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SCALA programme workshop report: Cambodia – Exercises and training on the Nationally Determined Contribution Expert Tool (NEXT)

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Abbreviation

AFOLU	agriculture, forestry and other land use
AGB	above-ground biomass
AR5	Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC)
BAU	business-as-usual
BGB	below-ground biomass
C	conditional
CSA	climate-smart agriculture
DAP	diammonium phosphate
E	exponential
FAO	Food and Agriculture Organization of the United Nations
FAOSTAT	FAO Statistics Division
GDP	gross domestic product
GHG	greenhouse gas
GWP	global warming potential
HAC	high activity clay soil
HWP	harvested wood product
IPCC	Intergovernmental Panel on Climate Change
IPPU	industrial processes and product use
LAC	low activity clay soil
LTS4CN-LEDS	long-term strategy for carbon neutrality
NC	national communication
NDC	nationally determined contribution
NEXT	Nationally Determined Contribution Expert Tool
nGHGi	national greenhouse gas inventories
O	observed
PA	Paris Agreement
REDD+	reducing emissions from deforestation and forest degradation in developing countries
S	sigmoid

SOC	soil organic carbon
U	unconditional
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change

Chemical formulae and elements, units of measurement

C	carbon
CH_4	methane
CO_2	carbon dioxide
CO_2-eq	carbon dioxide equivalent
N_2O	nitrous oxide
t	metric tonne
tC	tonne of carbon
tCO_2-eq	tonne of carbon dioxide equivalent
td.m	tonne of dry matter

About this booklet

The Food and Agriculture Organization of the United Nations (FAO) delivered a comprehensive training on the **Nationally Determined Contribution Expert Tool (NEXT)** to representatives from the Ministry of Agriculture, Forestry, and Fisheries (MAFF) in October 2024, following the validation of Cambodia's zero draft Climate Change Priorities Action Plan III (CCPAP III) for the 2023–2030 period. The training, organized by FAO Cambodia in partnership with MAFF, took place 22–25 October, 2024, at the Regency Angkor Hotel in Siem Reap. It brought together 30 participants from various institutions, including MAFF, the Royal University of Agriculture (RUA), the PREK LEAP National Institute of Agriculture, the Ministry of Environment (MoE), and FAO staff.

The primary goal of the training was to strengthen the participants' capacity to apply NEXT for estimating greenhouse gas (GHG) emissions within the Agriculture, Forestry, and Other Land Uses (AFOLU) sector. This would also support the development, monitoring, and reporting of climate policies in alignment with the United Nations Framework Convention on Climate Change (UNFCCC) requirements. The training focused on the technical application of NEXT, specifically for GHG emissions estimation, emission reduction potential, and scenario development. Participants were trained on essential data collection methods, including Tier 2 for key category mitigation actions, and how to use NEXT in preparation of the nationally determined contribution for year 2025 (NDC 3.0).

The training was part of the **Scaling up Climate Ambition on Land Use and Agriculture through Nationally Determined Contributions and National Adaptation Plans (SCALA) programme – led by FAO and the United Nations Development Programme (UNDP)** – which aims to help countries translate their NDCs and national adaptation plans (NAPs) into transformative climate actions within the land use and agriculture sectors. **SCALA supports Cambodia in meeting its climate change mitigation commitments under the Paris Agreement.**

The collaboration between the FAO NEXT team and Cambodia began in 2021 when the Cambodian government selected NEXT for developing its long-term forestry strategy. Since then, FAO Cambodia and the government have collaborated on various programs, including SCALA.

The objective of this training was to strengthen Cambodia's capacity for validating, implementing, and tracking the CCPAP III once validated and approved for the AFOLU sector. Specific training goals included:

1. Engaging in a participatory process to discuss the assumptions, scenarios, policies, and measures in the CCPAP III, with the aim of refining and validating them.

2. Building the capacity of MAFF, the Ministry of Environment (MoE), and FAO Cambodia staff on NEXT and fostering a network for its institutionalization.
3. Reviewing the available data at different geographical scales and identifying additional data required to support the estimation and tracking of policies and measures in the CCPAP III.
4. Designing templates to prioritize data collection for climate change mitigation actions with high transformative potential.

This booklet serves as a follow-up to the training, offering a series of seven exercises to help participants deepen their understanding of NEXT and its application in real-world climate policy development. These exercises are designed to enhance technical expertise and improve participants' ability to support effective climate action initiatives. All sources are cited in the appendices or page notes. The final version of booklet of exercises was prepared between October and December 2024, and the analyses and results were updated using the NEXT version prior to the publication of the first biennial transparency report and the NDC 3.0,[1] for which one NEXT was used for the agricultural sector.

ABOUT SCALA

The Scaling up Climate Ambition on Land Use and Agriculture through Nationally Determined Contributions and National Adaptation Plans (SCALA) programme supports countries to translate priorities in their NDCs and NAPs into transformative climate actions in the land-use and agriculture sectors in more than 20 countries, including Cambodia. In collaboration with NEXT, SCALA is supporting Cambodia to meet the present and future climate change mitigation commitments under the Paris Agreement (PA).

[1] The date of the NEXT version is available in the "About" worksheet. It is advised to visit the NEXT webpage and download the tool to work with the most up-to-date version.

Overview of NEXT

The NEXT (Nationally Determined Contribution Expert Tool) is a new generation greenhouse gas accounting tool developed by the FAO to support the annual environmental impact assessment for the AFOLU sector. It provides a 30-year time series of annual and cumulative estimates of carbon uptake and greenhouse gas (GHG) emission reductions resulting from actions determined by the Parties in their climate policies. NEXT has been developed using the methodologies of the Intergovernmental Panel on Climate Change (IPCC), and estimates can be made using either the 2006 IPCC Guidelines or the 2019 refinement of the 2006 IPCC Guidelines, both of which are supplemented by the 2013 IPCC Wetlands Supplement. The tool has been designed to provide results that respond directly to the provisions of the Enhanced Transparency Framework and support the development of nationally determined contributions (NDCs) as required by the modalities, procedures and guidelines under the Paris Agreement (PA).

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 meet mitigation targets. This tool helps countries to 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 hectares), as well as methane (CH_4) and nitrous oxide (N_2O) emissions, expressed in tonne of carbon dioxide equivalent (tCO_2-eq)/year. NEXT provides an annual and cumulative estimate of potential changes in GHG emissions from a range of climate actions over a 30-year time horizon (Schiettecatte *et al.*, 2022 a, b).

The tool can be used at several points in time of implementing climate actions, including NDCs, investments and projects:

- before the implementation of a climate action, to assess potential changes on GHG emission reductions,
- during the implementation of a climate action, to assess and report on progress towards the mitigation goal, and assess the additional GHG emission reductions needed to meet mitigation commitments,
- at the end of the climate action period, to assess the results achieved in terms of GHG emission reductions.

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 to define the actions and international and national investments needed, if countries are to meet their climate targets. The basic concept about the methodology can be found in Annex 2; for the full description of the tool please refer to the technical manual (Schiettecatte *et al.*, 2022a).

Emissions scenarios: Cambodia

The working data used in this manual comes from the climate change priority actions plan 2023–2030 (CCPAP III), the long-term strategy for carbon neutrality (LTS4CN, The General Secretariat of the National Council for Sustainable Development/Ministry of Environment, the Kingdom of Cambodia, 2021) such as the national communication (NC), biennial update report (BUR1; The National Council for Sustainable Development of the Kingdom of Cambodia, 2020) and the nationally determined contribution (NDC2) (The General Secretariat of the National Council for Sustainable Development/Ministry of Environment, the Kingdom of Cambodia, 2020), as well as discussions with national experts.

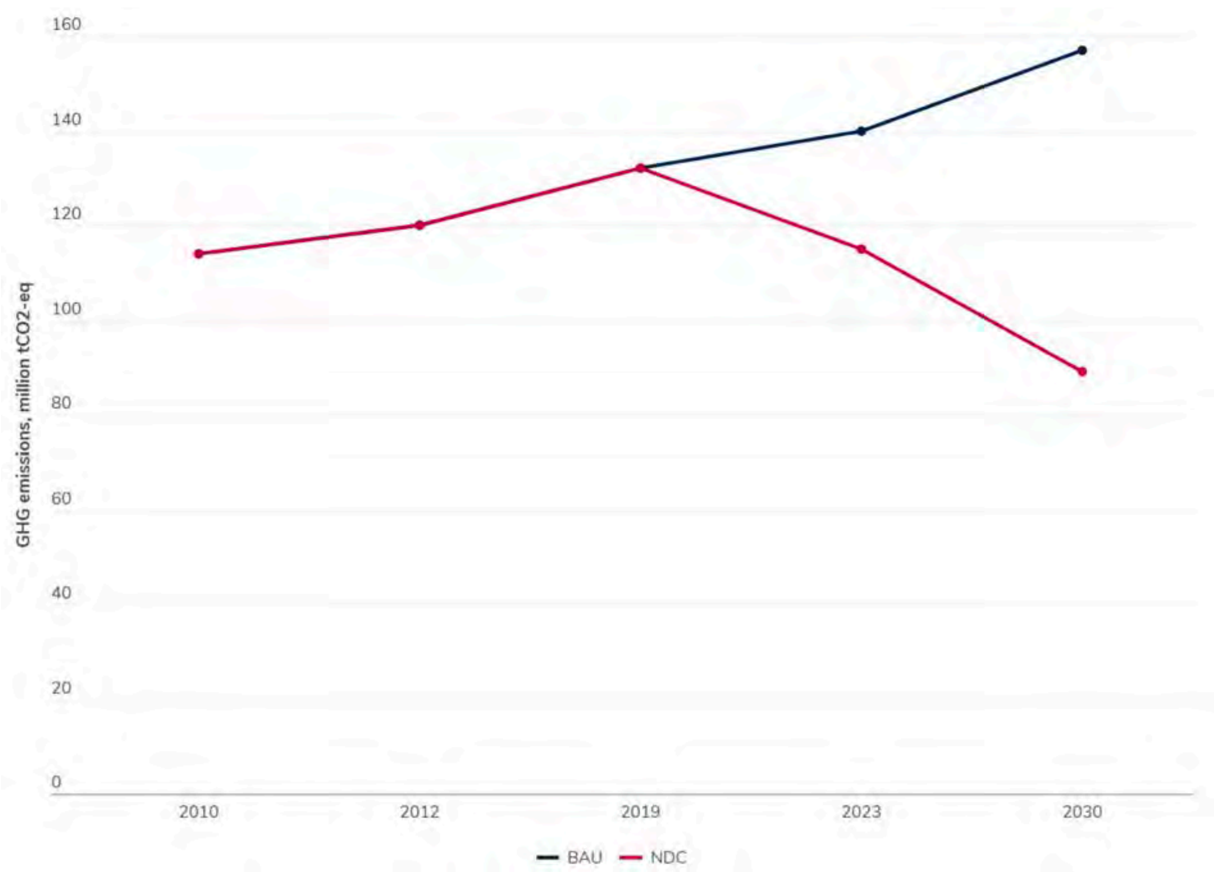
Cambodia became a Party to the UNFCCC on 17 March 1996, following its ratification in December 1995. The country ratified the Kyoto Protocol in 2002, which entered into force in 2005, and signed the Paris Climate Agreement on 22 April 2016, officially ratifying it on 6 February 2017. Committed to addressing climate change, Cambodia aims to transition to a climate-resilient, low-carbon, and sustainable development path. Despite being one of the smallest contributors to global emissions, Cambodia is highly vulnerable to the impacts of climate change. The country's first NDC (NDC1) was submitted in 2015, with an updated NDC in 2020 (NDC2), setting ambitious targets to reduce emissions and enhance resilience in line with national policies (Figure 1). Currently, the Forestry, Other Land Use (FOLU) sector is the largest source of emissions in Cambodia. By 2050, the energy sector is expected to account for 53 percent of total emissions, followed by agriculture at 22 percent, and FOLU at 14 percent. According to the LTS4CN modeling, Cambodia could achieve carbon neutrality by 2050, with the FOLU sector contributing a carbon sink of 50 million tCO_2-eq (Table 1, Figure 2).

Table 1. **Projection of Cambodia's GHG emissions by sector in 2050, BAU and LTS4CN scenarios. All emissions are in million tCO_2-eq**

Sector	BAU scenario	Emissions reduction in LTS4CN scenario	Emissions balance in LTS4CN scenario
Agriculture	34.9	-15.6	19.3
Energy	82.7	-54.3	28.4
FOLU	21.2	-71.4	-50.2
IPPU	10.7	-9.1	1.6
Waste	6.5	-5.3	1.2
Total	**156**	**-155.7**	**0.3**

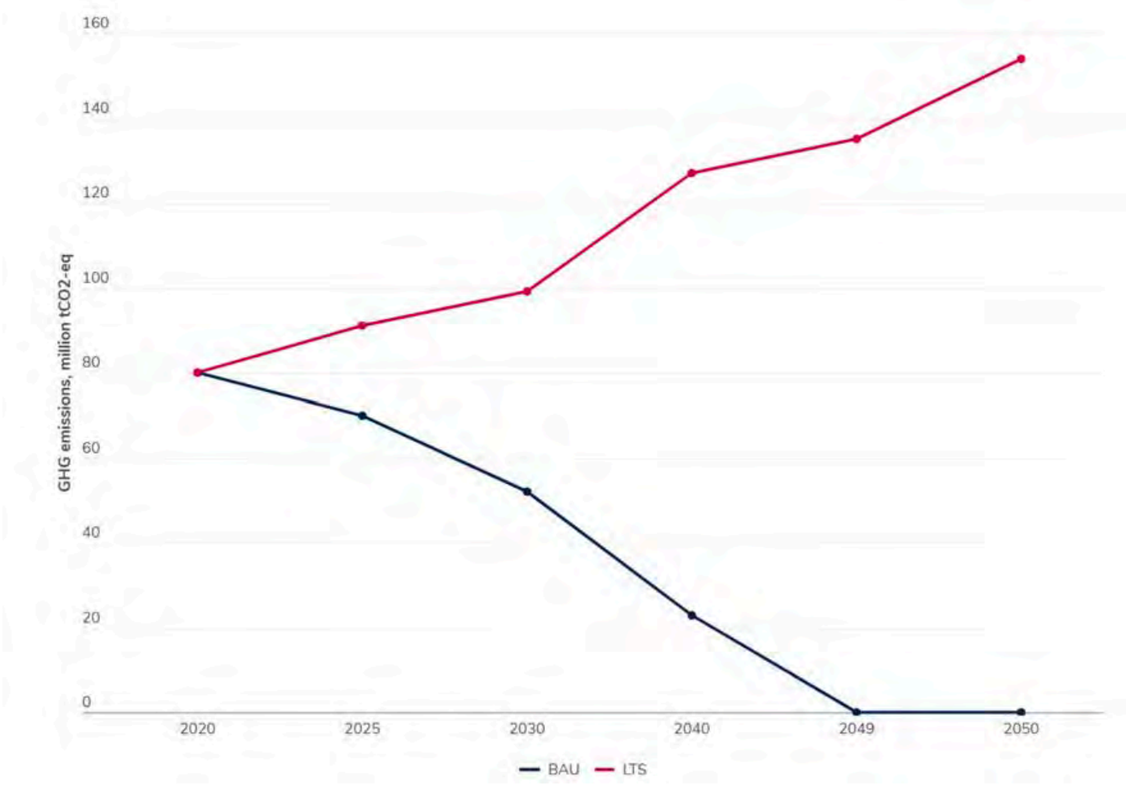
Source: Authors' elaboration based on **The General Secretariat of the National Council for Sustainable Development/Ministry of Environment, the Kingdom of Cambodia**. 2021. *Cambodia's Long-Term Strategy for Carbon Neutrality*.

Figure 1. **Cambodia's BAU and target pathways in the Nationally Determined Contribution, 2020**



Source: Authors' elaboration based on **The General Secretariat of the National Council for Sustainable Development/Ministry of Environment, the Kingdom of Cambodia.** 2020. *Cambodia's Updated Nationally Determined Contribution*.

Figure 2. **Cambodia's BAU and LTS4CN pathways in the Long-Term Strategy for Carbon Neutrality, 2020**



Source: Authors' elaboration based on **The General Secretariat of the National Council for Sustainable Development/Ministry of Environment, the Kingdom of Cambodia.** 2021. *Cambodia's Long-Term Strategy for Carbon Neutrality*.

Before starting the analyses:

This manual was produced to estimate the impact on climate change mitigation of a set of climate actions by Cambodia for the AFOLU sector. The model used is based on the methodology utilized in NEXT, as described in Annex 2.

This manual was produced to estimate the various mitigation strategies using the "Nationally Determined Contribution Expert Tool" NEXT model, described in the previous section. In this manual, unconditional mitigation measures will be placed under the "U" category in NEXT, while conditional measures will be placed under the "C" category. In this booklet, mitigation potential and carbon-balance will be used interchangeably. Similarly, the terms "without project", "business as usual (BAU)" and "reference" scenarios will be used interchangeably, as will "target" and the "with project" scenarios.

There are also scenarios with additional measures that represent the government's intention to increase the reduction in emissions. These additional measures can be identified from the analysis of a long-term strategy. They may also be different potential options for reducing GHG emissions in certain categories of the AFOLU sector.

The exercises are also aligned with the recommendations of the Paris Agreement's "modalities, procedures and guidelines", i.e. the use of the 2006 IPCC[2] for estimates of changes in carbon stocks and other GHGs, and the IPCC Fifth Assessment Report's 100-year global warming potentials, GWP-CH = 28; GWP-N_2O = 265 (Myrhe *et al.*, 2013).

Before carrying out the analysis, a certain number of parameters must be informed in NEXT under the "HOME" tab, which include:

- the name of the country where the activities (projects, policies, or climate actions) are implemented,
- the overall base year, or "Base year" for all analyses: the year in which the earliest activity begins,
- the methodology for estimating changes in carbon stock and GHG emissions: IPCC 2006 & IPCC 2013 or IPCC 2019 & IPCC 2013, and
- the GWP over 100 years: AR5 without climate-carbon feedback, Figure 3.

Figure 3. NEXT screenshot of the "home" tab for Cambodia

Source: Authors' elaboration based on **Schiettecatte, L.-S., Audebert, P., Umulisa, V., Dionisio, D. and Bernoux, M.** 2022a. *Technical guidance of the Nationally Determined Contribution Expert Tool (NEXT)*. Rome, FAO.

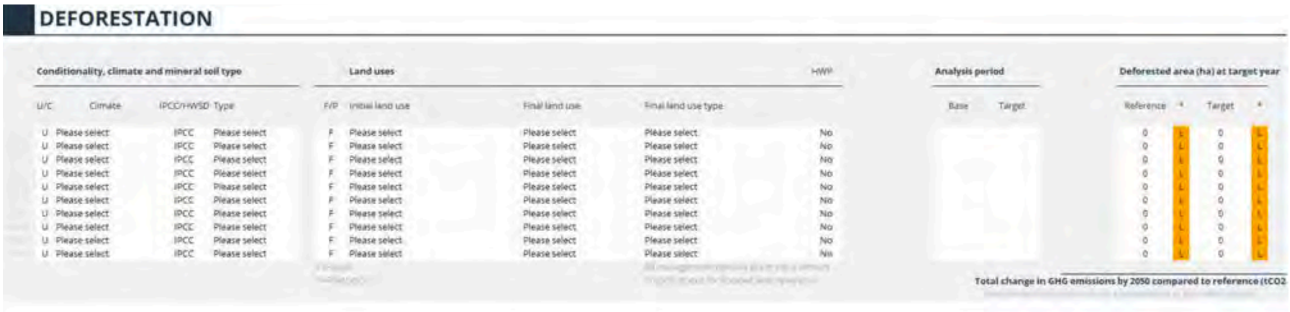
In the different modules, the user must specify some basic information to estimate changes in carbon stocks and GHG emissions. The information includes:

- the type of soil according to the IPCC or Harmonized World Soil Database (HWSD) classification,
- the climate according to the IPCC classification,

[2] At the time of the training, Cambodia was still using IPCC 2006 to report to UNFCCC.

- 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 or 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 4, and the number of animal heads for livestock.

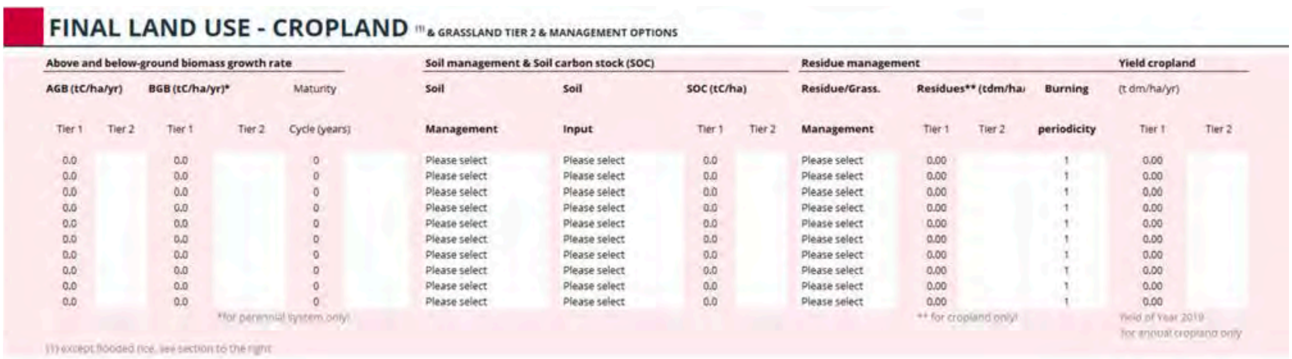
Figure 4. **NEXT screenshot of the main menu in the "deforestation" module**



Source: Authors' elaboration based on **Schiettecatte, L.-S., Audebert, P., Umulisa, V., Dionisio, D. and Bernoux, M.** 2022a. *Technical guidance of the Nationally Determined Contribution Expert Tool (NEXT)*. Rome, FAO.

Other information in the Tier 2 section may need to be filled to complete the GHG estimation of the activity. For example, in the "Forest land" module, soil management of cultivated land and pastures is to be provided in the Tier 2 section, Figure 5. 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.

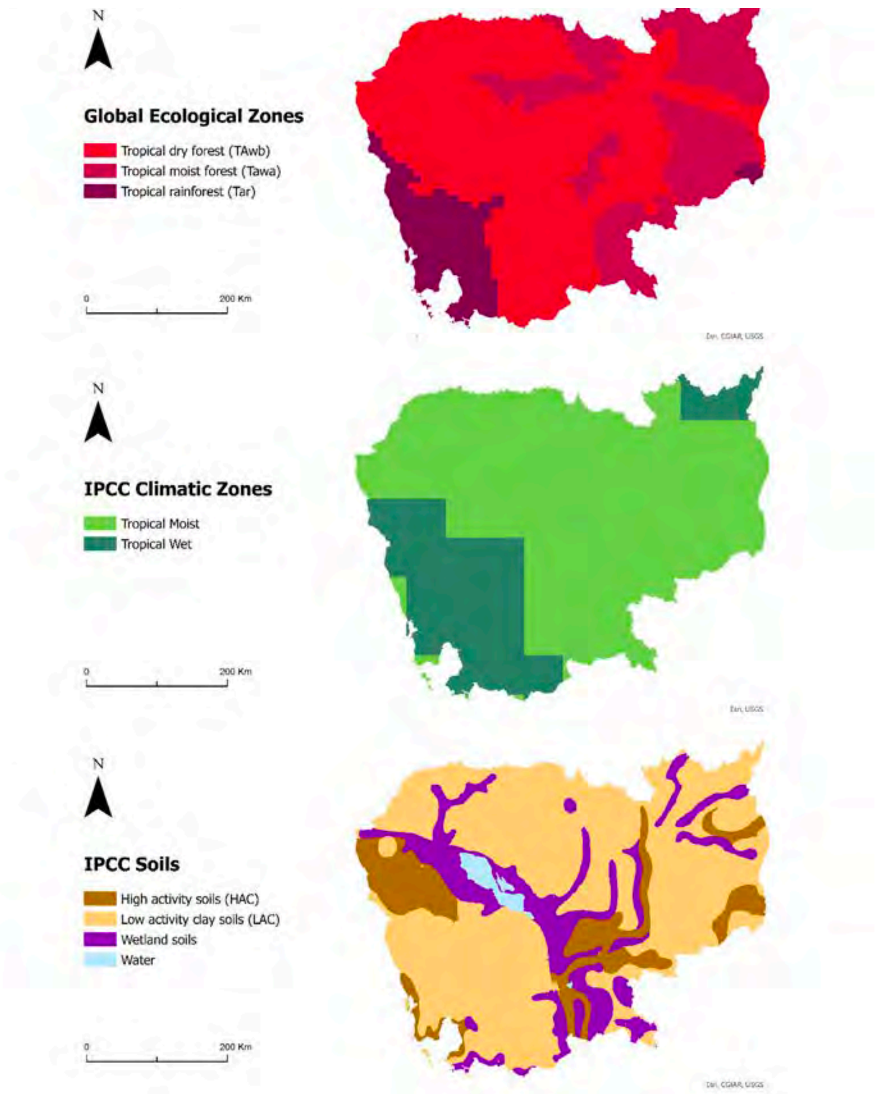
Figure 5. **NEXT screenshot of the Tier 2 section in the "deforestation" module**



Source: Authors' elaboration based on **Schiettecatte, L.-S., Audebert, P., Umulisa, V., Dionisio, D. and Bernoux, M.** 2022a. *Technical guidance of the Nationally Determined Contribution Expert Tool (NEXT).* Rome, FAO.

The "HELP" tab of the NEXT tool also allows the user to cartographically determine the ecological zone of the implemented activity, as well as the climate and the associated soil type, Figure 6.

Figure 6. **(i) IPCC global ecological zones map, (ii) climate zones map, and (iii) soil distribution map for Cambodia**



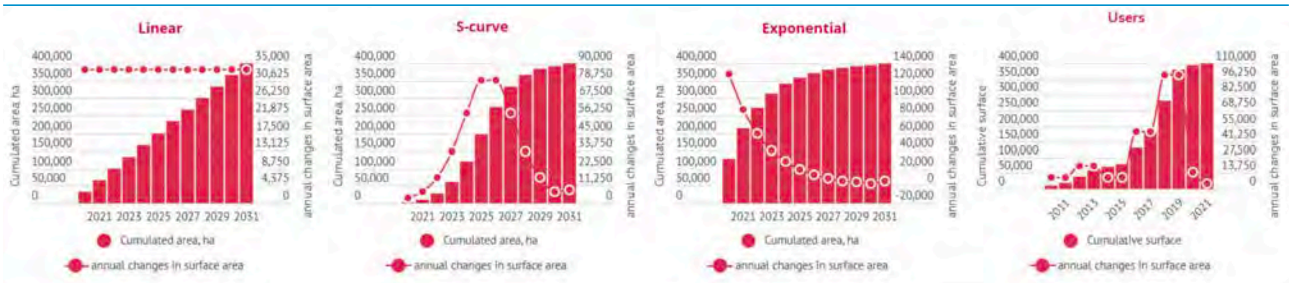
Note: *The boundaries and names shown and the designations used on these maps do not imply the expression of any opinion whatsoever on the part of FAO concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers and boundaries. Dashed lines on maps represent approximate border lines for which there may not yet be full agreement.*

Source: Authors' elaboration based on: (i) for global ecological zones, **FAO.** 2012. *Global ecological zones for FAO forest reporting: 2010 update*. Forest Resources Assessment Working Paper, 179; (ii) for climate, **IPCC.** 2019. 2019 *Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Calvo Buendia, E., Tanabe, K., Kranjc, A., Baasansuren, J., Fukuda, M., Ngarize S., Osako, A., Pyearozhenko, Y., Shermanau, P. and Federici, S. (eds). Published by IPCC, Switzerland; and (iii) for soil, **IPCC.** 2006. *2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 4: Agriculture, Forestry and Other Land Use*; **IPCC.** 2019. *2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Calvo Buendia, E., Tanabe, K., Kranjc, A., Baasansuren, J., Fukuda, M., Ngarize S., Osako, A., Pyearozhenko, Y., Shermanau, P. and Federici, S. (eds). Published by IPCC, Switzerland; and **Batjes, N.H.** 2010. *IPCC default soil classes derived from the Harmonized World Soil Data base (Ver. 1.1)*. Report 2009/02b, Carbon Benefits Projects (CBP) and ISRIC – World Soil Information, Wageningen (with dataset).

Dynamic of implementation

NEXT proposes different dynamics of implementation of the climate actions (Figure 7), i.e. linear, S-shaped curve, exponential and "users" (defined a O in the dropdown list). A linear dynamic considers a constant annual implementation of the activities. The S-shaped curve considers a smooth implementation of the climate action, followed by a strong increase, before reaching full implementation of the action. The exponential dynamic considers a steep implementation of the climate action at its beginning before reaching a plateau by its end. The Observed dynamic can be used when none of the previous ones reflect the implementation of the climate actions (a project, a policy, an investment), Figure 8. This also can be used for the project monitoring given user can specify in the "users activity data" the annual land use changes and or land management changes from the project implementation.

Figure 7. Dynamic of implementation available in NEXT, showing annual and cumulated implemented areas



Authors' elaboration based on **Schiettecatte, L.-S., Audebert, P., Umulisa, V., Dionisio, D. and Bernoux, M.** 2022a. *Technical guidance of the Nationally Determined Contribution Expert Tool (NEXT)*. Rome, FAO.

By default, the dynamic of implementation is L (for linear), but it can be changed according to users' needs to S for sigmoid, E for exponential or O for Users, Figure 8. When using the dynamic "O" users will have to enter annual changes in the corresponding line of the activity in the "Users activity data" module. The sum of annual changes will have to match the corresponding area entered for the activity.

Figure 8. NEXT screenshot of the afforestation module to illustrate the different dynamics of implementation

Land uses					Analysis period		Reforested area (ha) at target year			
Initial land use	Initial land use type	Final land use	F/P/R	Rotation, yrs*	Base	Target	Reference	*	Target	*
Grassland	Please select	Tropical shrubland	F	3	2010	2021	339.225	L	339.225	L
Annual cropland	Please select	Tropical shrubland	F	3	2010	2021	169.613	L	169.613	S
Grassland	Please select	Tropical shrubland	F	3	2021	2031	0	L	30.839	E
Annual cropland	Please select	Tropical shrubland	F	3	2021	2031	0	L	15.419	O
Grassland	Please select	Tropical mountain system	F	3	2021	2031	0	L	277.548	L
Annual cropland	Please select	Tropical mountain system	F	3	2021	2031	0	L	138.774	L
Grassland	Please select	Tropical shrubland	F	3	2021	2031	0	L	135.239	L
Annual cropland	Please select	Tropical shrubland	F	3	2021	2031	0	L	67.619	L
Grassland	Please select	Tropical mountain system	F	3	2021	2031	0	L	1.217.149	L
Annual cropland	Please select	Tropical mountain system	F	3	2021	2031	0	L	608.575	L

Source: Authors' elaboration based on **Schiettecatte, L.-S., Audebert, P., Umulisa, V., Dionisio, D. and Bernoux, M.** 2022a. *Technical guidance of the Nationally Determined Contribution Expert Tool (NEXT)*. Rome, FAO.

Exercise 1. Climate change mitigation potential from the AFFOR strategy

This exercise is aligning with the AFFOR scenario elaborated within the LTS4CN. This is the afforestation scenario which will establish 1.6 million ha of forest plantations on already cleared and degraded lands. In this exercise we will focus on the afforestation/reforestation of about 1.1 million ha (pine + natural forest), which are under the Ministry of Agriculture, Forestry and Fisheries (MAFF).

The following NEXT module will be used for this exercise: **FOREST** using the "afforestation/reforestation" sub-module.

Assumptions:

1. The climate is **"Tropical moist"** and the type of soil is **"LAC soil",**
2. Initial land use is assumed to be **"Annual cropland set-aside",** used as a proxy, without specifying information of the soil "condition" to remain conservative, see Equation 1 in Annex 2,
3. The afforestation will be disaggregated into 2 areas: one for pine plantations (**550 000 ha**) and one for natural forest (**550 000 ha**) represented by the most common ecological zones, i.e. see the map in the "HELP" module of NEXT,
4. Both will be represented as **"Tropical dry forest",**
5. The biomass growth rate of pine plantations will be corrected in Tier 2,
6. We will assume a survival growth rate of **80 percent,**[3]
7. The dynamic of implementation is **sigmoid,** and
8. The period of implementation will be **2023–2050,** Figure 9.

