Verification Report of the 2020-2021 Key Performance Indicators Report of Uruguay´s Sovereign Sustainability-Linked Bond

May 2023

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The United Nations Development Program is the leading United Nations agency dedicated to ending injustice of poverty, inequality and climate change. We work with our extensive network of experts and partners in 170 countries to help nations build integrated and lasting solutions for people and the planet.

Introduction

Pursuant to the signing of the Agreement for the provision of development services dated September 19, 2022 (hereinafter, the Agreement), the Government of Uruguay requested the United Nations Development Programme (UNDP) to fulfill the role of external verifier of the key performance indicators (KPIs) included in the Sovereign Sustainability-Linked Bond (SSLB) Framework[1] published in September 2022.

UNDP has carried out the verification process of KPI 1 and KPI 2 presented in the 2020-2021 KPI Report for the SSLB (2020-2021 KPIR) dated April 2023, and calculated on the basis of the SSLB Emissions Report (EMR time series 1990-2021, hereinafter, EMR) and the Native Forest Report for the SSLB (2021 NFR)[2].

The 2020-2021 KPIR, EMR and 2021 NFR were provided to UNDP by the Government of Uruguay between January and April 2023, according to schedule, together with the following documents and files:

- Database with the information needed to calculate the KPIs ;
- Methodological note on the estimation of greenhouse gas emissions for the preparation of the EMR;
- EMR auxiliary spreadsheets (quality control spreadsheets, recalculations and sectoral spreadsheets);
- KPI 1 GHG emissions estimates included in IPCC inventory software v 2.691;
- Methodology and results of 2021 native forest mapping report;
- Uruguay's 2021 native forest mapping validation report;
- File in Shapefile format of the 2021 native forest mapping with Sentinel:
- Methodology applied for the elaboration of Uruguay's native forest cover map for the year 2016 with Sentinel 2 images[3] and Landsat 8 images[4];
- Methodology and results of the validation of the native forest cover map of Uruguay for the year 2016 with Sentinel 2 images[5] and Landsat 8 images[6]; and
- URU/10/G31-486 Final Report - National Forest Cartography Update (2012).

[1] Available at: http://sslburuguay.mef.gub.uy/innovaportal/file/30690/20/uruguay_sslb_framework__2.pdf
[2] Available at: http://sslburuguay.mef.gub.uy/30672/20/areas/reporting-methodology-and-sslb-annual-report.html
[3] Available at: https://www.gub.uy/ministerio-ganaderia-agricultura-pesca/sites/ministerio-ganaderia-agricultura-pesca/files/documentos/publicaciones/15.%20Sentinel_2_Metodolog%C3%ADa_Mapa_Bosque_Nativo_2016_Proyecto_REDD%2B_UY_0.pdf
[4] Available at: https://www.gub.uy/ministerio-ganaderia-agricultura-pesca/sites/ministerio-ganaderia-agricultura-pesca/files/documentos/publicaciones/13.%20Landsat_8_Metodolog%C3%ADa_Mapa_Bosque_Nativo_2016_Proyecto_REDD%2B_UY.pdf
[5] Available at: Metodología y resultados de la validación del mapa de cobertura de bosque nativo de Uruguay para el año 2016 | Ministerio de Ganadería, Agricultura y Pesca (www.gub.uy)
[6] Available at: Landsat_8_Validación_Mapa_Bosque_Nativo_2016_Proyecto_REDD+_UY_0.pdf (www.gub.uy)

The Government of Uruguay is responsible for the preparation of the 2020-2021 KPIR, the EMR time series 1990-2021, the 2021 NFR and the other documents, database and files provided to UNDP.

As per the Agreement, the Government of Uruguay warrants to UNDP the accuracy, integrity, quality, reliability and completeness of all technical data, files, documents, test data, sample results, emission reports, databases or sheets, KPI value calculations and technical records, as well as any other data and materials made available to UNDP pursuant to the Agreement.

Scope of verification

The verification includes the key performance indicators KPI 1 and KPI2 included in the Sovereign Sustainability-Linked Bond (SSLB) Framework published in September 2022 and reported in the 2020-2021 KPIR dated April 2023 prepared by the Government of Uruguay:

KPI-1: Reduction of aggregate gross CO_2, N_2O and CH_4 emissions (in CO_2eq) per real GDP unit with respect to reference year 1990 (in %). For the calculation of this KPI, the emissions are those reported in the December 2022 EMR, which exclusively considers the emissions corresponding to the gases, sectors, categories and sources estimated and reported in the 2012 National Greenhouse Gas Inventory (NGHGI), on which the 2017 Nationally Determined Contribution´s emissions intensity reduction commitment was established. For GDP, the latest official series published by the National Accounts System (Sistema de Cuentas Nacionales, SCN) of the Central Bank of Uruguay (Banco Central de Uruguay, BCU) is used, retropolated to 1990 using the variation rate method as a statistical splicing technique.

KPI-2: Maintenance of native forest area (in hectares) with respect to reference year 2012 (in %). For the calculation of this KPI, the areas reported in the 2021 FNR dated December 2022 are used, which are estimated from a mapping of native forest from Sentinel 2 satellite images.

Verification Methodology

The technical review of the EMR time series 1990-2021 of CO_2, CH_4 and N_2O from Energy, Industrial Processes, Agriculture and Waste Sectors is conducted according to the methodology contained in the United Nations Framework Convention on Climate Change's (UNFCCC) Guide for Peer Review of National Greenhouse Gas Inventories (NGHGI), specifically concluding on:

i. adherence to the 2006 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories;

ii. whether the key Inventory requirements of Decisions 17/CP.8 (UNFCCC, 2002), 2/CP.17 (UNFCCC, 2011) and 18/CMA.1 (UNFCCC, 2018) are met, when applicable;

iii. the quality of the EMR, assessed primarily through the review of inventory principles, Transparency, Accuracy, Consistency, Comparability and Completeness (TACCC principles), TACCC established for reporting in the IPCC 2000 and 2003 Good Practice Guidance and also incorporated into the 2006 IPCC Guidelines.

iv. the relevance and quality of the revision of historical GHG emission values, derived from inventory adjustments, including additional data sources and recalculations due to methodological improvements.

The technical review of the Native Forest Report (2021 NFR) is conducted according to the following criteria:

i. adherence to the 2006 IPCC Guidelines, in particular Chapter 3 (Coherent Land Representation) of Volume 4 (AFOLU) of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories;

ii. Consistency with the relevant provisions and guiding principles of the Global Forest Observations Initiative (GFOI) Methods and Guidance (MGD).

iii. The quality of the report, by examining the TACCC principles (Transparency, Accuracy, Consistency, Comparability and Completeness) as established by the IPCC. Consistency includes the assessment of consistency in methodology, definitions and completeness between the calculation of native forest area from the base year and the years (Year t) of the reporting period undergoing verification.

For each KPI, the application of the calculation methodology established in the SSLB framework is verified. Methodologies are presented in detail in the corresponding technical sheets: Technical Data Sheet for KPI-1[7], Technical Data Sheet for Real GDP series[8] and Technical Sheet for KPI-2[9].

Declaration of Competence and Independence

The verification activities were carried out between January and May 2023 by a qualified, multidisciplinary team of UNDP experts with wide experience in technical review of NGHGI, estimation of forest area changes and review of forest reference emission levels.

The verification complied with the requirements of independence, impartiality and other ethical requirements established in the UNDP Code of Ethics, which is based on the principles of integrity, accountability, transparency, professionalism, mutual respect and results orientation.

[7] Available at: http://sslburuguay.mef.gub.uy/innovaportal/file/30671/19/technical-data-sheet-co2-equivalent-english.pdf

[8] Available at: http://sslburuguay.mef.gub.uy/innovaportal/file/30671/19/technical-data-sheet-real-gdp-english.pdf

[9] Available at: http://sslburuguay.mef.gub.uy/innovaportal/file/30671/19/technical-data-sheet-native-forest-english.pdf

Activities performed

For KPI-1, the technical review of the EMR of CO_2, CH_4 and N_2O for KPI-1 was conducted according to the methodology contained in the United Nations Framework Convention on Climate Change's (UNFCCC) Guide for Peer Review of National Greenhouse Gas Inventories (NGHGI),

The following documents provided by the Government of Uruguay were analyzed: EMR time series 1990-2021, database with the information needed to calculate the KPIs; methodological note on the estimation of greenhouse gas emissions for EMR preparation; EMR auxiliary spreadsheets (quality control spreadsheets, recalculations and sectoral spreadsheets); KPI 1 GHG emissions estimates included in IPCC inventory software v 2.691.

The calculation of the KPI 1 indicator contained in the 2020-2021 KPIR was reviewed, replicating its calculation according to the methodology described in the technical data sheet of KPI 1, Gross aggregate GHG emissions intensity/GDP. For the revision of GDP, its calculation was replicated using the methodology described in the technical data sheet Real Gross Domestic Product Series for Uruguay at constant prices since 1990. Virtual consultations were held with those responsible for preparing the reports, from the NGHG Inventory Working Group and the pMRV Working Group of the National Climate Change Response System.

For KPI 2, a review and analysis of the 2021 FNR and related documents and files provided by the Government of Uruguay was carried out. The following documents were reviewed: Uruguay's 2021 native forest mapping validation report, file in Shapefile format of the 2021 native forest mapping with Sentinel, Methodology applied for the elaboration of Uruguay's native forest cover map for the year 2016 with Sentinel 2 images and Landsat 8 images, Methodology and results of the validation of the native forest cover map of Uruguay for the year 2016 with Sentinel 2 images and Landsat 8 images; and National Forest Cartography Update (2012).

The calculation of the KPI 2 indicator for the year 2021 contained in the 2020-2021 KPIR was reviewed, in accordance with the technical datasheet for KPI 2. The national experts involved in the calculation of KPI-2 were consulted during the mission to the country by the expert reviewers between February 27 and March 3, 2023, which included a field visit.

The technical review reports of the EMR, NFR and KPIR are presented in the Annexes[10] of this report.

[10] Annexes:

- Technical review of the Emissions Report (EMR) and the KPIs Report (KPIR) for the KPI 1 of the Sovereign Sustainability-Linked Bond (SSLB) of Uruguay
- Technical review of the Native Forest Report (NFR) and the KPIs Report (KPIR) for the KPI-2 of the Sovereign Sustainability-Linked Bond (SSLB) of Uruguay

Verification Results

KPI-1

Both the institutional arrangements for inter-ministerial coordination (SSLB, pMRV and NGHGI, Working Groups) and the emissions of the 1990-2021 series for the calculation of KPI 1 (Energy, Industrial Processes, Agriculture, and Waste sectors), as well as the adjustments made for the inclusion of additional data sources and recalculations due to methodological improvements, have been carried out according to the good practices of the 2006 IPCC Guidelines for the preparation of the NGHGI.

Both the EMR time series 1990-2021 and the emissions estimates for the 1990-2021 series for the calculation of KPI 1 (Energy, Industrial Processes, Agriculture, and Waste sectors) comply with the principles of quality in terms of Transparency, Completeness, Consistency, Comparability, and Accuracy, established for reporting in the Good Practice Guidance incorporated into the 2006 IPCC Guidelines.

