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Strategic Carbon Accounting and Decarbonization approaches for Serbia



**NEXT training**

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# National Context

Most of the country’s area is dominated by a “**warm temperate dry**” climate. A few areas in the Southwest part are dominated by a “cool temperate moist” climate and “warm temperate moist” climate. In the Southeast, some “cool temperate dry” areas are found. **High activity clay soil** (HAC) dominates most of the country, while there are wetlands in the Northeast and low activity clay (LAC) soil in some areas around the country. The most important global ecological zone (GEZ) is the **temperate continental forest**, see Figures 1 to 3.

Figure 1. Map of the climate zones of Serbia

A picture containing map, text, diagram, atlas

Description automatically generated

Source: NEXT IPCC climate zones, FAO, 2024

Figure 2. Map of the ecological zones of Serbia

A green map of a forest

AI-generated content may be incorrect.

Subtropical dry forest

Source: NEXT GEZ, based on the global ecological zones (second edition) FAO, 2024

Figure 3. Map of the IPCC soil classes of Serbia

A map of soil with text

AI-generated content may be incorrect.

Source: NEXT, based on IPCC default soil classes derived from the Harmonized World Soil Data Base v2.0, 2024

Serbia became a Party to the United Nations Framework Convention on Climate Change (UNFCCC) upon ratification on 12 March 2001. It ratified the Kyoto Protocol on 19 October 2007, and later signed the Paris Agreement on 22 April 2016, officially ratifying it on 25 July 2017. In 2015, the Republic of Serbia submitted its Intended Nationally Determined Contributions (INDCs), committing to a 9.8% reduction in greenhouse gas (GHG) emissions by 2030 compared to 1990 levels. This initial submission also recognized the increasing frequency and severity of extreme weather events, highlighting the need for enhanced climate adaptation measures. On 24 August 2022, Serbia submitted its updated Nationally Determined Contribution (NDC) for the period 2021–2030, significantly raising its climate ambition by setting a target of a 13.2% reduction in GHG emissions relative to 2010 levels—equivalent to a 33.3% reduction compared to 1990 levels—by 2030. The GHG emission reduction target presented in this NDC is determined based on the Draft Low Carbon Development Strategy (LCDS), while its achievement is defined by an accompanying Action Plan

Historically, the GHG emissions in Serbia are driven by the energy sector, Table 1 and Figure 4, accounting for up to 80 percent of total emissions in 1990, mainly due to energy industries (half of the energy supply comes from coal[[1]](#footnote-2)). From 2010, GHG emissions from the energy sector are fluctuating around 50 milliontCO2-e. The IPPU sector is the one showing strongest variations along the time series, while the waste sector remains stable around 3 million tCO2-e over the whole period. Emissions from agriculture were around 5-6 million tCO2-e until 2020, when they started to decrease by about a million tCO2-e.

Table 1 – GHG emissions of the Republic of Serbia, in tCO2-e.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| nGHGi | 1990 | 2010 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
| Energy | 66,312,637 | 50,242,337 | 49,881,694 | 50,662,302 | 50,907,119 | 48,992,361 | 48,925,647 | 50,254,399 | 48,750,579 | 49,327,577 |
| IPPU | 5,515,645 | 4,971,724 | 4,078,929 | 4,391,837 | 5,285,068 | 5,969,786 | 5,236,356 | 4,626,198 | 5,066,494 | 5,141,135 |
| Agriculture | 6,538,156 | 5,552,228 | 5,551,258 | 5,926,932 | 5,625,099 | 5,114,826 | 5,184,547 | 5,616,940 | 4,732,440 | 4,878,676 |
| LULUCF | -1,411,847 | -6,059,246 | -5,267,258 | -4,940,639 | -5,059,492 | -4,819,411 | -5,096,933 | -4,947,369 | -4,981,842 | -4,548,886 |
| Waste | 4,300,391 | 3,033,701 | 3,012,016 | 3,019,899 | 2,920,923 | 2,994,212 | 3,069,967 | 3,130,846 | 3,192,069 | 3,224,166 |
| Total without LULUCF | 82,666,829 | 63,799,990 | 62,523,897 | 64,000,970 | 64,738,209 | 63,071,185 | 62,416,517 | 63,628,383 | 61,741,582 | 62,571,554 |
| Total with LULUCF | 81,254,982 | 57,740,744 | 57,256,639 | 59,060,331 | 59,678,717 | 58,251,774 | 57,319,584 | 58,681,014 | 56,759,740 | 58,022,668 |

