ha of degraded land will become tea plantations. Without the implementation of the project, the area will remain degraded land.

Furthermore, with the project, the farmers are encouraged to expand and improve grasslands through the promotion of Napier and Rhodes grass, whereby the two cultures are classified as grassland. Initially, there are 2 500 ha that are set aside lands, whilst 2 500 ha are already Napier grass. With the project, 40 per cent of the set aside land will be cultivated as Napier grass and 60 per cent as Rhodes grass, thus constituting an improvement of the existing area with inputs. Without the project, the area remains instead moderately degraded.

The existing Napier grasses are not improved in the scenarios with and without the project and remain therefore

moderately degraded.

LUC	Without Project (ha)	With Project (ha)
Degraded Land to Tea Plantation	Tropical Moist	
Set Aside to Napier Grass (Grassland)		
Set Aside to Rhode Grass (Grassland)		

- *Improved fodder production*

Initially, there are 10 000 ha of maize production in the area and the residues from maize are used as fodder. With the project, it is expected that improved varieties and no tillage practices will be implemented. No improved agronomic practices are expected without the project. The amount of ha will remain the same in both scenarios.

EX-ACT Module	Type of Production	Start (ha)	Without Project (ha)	With Project (ha)
Annual	Conventional Maize Production			
	Improved Maize Production			
Total				

- *Livestock*

With the project, it is expected that the total number of livestock, 159 000 dairy cattle (where approximately one farmer owns 3 cows), will be reduced by 40 per cent by the end of the project. Without the project, the number will augment by 10 per cent. Currently, only 3 per cent of the livestock is better fed. This rate should increase up to 10 per cent without the project and up to 90 per cent with the project. Moreover, improved breeding practices will be applied with 80 per cent of the cattle under project implementation. Presently, there are no improved breeding practices taking place.

- *Inputs*

With the project, only 3L instead of 6L of pesticides will be used for maize production. Half are insecticides, while the other half are herbicides.

Exercise 6 Rice Production in Ghana

Objectives:
This simulated situation aims at providing a good understanding of how to use EX-ACT for irrigated rice and other annual crop production as well as concerning fertilizer use. It involves the modules "Crop Production" as well as "Inputs and Investments".

Indicative time to make the exercise: 60 minutes


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Description of the Ghana rice sector:
Rice is an important food and cash crop in Ghana. Its consumption is increasing regularly in the country and the region, due to population growth and dietary preferences in urban areas. However, the country has to import almost two thirds of its internal demand and experiences for a variety of reasons problems to cover a higher share by domestic production. The following proposed activities aim at improving and increasing rice production.

Activities that are proposed:
Approximately 8 500 households cultivate an average of 1.25 ha of rice per household. There are two kinds of rice (i) non-flooded upland rice (40 per cent of the total area), (ii) rainfed and deep-water rice (flooded rice) (60 per cent of the total area).

The period of analysis will be 5 years of implementation and 15 years of capitalisation.

The flooded rice is currently cultivated during 150 days, without pre-season flooding (> 180 days). The straw is burnt for sanitary issues. No inputs are currently used on rice fields.

The residues of the upland rice are equally burned.

- *Improved Seed*

The proposed project will introduce improved seeds to both cultivation systems through the regular seed market, leading to higher yields, a shorter cultivation period (100 days) and advantages for weed competition, pest resistance and drought tolerance.

- *Water management on paddy rice*

The project will be realised over a period of 5 years. It is expected that only 30 per cent of the targeted farmers will change their water management regime (water control and saving, increased yields, better input management), which involves specifically the transformation from a deep-water regime to intermittently irrigated cultivation. Pre-season practices will remain unchanged.

- *Fertilisation management*

In synergy with the livestock services, an on-going programme wildly diffuses the use of the rice straw as organic fertilizer. Therefore the straw will be exported (from both types of rice) and mixed with manure. The resulting compost fertilizer will be spread on the whole upland rice area. Furthermore, the crop rotation of the upland rice will be improved as a measure of integrated pest management.

With the project all irrigated rice will be fertilized with 120 kg/ha/year of urea.

Without the implementation of the project it is expected that:

- 30 per cent of the total upland rice will be converted to other annual crops, because of low yield. Burning practices are still on-going.
- Within the framework of a private business initiative, 10 per cent of the deep-water rice will switch to continuously flooded rice. Pests will be controlled by the adoption of a long flooded pre-season and residue burning. The fertilisation brought in into this cultivation system would be 200 kg/ha/year of urea.