The quality control (QC) system applied to the indicator performs rigorous quality control of each of the parameters, activity data, and emission factors, identifying calculation errors that are corrected prior to submission of the GHG emissions estimates used in KPI 1. For each of the emission categories included in the indicator, the consistency of the time series is analysed as part of the QC process, where the values of the auxiliary spreadsheets are thoroughly corroborated with the original data with respect to the data extracted from the IPCC software for the entire time series. Each of the activity data, parameters, and emission factors are compared with respect to the original data source, auxiliary spreadsheets from which the data was extracted, and other original sources, for each year of the historical series. Possible errors and inconsistencies in the data and parameters of the entire series are analysed and, if found, are modified and reported in the corresponding recalculation spreadsheet according to the good practices of the 2006 IPCC Guidelines.

The EMR time series 1990-2021, fully complies with the fundamental inventory requirements of Decisions 17/CP.8, 2/CP.17 y 18/CMA.1[11], where applicable.

All issues were solved through a series of consultations with the NGHGI compilers who demonstrated a thorough understanding of the quality standards required for the compilation of GHG inventories and that emissions are estimated using the best available data.

According to the review procedures carried out, no deficiencies have been detected in the application of the methodology for KPI 1 or in the calculation of real GDP.

[11] Decision 18/CMA.1 applies as of December 2024

KPI-2

For the purpose of generating the 2021 native forest area estimate, the sources of information and methods applied were considered adequate and the activity data are complete and consistent.

From the point of view of transparency, the 2021 NFR presents complete information about the activity data and methods used for the calculation of the estimates of the native forest area, including: i) Map with the distribution of sampling points and table with the number of points per forest class; ii) Diagram with explanations of each of the steps and main parameters used for the classification of non-forest areas and different types of native forest; and iii) Detailed explanations of the methods used for differentiation between forest plantations and native forest, including examples of visual interpretation.

With respect to consistency, through the reports presented, Uruguay has demonstrated that the difference between the 2012 and 2021 areas does not result from differences in sensors and methods used, as the area of native forest estimated in 2021, using *Sentinel,* is within the confidence interval (or margin of error) of the 2012 area estimated using *Landsat.*

In general terms, the activity data (i.e., native forest area, in hectares), methods applied for the estimation of the area in the base year (2012) and the report of the year 2021, related to KPI-2, can be considered adequate, consistent, complete, and transparent.

As a result of the evaluation, it can be concluded that the Native Forest Report (NFR) and the KPIs Report (KPIR) for the KPI-2 of the Sovereign Sustainability-Linked Bond (SSLB) of Uruguay:

- Has adherence to international best practices for estimating forest area change over time, in particular on the application of remote sensing techniques, as contained in the relevant provisions of the 2006 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories and the 2003 IPCC Good Practice Guidance;
- Are consistent with the relevant provisions and guiding principles of the Methods and Guidance (MGD) of the Global Forest Observation Initiative (GFOI); and
- Follow the TACCC principles (Transparency, Accuracy, Consistency, Comparability and Completeness) established by the IPCC.

Conclusions

In UNDP´s opinion, KPI 1 and KPI 2 reported in the 2020-2021 Key Performance Indicators Report for the Sovereign Sustainability-Linked Bond have been prepared in accordance with the methodologies established in Uruguay's Sovereign Sustainability-Linked Bond (SSLB) Framework.

KPI 1 and KPI 2 adhere to the methodology and good practices established in the 2006 IPCC Guidelines for the preparation of National Greenhouse Gas Inventories. KPI 2 is consistent with the relevant provisions and guiding principles of the Methods and Guidance (MGD) of the Global Forest Observations Initiative (GFOI).

The Emissions Report, the Native Forest Report and the KPIs Report comply with the quality principles in terms of Transparency, Accuracy, Consistency, Comparability and Completeness established by the IPCC.

Uruguay submitted the Emissions Report, the Native Forest Report and the KPIs Report, complying with the frequency and timeliness established in the SSLB Framework.

The institutional arrangements for inter-ministerial coordination through the SSLB, pMRV and NGHGI Working Groups of the National Response System to Climate Change provide a robust design for the operationalization of Uruguay's Sovereign Sustainability-Linked Bond.

For UNDP

DocuSigned by:
Jose Cruz-Osorio
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José Cruz Osorio
Manager, Regional Hub for UNDP Latin America and the Caribbean
Panamá City, May 12, 2023

ANNEXES

Verification Report of the 2020-2021 Key Performance Indicators Report of Uruguay´s Sovereign Sustainability-Linked Bond

Mayo 2023

Technical review of the Emissions Report (EMR) and the KPIs Report (KPIR) for the KPI 1 of the Sovereign Sustainability-Linked Bond (SSLB) of Uruguay

May 2023

Technical review of the Emissions Report (EMR) and the KPIs Report (KPIR) for the KPI 1 of the Sovereign Sustainability-Linked Bond (SSLB) of Uruguay

United Nations Development Programme (UNDP).

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Review team for the technical review SSLB Emissions Report (EMR) for the Sovereign Sustainability-Linked Bond (SSLB): María José López (Cross-cutting and cross-sectoral aspects), Juan L. Martín (Energy, Industrial Processes, and Waste sectors) and Marcelo Rocha (Agriculture sector).

Review team for the technical review of the KPIs Report (KPIR) for KPI 1 of Sovereign Sustainability-Linked Bond (SSLB) of Uruguay: María José López, Juan L. Martín y Yannis Robles, Gauss International Consulting.

First edition, May 2023.

This report covers the technical review of the SSLB Emissions Report (EMR) and the Key Performance Indicators Report (KPIR) for the KPI 1 and is part of the technical documents used for the preparation of the Verification Report of the 2020 and 2021 KPI Report for the Sovereign Sustainability-Linked Bond (SSLB), prepared by UNDP.

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Executive Summary

The Oriental Republic of Uruguay has requested the United Nations Development Programme (UNDP) to act as the external verifier of the Key Performance Indicators (KPIs) of Sovereign Sustainability-Linked Bond (SSLB).

KPI 1:

- presents the gross aggregate greenhouse gas (GHG) emissions intensity GHG/GDP, which is used to assess the reduction of aggregate CO_2, N_2O, and CH_4 emissions expressed in CO_2 equivalent emissions per unit of real GDP with respect to 1990;
- exclusively considers the emissions corresponding to the gases, sectors, categories, and sources estimated and reported in the national greenhouse gas inventory 1990-2012 (NGHGI 2012), through which the GHG emissions reduction commitments of the first Nationally Determined Contribution (NDC) were established in 2017;
- aggregates, per unit of GDP, the emissions of the greenhouse gases CO_2, N_2O, and CH_4 under the 100-year Global Warming Potential (GWP) metric established in the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC).

For the calculation of KPI 1, the emissions reported in the December 2022 Emissions Report (EMR) are used, which exclusively considers the emissions corresponding to the gases, sectors, categories, and sources estimated and reported in the NGHGI 2012, on which the emissions intensity reduction commitment of the first nationally determined contribution (NDC) was established in 2017.

For the GDP, the latest official series published by the national accounts system (SCN – Sistema de Cuentas Nacionales in Spanish) of the central bank of Uruguay (BCU – Banco Central del Uruguay in Spanish) were used, backpolated to 1990 using the variation rate method as a statistical splicing technique. GDP is based on 2016, and he backpolation of the series between 1990 and 2015 was performed by the Ministry of Economy and Finance using, as a source, the available public information of the National Accounts published by the BCU.

This document presents the results of the technical review of the SSLB emissions report (EMR): CO2, CH4 y N2O of the Energy, Industrial Processes, Agriculture, and Waste sectors, and the technical review of the KPIs Report (KPIR) for KPI 1.

The technical review of the SSLB Emissions Report (EMR) followed the methodology of the United Nations Framework Convention on Climate Change (UNFCCC) Guidelines for the Peer Review of National Greenhouse Gas Inventories (NGHGI), and specifically drawing conclusions on:

i) the adherence to the 2006 IPCC Guidelines for the preparation of NGHGIs;

ii) whether the key inventory requirements of Decisions 17/CP.8, 2/CP.17 and 18/CMA.1 are met, where applicable;

iii) the quality of emissions reporting, assessed primarily through examination of the inventory principles of transparency, completeness, consistency, comparability, and accuracy (TCCCA), set out for reporting in the Good Practice Guidance incorporated in the 2006 IPCC Guidelines;

iv) the relevance and quality of the revision of historical GHG emission values, derived from inventory adjustments, including additional data sources and recalculations due to methodological improvements.

The technical review of GHG emissions estimates for the 1990-2021 series by the Energy, Industrial Processes, Agriculture, and Waste sectors of KPI 1 was conducted during the months of January through March 2023, using the following materials:

- SSLB Emissions Report (EMR) prepared by the NGHGI Group of the National System for Climate Change and Variability Response (SNRCC);
- KPIs Report (KPIR) which contains the calculation of KPI 1, carried out by the pMRV Group (programming, Monitoring, Reporting, and Verification) of the SNRCC;
- Methodological note on the estimation of GHG emissions for the preparation of the EMR (hereinafter referred to as "methodological note");
- Auxiliary spreadsheets (quality control spreadsheets, recalculations, and sectoral spreadsheets);
- KPI 1 emissions estimates included in the IPCC inventory software version 2.691.

And it can be concluded that:

- Both the institutional arrangements for inter-ministerial coordination and the emission estimates for the 1990-2021 series for the calculation of KPI 1 (energy, industrial processes, agriculture, and waste sectors) as well as the adjustments made for the inclusion of additional data sources and recalculations for methodological improvements fully adhere to the good practices of the 2006 IPCC Guidelines for the development of the NGHGI.
- Both the report (EMR) and the emissions estimates for the 1990-2021 series for the calculation of KPI 1 (energy, industrial processes, agriculture, and waste sectors) comply with the quality principles in terms of transparency, completeness, consistency, comparability, and accuracy.
- The quality control (QC) system applied to the indicator follows rigorous quality control procedures for each of the parameters, activity data, and emissions factors used, identifying calculation errors that are corrected prior to the presentation of the GHG emissions estimates used in KPI 1. For each of the emission categories included in the

indicator, the consistency of the time series is analysed as part of the QC process, where values from the auxiliary spreadsheets are thoroughly corroborated with the original data with respect to the data extracted from the IPCC software for the entire time series. Each of the activity data, parameters, and emission factors are compared with respect to the original data source, auxiliary spreadsheets from which these data were extracted, and other original sources for each year of the historical series. Possible errors and inconsistencies in the data and parameters of the entire series are analysed and, if found, are modified and reported in the corresponding recalculation spreadsheet following the good practices of the 2006 IPCC Guidelines.

- The EMR fully complies with the fundamental inventory requirements of Decisions 17/CP.8, 2/CP.17 y 18/CMA.1[1], where applicable.

For the technical review of the KPIs Report (KPIR) for KPI 1, conclusions were made specifically on the application of the calculation methodology defined in the KPI 1 Fact Sheet: Reduction of aggregate gross greenhouse gas (GHG) emissions per unit of real GDP, with respect to 1990, established in the SSLB emission framework as well as the real GDP published by the central bank of Uruguay (BCU).

