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THE REPORT SHOULD BE CITED AS FOLLOWS

IEEP, Trinomics, IVM and UNEP-WCMC (2021). Methodology for assessing the impacts of trade agreements on biodiversity and ecosystems. Service contract for the European Commission (No 07.0202/2019/812941/SER/ENV.D.2), Institute for European Policy (IEEP), Brussels/London.

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ACKNOWLEDGEMENTS

This methodology has benefitted from a close cooperation with and support from the key European Commission DGs including DG ENV, DG TRADE and DG INTPA. The project team would also like to thank the participants to the expert workshop held in July 2020 for their valuable inputs to developing the methodology. In particular, the team would like to acknowledge the useful insights and expert review provided by the Trade Hub team during the project.

Luxembourg: Publications Office of the European Union, 2021

PDF ISBN 978-92-76-34171-0 doi:10.2779/082377 KH-02-21-475-EN-N

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CONTENTS

ABSTRACT

This document provides a methodological framework for assessing the impact of EU Free Trade Agreements (FTAs) on biodiversity. The methodology outlines a stepwise process on how to set up and carry out an assessment of the impacts of trade liberalisation on biodiversity in a structured and consistent manner, with a special focus on quantifying the impacts. The methodology is designed to be implemented as part of the Commission's overall trade impact assessment process, both before and/or during the trade negotiations (ex-ante) and when trade agreements are in place (ex-post). It is flexible to be used in the context of various types of agreements and partner countries.

EXECUTIVE SUMMARY

Trade liberalisation introduces changes to economic sectors, increasing or decreasing demand – and therefore production – in trade partner countries. These changes can have an impact on biodiversity, ecosystems and the services they provide.

Consequently, biodiversity impacts of EU free trade agreements (FTAs) need to be systematically identified. At minimum, these impacts should be assessed in a qualitative manner, using existing case studies, expert knowledge and stakeholder interviews. For the most significant biodiversity impacts, quantified analysis should be carried out whenever possible.

This document provides a dedicated methodological framework for assessing the impact of EU Free Trade Agreements on biodiversity in a structured and consistent manner, with a view to improve the transparency and robustness of the assessment.

The methodology underpins the delivery of the EU Biodiversity Strategy for 2030, in particular the commitment for the Commission to *'better assess the impact of trade agreements on biodiversity, with follow-up action to strengthen the biodiversity provisions of existing and new agreements if relevant.*' This commitment has been explicitly endorsed by the Member States, as part of the Council Conclusions in 2020.

The methodology is foreseen to be used as part of the Commission's overall trade impact assessment process and it is applicable to ex-ante and ex-post evaluations alike. It is flexible to be used in the context of all types of trade agreements and with different trade partner countries. Furthermore, the overall approach could also easily be generalised and applied to the assessment of a broader range of environmental impacts of FTAs.

The document consists of the following elements:

- Chapter 2: Introduction to biodiversity impacts linked to trade
- Chapter 3: Overview of how impacts can be assessed
- Chapter 4: Overview of the methodology
- Chapter 5: Stepwise application of the methodology
- Chapter 6: Practical considerations

- Annex I - II: Examples of applying the methodology
- Annex III: Overview of biodiversity indicators
- Annex IV: Overview of models

Overview of the methodology

The methodology centres around the identification and systematic application of a set of indicators that capture changes in biodiversity status and trends:

Driver for change (i.e. changes in economic sectors generated by an FTA) → **Pressure** on biodiversity (i.e. land- / resource use or resource quality change linked to economic change) → **Impact** on biodiversity (i.e. change in biodiversity and ecosystems linked to pressure) → **Response** to address change (i.e. existing or new safeguards to prevent negative impacts or measures to amplify positive impacts).

The quantitative assessment of biodiversity impacts takes placed through a 'modelling chain' that uses the outputs of the economic modelling (driver) to feed into land or resource use models (pressure) which then can be linked to biodiversity models (impact):

Economic modelling (i.e. changes in economic sector outputs at national level) → **Land use** modelling (i.e. spatially explicit changes in land- / resource use within country) → **Biodiversity** modelling (i.e. changes in ecosystems and/or species links to land- / resource use).