Additional help:

You can use the table below to identify the surface areas concerned by the project. Insert the amount of hectares for each situation. The total surface area must be the same in the 3 situations (initial, without and with).

EX-ACT Module	Type of Land Use	Initial Situation	Without Project	With Project
Annual	Conventional Upland Rice			
	Improved Upland Rice			
	Annual Crops (Other)			
Irrigated Rice	Conventional Deep-water Paddy			
	Improved Paddy (Deep-water)			
	Improved Paddy (Intermittently Flooded)			
	Rice System of Private Business Initiative			
Total				

Main outputs:

Implementing such activities should allow (i) enhancing capacities of rural communities and (ii) increasing food security and supply.

References:

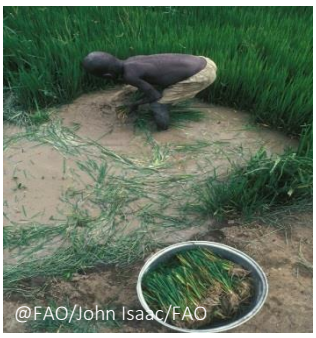
http://www.afdb.org/fr/projects-operations/project-portfolio/project/p-gh-aab-001/

Exercise 7 Markala Sugar Project in Mali

Objectives:

This simulated situation aims at providing a good understanding of how to use the EX-ACT modules *"Land Use Change"*, *"Crop Production"* as well as *"Inputs and Investments"*. It focuses on activities related to deforestation, non-forest land use changes, production of annual crops and irrigated rice as well as the use of inputs and the realisation of further investments.

Indicative time to carry out the exercise: 60 minutes



Description of the context:

The Markala Sugar Project is the first Public-Private Partnership operation between Mali and the African Development Bank in the agro-industrial sector. The objective of the project is to ensure a sustainable increase in the income of sugar sector stakeholders, in order to cover the country's sugar demand. It also takes into account the production of biofuel as a renewable energy as part of sugar processing. Implementing the project will require optimal management of water resources, especially during the dry season.

Proposed activities:

The present exercise is based on a real but simplified case study, also including some land use change activities that will occur as part of the project. The project will be implemented during 5 years, and the capitalization phase is expected to last 15 years.

At present, there is no plantation of sugar cane. Of the 16 382 ha of interest, 6770 ha are currently cultivated as dry cereal (rice, sorghum, millet), 900 ha are tree savannah land, while the rest is either degraded land (4231 ha) or set aside land (4481 ha). It is expected that, without the implementation of the project, the situation would remain the same as currently.

- *Development of sugar cane*

The project will develop the plantation of 14 132 ha of sugar cane through land use changes and conversion between different annual crops. The sugar cane will be cultivated with improved water and nutrient management and without residue burning.

The 900 ha of tree savannah land will be deforested and sugar cane will be planted instead. The conversion will be done with fire use.

The 6770 ha of dry cereals whose residues are presently burnt will be converted into sugar cane.

The remaining area of the foreseen sugar cane plantation (6462 ha) will result from land use change, half from set aside and half from degraded land.

- *Development of other crops*

1250 ha of food crops will be implemented on current set aside land. Those food crops will have improved water management and no residue burning practices.

1000 ha of degraded land will be converted into paddy rice, intermittently flooded and with a non-flooded preseason (> 180 days), whereby straw is incorporated long before cultivation.

- *Use of fertilizers and pesticides*

With the project, fertilizers and pesticides will be used on sugar cane. The quantity of fertilizers used per year and per hectare is 200kg of Nitrogen (N), 125 kg/ha of potassium synthetic fertilizer (K20) and 12 kg of Phosphorous synthetic fertilizer (P2O5).

The whole sugar cane area will receive an insecticide treatment of 2 litres per ha per year.

Independent farmers, who cultivate 40 per cent of the sugar cane area, will apply only half of the herbicide quantity than the plantation company, which cultivates 60 per cent of sugar cane area. Therefore, they will make 2 treatments of 3 litres per year instead of 4 treatments for the estate company.

For the sake of simplicity, we consider that the mass density of all pesticides is equal to 1 litre per kg, and that the proportion of active ingredients is 100 per cent. It is assumed that the irrigated rice and other food crops will not require the use of any fertilizers.

- *Use of irrigation*

With the project, sugar cane is irrigated using newly installed centre pivot sprinklers.

- *Industrial process of sugar cane*

The plant will produce an annual output of 190 000 tonnes of sugar, 15 000 m^3 of anhydrous ethanol (substituting gasoline) and the cogeneration of 30 MW of electricity per hour. The plant will operate half of the year, 24 hours a day.