Note: IPPU stands for Industrial processes and product use

Source: Authors’ elaboration based on the NIR 2024.

Figure 4. Time series of the sectoral GHG emissions of the Republic of Serbia, in million tCO2-eq

A graph of different colored bars

AI-generated content may be incorrect.

Source: Authors’ elaboration based on the NIR 2024.

# Case study: Serbia

This manual was produced to estimate the impact on climate change mitigation of a set of climate actions improvised for Serbia for the agriculture, forestry and other land uses (AFOLU) sector. The model used is the one of the “Nationally Determined Contribution Expert Tool” NEXT, described in the annex.

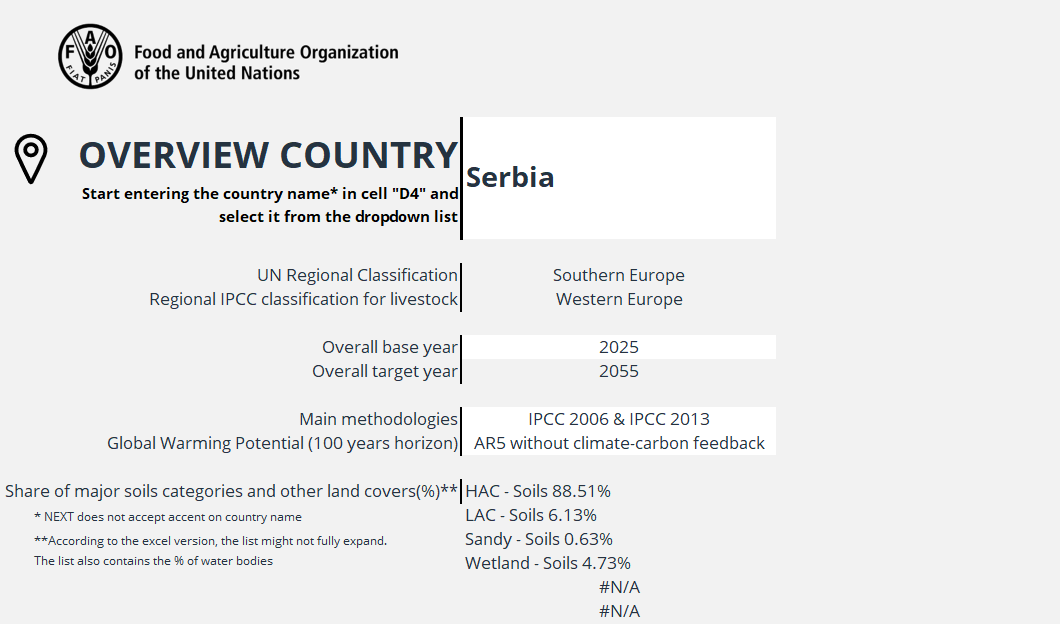
The exercises will align with the recommendations of the modalities, procedures and guidelines (MPGs) of the Paris Agreement, i.e. the use of the IPCC 2006 for estimates of changes in carbon stocks and other greenhouse gases (GHGs), and the 100-year global warming potentials (GWP) from the Intergovernmental Pannel on Climate Change (IPCC) Fifth Assessment Report, GWP-CH4 = 28; GWP-N2O = 265 (Myrhe et al., 2013).