The methodology process itself has three stages:

Stage I – Preparatory stage: Prior to the impact assessment itself, an understanding of the current state of play (the baseline) needs to be established followed by a comprehensive screening of foreseen impacts. This information will then be used to identify **priority impacts** to be assessed in detail in the impact assessment stage. The aim of Stage I is to provide a comprehensive overview of the range of (possible) impacts while focusing the attention – and resources – on assessing those impacts with most the significant consequences on biodiversity.

Stage II – Method selection and impact logic*:* Stage II focuses on determining the **level of analytical ambition** to be used to assess priority impacts and setting out the **analytical 'logic'** for assessing impacts. The ambition can range between 'moderate' and 'high' with the former using qualitative means to determine the impacts and the latter assessing impacts in a quantitative manner through modelling. Impact logic needs to be established for each priority impact, identifying the interlinkages between different components of the analysis (i.e. driver – pressure – impact – response) and describing relationships between each step along the chain to make causal assumptions transparent.

Stage III – Impact assessment and related conclusions*:* In this final stage of the methodology, identified priority impacts on biodiversity are assessed and the results are placed in the broader context of the impact assessment, with most **significant findings** identified and discussed. One of the key functions of Stage III is to draw conclusions and provide **recommendations** to the overall negotiation (ex-ante) and/or implementation evaluation (ex-post) process.

Implementing the methodology

Implementing the methodology for assessing biodiversity impacts involves some practical considerations of best practice linked to expertise, resources, time scale and stakeholder engagement.

Expertise of the assessment team: The application of the methodology requires explicit expertise on biodiversity, ecosystems and related services. This expertise is two-fold including, at minimum, good understanding of issues linked to biodiversity status, impacts and how to assess them (e.g. biodiversity indicators) and, for the 'high' ambition assessment, dedicated expertise on modelling impacts through the different elements of the modelling chain.

Robust economic information base: The methodology highlights the important role of economic modelling in facilitating and/or enabling the assessment of biodiversity impacts. EU trade impact assessments are commonly underpinned by Computable General Equilibrium (CGE) modelling that is carried out by the Commission, i.e. not by the team carrying out impact assessments. To ensure the applicability of economic modelling as a basis for biodiversity assessments the underlying assumptions of modelling and linking the economic analysis with environmental analysis should be explicitly and jointly considered by the Commission and assessment team.

Adequate resources: No clarification on minimum resources or budget is provided in the existing official Sustainability Impact Assessment (SIA) guidance by the Commission. However, experts carrying out trade impact assessments indicate that the budget allocated to biodiversity – and environmental aspects in general – are typically inadequate to carry out detailed evaluation of impacts. For example, the budget for the biodiversity component is typically in the order of magnitude €1000 to €3000 per evaluation. Consequently, a successful uptake and implementation of the methodology requires adequate resources to be made available by the Commission to carry out the assessment in practice. It could be envisaged, for instance, to clearly earmark these resources for the environmental element of any given assessment (%) with an indicative (minimum) share for the biodiversity analysis (e.g. based on prior knowledge of partner country).

Adequate time scale: Upgrading the rigour of biodiversity and/or broader environmental component of trade impact assessments and evaluations has implications on the time scale within which they can be performed. This needs to be carefully reflected within the FTA negotiation or implementation framework, in order to feed into the broader process in a timely manner. As future best practice, the Commission should ensure that an adequate timeframe vis-à-vis the policy process is provided for trade impact assessments and evaluations to be carried out.

Stakeholder consultation: Stakeholder consultation is an existing core element of EU trade impact assessment procedures and it also plays an important role in delivering robust biodiversity assessments, especially when it comes to consulting experts in the trade partner countries. Traditionally, reaching out to expert stakeholders takes place especially during the screening and scoping phase, to limit the burden on resource use. Arguably – and resources and timescale permitting – engagement with expert stakeholders would be beneficial throughout the assessment process, supporting the development of an as comprehensive as possible baseline and helping to peer-review the outcomes of the assessment process. As future best practice, the consultation of expert stakeholders should be structured around the 'driver – pressure – impact – response' chain, seeking to gather information across these different aspects of biodiversity status, trends and possible trade-related impacts in a systematic manner. A simple standardised questionnaire could be developed to be used in this context across all future assessments and evaluations where appropriate.