Figure 9. **NEXT screenshot of the main menu in the "afforestation/reforestation" module**

Source: Authors' elaboration based on **Schiettecatte, L.-S., Audebert, P., Umulisa, V., Dionisio, D. and Bernoux, M.** 2022a. *Technical guidance of the Nationally Determined Contribution Expert Tool (NEXT)*. Rome, FAO.

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[3] The percentage of survival will be integrated into the biomass growth rate.

Tier 2

1. For the pine plantations, we will use the default above-ground biomass (AGB) growth rate provided in Table 4.10 of the IPCC 2019 report for tropical dry forests (pine trees) in Africa, North America and South America. The growth rates from Table 2 will be averaged for this analysis,
2. We will use 0.47 as the fraction of carbon present within dry matter (see Table 4.3, IPCC, 2006 & IPCC, 2019),
3. The below-ground biomass (BGB) will be corrected accordingly, see Box 1, and
4. The ratio R used can be calculated with the Tier 1 values provided by NEXT.

Table 2. **Above-ground net biomass growth rate in t of dry matter per hectare per year**

Continent	Above-ground net biomass growth ≤ 20 years	Above-ground net biomass growth > 20 years
Africa	6	9
North and South America	7	7

Source: Authors' elaboration based on Table 4.10, **IPCC.** 2019. 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Calvo Buendia E., Tanabe K., Kranjc A., Baasansuren J., Fukuda M., Ngarize S., Osako A., Pyearozhenko Y., Shermanau P., & Federici S. (eds). Published by IPCC, Switzerland.

Essential point to be highlighted

The below-ground biomass (BGB) is derived from the product above-ground biomass (AGB) by the ratio R of below-ground biomass to above-ground biomass, expressed in tonnes root dm/ tonnes shoot dm (dm being dry matter), as AGB*R. This rate is specific to each ecological zone and continent, and with its AGB they are defined by the IPCC (default value). If a Tier 2 value is used for AGB, the BGB must be adjusted.

Analysis questions:

1. What is the carbon-balance in 2030, 2035 and 2049? *[Dashboard]*
2. What is the variable driving carbon sequestration? *[Results summary]*
3. How many hectares are reforested by 2030, 2035 and 2049? *[Dashboard] & [Land & Soc indicators]*
4. Change the dynamic of implementation to linear and then exponential. What is the impact that you observe on the carbon-balance by 2049 and the annual land use changes? *[Dashboard] & [Users activity data]*
5. Which indicators could you use to track the implementation of that policy?
6. Which information and/or activity data should be refined to improve the analysis?

Exercise 2. Improving soil organic carbon

CCPAP 2030 Priority action 001 CROP/06: Promote Conservation Agriculture (cover crops) to improve soil organic carbon.

Rationale CCPAP III: In Cambodia, 6.3 million people were living on degraded agricultural land in 2010 – an increase of 38 percent in a decade, bringing the share of rural residents who inhabit degraded agricultural land up to 55 percent of the total rural population. Land degradation can severely influence populations' livelihoods by restricting people from vital ecosystem services (including food and water), increasing the risk of poverty. Land degradation leads to a reduction in the provision of ecosystem services that take different forms – deterioration in food availability, soil fertility, carbon sequestration capacity, wood production, groundwater recharge, etc. – with significant social and economic costs to the country. The returns on taking action against land degradation are estimated at USD 3 for every dollar invested in restoring degraded land in Cambodia.

This action is designed to promote conservative agriculture by promoting intercropping, covering crops, and increasing soil organic carbon (SOC) stock in cropland. By implementing these practices, farmers can not only improve soil health and crop performance but also contribute to sustainable land management and climate change mitigation. Increasing the SOC stock in cropland helps sequester CO_2 from the atmosphere, reducing GHG emissions. This approach aligns with the principles of conservative agriculture, aiming to protect natural resources while ensuring long-term agricultural productivity. This action also aligns with the National Cassava Policy 2020–2025 (Ministry of Commerce, General Directorate of Trade Promotion & Trade Policy Department of the Royal Government of Cambodia, 2020).

The following exercise will focus on the SOC enhancement from a case study on cassava.

A case study of the cassava production

In its National Cassava Policy 2020–2025, (Ministry of Commerce, General Directorate of Trade Promotion & Trade Policy Department of the Royal Government of Cambodia, 2020), Cambodia is considering capitalizing on the potential of cassava as a crop for resource-poor smallholder farmers to improve their livelihoods. The growing increase in cassava production is linked to China's demand for dry chips and starch. As a result, cassava has been grown mostly along borders and over time, spread into areas where land is available, such as cashew nut and rubber plantations and/or abandoned land and newly deforested plots (Ministry of Commerce, General Directorate of Trade Promotion & Trade Policy Department of the Royal Government of Cambodia, 2020).

The following exercise will focus on the SOC enhancement from a case study on cassava.

Assumptions:

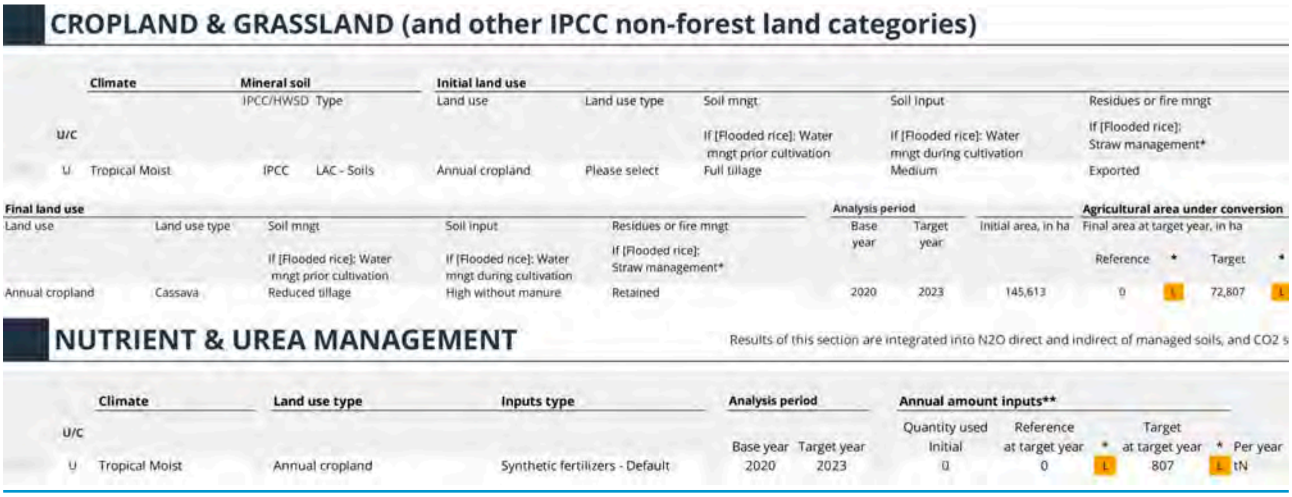
1. The climate is **"Tropical moist"** and the type of soil is **"LAC soil",**
2. According to FAO, 2024, over the period 2020–2023, the harvested area of cassava increased by 145 613 ha, Table 3,
3. We will consider that the initial land was **"Annual cropland"** (mainly food crops and/or land with low economic return) before conversion to cassava,
4. The initial soil management practices are described as the following: **"Full tillage", "Medium inputs" and "Residues exported",**
5. The following management practices will be adopted on 50 percent of the **cassava** area (final land): **"Reduced tillage" and "High input without manure"** as the residues will be **"Retained"** and there will be **crop rotation** (such as soybeans, legumes),
6. On the remaining areas, there will be no changes in the soil management practices but about **73.85 kg/ha** of NPK (nitrogen, phosphorus, and potassium), (15:15:15) will be applied once a year, and
7. The implementation is **linear** between **2020–2023,** Figure 10.

Table 3. **Information on cassava production in Cambodia from 2015 to 2022**

Cassava	2015	2016	2017	2018	2019	2020	2021	2022
Cultivation area, ha	546 400	643 000	612 900	650 500	652 500	612 994	718 378	758 607
Production, tonne	13 298 100	14 175 500	13 817 300	13 750 100	13 512 800	13 757 218	17 048 501	17 698 784
Yield, tonne/ha	24.34	22.05	22.54	21.14	20.71	22.44	23.73	23.33

Source: Authors' elaboration based on **FAO,** 2024. FAOSTAT: Crops and livestock products. [Accessed on 25 August 2024]. https://www.fao.org/faostat/en/#data/QCL. Licence: CC-BY-4.0

Figure 10. **NEXT screenshot of the main menus in the "CROP&GRASS" and "NUTRIENTS" modules for cassava plantations**



CROPLAND & GRASSLAND (and other IPCC non-forest land categories)

U/C	Climate	Mineral soil: IPCC/HWSD	Mineral soil: Type	Initial land use: Land use	Land use type	Soil mngt (If [Flooded rice]: Water mngt prior cultivation)	Soil input (If [Flooded rice]: Water mngt during cultivation)	Residues or fire mngt (If [Flooded rice]: Straw management*)
U	Tropical Moist	IPCC	LAC - Soils	Annual cropland	Please select	Full tillage	Medium	Exported

Final land use: Land use	Land use type	Soil mngt (If [Flooded rice]: Water mngt prior cultivation)	Soil input (If [Flooded rice]: Water mngt during cultivation)	Residues or fire mngt (If [Flooded rice]: Straw management*)	Analysis period: Base year	Target year	Initial area, in ha	Agricultural area under conversion – Final area at target year, in ha: Reference	*	Target	*
Annual cropland	Cassava	Reduced tillage	High without manure	Retained	2020	2023	145,613	0	L	72,807	L

NUTRIENT & UREA MANAGEMENT

Results of this section are integrated into N2O direct and indirect of managed soils, and CO2 s

U/C	Climate	Land use type	Inputs type	Analysis period: Base year	Target year	Annual amount inputs**: Quantity used Initial	Reference at target year	*	Target at target year	*	Per year
U	Tropical Moist	Annual cropland	Synthetic fertilizers - Default	2020	2023	0	0	L	807	L	tN

Source: Authors' elaboration based on **Schiettecatte, L.-S., Audebert, P., Umulisa, V., Dionisio, D. and Bernoux, M.** 2022a. *Technical guidance of the Nationally Determined Contribution Expert Tool (NEXT).* Rome, FAO.

Intermediary questions:

1. What is the carbon-balance in 2025, 2030 and 2035? *[Dashboard]*
2. What is the variable driving carbon sequestration? *[Results summary]*
3. Where do the N_2O emissions come from?
4. If this policy was integrated into the NDC 3, what types of indicators could you use to track and report on its implementation? *[Land & SOC indicators]*

Cashew nuts

As part of the CCPAP III, one of the activities aims to improve the cashew nuts sector. Cambodia seeks to expand 400 000 ha of cashew nut tree plantations from 2023 to 2030 and implement changes in soil management practices on already existing 100 000 ha.[4] The exercise will focus on the expansion of the cashew plantations.

Assumptions:

1. For all activities, the climate is **"Tropical moist"** and the soil is a **"LAC soil",**
2. We will consider that for the period **2023–2031, 400 000 hectares** of cashew trees will be planted on agricultural land (50 percent) as intercropping, and set-aside land (50 percent) as monoculture,
3. For the initial land we will retain **"Full tillage" and "Low inputs"** for the agricultural systems. **Residues will be left** on the field,

[4] The cashew nut production and harvested areas are currently not mentioned in FAOSTAT.

4. For the **cashew trees planted on agricultural land,** the new system is categorized as intercropping, with cassava, mung bean or soybean for the first 3 years, and then turmeric, lemon grass or galangal.[5] This corresponds to the **"Perennial agroforestry"** system **"Alley cropping"**,
5. For the **cashew trees planted on set-aside land** we will use **"Tea camelia"** as a proxy. The AGB and BGB growth rate will be corrected in Tier 2 from a similar system,
6. In both cashew systems, no soil management will be considered, and the **residues are "Retained"**,
7. The conversion will be done following a **sigmoid** dynamic of implementation between **2023–2031,** Figure 10.

Figure 11. **NEXT screenshot of the main menus in the "CROP&GRASS" and "NUTRIENTS" modules for cashew plantations**

CROPLAND & GRASSLAND (and other IPCC non-forest land categories)

U/C	Climate	Mineral soil: IPCC/HWSD	Mineral soil: Type	Initial land use: Land use	Land use type	Soil mngt (If [Flooded rice]: Water mngt prior cultivation)	Soil input (If [Flooded rice]: Water mngt during cultivation)	Residues or fire mngt (If [Flooded rice]: Straw management*)
U	Tropical Moist	IPCC	LAC - Soils	Annual cropland	Please select	Full tillage	Medium	Exported
U	Tropical Moist	IPCC	LAC - Soils	Annual cropland	Cassava	Full tillage	Low	Retained
U	Tropical Moist	IPCC	LAC - Soils	Annual cropland set-aside	Please select	Full tillage	Low	Retained

Final land use: Land use	Land use type	Soil mngt (If [Flooded rice]: Water mngt prior cultivation)	Soil input (If [Flooded rice]: Water mngt during cultivation)	Residues or fire mngt (If [Flooded rice]: Straw management*)	Analysis period: Base year	Target year	Initial area, in ha	Agricultural area under conversion – Final area at target year, in ha: Reference	*	Target	*
Annual cropland	Cassava	Reduced tillage	High without manure	Retained	2020	2023	145,613	0	L	72,807	L
Perennial agroforestry	Alley cropping	Please select	Please select	Retained	2023	2031	200,000	0	L	200,000	S
Perennial monoculture	Tea camelia	Please select	Please select	Retained	2023	2031	200,000	0	L	200,000	S

Source: Authors' elaboration based on **Schiettecatte, L.-S., Audebert, P., Umulisa, V., Dionisio, D. and Bernoux, M.** 2022a. *Technical guidance of the Nationally Determined Contribution Expert Tool (NEXT).* Rome, FAO.

Tier 2

We will consider the following AGB and BGB growth rate for all the cashew plantations, indifferently of the agroforestry type, where AGB is **1.68 tC/ha/yr** and BGB is **0.39 tC/ha/yr.** The maturity cycle is **20 years,** Figure 12. These values are based on measurements done on trees in cashew plantations of 20 years old in Cameroon (Awé *et al.*, 2020).

[5] Chenda, K., Hong, N., Blaser, M. Sann, S. and Bonditphop, K. 2019. Cambodian Cashew Nut Value Chain Assessment Report. Swiss Church Aid – HEKS/EPER. https://ampleap.com/wp-content/uploads/2021/12/Cambodian-Cashew-Nut-Value-Chain-Assessment-2019-HEKS-Swiss-Church-Aid.pdf

Figure 12. 12. NEXT screenshot of the Tier 2 section for cashew plantations

FINAL LAND USE - CROPLAND (1) & GRASSLAND TIER 2

Above and below-ground biomass growth rate & HWP perennial								Soil - CO2 SOC & CH4 rewetting IWMS				Residue mngt				
AGB tC/ha/yr		BGB tC/ha/yr		Maturity Cycle (years)		HWP - Perennial		SOC tC/ha		CH4 rewetting kg CH4/ha/yr		Residues (tdm/ha)**		Periodicity Burning	Yield cropland t dm/ha/yr	
Tier 1	Tier 2	Tier 1	Tier 2	Tier 1	Tier 2	Rotation*	Years	Tier 1	Tier 2	Tier 1	Tier 2	Tier 1	Tier 2	Years	Tier 1	Tier 2
5.0		0.0		1		No	3	28.8		0		0.60		1	5.99	
2.6	1.7	0.0	0.4	13	20	No	3	47.0		0		10.00		1	0.00	
2.6	1.7	0.0	0.4	13	20	No	3	47.0		0		10.00		1	0.00	

Note: the AGB and BGB growth and the maturity cycle are based on **Awé DV, Noiha NV, Nyeck B, Vroh Bi Tra A & Zapfack L.** 2020. Carbon storage in cashew plantations in Central Africa: Case of Cameroon. Carbon management, https://doi.org/10.1080/17583004.2020.1858682

Source: Authors' elaboration based on **Awé DV, Noiha NV, Nyeck B, Vroh Bi Tra A & Zapfack L.** 2020. Carbon storage in cashew plantations in Central Africa: Case of Cameroon. Carbon management, https://doi.org/10.1080/17583004.2020.1858682; and **Schiettecatte, L.-S., Audebert, P., Umulisa, V., Dionisio, D. and Bernoux, M.** 2022a. *Technical guidance of the Nationally Determined Contribution Expert Tool (NEXT).* Rome, FAO..

Analysis questions:

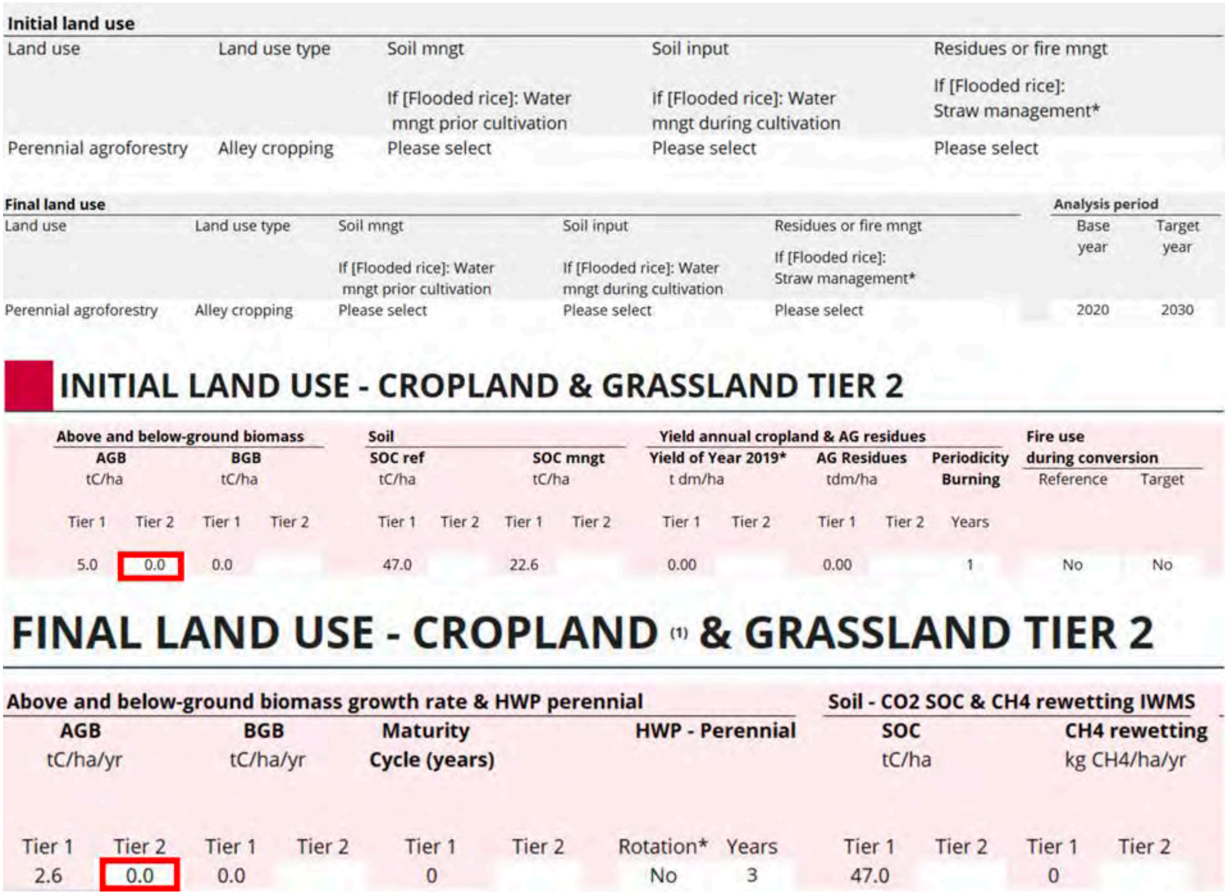
1. What are the GHG emissions in 2030, 2035 and 2049 in tCO_2-eq? *[Dashboard]*
2. Which driver creates the strongest mitigation potential in the long run? *[Results summary]*
3. Can you explain the GHG emissions in the reference scenario? *[Results summary]*
4. Why is the sequestration in biomass decreasing over time in the annual balance? *[Results summary]*
5. What are the initial and final values of the SOC for each system? *[Crop&Grass]*
6. What indicators could you use for the tracking and monitoring of the policy on cashew nuts if it was integrated into the next NDC? *[Land & SOC indicators]*. Can you identify some other indicators linked to the cassava and cashew policies?

Essential point to be highlighted

All NEXT modules consider changes in carbon stock from one initial land use to another. For instance, when switching from an annual system to an agroforestry system, NEXT will take into account the biomass loss (carbon stock loss) of the annual system and the biomass gain (biomass regrowth) resulting from the development of agroforestry. All the modules are based on the same logic. This means that in the case of a change in the soil management practices of an agroforestry system that remains unchanged, or a land-use type remaining the same land-use type without any biomass removal, users will have to force the tool to not take into account the loss of carbon stock from the biomass of the initial cashew trees and the gain in biomass from the new cashew trees assumed. This is done by setting the initial land biomass and final land biomass growth rate to zero in their respective Tier 2 section. This is illustrated in Figure 13.

Proceeds on the next page

Figure 13. **NEXT screenshot of the "CROP&GRASS" module indicating cells to be zeroed in case of a system without biomass removal**

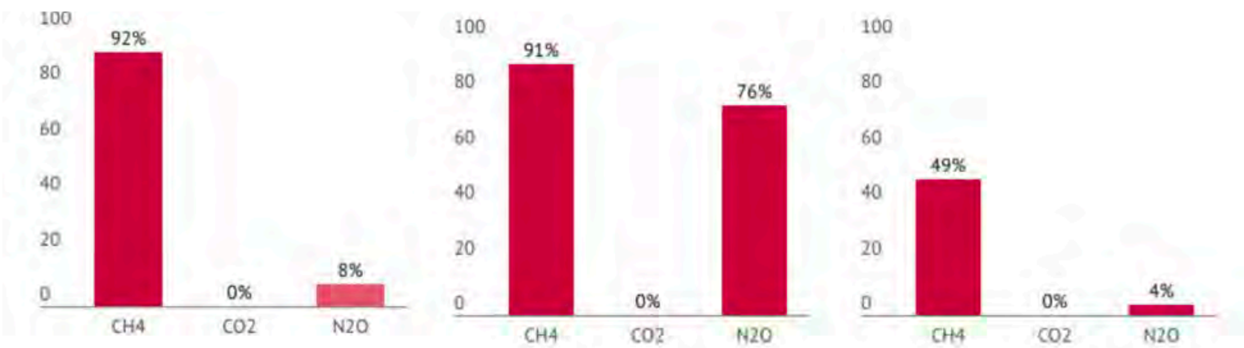


Source: Authors' elaboration based on **Schiettecatte, L.-S., Audebert, P., Umulisa, V., Dionisio, D. and Bernoux, M.** 2022a. *Technical guidance of the Nationally Determined Contribution Expert Tool (NEXT).* Rome, FAO.

Exercise 3. Flooded rice

The rice sector is also a major source of GHG emissions in Cambodia (**The National Council for Sustainable Development of the Kingdom of Cambodia,** 2020; BUR1). It is the main contributor to national CH_4 emissions, about 50 percent (**The National Council for Sustainable Development of the Kingdom of Cambodia,** 2023. Third National Communication submitted under the United Nations Framework Convention on Climate Change; NC3); while CH_4 emissions from the agricultural sector also represent up to 91 percent of the national CH_4 emissions, Figure 14.

Figure 14. **Share of CO_2, CH_4 and N_2O within the agricultural sector (left), share of these gases from agriculture compared to their national equivalent (center) and share of these gases compared to national GHG emissions (right)**

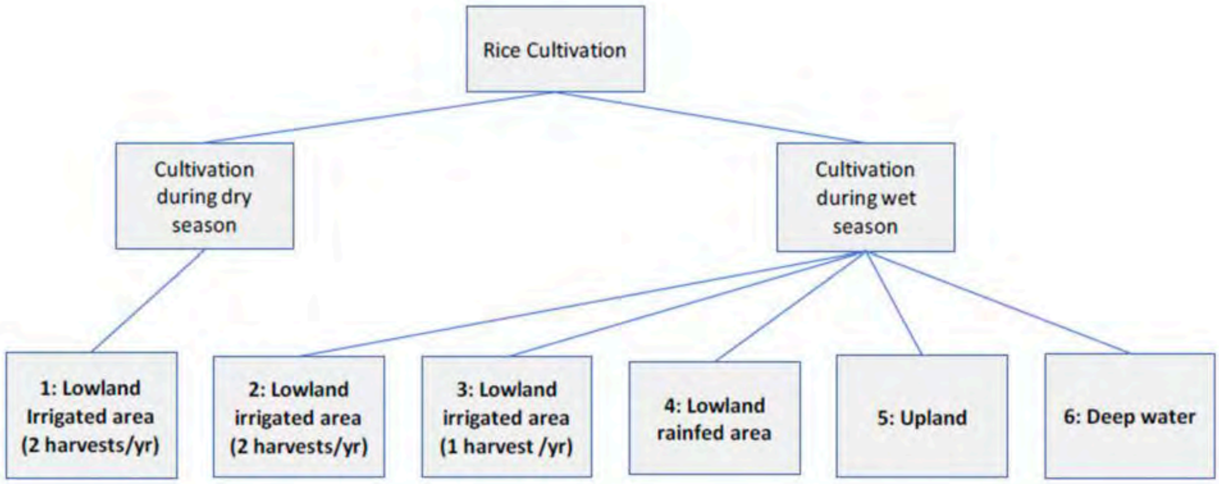


Source: Authors' elaboration based on **EDGAR (Emissions Database for Global Atmospheric Research) Community GHG Database,** a collaboration between the European Commission, Joint Research Centre (JRC), the International Energy Agency (IEA), and comprising IEA-EDGAR CO_2, EDGAR CH_4, EDGAR N_2O, EDGAR F-GASES version EDGAR_2024_GHG (2023) European Commission, JRC (Datasets).

The LTS4CN provides guidance on how to reach carbon neutrality by 2050 across all sectors, as illustrated in Annex 1. It includes agricultural practices aimed at reducing GHG emissions from the rice sector, such as low CH_4 rice cultivars, alternate wetting and drying (AWD) practices, among others. The rice sector was also covered in the NDC 2 but under the adaptation component "Development of rice crops for increase production, improved quality safety, harvesting and post harvesting technique and agrobusiness enhancement".

The following exercise aims at estimating GHG emissions reductions from a set of actions within the rice sector. The exercise uses a **simplified approach** of the various rice cultivation management systems, about 24 identified under the BUR1, Figure 15.[6] The 24 rice cultivation management systems come from a combination of the different rice water management systems and the 4 types of organic amendments management systems, i.e. manure and stubble incorporated, manure and stubble burned, stubble incorporated alone, and stubble burned (The National Council for Sustainable Development of the Kingdom of Cambodia, 2020).

Figure 15. Rice cultivation management systems

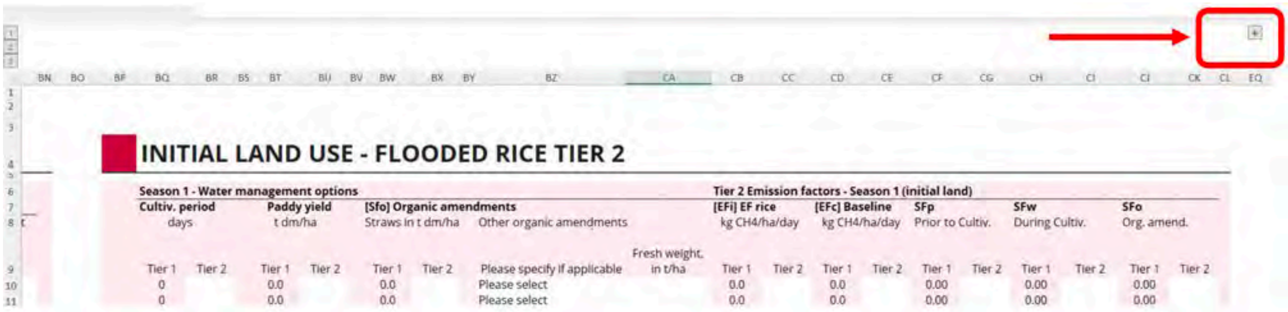


Source: Authors' elaboration based on **The National Council for Sustainable Development of the Kingdom of Cambodia,** 2020. First biennial update report to the United Nations Framework Convention on Climate Change.

For this exercise the modules **"CROP&GRASS"** and **"NUTRIENT"** will be used. Note that all rice management systems except upland rice should be considered under the "flooded rice" IPCC land use type. Upland rice is treated as an annual crop, such as wheat or maize. Information on water management for flooded rice is available in the main "CROP&GRASS" section for the first season. Cultivation practices for the second and third cultivation periods or seasons are available in the Tier 2 section of the tool by clicking on the "+" button, Figure 16.

6 Since the NDC 3.0, the rice ecosystems and nutrient applications in Cambodia and consequently associated GHG emissions were revised. The below assumptions might not all true, but they are kept for the exercise.

Figure 16. **NEXT screenshot on the Tier 2 section for the rice management in the "CROP&GRASS" module**



Source: Authors' elaboration based on **Schiettecatte, L.-S., Audebert, P., Umulisa, V., Dionisio, D. and Bernoux, M.** 2022a. *Technical guidance of the Nationally Determined Contribution Expert Tool (NEXT)*. Rome, FAO.

Information on the rice production

This action will be implemented on two types of rice between **2023–2031.** The water management characteristics are described in Table 4.

Key assumptions for the BAU (Business-As-Usual) scenario:

1. *Non-irrigated/Rainfed rice:*
    - Area: **2 400 136 ha,**
    - Cultivated only during the **wet season,**
    - No fertilizer application.

1. *Irrigated continuously flooded rice:*
    - Area: **141 900 ha,**
    - Cultivated during both **dry and wet seasons,**
    - Application of manure and fertilizers in both seasons. Manure management will be filled in the Tier 2 section of the **"CROP&GRASS"** module; fertilizers information will be filled in the **"NUTRIENT"** module.

Key assumptions for the target scenario:

- **80 percent of the irrigated rice, 113 520 ha,** will adopt **AWD** with one aeration event only during the cultivation period,
- The implementation is **sigmoidal.**

Wet season:

- Cultivation period: **165 days,**
- Yield: 2.44 tonne/ha.

Dry season:

- Cultivation period: **115 days,**
- Yield: **3.93 tonne/ha.**[7]

Fertilizers:

- 200 kg manure will be applied before plowing if available, complemented with 8 kg fertilizer (N:18-P:46-K:0) at around 10 days after sowing, and 2 splits of 50 kg urea after transplantation, IRRI 2025,
- The nitrogen content of manure is 0.6 percent.

CROP&GRASS module

The **CROP&GRASS** module should be completed as described in Figure 17 & 18 and Table 4.