Before starting the analysis:

A certain number of parameters must be informed in NEXT before carrying out the analysis. They are in the “HOME” menu and are:

* Name of the country where the activities (projects, policies among others) are implemented,
* Overall base year, or “Base year” for all analyses: the year in which the oldest activity begins.
* The methodology for estimating changes in carbon stock and GHG emissions: IPCC 2006 & IPCC 2013 or IPCC 2019 & IPCC 2013,
* The GWP over 100 years: AR5 without climate-carbon feedback, Figure 6.

Figure 5. NEXT screenshot of the “home” module

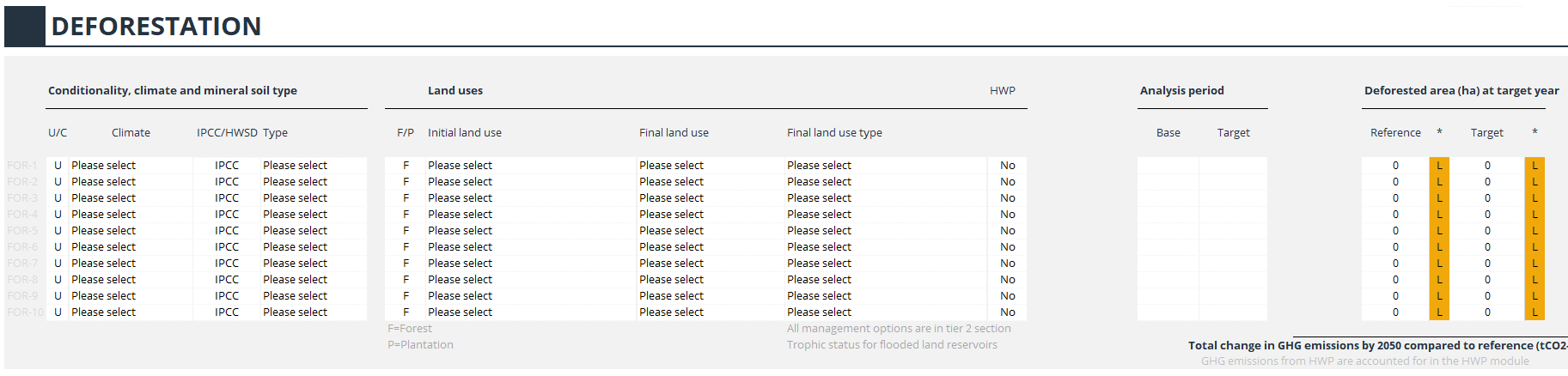


Source: FAO, 2024.

In the different modules, the user must specify a certain amount of information to estimate changes in carbon stocks and GHG emissions. The basic information is:

* The type of soil according to the IPCC or Harmonized World Soil Database (HWSD) classification,
* The climate according to the IPCC classification,
* The initial land use and, if necessary, the type of cultivation or use,
* The final land use and, if necessary, the type of cultivation or use,
* The analysis period is the implementation period of the policy or project activity. For example, if an activity starts in 2020 (base) and ends in 2024 (target), its analysis period in NEXT will be 2020-2025 as NEXT reads the years as 01/01/2020 or 01/01/2025,
* The number of hectares for the reference situation (or situation without project) and for the target (situation with project), Figure 6, and the number of animal heads for livestock.

Figure 6. NEXT screenshot of the ‘’deforestation’’ module



Source: FAO, 2024.

Other information in the Tier 2 section can complete these first elements. For example, in the “Forest land” module, soil management of cultivated land and pastures is to be provided in the Tier 2 section, Figure 7. The use of fire during the conversion from one land use to another must also be provided in the tier 2 section of the initial land. These different options will be seen through the exercises.

Figure 7. NEXT screenshot of the tier 2 section of the final land in the ‘’deforestation’’ module

A screenshot of a computer screen

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Source: FAO, 2024.

The “HELP” tab of the NEXT tool also allows you to find cartographic elements to determine the ecological zone of the policy or project, as well as the climate and the associated soil type when requested.