40 per cent of the electricity produced will be used by the plant. The other 60 per cent will be fed into the electrical grid. We will take into account only the electricity used within the project. We assume that the emissions are 0.25 t CO_2-e/MWh. A further analysis involves to calculate the GHG reduction due to the substitution of conventional energy by this “green” electricity.

While ethanol will replace a proportion of the gasoline consumption in Mali, the energy density of ethanol is however less than for gasoline: 1L of ethanol provides only 2/3 of the energy of 1L of gasoline. For the same amount of energy, thus 1.5 times the quantity of ethanol are needed.
During the combustion of ethanol, methane and nitrous oxide emissions will occur. The emission factor is 0,025 t CO_2-e/m^3 for ethanol.

Furthermore, also the gasoil consumption due to land preparation and planting has to be accounted for. For the total area, this total consumption is estimated 2544 l.

Additional help:
You can use the table below to identify the surface areas concerned by the project. Insert the amount of hectares for each situation.

EX-ACT Module	Type of Land Use	Initial Situation	Without Project	With Project
Deforestation	Savannah Tree to Sugar Cane			
Other LUC	Degraded Land to Sugar Cane			
Other LUC	Set Aside to Sugar Cane			
Annual	Annual to Sugar Cane			
Total Sugar Cane				
Other LUC	Set Aside to Food Crop			
Other LUC	Degraded Land to Paddy Rice			

Main outputs:
This simulation allows (i) using the EX-ACT tool with biofuel considerations and (ii) raising questions about biofuel projects.

References:
http://www.afdb.org/fileadmin/uploads/afdb/Documents/Project-and-Operations/MALI%20-%20AR%20Agricultural%20Component%20Markala%20Project.pdf

Exercise 8 Agro-Forestry Project in the Cross River Region of Nigeria

Objective:

The following exercise encourages users to utilise, besides the pre-defined Tier 1 options in EX-ACT, refined and regional specific Tier 2 coefficients for the forestry and agricultural sectors.

Indicative time to carry out the exercise: 45 minutes

Description of the context:

REDD+ is a program aiming at Reducing the Emissions linked to Deforestation and Forest Degradation. For the exercise at hand, the focus is on the REDD+ program that has been implemented in the Cross River region of Nigeria. The dominant soil type is LAC soil. The implementation phase is 5 years and the capitalisation phase amounts to 15 years.

Proposed activities:

- *Deforestation 1*

Deforestation practices will stop with the project. Without the project, 1000 ha of tropical moist forest (primary forest) will be deforested for logging. 10 logs/ha will be exported, with each log being equivalent to 5 m^3 with an average density of 0.8 t/m^3. The land will become set aside.

- *Deforestation 2*

The Government of Nigeria suggests developing perennial crops on 500 ha, in particular palm trees on degraded secondary forest-land. This activity will provide revenues and should thus reduce the pressure on primary forests as far as stemming from local communities. The forest coefficients defined in EX-ACT are only for primary forests. However, secondary forests are less dense. The carbon content of degraded secondary forests in the Cross River region is 89.4 t of above ground biomass/ha, whereby 1 t of biomass contains 0.47 t of carbon. The below ground biomass is proportionally 0.37 times the above ground biomass.

The carbon contents of the litter, dead wood and soil is hypothetically the same as for the primary forests (tier 1 coefficients).

- *Annuals*

The low agricultural yields have been identified as the major cause of deforestation. In order to successfully implement the project, the Government of the Cross-River state is suggesting to improve 250 ha of annuals (mainly yam), through the use of manure. Previously 5 kg of urea was used per ha. With the project, 75 kg of N, 15 kg of P and 10 kg of K will be used and crop residues (12 t/ha) will be reincorporated in the soil. Initially, the crop residues (5 t/ha) were burnt. An experimental plot has shown that soil carbon levels increase under such conditions by 4 t of carbon per ha during a 5-year period. In order to derive the equivalent amount of CO_2 that will not be emitted to the atmosphere but stored in soil, one has to multiply the amount of soil carbon with the ratio 44/12.

- *Perennials*

With the project, the cultivated perennial crops will consume per hectare 125 kg of N, 35 kg of P and 25 kg of K. The fertilization procedure will allow an above ground biomass growth rate of 11t C/ha per year. However, residues will be burned.

- *Economics*

The project could be eligible for the voluntary market. Average prices for Independent Forest Monitoring (IFM) credits in 2010 were reported at US$ 6/t CO_2-eq (Forest Carbon Market Update, July 2011).