Figure 17. NEXT screenshot of the main menu and Tier 2 information for the initial system – season 1 (main menu on top and center) and season 2 (bottom)

CROPLAND & GRASSLAND (and other IPCC non-forest land categories)

U/C	Climate	Mineral soil IPCC/HWSD	Mineral soil Type	Initial land use: Land use	Land use type	Soil mngt (If [Flooded rice]: Water mngt prior cultivation)	Soil input (If [Flooded rice]: Water mngt during cultivation)	Residues or fire mngt (If [Flooded rice]: Straw management*)
U								
U								
U								
U	Tropical Moist	IPCC	LAC - Soils	Flooded rice	Please select	Non flooded pre-season <180 d	Rainfed, regular rainfed	Straw incorporated <30 days before cultivation
U	Tropical Moist	IPCC	LAC - Soils	Flooded rice	Please select	Flooded pre-season > 30 d	Irrigated, continuously flooded	Straw incorporated <30 days before cultivation

INITIAL LAND USE - FLOODED RICE TIER 2

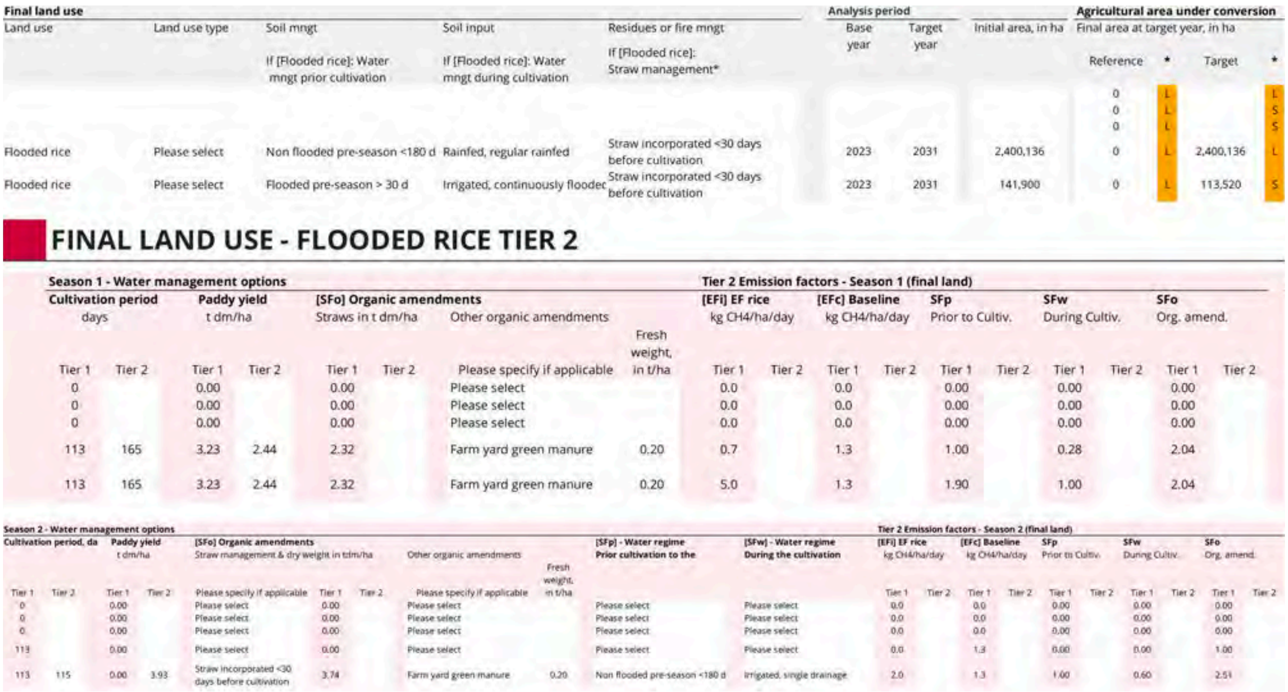
Season 1 - Water management options: Cultiv. period (days) Tier 1	Cultiv. period Tier 2	Paddy yield (t dm/ha) Tier 1	Paddy yield Tier 2	[Sfo] Organic amendments: Straws in t dm/ha Tier 1	Straws Tier 2	Other organic amendments: Please specify if applicable	Fresh weight, in t/ha	Tier 2 Emission factors - Season 1 (initial land): [EFi] EF rice (kg CH4/ha/day) Tier 1	[EFi] Tier 2	[EFc] Baseline (kg CH4/ha/day) Tier 1	[EFc] Tier 2	SFp (Prior to Cultiv.) Tier 1	SFp Tier 2	SFw (During Cultiv.) Tier 1	SFw Tier 2	SFo (Org. amend.) Tier 1	SFo Tier 2
0		0.0		0.0		Please select		0.0		0.0		0.00		0.00		0.00	
0		0.0		0.0		Please select		0.0		0.0		0.00		0.00		0.00	
0		0.0		0.0		Please select		0.0		0.0		0.00		0.00		0.00	
113	165	3.2	2.44	2.3		Farm yard green manure	0.20	0.7		1.3		1.00		0.28		2.04	
113	165	3.2	2.44	2.3		Farm yard green manure	0.20	5.0		1.3		1.90		1.00		2.04	

Season 2 - Water management options: Cultiv. period (Days) Tier 1	Cultiv. period Tier 2	Paddy yield (t dm/ha) Tier 1	Paddy yield Tier 2	Organic amendments [SFo]: Straw management & dry weight in tdm/ha: Please specify if applicable	Tier 1	Tier 2	Other organic amendments: Please specify if applicable	Fresh weight, in t/ha	[SFp] - Water regime Prior cultivation	[SFw] - Water regime During the cultivation	Tier 2 Emission factors - Season 2 (initial land): [EFi] EF rice (kg CH4/ha/day) Tier 1	[EFi] Tier 2	[EFc] Baseline (kg CH4/ha/day) Tier 1	[EFc] Tier 2	SFp (Prior to Cultiv.) Tier 1	SFp Tier 2	SFw (During Cultiv.) Tier 1	SFw Tier 2	SFo (Org. amend.) Tier 1	SFo Tier 2
0		0.00		Please select	0.00		Please select		Please select	Please select	0.00		0.00		0.00		0.00		0.00	
0		0.00		Please select	0.00		Please select		Please select	Please select	0.00		0.00		0.00		0.00		0.00	
0		0.00		Please select	0.00		Please select		Please select	Please select	0.00		0.00		0.00		0.00		0.00	
113		0.00		Please select	0.00		Please select		Please select	Please select	0.00		1.30		0.00		0.00		1.00	
113	115	0.00	3.93	Straw incorporated <30 days before cultivation	3.74		Farm yard green manure	0.20	Non flooded pre-season <180 d	Irrigated, continuously flooded	3.27		1.30		1.00		1.00		2.51	

Source: Authors' elaboration based on **Schiettecatte, L.-S., Audebert, P., Umulisa, V., Dionisio, D. and Bernoux, M.** 2022a. *Technical guidance of the Nationally Determined Contribution Expert Tool (NEXT)*. Rome, FAO.

[7] NC 3.

Figure 18. **NEXT screenshot of the main menu and Tier 2 information for the initial system – season 1 (main menu on top and center) and season 2 (bottom)**



Source: Authors' elaboration based on **Schiettecatte, L.-S., Audebert, P., Umulisa, V., Dionisio, D. and Bernoux, M.** 2022a. *Technical guidance of the Nationally Determined Contribution Expert Tool (NEXT)*. Rome, FAO.

Table 4. **Rice production characteristics in Cambodia**

Season	Cultivation periods, days	Paddy yield, t dm/ha	Water regime prior to the cultivation	Water regime during the cultivation	Organic amendment
Non-irrigated rice					
Season 1, 2 400 136 ha	165	2.44	Non flooded pre-season <180 days	Rainfed, regular rainfed	Straw incorporated <30 days before cultivation
Irrigated rice under BAU					
Season 1 (wet), 141 900 ha	165	2.44	Flooded pre-season >30 days	Irrigated, continuously flooded	Straw incorporated <30 days before cultivation + manure
Season 2 (dry), 141 900 ha	115	3.93	Non flooded pre-season <180 days	Irrigated, continuously flooded	Straw incorporated <30 days before cultivation + manure
Irrigated rice under the target					
Season 1 (wet), 113 520 ha	165	2.44	Flooded pre-season > 30 days	Irrigated, continuously flooded	Straw incorporated <30 days before cultivation + manure
Season 2 (dry), 113 520 ha	115	3.93	Non flooded pre-season <180 days	Irrigated, one aeration	Straw incorporated <30 days before cultivation + manure

Note: This is a simplified approach of the different rice cultivation systems. The scope here is to let users see the different options to estimate CH_4 emissions from flooded rice. the number of days for the cultivation period is from the **The National Council for Sustainable Development of the Kingdom of Cambodia,** 2020. First biennial update report., p.64. Hectares are coming from values taken from previous exercises.

Source: Authors' elaboration based on The National Council for Sustainable Development of the Kingdom of Cambodia, 2020. First biennial update report and **The National Council for Sustainable Development of the Kingdom of Cambodia,** 2022. Third National Communication submitted under the United Nations Framework Convention on Climate Change.

“NUTRIENT” module

As mentioned previously, 200 kg of manure will be applied, complemented with 8 kg of fertilizer (18-46-0) and 2 splits of 50 kg urea, IRRI 2025. We will assume the nitrogen content of manure to be 0.6 percent. There are no changes forecasted on the urea consumption under the reference scenario in 2031. This information will be assumed only for the irrigated rice, as described in Box 1. The period and dynamic of implementation are assumed to be the same as those outlined for the flooded rice management activities.

Box 1. N_2O emissions estimations from application of N-based fertilizers on flooded rice

The IPCC methodologies provide a specific emission factor (EF1) to account for direct N_2O emissions for flooded rice. While this factor is the same regardless of the water management during the cultivation period for irrigated rice, the 2019 IPCC methodology disaggregates them in two categories, i.e. one when the rice is continuously flooded when irrigated and one in case there is at least one aeration event during the cultivation period.

The disaggregation for rainfed and deep-water systems are not provided due to lack of data. **Therefore, those emissions will not be accounted for in our case for the 2 400 136 ha.**

In case of fertilizer application to upland rice, the land-use type to indicate in the “nutrients” module is “annual crop”.

Source: Authors’ elaboration based on Chapter 11, **IPCC.** 2006. 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 4 Agriculture, Forestry and Other Land Use; and **IPCC.** 2019. 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Calvo Buendia E., Tanabe K., Kranjc A., Baasansuren J., Fukuda M., Ngarize S., Osako A., Pyearozhenko Y., Shermanau P., & Federici S. (eds). Published by IPCC, Switzerland.

The **NUTRIENTS** module should be completed as described in Figure 19 and Table 5.

Figure 19. NEXT screenshot of the main menu in the “nutrients” module

NUTRIENT & UREA MANAGEMENT

Results of this section are integrated into N2O direct and indirect of managed soils, and CO2 s

U/C	Climate	Land use type	Inputs type	Analysis period: Base year	Analysis period: Target year	Annual amount inputs**: Quantity used Initial	Reference at target year	*	Target at target year	*	Per year
U						0	0	L		L	tN
U	Tropical Moist	Flooded rice - continuously flooded	Synthetic fertilizers - Urea	2023	2031	28,380	28,380	L	17,028	L	t urea
U	Tropical Moist	Flooded rice - at least 1 areation	Synthetic fertilizers - Urea	2023	2031	0	0	L	11,352	S	t urea
U	Tropical Moist	Flooded rice - continuously flooded	Synthetic fertilizers - Default	2023	2031	409	409	L	245	L	tN
U	Tropical Moist	Flooded rice - at least 1 areation	Synthetic fertilizers - Default	2023	2031	0	0	L	163	S	tN
U	Tropical Moist	Flooded rice - continuously flooded	Manure	2023	2031	341	341	L	204	L	tN
U	Tropical Moist	Flooded rice - at least 1 areation	Manure	2023	2031	0	0	L	136	S	tN

Source: Authors’ elaboration based on **Schiettecatte, L.-S., Audebert, P., Umulisa, V., Dionisio, D. and Bernoux, M.** 2022. *Technical guidance of the Nationally Determined Contribution Expert Tool (NEXT)*. Rome, FAO.

Table 5. Information on the fertilizers type and quantity to use for the NEXT "nutrients" module

Rice systems	Fertilizers type	Quantity in tN/year Start	Reference	Target
Flooded rice continuously flooded	Urea	=2*50/1 000*141 900*2	=2*50/1 000*141 900*2	=2*50/1 000*141 900+2*50/ 1 000*141 900* (1-80%)
Flooded rice at least one aeration	Urea	0	0	=2*50/1 000*141 900*80%
Flooded rice continuously flooded	N synthetic fertilizer (default)	=8/1 000*18%*141 900*2	=8/1 000*18%*141 900*2	=8/1 000*18%*141 900+8/ 1 000*18%*141 900* (1-80%)
Flooded rice at least one aeration	N synthetic fertilizer (default)	0	0	=8/1 000*18%*141 900*80%
Flooded rice continuously flooded	Manure	=200/1 000*0.6%*141 900*2	=200/1 000*0.6%*141 900*2	=200/1 000*0.6%*141 900+200/ 1 000*0.6%*141 900* (1-80%)
Flooded rice at least one aeration	Manure	0	0	=200/1 000*0.6%*141 900*80%

Source: Authors' elaboration based on **IRRI.** 2025. SROC PHAL for rainfed lowland r ice in Cambodia: Kampong Cham and Siem Reap province. [Accessed on 30 September 2024] http://www.knowledgebank.irri.org/images/docs/Best-Management-Practices-for-rainfed-lowland-rice-in-Cambodia-Kampong-Cham-and-Siem-Reap-province.pdf

Analysis questions:

1. What would the GHG emissions be by 2030, 2035 and 2049 in tCO_2-eq? *[Dashboard]*
2. How many rice management systems do we have and what are their CH_4 emission factors in $kgCH_4$/ha/day?*[Crop&Grass]*
3. Given that the mitigation objective from the NDC2 is about 6.2 million tCO_2-eq for the agriculture sector, based on our assumptions, how much does the adoption of AWD contribute to this goal?
4. Return to the "Home" tab of NEXT and select the IPCC 2019 methodologies. What are the changes that can be observed in the "Nutrients" module?
5. As Cambodia is one of the signatories of the Global Methane Pledge (Box 2), what would be the contribution of AWD in this exercise to reducing national CH_4 emissions by 2030? *[Results summary] & [Balance cumulated, CH_4 part]*

Potential priority work on the rice sector

As mentioned in the BUR1, the calculation of the rice GHG emissions is currently based on Tier 1 methodology from the IPCC, but the calculation is made for **24 different types of rice cultivation.** "It represents a very detailed calculation and could nearly be considered as a Tier 2 analysis (some country-specific parameters are used, and the categorization is high). The main improvements to be addressed include the **amount of residues** incorporated after harvest and the **amount of organic manure** brought to soils. It could prove interesting to collect additional data on the area with high irrigation since the current estimates are based on different sources, but not on dedicated statistics. Currently, the cultivation period is defined by type but does not adjust. In practice, varieties of rice have improved, and cultivation periods are becoming shorter. It could be included in the calculations." (**The National Council for Sustainable Development of the Kingdom of Cambodia,** 2020).

Box 2. The Global Methane Pledge

Methane is a powerful but short-lived climate pollutant that accounts for a third of net warming since the Industrial Revolution. Rapidly reducing methane emissions from the energy, agriculture, and waste sectors can achieve near-term gains in our efforts in this decade for decisive action. It is regarded as the most effective strategy to keep the goal of limiting warming to 1.5 ˚C within reach while yielding co-benefits, including improving public health and agricultural productivity.

The Global Methane Pledge (GMP) was launched at COP26 by the European Union and the United States who have been joined by many countries. In March 2024, GMP counted 158 participants. Since its launch, the GMP has generated unprecedented momentum for methane mitigation, with major work underway in six action areas including: the Energy Pathway, the Waste Pathway, the Food and Agriculture Pathway, Methane Plans and Policies, Data for Methane Action, and Finance for Methane Abatement.

Source: Authors' elaboration based on The global methane pledge, 2024.

Exercise 4. Forestry & Fisheries – mangrove restoration and seagrass management

"*Cambodia was reported to once have been the vastest and most diverse seagrass meadows in the world*" (Marine Conservation Cambodia, 2025).

Background

Mangroves: "*Analysis of satellite imagery showed the decadal changes in mangrove forests along the Cambodian coastline. About 42 percent (36 810 ha) of the mangrove forests in Cambodia has been cleared between 1989 and 2017. Loss of mangroves in different coastal provinces of Cambodia during this period was: Koh Kong (39 percent, 26 437 ha), Kampot (45 percent, 1 986 ha), Sihanoukville (52 percent, 8 127 ha) and Kep (34.3 percent, 260 ha)*" – see Veettil & Quang, 2019, and Figure 20. The loss of mangroves is attributed to the development of shrimp ponds, charcoal production and coastal infrastructures for tourism (Veettil & Quang, 2019).

Seagrass: Seagrass beds in Cambodia were estimated to cover about 33 814 ha in the early 2010's, (Leng *et al.*, 2014), Figure 21. Seagrass in Cambodia is threatened by destructive fishing practices, such as trawling for shrimp and push-netting. The high levels of nutrient input from terrestrial run-off following agricultural use of fertilizers, increasing sedimentation following erosion from unsustainable logging practices have also contributed to the reduction of the water quality, therefore increasing water turbidity, reducing light and thus inhibiting seagrass growth, (Leng *et al.*, 2014; Veettil & Quang, 2019).

In addition, in the recent years, fisheries resources have experienced prolonged drought and extreme weather events, exacerbating fish and aquatic animal stock and making these animals more vulnerable. Human induced disturbances are also considered as one of key contributors to reduced fish populations in addition to direct climate change impacts. These include land filling and encroachment, illegal fishing practices, cutting flooded forests and mangroves, damaging seagrass areas etc. The increasing prevalence of human disturbances in coastal areas and blue carbon ecosystems, in this case seagrass and mangroves, has contributed to increased carbon emissions. This, in turn, has reduced the capacity of the ocean to absorb and retain carbon. To mitigate these effects, appropriate blue carbon actions aimed at preserving these unique ecosystems, and coastal and inland fisheries (CCPAP III).

The CCPAP 2030 Priority action 004 Fisheries/02 (draft) aims at managing and rehabilitating critical aquatic habitats in response to the impacts of climate change.

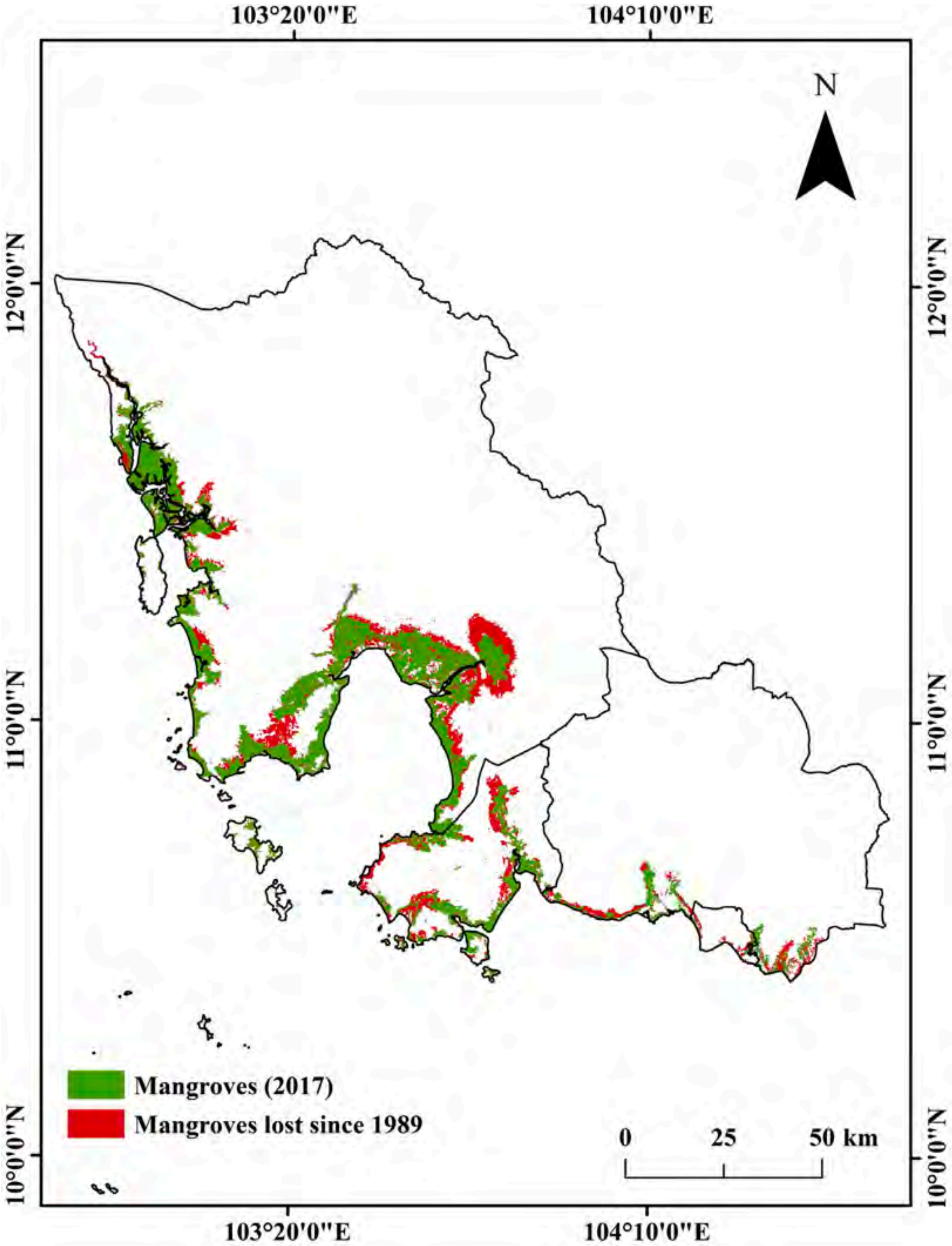
Rationale: Increased population growth has increased the demand for food, placing a greater pressure on fisheries to catch fish. The accelerated capture of already dwindling fish populations has exacerbated the vulnerability of fresh and coastal ecosystems. Additionally, smallholder fishing communities that depend on marine and inland aquatic resources for their livelihoods have experienced declining wild catch due to overfishing and changing climatic conditions.

Appropriate actions are needed to address the impacts of climate change and human disturbances on these aquatic ecosystems. These include public awareness raising to relevant stakeholders on climate adaptation and resource protection, physical infrastructure investment, research on tolerant species via restocking activities, introduction of digital solutions for control and surveillance, etc.

The following activities will be implemented under this action:

1. 3 000 ha of flooded forests and mangroves planted, including updating mangrove and flooded forest area and aerial monitoring,
2. 10 percent of prioritized conservation areas are restored,
3. 70 percent of seagrass areas are well managed,
4. 100 percent coral reefs areas are well managed,
5. At least ten critical inland and marine habitats studied and reported, and
6. 50 percent of critical marine habitats included critical habitats protected and fisheries ecotourism established.

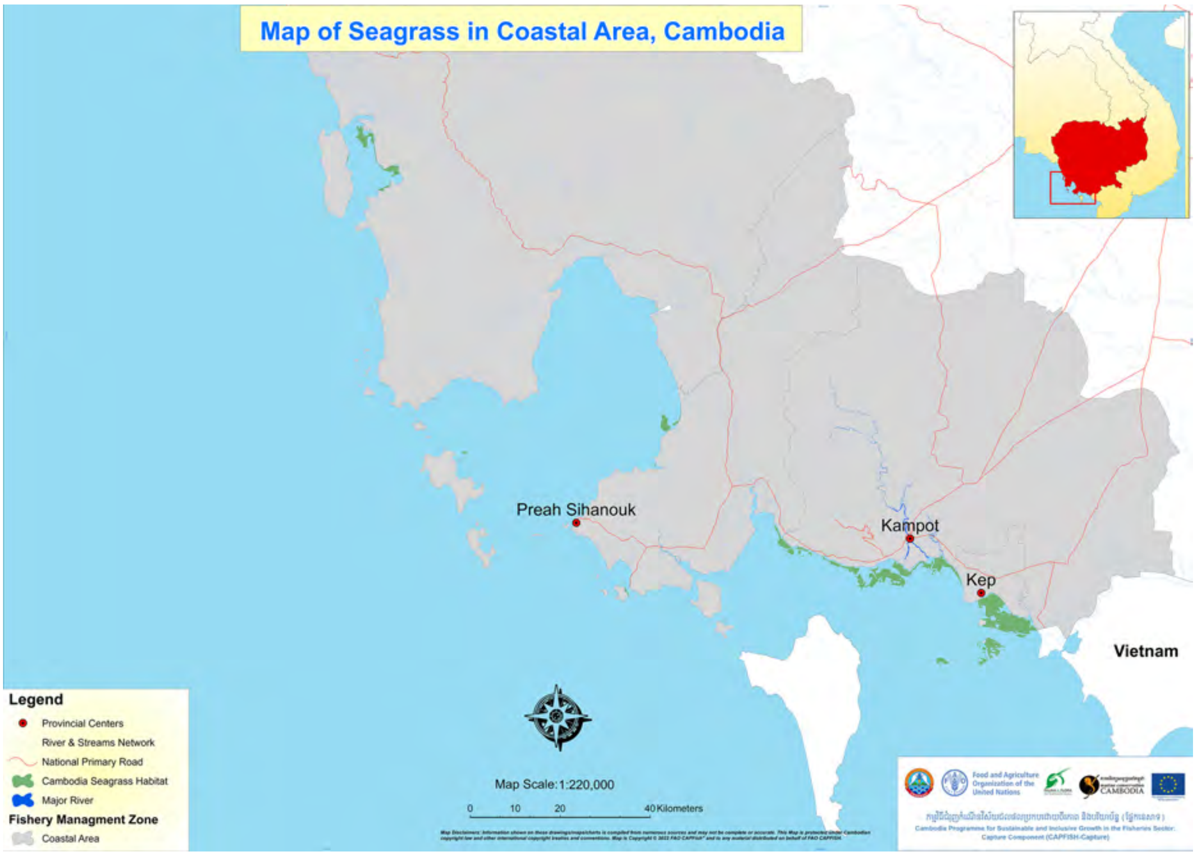
Figure 20. Existing mangrove coverage and loss of mangroves areas since 1989 in Cambodia



Note: *The boundaries and names shown and the designations used on this map do not imply the expression of any opinion whatsoever on the part of FAO concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers and boundaries. Dashed lines on maps represent approximate border lines for which there may not yet be full agreement.*

Source: Authors' elaboration based on **Veettil & Quang,** 2019. Mangrove forests of Cambodia: Recent changes and future threats. *Ocean and Coastal Management*, 181, 104895.

Figure 21. Map of Seagrass area in Cambodia



Note: *The boundaries and names shown and the designations used on this map do not imply the expression of any opinion whatsoever on the part of FAO concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers and boundaries. Dashed lines on maps represent approximate border lines for which there may not yet be full agreement.*

Source: Authors' elaboration based on Open Development Cambodia, 2025. Map of seagrass in coastal and coastal provinces of Cambodia. [Accessed 30 September 2025]. Map of seagrass in coastal and coastal provinces of Cambodia – Library records OD Mekong Datahub.

Box 3. Blue carbon definition

Blue carbon is a term used to describe the carbon stored in three types of coastal ecosystems: mangroves, seagrass beds and coastal marshes. The carbon is mainly stored in their sediments up to a depth of several meters.

Blue carbon ecosystems can store greater quantities of carbon than their terrestrial counterparts. This is because the presence of a permanent or near-permanent water table favors anaerobic processes, therefore slowing the decomposition of organic matter incorporated into the sediment.

In 2013, the IPCC proposed methodological approaches and default emission factors and carbon stocks to account for their climate change mitigation potential, (IPCC, 2013).

Source: Authors' elaboration based on IPCC 2013. 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands. Hiraishi T., Krug T., Tanabe K., Srivastava N., Baasansuren J., Fukuda M., & Troxler TG (eds). Published by IPCC, Switzerland.

NEXT analysis

Activities 1 and 3 will be analyzed to estimate their climate change mitigation potential. The analysis will be performed using Tier 1 emission factors and carbon stock values. As there are no methodologies to estimate carbon stock changes and potential GHG emissions from flooded land, we will assume that only mangroves will be planted under activity 1.

The "coastal wetlands management" section of the **WETLANDS** module will be used.

Activity #1: 3 000 ha of mangroves planted

Assumptions:

- The climate is **"Tropical Wet",**
- The initial land is **"Other coastal land use",**
- The management used during the conversion is **"Rewetting and revegetation",**
- The final land is **"Mangrove",**
- The soil type is **"Mineral",**
- The average salinity in these areas is **">18",** and
- **3 000 ha** will be planted over the period **2023–2031**, in a **linear manner.**

Activity #2: 70 percent of all seagrasses are well-managed

Assumptions:

- The climate is **"Tropical Wet",**
- The initial land is **"Seagrass",**
- The management used during the conversion is **"Rewetting and revegetation",**
- The final land is **"Seagrass",**
- The soil type is **"Mineral",**
- The average salinity is these areas is **">18",** and
- We will consider that seagrass regrowth will happen on 15 percent of the managed seagrass area, i.e. **3 550 ha,**
- The analysis period (or period of implementation) is **2023–2031.**

Analysis questions:

1. What is the carbon-balance of these two activities in 2030, 2035 and 2049? *[Dashboard]*
2. What is the variable driving carbon sequestration? *[Results summary]*
3. Which driver contributes to the most mitigation for the longest period? *[Results summary]*

Pros and Cons of using blue carbon ecosystems as the primary climate mitigation action in national commitments and carbon offsetting.

Coastal "blue carbon" ecosystems are recognized as natural climate solutions in two ways: by conservation, reducing the greenhouse gas emissions arising from the loss and degradation of such habitats, and by restoration, to increase CO_2 drawdown and its long-term storage. However, several issues affect the reliability of carbon accounting of blue carbon ecosystems, including high variability in carbon burial rates, errors in determining carbon burial rates, vulnerability to future climate change and to non-climatic factors, among others. As mentioned by Williamson & Gattuso, 2022, *"**CO_2 removal using coastal blue carbon restoration therefore has questionable cost-effectiveness when considered only as a climate mitigation action, either for carbon-offsetting or for inclusion in Nationally Determined Contributions.** Many important issues relating to the measurement of carbon fluxes and storage have yet to be resolved, affecting certification and resulting in potential over-crediting. The restoration of coastal blue carbon ecosystems is nevertheless highly advantageous for climate adaptation, coastal protection, food provision and biodiversity conservation. Such action can therefore be societally justified in very many circumstances, based on the multiple benefits that such habitats provide at the local scale."*

In summary, blue carbon ecosystems restoration should be in addition to, not as a substitute for, near-total emission reductions.

Potential way forward for Cambodia with regards to blue carbon ecosystems:

- Improve the mapping of seagrass; the seagrass area used in this exercise was estimated in the 2010s,
- If included in the mitigation component,
  a. Focus on the conservation area to estimate GHG emissions that would be avoided by preventing biomass loss and potential emissions from the soil, which could occur if the area were drained or excavated.
  b. Develop Tier 2, such as carbon stocks, accumulation rate in sediments of mangroves and seagrass.
  c. Estimate SOC at 1 meter depth.
- Implement the adaptation benefits brought from blue carbon restoration. For instance, see some examples from policies and measures from other NDCs, Box 4.

Box 4. Some examples of countries that have integrated coastal wetlands in their NDC for the 2020 cycle

Mitigation component

Belize: "Complete an in situ assessment of the below ground carbon stock of mangroves by 2022, leading to the application of relevant IPCC methodologies to assess the feasibility of including seagrass in a wetlands component, alongside a comprehensive assessment of mangrove-based carbon stock, in the National Greenhouse Gas Inventory, and other relevant reports by 2025."

Costa Rica: "Costa Rica aspires to stop or reverse the net loss of coastal wetlands by 2030, through the attention to the main causes of deforestation and degradation that threatens very existence, health and vitality of wetlands coastal areas, according to the National Forest Inventory."

Costa Rica: "As a general ambition of the blue carbon goal, Costa Rica will continue to lead in conservation, responsible use and restoration of wetlands coastal areas through the deepening of the scientific knowledge of services ecosystems that these habitats provide and will take steps to better protect and restore these spaces in the future."

Sudan: "Conservation and sustainable use of wetlands for improved carbon sequestration. South Sudan will collaborate with international research institutes and agencies to conduct ground research on the release of methane emissions from the Sudd wetland and develop measures to sustainably manage and mitigate high emissions coming from the country's wetlands: • Build the capacity of government and research institutions on wetland processes and associated GHG emissions; • Identify and classify wetlands, and assess their biodiversity; • Bring wetlands under protection for sustainable management."

Adaptation component

Bahrain: "Creating a blue carbon inventory to augment Bahrain's existing GHG emission tracking system to estimate and document carbon pools/fluxes in Tubli Bay consistent with international methodological guidance. [Mangrove Habitats]"

Pakistan: "vi. REDD+ Indus delta (2019–2030 Delta Blue Carbon Phase I): Restoring 350 000 ha in the Districts of Thatta and Sujawal in Sindh province through plantation in 60 years via a multi-phase public private partnership. Phase 1 aims at restoration of 224 997 ha of degraded land through large scale reforestation of which 75 000 ha was restored by 2020 with mangrove plantations."

Seychelles: "Coastal Risk Mapping and Monitoring."

Source: Crumpler *et al.*, 2024; and Schiettecatte *et al.*, 2025.

Additional exercise: Estimate the quantity of carbon loss from mangrove deforestation

The overall loss of mangrove forests between 1989 and 2017 has been estimated to be 1 415 ha/year in the four coastal provinces of Cambodia: Koh Kong, Kampot, Preah Sihanoukville and Kep. The three main causes of mangrove destruction are salt farming, charcoal production and shrimp farming (Veettil & Quang, 2019).