In this booklet, mitigation potential and carbon-balance will be used interchangeably. The same is true for the situation without project, the business as usual (BAU) and the reference, as well as target and the with project situation.

# Exercise #1. Development of irrigation

This exercise is based on the NDC analysis conducted in late 2023, with some simplified adjustments made for the purpose of this introduction to NEXT.

In its updated NDC (NDC 2) Serbia is considering the implementation of new irrigation systems construction and efficient use of existing ones as one the co-mitigation benefits measures.

The First Adaptation Plan states that “About 86 000 ha could benefit of new irrigation systems”, Table P5 of the first adaptation plan (draft 2015 at the time of the analysis), Ministry of Agriculture and Environmental Protection 2015. Specific geographical areas and crops are provided in that table. However, here we will simplify the measures to one region.

## Assumptions:

* The measures will be implemented in the Southern and Eastern Serbia, where the climate is defined as “cool temperate dry”
* The soil is a low activity clay soil
* 43 000 of annual croplands (without specifying the type) will benefit from irrigation. The initial soil management is described as full tillage with medium inputs. Residues are exported. See boxes 1 and 2 for explanation of the different tillage and soil inputs as described by the default IPCC methodologies.
* 43 000 of annual croplands (mainly potatoes) will be converted to orchard and benefit from irrigation and the soil management will be changed from full tillage to reduced tillage.
* The residues are exported in all situations.
* The measures should be implemented from 2015 to 2025 included.

Box 1. Definition of tillage practices to cropland according to default IPCC methodology

|  |
| --- |
| Tillage practices are divided into no-till (direct seeding without primary tillage and only minimal soil disturbance in the seeding zone; herbicides are typically used for weed control), reduced tillage (primary and/or secondary tillage but with reduced soil disturbance that is usually shallow and without full soil inversion; normally leaves surface with >30% coverage by residues at planting) and full tillage (substantial soil disturbance with full inversion and/or frequent, within year tillage operations, while leaving <30% of the surface covered by residues at the time of planting). It is *good practice* only to consider reduced and no-till if they are used continuously (every year) because even an occasional pass with a full tillage implement will significantly reduce the soil organic C storage expected under the reduced or no-till regimes, IPCC 2019. |

Source: IPCC, 2019.

Box 2. Definition of soil inputs practices for annual croplands according to default IPCC methodology

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  | | --- | --- | | **Low input** | Low residue return occurs when there is removal of residues (via collection or burning), frequent bare-fallowing, production of crops yielding low residues (e.g. vegetables, tobacco, cotton), no mineral fertilization or N-fixing crops | | **Medium input** | Representative of annual cropping with cereals where all crop residues are returned to the field. If residues are removed then supplemented with organic matter. Also requires mineral fertilization or N-fixing crop in rotations | | **Input high without manure** | Represents significantly greater crop residue inputs over medium carbon input cropping systems due to additional practices, such as production of high residue yielding crops, use of green manures, cover crops, improved vegetated fallows, irrigation, frequent use of perennial grasses in annual crop rotations, but without manure applied (see below) | | **Input high with manure** | Represents significantly higher C input over medium carbon input cropping systems due to an additional practice of regular addition of animal manure | |

Note: the input management apply only to annual crops, thus not to agroforestry systems.

Source: IPCC, 2019.

Complete NEXT following the above information and as described in Figure 8. The overall base year will be 2015, corresponding to the year these measures are assumed to start.

Figure 8. NEXT screenshot of the main menu of the [Crop&Grass] module





Source: IPCC, 2019.

## Questions:

1. What is the carbon-balance in 2025, 2030 and 2035? [Dashboard]
2. What is the variable driving GHG emissions reduction over the time? [results summary]
3. On 24 August 2022, Serbia submitted its updated Nationally Determined Contribution (NDC) for the period 2021–2030, significantly raising its climate ambition by setting a target of a 13.2% reduction in GHG emissions relative to 2010 levels—equivalent to a 33.3% reduction compared to 1990 levels—by 2030. What would be the contribution of these measures to the expected GHG emissions reduction by 2030 (pay attention to the choice of the mitigation potential, i.e. annual versus cumulated)?
4. Can you classify activities according to Scope 1 to 3?

