NextGenCarbon

Monitoring Earth's Carbon Balance

Deliverable 9.1

Impact Evaluation Plan

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Project	NextGenCarbon - Next Generation Modelling of Terrestrial Carbon Cycle by assimilation of in-situ campaigns and Earth Observations
Project Duration	January 2025 – December 2029 (60 months)
Deliverable	Impact Evaluation Plan (IEP)
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Work Package Lead	SLU
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Reviewers	Dario Papale, CMCC
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PU = Public
PP = Restricted to other programme participants (including the Commission Services)
RE = Restricted to a group specified by the consortium (including the Commission Services)
CO = Confidential, only for members of the consortium (including the Commission Services)

History of changes

Version	Date	Beneficiary	Author	Description
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1.1	01.07.25	SLU	Sanna Riihimaki, Niina Valbuena, Ruben Valbuena	Review
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1.3	11.07.25	SLU	Sabina Klausmeyer	Updated
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1.5	28.07.25	SLU	Sabina Klausmeyer	Finalising first version

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Contents

Figures

Abbreviations

AIMES - Analysis, Integration, and Modeling of the Earth System
EC - European Commission
EEAB – External Expert Advisory Board
eLTER - Integrated European Long-Term Ecosystem, critical zone and socio-ecological Research
EO - Earth Observation
EEA - European Environment Agency
FAO - Food and Agriculture Organization of the United Nations
FLUXNET - The Data Portal serving the FLUXNET community
GHG - Greenhouse Gas
GCB - Global Carbon Budget
HPC - High Performance Computing
ICOS - Integrated Carbon Observation System
IEP - Impact Evaluation Plan
IPPC - Intergovernmental Panel on Climate Change
JRC - Joint Research Centre
KPI - Key Performance Indicators
LULUCF - Land use, Land-use change and Forestry
LUCAS - Land Use/Cover Area frame Survey
ML - Machine Learning
NGC - NextGenCarbon
NGHGI - National Greenhouse Gas Inventories
OA - Open Access
PCDE - The Plan for Communication, Dissemination, Exploitation
SteCo – Steering committee
UNFCCC - United Nations Framework Convention on Climate Change
WP - Work Package (in the project)

Project Consortium:

SLU - Swedish University of Agricultural Sciences
LSCE - Laboratoire des Sciences du Climat et de l'Environnement
WENR - Stichting Wageningen Research
WUR - Wageningen University
UNIFI - University of Florence
GFZ - Helmholtz Geo-Research Centre Potsdam
MPI/MPG - Max Planck Institute for Biogeochemistry
LUKE - Natural Resources Institute Finland
CICERO - Centre for International Climate Research
LMU - Ludwig-Maximilians University Munich
KIT - Karlsruhe Institute of Technology
UNEXE - University of Exeter
IIASA - International Institute for Applied Systems Analysis
SP - Science Partners

LU - Leipzig University
CMCC - Euro-Mediterranean Centre on Climate Change
UA - University of Antwerp
PIK - Potsdam Institute for Climate Impact Research
GAMMA - Gamma Remote Sensing
ETHZ - Eidgenössische Technische Hochschule Zürich
UZH - University of Zurich
UNIBO - University of Bologna

1 Summary

This Impact Evaluation Plan (IEP) is the result of Task 9.1 Impact Assurance. The goal of this task is the development of an Impact Monitoring, Evaluation and Learning Framework to measure the effectiveness of NGC outcomes through key performance indicators (KPI). The IEP details how the project measures its impact and organises its monitoring procedures. It has been developed together with the consortium and is to be used by all team members when collecting KPIs of developing impacts, and gathering data on processes and steps in impact development.

The yearly monitoring system will help to identify potential risks or challenges so that appropriate counter measures can be implemented. A list of possible critical risks that could hinder the NGC project with proposed mitigation measures has been developed as part of the Grant Agreement. To prevent for example that a loss of critical competencies could hinder the project, all partners make sure that key competencies are replaced internally. In addition, some level of overlap in competencies was created between partners, so that if internal replacement is not possible, tasks and resources could even be reallocated to partners that can offer respective competencies.

The monitoring will also give a running overview over the project's results and their impact allowing for adjustments where necessary.