The technical review was carried out during the second half of April 2023 using the following materials:

- Technical data sheet URUGUAY'S REAL GROSS DOMESTIC PRODUCT SERIES AT CONSTANCE PRICES, SINCE 1990 (SERIE DEL PRODUCTO INTERNO BRUTO REAL DE URUGUAY A PRECIOS CONSTANTES, DESDE 1990 in Spanish).
- Technical data sheet INTENSITY OF AGGREGATE GROSS GHG EMISSIONS/GDP (INTENSIDAD DE EMISIONES AGREGADAS BRUTAS DE GEI/ PIB in Spanish).
- KPIR for 2020 and 2021 from April 2023.
- KPIR Spreadsheet called Excel file BICC - 2023-04-10.

And it allows for the conclusion that no deficiencies have been detected in the application of the methodology for KPI 1 nor in the calculation of real GDP.

[1] Decision 18/CMA.1 applies as of December 2024.

Background

The Oriental Republic of Uruguay has requested the United Nations Development Programme (UNDP) to serve as an external verifier of the Key Performance Indicators (KPIs) of the of the Sovereign Sustainability-Linked Bond (SSLB). These indicators are focused on the areas of climate change and native forest protection, aligned with the objectives of Uruguay's first Nationally Determined Contribution (NDC) submitted to the Paris Agreement in 2017.

The SSLB framework is available at:

http://sslburuguay.mef.gub.uy/30694/20/areas/framework-for-the-sovereign-issuance-of-sslb.html

This consultancy is part of the verification activities of the SSLB KPIs and represents the part of the technical review of KPI 1 that presents the intensity of gross aggregate GHG emissions/GDP, which is used to assess the reduction of aggregate emissions of CO2, N2O, and CH4, expressed in CO2 equivalent emissions per unit of real GDP compared to 1990, for which the technical sheet is published at:

https://www.mef.gub.uy/innovaportal/file/30671/19/technical-data-sheet-co2-equivalent-english.pdf

The annual technical review focused on the review of the:

i) SSLB Emissions Report (EMR) prepared by the National Greenhouse Gas Inventory (NGHGI) Group of the National System for Climate Change and Variability Response (SNRCC).
ii) KPIs Report for the SSLB (KPIR) containing calculation of KPI 1, carried out by the pMRV (programming, Monitoring, Reporting, and Verification) Group of the SNRCC.

KPI 1 is measured annually with a lag of one year.

Scope

For the technical review of the greenhouse gas (GHG) emissions report for the 1990-2021 series, this report includes only the categories and sources of emissions contemplated in the global intensity targets with respect to the evolution of the economy presented in the first NDC. This means that only emissions of the direct GHGs, CO_2, CH_4 and N_2O, are considered, leaving outside of the scope of the EMR the estimates of emissions of HFCs, SF_6 and indirect GHGs or precursors (CO, NO_X, COVDM y SO_2), which are estimated in the Uruguayan national inventory of greenhouse gases (NGHGI).

The categories and sources included in the global targets and quantified in this report correspond to those reported in the 1990-2012 NGHGI, presented in the Fourth National Communication to the Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC) in 2016, an inventory which was used as the basis for the development of the NDC. The emissions intensity reduction commitments established in the NDC apply to the Energy, Industrial Processes, Agriculture, and Waste sectors.

The 1990-2012 NGHGI was prepared based on the revised 1996 IPCC Guidelines, which provided methodologies for estimating GHG emissions from the following sectors: Energy, Industrial Processes, Solvent Use and Use of Other Products, Agriculture, Land Use and Land Use Change and Forestry, and Waste. As of the 2014 NGHGI, NGHGIs are prepared based on the 2006 IPCC Guidelines, estimated emissions derived from the Energy, Industrial Processes and Product Use, Agriculture, Forestry, and Other Land Use, and Waste sectors.

The change in the Guidelines not only implied a change in the denomination of the sectors, but also in the incorporation of new categories and emission sources with respect to those used in the preparation of the NDC. In addition, due to the process of continuous improvement of the NGHGI, categories are currently estimated which were not estimated in the NGHGI that was taken as a reference for the elaboration of the NDC, the 1990-2012 NGHGI.

Therefore, for the estimation of GHG emissions for KPI 1, only emissions corresponding to the gases, sectors, categories, and sources estimated and reported in the 1990-2012 NGHGI, on which the NDC's emission reduction commitments were established, are considered.

For the technical review of the KPIs Report (KPIR) for KPI 1, this report presents the results for the years 2020 and 2021. The report aims to summarise the actions carried out during the verification procedures and briefly describe the results on the application of the calculation methodology defined in the KPI 1 technical fact sheet: Reduction of aggregate gross greenhouse gas (GHG) emissions per unit of real GDP, with respect to the year 1990, established in the SSLB emission framework, as well as the real GDP published by the central bank of Uruguay (BCU), highlighting the deficiencies found and proposing recommendations to solve the mentioned deficiencies, if any.

Methodology of the technical review

For the technical review of the SSLB Emissions Report (EMR) of CO_2, CH_4 and N_2O from the Energy, Industrial Processes, Agriculture, and Waste sectors, this document presents the results following the methodology of the UNFCCC NGHGI Peer Review Guidelines, specifically concluding on:

- the adherence to the 2006 IPCC Guidelines for the preparation of the NGHGI;
- the relevance and quality of the revision of historical GHG emissions values, derived from inventory adjustments, including additional data sources and recalculations due to methodological improvements;
- the quality of emissions reporting, assessed primarily through examination of the inventory principles of transparency, completeness, comparability, and accuracy (TCCCA), set out for reporting in the Good Practice Guidance incorporated in the 2006 IPCC Guidelines;
- whether the key inventory requirements of Decisions 17/CP.8, 2/CP.17, and 18/CMA.1 are met, where applicable.

Quality assurance and quality control includes two different types of activities. The IPCC defines them as:

- Quality Control (QC): a system of routine technical activities implemented by the inventory development team for the purpose of measuring and controlling the quality of the inventory as it is developed.
- Quality Assurance (QA): a planned system of review processes conducted by personnel not involved in the inventory development process.

The quality control system for emissions used in Uruguay's KPI 1 has quality control and assurance procedures.

Internal sectoral reviews are carried out by each ministry. Additionally, the Ministry of Environment performs a global quality control of estimates and reports.

The quality assurance process is managed through UNDP by contracting external reviewers. UNDP has contracted international reviewers to carry out the technical review of the emissions estimates for the 1990-2021 series. This technical review process constitutes the quality assurance mentioned in the SSLB Emissions Report (EMR section 1.4.2.).

The technical review was conducted during the months of January through March 2023 by international reviewers in collaboration with UNDP and in consultation with the sectoral stakeholders involved in the compilation of the SSLB Emissions Report (EMR).

The technical review process verifies adherence to the 2006 IPCC Guidelines, the transparency, completeness, consistency, comparability, and accuracy of the 2021 emissions of the sectors, categories, sources, and gases included in KPI 1, as well as the conformity of the adopted procedures with international commitments.

To assess **transparency,** it was verified whether there is sufficient documentation and clear references to understand how the GHG emissions estimates for KPI 1 were made.

It was verified whether the emissions and removals were estimated in a **complete** and comprehensive manner including all gases and all relevant KPI 1 source and sink categories nationwide, whether notation keys were used, and how the absence of estimates were justified.

The **consistency** of estimates for different years, gases, and categories was assessed, and it was verified whether annual trends are calculated using the same methods and data sources in all years, without being subject to changes resulting from methodological differences.

To assess **comparability**, it was checked whether the guidance, classifications, definitions, methodologies, and values of the 2016 IPCC Guidelines and the 2019 Refinement were used.

The **accuracy** of the data was also checked by reviewing whether each sector did not contain over or underestimates, insofar as can be judged.

The detailed review focused on the principles of completeness, comparability, consistency, accuracy, and transparency, taking into account the method used, activity data, emission factors, parameters, and estimated emissions.

In each category included in KPI 1, the following aspects were reviewed:

Method: It was evaluated which information was collected, how the data was obtained, and what methods were used. It was reviewed and evaluated whether, for each category, the best method was used according to the available information and whether the assumptions used in each case are appropriate. The methodological and data changes that presented divergences with respect to the latest estimates from the 2019 NGHGI were verified, including the provision of justifications for recalculations and how the recalculations were carried out.

Activity Data: Activity data at the national level was reviewed. The consistency in magnitude with respect to international parameters was reviewed and it was assessed whether the time series data are consistent by, in particular, observing the presence of outliers. The assumptions and criteria for the selection of activity data was reviewed, as well as the consistency of the data across categories The temporal consistency in the input data for each category was verified, as well as the consistency in the method used for the calculations. At the same time, any unusual or unexplained trends reported for the activity data or other parameters across the time series was checked. Alternative data sources, such as data presented in the national energy balance, were considered, comparing activity data from multiple references whenever possible.

Emission Factors (EF): It was reviewed how the default IPCC Tier 1 emission factors have been used. It was determined whether appropriate emission factors were used and the justifications for their use. The relevance of the IPCC default factors as well as country-specific factors were assessed by reviewing the quality of the data used and comparing them with the IPCC default values. The emission factors used were also compared with those of other Latin American countries which have submitted their BURs. Consistency was additionally evaluated through the time series and the value of the implied emission factors (aggregate emissions divided by the activity data) were verified through the time series.

Parameters: It was evaluated whether the IPCC default parameters have been used. If not, the justification of the values used was checked in order to assess transparency. Parameters that are common in the categories were identified in order to verify consistency. It was verified that the same data set is used for categories that share common data.

Emissions: How the data was documented, the calculation tools used in the development of emissions and removals estimates, and the systems for producing the information and disaggregated data were evaluated. The completeness of the categories in the 1990-2021 series was verified. It was verified whether the estimates are presented for all categories present in the country which are included in KPI 1. It was also checked that data whose unavailability is known, resulting in incomplete emissions estimates for a category, were documented (e.g., subcategories classified as 'not estimated'). Estimates for each category were compared over the 1990-2001 series.

In the event that there were significant changes or deviations from expected trends, the estimates were rechecked, and the relevant stakeholders were asked to provide explanations for the differences. The consistency of the time series was assessed by further reviewing significant changes (>10%) in annual estimates for categories and subcategories and their justifications. Estimates made with top-down and bottom-up approaches were compared to verify that they were of similar orders of magnitude (sectoral and baseline approach in the

energy sector). It was verified that emissions are reported consistently, in terms of significant digits or decimal places, in the categories and that emissions data are aggregated correctly from the lowest to the highest reporting levels. Estimates were compared with other national or international estimates at the sector, sub-sector, gas, or national level, where possible. Intensity indicators were compared between countries in order to check the accuracy of emissions. Measurements of biogas recovery at landfills were also reviewed and documentation and justification for any significant discrepancies were verified.