IFM, which is a programme of Global Witness, is developing Independent Monitoring of REDD (IM-REDD), focused on transparency, accountability, enforcement and governance in the forest sector. Reference: https://www.forestcarbonpartnership.org/fcp/sites/forestcarbonpartnership.org/files/Documents/PDF/Jul2011/Forest%20Carbon%20Market%20Update_July%202011.pdf.

The cost of MRV (Monitoring, Reporting and Verification) is approximately US$ 20 ha/yr. Reference: http://www.maff.go.jp/primaff/meeting/kaisai/pdf/0309_3.pdf.

The implementation cost of this REDD project is about 650 000 $. Reference: http://data.iucn.org/dbtw-wpd/edocs/2009-047.pdf.

If these conditions are satisfied, what are the net financial benefits the project could bring about if it takes part in the voluntary Carbon market?

Exercise 9 Forest Rehabilitation in Kazakhstan

Objectives:
This simulated situation aims at providing a good understanding of how to use EX-ACT for forest degradation as part of the "*Land Degradation*" module.

Indicative time to carry out the exercise: 30 minutes


@FAO/Jake Salvador/FAO


@FAO/Sean Gallagher/FAO


@FAO/Zinyange Auntony/FAO

Description of the Kazakh context:
Kazakhstan possesses 11.5 million hectares of forested land, playing an important role for soil conservation, rural development, wildlife and watershed management, as well as tourism. Kazakh forests are key for the protection of the watershed of the Aral Sea Basin, and for the reduction of desertification and siltation of waterways and reservoirs.

The World Bank "Forest Protection and Reforestation Project" develops cost-effective and sustainable actions for environmental rehabilitation and management of forest lands and associated rangelands, with a focus on:

1. Reforestation activities and the purchase of fire management equipment in the Irtysh Pine Forest
2. Amelioration of the Dry Aral Seabed
3. Capacity building of the national forestry institutions

The project is carried out with an implementation phase of 12 years on 660,000 ha of project's areas, while the dominant soil types are High Activity Clays.

Proposed activities:

Forest management - Reducing forest fires & Forest rehabilitation (with Tier 2)

- On 642 000 ha currently forest fires occur every second year affecting 5 percent of the total forest area. The project initiates the installation of fire prevention teams supported by forest fire stations and fire detection towers. All measures are expected to an overall improved forest fire management so that only 1 per cent of the forested area is foreseen to be affected through fires every second year.
- The forest in the project area has initially a state of low degradation, equal to a loss of 10 percent of the total biomass as compared to a non-degraded forest. This state of degradation will be maintained in the absence of the project, while the project activities will rehabilitate the forest to a state of very low degradation, equal to 5 per cent of biomass lost as compared to a non-degraded situation.
- Thereby, non-degraded forest in the project area is characterised by an above ground biomass of 30.5 t C and a below ground biomass of 4.1 t C per hectare (litter, deadwood and soil carbon levels are assumed equal to any standard temperate continental forest).

Development of Agroforestry
On 18 000 ha of formerly degraded land agroforestry activities will be put in place with the help of forest user groups.

Analysis: Evaluation of the economic public value generated by the project
The project also considers to put in place a payment system for environmental services targeting the forest user groups that effectively contribute to the above listed measures. In order to adjust the payment level to user

groups, policy designer need to have a first appraisal of the benefits that could be generated by adopting these actions. Please estimate the public value generated per year through both fire prevention and forest rehabilitation, when assuming that:

- Every tonne of CO_2-e mitigated prevents future costs of 21 USD occurring to society (social costs of carbon, US-IDWG).
- The project also increases the availability of commercial timber. The results section of EX-ACT provides an estimate of tCO_2-e that is sequestered due to newly created biomass through the project. It is assumed that 45 percent of the newly generated biomass is woody biomass of which roughly a third (/3.4) is commercial timber with a value of 87.72 USD/t dry matter. In order to calculate the amounts of dry matter generated, the value in tCO_2-e has first to be converted to tonnes of C (*12/44) and then to tonnes of dry matter (/0.47).
- The above mentioned measures prevent soil erosion on 18,000 ha of agroforestry land, thereby conserving soil organic matter and increasing fertility levels. A survey indicated that farmers are willing to pay the equivalent of US$ 1.75 per hectare for this advantage, which can be used as a proxy variable to estimate the impact generated through the action.

Exercise 10 Rice Cropping in Vietnam

Objectives:

This simulated situation aims at providing a good understanding of how to use EX-ACT for irrigated rice as part of the "Crop Production" module.