More specifically, we will estimate the impact of shrimp farming in Koh Kong. In 1994, the area of shrimp farming increased from 840 ha to 1 240 ha (Veettil & Quang, 2019, after MoE data).

The development of shrimp farming ponds (feed-fed) requires the removal and drainage of soil, biomass removal (above-ground and below-ground), and soil extraction (for sake of simplicity, we will assume the soil extraction to be over one meter depth, which is also the default variable in the IPCC wetland supplement).

Assumptions:

- The base year of the analysis is **1994,**
- We will use the I**PCC 2019 methodology,**
- The climate is **"Tropical wet",**
- The initial land is **"Mangrove",**
- The management used during the conversion is **"Drainage & soil extraction",**
- The final land is **"Saline ponds",**
- The eutrophication state of the shrimp farming waters will not be considered in this case,[8]
- The soil type is **"Mineral",**
- The average salinity is these areas is **"More than 18",**
- The period of implementation is **1994–1995,** and
- The shrimp pond production is assumed to be **1 000 kg/ha/yr.**
- The carbon footprint of the feed is not considered.

Tier 2

We will use the **AGB and BGB** values from the FREL 2021 (**Government of the Kingdom of Cambodia,** 2021) for mangrove carbon stock, i.e. **AGB = 66.7 tC/ha** (Table 10, p32/57, FREL, 2021).

Analysis questions:

1. What is the carbon balance of the conversion from mangroves to shrimp farming pond in the first year, 10, 20 and 30 years after? *[Dashboard]*
2. What is the variable driving the GHG emissions? *[Results summary]*
3. Convert the emissions into tC/ha and compare it with the carbon sequestration potential from the development of mangroves (previous exercise).
4. What is the carbon footprint of the shrimp, annual and cumulated?[9]
5. Adjust the water quality to "eutrophic" in the main menu. What changes do you observe?

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8 It can be assessed only when the IPCC 2019 Refinement & IPCC 2013 methodologies is selected in the "home" menu.

9 To be estimated over a life cycle production. Here we could consider 30 years.

Exercise 5. Halting deforestation

The NODEFOR action plan aligns with the REDD+ strategy and aims at reducing the deforestation rate by 50 percent by 2030[10] and eliminate deforestation by 2045. This will be implemented through three strategies (REDD+ 2017):

- Improving management and monitoring of forest resources and forest land use,
- Strengthening implementation of sustainable forest management, and
- Implementing approaches to reduce deforestation, build capacity, and engage stakeholders.

The aim of this exercise is to assess the impact of NODEFOR on forest carbon stock changes on its period of implementation, and in a second phase, understand the impact of other land-use changes on national GHG emissions. The FOREST module will be used in this exercise.

Assumptions:

Step 1:

a. Elaboration of the projection and distribution of land uses coming from the deforestation

The distribution of the different land uses coming from deforestation and their respective areas were estimated from the extrapolation of past trends in deforestation over the periods 2014–2016, 2016–2018, shared by the Ministry of Environment (MoE) in 2022/2023. The assumptions used for the distribution of land uses coming from deforestation are presented in Box 5 and the resulting areas are presented in Table 6.

[10] Under the [REDD+ Cambodia 2017-2026] The Cambodia REDD+ strategy aims to achieve a key milestone by 2026. The objective is to reduce its annual deforestation by half compared to the rate during the FRL period of 2006-2014.

Box 5. Assumptions taken to project the distribution of land uses from 2020 to 2050

The reference scenario

Under a reference (or BAU or without measures scenario), the expansion of cropland and settlement is enabled by deforestation. The average annual change per land-use type observed over the period 2014–2018 is assumed constant and is used for the projection of land uses from 2020 to 2050. Thus, by 2050, the BAU scenario leads to an increase in cropland and settlement areas by about 2.5 million ha and about 295 000 ha, respectively.

The target scenario

Under "climate scenario", the cropland and settlement areas will still increase by 2050, but to a lesser extent than that outlined in the reference scenario. Cropland will increase by about 1.1 million ha and settlement by about 217 000 ha.

Table 6. Distribution of land uses, in hectares, coming from deforestation under the reference and target scenario over the period 2020-2050 in Cambodia

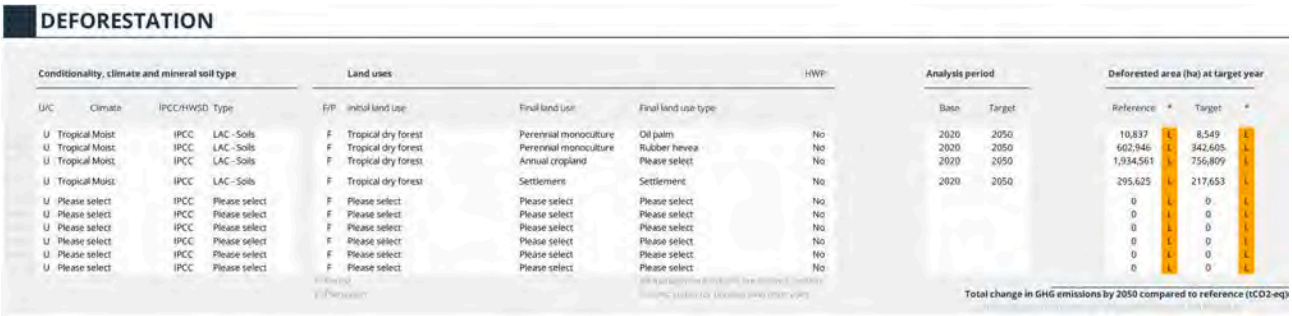
Forest to:	BAU	LTS
Oil Palm	10 837	8 549
Rubber	602 946	342 605
Agricultural land	1 934 561	756 809
Settlement	10 837	8 549
Total	**2 843 969**	**1 325 616**

Source: Authors' elaboration based on data communicated by The Ministry of Environment in 2022 and **The General Secretariat of the National Council for Sustainable Development/Ministry of Environment, the Kingdom of Cambodia.** 2021. *Cambodia's Long-Term Strategy for Carbon Neutrality.*

b. NEXT parametrization:

- The climate is "Tropical moist",
- The soil is a "LAC soil",
- The forest is a "Tropical dry forest",
- The period of implementation for all conversion lines is 2020-2050,
- The dynamic of implementation is linear, Figure 22.

Figure 22. **NEXT screenshot of the main menu in the "deforestation" module**



DEFORESTATION

Conditionality, climate and mineral soil type				Land uses				HWP	Analysis period		Deforested area (ha) at target year			
U/C	Climate	IPCC/HWSD	Type	F/P	Initial land use	Final land use	Final land use type		Base	Target	Reference	*	Target	*
U	Tropical Moist	IPCC	LAC - Soils	F	Tropical dry forest	Perennial monoculture	Oil palm	No	2020	2050	10,837	L	8,549	L
U	Tropical Moist	IPCC	LAC - Soils	F	Tropical dry forest	Perennial monoculture	Rubber hevea	No	2020	2050	602,946	L	342,605	L
U	Tropical Moist	IPCC	LAC - Soils	F	Tropical dry forest	Annual cropland	Please select	No	2020	2050	1,934,561	L	756,809	L
U	Tropical Moist	IPCC	LAC - Soils	F	Tropical dry forest	Settlement	Settlement	No	2020	2050	295,625	L	217,653	L
U	Please select	IPCC	Please select	F	Please select	Please select	Please select	No			0	L	0	L
U	Please select	IPCC	Please select	F	Please select	Please select	Please select	No			0	L	0	L
U	Please select	IPCC	Please select	F	Please select	Please select	Please select	No			0	L	0	L
U	Please select	IPCC	Please select	F	Please select	Please select	Please select	No			0	L	0	L
U	Please select	IPCC	Please select	F	Please select	Please select	Please select	No			0	L	0	L
U	Please select	IPCC	Please select	F	Please select	Please select	Please select	No			0	L	0	L

Total change in GHG emissions by 2050 compared to reference (tCO2-eq)

Source: Authors' elaboration based on **Schiettecatte, L.-S., Audebert, P., Umulisa, V., Dionisio, D. and Bernoux, M.** 2022a. *Technical guidance of the Nationally Determined Contribution Expert Tool (NEXT)*. Rome, FAO.

Analysis questions:

1. What is the mitigation potential for the years 2030, 2035 and 2049? *[Dashboard]*
2. What can you tell about the reference and target scenarios? *[Dashboard]*
3. When do the last land use changes occur for both scenarios? *[User activity data]*

Step 2:

Change the dynamic of implementation of each activity under the Target to "O" (observed), and using the land use changes.xls file, copy and paste the annual area of each new land use for both the reference and target scenario in the "User activity data" spreadsheet.

Analysis questions:

1. What is the mitigation potential for the years 2030, 2035 and 2049? *[Dashboard]*
2. What are the trends that can be observed in the reference and target scenarios? *[Dashboard]*
3. When do the last land-use changes occur for both scenarios? *[User activity data]*

Analysis questions:

- What is the mitigation potential for the years 2030, 2035 and 2049? *[Dashboard]*
- What are the trends that can be observed in the reference and target scenarios? *[Dashboard]*
- When do the last land-use changes occur for both scenarios? *[User activity data]*
- Which carbon stock or GHG emission undergoes changes over the long run? *[Results summary]* What are the implications of this?
- Compare the annual GHG emissions from step 2 and step 3 for years 2030, 2035 and 2049. What do you observe?

Exercise 6. Livestock measures under Cambodia's CCPAP III for 2030

Cambodia seeks to reduce its livestock emissions by 2030 through the implementation of the following investment priority actions outlined in its CCPAP III for 2030:

1. Raising animal breeds (cattle and swine) in an environmentally friendly, adaptive production system, and that are resilient to variable climatic conditions,
2. Transferring technology and knowledge of animal waste management to control pandemics of animal diseases and reduce GHG emissions through the expansion of biodigester use in the swine population,
3. Increasing awareness of disaster crises (flood, drought heat stress, disease outbreak) in animal production and develop readiness to respond to hazards, including the use of improved feeding practices to reduce emissions and improve resilience of livestock, and
4. Promoting research and development of animal breeds that are resilient to improve livestock productivity.

In this exercise, the **LIVESTOCK** module will be used. Implementation of action 1 and 3 using climate resilient livestock breeds and improved feeding practices is expected to **reduce enteric fermentation and methane emissions by 3 percent** compared to the BAU scenario. According to BUR1, (The National Council for Sustainable Development of the Kingdom of Cambodia, 2020) and National GHG Inventory Report (nGHGi) (The Kingdom of Cambodia, 2019), the enteric fermentation Tier 2 emission factors for the different livestock populations are indicated as in Table 7:

Table 7. **Enteric fermentation Tier 2 emission factors**

Animal category	Enteric fermentation, in kgCH_4/head/year
Cattle (Other)	47
Buffalo (Other)	55
Swine (growing)	2

Source: Authors' elaboration based on The Kingdom of Cambodia, 2019. National GHG emissions inventory report & The National Council for Sustainable Development of the Kingdom of Cambodia, 2020, and **The National Council for Sustainable Development of the Kingdom of Cambodia,** 2020. First biennial update report.

The implementation of action 2 will only be applied to the swine population and will aim to shift the share of manure management systems (MMS). As a result, the drylot MMS will decrease to 25 percent, and biodigesters will increase to 35 percent. The initial share of MMSs is as stated in the BUR1, outlined in Table 8.

Table 8. Share of manure management systems, in percent, for main livestock categories in Cambodia

Manure management system	Cattle	Buffaloes	Pigs	Poultry
Lagoon				
Liquid/slurry			40	
Solid storage				
Dry lot	46	41	54	
Pasture range	50	50		
Daily spread	2	4		
Digester			6	
Burned for fuel	2	5		
Pit < 1 month				
Pit > 1 month				
Poultry manure with litter				100

Source: Authors' elaboration based on **The National Council for Sustainable Development of the Kingdom of Cambodia,** 2020. First biennial update report.

Other Tier 2 emissions related to Cambodia's MMSs are highlighted in Tables 9 and 10, as stated in the BUR1.

Table 9. Methane emission factors for manure management systems based on livestock type, in kgCH_4/head/year

Cattle	Buffaloes	Pigs	Poultry
1	2	7	0.02

Source: Authors' elaboration based on **The National Council for Sustainable Development of the Kingdom of Cambodia,** 2020. First biennial update report.

Table 10. Nitrous oxide emission factors for manure management systems, in kgN_2O-N/kgN

Lagoon	Liquid/slurry	Solid storage	Dry lot	Daily spread	Digester	Pit <1 month	Pit >1 month	Poultry manure
0	0.005	0.005	0.02	0	0	0.002	0.002	0.001

Source: Authors' elaboration based on **The National Council for Sustainable Development of the Kingdom of Cambodia,** 2020. First biennial update report.

Improved livestock productivity through the implementation of action 4 will reduce the livestock populations in the target scenario compared to the baseline scenario for 2030. The population numbers outlined in Table 11 are based on expected growth projections for each type of livestock by 2030.

Table 11. **Livestock population for 2020 and 2030 in Cambodia**

Animal category	Productivity system	Base	Target	Initial (no. of heads)	Target (no. of heads)	Target (no. of heads)
Cattle (Other)	High productivity	2020	2030	2 759 878	3 071 225	3 014 259
Buffalo (Other)	N/A	2020	2030	424 036	622 485	606 202
Swine (growing)	High productivity	2020	2030	2 516 679	2 255 000	2 230 334
Chicken (broiler)	High productivity	2020	2030	15 801 261	25 850 863	25 111 364

Source: Authors' elaboration based on **The National Council for Sustainable Development of the Kingdom of Cambodia,** 2020. First biennial update report.

Assumptions:

1. It is assumed that the implementation period will be 2020–2030,
2. All the livestock populations are under a "High productivity system" and a tropical moist area with an average temperature of 27 °C,
3. Enteric fermentation is assumed to remain the same in the baseline and reference scenario with a reduction by 3 percent under the target scenario due to improved feeding practices (Tier 2) (Smith *et al.*, 2007).[11] This is only applied to the cattle and buffalo populations,
4. Under improved MMS it is assumed that the MMS shares under the initial and the reference scenarios will remain the same. The N_2O Tier 2 emission factors for MMSs will apply for all livestock types. The Tier 2 emission factors for N_2O and CH_4 under MMSs will remain the same under all scenarios,
5. We will assume that chickens are alive for 30 days.

Analysis questions:

1. What are the overall GHG emissions in the reference scenario for the period 2020–2030? What is the impact of implementing the livestock measures under CCPAP by 2030?
2. What are the GHG emissions annually for 2025 and 2030?
3. What is the cumulated emission reduction by 2030 and 2040 that stems from enteric fermentation?
4. What are the CH_4 related emission reductions by 2030 from the livestock interventions implemented?

11 See Table 8.5 from Smith *et al.*, 2007.

Exercise 7. Climate change priority action plan partial analysis

Starting with the last deforestation exercise, add all other activities from the different exercises and answer the following questions:

1. What is the mitigation potential for the years 2030, 2035 and 2049? *[Dashboard]*
2. What are the trends that can be observed in the reference and target scenarios? *[Dashboard]*
3. When do the last land-use changes occur for both scenarios? *[User activity data]*
4. Which carbon stock or GHG emission undergoes changes over the long run? *[Results summary]* What are the implications of this?
5. What are the reduction potentials for CH_4 in 2030? *[Balance annual]* Where does it come from? What could be the implications on the global methane pledge?

Answers to Exercise 1. Climate change mitigation potential from the AFFOR strategy

For this exercise, the "afforestation/reforestation" module should be completed according to Figure 23 by filling in the information provided in the instructions.

To calculate the biomass growth rate for pine plantations, these steps are followed:

- Above-Ground Biomass (AGB):

First, determine the average value of AGB in tonnes of dry matter per hectare per year by averaging the values provided for Africa, and for North America and South America (as shown in Table 2). Next, convert this dry biomass value to carbon by multiplying it by 0.47. This represents the fraction of carbon in dry matter as outlined in IPCC's GHG guidelines. Then, adjust for the survival growth rate of the plantation, which is 80 percent. Multiply the AGB carbon value by 0.80 to get the final carbon in AGB, measured in tons of carbon per hectare per year.

- Below-Ground Biomass (BGB):

To estimate the BGB, use a ratio (R) to convert the AGB value to BGB. R is calculated by dividing the BGB value from a Tier 1 approach by the corresponding AGB value from the Tier 1 approach. Multiply the AGB value (in tonne of carbon per hectare per year) by R to estimate BGB.

Figure 23. **NEXT screenshot of the Tier 2 section in the "deforestation" module with correction for the mortality rate**

FINAL LAND USE RE/AFFORESTATION - TIER 2 CARBON STOCK

Final land use - Forest/Plantation carbon stock (in tC/ha/yr for AGB and BGB, tC/ha for litter and deadwood)														IWMS Rewetting, EFCH4		
AGB <= 20 years		BGB <= 20 years		AGB > 20 years		BGB > 20 years		Litter		Deadwood		Soil Carbon			EF, kgCH4/ha/yr	
Tier 1	Tier 2	Tier 1	Tier 2	Tier 1	Tier 2	Tier 1	Tier 2	Tier 1	Tier 2	Tier 1	Tier 2	SOC ref	Tier 1	Rewetting	Tier 1	Tier 2
3.29		0.92		0.94		0.26		3.7		0.0		47.0		No	0	
3.76	2.4	1.05	0.7	3.76	3.0	1.05	0.8	3.7		0.0		47.0		No	0	

Source: Authors' elaboration based on **Schiettecatte, L.-S., Audebert, P., Umulisa, V., Dionisio, D. and Bernoux, M.** 2022a. *Technical guidance of the Nationally Determined Contribution Expert Tool (NEXT)*. Rome, FAO.

1. What is the carbon balance in 2030, 2035 and 2049? [Dashboard]

The results are available on the left panel of the "Dashboard" spreadsheet (Figure 24), after selecting the requested years (orange cells). The impact of reforestation leads to carbon sequestration. The carbon balance is **-3 267 402 tCO_2-eq** by 2030. The mitigation potential increases to **-21 313 023 tCO_2-eq** by 2035 and finally reaches **-216 776 133 tCO_2-eq** by 2049.

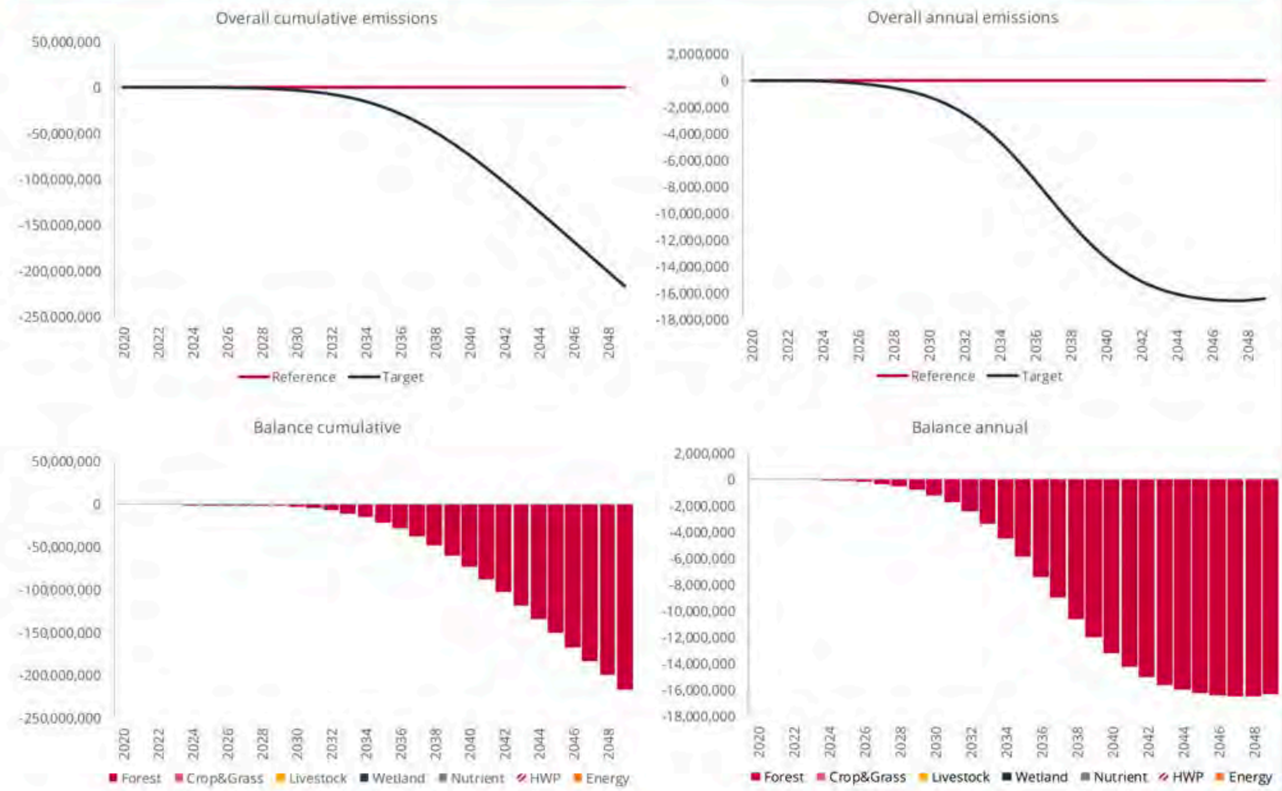
A negative mitigation potential refers to a reduction in greenhouse gas emissions and/or an increase in carbon removal (carbon stock). In this case, the negative mitigation potential arises from greater carbon sequestration in the target scenario compared to the reference scenario.

Figure 24. **NEXT screenshot of the dashboard for the sigmoid afforestation**

NEXT indicators*

* indicators from the strategies implemented in the present analysis

Cumulative emissions - Emissions expected by:	**2030**		**2035**		**2049**	
Reference scenario:	0	tCO2-eq	0	tCO2-eq	0	tCO2-eq
Target scenario:	-3,267,402	tCO2-eq	-21,313,023	tCO2-eq	-216,776,133	tCO2-eq
Mitigation potential:	-3,267,402 ▼	tCO2-eq	-21,313,023 ▼	tCO2-eq	-216,776,133 ▼	tCO2-eq
Carbon stock changes (balance):	-3,267,402 ▼	tCO2	-21,313,023 ▼	tCO2	-216,776,133 ▼	tCO2
Total emissions changes, excluded carbon stock (balance):	0	tCO2-eq	0	tCO2-eq	0	tCO2-eq
Annual emissions - Emissions expected by:	**2030**		**2035**		**2049**	
Reference scenario:	0	tCO2-eq	0	tCO2-eq	0	tCO2-eq
Target scenario:	-1,213,315	tCO2-eq	-5,910,268	tCO2-eq	-16,378,286	tCO2-eq
Forest cover (balance, cumulative area):	119,544	ha	491,857	ha	1,100,000	ha



Source: Authors' elaboration based on **Schiettecatte, L.-S., Audebert, P., Umulisa, V., Dionisio, D. and Bernoux, M.** 2022a. *Technical guidance of the Nationally Determined Contribution Expert Tool (NEXT)*. Rome, FAO.

2. What is the variable driving carbon sequestration? [Results summary]

The central panel of the "Dashboard" spreadsheet confirms that CO_2 is the primary greenhouse gas involved in mitigation. This is further validated by the "Results Summary" spreadsheet, which provides detailed information on GHG emissions across different pools and sources. The main driver of climate change mitigation in this context is carbon sequestration in both biomass and soil, as emphasized in the results summary sheet (rows 38 and 40 in NEXT, Figure 25).

Figure 25. **NEXT screenshot of the results summary for the sigmoid afforestation**

Cumulative RESULTS

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Biomass CO2	0	0	0	13,754	-12,636	-96,834	-264,063	-550,111	-1,005,288	-1,699,375	-2,727,278
HWP CO2 net	0	0	0	0	0	0	0	0	0	0	0
Soil mineral CO2	0	0	0	-5,069	-17,426	-40,228	-77,928	-136,739	-225,191	-354,712	-540,124

Source: Authors' elaboration based on **Schiettecatte, L.-S., Audebert, P., Umulisa, V., Dionisio, D. and Bernoux, M.** 2022a. *Technical guidance of the Nationally Determined Contribution Expert Tool (NEXT)*. Rome, FAO.

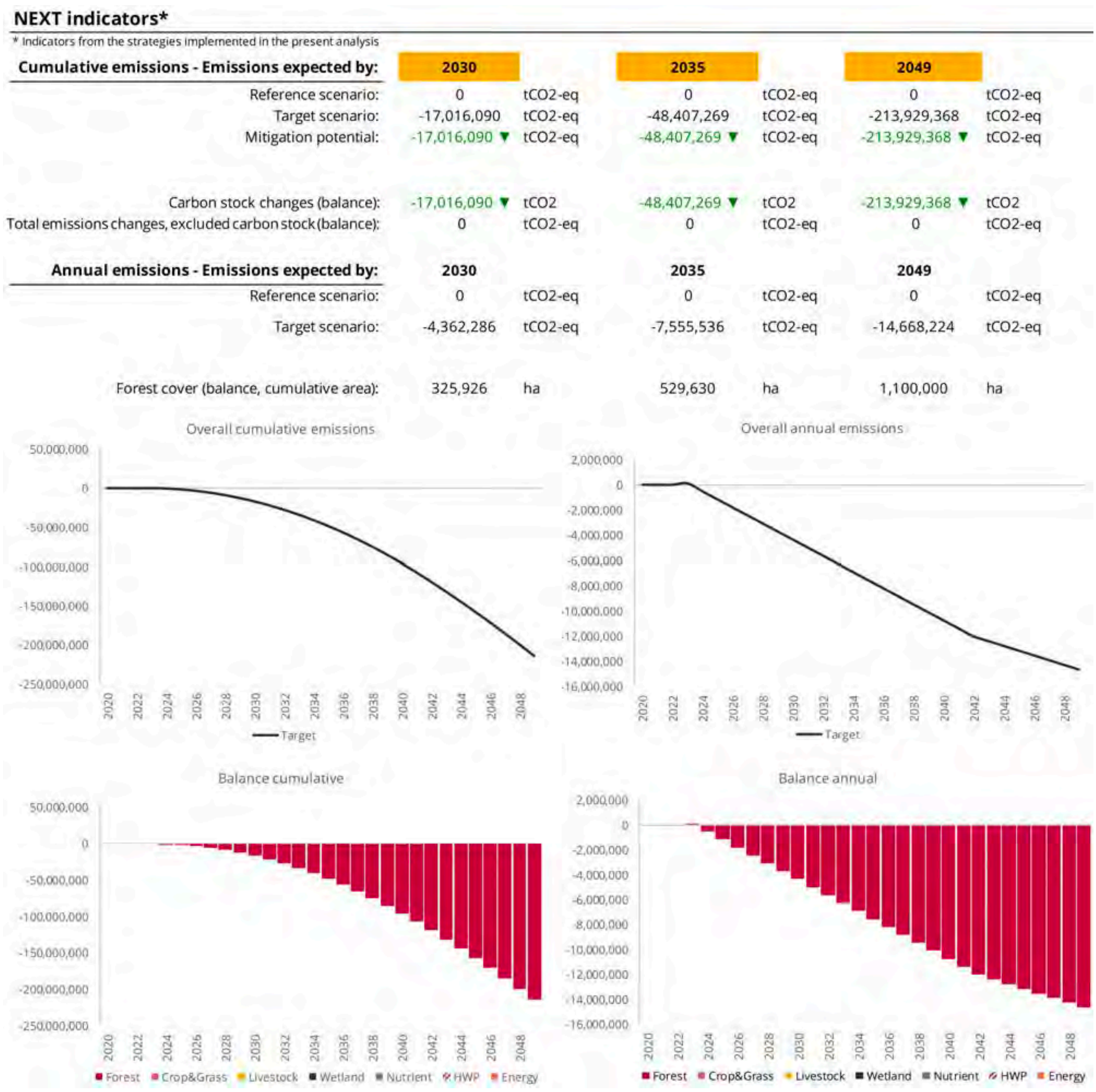
3. How many hectares are reforested by 2030, 2035 and 2049? [Dashboard] & [Land & Soc indicators]

The forest cover area is displayed in the dashboard (Figure 24). By 2030, **119 544 ha** have been reforested. This increases to **491 857 ha** by 2035 and finally reaches the goal of **1 100 000 ha** by 2049.

4. Change the dynamic of implementation to linear and then exponential. What is the impact that you observe on the carbon balance by 2049 and the annual land-use changes? [Dashboard] & [Users activity data]

The dynamic of implementation can be changed in the main menu of the "afforestation/reforestation" sub-module. Under linear mode, the carbon balance reaches **-213 929 368 tCO_2-eq** by 2049, with **325 926 ha** reforested by 2030 and **529 630 ha** by 2035. In the exponential mode, the carbon balance improves to **-330 850 786 tCO_2-eq** by 2049, with reforestation expanding to **818 939 ha** by 2030 and **980 207 ha** by 2035 (Figure 26).

Figure 26. **NEXT screenshot of the dashboard for the linear (above) and exponential (below) afforestation**



NEXT indicators*

* Indicators from the strategies implemented in the present analysis

Cumulative emissions - Emissions expected by:	2030		2035		2049	
Reference scenario:	0	tCO2-eq	0	tCO2-eq	0	tCO2-eq
Target scenario:	-17,016,090	tCO2-eq	-48,407,269	tCO2-eq	-213,929,368	tCO2-eq
Mitigation potential:	-17,016,090 ▼	tCO2-eq	-48,407,269 ▼	tCO2-eq	-213,929,368 ▼	tCO2-eq
Carbon stock changes (balance):	-17,016,090 ▼	tCO2	-48,407,269 ▼	tCO2	-213,929,368 ▼	tCO2
Total emissions changes, excluded carbon stock (balance):	0	tCO2-eq	0	tCO2-eq	0	tCO2-eq
Annual emissions - Emissions expected by:	**2030**		**2035**		**2049**	
Reference scenario:	0	tCO2-eq	0	tCO2-eq	0	tCO2-eq
Target scenario:	-4,362,286	tCO2-eq	-7,555,536	tCO2-eq	-14,668,224	tCO2-eq
Forest cover (balance, cumulative area):	325,926	ha	529,630	ha	1,100,000	ha

5. Which indicators could you use to track the implementation of that policy?

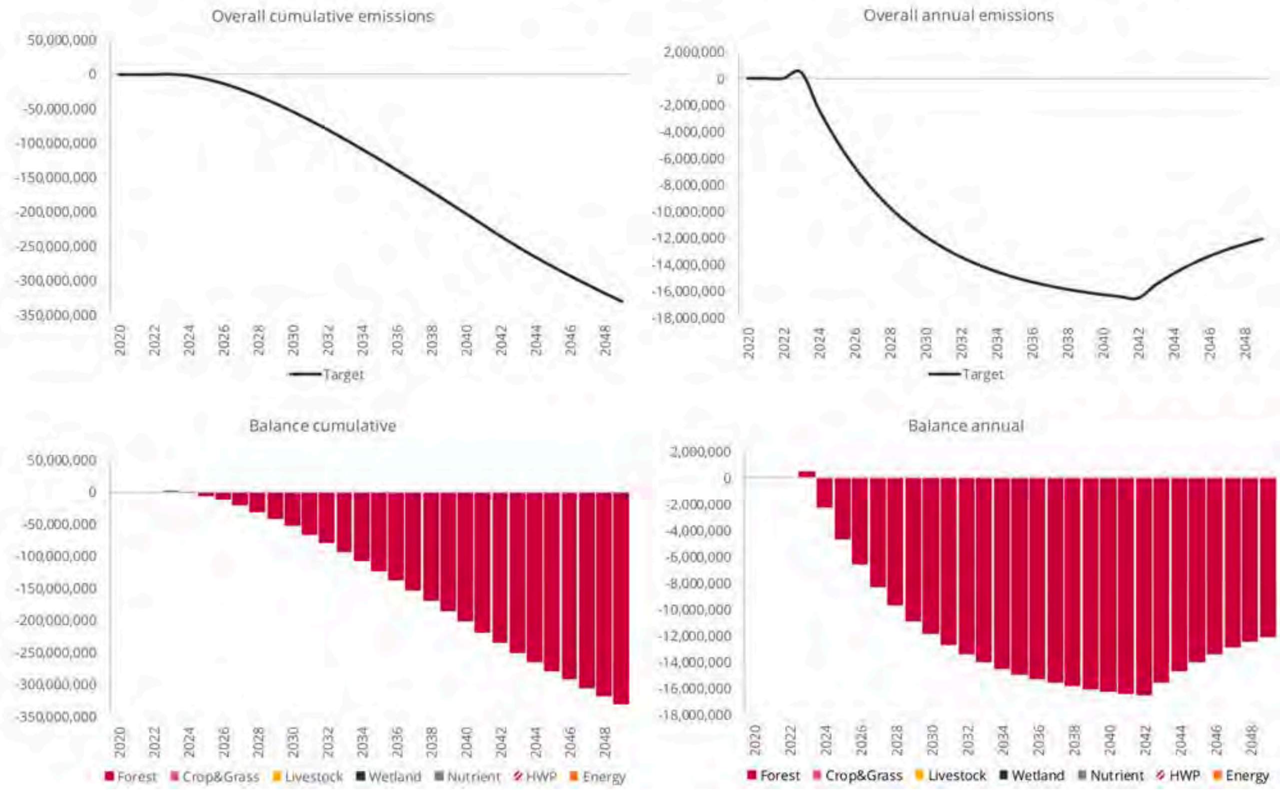
The two key indicators that can be used to track the progress of the policy are the **forest cover area** (in ha) and the **mitigation potential** (in tCO_2-eq).