Also evaluated were the emissions estimation methodologies used and the adequacy of the methodological level, or tier, to the relative weight of the category in the overall inventory, the emission factors applied and their comparison with the default emission factors, the completeness and consistency of the emission data series, the inter-annual differences in emissions, and the justifications provided.

This determined the degree of quality related to the inclusion of the best possible emission estimates, given the current state of scientific knowledge and data availability.

For each of the elements described above, it was evaluated whether:

- All significant issues in relation to the requirements and suggestions of the UNFCCC Guidelines for National Communications and the Decisions on Biennial Update Reports and the Paris Agreement Modalities, Procedures, and Guidelines (MPGs) are satisfactorily met, where applicable. Requirement means any provision drafted with the auxiliary "shall" and suggestions are any provisions drafted with the auxiliary "should" or the verbs "may" and "encourage".
- There is deviation from the general good practices of the IPCC.
- There are problems of: i) Transparency; ii) Accuracy; iii) Consistency, iv) Comparability; and/or v) Completeness.

Finally, the compliance of KPI 1 emissions estimates with the information requirements established both from the submission of BURs (Decisions 17/CP.8 and 2/CP.17) and for the submission of BTRs (Decision 18/CMA.1), which will replace them in 2024 and contain more stringent requirements where applicable, was reviewed.

It should be noted that the scope of the technical review carried out is similar to the reviews officially carried out by the United Nations Framework Convention on Climate Change for the inventories of Annex I Parties[2], far exceeding the information requirements of National Communications and BURs for non-Annex I Parties such as Uruguay, including the MPGs applicable for BTR reporting as of December 2024.

[2] The Parties of Annex I are presented on page 25 of the UNFCCC in the following link: https://unfccc.int/resource/docs/convkp/convsp.pdf

For the technical review of the KPIs Report (KPIR) for the KPI 1, the application of the calculation methodology defined in the KPI 1 technical fact sheet was verified during the second half of April 2023: Reduction of aggregate gross greenhouse gas (GHG) emissions per unit of real GDP, with respect to 1990, established by the SSLB emission framework as well as real GDP published by the central bank of Uruguay (BCU).

The methodologies used were reviewed with the following technical fact sheets:

- For the calculation of GDP, the technical fact sheet SERIES OF URUGUAY'S REAL GROSS DOMESTIC PRODUCT AT CONSTANT PRICES, SINCE 1990 (In Spanish, SERIE DEL PRODUCTO INTERNO BRUTO REAL DE URUGUAY A PRECIOS CONSTANTES, DESDE 1990), published at: technical-data-sheet-co2-equivalent-english.pdf was reviewed and the calculation of the GDP was replicated using the methodology described.

- For the calculation of KPI 1, the technical fact sheet GROSS AGGREGATE GHG EMISSIONS INTENSITY/GDP (In Spanish, INTENSIDAD DE EMISIONES AGREGADAS BRUTAS DE GEI/PIB), published at: technical-data-sheet-co2-equivalent-english.pdf was reviewed and the calculation of KPI 1 was replicated following the methodology described.

Likewise, during the verification process for the KPIs Report for the SSLB (KPIR) for 2020 and 2021 produced in April 2023, the following were reviewed:

- The numerical values and percentages presented for emission, GDP, and KPI 1 indicator by contrasting with the Excel file BICC – 2023-04-10 and with the KPI 1 Emissions Report and its methodological note.
- The explanations of the trend and annual variations of emissions, GDP, and the two performance indicators, KPI 1 and KPI 2, against the national circumstances presented in other official documents of the country such as the NGHGI 1990-2019 presented to the UNFCCC in 2021, the third biennial update report (BUR) sent to the UNFCCC, and the 2021 economic study conducted by the Economic Commission for Latin America and the Caribbean (CEPAL - Comisión Económica para América Latina in Spanish), based on official national figures.

Adherence to the 2006 IPCC Guidelines

The main findings of the technical review of the KPI 1 emissions report for the Energy, Industrial Processes, Agriculture, and Waste sectors with respect to the cross-cutting (institutional arrangements and recalculations) and sectoral (application of good practices) aspects of the 2006 IPCC Guidelines are presented below.

Aspect of the 20016 IPCC Guidelines	Conclusions
Institutional Arrangements	For effective coordination of the preparation and management of KPI 1, it is important to have an institution that takes responsibility for and coordinates the compilation of data for the development of the indicator. This will ensure knowledge and application of the mandatory reporting guidelines and the use of correct methodologies for emissions estimation and subsequent reporting. In particular, this will facilitate effective planning, oversight, management, and implementation of annual KPI 1 development, documentation, and archiving, implementation of a plan, and quality control and technical review procedures. The administration of SSLB is a multidisciplinary and inter-ministerial effort with the participation and joint work of all the ministries involved: Ministry of Economy and Finance (MEF), Ministry of Environment (MA), Ministry of Industry, Energy, and Mining (MIEM), and the Ministry of Livestock, Agriculture, and Fisheries (MGAP), with the support of the Ministry of Foreign Affairs (MRREE). There is an institutional framework that defines the assignment of responsibilities and roles which ensure timely compliance with the legal and contractual commitments established for the sovereign issuance of the SSLB. Uruguay has developed an institutional structure which ensures a robust design and operationalisation of the SSLB through the SSLB Group, which is composed of representatives from four ministries: MEF, MA, MIEM, and the MGAP. The SSLB Group is tasked with coordinating between ministries, establishing concrete and measurable objectives, timelines, and responsibilities, and ensuring that the goals are communicated and understood throughout the public sector throughout the life of the bond. The SSLB Group oversees progress on the estimation, monitoring, and timely reporting and external verification of KPIs for the SSLB. There is an Inter-ministerial Coordination and Cooperation Agreement for the Issuance of Bonds Indexed to Climate Change Indicators between the MEF, MA, MIEM, MGAP and the MRREE. This agreement establishes the responsibilities of each ministry and the work schedule for the preparation and publication of the SSLB Annual Report. The agreement established that MIEM, MGAP, and MA submit to the NGHGI Working Group the previous year's sectoral GHG emissions report, which is necessary for the calculation of the SSLB KPI 1, together with a sectoral methodological note and computational support of the GHG estimates (database, auxiliary spreadsheets), in accordance with the competencies established in Decree No. 181/020, of 24th June 2020, which formalizes the NGHGI Working Group.

Institutional Arrangements	The MA performs the general coordination, compilation of the sectoral information submitted by other ministries, quality control and preparation of the final EMR document, and the methodological note with specifications of the emissions estimation. It also carries out the estimation of emissions and their evolution for the Industrial Processes and Waste sectors. On the other hand, the MGAP carries out the estimation and reporting of greenhouse gas emissions and their evolution corresponding to the Agriculture sector while the MIEM carries out the estimation and reporting of greenhouse gas emissions and their evolution corresponding to the Energy sector. All relevant institutions that collect the data needed for the estimation of KPI 1 emissions are involved in its elaboration. The existence of a common and adequate understanding of data needs has been verified, as well as communication between the working groups involved in the development of the EMR KPI 1 (SSLB Working Group, MRV Working Group, and NGHGI Working Group), which are crucial elements for the formulation of a quality indicator that complies with the principles of transparency, completeness, consistency, comparability, and accuracy (TCCCA principles). There is an agreed annual cycle that includes a detailed work plan addressed to all institutions and all experts involved in the EMR and indicator development process. In addition, there is a set of general quality control (QC) procedures according to the 2006 IPCC Guidelines (vol.1, chap. 6, table 6.1). The QC system for emissions used in Uruguay's KPI 1 has quality control and quality assurance procedures, sectoral QC checklists, a compilation checklist, a reporting document checklist, and a list with observations found and corrective actions taken by sector. Internal sectoral reviews are performed by each ministry, and the Ministry of Environment additionally performs a global quality control of the estimates and reporting. QC checks are implemented annually to avoid errors due to oversights and/or inconsistencies in the estimation of emissions and in the presentation of the IEM. QC activities include general methods such as accuracy checks during data acquisition and calculation as well as the use of approved standardised procedures for emissions calculations. QC activities also include technical reviews of categories, activity data, emission factors, and other parameters and calculation methods.

Good Practices	The IPCC Guidelines typically include three alternative methods, or methodological tiers, for estimating emissions and removals for each category. In general, a higher tier Will provide a more accurate estimation of emissions and removals, and is therefore preferred. In some cases, the use of a higher tier will not result in a significant increase in accuracy and the use of a lower tiers may be the best option for some categories which are not key, because of, for example, low emissions or no pronounced emissions trend. The choice of the most appropriate tier for the category depends on resources, data availability, country priorities, and the methodological priorities presented in the category-specific decision tree in the 2006 IPCC Guidelines. Some emissions estimates from key KPI 1 categories[3] have not been able to utilise a higher tier method due to a lack of data availability. This means that data required for a higher tier could not be collected or that emission factors or other country-specific parameters and other data required for the use of Tier 2 and 3 methods could not be determined. The KPI 1 emissions report provides an overview of the sectors and categories covered, the methods and data used, and the gases included. The estimates have been made following the good practices provided by the 2006 IPCC Guidelines.
Recalculations	Changes in methods, activity data, emission factors, error corrections, and the change from a category to a key category have led to recalculations of the entire time series in accordance with the 2006 IPCC Guidelines. When Uruguay began using the 2006 IPCC Guidelines, when it previously used the 1996 Revised IPCC Guidelines, the inventory team properly recalculated the entirety of the time series by changing the methodology of each category, this obtaining greater accuracy of the emission calculation. KPI 1 emissions have been estimated using the same method to ensure a consistent time series. The EMR complies with the good practice of reporting and documenting all recalculations.

[3] When applying decision 18/CMA.1 in the development of BTRs from December 2024 onwards, when using a Tier 1 method for key categories it should be documented as to why the methodological choice is not in line with the prioritisation provided in the decision tree of the 2006 IPCC Guidelines.

Review of the TACCC inventory principles

The main conclusions of the technical review of the emissions report for the Energy, Industrial Processes, Agriculture, and Waste sectors of KPI 1 for each quality principle are presented below.

Quality Principle	Conclusions
Accuracy	The basic formula for calculating emissions is the product of emission factors and activity data. The KPI 1 emissions estimate correctly uses emission factors, activity data, and other parameters in its calculation. The methods used for some of the key categories are Tier 1. They utilise available national statistics and censuses or the national energy balance as sources of information for activity variables and other parameters, along with default emission factors and coefficients from the 2006 IPCC Guidelines. For some categories, KPI 1 emission estimations use higher tier methods or country-specific emission factors that product more accurate results with less uncertainty. For country-specific data, the value used is representative of national circumstances and comes from reliable sources. The country-specific data correspond to that of other countries with similar national circumstances and are within the range of emission factors and default parameters provided by the 2006 IPCC Guidelines. The emissions estimated in KPI 1 do not contain under or overestimates, insofar as they could be judged.
Transparency	KPI 1 of the EMR includes sufficient and clear documentation to provide and understanding of how emissions were estimated and ensures compliances with good practices for national GHG emissions inventories. The sources of information, assumptions, and methodologies leveraged are clearly explained.
Completeness	Emission estimates included in KPI 1 include all national estimates for all sources and for all gases listed in the 2006 IPCC Guidelines included in the indicator. All existing categories in the country that are part of KPI 1 have been estimated and reported.