Indicative time to carry out the exercise: 60 minutes

Description of the Vietnamese context:

As the fifth largest rice producer and second largest global exporter[1], rice is a major source of income for rural, resource-poor households in Vietnam with roughly 9 million households, mainly in Northern Vietnam, growing rice on less than 0.5 hectares. The country's two main rice producing regions, the Mekong and Red River Delta, are irrigated, use high seed rates and apply high amounts of fertilizer and pesticides, while some geographical variation can be found throughout the rest of the country. High input costs, decreasing soil fertility, water scarcity, salinity intrusion to inland water bodies from the sea, and the continuous focus on yield increases are some of the central shared challenges of the sector. Furthermore, pesticide poisoning and biodiversity loss from the constant and intense use of pesticides are additional recognised problems.

In this context, improved production systems, including the System of Rice Intensification (SRI), "Three Reductions, Three Gains" (3R3G) and "One Must, Five Reductions" (1M5R)[2] gained recognition as relevant agricultural policy options with multiple benefits in terms of economic and environmental performance as well as climate mitigation.

Proposed activities:

- *Improving irrigated rice production*

A project operating in various rice growing areas of the country offers farmers to adopt improved agricultural management practices, depending on the agro-ecological context, socio-economic conditions, and individual preferences of the households. The project expects to achieve the targets after a 5-year implementation period, while the pace of adoption will follow a linear pattern.

Farmers currently practice two dominant systems of rice cultivation in the project area. On 80,000 ha, farmers cultivate two rice crops per year (total cultivation period of 180 days), using continuous flooding during cultivation, a flooded preseason (> 30 days of duration) and incorporating rice straw long before the cultivation period. Farmers apply 200 kg of Urea (46-0-0), 150 kg of DAP (18-46-0), and 150 kg of Potassium Chloride (0-0-60) per hectare per year. Pesticides are applied at a rate of 3 L (insecticides) and 4 L (herbicides).

Further 20 000 hectares are cultivated with the same water management practices, but are farmed with three consecutive rice crops (270 days). Thus rice straw is only incorporated shortly before the cultivation period. The farmers apply the same type of inputs as identified above, but 1.5 times the quantities. Due to increasing salinity in the dry season, the yields for the third rice crop are poor.

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[1] The reference year is 2011.

[2] 3R3G: Reductions in seed, nitrogen fertilizer and pesticides, while benefiting from lower production costs, farmers' health and environmental benefits.

1M5R: Obligatory application of certified seeds, while reducing the amount of seeds, nitrogen fertilizer, pesticides, irrigation water and post-harvest losses.

With the project the double cropped rice systems will be improved half with 3R3G and half with 1M5R:

- 3R3G will decrease the rate of Urea to 130 kg, DAP and Potassium Chloride each to 100 kg, insecticides to 1 L and herbicides to 3 L per hectare. Water management practices will be maintained as previously. Rice straw will be composted before application to the field.
- 1M5R will introduce the exact same reductions in pesticide and fertilizer use and moreover change the water management to intermittently flooded with a non-flooded pre-season (duration: <180 days). Again, rice straw will be composted before application to the field.

The 20,000 hectares that formerly were cultivated with three rice crops, will be converted to two rice crops only, using likewise the practices of 1M5R. The dry season will be used for shrimp and prawn production, considering its suitability to the higher salinity conditions.

You may want to fill the following table first in order to correctly identify the management changes introduced by the project.

Type of Rice Production System	Start (ha)	Future Without Project (ha)	Future With Project (ha)	Cultivation Period (days per year)	Water Regime During Cultivation	Water Regime Before Cultivation	Management of Organic Amendments
Conventional 3 Rice Crops							
Conventional 2 Rice Crops							
3R3G 2 Rice Crops							
1M5R 2 Rice Crops							
Total							

- *Improving rice processing*

Besides the identified improvements, the project will also improve the valorisation of rice husk into briquettes. Each of the one hundred pilot husk briquette making systems under the project can output 800 kg of briquettes per day, or 120 t per year (operating 150 days). A tonne of rice husk is characterized by an emission factor of 65.7 kg CO_2-e (CO_2-neutral) and an energy density of 0.01728 TJ/t. The average density of a rice husk briquette is 1.3 g/cm^3. The newly generated energy from rice husk will replace the equivalent amount of energy stemming from gasoline (roughly 4,680 m^3).

Exercise 11 Refining GHG Emission Estimates for Rice and Livestock in India

Objectives:

This exercise guides the user to utilise Tier 2 GHG emission factors for flooded rice and livestock systems in India.