Figure 26. NEXT screenshot of the dashboard for the linear (above) and exponential (below) afforestation

NEXT indicators*

* Indicators from the strategies implemented in the present analysis

Cumulative emissions - Emissions expected by:	**2030**		**2035**		**2049**	
Reference scenario:	0	tCO2-eq	0	tCO2-eq	0	tCO2-eq
Target scenario:	-53,904,095	tCO2-eq	-123,571,567	tCO2-eq	-330,850,786	tCO2-eq
Mitigation potential:	-53,904,095 ▼	tCO2-eq	-123,571,567 ▼	tCO2-eq	-330,850,786 ▼	tCO2-eq
Carbon stock changes (balance):	-53,904,095 ▼	tCO2	-123,571,567 ▼	tCO2	-330,850,786 ▼	tCO2
Total emissions changes, excluded carbon stock (balance):	0	tCO2-eq	0	tCO2-eq	0	tCO2-eq
Annual emissions - Emissions expected by:	**2030**		**2035**		**2049**	
Reference scenario:	0	tCO2-eq	0	tCO2-eq	0	tCO2-eq
Target scenario:	-11,879,387	tCO2-eq	-14,957,258	tCO2-eq	-12,089,015	tCO2-eq
Forest cover (balance, cumulative area):	818,939	ha	980,207	ha	1,100,000	ha



Source: Authors' elaboration based on **Schiettecatte, L.-S., Audebert, P., Umulisa, V., Dionisio, D. and Bernoux, M.** 2022a. *Technical guidance of the Nationally Determined Contribution Expert Tool (NEXT)*. Rome, FAO.

6. Which information and/or activity data should be refined to improve the analysis?

To improve the accuracy of the analysis, data and emission factors specific to the region would help. Tier 2 emission factors on climate conditions and soil types in the area undergoing the intervention would enhance the analysis. This would enable precise, location-specific data to be incorporated into the analysis.

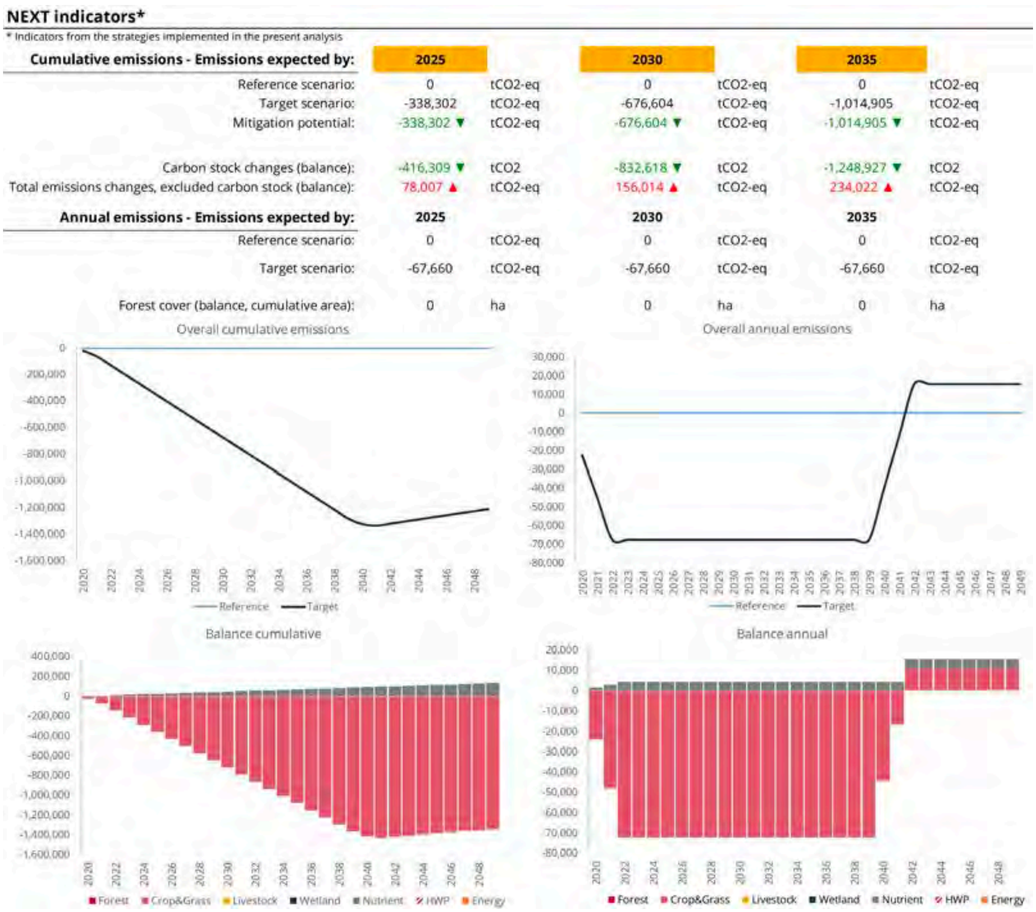
Answers to Exercise 2. Improve soil organic carbon

Intermediary questions:

1. What is the carbon balance in 2025, 2030 and 2035? [Dashboard]

The results are available on the left panel of the "Dashboard" spreadsheet (Figure 27), after selecting the requested years (orange cells). In this case, the conversion to cassava leads to carbon storage, however, the use of fertilizers emits GHGs. The overall mitigation potential reaches **-338 302 tCO_2-eq** by 2025, **-676 604 tCO_2-eq** by 2030 and **-1 014 905 tCO_2-eq** by 2035.

Figure 27. **NEXT screenshot of the dashboard for the sigmoid afforestation**



Source: Authors' elaboration based on **Schiettecatte, L.-S., Audebert, P., Umulisa, V., Dionisio, D. and Bernoux, M.** 2022a. *Technical guidance of the Nationally Determined Contribution Expert Tool (NEXT)*. Rome, FAO.

2. What is the variable driving carbon sequestration? [Results summary]

Climate change mitigation is primarily driven by **carbon sequestration in the soil,** as shown in row 40, "Soil mineral CO_2" of the results summary sheet in NEXT (Figure 28). The conversion to cassava, along with the shift in farming practices, contributes to enhanced soil quality, reduced erosion, and greater organic matter input. These changes result in improved soil fertility and increased carbon storage. As cassava plants grow, their deep root systems capture and store carbon, while the decomposition of plant biomass further enriches the soil with organic carbon, leading to long-term carbon sequestration.

Figure 28. **NEXT screenshot of the results summary for the cassava plantation**

Cumulative RESULTS

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Biomass CO2	0	0	0	0	0	0	0	0	0	0	0
HWP CO2 net	0	0	0	0	0	0	0	0	0	0	0
Soil mineral CO2	-27,754	-83,262	-166,524	-249,785	-333,047	-416,309	-499,571	-582,833	-666,094	-749,356	-832,618
Soil mineral CH4 (WMS rewetted)	0	0	0	0	0	0	0	0	0	0	0
Direct N2O from managed soils (include N2O PRP)	4,134	12,403	24,806	37,209	49,612	62,015	74,418	86,821	99,224	111,627	124,030
Indirect N2O from managed soils (include N2O PRF	1,066	3,198	6,397	9,595	12,794	15,992	19,191	22,389	25,588	28,786	31,985

Source: Authors' elaboration based on **Schiettecatte, L.-S., Audebert, P., Umulisa, V., Dionisio, D. and Bernoux, M.** 2022a. *Technical guidance of the Nationally Determined Contribution Expert Tool (NEXT)*. Rome, FAO.

3. Where do the N_2O emissions come from?

The N_2O emissions are primarily direct emissions (4/5) and, to a lesser extent, indirect emissions (1/5) resulting from the soil management practices. The availability of inorganic nitrogen in the soil is influenced by factors such as the application of synthetic NPK fertilizers, increased nutrient inputs, the retention of crop residues containing nitrogen, and the use of legume crop rotations that fix nitrogen.

4. If this policy was integrated into the NDC 3.0, what types of indicators could you use to track and report on its implementation? [Land & SOC indicators]

The implementation of this policy could be tracked through several indicators: the N_2O emissions, the annual cropland SOC and the cumulative non-forest area with enhanced mineral SOC.

Analysis questions:

1. What are the GHG emissions in 2030, 2035 and 2049 in tCO_2-eq? [Dashboard]

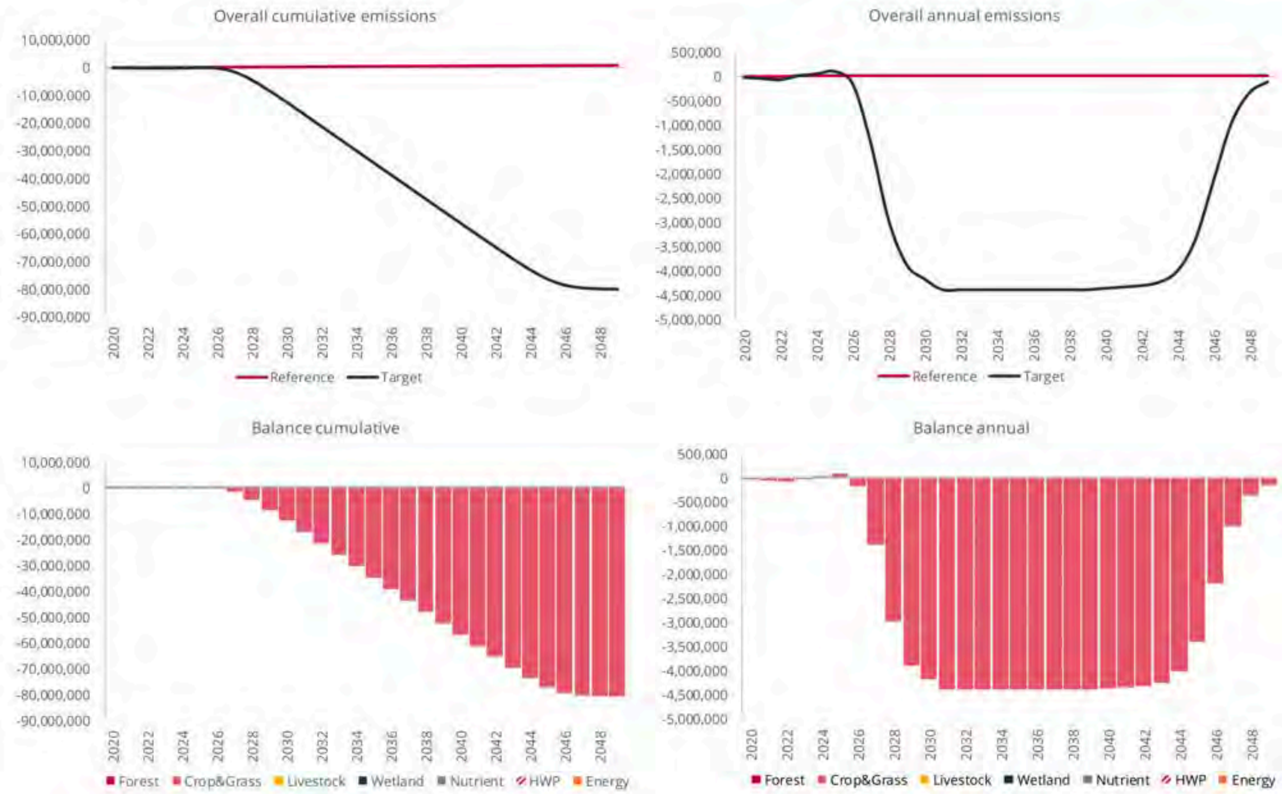
The results can be found on the left panel of the "Dashboard" spreadsheet (Figure 29), after selecting the desired years (highlighted in orange cells). In the target scenario, the GHG emissions are negative with -12 421 760 tCO_2-eq by 2030 against 243 481 tCO_2-eq emitted in the reference scenario, leading to a mitigation potential of **-12 665 241 tCO_2-eq.** The mitigation potential reaches **-34 698 266 tCO_2-eq** by 2030 by 2035 and **-80 763 448 tCO_2-eq** by 2049.

Figure 29. NEXT screenshot of the dashboard for the cassava and cashew plantations

NEXT indicators*

* Indicators from the strategies implemented in the present analysis

Cumulative emissions - Emissions expected by:	**2030**		**2035**		**2049**	
Reference scenario:	243,481	tCO2-eq	395,657	tCO2-eq	821,750	tCO2-eq
Target scenario:	-12,421,760	tCO2-eq	-34,302,608	tCO2-eq	-79,941,698	tCO2-eq
Mitigation potential:	-12,665,241 ▼	tCO2-eq	-34,698,266 ▼	tCO2-eq	-80,763,448 ▼	tCO2-eq
Carbon stock changes (balance):	-12,685,723 ▼	tCO2	-34,644,579 ▼	tCO2	-80,502,089 ▼	tCO2
Total emissions changes, excluded carbon stock (balance):	20,482 ▲	tCO2-eq	-53,687 ▼	tCO2-eq	-261,359 ▼	tCO2-eq
Annual emissions - Emissions expected by:	**2030**		**2035**		**2049**	
Reference scenario:	30,435	tCO2-eq	30,435	tCO2-eq	30,435	tCO2-eq
Target scenario:	-4,158,588	tCO2-eq	-4,376,170	tCO2-eq	-112,233	tCO2-eq
Forest cover (balance, cumulative area):	0	ha	0	ha	0	ha



Source: Authors' elaboration based on **Schiettecatte, L.-S., Audebert, P., Umulisa, V., Dionisio, D. and Bernoux, M.** 2022a. *Technical guidance of the Nationally Determined Contribution Expert Tool (NEXT)*. Rome, FAO.

2. Which driver creates the strongest mitigation potential in the long run? [Results summary]

The mitigation potential comes from the carbon sequestration in the soil mineral CO_2 and biomass CO_2. In the long-term, the strongest carbon sink is **biomass,** storing more than 50 000 000 tCO_2-eq out of the 80 000 000 tCO_2-eq mitigated by 2049 (Figure 30).

Figure 30. **NEXT screenshot of the results summary for the cassava and cashew plantations**

Cumulative RESULTS

TARGET	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Biomass CO2	0	0	0	69,980	247,787	668,830	1,204,681	898,651	-809,883	-3,368,012	-6,186,430	-9,222,430	-12,258,430
HWP CO2 net	0	0	0	0	0	0	0	0	0	0	0	0	0
Soil mineral CO2	-27,754	-83,262	-166,524	-270,508	-441,783	-799,916	-1,510,916	-2,574,782	-3,825,506	-5,143,522	-6,499,293	-7,855,064	-9,210,835
Soil mineral CH4 (IWMS rewetted)	0	0	0	0	0	0	0	0	0	0	0	0	0
Direct N2O from managed soils (include N2O P	4,134	12,403	24,806	61,649	97,179	129,060	154,052	172,154	186,608	199,748	212,151	224,554	236,957
Indirect N2O from managed soils (include N2O	1,066	3,198	6,397	15,095	23,497	31,078	37,109	41,589	45,249	48,614	51,812	55,011	58,209
CO2 soil (fertilizers)	0	0	0	0	0	0	0	0	0	0	0	0	0
Organic soil CO2	0	0	0	0	0	0	0	0	0	0	0	0	0
Organic soil CH4	0	0	0	0	0	0	0	0	0	0	0	0	0
Organic soil N2O	0	0	0	0	0	0	0	0	0	0	0	0	0
CH4 flooded rice	0	0	0	0	0	0	0	0	0	0	0	0	0
CO2 coastal and flooded land	0	0	0	0	0	0	0	0	0	0	0	0	0
CH4 coastal and flooded land	0	0	0	0	0	0	0	0	0	0	0	0	0
N2O Aquaculture - Coastal wetlands	0	0	0	0	0	0	0	0	0	0	0	0	0
CH4 livestock - Enteric fermentation	0	0	0	0	0	0	0	0	0	0	0	0	0
CH4 livestock - Manure management (except PI	0	0	0	0	0	0	0	0	0	0	0	0	0
N2O livestock - Manure management (except P	0	0	0	0	0	0	0	0	0	0	0	0	0
Fire CO2	0	0	0	0	0	0	0	0	0	0	0	0	0
Fire CH4	0	0	0	0	0	0	0	0	0	0	0	0	0
Fire N2O	0	0	0	0	0	0	0	0	0	0	0	0	0
Fire CO2 (organic soil)	0	0	0	0	0	0	0	0	0	0	0	0	0
Fire CH4 (organic soil)	0	0	0	0	0	0	0	0	0	0	0	0	0
Fossil fuel combustion CO2	0	0	0	0	0	0	0	0	0	0	0	0	0
Fossil fuel combustion CH4	0	0	0	0	0	0	0	0	0	0	0	0	0
Fossil fuel combustion N2O	0	0	0	0	0	0	0	0	0	0	0	0	0
CO2	-27,754	-83,262	-166,524	-200,528	-193,996	-131,086	-306,234	-1,676,131	-4,635,390	-8,511,534	-12,685,723	-17,077,494	-21,469,266
CH4	0	0	0	0	0	0	0	0	0	0	0	0	0
N2O	5,200	15,601	31,203	76,744	120,675	160,138	191,161	213,744	231,858	248,362	263,963	279,565	295,166
Total	-22,553	-67,660	-135,321	-123,784	-73,321	29,051	-115,074	-1,462,388	-4,403,532	-8,263,172	-12,421,760	-16,797,929	-21,174,099

TARGET	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049
Biomass CO2	-15,294,430	-18,330,430	-21,366,430	-24,402,430	-27,438,430	-30,474,430	-33,510,430	-36,546,430	-39,582,430	-42,618,430	-45,604,990	-48,431,004	-50,811,206	-52,349,526	-53,045,963	-53,296,588	-53,386,667
HWP CO2 net	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Soil mineral CO2	-10,566,606	-11,922,378	-13,278,149	-14,633,920	-15,989,691	-17,345,462	-18,701,233	-20,029,250	-21,329,514	-22,602,023	-23,853,810	-25,038,306	-26,035,944	-26,680,715	-26,972,620	-27,077,667	-27,115,423
Soil mineral CH4 (IWMS rewetted)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Direct N2O from managed soils (include N2O P	249,360	261,763	274,166	286,569	298,972	311,375	323,778	336,181	348,584	360,987	373,390	385,793	398,196	410,599	423,001	435,404	447,807
Indirect N2O from managed soils (include N2O	61,408	64,606	67,805	71,003	74,202	77,400	80,599	83,797	86,996	90,194	93,393	96,591	99,790	102,988	106,187	109,385	112,584
CO2 soil (fertilizers)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Organic soil CO2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Organic soil CH4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Organic soil N2O	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CH4 flooded rice	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CO2 coastal and flooded land	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CH4 coastal and flooded land	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N2O Aquaculture - Coastal wetlands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CH4 livestock - Enteric fermentation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CH4 livestock - Manure management (except PI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N2O livestock - Manure management (except P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fire CO2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fire CH4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fire N2O	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fire CO2 (organic soil)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fire CH4 (organic soil)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fossil fuel combustion CO2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fossil fuel combustion CH4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fossil fuel combustion N2O	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CO2	-25,861,037	-30,252,808	-34,644,579	-39,036,350	-43,428,121	-47,819,892	-52,211,663	-56,575,681	-60,911,944	-65,220,453	-69,458,801	-73,469,310	-76,847,150	-79,030,241	-80,018,583	-80,374,255	-80,502,089
CH4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N2O	310,768	326,369	341,971	357,572	373,174	388,775	404,377	419,978	435,579	451,181	466,782	482,384	497,985	513,587	529,188	544,790	560,391
Total	-25,550,269	-29,926,439	-34,302,608	-38,678,778	-43,054,948	-47,431,117	-51,807,287	-56,155,703	-60,476,365	-64,769,272	-68,992,018	-72,986,927	-76,349,165	-78,516,655	-79,489,395	-79,829,465	-79,941,698

Source: Authors' elaboration based on **Schiettecatte, L.-S., Audebert, P., Umulisa, V., Dionisio, D. and Bernoux, M.** 2022a. *Technical guidance of the Nationally Determined Contribution Expert Tool (NEXT)*. Rome, FAO.

3. Can you explain the GHG emissions in the reference scenario? [Results summary]

In the reference scenario, the GHG emissions can be attributed to cassava and their associated management practices, totaling 821 750 tCO_2-eq by 2049. Nitrous oxide (N_2O) emissions occur annually, with direct emissions amounting to 24 845 tCO_2-eq per year and indirect emissions contributing 5 590 tCO_2-eq. These emissions are driven by soil management practices, such as the retention of crop residues, which increase the nitrogen content in the soil and lead to higher N_2O

emissions from soil management activities.

4. Why is the sequestration in biomass decreasing over time in the annual balance? [Results summary]

The decrease in biomass sequestration over time in the annual balance is linked to the dynamics of carbon release and capture in the plantation. From 2023 to 2026, CO_2 emissions from biomass increase significantly, rising from 69 908 tCO_2-eq to 535 852 tCO_2-eq due to land conversion (Figure 31). The default biomass carbon stock from the initial land is 5 tC/ha (see tier 2 section of the "crop&grass" module). After 2026, the sum of carbon sequestration from the new land (about 2.1 tC/ha/yr) offset the initial biomass loss. The balance between biomass loss and biomass gain goes from -300 000 tCO_2-eq in 2027 to -3 036 000 tCO_2-eq by 2031. This high level of sequestration persists until around 2042, after which it declines rapidly, reaching -90 079 tCO_2-eq by 2049. In the initial phase, the plantation transitions from being a carbon source to a carbon sink as it matures. After about 20 years, the plantation reaches the end of its growth cycle, at which point its ability to sequester carbon significantly diminishes.

Figure 31. NEXT screenshot of the balance annual time series for the cassava and cashew plantations

ANNUAL RESULTS

BALANCE	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Biomass CO2	0	0	0	69,980	177,807	421,043	535,852	-306,031	-1,708,534	-2,558,129
HWP CO2 net	0	0	0	0	0	0	0	0	0	0
Soil mineral CO2	-27,754	-55,508	-83,262	-103,984	-171,275	-358,133	-711,000	-1,063,866	-1,250,724	-1,318,016
Soil mineral CH4 (IWMS rewetted)	0	0	0	0	0	0	0	0	0	0
Direct N2O from managed soils (include N2O PRP)	4,134	8,269	12,403	11,998	10,685	7,036	147	-6,743	-10,391	-11,705
Indirect N2O from managed soils (include N2O PRP)	1,066	2,132	3,198	3,107	2,812	1,991	441	-1,109	-1,930	-2,226
CO2 soil (fertilizers)	0	0	0	0	0	0	0	0	0	0
Organic soil CO2	0	0	0	0	0	0	0	0	0	0
Organic soil CH4	0	0	0	0	0	0	0	0	0	0
Organic soil N2O	0	0	0	0	0	0	0	0	0	0
CH4 flooded rice	0	0	0	0	0	0	0	0	0	0
CO2 coastal and flooded land	0	0	0	0	0	0	0	0	0	0
CH4 coastal and flooded land	0	0	0	0	0	0	0	0	0	0
N2O Aquaculture - Coastal wetlands	0	0	0	0	0	0	0	0	0	0
CH4 livestock - Enteric fermentation	0	0	0	0	0	0	0	0	0	0
CH4 livestock - Manure management (except PRP)	0	0	0	0	0	0	0	0	0	0
N2O livestock - Manure management (except PRP)	0	0	0	0	0	0	0	0	0	0
Fire CO2	0	0	0	0	0	0	0	0	0	0
Fire CH4	0	0	0	0	0	0	0	0	0	0
Fire N2O	0	0	0	0	0	0	0	0	0	0
Fire CO2 (organic soil)	0	0	0	0	0	0	0	0	0	0
Fire CH4 (organic soil)	0	0	0	0	0	0	0	0	0	0
Fossil fuel combustion CO2	0	0	0	0	0	0	0	0	0	0
Fossil fuel combustion CH4	0	0	0	0	0	0	0	0	0	0
Fossil fuel combustion N2O	0	0	0	0	0	0	0	0	0	0
CO2	-27,754	-55,508	-83,262	-34,004	6,531	62,910	-175,148	-1,369,897	-2,959,258	-3,876,144
CH4	0	0	0	0	0	0	0	0	0	0
N2O	5,200	10,401	15,601	15,106	13,496	9,027	588	-7,852	-12,321	-13,931
Total	-22,553	-45,107	-67,660	-18,898	20,028	71,937	-174,560	-1,377,749	-2,971,579	-3,890,075

BALANCE	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Biomass CO2	-2,818,418	-3,036,000	-3,036,000	-3,036,000	-3,036,000	-3,036,000	-3,036,000	-3,036,000	-3,036,000	-3,036,000
HWP CO2 net	0	0	0	0	0	0	0	0	0	0
Soil mineral CO2	-1,355,771	-1,355,771	-1,355,771	-1,355,771	-1,355,771	-1,355,771	-1,355,771	-1,355,771	-1,355,771	-1,355,771
Soil mineral CH4 (IWMS rewetted)	0	0	0	0	0	0	0	0	0	0
Direct N2O from managed soils (include N2O PRP)	-12,442	-12,442	-12,442	-12,442	-12,442	-12,442	-12,442	-12,442	-12,442	-12,442
Indirect N2O from managed soils (include N2O PRP)	-2,392	-2,392	-2,392	-2,392	-2,392	-2,392	-2,392	-2,392	-2,392	-2,392
CO2 soil (fertilizers)	0	0	0	0	0	0	0	0	0	0
Organic soil CO2	0	0	0	0	0	0	0	0	0	0
Organic soil CH4	0	0	0	0	0	0	0	0	0	0
Organic soil N2O	0	0	0	0	0	0	0	0	0	0
CH4 flooded rice	0	0	0	0	0	0	0	0	0	0
CO2 coastal and flooded land	0	0	0	0	0	0	0	0	0	0
CH4 coastal and flooded land	0	0	0	0	0	0	0	0	0	0
N2O Aquaculture - Coastal wetlands	0	0	0	0	0	0	0	0	0	0
CH4 livestock - Enteric fermentation	0	0	0	0	0	0	0	0	0	0
CH4 livestock - Manure management (except PRP)	0	0	0	0	0	0	0	0	0	0
N2O livestock - Manure management (except PRP)	0	0	0	0	0	0	0	0	0	0
Fire CO2	0	0	0	0	0	0	0	0	0	0
Fire CH4	0	0	0	0	0	0	0	0	0	0
Fire N2O	0	0	0	0	0	0	0	0	0	0
Fire CO2 (organic soil)	0	0	0	0	0	0	0	0	0	0
Fire CH4 (organic soil)	0	0	0	0	0	0	0	0	0	0
Fossil fuel combustion CO2	0	0	0	0	0	0	0	0	0	0
Fossil fuel combustion CH4	0	0	0	0	0	0	0	0	0	0
Fossil fuel combustion N2O	0	0	0	0	0	0	0	0	0	0
CO2	-4,174,190	-4,391,771	-4,391,771	-4,391,771	-4,391,771	-4,391,771	-4,391,771	-4,391,771	-4,391,771	-4,391,771
CH4	0	0	0	0	0	0	0	0	0	0
N2O	-14,834	-14,834	-14,834	-14,834	-14,834	-14,834	-14,834	-14,834	-14,834	-14,834
Total	-4,189,023	-4,406,605	-4,406,605	-4,406,605	-4,406,605	-4,406,605	-4,406,605	-4,406,605	-4,406,605	-4,406,605

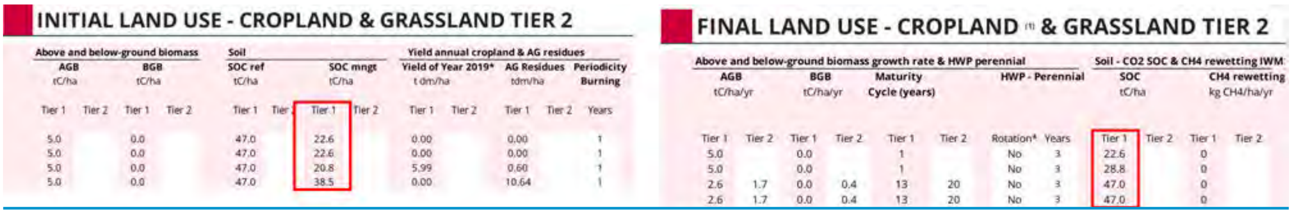
BALANCE	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049
Biomass CO2	-3,036,000	-3,036,000	-3,036,000	-2,986,560	-2,826,014	-2,380,202	-1,538,319	-696,437	-250,625	-90,079
HWP CO2 net	0	0	0	0	0	0	0	0	0	0
Soil mineral CO2	-1,328,017	-1,300,263	-1,272,509	-1,251,787	-1,184,496	-997,638	-644,771	-291,905	-105,047	-37,756
Soil mineral CH4 (IWMS rewetted)	0	0	0	0	0	0	0	0	0	0
Direct N2O from managed soils (include N2O PRP)	-12,442	-12,442	-12,442	-12,442	-12,442	-12,442	-12,442	-12,442	-12,442	-12,442
Indirect N2O from managed soils (include N2O PRP)	-2,392	-2,392	-2,392	-2,392	-2,392	-2,392	-2,392	-2,392	-2,392	-2,392
CO2 soil (fertilizers)	0	0	0	0	0	0	0	0	0	0
Organic soil CO2	0	0	0	0	0	0	0	0	0	0
Organic soil CH4	0	0	0	0	0	0	0	0	0	0
Organic soil N2O	0	0	0	0	0	0	0	0	0	0
CH4 flooded rice	0	0	0	0	0	0	0	0	0	0
CO2 coastal and flooded land	0	0	0	0	0	0	0	0	0	0
CH4 coastal and flooded land	0	0	0	0	0	0	0	0	0	0
N2O Aquaculture - Coastal wetlands	0	0	0	0	0	0	0	0	0	0
CH4 livestock - Enteric fermentation	0	0	0	0	0	0	0	0	0	0
CH4 livestock - Manure management (except PRP)	0	0	0	0	0	0	0	0	0	0
N2O livestock - Manure management (except PRP)	0	0	0	0	0	0	0	0	0	0
Fire CO2	0	0	0	0	0	0	0	0	0	0
Fire CH4	0	0	0	0	0	0	0	0	0	0
Fire N2O	0	0	0	0	0	0	0	0	0	0
Fire CO2 (organic soil)	0	0	0	0	0	0	0	0	0	0
Fire CH4 (organic soil)	0	0	0	0	0	0	0	0	0	0
Fossil fuel combustion CO2	0	0	0	0	0	0	0	0	0	0
Fossil fuel combustion CH4	0	0	0	0	0	0	0	0	0	0
Fossil fuel combustion N2O	0	0	0	0	0	0	0	0	0	0
CO2	-4,364,017	-4,336,263	-4,308,509	-4,238,347	-4,010,510	-3,377,840	-2,183,091	-988,342	-355,672	-127,834
CH4	0	0	0	0	0	0	0	0	0	0
N2O	-14,834	-14,834	-14,834	-14,834	-14,834	-14,834	-14,834	-14,834	-14,834	-14,834
Total	-4,378,851	-4,351,097	-4,323,343	-4,253,181	-4,025,344	-3,392,674	-2,197,925	-1,003,176	-370,506	-142,668

Source: Authors' elaboration based on **Schiettecatte, L.-S., Audebert, P., Umulisa, V., Dionisio, D. and Bernoux, M.** 2022a. *Technical guidance of the Nationally Determined Contribution Expert Tool (NEXT)*. Rome, FAO.