# Exercise #2: Impact of modernizing operations and soil management practices on THE winter WHEAT carbon footprint

This exercise is a combination of a simplified study done for Central Asia (modernization of the equipment and diesel consumption) on wheat and information gathered on the use of nitrogen-based fertilizer in Serbia.

In Serbia, for the period 2017–2019, winter wheat production occupied around 17% of total arable land. Despite the yearly fluctuations in the area cultivated with wheat in Serbia, the total amount of produced grain has constantly increased over the past decades, Table 2. This is attributed to the increasing trends of yield potential as a result of the better crop management and improved genetic material, which gradually increased the yields acquired by the farmers on a global basis, Kostic et al., 2021.

Table 2. Wheat production (in tonne), harvested area (in ha) and yield (in kg/ha)

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
| Area harvested, ha | 539,813 | 559,257 | 487,399 | 567,654 | 484,205 | 493,006 | 603,275 | 631,640 | 604,748 |
| Yield, kg/ha | 3,474 | 3,333 | 4,299 | 3,642 | 3,367 | 4,211 | 3,977 | 4,259 | 3,947 |
| Production, tonne | 1,875,335 | 1,863,811 | 2,095,400 | 2,067,555 | 1,630,404 | 2,076,237 | 2,399,225 | 2,690,266 | 2,387,202 |
|  | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
| Area harvested, ha | 589,922 | 595,118 | 556,115 | 643,083 | 577,499 | 581,128 | 598,735 | 631,086 | 682,246 |
| Yield, kg/ha | 4,116 | 4,847 | 4,092 | 4,574 | 4,389 | 4,945 | 5,749 | 4,928 | 5,055 |
| Production, tonne | 2,428,203 | 2,884,537 | 2,275,623 | 2,941,601 | 2,534,643 | 2,873,503 | 3,442,308 | 3,109,827 | 3,448,700 |

Source: FAOSTAT, 2025.

Wheat-Agro is launching a strategic project focused on modernizing its operations with the aim of enhancing overall efficiency and sustainability in agriculture. The key objective is to replace outdated machinery with more efficient and environmentally friendly alternatives and adopt better soil management practices.

From the information below, we will estimate the GHG emissions generated without (reference) and with (target) the investments, and we will derive the carbon footprint of the wheat.

Table 3. Investments’ key components

|  |  |
| --- | --- |
| Company | Wheat-Agro |
| Location | The equipment will be utilized on 35 000 hectares in Vojvodina. |
| Baseline | Before the investment the company consumed on the concerned field of operations 2 631 330 litres/year of diesel fuel[[2]](#footnote-3) for an output of 5.1 tonnes of wheat per hectare |
| Objective | Modernize operations by replacing outdated machinery with modern more energy efficient alternatives |
| Equipment acquisition | * New equipment includes a self-propelled high-capacity sprayers equipped with height sensors on the boom, some combine harvester-threshers and tractors (GPS-equipped) |
| Goals | * Optimize and digitize production processes * Increase yield by 20% (currently about 5.1 tonne per hectare) and productivity of land * Reduce the use of synthetic fertilizer, from about 200 kg N/ha/year to 170 kg/ha/yr according to the study from Kostic et al, 2021[[3]](#footnote-4) * Reduce air pollutants and GHG emissions * Cut diesel consumption by 20% |

The following NEXT module will be used for this exercise: [**CROP&GRASS], [Nutrients]** **& [ENERGY] modules.** We will use the IPCC 2006 methodologies.