Indicative time to carry out the exercise: 60 minutes


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@FAO/Noah Seelam/FAO

Description of the Indian context:

The Indian government estimates in its second National Communication to the UNFCCC that the agriculture sector contributes 23 percent of national anthropogenic GHG emissions. Livestock production and irrigated rice are considered the most sizable contributors to GHG impacts in agriculture.

In this hypothetical exercise, the Indian government contracts you to provide an update of national GHG emissions from livestock and rice for the next National Communication.

As it is considered a good practice to utilise country-specific GHG emission factors for all major national GHG emission sources, a national research institute provides you with Tier 2 GHG emission factors. The government requests you to provide two final GHG emission results based on (i) IPCC default emission factors and (ii) national specific Tier 2 GHG emission factors.

Proposed activities:

- *Irrigated rice production*

The government provides you with the table below that specifies information on (i) total rice cultivation area by system and (ii) cultivation days per season for a total of seven rice production systems.

As a first step, estimate total methane emissions using the IPCC approach. For this you will need to enter all the rice systems into the EX-ACT tool and specify for each system the most common water management system (during and before the growing season) as well as the management practice of organic amendments. You may want to insert this information by hand into the above table first. Once you have a total estimate of annual methane emissions using the IPCC approach, note it down for later comparison.

As a second step, navigate to the Tier 2 section for flooded rice systems. Here, enter the Tier 2 emission factors that you received from the national research institute (beware of the unit: in EX-ACT methane emission factors are expressed per cultivation day).

Once you finished, compare the total estimate of methane emissions as well as methane emissions for each production system. Are there strong differences?

Rice Production Systems		Rice Area (ha)	IPPC 2006 Approach				Tier 2 Approach
			Cultivation Days	Water Regime During Cultivation	Water Regime Before Cultivation	Organic Amendment	Tier 2 Emission Factor (kg CH_4/ha per year)
Irrigated	Continuous Flooding	6747000	80				162
	Single Aeration	8192000	80				66
	Multiple Aeration	9911000	80				18
Rainfed	Flood Prone	3686000	90				190
	Drought Prone	3686000	90				66
Deep Water		1353000	90				190
Upland		4949000	90				0
Total		43860000					

- *Livestock production*

Next, the government wants you to calculate GHG emissions from the adult livestock population.
Derive again the GHG estimates using default GHG emission factors from the IPCC as provided in EX-ACT. For this purpose, utilise the total animal numbers reported in the table below.

Afterwards, enter the Tier 2 emission factors displayed in the table below and compare the difference regarding (i) the total annual GHG emissions for the whole livestock sector, and (ii) the GHG emissions for each livestock category.

For which livestock category does it make a big difference whether default emission factors or Tier 2 emission factors are used?

Livestock Types	Livestock Heads	Enteric Fermentation (kg CH_4/head/year)	Manure management (kg CH_4/head/year)
Dairy Cattle	113379000	28	3.5
Other Cattle	37793000	32	2.9
Buffalo	108702000	50	4.4
Sheep	65069000	4	0.3
Goat	135173000	4	0.2
Horses	625000	18	1.6
Camels	400000	46	1.6
Pigs	10294000	1	4

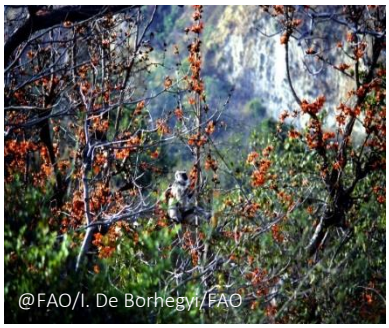
Exercise 12 Comparing Hypothetical INDC Scenarios in India

Objectives:

This exercise aims at developing the capacity to devise alternative policy scenarios and identify the implications for climate change mitigation. Thereby, this exercise does not foresee any solution that is "right" or "wrong" but aims at pointing out the implications of different policy decisions in terms of GHG benefits.

Indicative time to carry out the exercise: 60 minutes


@FAO/Franco Mattioli/FAO


@FAO/I. De Borhegyi/FAO


@FAO/P. Johnson/FAO

Description of the Indian context:

The Indian government has put in place a set of policies that target the scaling-up of climate change adaptation practices. These include the National Mission on Sustainable Agriculture (NMSA), the National Initiative on Climate Resilient Agriculture (NICRA), the National Agroforestry Policy (NAP), as well as the Intended National Determined Contribution (INDC) of India. Climate change adaptation actions have the possibility of providing sizable co-benefits for carbon sequestration or reduced GHG emissions.