The complete list of KPIs is included in this plan, detailing information on timing and type of measurements, responsible person and target values. At every measuring interval the KPI themselves will also be analysed and updated if necessary, to ensure that we measure the right indicators at the right time and gain the best possible benefit from our monitoring and evaluation.

2 Introduction – about the project

NextGenCarbon will create a long-lasting, scientifically sound and practical impact on the Carbon cycle monitoring and modelling system and the evaluation of the natural and anthropogenic disturbances and management activities. Our project strengthens the scientific basis of decision-making on the role of terrestrial ecosystems in climate change mitigation and adaptation.

This scientific information will be translated into materials that allow us to work with various stakeholders. To achieve high engagement with information users, we will engage with several key stakeholder groups to establish a meaningful dialogue and share our results.

Those who will benefit from NextGenCarbon will be:

(i) the ecosystem monitoring community, much in particular those utilising Earth Observation (EO) data and communities using EO and in situ measurements like the ones collected in ICOS and eLTER

(ii) Earth system modellers, particularly modelers of Carbon, water, GHG fluxes

(iii) the GCB community, particularly for improved terrestrial removals and emissions estimate

(iv) NGHGI experts and national environment authorities, and those for other operational monitoring programmes (e.g. NFIs); (v) EU and potentially national policymakers; and

(v) technology companies and service providers.

NextGenCarbon will have several impacts pertinent to the Horizon Europe Strategic Plan (2021-2024), which aims to promote advancing climate science and create a user-centric knowledge base to catalyse the global transition to a climate-neutral and resilient economy.

To boost impacts from cooperation with other projects, NextGenCarbon will also apply to the Horizon Results Booster to define a joint dissemination strategy portfolio with other EU projects (e.g., FORWARDS, CONCERTO,

RESONATE). To facilitate this, the project has established a cross-project-collaboration list to keep track of ongoing, future as well as past collaborations.

Stakeholder group	Examples
EU level Policymakers	EC DGs (CLIMA, ENER, AGRI, ENV)
Policy support organisations	JRC, EEA, EFI, FAO, UNFCCC
Scientific community	GHG modelling community, FLUXNET, ICOS, eLTER, International Land Model Forum. AIMES
Civil society	Landowners (European Landowners Organisation), COPA COGECA (farmers representation in Brussels), CEPF (Forest owners)
National-level GHG reporting bodies	National ministries, GHG inventories in each EU Member State, EEA as data collecting institute, IPCC taskforce on GHG reporting guidelines
Global	Bureau of the IPCC Task Force on National Greenhouse Gas Inventories (TFI), Global Greenhouse Gases Watch (GGGW-WMO)

Figure 1 Overview Stakeholders

3 Objectives and Impacts

NextGenCarbon aims to develop the next generation of global carbon models, harnessing the potential of combining EOs, in situ data with novel demographic model structures and advanced assimilation techniques to create an unprecedentedly well-informed understanding of terrestrial carbon stocks and fluxes to inform multiple emerging policy frontiers.

To this end the following Objectives were developed:

Objective 1: Efficiently coordinate our efforts to provide a platform combining EO and in situ data streams with advanced vegetation and land surface modelling through high-performance computing capacities [WP1].

Objective 2: Provide enhanced observational capacity of key terrestrial ecosystem types under different management regimes by synergistically combining complementary in situ and space-based data streams to facilitate improved understanding and predictability of the carbon cycle and its interactions with the water cycle [WP2].

Objective 3: Develop and improve methods to monitor carbon status and dynamics for key European ecosystems by integrating data from multiple data sources (such as multi-platform EO imagery and field measures) [WP3].

Objective 4: Increase our capacity to incorporate vegetation demographics into land surface models (LSMs), including new technologies to assess canopy structures and age-structure of terrestrial ecosystems [WP4].

Objective 5: Enhance the representation of anthropogenic and natural disturbances in LSMs [WP5].

Objective 6: Improve the estimation of the carbon cycle using model-data fusion approaches and develop DA for newly available data streams [WP6].

Objective 7: Assess and improve the consistency of models with observations from in situ data and EOs, reconciling top- down and bottom-up approaches [WP7].

Objective 8: Provide seamless scenario simulations of the outcomes of near-term land carbon management strategy using a novel factorial scenario design combined with semi-empirical representations of time-evolving disturbance risks [WP8].

Objective 9: Expand the outreach of NextGenCarbon developments, enabling the update of global and European carbon budgets and digesting the results from scenario modelling into EU policy recommendations [WP9].