Consistency	Annual emission trends for KPI 1 have been estimated using the same method and data sources in all years, where this is possible. These trends reflect actual annual fluctuations as recalculations were performed to avoid producing trends subject to chance as a result of methodological differences in accordance with the 2006 IPCC Guidelines (vol. 1, ch. 2, 4, and 5). In some cases where more than one methodology was used, the consistency of the series is justified. This happened, for example, in the case of cement production as, throughout the series, more detailed data was obtained directly from the producing plants which enabled moving from a Tier 1 methodology to a Tier 2 and Tier 3 methodology. When new sources were used for activity data during the time series, emissions were recalculated using methods from the 2006 IPCC Guidelines (vol. 1, ch. 5). The parameters and assumptions used are realistic throughout the time series.
Comparability	The EMR uses the same reporting formats and methodologies recommended by the IPCC Guidelines. During the technical review, no misallocations, omissions, or double counting was detected, and it was verified that the formats and methods recommended in the IPCC Guidelines were followed. It is concluded that the KPI 1 emissions report makes good use of the reporting formats and guidance of the 2006 IPCC Guidelines.
Fulfilment of commitments and continuous improvement	During the technical review, all issues were resolved through a series of consultations with NGHGI compilers who demonstrated a thorough understanding of the quality standards required in the compilation of GHG inventories and that emissions are estimated using the best available data. The team is also developing a continuous improvement plan. The technical level of the team responsible for the inventory and KPI 1 is very high, and the results of the technical review allow for the conclusion that the emissions for KPI 1 are of very high quality. It is also concluded that the KPI 1 emissions report meets all of the requirements for the BUR (see next section) and most of the reporting requirements which are required of the BTR which will is to be submitted from December 2024.

Compliance with the fundamental inventory requirements of Decisions 17/CP.8, 2/CP.17, and 18/CMA.1

Based on the information presented for GHG emissions for the 1990-2021 series, the current compliance of the emissions categories included in KPI 1 with the inventory requirements to be submitted in the biennial update reports (BURs) was assessed.

As illustrated below, all requirements of the inventory chapter of the BUR which apply to the KPI 1 emissions report are fully satisfied.

BUR inventory chapter requirements

Requirement	Results
The last year of the inventory must not be older than four years prior to the year of submission of the first BUR	Complies
The NGHGI is based on the methodologies of the IPCC Guidelines (1996 o 2006)	Complies
The NGHGI is based on updated activity variables using the best available information	Complies
The NGHGI presents tables in CRF format	NA
The NGHGI presents consistent series since the year presented in the latest national communication	Complies
A comparison with previous NGHGIs is presented	Complies
A table with GHGs and precursors is presented	NA
A table with HFCs, PFCs, and SF6 is presented	NA
The NGHGI is accompanied by a report presenting sector-specific information	Complies

Information is included on the procedures and arrangements for data collection and inventory archiving, as well as the efforts to implement a continuous process, along with the roles and responsibilities of the institutions involved.	Complies
Information is presented by gas in units of mass for CO2, CH4, and N2O	NA
Information is presented on the fluorinated gases, HFCs, PFCs, and SF6	NA
Information is presented on the precursor gases, CO, NOX, and NMVOCs	NA
Information is presented on SOX	NA
Information is presented on CO2 emissions from fuel combustion using the sectoral and reference approaches and explaining significant differences between the results of the two approaches	NA
Emissions from international aviation and marine vessels are reported individually and separately from national emissions, and are not included (summed) in total national emissions	Complies
Aggregated CO2 equivalent emissions are presented using the appropriate global warming potentials	Complies
Information is provided on the methodologies utilised	Complies
Sources used for determining emission factors are explained	Complies
Sources used for activity variables are explained	Complies
Areas for future improvement are identified	NA
An uncertainty analysis is presented, explaining the methodologies used and assumptions made to calculate the uncertainty	NA

NA: Not applicable

Conclusions of the review

SSLB Emissions Report (EMR)

All issues were resolved through a series of consultations with the NGHGI compilers who demonstrated a thorough understanding of the quality standards required for the compilation of GHG inventories and that emissions are estimated using the best available data.

Both the institutional arrangements for inter-ministerial coordination and the emissions of the 1990-2021 series for the calculation of KPI 1 (Energy, Industrial Processes, Agriculture, and Waste sectors), as well as the adjustments made for the inclusion of additional data sources and recalculations due to methodological improvements, have been carried out according to the good practices of the 2006 IPCC Guidelines for the preparation of the NGHGI.

Both the EMR time series 1990-2021 and the emissions estimates for the 1990-2021 series for the calculation of KPI 1 (Energy, Industrial Processes, Agriculture, and Waste sectors) comply with the principles of quality in terms of Transparency, Completeness, Consistency, Comparability, and Accuracy, established for reporting in the Good Practice Guidance incorporated into the 2006 IPCC Guidelines.

The quality control (QC) system applied to the indicator performs rigorous quality control of each of the parameters, activity data, and emission factors, identifying calculation errors that are corrected prior to submission of the GHG emissions estimates used in KPI 1. For each of the emission categories included in the sectoral report, the consistency of the time series is analysed as part of the QC process, where the values of the auxiliary spreadsheets are thoroughly corroborated with the original data with respect to the data extracted from the IPCC software for the entire time series. Each of the activity data, parameters, and emission factors are compared with respect to the original data source, auxiliary spreadsheets from which the data was extracted, and other original sources, for each year of the historical series. Possible errors and inconsistencies in the data and parameters of the entire series are analysed and, if found, are modified and reported in the corresponding recalculation spreadsheet.

The emissions report fully complies with the fundamental inventory requirements of Decisions 17/CP.8, 2/CP.17 y 18/CMA.1[4], where applicable.

[4] Decision 18/CMA.1 applies as of December 2024.

KPIs Report (KPIR) for KPI 1

According to the review procedures carried out, no deficiencies have been detected in the application of the methodology for KPI 1 or in the calculation of real GDP.

With respect to the estimation of gross CO_2 emissions, when in year *t* hydroelectric generation falls outside the range between 4,900 and 8,300 GWh, an adjustment is made for average hydraulicity. The adjustment consists of simulating the dispatch of electricity for supplying the internal demand assuming a scenario of average hydroelectric generation. This range, defined to make the correction, arises from the analysis of the historical series of internal demand and hydroelectric generation. The average generation for the 110 years of the series is 6,600 GWh and its standard deviation is 1,700 GWh, so the range covers the values of the mean +/- one standard deviation (6,600 ± 1,700 GWh). Once the adjustment is obtained, emissions are recalculated for the Electricity and Heat Production Category (1A1a of the NGHGI) and thus for emissions in the Energy sector. The adjusted estimate of gross CO_2 emissions is the one used in the calculation of the indicator for year *t* in which the adjustment is made.

The review team considers it good practice to adjust for average hydraulicity to avoid variability associated with exogenous factors, but has not been able to find, in the documents consulted, the reasons why the country uses only this factor.

Technical review of the Native Forest Report (NFR) and the KPIs Report (KPIR) for the KPI-2 of the Sovereign Sustainability-Linked Bond (SSLB) of Uruguay

May 2023

Technical review of the Native Forest Report (NFR) and the KPIs Report (KPIR) for the KPI-2 of the Sovereign Sustainability-Linked Bond (SSLB) of Uruguay

United Nations Development Programme (UNDP).

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First edition, May 2023.

This report covers the technical review of the Native Forest Report (NFR) and the Key Performance Indicators Report (KPIR) for the KPI-2 and is part of the technical documents used for the preparation of the Verification Report of the 2020 and 2021 KPI Report for the Sovereign Sustainability-Linked Bond, prepared by UNDP.

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Executive Summary

The Eastern Republic of Uruguay has requested **UNDP to fulfill the role of external verifier of SSLB KPIs**

This report presents the conclusions and recommendations arising from the technical review **of KPI-2: Maintenance of native forest area (in hectares) with respect to reference year (in %)**

The technical review specifically assessed:

- Adherence to international best practices for estimating forest area change over time, in particular on the application of remote sensing techniques, as contained in the relevant provisions of the **2006 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories** and the **2003 IPCC Good Practice Guidance**;
- Consistency with the relevant provisions and guiding principles of the **Methods and Guidance (MGD) of the Global Forest Observation Initiative (GFOI)**; and
- The quality of the report, by examining the **TACCC principles** (Transparency, Accuracy, Coherence, Comparability and Completeness) established by the IPCC.

For KPI-2, the technical review was focused on the review of:

- **SSLB Native Forest Report (NFR)** prepared by the General Directorate of Forestry (DGF) of the Ministry of Agriculture, Livestock and Fisheries (MGAP) and the National Directorate of Climate Change (DINACC) of the Ministry of Environment (MA); and
- **SSLB KPIs Report (KPIR)** that contains the calculation of the KPI-2, carried out by the pMRV Group (programming, Monitoring, Report, and Verification) of the National System of Response to Climate Change and Variability (SNRCC).

The revisions were carried out jointly for the NFR and the KPIR

In addition to the revisions of the documents listed above, consultations were also held with the national experts involved in the calculation of the KPI-2, during **the in-country mission** carried out between February 27 and March 3, 2023.

For the purposes of generating the 2021 native forest area estimate, the **sources of information and methods applied were considered adequate and the activity data are complete and consistent.**

From the point of view of **transparency**, the NFR presents complete information about the activity data and methods used for the calculation of the estimates of the native forest area, including:

- Map with the distribution of sampling points and table with the number of points per forest class;
- Diagram with explanations of each of the steps and main parameters used for the classification of non-forest areas and different types of native forest; and

- Detailed explanations of the methods used for differentiation between forest plantations and native forest, including examples of visual interpretation.

Uruguay has **demonstrated that the difference between the 2012 and 2021 areas does not result from differences in sensors and methods used**, as the area of native forest estimated in 2021, using *Sentinel,* is within the confidence interval (or margin of error) of the 2012 area estimated using *Landsat.*

As a result of the evaluation, it can be concluded that the **SSLB Native Forest Report (NFR)** and the **SSLB KPIs Report (KPIR)** for the KPI-2 of the Sovereign Sustainability-Linked Bond (SSLB) of Uruguay:

- **Has adherence** to international best practices for estimating forest area change over time, in particular on the application of remote sensing techniques, as contained in the relevant provisions of the 2006 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories and the 2003 IPCC Good Practice Guidance;
- **Are consistent** with the relevant provisions and guiding principles of the Methods and Guidance (MGD) of the Global Forest Observation Initiative (GFOI); and
- **Follow the TACCC principles** (Transparency, Accuracy, Coherence, Comparability and Completeness) established by the IPCC.

Background[1]

The technical review is part of the verification activities of the **Key Performance Indicators ("KPI")** of the **Sovereign Sustainability-Linked Bond (SSLB)[2].**

The Eastern Republic of Uruguay has requested **UNDP to fulfill the role of external verifier of SSLB KPIs.** These indicators are focused on climate change and native forest protection, aligned with the objectives of Uruguay's first Nationally Determined Contribution (NDC) presented to the Paris Agreement in 2017[3].