Proposed activities:

In this hypothetical exercise, you are requested by the government of India to develop national or state-level targets for the total area that will be improved with enhanced management practices. You are also assigned the task to estimate the likely climate change mitigation co-benefits that will result from your propositions.

- *Develop targets for the total area with improved management practices*

Starting from the options displayed in the table below, but with the possibility of expanding beyond them, please develop a scenario for the total area that can be improved through various enhanced management practices. For the development of your scenario, you may consider which improved management practices you judge to have a particular priority to be adopted by farmers for climate change adaptation benefits as well as their feasibility from an economic point of view.

- *Estimate the climate change co-benefits of your agriculture scenario*

Enter the developed scenario into EX-ACT and estimate the climate change mitigation co-benefits. Compare your scenario to those of other participants.

Activity	Area	Annual Mitigation Impacts (tCO_2-e)
Reforestation on set-aside land		
Rehabilitation of degraded forest land		
Preventing the conversion of shrub land to annual cropland		
Expansion of agro-forestry systems		
Shifting to multiple aeration in irrigated rice systems		
Rehabilitate degraded cropland		
Scale-up manure application on annual cropland		
Reduce crop residue burning on annual cropland		
Reduce crop residue burning on annual cropland		
Rehabilitate moderately degraded grassland to non-degraded grassland		
Improved feeding practices of cattle		
Improve breeding practices of cattle		
Total		

Exercise 13 Peatland Restoration in Indonesia

Objectives:

This case study aims at providing a good understanding of the "*Management Degradation"* module of EX-ACT, in particular of the sections "*Forest Degradation and Management*" and "*Degradation and Management of Organic Soils*". It focuses on the drainage and rewetting aspects of peatlands and on forest rehabilitation.

Indicative time to complete the exercise: 30 minutes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@FAO/Adek Berry/FAO


@FAO/Giulio Napolitano/FAO

Description of the Indonesian context:

The extensive degradation of Indonesian peatlands resulting from deforestation, drainage and recurrent fires, causes the release of huge amounts of peat soil carbon into the atmosphere. The construction of drainage canals is associated with the conversion to other land uses, especially oil palm plantations and pulpwood trees, and with widespread illegal logging to facilitate timber transport. A lowering of the groundwater levels leads to an increase in oxidation and subsidence peat. CO_2 emissions from peatlands are, therefore, mainly dependent on the groundwater level. Restoring the hydrology of peatlands is the only way to prevent peat oxidation, mitigate CO_2 emissions and reduce land subsidence.

Proposed activities:

The area in Central Kalimantan, Indonesia, is occupied by a vast disturbed and drained peat swamp forest of 59 000 ha. The project is implemented over a period of 10 years. The construction of dams will depend on locally available wood.

- *Forest degradation and management*

Initially, the drained forest (tropical rain forest) is characterized by a state of large degradation (70 percent), which would worsen, thus reaching extreme levels, in the absence of the project. The project activities would, instead, rehabilitate the forest area, leading to a low degradation level (equal to a 40 percent biomass loss as compared to a non-degraded situation). Both with and without the project, fire is assumed not to be used.

- *Rewetting of organic soils*

The project seeks the rewetting of the whole area, which would eventually lead to a restoration of the degraded peat swamp forest[3]. The starting point is a surface of no rewetted organic soils.

[3]Since the tier 1 default coefficients are the same for both nutrient-poor and nutrient-rich peat (41 by default), the user can autonomously select the type of peat.

Exercise 14 Adaptation to Salinity Intrusion in Vietnam

Objectives:
The simulated situation aims at providing a good understanding of the use of EX-ACT in a project covering "irrigated rice", "forest management", "coastal wetlands" as well as "aquaculture". It includes the Crop Production, Management Degradation, Coastal Wetlands and Fisheries Aquaculture modules.

Indicative time to carry out the exercise: 45 min


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@FAO/Munir Uz Zaman/FAO

Description of the Mekong Delta context:
Salinity intrusion into the Delta estuary is reducing agricultural productivity and causing dry season freshwater shortages. Tidal fluctuations drive saline intrusion more than 80km inland, affecting 40 percent of the Mekong Delta. The consequent sea level rise will further increase the salinity levels in the Delta's river branches and its water networks. Water control infrastructures have been constructed in coastal provinces to control for salinity intrusion into the estuaries. Saline water is prevented to enter the canals thanks to the construction of sluices that can be closed when the seawater rises with water tides above river water levels. To meet the needs of freshwater agriculture, brackish-water aquaculture is required to effectively adapt to salinity intrusion in the Delta estuary. Located within the tropical monsoon belt, Vietnam is extremely vulnerable to climate change, particularly to increases in storm intensity and sea levels. Due to its vulnerability, Vietnam has been consolidating its experience in adaptation approaches for the protection of coastal infrastructures from sea level rise, especially through the use of mangroves.