4 Data Management and Analysis

4.1 Data Collection and Management

The *D1.2 Data Management Plan* details how and which information will be gathered to ensure ethical data handling and data quality assurance. The DMP is not public and thus only available in the consortium's online repository and for the EC.

The data collection for the impact measurement is detailed in the KPI List. Each KPI will be measured by the corresponding person, adding where

appropriate comments. Should data sources become unavailable or change, the KPI List will be updated.

4.2 Analysis and Reporting

The Task 9.1 Lead will compile the analysis from the information filled in by the corresponding responsible person and the document will be available to the entire consortium for comments and discussion.
The flow of information is as detailed in the following chart:

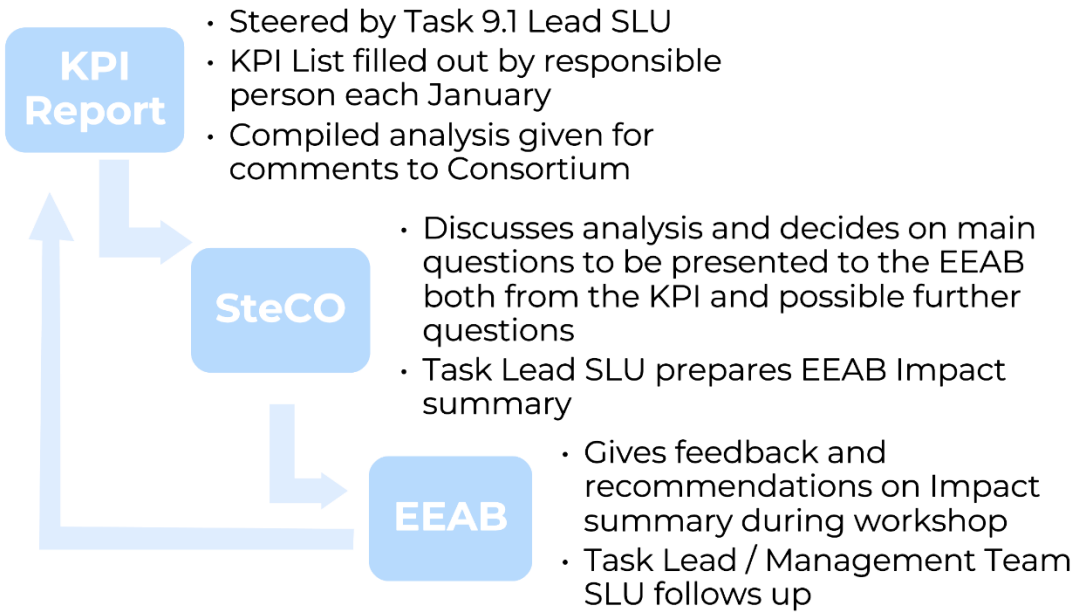

Figure 2 Overview Information flow of impact measuring data

The KPI report will then be present to the SteCo and discussed in a SteCo meeting to decide the main points to be further discussed with the EEAB. To broaden our view and follow a holistic approach, further questions from the WPs can be included in this report to the EEAB as not everything will be measurable by KPIs, especially in the beginning, and the catalogue may be adjusted over the years, depending on development. The report shall span the entire project, with a focus on policy relevance to give a comprehensive picture of the project and invite a broad and open feedback that is not too narrowed on the KPIs alone.

The Management Team at SLU prepares a corresponding overview and the report is discussed between the SteCo and the EEAB in a dedicated workshop. The resulting recommendations will then be documented in the online repository and followed up by the SLU Management Team.

4.3 Stakeholder Engagement

Stakeholder Engagement is detailed in *D9.2 Plan for Communication, Dissemination, Exploitation*. The PCDE is a public document and available via the EC Portal and the project website.

5 Indicators

NGC Objectives were developed during the proposal phase and are part of the impact section of the Grant Agreement. Based on these, the NextGenCarbon project will utilise Key Performance Indicators (KPI) to measure how the project succeeds in creating impact. The KPIs were developed with the consortium at a workshop at the first annual meeting (June 2025) and finalised in the following weeks. The collaborative effort allowed for input and feedback from all partners. The proposed KPIs were circulated to all partners for validation.