This report is part of the technical review of **KPI-2: Maintenance of native forest area (in hectares) with respect to reference year (in %)**.

Native forest "refers to areas covered by plant associations in which the tree component predominates, which maintain their natural characteristics. All types of native forest (e.g., serrano, ravine, park and gallery) are included in this category, except in the case of communities of low-density palm groves due to the difficulty of being able to detect these areas with high-resolution satellite images[4]. Native forest is considered those segments with

[1] Excerpted and adapted from the Terms of Reference
[2] SSLB Framework: http://sslburuguay.mef.gub.uy/30694/20/areas/framework-for-the-sovereign-issuance-of-sslb.html
[3] Available at: https://unfccc.int/sites/default/files/NDC/2022-06/Uruguay_Primera%20Contribución%20Determinada%20a%20nivel%20Nacional.pdf
[4] Sentinel is considered to have sensors with high spatial resolution, although some could be considered medium resolution, the same as Landsat.

a crown coverage of native woody species greater than or equal to 30% of its area. This definition does not consider the height of trees or other thresholds, such as minimum width"[5].

Technical review methodology

The technical review specifically assessed:

- Adherence to the **2006 IPCC Guidelines**, in particular Chapter 3 (Coherent Land Representation) of Volume 4 (AFOLU)[6] of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, hereinafter referred to as IPCC 2006 GL;
- Consistency with the relevant provisions and guiding principles of the **Methods and Guidance (MGD) of the Global Forest Observation Initiative (GFOI)**; and
- The quality of the report, by examining the **TACCC principles** (Transparency, Accuracy, Coherence, Comparability and Completeness) established by the IPCC.

Information evaluated

For KPI-2 the technical review was focused on the review of:

i. **SSLB Native Forest Report (NFR)** prepared by the General Directorate of Forestry (DGF) of the Ministry of Agriculture, Livestock and Fisheries (MGAP) and the National Directorate of Climate Change (DINACC) of the Ministry of Environment (MA); and
ii. **SSLB KPIs Report (KPIR)** that contains the calculation of the KPI-2, carried out by the pMRV Group (programming, Monitoring, Report, and Verification) of the National System of Response to Climate Change and Variability (SNRCC).

In addition, the following documents were also evaluated:

- Methodology and results of 2021 native forest mapping report;
- Uruguay's 2021 native forest mapping validation report;
- Methodology applied for the elaboration of Uruguay's native forest cover map for the year 2016 with Sentinel 2 images[7] and Landsat 8 images[8];

[5] Excerpted from the "Methodology and results of 2021 native forest mapping report", March 2023.
[6] Available at: https://www.ipcc-nggip.iges.or.jp/public/2006gl/spanish/pdf/4_Volume4/V4_03_Ch3_Representation.pdf
[7] Available at: https://www.gub.uy/ministerio-ganaderia-agricultura-pesca/sites/ministerio-ganaderia-agricultura-pesca/files/documentos/publicaciones/15.%20Sentinel_2_Metodolog%C3%ADa_Mapa_Bosque_Nativo_2016_Proyecto_REDD%2B_UY_0.pdf
[8] Proyecto REDD+ Uruguay (2019). Metodología aplicada en la elaboración del mapa de cobertura de bosque nativo de Uruguay para el año 2016 con imágenes Landsat 8. Bernardi, L., Boccardo, A., Miguel. C., Olivera, J., Penengo, C. y Rama, G., Serafini, J., Kindgard, A.Ministerio de Ganadería, Agricultura y Pesca - Ministerio de Vivienda, Ordenamiento Territorial y Medio Ambiente. Montevideo. Available at: https://www.gub.uy/ministerio-ganaderia-agricultura-pesca/sites/ministerio-ganaderia-agricultura-

- Methodology and results of the validation of the native forest cover map of Uruguay for the year 2016 with Sentinel 2 images[9] and Landsat 8 images[10]; and
- Final Report - National Forest Cartography Update (2012).

In addition to document revisions, consultations were also held with the national experts involved in the calculation of the **KPI-2**, during the in-country mission carried out between February 27 and March 3, 2023 (details of the mission are available in the ANNEXES).

Table 1 presents the main technical elements used for the determination of the native forest area in the years 2012 and 2021. These elements were evaluated according to the requirements listed above.

It should be clarified that the revisions were carried out jointly for the NFR and the KPIR.

pesca/files/documentos/publicaciones/13.%20Landsat_8_Metodolog%C3%ADa_Mapa_Bosque_Nativo_2016_Proyecto_REDD%2B_UY.pdf

[9] Available at: Metodología y resultados de la validación del mapa de cobertura de bosque nativo de Uruguay para el año 2016 | Ministerio de Ganadería, Agricultura y Pesca (www.gub.uy)

[10] Proyecto REDD+ Uruguay (2019). Metodología y resultados de la validación del mapa de cobertura de bosque nativo de Uruguay para el año 2016 con imágenes Landsat 8. Riaño, M.E., Bernardi, L., Boccardo, A., Miguel. C., Olivera, J., Penengo, C. y Rama, G. Ministerio de Ganadería, Agricultura y Pesca y Ministerio de Vivienda, Ordenamiento Territorial y Medio Ambiente. Montevideo. Available at: https://www.gub.uy/ministerio-ganaderia-agricultura-pesca/sites/ministerio-ganaderia-agricultura-pesca/files/documentos/publicaciones/14.%20Landsat_8_Validación_Mapa_Bosque_Nativo_2016_Proyecto_REDD%2B_UY_0.pdf

Table 1 - Main technical elements used for the determination of the native forest area

Year / period	2012 (KPIR - base year KPI 2)[11]	2021 (NFR) [12]
Satellite/Sensor	Because the Landsat ETM 7 satellite operates with the Scan Line Corrector disabled and has severe data losses on both sides of the capture, it was necessary to discard this option and select images from the Landsat TM 5 satellite However, the latter also presents problems of data storage on board the satellite (it does not acquire images continuously), presenting significant temporal gaps between captures of each orbit Due to this, and also taking into account the nature of the work, the date closest to the present and cloudiness, for the development of this work fourteen (14) images (of 2011) were selected and proposed to the DGF.	Satellite data from different sensors (Sentinel-2 and Sentinel-1) were integrated in the same work environment, with the aim of improving classification accuracy The use of images from the Sentinel-2 satellite was chosen to take advantage of the spectral discrimination potential of its optical resources, combining these with SAR (synthetic aperture radar) data from the Sentinel-1 satellite for the acquisition of cloud-free data.
Method	**Supervised classification:** For the generation of spectral signatures and the subsequent classification of orthoimages, the main module Classification of Erdas IMAGINE was used The AOIs (Area of Interest) polygons were defined on the orthoimages including the sample point, trying to cover the part of the paddock that corresponded to the sample and avoiding the edges of it, where the signature is always impure for several reasons In this way, the training areas of each coverage were defined for each image, taking care for each demarcated polygon, not to cover areas of the terrain where the variable to be estimated is not present, such as trails, deforested spaces, firebreaks, etc. Once the AOIs were defined with the necessary repetitions to stabilize the statistical drift, the spectral signatures of the different thematic classes were automatically	**Supervised classification:** Supervised classification uses spectral information obtained from samples corresponding to different types of coverage to classify an entire image or mosaic of images. In this case, the classifier used the information of the combination of bands and indices established of each image that makes up the stack, assigning a class to each pixel of the mosaic. This stage was also carried out on the GEE platform For the generation of a layer corresponding to the native forest cover, a two-level classification scheme was chosen. In the first step, a supervised classification was applied to distinguish a forest stratum (which covers the area covered by forest plantations and native or natural forests), differentiating it from the rest of the soil covers, and then masking on this layer and applying a new supervised classification. The second step was to distinguish the native forest within the forest cover mask. Thus, the legend for the first classification consisted of four classes: Water bodies, Forest cover, Non-forest cover and Non-vegetation cover. The legend for the second stage of the classification consisted of three classes: Native Forest, Afforestation and Other Cover (in this class we tried to classify sites of

[11] Extraído del informe "URU/10/G31-486: Informe Final - Actualización Cartografía Nacional Forestal" (Aeroterra S.A., 2011)

[12] Extraído del informe "Metodología y Resultados de la Cartografía de Bosque Nativo 2021" (DGF/MGAP – DINACC/MA, marzo 2023)

Year / period	2012 (KPIR - base year KPI 2)[11]	2021 (NFR) [12]
	generated by the system. This step was carried out through the use of the Signature Editor tool, present in the classification module of the software.	confusion of the first stage of the classification, where the cover did not correspond to forest cover) **Segmentation:** To perform an object-based image analysis, the image composite was segmented, using the segmentation tool of the ArcGIS Pro software, based on spectral information from the Sentinel-2 images These objects originate through an image segmentation process in which pixels close to each other and with similar spectral characteristics are grouped into a segment, representing terrain features. Ideally, a segmented image will represent discrete objects, while also representing them completely and separately from neighboring objects. A group of neighboring pixels (grouped on the basis of their spectral homogeneity and spatial arrangement) can better represent the characteristics of objects than individual pixels, as well as making it easier to handle the generated data. The parameters used for Sentinel-2 were: Spatial Range: 20, Spectral Detail: 18 and Minimum Segment Size: 50 The result is a finite set of objects, which still lack a legend category, which is assigned in a subsequent classification process. Both the products of the segmentation and the supervised classification were exported for the subsequent application of editions / corrections in GIS environment
Area (ha)	Native forest: **849.960 ha**	Native forest: **847.181 ha**, corresponding to approximately 4.84% of the total land area of the country

Source: Authors

Adherence to the 2006 IPCC Guidelines for Coherent Land Representation

According to the 2006 IPCC Guidelines, countries use several methods to obtain area data for different land-use categories, including "annual censuses, periodic surveys and remote sensing. Each of these data collection methods provides different types of information (e.g., maps or tabulations), with different reporting frequencies and with different attributes".

The 2006 IPCC Guidelines in Chapter 2 of Volume 4 provide guidance on **three generic methods for consistent representation of the land area for each type of land use category**[13]:

- **Method 1** identifies the total area of each individual land-use category within the country, but does not provide detailed information on the nature of conversions between land uses;
- **Method 2** presents tracking conversions between land-use categories; and
- **Method 3** expands on the information available in Method 2 by allowing land-use conversions to be tracked on an explicit space basis.

Countries may use a mix of methods for different regions over time.

For KPI-2, **Uruguay** selected satellite information for both 2012 and 2021 using sensor data from different satellites. For the year 2021, data of higher spatial and temporal resolution provided by the Sentinel-1[14] and Sentinel-2[15] satellites were used, while in 2012 data from the Landsat-5 satellite (30 meters) were used.

In addition, different classification methods were used in those two years. For 2021, a composite classification was used, where a supervised classification was considered at first (pixel by pixel, based on samples of polygons of the same class selected individually and directly on high-resolution images or orthophotographs). These samples were classified using the *Random Forest* algorithm, followed by a post-classification stage where the misclassified polygons identified by visual inspection process were adjusted and assigned to the correct class, thus decreasing the probability of classification errors. The 2012 native forest mapping classified Landsat-5 satellite imagery using only supervised classification based on the MaxVer algorithm with the use of sampling data.