RÉSUMÉ EXÉCUTIF

Introduction

La libéralisation du commerce entraîne des transformations des secteurs économiques en augmentant ou réduisant la demande – et donc la production – dans les pays partenaires. Ces changements peuvent avoir des conséquences sur la biodiversité, les écosystèmes et les services rendus par ces derniers.

Les conséquences des accords de libre-échange (ALE) de l'UE sur la biodiversité doivent par conséquent être systématiquement identifiées. Ces conséquences devraient au minimum être évaluées de manière qualitative, à l'aide d'études de cas, de connaissances spécialisées et d'entretiens avec les parties prenantes. En ce qui concerne les effets les plus importants sur la biodiversité, si une analyse quantifiée peut être réalisée, elle devrait l'être.

Ce document apporte un cadre méthodologique dédié pour l'évaluation de l'impact des accords de libre-échange (ALE) de l'UE sur la biodiversité de manière structurée et cohérente, dans le but d'améliorer la transparence et la solidité de ces évaluations.

Cette méthodologie soutient la mise en œuvre de la Stratégie de l'UE en faveur de la biodiversité à l'horizon 2030, et en particulier l'engagement de la Commission de *« mieux évaluer l'incidence des accords commerciaux sur la biodiversité en menant des actions de suivi pour renforcer les dispositions en matière de biodiversité dans les accords à venir et dans les accords existants [...] le cas échéant »*. Cet engagement a été explicitement approuvé par les États membres dans la cadre de conclusions du Conseil en 2020.

Cette méthodologie devrait être utilisée dans le cadre du processus général d'évaluation des conséquences des accords commerciaux et est applicable à la fois aux évaluations préalables et rétrospectives. Elle est flexible et peut être utilisée dans le contexte de tous types d'accords commerciaux avec différents pays partenaires. De plus, l'approche globale pourrait être facilement généralisée et appliquée à l'évaluation d'un plus grand éventail de conséquences environnementales des ALE.

Le présent document est constitué des éléments suivants :

- Chapitre 2 : Introduction aux impacts du commerce sur la biodiversité
- Chapitre 3 : Présentation de l'évaluation des impacts
- Chapitre 4 : Présentation de la méthodologie
- Chapitre 5 : Application progressive de la méthodologie
- Chapitre 6 : Considérations pratiques

- Annexe I – II : Exemples d'applications de la méthodologie
- Annexe III : Présentation des indicateurs de biodiversité

- Annexe IV : Présentation des modèles

Présentation de la méthodologie

La méthodologie se concentre sur l'identification et l'utilisation systématique d'une série d'indicateurs démontrant les changements d'états et tendances de la biodiversité :

Moteur de changement (transformations des secteurs économiques générés par les ALE) → **Pression** sur la biodiversité (utilisation des terres/ressources ou changement de la qualité des ressources liés à cette pression) → **Réaction** au changement (garde-fous, nouveaux ou existants, pour prévenir les conséquences négatives ou mesures d'amplification des conséquences positives).

L'évaluation quantitative des impacts sur la biodiversité se fait via une « chaîne de modélisation » utilisant les résultats de la modélisation économique (moteur) pour alimenter les modèles d'utilisation des terres et ressources (pression) qui ont tendance à être liés aux modèles de biodiversité (impacts) :

Modélisation **économique** (modification de la production des secteurs économiques au niveau national) → Modélisation de l'**utilisation des terres** (changements spatiaux explicites de l'utilisation des terres/ressources dans le pays) → Modélisation de la biodiversité (changements des écosystèmes et/ou espèces liés à l'utilisation des terres/ressources).

Le processus méthodologique lui-même se fait en trois phases :

Phase I – Étape préparatoire : Avant l'évaluation d'impact elle-même, il est essentiel de comprendre l'état actuel des choses (la référence), puis d'établir une liste exhaustive des effets prévisibles. Ces informations seront ensuite utilisées pour identifier des **conséquences prioritaires** à évaluer en détail durant la phase d'évaluation d'impact. L'objectif de la phase I est de fournir un aperçu complet de l'éventail des impacts (possibles) tout en permettant de concentrer l'attention - et les ressources - sur l'évaluation de ceux qui auront le plus d'incidence sur la biodiversité.