## Assumptions

* The climate is **Warm temperate dry** and the type of soil is **HAC**,
* The land is defined as annual cropland /wheat
* The soil management remains unchanged in both situations, i.e. full tillage, medium inputs, half of the residues are exported as they are used for livestock, the remained is left on the soil;
* We will assume a moisture content of about 14 percent;
* The loan period is 5 years starting in 2025, Figure 9.
* Given the wide range of N fertilizer type, the default option will be retained for the without project situation in the [Nutrient] module. With the investment, 80 % of the fertilizer used will be in form of urea while the remained will be considered under the default category.

## NEXT [Crop&Grass] module

Here the following information must be provided:

* Climate
* Soil type
* Initial land and it soils management practices
* Final land and its soils management practices
* Loan period/analysis period
* Initial area in hectares of land under the initial land management
* Number of hectares that will be converted from the initial land management to the final land management

Figure 9. NEXT screenshot of the main menu in the “Crop&Grass” module





Source: FAO, 2024.

Some information can be further refined in the tier 2 section. In this specific case, and according to the information shared by wheat-agro, the yield and quantity of residues will be corrected within the “tier 2” section of the module, Figure 10.

Figure 10. NEXT screenshot of the Tier 2 section in the “Crop&Grass” module





Source: FAO, 2024.

## NEXT [Nutrients] module

In this module, information on the type of climate, land use and type of fertilizer must be provided. Pay attention to the unit requested.

Also in this scenario, the type of nutrients applied to wheat will change with the loan. While in the without loan/reference scenario farmers are using generic N-based fertilizers (synthetic default), with the loan, they will also adopt urea, Figure 11.

Figure 11. NEXT screenshot of the main menu of the [Nutrient] module



Source: FAO, 2024.

## NEXT [ENERGY] module

In this module, users should work with the appropriate type of combustion, and specify the type of fuel use (in tonne per year) before the implementation of the loan, and the expected quantity at the end of the loan period. Information is also expected without the loan situation, thus is a business as usual situation, Figure 12.

Figure 12. NEXT screenshot of the main menu of the [Energy] module



Source: FAO, 2024.

## Questions:

1. What is the carbon-balance in 2030, 2044 and 2050? [Dashboard]
2. What is the variable driving GHG emissions reductions over the time? [results summary]
3. Can you classify activities according to Scope 1 to 3?
4. Estimate the annual and cumulated carbon footprint with and without the loan
5. Change the soil management practices, from full tillage to reduced tillage. What impact does it have on the overall results and on the annual and cumulated carbon footprint? Do the same changing from medium to high inputs without manure, in combination or not with the tillage. What changes can you see? What does it imply?
6. Which information and or activity data should be refined to improve the analysis, such as activities upstream or downstream the value chain?

# Annex 1. Methodologies

The NEXT tool (Nationally Determined Contribution Expert Tool) is the new generation of GHG accounting tool developed by the Food and Agriculture Organization of the United Nations (FAO) to support the annual environmental impact assessment for the agriculture forestry and other land uses (AFOLU) sector. It provides a 30-year time series of annual and cumulative estimates of carbon sequestration and GHG emission reductions resulting from actions determined by parties and stakeholders in their climate policies. NEXT was developed using the IPCC methodologies and estimates can be made using either the 2006 IPCC guidelines or the refinement 2019 IPCC 2006 both of which are supplemented by the 2013 IPCC Wetlands Supplement. The tool has been designed to provide results that directly respond to the provisions of the Enhanced Transparency Framework and support the development of NDCs as required by the terms procedures and guidelines. NEXT provides a detailed time series of results and a wide range of indicators including the social value of carbon providing an environmental and economic overview of climate actions taken to achieve mitigation goals. This tool helps countries interpret, monitor and strengthen the ambition of their climate actions. NEXT is a land accounting standard for national and subnational GHG reduction targets which measures annual changes in carbon stocks per unit of land (in hectare) as well as CH4 and N2O emissions expressed in tCO2-eq /year. NEXT provides an annual and cumulative estimate of potential changes in GHG emissions from a set of climate actions over a 30-year reading grid (Schiettecatte et al. 2022 a b).