[13] For GHG inventory reporting, land use categories include forest land, cropland, grassland, wetlands, settlements, and other land.

[14] Satellite with SAR (Synthetic Aperture Radar) sensors launched in 2014 and 2016, with spatial resolution of 5 – 20 meters. According to the 2006 IPCC GL, the most common type of radar data is so-called synthetic aperture radar (SAR) systems operating at microwave frequencies. One of the main advantages of these systems is that they can penetrate clouds and haze, and acquire data at night. Therefore, they may be the only reliable source of remote sensing data in many areas of the world with almost permanent cloudiness. By using different wavelengths and different polarizations, SAR systems may be able to distinguish land cover categories (e.g., forest/non-forest), or biomass content from that of vegetation, although there are currently some limitations on high biomass due to signal saturation.

[15] Satellite with multispectral sensors with 10 bands, launched in 2015 and 2017, with spatial resolution of 10 – 20 and 60 meters.

According to the 2006 IPCC Guidelines[16], activity data (i.e., native forest area) should be, in general:

- **Adequate,** i.e., capable of representing land-use categories and conversions between them, as needed to estimate changes in carbon stocks and GHG emissions and removals;
- **Coherent,** i.e., able to represent land-use categories consistently over time, without being overly affected by artificial discontinuities in the time series data;
- **Complete,** meaning that all land in a country must be included, increases in some areas offset by decreases in others, recognizing that biophysical stratification of land if necessary (and in a way that can be supported by data) for the estimation and reporting of GHG emissions and removals; and
- **Transparent,** i.e., data sources, definitions, methodologies, and hypotheses must be clearly described.

Table 2 indicates the **assessment and justification of adherence to the 2006 IPCC Guidelines**, in particular Chapter 3 (Coherent land representation) of Volume 4 (AFOLU)[17]

[16] Page 3.5 of Chapter 3 of Volume 4 (AFOLU). Available at: https://www.ipcc-nggip.iges.or.jp/public/2006gl/spanish/pdf/4_Volume4/V4_03_Ch3_Representation.pdf
[17] Available at: https://www.ipcc-nggip.iges.or.jp/public/2006gl/spanish/pdf/4_Volume4/V4_03_Ch3_Representation.pdf

Table 2 - Adherence to the 2006 IPCC Guidelines requirements for land use representation

IPCC requirement		Activity data: "native forest area (in hectares)"
Adequate	**Yes**	For the purposes of generating the 2021 native forest area estimate, the sources of information and methods applied were considered adequate This assessment is based on the sources and methods applied to generate the 2021 native forest mapping Regarding the activity data sources (i.e., satellite images), high spatial resolution images were used, with the incorporation of synthetic aperture radar data, which allows to visualize the coverage of the earth over clouds All procedures used to extract information from satellite data are recognized in the international literature and widely used.
Coherent	**Yes**	Regarding the coherence of the data, the assessment only considers that the data are capable of consistently represent the native forest, seeking to reduce the impact of temporal effects on its classification. Therefore, it can be considered coherent When choosing, in the selection of the scenes time series, dates close to the spring-summer period (October 2021 and February 2022), when the photosynthetic activity of the native forest is clearer (and avoiding the period of foliar senescence of many species), classification errors are reduced In addition, Uruguay demonstrated that the difference between the 2012 and 2021 areas does not result from differences in sensors and methods used - see details in the section "Quality of the report under the TACCC principles"

Complete	**Yes**	The justification for a positive assessment on complete data is based on the very definition of the 2006 IPCC Guidelines that the entire land area should be included, with increases in some areas balanced by decreases in others Although this IPCC definition was developed for GHG inventory purposes, it is understood that in the context of cartography the definition also applies To generate the cartography of the country in 2021, sampling data were not used (a method that is also recognized by the IPCC) but a complete classification (i.e., wall-to-wall) was made, normally recognized as more accurate, mainly with the use of images with better spatial resolution, such as the Sentinel In addition, the use of approach 3 for land representation generates spatially explicit data that has as its main advantage the fact that analysis tools such as Geographic Information Systems can be used to link multiple spatially explicit data sets and describe in detail the conditions in a particular part of the country Therefore, future developments in native forest mapping can be compared to facilitate the identification of native forest losses and gains.
Transparent	**Yes**	Regarding transparency, it was evaluated that the report includes detailed information on the process of generating native forest cartography, describing the sources of the activity data, definitions, methodologies and hypotheses, diagrams and illustrative figures that facilitate the understanding of the reading of the report Regarding the Uruguay Native Forest Mapping Validation report created from Sentinel 2021 images, the description of the sample design detail, definitions and estimator plan ensure that the report is considered transparent (more details in the Uncertainties section).

Source: Authors

Uncertainty associated with native forest mapping

The "Validation Report of the Native Forest Cartography of Uruguay" created from Sentinel 2021 images aimed to present the methodology for obtaining the results of the global accuracy and commission and omission errors of the native forest cover map of Uruguay. The assessment of the report was based on the 2006 IPCC Guidelines and the use of methodologies published in the scientific literature.

There are many recommended strategies for assessing the quality of thematic classifications, especially when object-oriented analysis (segmentation) is adopted. Uruguay adopted the

Olofsson et al. (2014)[18] good practices to determine the thematic accuracy of the native forest mapping. According to references[19], good practices for assessing thematic accuracy involving the evaluation of error matrices described by Olofsson et al. (2014) and Strahler et al. (2006) can be adopted in many cases, even when using image segmentation and object-oriented classification. Olofsson et al. (2014) good practices are also adopted in the practical guide developed by the Food and Agriculture Organization of the United Nations (FAO) (2016).

The use of methodology in Olofsson et al. (2014) is being considered a reference for the estimation of map coherence, replacing others adopted in the recent past (e.g., Kappa method).

Consistency with relevant provisions and guiding principles of MGD/GFOI

GFOI-GOLD (Global Observation of Forest Cover & Forest Dynamics)[20]

The GFOI delves into the methods and procedures included in the IPCC guidelines and are consistent with these guidelines. Therefore, it is understood that the native forest mapping and accuracy developed according to the IPCC are also consistent with the methods and procedures of the GFOI.

GOFC (2000)[21] addresses the problem of the use of satellites of different resolutions in section "*4.1.2* Combining remote sensing data from different sources", stating that "rapid advances in *remote sensing* technology have increased data availability and that new data sets from these sensors can bring spatial and temporal benefits to replace or enhance historical data sets and improve estimates. Often the most important factor, when combining remote sensing data from different sources, **is dealing with the inevitable differences in spatial resolution**.

GFOI-GOLD also address the issue of mapping accuracy and indicates that accuracy could be estimated following the recommendations of section 5 of the 2003 IPCC Good Practice Guidance[22]. Accuracies of 80 to 95% can be achieved with medium resolution images to discriminate between forest and non-forest. Accuracies can be assessed through *in-situ* observations or analysis of very high-resolution aircraft or satellite data. In both cases, a

[18] Olofsson, P., Foody, G.M., Herold, M., Stehman, S.V., Woodcock, C.E., & Wulder, M.A. (2014) Good practices for estimating area and assessing accuracy of land change. Remote Sensing of Environment 148: 42-57.
[19] Manual de análise da paisagem: vol. 2: procedimento para a execução do mapeamento de uso e cobertura da terra. [recurso eletrônico] / Naissa Batista da Luz ... [et al.]. - Colombo : Embrapa Florestas, 2018. V. 2 : 37 p. : Il. colour. - (Documents / Embrapa Florestas, ISSN 1980-3958; 317)
[20] Available at: http://www.gofcgold.wur.nl/redd/sourcebook/GOFC-GOLD_Sourcebook.pdf
[21] Available at: https://www.reddcompass.org/mgd/resources/GFOI-MGD-3.1-es.pdf
[22] Available at: https://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf/spanish/ch5.pdf

statistically valid sampling procedure should be used to estimate accuracy, which is also the guidance of the IPCC.

According to GOFC-GOLD's REDD+ Monitoring and Reporting Training Materials Sourcebook[23] and its module 2.7 (uncertainty estimation)[24], for land cover maps, the accuracy of remote sensing data can be assessed with widely accepted methods. These methods involve assessing the accuracy of a map using independent reference data (of higher quality than the map) to obtain, by land cover class or by region, total accuracy, and **omission errors** (i.e., exclusion of an area from a category to which it actually belongs, i.e. underestimation of the area) and **commission errors** (i.e., including an area in a category to which it does not truly belong, that is, overestimation of the area). This has been done in the case of the validation of the 2021 native forest mapping of Uruguay, consistent with the IPCC guidelines and also with the general GFOI guidelines.

Quality of the report within the TACCC principles

The **2006 IPCC Guidelines** provide guidance on quality assurance at all steps of inventory compilation; from data collection to reporting. The INGEI quality indicators are specific to assess GHG emissions and removals[25]:

- **Transparency:** There is sufficient clear documentation for individuals or groups other than the inventory compilers to understand how the inventory was compiled and to ensure that it meets the best practice requirements for national GHG emission inventories.
- **Completeness:** estimates are reported for all relevant source and sink categories and gases. IPCC Guidelines recommend the geographical areas within the scope of the national GHG inventory. In cases where elements are missing, their absence should be clearly documented along with the respective justification for the exclusion.
- **Coherence:** estimates are made for different years, gases, and inventory categories, so that the differences in results between the years and categories reflect the actual differences in emissions. Annual inventory trends should, to the extent possible, be calculated by the same method and data sources in all years and should aim to reflect actual annual fluctuations in emissions or removals, without being subject to changes resulting from methodological differences.
- **Comparability:** The national GHG inventory is reported in a way that allows it to be compared with national GHG inventories for other countries. This comparability should be reflected in the appropriate selection of headline categories and in the use

[23] Available at: http://www.gofcgold.wur.nl/documents/REDD_Addis_2016/Day1_06.pdf
[24] Available at: https://www.forestcarbonpartnership.org/system/files/documents/Module%202.7%20Lecture_V2_02_12_16.pdf
[25] Excerpted from Chapter 1 (Introduction to the 2006 Guidelines) of Volume 1 (General Guidance and Reporting), available at: https://www.ipcc-nggip.iges.or.jp/public/2006gl/spanish/pdf/1_Volume1/V1_1_Ch1_Introduction.pdf

of guidance and tables for reporting, and in the use of classification and definition of emission and removal categories.

- **Accuracy:** The national GHG inventory does not contain over- or underestimates, as far as it can be judged. This means making every effort to remove bias from inventory estimates.

For the purposes of assessing the "**quality of the report on native forest area under the TACCC principles**", it is not necessary to assess GHG emissions or removals that are not the subject of the report. Therefore, under the IPCC TACCC principles, the KPI-2 reports were evaluated only considering the principles that do not refer to GHG emissions or removals, that is, the principle of **transparency and coherence**.