5. What are the initial and final values of the SOC for each system? [Crop&Grass]

The SOC values can be found on the Crop&Grass module (Figure 32). The conversion to agroforestry and the changes in soil management practices support the enhancement of SOC.

Figure 32. NEXT screenshot of the Tier 2 section in the "Crop&Grass" module



INITIAL LAND USE - CROPLAND & GRASSLAND TIER 2

Above and below-ground biomass AGB tC/ha		BGB tC/ha		Soil SOC ref tC/ha		SOC mngt tC/ha		Yield annual cropland & AG residues Yield of Year 2019* t dm/ha		AG Residues tdm/ha		Periodicity Burning
Tier 1	Tier 2	Tier 1	Tier 2	Tier 1	Tier	Tier 1	Tier 2	Tier 1	Tier 2	Tier 1	Tier 2	Years
5.0		0.0		47.0		22.6		0.00		0.00		1
5.0		0.0		47.0		22.6		0.00		0.00		1
5.0		0.0		47.0		20.8		5.99		0.60		1
5.0		0.0		47.0		38.5		0.00		10.64		1

FINAL LAND USE - CROPLAND (1) & GRASSLAND TIER 2

Above and below-ground biomass growth rate & HWP perennial AGB tC/ha/yr		BGB tC/ha/yr		Maturity Cycle (years)		HWP - Perennial		Soil - CO2 SOC & CH4 rewetting IWM SOC tC/ha		CH4 rewetting kg CH4/ha/yr	
Tier 1	Tier 2	Tier 1	Tier 2	Tier 1	Tier 2	Rotation*	Years	Tier 1	Tier 2	Tier 1	Tier 2
5.0		0.0		1		No	3	22.6		0	
5.0		0.0		1		No	3	28.8		0	
2.6	1.7	0.0	0.4	13	20	No	3	47.0		0	
2.6	1.7	0.0	0.4	13	20	No	3	47.0		0	

Source: Authors' elaboration based on **Schiettecatte, L.-S., Audebert, P., Umulisa, V., Dionisio, D. and Bernoux, M.** 2022a. *Technical guidance of the Nationally Determined Contribution Expert Tool (NEXT)*. Rome, FAO.

We can read the following:

- 200 000 hectares of annual croplands planted with cassava using new soil management practices maintain stable SOC levels, with both the initial and final values at **22.6 tC/ha.**
- The other 200 000 hectares of annual croplands converted to cassava under the same management practices, but with the addition of annual nutrient application, show a slight increase in SOC from **22.6 tC/ha to 28.8 tC/ha.**
- Cashew tree plantations also have a positive impact on SOC in both land types:
  - The initial agricultural land planted in agroforestry sees an increase in SOC from **20.8 tC/ha to 47.0 tC/ha.**
  - The annual croplands set aside for agroforestry show an increase in SOC from **38.5 tC/ha to 47.0 tC/ha.**

6. What indicators could you use for the tracking and monitoring of the policy on cashew nuts if it was integrated into the next NDC? [Land & SOC indicators]. Can you identify some other indicators linked to the cassava and cashew policies?

If the cashew nuts policy were integrated into the next NDC, several key indicators could be used to track and monitor its implementation (see Figure 33), including:

- The land use of ''cumulative non-forest area with enhanced mineral SOC" – in ha per year
- SOC values for different land uses as the ''agricultural SOC enhanced" – in tCO_2-eq per year
- N_2O emissions from soil management practices - in tCO_2-eq per year.

Figure 33. **NEXT screenshot of the Land&SOC indicators for the cassava and cashew plantations**

LAND USE INDICATORS (areas are expressed in ha)

BALANCE	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
% change - Forest cover Cumulative	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
% change - Deforestation Cumulative	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
% change - Deforestation annual	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Cumulative area with reduced deforestation	0	0	0	0	0	0	0	0	0	0
Cumulative area with restored forest	0	0	0	0	0	0	0	0	0	0
Cumulative area with enhanced (af/re)forestation	0	0	0	0	0	0	0	0	0	0
Cumulative non-forest area with enhanced mineral SOC	24,269	48,538	72,807	79,320	100,473	159,209	270,129	381,049	439,786	460,938
Area with applied manure	0	0	0	0	0	0	0	0	0	0

MINERAL SOILS INDICATORS

AREA UNDER SUSTAINABLE MANAGEMENT PRACTICES, in ha	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Cumulative area with enhanced SOC (except forest)	24,269	48,538	72,807	79,320	100,473	159,209	270,129	381,049	439,786	460,938
Cumulative forest area with enhanced SOC*	0	0	0	0	0	0	0	0	0	0
Cumulative annual cropland area with enhanced SOC	24,269	48,538	72,807	72,807	72,807	72,807	72,807	72,807	72,807	72,807
Cumulative agroforestry area with enhanced SOC	0	0	0	6,514	27,666	86,403	197,323	308,243	366,980	388,132
Cumulative grassland area with enhanced SOC	0	0	0	0	0	0	0	0	0	0
Soil area under no tillage	24,269	48,538	72,807	72,807	72,807	72,807	72,807	72,807	72,807	72,807
Soil area with manure inputs	24,269	48,538	72,807	72,807	72,807	72,807	72,807	72,807	72,807	72,807
Soil area with residues retained	24,269	48,538	72,807	79,320	100,473	159,209	270,129	381,049	439,786	460,938

*wetlands are not integrated

BALANCE MINERAL SOC, in tCO2-eq (Cumulative)*	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Forest SOC preserved	0	0	0	0	0	0	0	0	0	0
Forest SOC enhanced	0	0	0	0	0	0	0	0	0	0
Forest SOC loss	0	0	0	0	0	0	0	0	0	0
Agricultural SOC preserved	0	0	0	0	0	0	0	0	0	0
Agricultural SOC enhanced	-27,754	-83,262	-166,524	-270,508	-441,783	-799,916	-1,510,916	-2,574,782	-3,825,506	-5,143,522
Agricultural SOC lost	0	0	0	0	0	0	0	0	0	0
Annual cropland SOC preserved	0	0	0	0	0	0	0	0	0	0
Annual cropland SOC enhanced	-27,754	-83,262	-166,524	-249,785	-333,047	-416,309	-499,571	-582,833	-666,094	-749,356
Annual cropland SOC lost	0	0	0	0	0	0	0	0	0	0
Agroforestry SOC preserved	0	0	0	0	0	0	0	0	0	0
Agroforestry SOC enhanced	0	0	0	-20,722	-108,736	-383,607	-1,011,345	-1,991,950	-3,159,412	-4,394,166
Agroforestry SOC lost	0	0	0	0	0	0	0	0	0	0
Grassland SOC preserved	0	0	0	0	0	0	0	0	0	0
Grassland SOC enhanced	0	0	0	0	0	0	0	0	0	0
Grassland SOC lost	0	0	0	0	0	0	0	0	0	0
N2O emissions (direct & indirect) from soil management	5,200	15,601	31,203	46,309	59,805	68,832	69,420	61,568	49,247	35,316
N2O emissions (direct & indirect) from PRP	0	0	0	0	0	0	0	0	0	0
Total	**-22,553**	**-67,660**	**-135,321**	**-224,199**	**-381,978**	**-731,084**	**-1,441,496**	**-2,513,214**	**-3,776,260**	**-5,108,206**

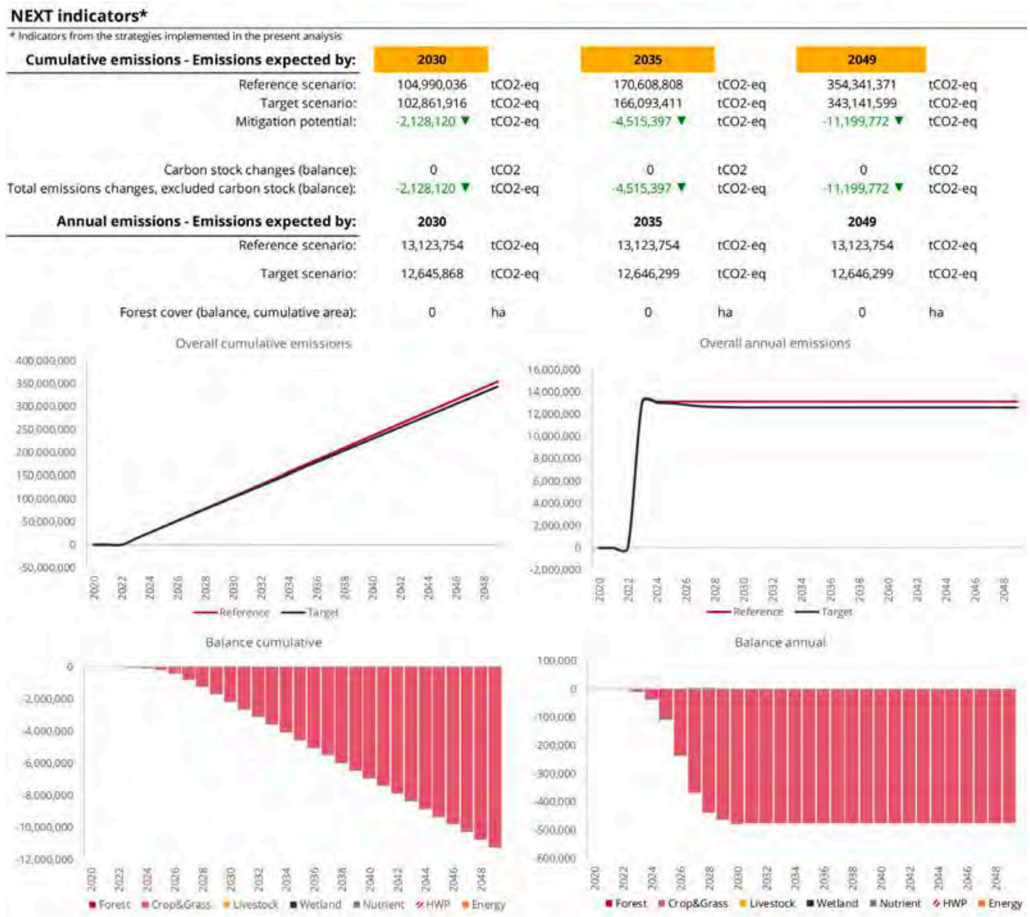
Source: Authors' elaboration based on **Schiettecatte, L.-S., Audebert, P., Umulisa, V., Dionisio, D. and Bernoux, M.** 2022a. *Technical guidance of the Nationally Determined Contribution Expert Tool (NEXT)*. Rome, FAO.

Answers to Exercise 3. Flooded rice

1. What would the GHG emissions be by 2030, 2035 and 2049 in tCO_2-eq? [Dashboard]

The GHG emissions of the reference scenario would be 104 990 036 tCO_2-eq by 2030, 170 608 808 tCO_2-eq by 2035 and 354 341 371 tCO_2-eq by 2049 (Figure 34). The GHG emissions of the target scenario would be 102 861 916 tCO_2-eq by 2030, 166 093 411 tCO_2-eq by 2035 and 343 141 599 tCO_2-eq by 2049. That represents a mitigation potential of **-2 128 120 tCO_2-eq** by 2030, **-4 515 397 tCO_2-eq** by 2035 and **-11 199 772 tCO_2-eq** by 2049.

Figure 34. **NEXT screenshot of the dashboard for the rice production**



Source: Authors' elaboration based on **Schiettecatte, L.-S., Audebert, P., Umulisa, V., Dionisio, D. and Bernoux, M.** 2022a. *Technical guidance of the Nationally Determined Contribution Expert Tool (NEXT)*. Rome, FAO.

2. How many rice management systems do we have and what are their CH_4 emission factors in kgCH_4/ha/day? [Crop&Grass]

In the target scenario, there are three distinct rice management systems with varying CH_2 emission factors:

- Wet Season:
  - Rainfed: 2 400 136 ha with an emission factor of **0.7 kg CH_4/ha/day**
  - Irrigated: 113 520 ha with an emission factor of **5 kg CH_4/ha/day**
- Dry Season:
  - Irrigated: 113 520 ha with an emission factor of **2.0 kg CH_4/ha/day** with the adoption of AWD compared to an emission factor of 3.07 kg CH_4/ha/day without.

3. Given that the mitigation objective from the NDC2 is about 6.2 million tCO_2-eq for the agriculture sector, based on our assumptions, how much does the adoption of AWD contribute to this goal?

The adoption of AWD is projected to contribute **2.13 million tCO_2-eq** in mitigation by 2030, representing approximately **a third of that sectoral target, although rice is under the adaptation component of NDC2.**

4. Return to the "Home" tab of NEXT and select the IPCC 2019 methodologies. What are the changes that can be observed in the "Nutrients" module?

Upon switching to the IPCC 2019 methodologies, we observe an increase in GHG emissions in the "Nutrients" module. This change is likely due to the incorporation of updated emission factors, more detailed data, and enhanced research on N_2O emissions from nutrient use. The revised methodology provides a more accurate and refined estimate of emissions.

5. As Cambodia is one of the signatories of the Global Methane Pledge (Box 2), what would be the contribution of AWD in this exercise to reducing national CH_4 emissions by 2030? [results summary] & [balance cumulated, CH_4 part]

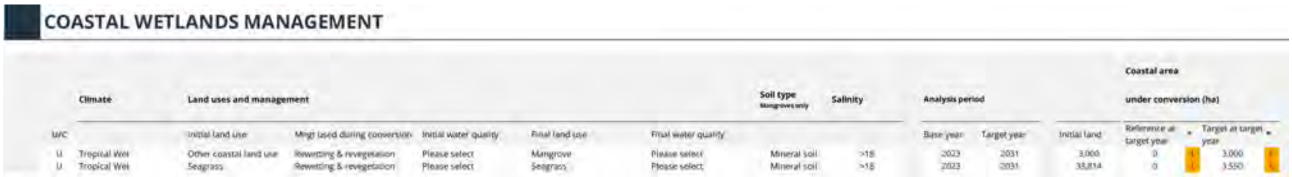
The adoption of AWD is projected to significantly reduce CH_4 emissions, with a reduction of about **2 million tCO_2-eq by 2030.** This contribution supports Cambodia's commitment to the Global Methane Pledge, helping to mitigate national CH_4 emissions in line with global climate goals.

Answers to Exercise 4. Forestry & Fisheries – mangrove restoration and seagrass management

Activity #1: 3 000 ha of mangrove planted & Activity #2: 70 percent of all seagrasses are well managed

The plantation of mangroves & regrowth of seagrass is analyzed as outlined below (Figure 35).

Figure 35. NEXT screenshot of the main menu in the "coastal wetlands management" module for mangrove and seagrass



COASTAL WETLANDS MANAGEMENT

	Climate	Land uses and management					Soil type (Mangroves only)	Salinity	Analysis period			Coastal area under conversion (ha)	
U/C		Initial land use	Mngt used during conversion	Initial water quality	Final land use	Final water quality			Base year	Target year	Initial land	Reference at target year	Target at target year
U	Tropical Wet	Other coastal land use	Rewetting & revegetation	Please select	Mangrove	Please select	Mineral soil	>18	2023	2031	3,000	0	3,000
U	Tropical Wet	Seagrass	Rewetting & revegetation	Please select	Seagrass	Please select	Mineral soil	>18	2023	2031	33,814	0	3,550

Source: Authors' elaboration based on **Schiettecatte, L.-S., Audebert, P., Umulisa, V., Dionisio, D. and Bernoux, M.** 2022a. *Technical guidance of the Nationally Determined Contribution Expert Tool (NEXT)*. Rome, FAO.

1. What is the carbon balance of these two activities in 2030, 2035 and 2049? [Dashboard]

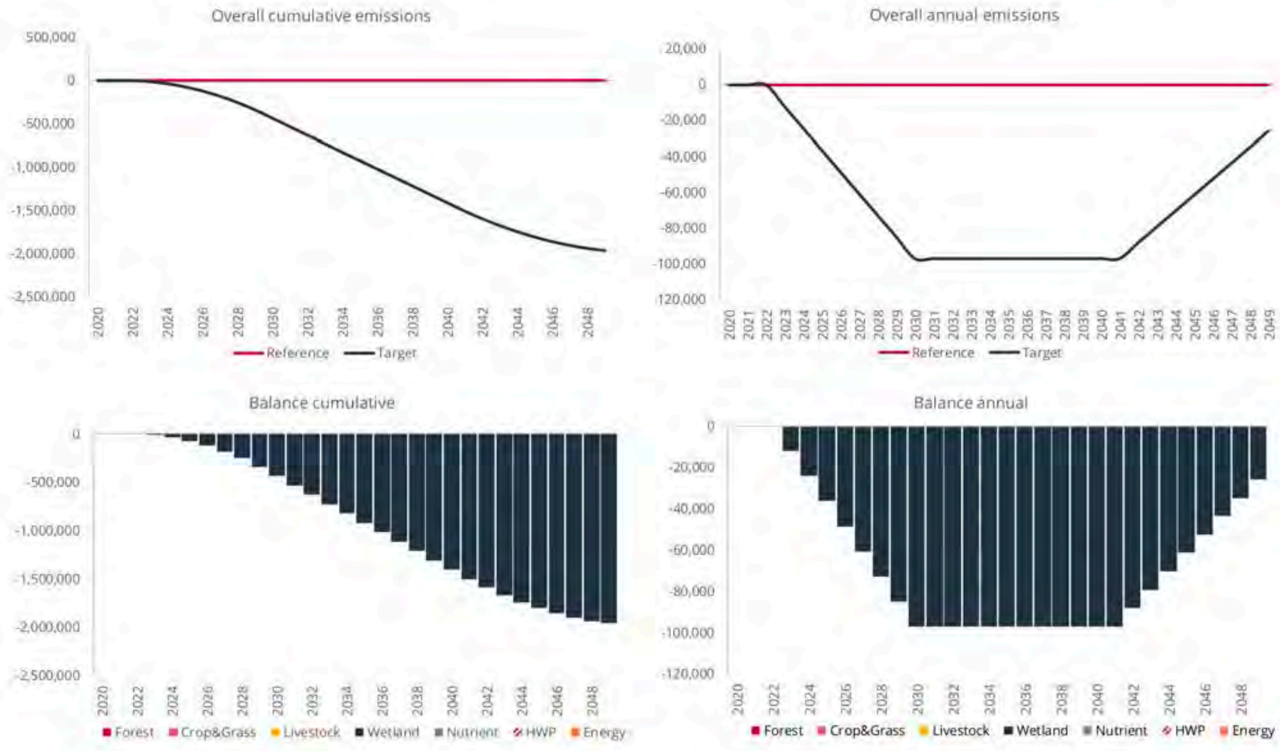
The results are available on the left panel of the "Dashboard" spreadsheet (Figure 36), after selecting the requested years (orange cells). Both the plantation of mangroves and the regrowth of seagrass contribute to carbon storage, of about 2 million tCO_2-eq by 2049. However, the mitigation potential of mangrove planting is significantly higher than that of seagrass regrowth. By 2030, coastal management allow to enhance carbon stock by **436 866 tCO_2-eq.** By 2035, the carbon sequestration potential increases to **-922 272 tCO_2-eq** and, by 2049, the total carbon storage from mangrove and seagrass is projected to reach **-1.9 million tCO_2-eq.** The contribution of each ecosystem can be individually read in the "balance cumulated" spreadsheet in lines 107 and 108.

Figure 36. NEXT screenshot of the dashboard for the coastal wetlands activities

NEXT indicators*

* Indicators from the strategies implemented in the present analysis

Cumulative emissions - Emissions expected by:	**2030**		**2035**		**2049**	
Reference scenario:	0	tCO2-eq	0	tCO2-eq	0	tCO2-eq
Target scenario:	-436,866	tCO2-eq	-922,272	tCO2-eq	-1,960,721	tCO2-eq
Mitigation potential:	-436,866 ▼	tCO2-eq	-922,272 ▼	tCO2-eq	-1,960,721 ▼	tCO2-eq
Carbon stock changes (balance):	-436,866 ▼	tCO2	-922,272 ▼	tCO2	-1,960,721 ▼	tCO2
Total emissions changes, excluded carbon stock (balance):	0	tCO2-eq	0	tCO2-eq	0	tCO2-eq
Annual emissions - Emissions expected by:	**2030**		**2035**		**2049**	
Reference scenario:	0	tCO2-eq	0	tCO2-eq	0	tCO2-eq
Target scenario:	-97,081	tCO2-eq	-97,081	tCO2-eq	-25,817	tCO2-eq
Forest cover (balance, cumulative area):	3,000	ha	3,000	ha	3,000	ha



Source: Authors' elaboration based on **Schiettecatte, L.-S., Audebert, P., Umulisa, V., Dionisio, D. and Bernoux, M.** 2022a. *Technical guidance of the Nationally Determined Contribution Expert Tool (NEXT)*. Rome, FAO.

2. What is the variable driving carbon sequestration? [Results summary]

In the first activity, carbon sequestration is primarily driven by the storage of CO_2 in mangrove **biomass** (about 73 percent) and in the **soils** of coastal and flooded lands (Figure 37). The processes of rewetting and revegetation create optimal conditions for carbon storage. Through photosynthesis and growth, mangroves absorb CO_2 and store it in their biomass. In the soil, carbon is sequestered through the accumulation of organic matter, the reduced rate of decomposition due to waterlogged conditions, and the formation of peat. In the second activity, carbon sequestration is driven solely by the storage of CO_2 in the soils of coastal and flooded lands.

Figure 37. **NEXT screenshot of the results summary for mangroves plantation and seagrass regrowth**

		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
	Biomass CO2	0	0	0	-8,908	-26,724	-53,448	-89,080	-133,621	-187,069	-249,425	-320,689
	HWP CO2 net	0	0	0	0	0	0	0	0	0	0	0
	Soil mineral CO2	0	0	0	0	0	0	0	0	0	0	0
	Soil mineral CH4 (IWMS rewetted)	0	0	0	0	0	0	0	0	0	0	0
	Direct N2O from managed soils (include N2O PRP)	0	0	0	0	0	0	0	0	0	0	0
	Indirect N2O from managed soils (include N2O PRP)	0	0	0	0	0	0	0	0	0	0	0
	CO2 soil (fertilizers)	0	0	0	0	0	0	0	0	0	0	0
	Organic soil CO2	0	0	0	0	0	0	0	0	0	0	0
	Organic soil CH4	0	0	0	0	0	0	0	0	0	0	0
	Organic soil N2O	0	0	0	0	0	0	0	0	0	0	0
	CH4 flooded rice	0	0	0	0	0	0	0	0	0	0	0
BALANCE	CO2 coastal and flooded land	0	0	0	-3,227	-9,681	-19,363	-32,271	-48,407	-67,770	-90,360	-116,177
	CH4 coastal and flooded land	0	0	0	0	0	0	0	0	0	0	0
	N2O Aquaculture - Coastal wetlands	0	0	0	0	0	0	0	0	0	0	0
	CH4 livestock - Enteric fermentation	0	0	0	0	0	0	0	0	0	0	0
	CH4 livestock - Manure management (except PRP)	0	0	0	0	0	0	0	0	0	0	0
	N2O livestock - Manure management (except PRP)	0	0	0	0	0	0	0	0	0	0	0
	Fire CO2	0	0	0	0	0	0	0	0	0	0	0
	Fire CH4	0	0	0	0	0	0	0	0	0	0	0
	Fire N2O	0	0	0	0	0	0	0	0	0	0	0
	Fire CO2 (organic soil)	0	0	0	0	0	0	0	0	0	0	0
	Fire CH4 (organic soil)	0	0	0	0	0	0	0	0	0	0	0
	Fossil fuel combustion CO2	0	0	0	0	0	0	0	0	0	0	0
	Fossil fuel combustion CH4	0	0	0	0	0	0	0	0	0	0	0
	Fossil fuel combustion N2O	0	0	0	0	0	0	0	0	0	0	0
	CO2	0	0	0	-12,135	-36,405	-72,811	-121,352	-182,027	-254,838	-339,784	-436,866
	CH4	0	0	0	0	0	0	0	0	0	0	0
	N2O	0	0	0	0	0	0	0	0	0	0	0
	Total	0	0	0	-12,135	-36,405	-72,811	-121,352	-182,027	-254,838	-339,784	-436,866

Source: Authors' elaboration based on **Schiettecatte, L.-S., Audebert, P., Umulisa, V., Dionisio, D. and Bernoux, M.** 2022a. *Technical guidance of the Nationally Determined Contribution Expert Tool (NEXT)*. Rome, FAO.

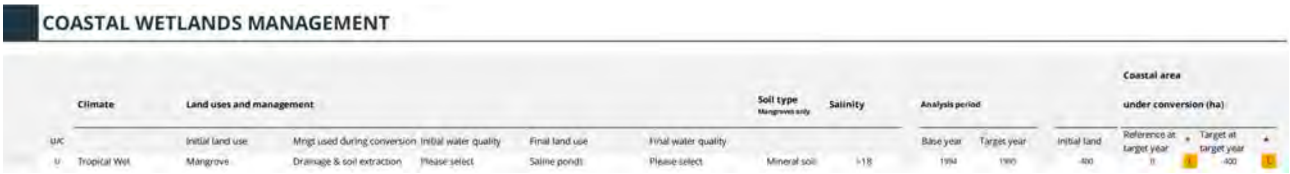
3. Which driver contributes to the most mitigation for the longest period? [Results summary]

For the plantation of mangroves, **biomass** is the biggest pool of CO_2 in the long term. It stores over -1 354 021 tCO_2-eq of the -1 960 721 tCO_2-eq stored by 2049, representing 73 percent of the carbon sequestered. In the seagrass activity, it is only the soil carbon pool that stores -187 930 tCO_2-eq by 2049 (see "Balance cumulated", cell AG108).

Additional exercise: Estimate the quantity of carbon loss from mangrove deforestation

The additional exercise follows these assumptions (Figures 38 & 39).

Figure 38. **NEXT screenshot of the main menu in the "coastal wetlands management" module for mangrove deforestation**



Source: Authors' elaboration based on **Schiettecatte, L.-S., Audebert, P., Umulisa, V., Dionisio, D. and Bernoux, M.** 2022a. *Technical guidance of the Nationally Determined Contribution Expert Tool (NEXT)*. Rome, FAO.

Figure 39. **NEXT screenshot of the Tier 2 section in the "coastal wetlands management" module**

Source: Authors' elaboration based on **Schiettecatte, L.-S., Audebert, P., Umulisa, V., Dionisio, D. and Bernoux, M.** 2022a. *Technical guidance of the Nationally Determined Contribution Expert Tool (NEXT)*. Rome, FAO.

1. What is the carbon balance of the conversion from mangroves to shrimp farming ponds in the first year, 10, 20 and 30 years after? [Dashboard]

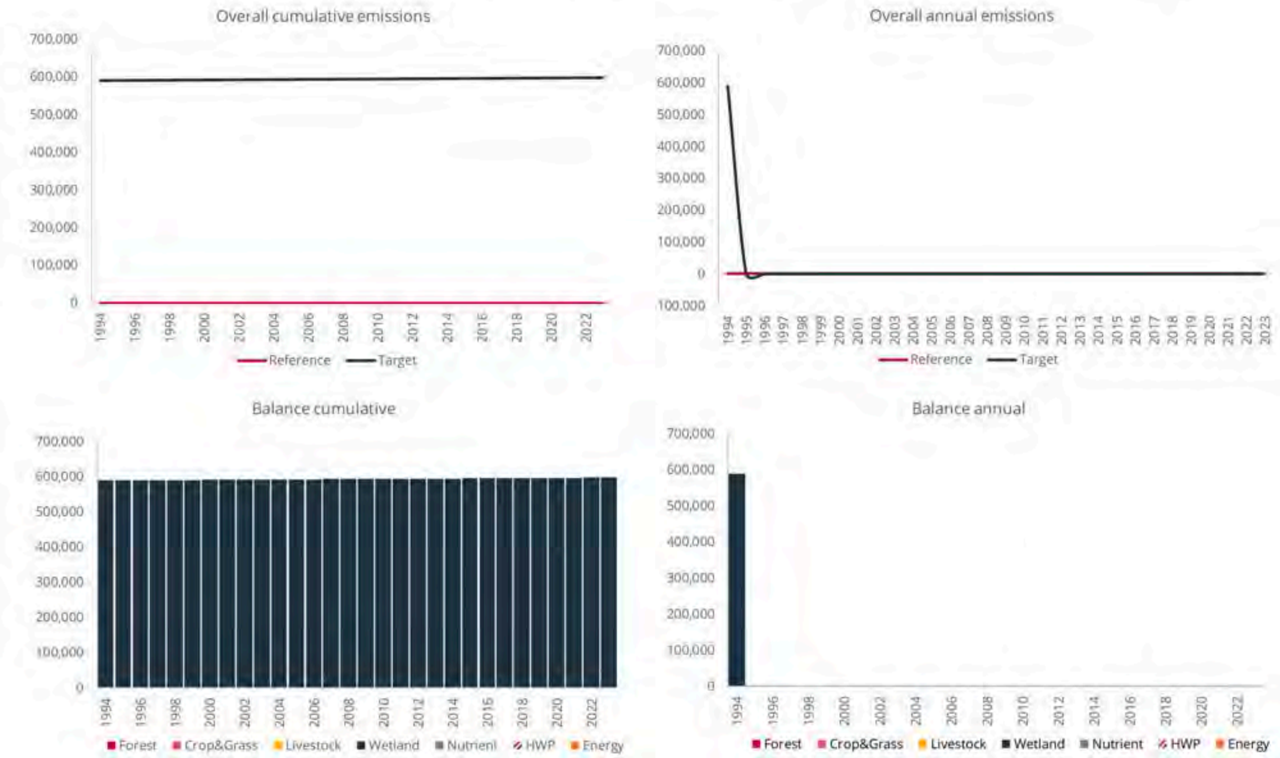
The conversion of mangroves into shrimp farming ponds leads to an initial release of **589 538 tCO_2-eq** in 1994, the year of conversion. After the conversion, an additional **282 tCO_2-eq** is emitted annually due to ongoing ecosystem changes. As a result, emissions reach **592 353 tCO_2-eq** ten years after the conversion, **595 168 tCO_2-eq** 20 years later, and **597 702 tCO_2-eq** 30 years post-conversion (Figure 40).

Figure 40. **NEXT screenshot of the dashboard for mangrove deforestation (without eutrophication status integrated)**

NEXT indicators*

* Indicators from the strategies implemented in the present analysis

Cumulative emissions - Emissions expected by:	**1994**		**2004**		**2014**	
Reference scenario:	0	tCO2-eq	0	tCO2-eq	0	tCO2-eq
Target scenario:	589,538	tCO2-eq	592,353	tCO2-eq	595,168	tCO2-eq
Mitigation potential:	589,538 ▲	tCO2-eq	592,353 ▲	tCO2-eq	595,168 ▲	tCO2-eq
Carbon stock changes (balance):	158,666 ▲	tCO2	158,666 ▲	tCO2	158,666 ▲	tCO2
Total emissions changes, excluded carbon stock(balance):	430,871 ▲	tCO2-eq	433,686 ▲	tCO2-eq	436,501 ▲	tCO2-eq
Annual emissions - Emissions expected by:	**1994**		**2004**		**2014**	
Reference scenario:	0	tCO2-eq	0	tCO2-eq	0	tCO2-eq
Target scenario:	589,538	tCO2-eq	282	tCO2-eq	282	tCO2-eq
Forest cover (balance, cumulative area):	-400	ha	-400	ha	-400	ha



Source: Authors' elaboration based on **Schiettecatte, L.-S., Audebert, P., Umulisa, V., Dionisio, D. and Bernoux, M.** 2022a. *Technical guidance of the Nationally Determined Contribution Expert Tool (NEXT)*. Rome, FAO.

2. What is the variable driving the GHG emissions? [Results summary]

In 1994, the conversion of mangroves to shrimp farming ponds results in 589 256 tCO_2-eq of emissions, primarily due to the loss of biomass (**158 666 tCO_2-eq**) and the disturbance of coastal and flooded soils (**430 590 tCO_2-eq**). This includes the removal of mangrove vegetation, soil drainage, and soil extraction. Under Tier 1, it is assumed that biomass, litter, deadwood, and soil are all removed and disposed of under aerobic conditions, releasing all the carbon from these pools as

CO_2 in the year of conversion. Each subsequent year, an additional **282 tCO_2-eq** is emitted from the aquaculture process, mainly from N_2O emissions associated with shrimp farming (Figure 41).