All indicators are based on SMART principles:

- Specific: provide clear and precise information on what is being measured.
- Measurable: can be quantified and assessed using data.
- Achievable: realistic and can be accomplished within the project's resources and time frame.
- Relevant: aligned with the project's goals and objectives.
- Time-bound: set within the project's time frame

as well as the impact categories:

- Scientific impact (SCI):

- Policy/Societal impact (SOC)
- Economic/technological impact (ECT)

NGC has currently 35 KPI.

5.1 Evaluation Design and Methodology

The basis of impact-oriented project management are regular impact measurement and monitoring.
Through the achievement of the set milestones and deliverables, as detailed in the Grant Agreement and documented in the EC Portal, the project measures its progress. To measure how these progresses reach the target groups and has the desired influence outside of the consortium it needs the additional measuring of outputs, outcomes and impact, with a focus on the last two. For this monitoring process the KPIs were set up as the first step. The second step of analysis and assessment is detailed under 5.2.

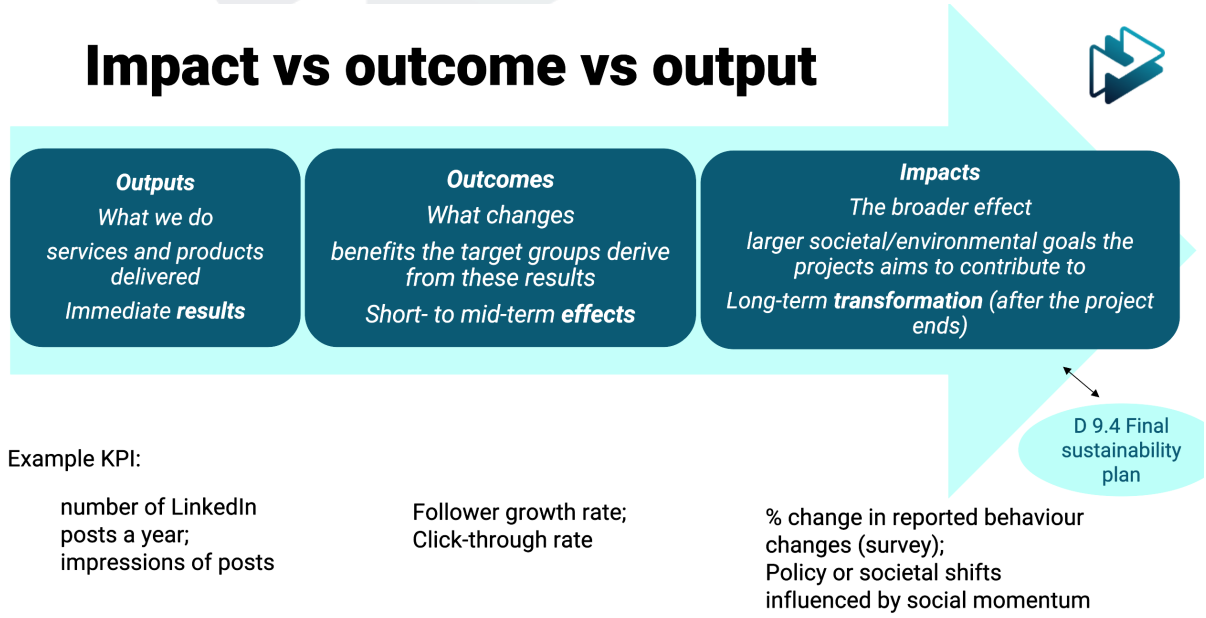

Figure 3 Overview Impact, Outcome, Output

For the NextGenCarbon project data collection methods will be mostly quantitative. These are e.g. number of sites that get measured or number of publications on specific topics. Currently several reports are planned as

qualitative measurements as part of the monitoring and there will be qualitative assessments in the analysis as well.

With the alignment of project and calendar year, the annual measuring will take place in January, looking back on the previous year. Since part of the project's Work Packages start later than others, the starting year of the measuring is also noted in the KPI list.

At the first annual meeting a dedicated workshop covered the basics of impact measurements and focused on the differences of output, outcome and impact.

5.2 KPI List

The project concentrates on outcome and impact measurement. Outputs do not deliver the right information to measure how well the goals are being reached. Many Impact measurements can only be measured after the project and will thus be covered in the Deliverable 9.4 Final sustainably plan, which will also cover a more qualitative assessment of impacts on e.g. the impact of our policy briefs on policies and decision making.