Project objectives:
The project will address challenges related to seawater intrusion, coastal erosion, sustainable aquaculture and improved livelihoods for communities living in the coastal areas. The activities that will be implemented are: (i) constructing coastal defences, (ii) supporting farmers' transition from conventional 3 or 2 crops to shrimp farming and rice polyculture (shrimp, fish, cash crop) as well as (iii) improving water and coastal infrastructures along the coastal zone in the Delta estuary and the coastal peninsula. In the upper Delta, the project will prioritize freshwater management to reduce groundwater abstraction for agriculture and aquaculture purposes and polyculture-based systems to boost the modernization and increased sustainability of aquaculture and rice cultivation. The project activities are estimated to directly benefit 1.2 million people living in these provinces on an area of approximately 110 000 ha.

The appraisal is done considering tropical moist climate and HAC Soils. The GHG analysis is conducted on a 20-year time frame (with an implementation phase of 6 years) for a project area of 111 600 ha, with 67 000 ha of irrigated rice which will be partly used for aquaculture with project implementation, 21 000 ha of mangrove trees and 22 300 ha already used for mangrove-shrimp aquaculture which will not change with the project.

Proposed activities:

- *Deforestation and afforestation*

Some marginal deforestation (400 ha of tropical moist deciduous forest and 100 ha of tropical shrub land, final use is set aside) is planned, in order to build wood aquaculture and water infrastructures, whilst afforestation of tropical moist deciduous forest (800 ha) on degraded area is planned for future wood needs. Fire is assumed not to be used for any land use transformation.

- *Mangrove restoration (forest management and rewetting)*

Mangrove restoration activities aim at restoring the coastal landscape with a view to enhance resilience of inland farming systems and reduce vulnerability to sea-level rise and coastal erosion.

1. 20,000 ha of mangrove forest area will be progressively improved with the project, from a moderate degradation level (40% biomass lost) to a low degradation level (20% of the biomass is still degraded). Without the project, the mangrove degradation process trend will carry on until reaching a biomass degradation of 60 per cent. No fire occurrence is expected both before and after the project.

2. From in situ measurements, the carbon stock is estimated at 105 tC ha^{-1} in the above ground biomass. With regard to the below ground biomass, the carbon stock amounts to 35 tC ha^{-1} and the soil carbon content is 56 tC ha^{-1}.

3. With the project, 1 000 ha of mangroves will be replanted after restoring the hydrology of the degraded area (with saline water, i.e. check tier 2 of coastal wetlands). The biomass recovery is assumed to be 80 percent.

- *Flooded rice systems*

1. Both before and after the implementation of the project, flooded rice (3 rice crops) in the Mekong Delta is continuously irrigated during the cultivation phase. Before the cultivation period, rice is irrigated with flooded preseason of more than 30 days. Straws are usually exported.

2. With the project, the conventional three-crop cultivation will switch to a two-crop cultivation, with shrimp replacing the third crop on an area of 7 000 ha. In the conventional three-crop production, the cultivation period is 270 days. With the shift to a two-crop cultivation combined with aquaculture, only the cultivation period will change, decreasing by 90 days, whilst all other characteristics relative to rice cultivation will remain unchanged.

3. The remaining area of conventional irrigated rice (60 000 ha) will be further transformed, by switching from a 3 rice cropping system to a double rice cropping system. Only the cultivation period changes (150 days), while other rice cultivation characteristics remain unchanged as compare to conventional rice. Straw is still exported.

- *Shrimp production*

The total shrimp production originating from the mangrove-shrimp farming system (22 300ha) will increase from 12 600 tonne to 16 000 tonne, due to improved aquaculture practices (i.e. reduction of mortality caused by viral diseases). The production of shrimps coming from transformed rice paddies is expected to reach 630 kg per hectare per year.

Main outputs:

Implementing such activities would allow to (i) prevent natural resources degradation, (ii) support farmers' transition to mangrove-shrimp farming and rice polyculture, (iii) improve water and coastal infrastructures along the coastal zone and (iv) enhance coastal resilience to high storm surge and coastal flooding.