Figure 41. NEXT screenshot of the results summary for mangrove deforestation

TARGET	1994	1995	1996	1997	1998	1999	2000
Biomass CO2	158,666	0	0	0	0	0	0
HWP CO2 net	0	0	0	0	0	0	0
Soil mineral CO2	0	0	0	0	0	0	0
Soil mineral CH4 (IWMS rewetted)	0	0	0	0	0	0	0
Direct N2O from managed soils (include N2O PRP)	0	0	0	0	0	0	0
Indirect N2O from managed soils (include N2O PRP)	0	0	0	0	0	0	0
CO2 soil (fertilizers)	0	0	0	0	0	0	0
Organic soil CO2	0	0	0	0	0	0	0
Organic soil CH4	0	0	0	0	0	0	0
Organic soil N2O	0	0	0	0	0	0	0
CH4 flooded rice	0	0	0	0	0	0	0
CO2 coastal and flooded land	430,590	0	0	0	0	0	0
CH4 coastal and flooded land	0	0	0	0	0	0	0
N2O Aquaculture - Coastal wetlands	282	282	282	282	282	282	282
CH4 livestock - Enteric fermentation	0	0	0	0	0	0	0
CH4 livestock - Manure management (except PRP)	0	0	0	0	0	0	0
N2O livestock - Manure management (except PRP)	0	0	0	0	0	0	0
Fire CO2	0	0	0	0	0	0	0
Fire CH4	0	0	0	0	0	0	0
Fire N2O	0	0	0	0	0	0	0
Fire CO2 (organic soil)	0	0	0	0	0	0	0
Fire CH4 (organic soil)	0	0	0	0	0	0	0
Fossil fuel combustion CO2	0	0	0	0	0	0	0
Fossil fuel combustion CH4	0	0	0	0	0	0	0
Fossil fuel combustion N2O	0	0	0	0	0	0	0
CO2	589,256	0	0	0	0	0	0
CH4	0	0	0	0	0	0	0
N2O	282	282	282	282	282	282	282
Total	589,538	282	282	282	282	282	282

Source: Authors' elaboration based on **Schiettecatte, L.-S., Audebert, P., Umulisa, V., Dionisio, D. and Bernoux, M.** 2022a. *Technical guidance of the Nationally Determined Contribution Expert Tool (NEXT)*. Rome, FAO.

3. Convert the emissions into tC/ha and compare it with the carbon sequestration potential from the development of mangroves (previous exercise)

The conversion of mangroves to shrimp farming results in emissions of **1 474 tC/ha** in 1994, to about **1 488 tC/ha** 20 years after conversion. In contrast, the development of mangroves leads to carbon sequestration of **-4 tC/ha** in the first year, **-223 tC/ha** after 10 years, and **-511 tC/ha** after 20 years. Deforestation associated with soil excavation and drainage has a much greater immediate impact, with emissions nearly 400 times higher than the sequestration potential in the first year. While the difference decreases over time, deforestation still results in twice the impact per hectare after 20 years compared to mangrove development.

4. What is the carbon footprint of the shrimp, annual and cumulated?

Over a pond cycle (assumed to be around 30 years), the cumulated shrimp carbon footprint is about 197 tCO_2-eq/tonne of shrimp, while the annual one ranges from 1 474 tCO_2-eq per tonne of shrimp the first year (because of the carbon stock changes) to 0.7 tCO_2-eq per tonne of shrimp in the successive years. The annual average over 30 years is about 50 tCO_2-eq per tonne of shrimp. The longer the pond is in use phase the more the cannula carbon footprint will tend to decrease, smoothing the impact of land use changes on the first year.

5. Adjust the water quality to “eutrophic” in the main menu. What changes do you observe?

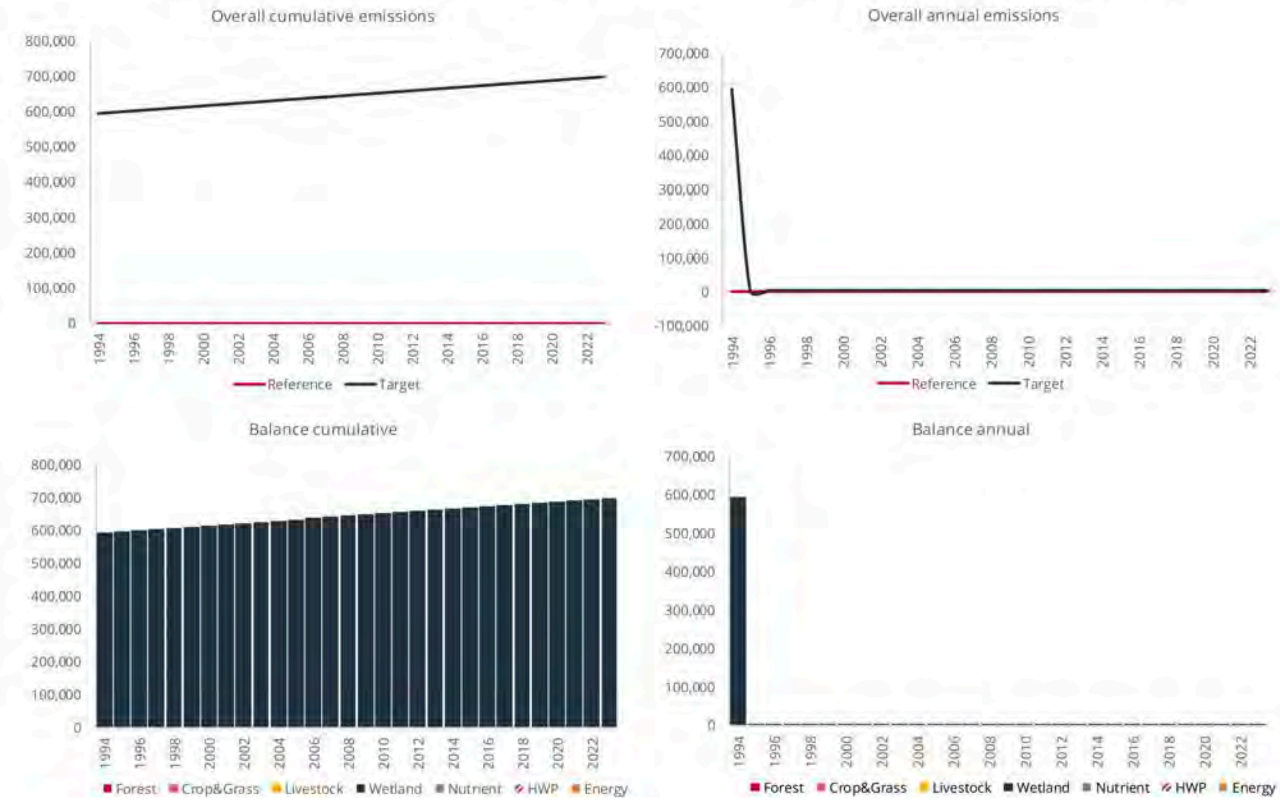
In eutrophic conditions, the GHG emissions are higher (Figure 42). 3 360 tCO_2-eq of CH_4 is emitted every year. Eutrophic waters emit CH_4 due to the high levels of organic matter from excessive nutrients, which stimulate microbial activity in anoxic conditions. This process leads to the production of CH_4 through methanogenesis, which is then released into the atmosphere.

Figure 42. NEXT screenshot of the dashboard for mangrove deforestation in eutrophic conditions

NEXT indicators*

* Indicators from the strategies implemented in the present analysis

Cumulative emissions - Emissions expected by:	1994		2004		2014	
Reference scenario:	0	tCO2-eq	0	tCO2-eq	0	tCO2-eq
Target scenario:	592,898	tCO2-eq	629,313	tCO2-eq	665,728	tCO2-eq
Mitigation potential:	592,898 ▲	tCO2-eq	629,313 ▲	tCO2-eq	665,728 ▲	tCO2-eq
Carbon stock changes (balance):	158,666 ▲	tCO2	158,666 ▲	tCO2	158,666 ▲	tCO2
Total emissions changes, excluded carbon stock (balance):	434,231 ▲	tCO2-eq	470,646 ▲	tCO2-eq	507,061 ▲	tCO2-eq
Annual emissions - Emissions expected by:	**1994**		**2004**		**2014**	
Reference scenario:	0	tCO2-eq	0	tCO2-eq	0	tCO2-eq
Target scenario:	592,898	tCO2-eq	3,642	tCO2-eq	3,642	tCO2-eq
Forest cover (balance, cumulative area):	-400	ha	-400	ha	-400	ha



Source: Authors' elaboration based on **Schiettecatte, L.-S., Audebert, P., Umulisa, V., Dionisio, D. and Bernoux, M.** 2022a. *Technical guidance of the Nationally Determined Contribution Expert Tool (NEXT)*. Rome, FAO.

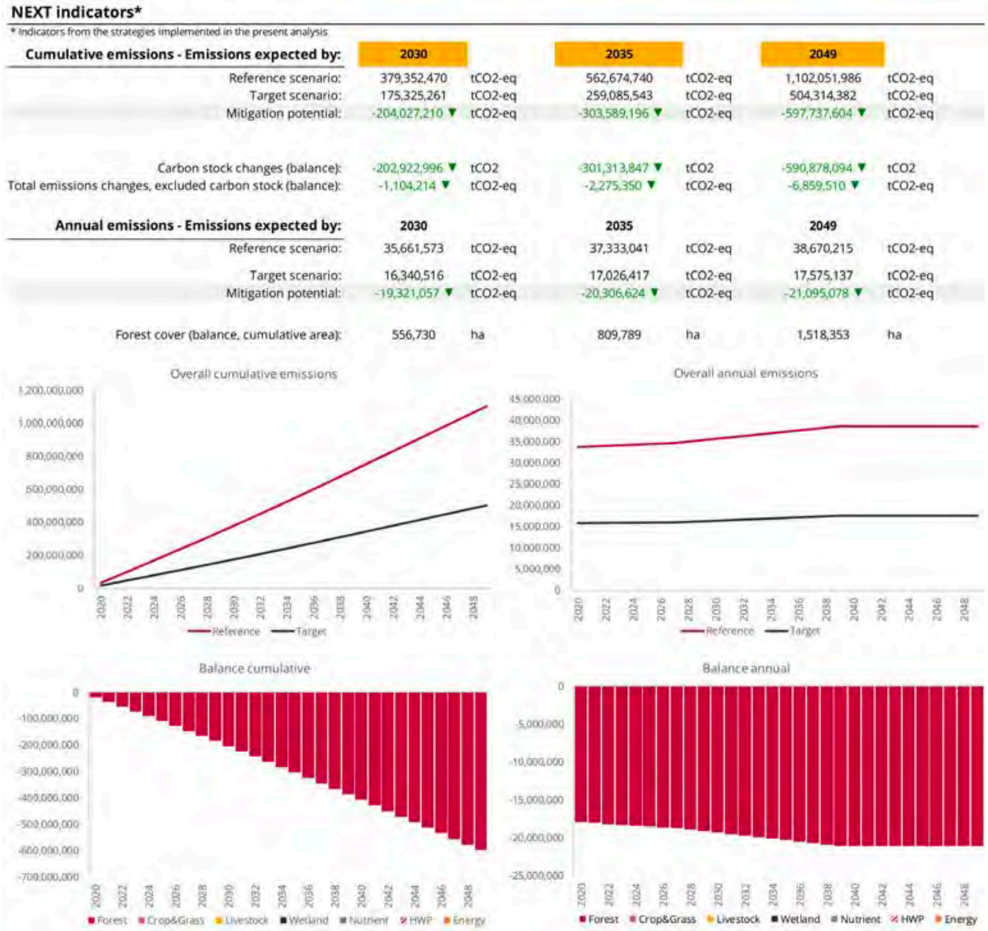
Answers to Exercise 5. Halting deforestation

Step 1:

1. What is the mitigation potential for the years 2030, 2035 and 2049? [Dashboard]

Under the combined forestry and non-forest land use change scenario, greenhouse gas emissions are reduced, resulting in a mitigation potential of **-204 027 210 tCO_2-eq** by 2030, **-303 598 196 tCO_2-eq** by 2035, and -**597 737 604 tCO_2-eq** by 2049 (Figure 43).

Figure 43. **NEXT screenshot of the dashboard when halting deforestation using the linear dynamic**



Source: Authors' elaboration based on **Schiettecatte, L.-S., Audebert, P., Umulisa, V., Dionisio, D. and Bernoux, M.** 2022a. *Technical guidance of the Nationally Determined Contribution Expert Tool (NEXT)*. Rome, FAO.

2. What are the trends that can be observed in the reference and target scenarios? [Dashboard]

The reference and target scenarios both follow linear trajectories, meaning that their emissions profiles remain constant over time. In the annual emissions graph, this is reflected by steady, year-over-year emissions. In the target scenario, emissions remain consistently at around 15 million tCO_2-eq per year, while the reference scenario shows emissions are close to 35 million tCO_2-eq annually. When looking at cumulative emissions, both scenarios show a gradual increase over time, but the target scenario has a slower rate of increase and lower overall value compared to the reference scenario.

3. When do the last land-use changes occur for both scenarios? [User activity data]

The land-use changes for both scenarios can be found in the "Land & SOC Indicators" module (Figure 44). In the reference scenario, the final deforestation occurs in 2048, at which point all remaining forest areas have been converted into cropland and settlements. In contrast, the land-use changes in the target scenario continue through the final year of the simulation since there are still some forests remaining.

Figure 44. NEXT screenshot of the land use changes for deforestation

LAND USE CHANGES

REFERENCE	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Forest	2,749,170	2,654,371	2,559,572	2,464,773	2,369,974	2,275,175	2,180,376	2,085,577	1,990,778	1,895,979	1,801,180	1,706,382	1,611,583
Cropland	84,945	169,890	254,834	339,779	424,724	509,669	594,614	679,558	764,503	849,448	934,393	1,019,338	1,104,282
Grassland	0	0	0	0	0	0	0	0	0	0	0	0	0
Wetlands	0	0	0	0	0	0	0	0	0	0	0	0	0
Settlement	9,854	19,708	29,563	39,417	49,271	59,125	68,979	78,833	88,688	98,542	108,396	118,250	128,104
Other land	0	0	0	0	0	0	0	0	0	0	0	0	0
Total, in ha	2,843,969	2,843,969	2,843,969	2,843,969	2,843,969	2,843,969	2,843,969	2,843,969	2,843,969	2,843,969	2,843,969	2,843,969	2,843,969

TARGET	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Forest	2,799,782	2,755,595	2,711,408	2,667,220	2,623,033	2,578,846	2,534,659	2,490,472	2,446,284	2,402,097	2,357,910	2,313,723	2,269,536
Cropland	36,932	73,864	110,796	147,728	184,660	221,593	258,525	295,457	332,389	369,321	406,253	443,185	480,117
Grassland	0	0	0	0	0	0	0	0	0	0	0	0	0
Wetlands	0	0	0	0	0	0	0	0	0	0	0	0	0
Settlement	7,255	14,510	21,765	29,020	36,275	43,531	50,786	58,041	65,296	72,551	79,806	87,061	94,316
Other land	0	0	0	0	0	0	0	0	0	0	0	0	0
Total, in ha	2,843,969	2,843,969	2,843,969	2,843,969	2,843,969	2,843,969	2,843,969	2,843,969	2,843,969	2,843,969	2,843,969	2,843,969	2,843,969

2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049
1,516,784	1,421,985	1,327,186	1,232,387	1,137,588	1,042,789	947,990	853,191	758,392	663,593	568,794	473,995	379,196	284,397	189,598	94,799	0
1,189,227	1,274,172	1,359,117	1,444,062	1,529,006	1,613,951	1,698,896	1,783,841	1,868,786	1,953,730	2,038,675	2,123,620	2,208,565	2,293,510	2,378,454	2,463,399	2,548,344
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
137,958	147,813	157,667	167,521	177,375	187,229	197,083	206,938	216,792	226,646	236,500	246,354	256,209	266,063	275,917	285,771	295,625
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2,843,969	2,843,969	2,843,969	2,843,969	2,843,969	2,843,969	2,843,969	2,843,969	2,843,969	2,843,969	2,843,969	2,843,969	2,843,969	2,843,969	2,843,969	2,843,969	2,843,969

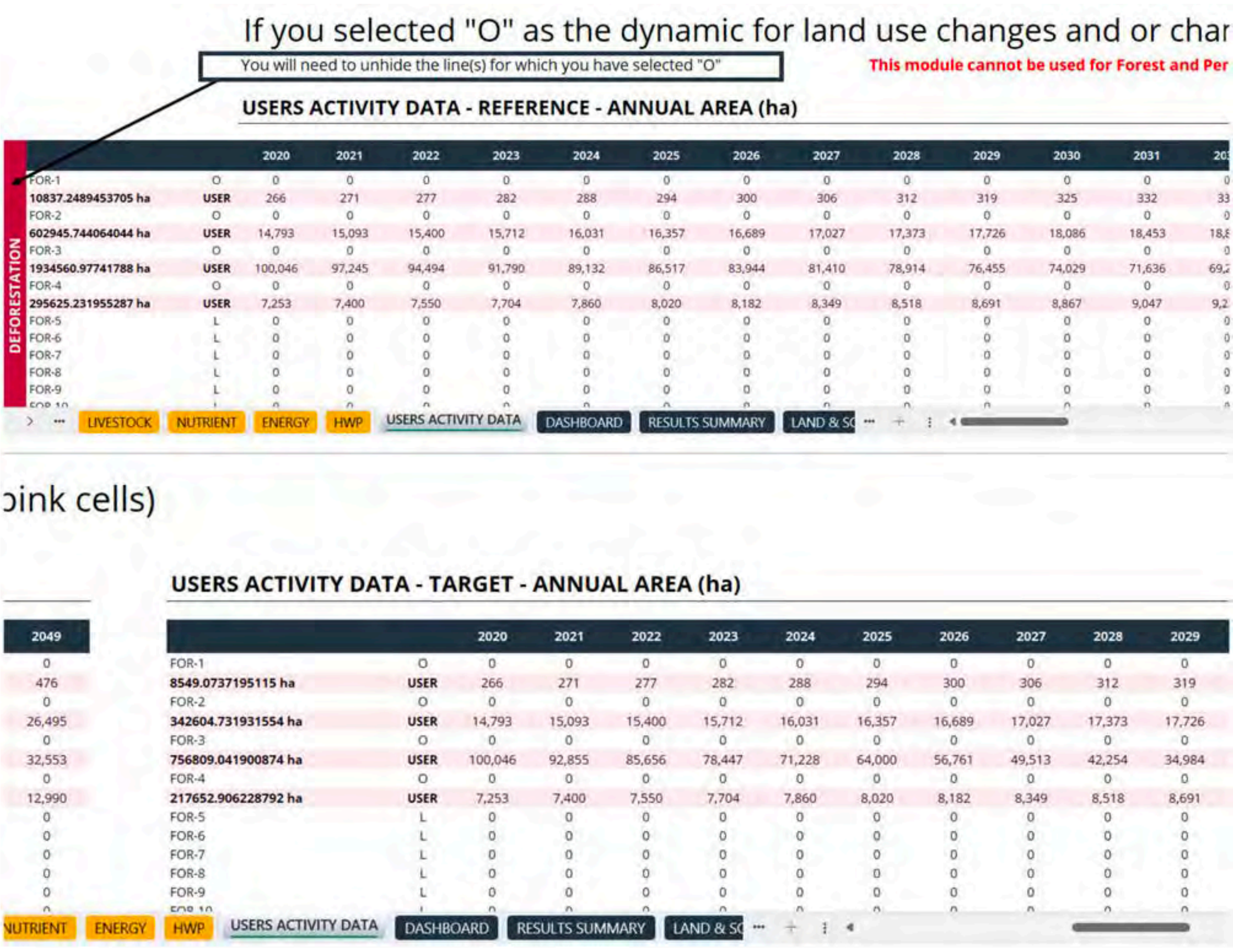
2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049
2,225,349	2,181,161	2,136,974	2,092,787	2,048,600	2,004,413	1,960,225	1,916,038	1,871,851	1,827,664	1,783,477	1,739,289	1,695,102	1,650,915	1,606,728	1,562,541	1,518,353
517,049	553,981	590,914	627,846	664,778	701,710	738,642	775,574	812,506	849,438	886,370	923,302	960,234	997,167	1,034,099	1,071,031	1,107,963
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
101,571	108,826	116,082	123,337	130,592	137,847	145,102	152,357	159,612	166,867	174,122	181,377	188,633	195,888	203,143	210,398	217,653
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2,843,969	2,843,969	2,843,969	2,843,969	2,843,969	2,843,969	2,843,969	2,843,969	2,843,969	2,843,969	2,843,969	2,843,969	2,843,969	2,843,969	2,843,969	2,843,969	2,843,969

Source: Authors' elaboration based on **Schiettecatte, L.-S., Audebert, P., Umulisa, V., Dionisio, D. and Bernoux, M.** 2022a. *Technical guidance of the Nationally Determined Contribution Expert Tool (NEXT)*. Rome, FAO.

Step 2:

The "User activity data" can be adjusted with the detailed land use changes data (Figure 45).

Figure 45. NEXT screenshot of the “users activity data” for observed deforestation



Source: Authors’ elaboration based on **Schiettecatte, L.-S., Audebert, P., Umulisa, V., Dionisio, D. and Bernoux, M.** 2022a. *Technical guidance of the Nationally Determined Contribution Expert Tool (NEXT)*. Rome, FAO.

1. What is the mitigation potential for the years 2030, 2035 and 2049? [Dashboard]

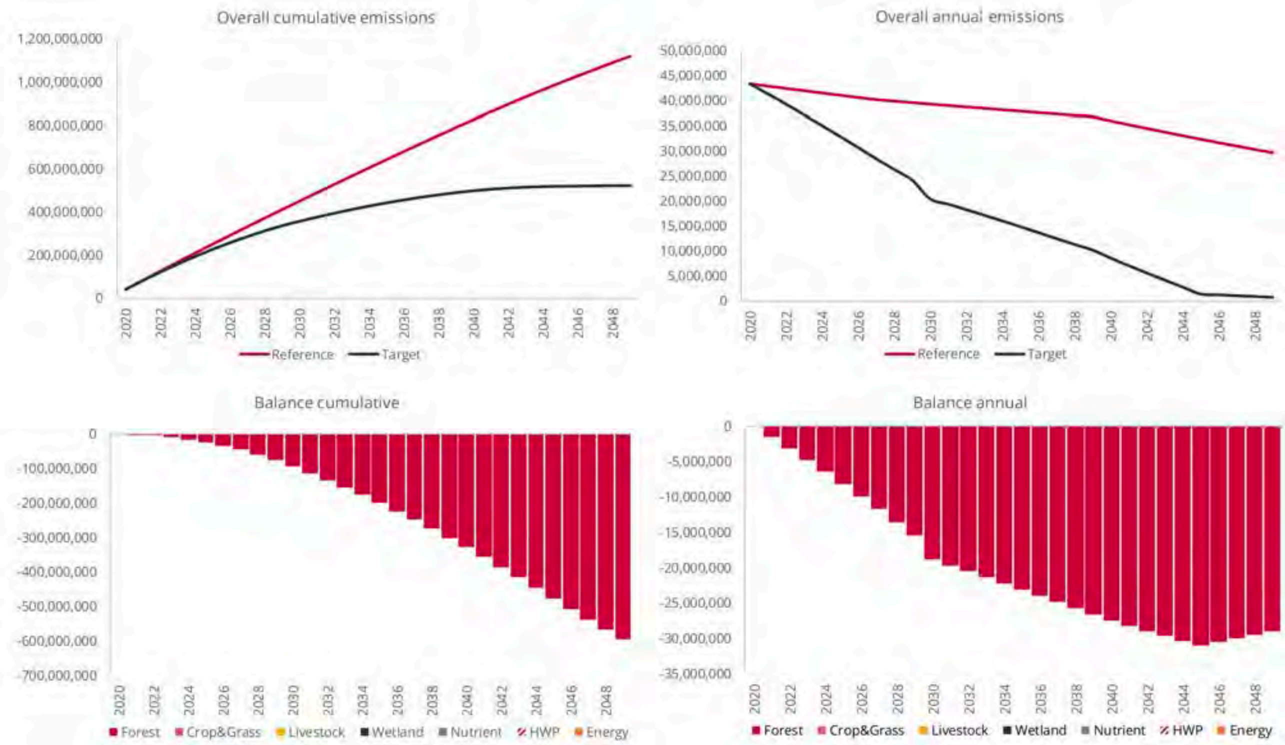
Under the observed mode, the mitigation potential is **-93 572 395 tCO_2-eq** by 2030, **-200 252 277 tCO_2-eq** by 2035, and **-596 048 710 tCO_2-eq** by 2049 (Figure 46).

Figure 46. NEXT screenshot of the dashboard for observed halting deforestation

NEXT indicators*

* Indicators from the strategies implemented in the present analysis

Cumulative emissions - Emissions expected by:	**2030**		**2035**		**2049**	
Reference scenario:	452,701,128	tCO2-eq	644,836,376	tCO2-eq	1,120,921,688	tCO2-eq
Target scenario:	359,128,733	tCO2-eq	444,584,099	tCO2-eq	524,872,978	tCO2-eq
Mitigation potential:	-93,572,395 ▼	tCO2-eq	-200,252,277 ▼	tCO2-eq	-596,048,710 ▼	tCO2-eq
Carbon stock changes (balance):	-93,157,770 ▼	tCO2	-198,969,348 ▼	tCO2	-589,720,517 ▼	tCO2
Total emissions changes, excluded carbon stock (balance):	-414,625 ▼	tCO2-eq	-1,282,929 ▼	tCO2-eq	-6,328,192 ▼	tCO2-eq
Annual emissions - Emissions expected by:	**2030**		**2035**		**2049**	
Reference scenario:	39,281,098	tCO2-eq	37,866,775	tCO2-eq	29,618,206	tCO2-eq
Target scenario:	20,406,368	tCO2-eq	14,816,299	tCO2-eq	644,958	tCO2-eq
Mitigation potential:	-18,874,731 ▼	tCO2-eq	-23,050,476 ▼	tCO2-eq	-28,973,248 ▼	tCO2-eq
Forest cover (balance, cumulative area):	254,857	ha	532,021	ha	1,518,353	ha



Source: Authors' elaboration based on **Schiettecatte, L.-S., Audebert, P., Umulisa, V., Dionisio, D. and Bernoux, M.** 2022a. *Technical guidance of the Nationally Determined Contribution Expert Tool (NEXT)*. Rome, FAO.

2. What trends can be observed in the reference and target scenarios? [Dashboard]

The reference scenario shows a gradual, almost linear decrease in annual emissions, starting from nearly 45 million tCO_2-eq in 2020 and dropping to about 30 million tCO_2-eq by 2049. This results in a steady, linear increase in cumulative emissions over time. In contrast, the target scenario experiences a more rapid and pronounced decrease in annual emissions compared to the reference scenario, with a sharp decline in the final years. The cumulative emissions profile for the target scenario differs significantly from the reference, following a logarithmic curve that reaches a maximum of approximately 600 million tCO_2-eq by 2040.

3. When do the last land-use changes occur for both scenarios? [User activity data]

The last land-use changes occur in 2049 for the BAU scenario, while with the implementation of the NODEFOR scenario, deforestation ends in 2045.

Answers to Exercise 6. Livestock measures under Cambodia's CCPAP III draft 0 for 2030

The livestock measures were analysed based on the following assumptions (Figure 47) and the Tier 2 information provided (Figure 48).

Figure 47. NEXT screenshot of the main menu in the "livestock management" module

LIVESTOCK MANAGEMENT

u/c	Description	Climate	Annual average temperature, °C	Livestock management system: Animal categories	Livestock management system: Productivity system	Analysis period: Base year	Analysis period: Target* year	Livestock population (heads): Initial level	Livestock population (heads): Reference level		Livestock population (heads): Target level	
u	Cattle	Tropical Moist	27	Cattle (other)	High-productivity	2020	2030	2,759,878	3,071,225	L	3,014,259	L
u	Buffalo	Tropical Moist	27	Buffaloes (other)	High-productivity	2020	2030	424,036	622,485	L	606,202	L
u	Swine	Tropical Moist	27	Swine (growing)	High-productivity	2020	2030	2,516,679	2,255,000	L	2,230,334	L
u	Chicken	Tropical Moist	27	Chicken (broiler)	High-productivity	2020	2030	15,801,261	25,850,863	L	25,111,364	L

Source: Authors' elaboration based on **Schiettecatte, L.-S., Audebert, P., Umulisa, V., Dionisio, D. and Bernoux, M.** 2022a. *Technical guidance of the Nationally Determined Contribution Expert Tool (NEXT)*. Rome, FAO.