The first version of the list of KPIs is included in this deliverable. The KPI will be updated at the annual monitoring checkpoint as described and depending on the development of the project might get updated.

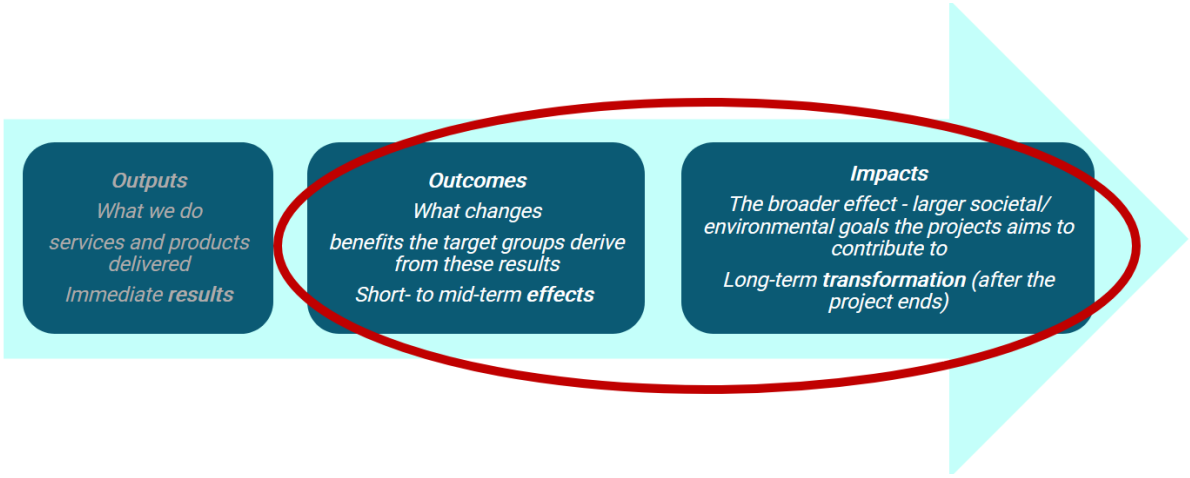

Figure 4 Focus areas for KPI

KPI No.	Specific Indicator	Description / Definition	Measure-ment Unit	Objec-tive	Target Value	Starting from Year	Dimen-sion
1	Explained variance of between-site NEE in-ferred by FLUXCOM-X		%	Objec-tive 2	0,5	2	ECT
2	Number of operational GNSS-T VOD sites at ICOS sites for monitoring of diurnal changes in VOD as an indicator for AGB and water budget		#	Objec-tive 2	2/year	1	ECT
3	Number of datasets collocated at ICOS sites	Number of sites with collo-cated measurements	#	Objec-tive 2	2/year	1	ECT
4	Number new generation of satellite missions leveraged	Number of sensors used to generate carbon-related maps	#	Objec-tive 3	5	2	ECT
5	Number of AGB maps derived from satellite images for 2005-2025 at two spatial scales (100 m and 25 km)	Target value for a specific spatial resolution	#	Objec-tive 3	20	2	ECT
6	Number of algorithms to estimate biomass (AGB stored in pools other than woody vegeta-tion)		#	Objec-tive 3	2	1	SCI, SOC
7	Spatial data on soil C change across European forest soils map available	High resolution data on soil C change estimates	#	Objec-tive 3	1	1	SCI; SOC
8	Accuracy (OA, UA, PA) of forest disturbance detection	Accuracy of disturbance de-tection	%	Objec-tive 3	OA: 85%	1	ECT
9	Update frequency (weekly, monthly, annual) of forest disturbance detection	Timeliness of disturbance detection	time period	Objec-tive 3	update fre-quency: weekly	1	ECT
10	Number of European disturbance types	Number of European dis-turbance types, Target dis-turbance types: Har-vest/clearcut, wind, bark beetle, fire	#	Objec-tive 3	4	1	ECT
11	Number of burned severity classes	Number of burned severity classes, Target burn severity classes: Very low, low, me-dium, high, very high	#	Objec-tive 3	5	1	ECT