From the point of view of **transparency**, the report presents complete information about the activity data and methods used for the estimates of the native forest area, including:

- Map with the distribution of sampling points and table with the number of points per forest class;
- Diagram with explanations of each of the steps and main parameters used for the classification of non-forest areas and different types of native forest; and
- Detailed explanations of the methods used for differentiation between forest plantations and native forest, including examples of visual interpretation.

From the point of view of **consistency**, the report presents data for 2012 and 2021. The fact that the native forest maps of 2012 and 2021 have been elaborated using different satellites and sensors (Sentinel in 2021 and Landsat in 2012), as well as classification methods, could generate "artificial" differences, not due to the difference in areas between those two years.

A recent study[26] comparing data from three satellites, including Landsat-8 and Sentinel-2, showed that these satellite images have comparable capabilities in distinguishing forest and non-forest areas. Meanwhile, the results show that, although the differences in classification accuracy between the three satellite datasets are not striking, Sentinel-2 data have the highest accuracy and Landsat 8 the lowest.

Uruguay has **demonstrated that the difference between the 2012 and 2021 areas does not result from differences in sensors and methods used**, as the area of native forest estimated in 2021, using *Sentinel,* is within the confidence interval (or margin of error) of the 2012 area estimated using *Landsat.*

[26] Peng, X.; He, G.; She, W.; Zhang, X.; Wang, G.; Yin, R.; Long, T. A Comparison of Random Forest Algorithm-Based Forest Extraction with GF-1 WFV, Landsat 8 and Sentinel-2 Images. Remote Sens. 2022, 14, 5296. https://doi.org/10.3390/rs14215296

NFR and KPIR conclusions

As a result of the evaluation, it can be concluded that the **SSLB Native Forest Report (NFR)** and the **SSLB KPIs Report (KPIR)** for the KPI-2 of the Sovereign Sustainability-Linked Bond (SSLB) of Uruguay:

1. **Has adherence** to international best practices for estimating forest area change over time, in particular on the application of remote sensing techniques, as contained in the relevant provisions of the 2006 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories and the 2003 IPCC Good Practice Guidance;
2. **Are consistent** with the relevant provisions and guiding principles of the Methods and Guidance (MGD) of the Global Forest Observation Initiative (GFOI); and
3. **Follow the TACCC principles** (Transparency, Accuracy, Coherence, Comparability and Completeness) established by the IPCC

In general terms, the activity data (i.e., native forest area, in hectares), methods applied for the estimation of the area in the base year (2012) and the report of the year 2021, related to KPI-2, can be considered adequate, coherent, complete, and transparent.

ANNEXES

Information boxes

Box 1 – Land cover classification using satellite data

The use of satellite data to generate land cover map is consistent with the 2006 IPCC GL, which indicates that classification can be done visually or through digital analysis. Each of these forms has advantages and disadvantages. The **visual** analysis of images allows human inference through the evaluation of the general characteristics of the scene (i.e., analysis of the contextual aspects of the image). **Digital classification**, on the other hand, allows various manipulations to be performed with the data, such as merging different spectral data, which can help improve the modeling of biophysical data of the terrain (such as tree diameter, height, basal area, biomass) using remote sensing data. In addition, digital analysis allows the immediate computation of areas associated with the different categories of land use, and has developed rapidly during the last decade, along with the associated computer technical development, the manufacture of hardware, software and also satellite data readily available at low cost in most countries. Although, the ability to use these data and facilities may have to be outsourced, particularly in mapping at the national level.

Box 2 – Classification methods

Image classification consists of establishing a decision process in which a group of pixels is defined as belonging to a certain class (or category of use). In this sense, computer systems help the user in the interpretation of orbital images. Digital classification methods can be grouped according to the presence or absence of a training phase where the analyst interacts with the computer. The method is said **to be unsupervised** when the classifier does not use, a priori, any knowledge about the existing classes in the image. The classification method is said **to be supervised** when there is prior knowledge of some areas, allowing a selection of reliable training samples. The classifier algorithm works based on the probability distribution of each selected class. In other words, the analyst first trains the classifier and then associates the other pixels to a certain class (previously defined), using pre-established statistical rules. The maximum likelihood classification method is based on the calculation of the statistical distance between each pixel and the average of the gray levels of the previously defined class from training samples.

In supervised classification systems, the resolution element of an image is the pixel. Some users have described certain limitations in this pixel-by-pixel classification approach. Small variations of relief or simply a few pixels of inconsequential radiometric behavior (due to the work scale) are presented as a problem in a classification process, which can generate a not accurate thematic map. An alternative to this problem is the use of a technique to group

pixels with similar characteristics in tonal and textural terms, forming homogeneous regions. These are then subjected to the classification process. The segmentation process represents a step towards preparing satellite imagery for future thematic classification, where the elements analyzed and used in classification are the regions resulting from the application of a segmentation technique to define the classification attribute space. Some authors define segmentation as a process that subdivides an image into its constituent parts or objects (regions), according to some intrinsic properties of the scene, i.e., gray level, contrast, or textures. The goal is to divide the image into a set of regions that correspond to the characteristics of the surface, which will serve as a basis for thematic analysis and mapping. The act of segmenting an image corresponds to the formation of areas composed of a certain number of pixels joined by a similarity criterion. The result of this process are areas with a continuous appearance. and uniform, where each area has spectral characteristics very different from the neighboring ones that surround it.

Box 3 – Assessing mapping accuracy[27]

Whenever a land cover or land use map is used, information about the reliability of the map should be acquired. Where such maps are generated from the classification of remote sensing data, it should be recognized that the reliability of the map is likely to vary between different land categories. Some categories may be uniquely distinguished, while others may be confused with others. For example, coniferous forest is usually classified more accurately than deciduous forest because its reflectance characteristics are more distinct, while deciduous forest can easily be confused, for example, with grassland or cropland.

To estimate the accuracy of land use/land cover maps, several sample points on the map and their corresponding real-world categories are used to create a confusion matrix with the diagonal showing the correct identification ratio and the off-diagonal elements showing the relative proportion of misclassification of a land category in one of the other possible categories. The confusion matrix expresses not only the accuracy of the map, but it is also possible to evaluate which categories are easily confused with each other.

The words accuracy and precision are sometimes taken interchangeably, but they have different meanings; see definitions in the 2003 IPCC Good Practice Guide below.

Statistical definition: *Accuracy* is a general term that describes the degree to which an estimate of a quantity is not affected by bias due to systematic error. It must be distinguished from precision.

[27] IPCC 2006 GL, Chapter 3, page 3.28; IPCC 2003 - Good Practice Guide for Land Use, Land Use Change and Forestry, page 2.21 (Mapping Accuracy Assessment)

Statistical definition: Precision is the proximity of agreement between independent results of measurements obtained under stipulated conditions.

Box 4 – Solutions for differences in spatial resolution

Solutions include using the same value of a lower-resolution pixel for all associated higher-resolution pixels, and resampling lower-resolution data to obtain a higher resolution. To estimate activity data, interpreted fine-resolution images serve as reference data. From an activity data perspective, Sentinel-2 and Landsat are the two most relevant satellite systems. NASA is currently in the process of creating a harmonized surface reflectance (HLS) product, based on the combination of Landsat and Sentinel-2 data (Claverie et al., 2018). However, the use of these data could lead to inconsistencies in the time series. These inconsistencies can be addressed using the same techniques that address recalculation in complex scenarios. Where bias caused by inconsistency persists, the error should be assessed and eliminated as far as possible.

A common example of potential inconsistencies caused by using more advanced data series is when baseline data is augmented with different data from a new remote sensor. For example, if the Landsat data was used exclusively to estimate the baseline level, and then the Sentinel-2 data is added to the Landsat data using the HLS product for example, for mapping and/or to collect baseline observations. This change in data could produce different (i.e., better) results than using Landsat alone. Acomparative analysis of these differences should make it possible to identify and eliminate biases as far as possible, if any.

Field mission agenda

From February 27 to March 3, 2023, a field mission was carried out to learn about the different types of native forests in the country and conduct interviews with national experts involved in the calculation of KPI-2.

The main activities carried out were:

- February 26: arrival in Montevideo
- February 27 and 28: Field visit (along routes 9, 39, 14, 16 and 10) for better understanding and visualization of the different types of native forest present in the cartography made for KPI-2 (***Figure 1***): "Serranos"; River; Park and Streams
- March 01 and 02: Meetings with national experts for presentation and discussion of the methods used and results of the estimation of the native forest area in the years 2012 (base year) and 2021.
- March 3: departure from Montevideo

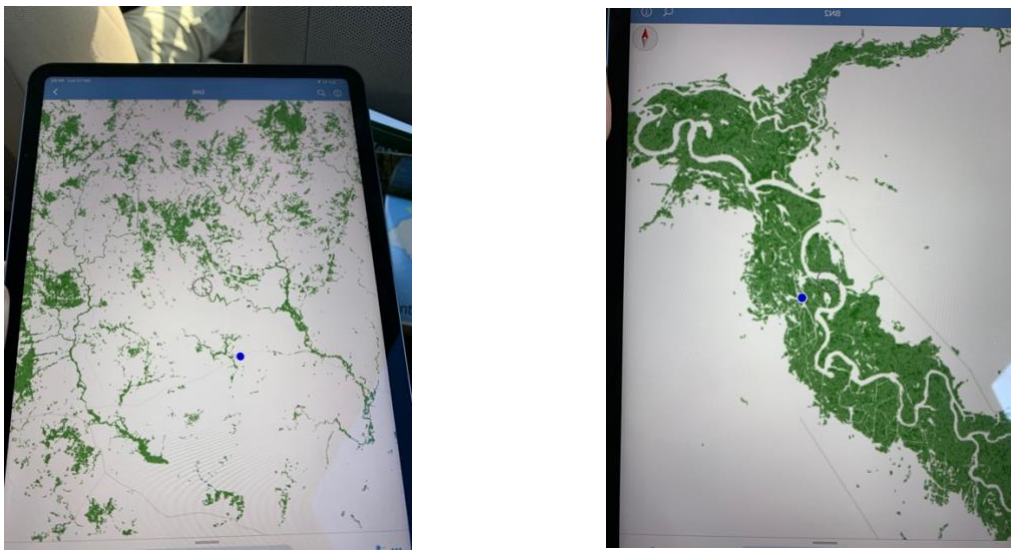

Figure 1 Detail of native forest mapping done for KPI-2

Source: own images

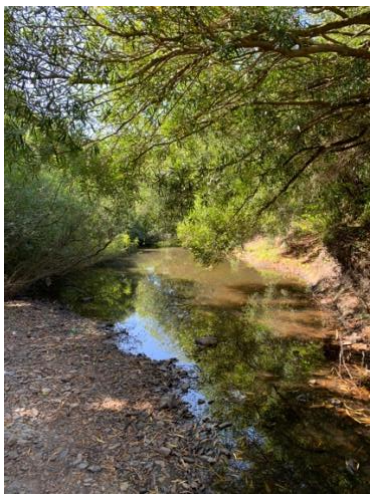

Figure 2 - Example of native river forest

Source: own images

Figure 3 - Example of "serrano" native forest

Source: own images

Figure 4 - Example of a creek forest

Source: own images

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