Figure 48. NEXT screenshot of the Tier 2 section in the " livestock" module

Tier 2 - Enteric fermentation

Description of the action on enteric fermentation

Enteric fermentation, in kgCH4/head/year

Livestock systems	Tier 1	Initial Tier 2	Ref. Tier 2	Target Tier 2
Cattle (other) High-productivity	56	47.0	47.0	45.6
Buffaloes (other) High-productivity	55	55.0	55.0	53.4
Swine (growing) High-productivity	2			
Chicken (broiler) High-productivity	0			

Tier 2 - Averaged CH4 and N2O emissions from m

Emission factors are temperature dependent (IPCC 2006) or the average of regional manure management systems (if

CH4 emissions, in kgCH4/head/year*

Livestock systems	Initial Tier 1	Initial Tier 2	Reference Tier 1	Reference Tier 2	Target Tier 1	Target Tier 2
Cattle (other) High-productivity	1.0	1.0	1.0	1.0	1.0	1.0
Buffaloes (other) High-productivity	0.0	2.0	0.0	2.0	0.0	2.0
Swine (growing) High-productivity	7.0	7.0	7.0	7.0	7.0	7.0
Chicken (broiler) High-productivity	0.0	0.0	0.0	0.0	0.0	0.0

Tier 2 - Manure management systems

Share of manure management systems, regional average, in percentage

	Lagoon Tier 1	Lagoon Initial Tier 2	Lagoon Ref. Tier 2	Lagoon Target Tier 2	Liquid/slurry Tier 1	Liquid/slurry Initial Tier 2	Liquid/slurry Ref. Tier 2	Liquid/slurry Target Tier 2	Solid storage Tier 1	Solid storage Initial Tier 2	Solid storage Ref. Tier 2	Solid storage Target Tier 2	Dry lot Tier 1	Dry lot Initial Tier 2	Dry lot Ref. Tier 2	Dry lot Target Tier 2
Tropical MoistCattle (other)High-proc	0%				0%				0%				46%			
Tropical MoistBuffaloes (other)High-p	0%				0%				0%				0%	41%	41%	41%
Tropical MoistSwine (growing)High-pr	0%				40%	40%	40%	40%	0%				54%	54%	54%	25%
Tropical MoistChicken (broiler)High-p	25%	0%	0%	0%	0%				0%				0%			

	Pasture (P/R/P)* Tier 1	Pasture Initial Tier 2	Pasture Ref. Tier 2	Pasture Target Tier 2	Daily spread Tier 1	Daily spread Initial Tier 2	Daily spread Ref. Tier 2	Daily spread Target Tier 2	Digester Tier 1	Digester Initial Tier 2	Digester Ref. Tier 2	Digester Target Tier 2	Burned for fuel Tier 1	Burned for fuel Initial Tier 2	Burned for fuel Ref. Tier 2	Burned for fuel Target Tier 2
Tropical MoistCattle (other)High-proc	50%				2%				0%				2%			
Tropical MoistBuffaloes (other)High-p	0%	50%	50%	50%	0%	4%	4%	4%	0%				0%	5%	5%	5%
Tropical MoistSwine (growing)High-pr	0%				0%				0%			35%	7%			
Tropical MoistChicken (broiler)High-p	25%	0%	0%	0%	0%				0%				0%			

	Pit<1Month Tier 1	Pit<1Month Initial Tier 2	Pit<1Month Ref. Tier 2	Pit<1Month Target Tier 2	Pit>1 month Tier 1	Pit>1 month Initial Tier 2	Pit>1 month Ref. Tier 2	Pit>1 month Target Tier 2	Poultry manure Tier 1	Poultry manure Initial Tier 2	Poultry manure Ref. Tier 2	Poultry manure Target Tier 2	Deep bedding Tier 1	Deep bedding Initial Tier 2	Deep bedding Ref. Tier 2	Deep bedding Target Tier 2
Tropical MoistCattle (other)High-proc	0%				0%				0%				0%			
Tropical MoistBuffaloes (other)High-p	0%				0%				0%				0%			
Tropical MoistSwine (growing)High-pr	0%				0%				0%				0%			
Tropical MoistChicken (broiler)High-p	0%				0%				50%	100%	100%	100%	0%			

	Composting Tier 1	Composting Initial Tier 2	Composting Ref. Tier 2	Composting Target Tier 2	Aerobic treatment Tier 1	Aerobic treatment Initial Tier 2	Aerobic treatment Ref. Tier 2	Aerobic treatment Target Tier 2	Others Tier 1	Others Initial Tier 2	Others Ref. Tier 2	Others Target Tier 2
Tropical MoistCattle (other)High-proc	0%				0%				0%			
Tropical MoistBuffaloes (other)High-p	0%				0%				0%			
Tropical MoistSwine (growing)High-pr	0%				0%				0%			
Tropical MoistChicken (broiler)High-p	0%				0%				0%			

Tier 2 - Direct N2O emissions from manure management systems

Direct N2O emissions from manure management systems, regional values, in kgN2O-N/kgN

	Lagoon Tier 1	Lagoon Initial Tier 2	Lagoon Ref. Tier 2	Lagoon Target Tier 2	Liquid/slurry Tier 1	Liquid/slurry Initial Tier 2	Liquid/slurry Ref. Tier 2	Liquid/slurry Target Tier 2	Solid storage Tier 1	Solid storage Initial Tier 2	Solid storage Ref. Tier 2	Solid storage Target Tier 2	Dry lot Tier 1	Dry lot Initial Tier 2	Dry lot Ref. Tier 2	Dry lot Target Tier 2
Cattle (other) High-productivity	0.0000	0.0000			0.0025	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0200	0.0200	0.0200	0.0200
Buffaloes (other) High-productivi	0.0000	0.0000			0.0000	0.0050	0.0050	0.0050	0.0000	0.0050	0.0050	0.0050	0.0000	0.0200	0.0200	0.0200
Swine (growing) High-productivit	0.0000	0.0000			0.0025	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0200	0.0200	0.0200	0.0200
Chicken (broiler) High-productivit0 0	0.0000	0.0000			0.0025	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0200	0.0200	0.0200	0.0200

	Pasture (P/R/P)* Tier 1	Pasture Initial Tier 2	Pasture Ref. Tier 2	Pasture Target Tier 2	Daily spread Tier 1	Daily spread Initial Tier 2	Daily spread Ref. Tier 2	Daily spread Target Tier 2	Digester Tier 1	Digester Initial Tier 2	Digester Ref. Tier 2	Digester Target Tier 2	Burned for fuel Tier 1	Burned for fuel Initial Tier 2	Burned for fuel Ref. Tier 2	Burned for fuel Target Tier 2
Cattle (other) High-productivity	0.0200				0.0000				0.0000				0.0000			
Buffaloes (other) High-productivi	0.0000				0.0000				0.0000				0.0000			
Swine (growing) High-productivit	0.0200				0.0000				0.0000				0.0000			
Chicken (broiler) High-productivit0 0	0.0200				0.0000				0.0000				0.0000			

	Pit<1Month Tier 1	Pit<1Month Initial Tier 2	Pit<1Month Ref. Tier 2	Pit<1Month Target Tier 2	Pit>1 month Tier 1	Pit>1 month Initial Tier 2	Pit>1 month Ref. Tier 2	Pit>1 month Target Tier 2	Poultry manure Tier 1	Poultry manure Initial Tier 2	Poultry manure Ref. Tier 2	Poultry manure Target Tier 2	Deep bedding Tier 1	Deep bedding Initial Tier 2	Deep bedding Ref. Tier 2	Deep bedding Target Tier 2
Cattle (other) High-productivity	0.0020	0.0200	0.0200	0.0200	0.0020	0.0020	0.0020	0.0020	0.0010	0.0010	0.0010	0.0010	0.0400			
Buffaloes (other) High-productivi	0.0000	0.0200	0.0200	0.0200	0.0000	0.0020	0.0020	0.0020	0.0000	0.0010	0.0010	0.0010	0.0000			
Swine (growing) High-productivit	0.0020	0.0200	0.0200	0.0200	0.0020	0.0020	0.0020	0.0020	0.0010	0.0010	0.0010	0.0010	0.0400			
Chicken (broiler) High-productivit0 0	0.0020	0.0200	0.0200	0.0200	0.0020	0.0020	0.0020	0.0020	0.0010	0.0010	0.0010	0.0010	0.0000			

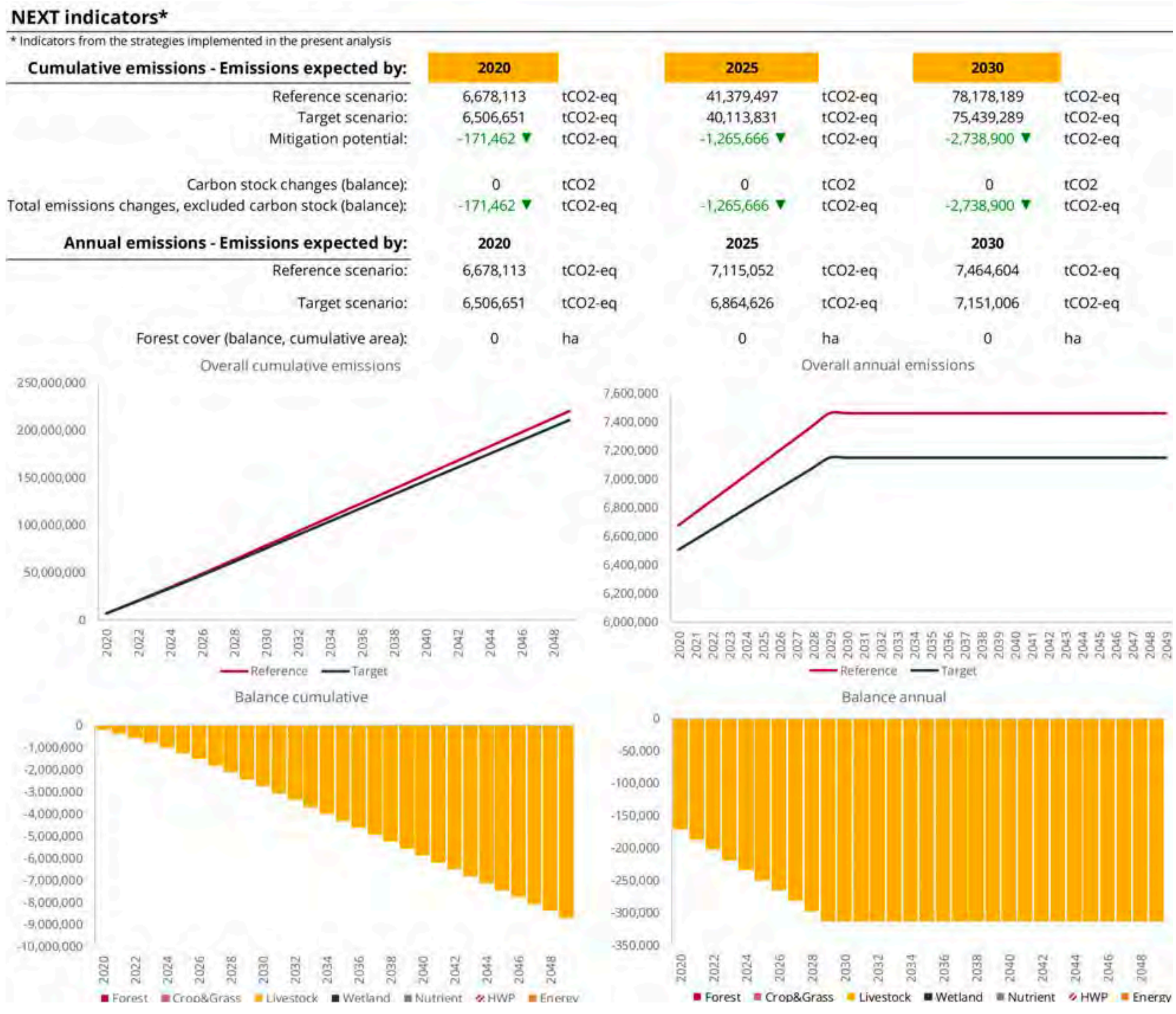
	Composting Tier 1	Composting Initial Tier 2	Composting Ref. Tier 2	Composting Target Tier 2	Aerobic treatment Tier 1	Aerobic treatment Initial Tier 2	Aerobic treatment Ref. Tier 2	Aerobic treatment Target Tier 2	Others Tier 1	Others Initial Tier 2	Others Ref. Tier 2	Others Target Tier 2
Cattle (other) High-productivity	0.0305				0.0075				0.0000			
Buffaloes (other) High-productivi	0.0000				0.0000				0.0000			
Swine (growing) High-productivit	0.0305				0.0075				0.0000			
Chicken (broiler) High-productivit0 0	0.0305				0.0075				0.0000			

Source: Authors' elaboration based on **Schiettecatte, L.-S., Audebert, P., Umulisa, V., Dionisio, D. and Bernoux, M.** 2022a. *Technical guidance of the Nationally Determined Contribution Expert Tool (NEXT)*. Rome, FAO.

1. What are the overall GHG emissions in the reference scenario for the period 2020-2030? What is the impact of implementing the livestock measures under CCPAP (draft 0) by 2030?

In the reference scenario, annual GHG emissions are projected to be **6 678 113 tCO_2-eq** by 2020, **41 379 497 tCO_2-eq** by 2025 and **78 178 189 tCO_2-eq** by 2030 (Figure 49). However, if the livestock measures outlined in the CCPAP are implemented, emissions are expected to be reduced to **75 439 289 tCO_2-eq** by 2030 which represent a mitigation potential of about **-3 million tCO_2-eq** by 2030.

Figure 49. **NEXT screenshot of the dashboard for the livestock system management**



Source: Authors' elaboration based on **Schiettecatte, L.-S., Audebert, P., Umulisa, V., Dionisio, D. and Bernoux, M.** 2022a. *Technical guidance of the Nationally Determined Contribution Expert Tool (NEXT)*. Rome, FAO.

2. What are the GHG emissions annually for 2025 and 2030?

The projected GHG emissions are:

In 2025:

- **Reference scenario:** 7 115 052 tCO_2-eq
- **Target scenario:** 6 864 626 tCO_2-eq

In 2030:

- **Reference scenario:** 7 464 604 tCO_2-eq
- **Target scenario:** 7 151 006 tCO_2-eq

3. What is the cumulated emission reduction by 2030 and 2040 that stems from enteric fermentation?

The implementation of livestock management measures is expected to reduce methane emissions from enteric fermentation by -2 191 052 tCO_2-eq by 2030 and -4 671 938 tCO_2-eq by 2040, accounting for 79 percent of the total emissions reduction (Figure 50).

Figure 50. **NEXT screenshot of the balance cumulative results for the livestock management**

BALANCE	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Biomass CO2	0	0	0	0	0	0	0	0	0	0	0
HWP CO2 net	0	0	0	0	0	0	0	0	0	0	0
Soil mineral CO2	0	0	0	0	0	0	0	0	0	0	0
Soil mineral CH4 (WMS rewetted)	0	0	0	0	0	0	0	0	0	0	0
Direct N2O from managed soils (include N2O PRP)	-1,298	-3,895	-7,789	-12,982	-19,473	-27,262	-36,349	-46,735	-58,418	-71,400	-84,382
Indirect N2O from managed soils (include N2O PRP)	-276	-828	-1,655	-2,759	-4,138	-5,793	-7,724	-9,931	-12,414	-15,173	-17,931
CO2 soil (fertilizers)	0	0	0	0	0	0	0	0	0	0	0
Organic soil CO2	0	0	0	0	0	0	0	0	0	0	0
Organic soil CH4	0	0	0	0	0	0	0	0	0	0	0
Organic soil N2O	0	0	0	0	0	0	0	0	0	0	0
CH4 flooded rice	0	0	0	0	0	0	0	0	0	0	0
CO2 coastal and flooded land	0	0	0	0	0	0	0	0	0	0	0
CH4 coastal and flooded land	0	0	0	0	0	0	0	0	0	0	0
N2O Aquaculture - Coastal wetlands	0	0	0	0	0	0	0	0	0	0	0
CH4 livestock - Enteric fermentation	-140,504	-292,962	-457,374	-633,740	-822,059	-1,022,333	-1,234,560	-1,458,741	-1,694,875	-1,942,964	-2,191,052
CH4 livestock - Manure management (except PRP)	-776	-2,327	-4,653	-7,756	-11,633	-16,287	-21,716	-27,920	-34,900	-42,656	-50,411
N2O livestock - Manure management (except PRP)	-28,608	-58,706	-90,293	-123,370	-157,936	-193,992	-231,537	-270,572	-311,096	-353,109	-395,123
Fire CO2	0	0	0	0	0	0	0	0	0	0	0
Fire CH4	0	0	0	0	0	0	0	0	0	0	0
Fire N2O	0	0	0	0	0	0	0	0	0	0	0
Fire CO2 (organic soil)	0	0	0	0	0	0	0	0	0	0	0
Fire CH4 (organic soil)	0	0	0	0	0	0	0	0	0	0	0
Fossil fuel combustion CO2	0	0	0	0	0	0	0	0	0	0	0
Fossil fuel combustion CH4	0	0	0	0	0	0	0	0	0	0	0
Fossil fuel combustion N2O	0	0	0	0	0	0	0	0	0	0	0
CO2	0	0	0	0	0	0	0	0	0	0	0
CH4	-141,280	-295,289	-462,028	-641,495	-833,693	-1,038,619	-1,256,275	-1,486,661	-1,729,775	-1,985,619	-2,241,464
N2O	-30,182	-63,428	-99,737	-139,110	-181,547	-227,047	-275,610	-327,237	-381,928	-439,682	-497,437
Total	-171,462	-358,717	-561,765	-780,606	-1,015,239	-1,265,666	-1,531,888	-1,813,898	-2,111,703	-2,425,302	-2,738,900

BALANCE	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049
Biomass CO2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HWP CO2 net	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Soil mineral CO2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Soil mineral CH4 (WMS rewetted)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Direct N2O from managed soils (include N2O PRP)	-97,364	-110,346	-123,328	-136,310	-149,292	-162,274	-175,255	-188,237	-201,219	-214,201	-227,183	-240,165	-253,147	-266,129	-279,110	-292,092	-305,074	-318,056	-331,038
Indirect N2O from managed soils (include N2O PRP)	-20,690	-23,449	-26,207	-28,966	-31,724	-34,483	-37,242	-40,000	-42,759	-45,518	48,276	-51,035	-53,794	-56,552	-59,311	-62,070	-64,828	-67,587	-70,346
CO2 soil (fertilizers)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Organic soil CO2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Organic soil CH4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Organic soil N2O	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CH4 flooded rice	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CO2 coastal and flooded land	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CH4 coastal and flooded land	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N2O Aquaculture - Coastal wetlands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CH4 livestock - Enteric fermentation	-2,439,141	-2,687,229	-2,935,318	-3,183,407	-3,431,495	-3,679,584	-3,927,672	-4,175,761	-4,423,849	-4,671,938	-4,920,026	-5,168,115	-5,416,203	-5,664,292	-5,912,380	-6,160,469	-6,408,557	-6,656,646	-6,904,734
CH4 livestock - Manure management (except PRP)	-58,167	-65,922	-73,678	-81,433	-89,189	-96,944	-104,700	-112,455	-120,211	-127,967	-135,722	-143,478	-151,233	-158,989	-166,744	-174,500	-182,255	-190,011	-197,767
N2O livestock - Manure management (except PRP)	-437,137	-479,150	-521,164	-563,178	-605,192	-647,205	-689,219	-731,233	-773,246	-815,260	-857,274	-899,287	-941,301	-983,315	-1,025,328	-1,067,342	-1,109,356	-1,151,369	-1,193,383
Fire CO2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fire CH4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fire N2O	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fire CO2 (organic soil)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fire CH4 (organic soil)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fossil fuel combustion CO2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fossil fuel combustion CH4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fossil fuel combustion N2O	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CO2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CH4	-2,497,308	-2,753,152	-3,008,996	-3,264,840	-3,520,684	-3,776,528	-4,032,372	-4,288,216	-4,544,060	-4,799,904	-5,055,748	-5,311,592	-5,567,437	-5,823,281	-6,079,125	-6,334,969	-6,590,813	-6,846,657	-7,102,501
N2O	-555,191	-612,945	-670,699	-728,453	-786,208	-843,962	-901,716	-959,470	-1,017,225	-1,074,979	-1,132,733	-1,190,487	-1,248,241	-1,305,996	-1,363,750	-1,421,504	-1,479,258	-1,537,012	-1,594,767
Total	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Source: Authors' elaboration based on **Schiettecatte, L.-S., Audebert, P., Umulisa, V., Dionisio, D. and Bernoux, M.** 2022a. *Technical guidance of the Nationally Determined Contribution Expert Tool (NEXT)*. Rome, FAO.

4. What are the CH_4-related emission reductions by 2030 from the livestock interventions implemented?

The livestock management measures are projected to reduce methane emissions by **2 191 052 tCO_2-eq** due to enteric fermentation and **-445 534 tCO_2-eq** from manure management by 2030 (Figure 50). Nearly all this reduction comes from a decrease in methane emissions due to reduced enteric fermentation.

Answers to Exercise 7. CCPAP III partial analysis

Starting with the last deforestation exercise, add all other activities from the different exercises and answer the following questions:

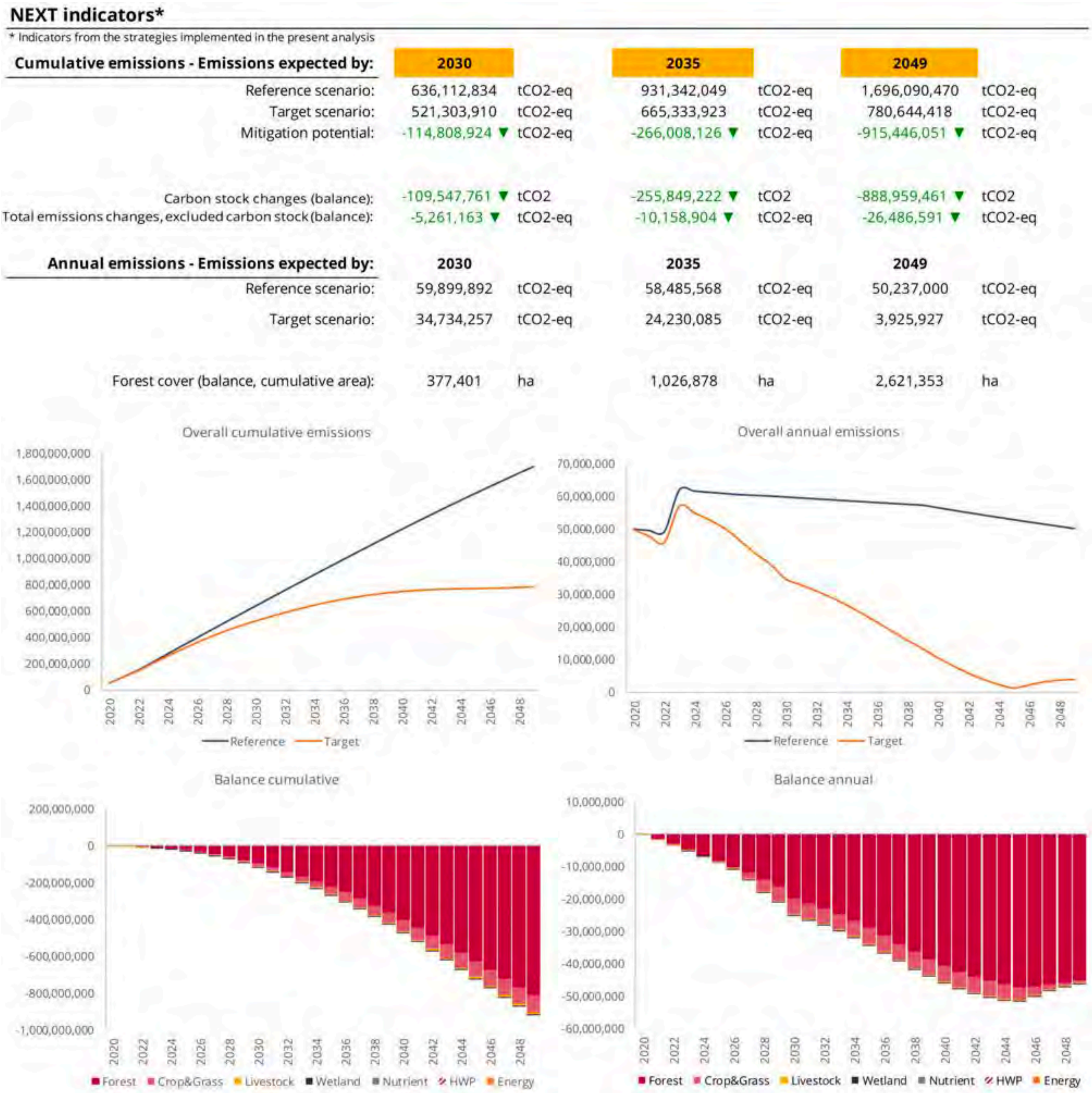
1. What is the mitigation potential for the years 2030, 2035 and 2049? [Dashboard]

When implementing the different policies, the overall mitigation potential reaches **-114 808 924 tCO_2-eq** in 2030, **-266 008 126 tCO_2-eq** in 2035 and **-900 million tCO_2-eq** in 2049 (Figure 51). By 2030, implementation of the different activities could help to reduce GHG emissions of about 25 million tCO_2-eq in the AFOLU sector. This value is more than half of the NDC2 objective, i.e. -38.1 million tCO_2-eq for FOLU and -6.2 million tCO_2-eq for agriculture. By 2049, GHG emissions reduction are even higher, about 46 million tCO_2-eq. However, looking at the time series (balance annual of the results summary), the reduction in emissions is decreasing (the highest mitigation potential is in 2045, about 52 million tCO_2-eq). This is explained by the end of the deforestation as per the NODEFOR scenario and the different carbon stocks (soil and biomass) that have reached their equilibrium.

2. What are the trends that can be observed in the reference and target scenarios? [Dashboard]

An analysis of the annual emissions shows a decrease in both scenarios from 2020 to 2023, followed by a peak in 2023 due to the implementation of various actions, such as rice (Figure 51). After 2023, emissions decline steadily through the end of the period. In the reference scenario, the reduction is gradual and is mainly driven by a reduction of the deforestation, reaching about 50 million tCO_2-eq by 2049. In contrast, the target scenario sees a sharper decline, reaching approximately 1.3 million tCO_2-eq by 2045, before increasing slightly as forestry-based activities conclude. These trends lead to distinct profiles for overall cumulative emissions in both scenarios. The reference profile shows a linear increase in cumulative emissions, reaching 1.7 billion tCO_2-eq by 2049. Meanwhile, the target scenario follows a logarithmic trajectory, with cumulative emissions leveling off around 800 million tCO_2-eq by the end of the time series.

Figure 51. NEXT screenshot of the dashboard for the CCPAP III partial zero draft analysis



NEXT indicators*

* Indicators from the strategies implemented in the present analysis

Cumulative emissions - Emissions expected by:	2030		2035		2049	
Reference scenario:	636,112,834	tCO2-eq	931,342,049	tCO2-eq	1,696,090,470	tCO2-eq
Target scenario:	521,303,910	tCO2-eq	665,333,923	tCO2-eq	780,644,418	tCO2-eq
Mitigation potential:	-114,808,924 ▼	tCO2-eq	-266,008,126 ▼	tCO2-eq	-915,446,051 ▼	tCO2-eq
Carbon stock changes (balance):	-109,547,761 ▼	tCO2	-255,849,222 ▼	tCO2	-888,959,461 ▼	tCO2
Total emissions changes, excluded carbon stock (balance):	-5,261,163 ▼	tCO2-eq	-10,158,904 ▼	tCO2-eq	-26,486,591 ▼	tCO2-eq
Annual emissions - Emissions expected by:	**2030**		**2035**		**2049**	
Reference scenario:	59,899,892	tCO2-eq	58,485,568	tCO2-eq	50,237,000	tCO2-eq
Target scenario:	34,734,257	tCO2-eq	24,230,085	tCO2-eq	3,925,927	tCO2-eq
Forest cover (balance, cumulative area):	377,401	ha	1,026,878	ha	2,621,353	ha

Source: Authors' elaboration based on **Schiettecatte, L.-S., Audebert, P., Umulisa, V., Dionisio, D. and Bernoux, M.** 2022a. *Technical guidance of the Nationally Determined Contribution Expert Tool (NEXT)*. Rome, FAO.

3. When do the last land-use changes occur for both scenarios? [User activity data]

In both scenarios, the last land-use changes occur in 2049, but for different activities: deforestation for the reference scenario and reforestation for the target one.

4. Which carbon stock or GHG emission undergoes changes over the longest period? [Results summary] What are the implications of this?

The carbon stock that undergoes changes over the longest period is biomass CO_2. Changes are explained by the combined effect of ending deforestation (thus avoiding losing carbon) and reforestation/agroforestry development (thus increasing carbon stocks). However, the mitigation potential of "biomass" is limited over time, as we can observe a decline in the reduction potential, which is explained by both the zero deforestation target and the saturation of the carbon stock (as it can be observed for the soil as well). This means, that even though policies addressing main GHG emissions drivers (such as deforestation) or focusing at enhancing carbon stock are efficient for the next 30/40 years to support the mitigation commitments, they will need to be complemented by other policies that will have to address other GHG emissions sources, such as flooded rice, livestock, nutrients for the AFOLU sector, or this could affect long-term climate change mitigation strategies.

5. What are the reduction potentials for CH_4 in 2030? [Balance annual] Where does it come from? What could be the implications on the global methane pledge?

The potential mitigation of CH_4 is about 735 000 tCO_2-eq by 2030. There are three different pools: flooded rice and the livestock management through enteric fermentation and manure management. This contribution supports Cambodia's commitment to the Global Methane Pledge, helping to mitigate national CH_4 emissions (of about 22 million tCO_2-eq in 2016, BUR1) in line with global climate goals.

ANNEX 1. Summary of key mitigation actions by sector in the LTS4CN

Agriculture	• Less methane-intensive rice cultivars • Direct seeding practices • Alternate wetting and drying practices • Promotion of organic fertilizer and deep fertilizer technology • Feed additives for cattle • Improved fodder management • Introduction of composting technology
Forestry and other land use	• Reducing the deforestation rate by 50 percent in 2030 • Stopping deforestation by 2045 • Afforestation, improved forest management and forest restoration • Agroforestry and commercial tree plantation • Full implementation of the REDD+ Investment Plan by 2050
Energy	• No new coal generation capacity beyond already committed projects • Use of natural gas as a dispatchable transtion fuel • Investments in liquified natural gas (LNG) import, storage and infrastructure • Increase in solar, hydro, biomass and other renewables to 35 percent of the generation mix by 2050, of which 12 percent is from solar • Investments in grid modernization, flexibility and storage Energy efficiency measures in buildings and industry • Fuel switching to electricity for cooking • Substitution of coal in the industrial and power sector
Transportation	• More use of public transpportation – 30 percent modal share in urban areas by 2050 • Moderate penetration of electric vehicles – 70 percent for motorcycles and 40 percent for cars and urban buses by 2050 • Increased fuel efficiency for internal combustion engine vehicles • Rail for freight and passengers • CNG penetration of 80 percent for interregional buses and 80 percent for trucks until 2050
Industrial processes and product use	• Clinker substitution in cement production • Carbon capture and storage for cement kilns • Use of recycled aggregate concrete • Increasing use of refreigerants with low global warming potential • Regular inspection of refrigeration and air-conditioning equipment and recovery of spent refrigerant
Waste	• Reducing open burning by expanding waste collection coverage to 85 percent in 2050 • Implementing reduce, reuse, and recycle strategy • Landfill gas management • Organic composting • Anaerobic digestion and wastewater treatment

Source: Kingdom of Cambodia, 2021.

Annex 2. Basic methodology of NEXT

a. Estimation of carbon stock in the soil

For mineral soil carbon, estimates of the default values are based on default references for soil organic carbon (SOC) stocks (SOCref) for mineral soils to a depth of 30 cm. When SOC changes over time (land-use change or management change) the 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) utilizing the following hypotheses:

i. 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 equation 1.

ii. Over time, SOC reaches a stable spatial average value specific to the land use and management practices and climate.

iii. 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).

$$SOC_{mineral} = SOC_{ref} * F_{LU} * F_{MG} * F_{I} * A \qquad \textbf{Equation 1}$$

Where:

- $SOC_{mineral}$ = 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

b. Definition of soil input management practices for annual cropland

Soil inputs	Definition
"Low input"	Low return of residues due to residue disposal (by collection or burning) frequent bare fallows or production of low residue crops (vegetables tobacco cotton etc.) no application of mineral fertilizers or nitrogen-fixing crops.
"Medium input"	Represents annual crops with cereals in which all crop residues return to the fields. If residues are removed additional organic matter (manure etc.) is added. Also requires mineral fertilizer or nitrogen-fixing crop rotations.
"High input without manure"	Represents a much higher level of crop residues due to the nature of the crops the use of green manure cover crops fallow with improved vegetation frequent use of perennial herbs in annual rotations crops but without application of manure (see below).
"High input with manure"	Represents much higher carbon inputs than for medium input cropping systems due to the additional input of animal manure.

Source: Authors' elaboration based on IPCC 2006

c. Generic approach for estimating greenhouse gases other than CO_2

For emissions of N_2O and CH_4, 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 N_2O and CH_4 are either associated with a category or under a specific land use category (e.g. CH_4 emissions from rice) or are estimated from aggregated project data (e.g. CH_4 emissions from livestock and N_2O emissions from fertilizers management of manure and coastal aquaculture).

$$\text{Emissions} = AD * EF \qquad \text{Equation 2}$$

Where:

- 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 (N_2O or CH_4) is obtained as outlined in equation 3:

$$GHG_{fire} = A * M_B * C_f * G_{ef} * 10^{-3} \qquad \text{Equation 3}$$

With:

- GHG_{fire} = quantity of GHG emitted by fire per ton of CH_4 and N_2O,
- A = area burned in ha,
- M_B = quantity of available biomass in tonne/ha,

- C_f = combustion factor dimensionless,
- G_{ef} = emission factor in g/kg ms. burned.

M_B theoretically includes litter and dead wood and are assumed to be zero by default, except in the event of land-use change. For the combustion factors we use the default factors (level 1) from tables 2.5 and 2.6 of the IPCC 2006 for G_{ef} and C_f respectively.

d. Estimates of methane emissions from flooded rice crops

GHG emissions from different water management methods for rice crops are calculated according to equation 4.

$$CH_{4\,rice} = \sum EF_{i\,j\,k} * t_{i\,j\,k} * A_{i\,j\,k} * 10^{-6}$$ **Equation 4**

With:

- $CH_{4\,rice}$ = Annual methane emissions in $GgCH_4$ per year,
- $EF_{i\,j}k$ = Daily emissions factor (or basic emissions factor) for conditions i j k in kg CH_4 per hectare per year,
- $t_{i\,j\,k}$ = The duration of rice cultivation for conditions i j k in days,
- $A_{i\,j\,k}$ = The rice harvest area for conditions i j k, and
- I, j, k = represent the different ecosystems water regimes type and amounts of amendments and other conditions for which CH_4 emissions from rice may vary.

At Tier 1 the base emissions factor depends on a set of scaling factors according to equation 5:

$$EF_i = EF_c * SF_w * SF_p * SF_0$$ **Equation 5**

With:

- EF_i = the basic emissions factor for a specific rice plot,
- EF_c = the basic emissions factor for permanently flooded fields without organic amendments,
- SF_w = Scaling factor allowing differences between water regimes to be taken into account during the cultivation period,
- SF_p = Scaling factor allowing differences between water regimes before the cultivation period to be taken into account, and
- SF_0 = Scaling factor which should vary depending on the type and quantity of organic amendment applied.

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SCALA supports more than 20 countries, including Cambodia, to strengthen policies, adopt innovative approaches to climate change adaptation, and remove barriers related to information gaps, governance, finance, gender mainstreaming and integrated monitoring and reporting. SCALA also supports countries to develop capacity to own and lead the process to meet targets set out in their national adaptation plans and nationally determined contributions under the Paris Agreement.

As part of its support to Cambodia, SCALA conducted workshops in October 2024 with representatives of Cambodian government ministries on the use of the Nationally Determined Contribution Expert Tool (NEXT), developed by FAO. This document presents exercises conducted for these workshops as well as exercise results based on inputs to the NEXT tool.

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