KPI No.	Specific Indicator	Description / Definition	Measure-ment Unit	Objec-tive	Target Value	Starting from Year	Dimen-sion
12	Provide European C budgets from JULES, OR-CHIDEE, CLM-FATES with optimised parame-ters for processes across temporal scales. Key step forward will be use of WP2 super sites if available.	Comparison with pre opti-mised models	Report	Objec-tive 6	n/a	3	ECT
13	Number of media outlet / pieces concerning annual GCB assessments and IPCC		#	Objec-tive 7	1000	1	SCI; SOC
14	Increase capacity to track progress towards meeting climate change mitigation goals for UN Paris Agreement	Reduction in the carbon budget imbalance (BIM)	#	Objec-tive 7	near-zero de-cadal value	1	SOC
15	GCB annual publication		#	Objec-tive 7	1	1	ECT, SCI
16	Produce future scenarios which extend the TRENDY simulations using a small number of alternative land use and climate forcing path-ways to provide improved understanding of impacts on C cycle of extreme event	Run or select message/Mag-PIE simulations which pro-duce diverse land use trajec-tories for future evolution. land use transitions will be downscaled and harmo-nised with HILDA+ historical pathways and used to drive extensions of LSM simula-tions used in TRENDY his-torical simulations.	Report	Objec-tive 8	n/a	3	SCI
17	Number of peer-reviewed publications on ter-restrial Carbon pools/fluxes		#	Objec-tive 9	3 per year	1	SCI, SOC
18	Develop new Database regrowth in forests and forests reserves in Europa, integrate them into EFISCEN-space and analyses	Database published	#	Objec-tive 9	1	3	SCI, ECT
19	Policy briefs to measure the impact on the im-plementation of the EU Soil Monitoring Law		#	Objec-tive 9	1	2	SOC
20	Policy briefs and presentations to impact the trilogue for EU Carbon Farming Regulation		#	Objec-tive 9	1	2	SOC

KPI No.	Specific Indicator	Description / Definition	Measure-ment Unit	Objec-tive	Target Value	Starting from Year	Dimen-sion
	and the incipient EU Forest Monitoring Regu-lation						
21	Followers LinkedIn	Providing universally under-standable information about the project to a broad audience	#	Objec-tive 9	800	1	SOC
22	Engagement rate LinkedIn		%	Objec-tive 9	1,25%	1	SOC
23	Followers Bluesky		#	Objec-tive 9	250	1	SOC
24	Engagement rate Bluesky		%	Objec-tive 9	0.50%	1	SOC
25	Unique visitors on website		#	Objec-tive 9	2500 per Year	1	SOC
26	Page visits on website		#	Objec-tive 9	3500 per year	1	SOC
27	Scientific papers & Policy brief to provide sci-entific evidence on land-based emissions and sinks related to the European Climate Law		#	all Ob-jectives	3	2	SOC
28	3D datasets of ground-level data, including TLS, used to collect data on 3D canopy struc-ture and biomass	TLS and other 3D canopy structure datasets collected, number of sites covered	#	Objec-tives 2 and 4	2/ year	1	ECT
29	Management variables in the published HILDA+ version	Management variables for agriculture	#	Objec-tive 5	1	1	SCI; SOC
30	New updated version of ORCHIDEE includes disturbances	Implementing disturbance processes in ORCHIDEE: sub-grid heterogeneity module that calculate bor-der length of each pixel, in-clude border length as a driver in the physiology pro-cesses module and re-duce/increase border length	#	Objec-tive 5	3	3	SCI, ECT

KPI No.	Specific Indicator	Description / Definition	Measure-ment Unit	Objec-tive	Target Value	Starting from Year	Dimen-sion
		based on disturbance re-gime					
31	Improved model of forest management rou-tines in the ground-based forest model EFISCEN-space internally released and docu-mented		#	Objec-tive 5	1	4	SCI
32	Improved industry model within forest re-source model EFISCEN-space internally re-leased and documented		#	Objec-tive 5	1	4	SCI
33	BLUE 2.0 published on resolution better than 0.25° x 0.25°	Number of publications on the topic	#	Objec-tive 5	1	3	SCI, ECT
34	BLUE 2.0 includes new PFTs, disturbances and management layers	Number of publications on the topic	#	Objec-tive 5	1	3	SCI, ECT
35	Compare different DA methodologies in han-dling multiple data streams. Best practices will be shared. Optimised models can be com-pared to global models from GCB.		Report	Objec-tives 6 and 7	n/a	3	ECT