Thanks to the 30-year reading grid NEXT can be used at multiple points in time for climate mitigation commitments including NDCs investments and projects:

- Before implementing climate action to assess potential changes in GHG emissions reductions

- During the implementation of climate action to assess and report progress towards the mitigation target and assess additional GHG emissions reductions needed to meet mitigation commitments

- at the end of the climate action period to assess the results obtained in terms of reducing greenhouse gas emissions.

The 30-year time series of results by gas by activity and by carbon reservoir helps to understand the impact of past and current climate actions and define necessary actions and corresponding international and national investments for countries to achieve their climate goals.

## 

# Annex 2. Methodologies generics

**Estimation of carbon stock in the soil**

For mineral soil carbon estimates default values are based on default references for soil organic carbon stocks (SOCref) for mineral soils to a depth of 30 cm. When SOC changes over time (land use change or management change) a default time period for transition to equilibrium is assumed to be 20 years. For mineral soils the default method is based on changes in SOC over a finite period of time (20 years) assuming that:

1. The change is calculated based on the carbon stock after the management change compared to the carbon stock under a reference condition (i.e. native vegetation that is not degraded or enhanced) see l equation 1.
2. Over time SOC reaches a stable spatial average value specific to land use and management practices and climate.
3. Changes in SOC stock during the transition to a new SOC equilibrium occur linearly over the analysis period (maximum 20 years).

Although hypothesis (ii) is widely accepted changes in soil carbon in response to management changes can often be better described by a nonlinear function. Assumption (iii) thus greatly simplifies the methodology and provides a good approximation over a period of several years (20 years maximum) (IPCC 2006; IPCC 2019).

SOC mineral = SOC ref \* F LU \* F MG \* F I \* A **Equation 1**

With:

* SOC mineral = total SOC mineral at the end of the analysis period (maximum 20 years) in tC / ha;
* SOC ref = SOC for soil that is neither managed nor degraded in tC / ha;
* F LU = Land use factor dimensionless;
* F MG = Soil work factor dimensionless;
* F I = Input factor dimensionless and
* A = Land area in ha.

**Generic approach for estimating greenhouse gases other than CO2**

For emissions of N2O and CH4 the generic approach considers the multiplication of an emission factor for a specific gas or source category with linked activity data to the emission source (this can be the number of animals in the area or the unit mass) see equation 2. Emissions of N2O and CH4 are either associated with a category or under -specific land use category (e.g. CH4 emissionsfrom rice) or are estimated from aggregated project data (e.g. CH4 emissions from livestock and N2O emissions from fertilizers management of manure and coastal aquaculture).

Emissions = AD \* EF **Equation 2**

With:

* AD = Activity data
* EF = Emission factor.

Emissions from biomass combustion are calculated based on the generic methods proposed in section 2.4 (see pages 2.40-2.43 IPCC 2006) and mainly equation 2.27 of the IPCC 2019 (IPCC 2019). In brief the emission of individual GHGs (N2O or CH4) is obtained as follows equation 3:

GHGfire = A \* MB \* Cf \* Gef \* 10-3  Equation 3

With:

* GHGfire = quantity of GHG emitted by fire per ton of CH4 and N2O,
* A = area burned in ha,
* MB = quantity of available biomass in tonne/ha,
* Cf = combustion factor dimensionless,
* Gef = emission factor in g/kg ms. burned.

M B theoretically includes litter and dead wood assumed to be zero by default except in the event of land change. For the combustion factors we use the default factors (level 1) from tables 2.5 and 2.6 of the IPCC 2006 for Gef and Cf respectively.

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1. Energy Supply – IEA: <https://www.iea.org/countries/serbia> [↑](#footnote-ref-2)
2. We assumed an average density for diesel of 0.814 kg/l. [↑](#footnote-ref-3)
3. Based on the common farmers’ practice in the region, approximately 50 kg of N ha−1 are applied as basic fertilization at sowing and up to 150 kg of N ha−1 are top-dressed in spring.  [↑](#footnote-ref-4)