Phase II – Sélection des méthodes et logique d'impact *:* La deuxième étape vise à déterminer le **degré d'ambition analytique** pour évaluer les conséquences prioritaires et à élaborer la **« logique » analytique** de l'évaluation. Le degré d'ambition peut varier de « modéré » à « élevé ». Dans le premier cas, des moyens qualitatifs seront déployés pour identifier les impacts. Dans le second, la modélisation permettra une évaluation quantitative. La logique d'impact doit être établie pour chaque conséquence prioritaire, grâce à l'identification des interconnexions entre les différentes composantes de l'analyse (moteur – pression – impact – réaction) et la description des relations entre chaque étape de la chaîne pour rendre transparentes les hypothèses de causalité.

Phase III – Évaluation d'impact et conclusions : Dans la phase finale de la méthodologie, les conséquences prioritaires préalablement identifiées sont évaluées et les résultats sont replacés dans le contexte global de l'évaluation d'impact, qui caractérisera et expliquera les **résultats les plus pertinents**. L'une des fonctions clés de la phase III est de tirer des conclusions et de fournir des recommandations pour la négociation globale (au préalable) et/ou le processus d'évaluation d'application (rétrospectivement).

Application de la méthodologie

L'application de la méthodologie d'évaluation des conséquences sur la biodiversité nécessite certaines considérations pratiques sur les meilleures pratiques liées à l'expertise, aux ressources, aux délais et à l'implication des parties prenantes.

Expertise de l'équipe d'évaluation : L'application de la méthodologie nécessite une expertise explicite dans les domaines de la biodiversité, des écosystèmes et des services associés. Cette expertise a deux dimensions incluant, au minimum, une bonne compréhension des problématiques liées à l'état de la biodiversité, aux impacts possibles et à leur évaluation (indicateurs de biodiversité). Pour une évaluation d'un degré d'ambition « élevé », cela impliquera également une expertise spécialisée sur la modélisation des impacts via les différents éléments de la chaîne de modélisation.

Base d'information économique solide : La méthodologie souligne le rôle crucial de la modélisation économique pour faciliter et/ou permettre l'évaluation des impacts sur la biodiversité. Les évaluations d'impact de l'UE liées au commerce sont généralement étayées par une modélisation CGE réalisée par la Commission, et non par l'équipe effectuant l'évaluation. Pour s'assurer de la pertinence de la modélisation économique comme base pour des évaluations d'impact sur la biodiversité, les hypothèses sous-tendant cette modélisation et l'association des analyses économique et environnementale devraient être étudiées explicitement et conjointement par la Commission et l'équipe d'évaluation.

Ressources adaptées : Les orientations SIA officielles existantes de la Commission ne stipulent pas de ressources ou budget minimum à prévoir pour les évaluations. Pourtant, les spécialistes qui effectuent les évaluations d'impact du commerce estiment que les budgets alloués à la biodiversité – et globalement aux aspects environnementaux– sont généralement inadaptés à la réalisation d'évaluations d'impact détaillées. À titre d'exemple, le budget pour le composant biodiversité est habituellement de l'ordre de 1 000 à 3 000 € par évaluation. Pour assurer l'application réussie de la méthodologie, la Commission devrait rendre disponibles les ressources nécessaires aux évaluations. Il serait par exemple envisageable d'affecter clairement ces ressources à l'aspect environnemental de toute évaluation (%) avec une part indicative (minimale) dédiée à l'analyse de la biodiversité (sur la base des connaissances préalables du pays partenaire).

Délais adéquats : L'amélioration de la rigueur des volets biodiversité et/ou plus largement environnement des évaluations et des études d'impact liées au commerce nécessite une réévaluation des délais applicables. Cet élément doit être soigneusement pris en compte dans le cadre de négociations ou de mise en œuvre des ALE, afin d’assurer que tout le processus se déroule dans les meilleurs délais. En termes de meilleure pratique à l’avenir, la Commission devrait veiller à ce qu’un délai adéquat soit prévu pour le processus politique de réalisation des évaluations d’impact.

Consultation des parties prenantes : La consultation des parties prenantes est un élément de base des procédures d’évaluation d’impact des accords commerciaux de l’UE. Elle constitue également un aspect clé pour la réalisation d’évaluations efficaces des conséquences sur la biodiversité, particulièrement lors des consultations d’experts dans les pays partenaires. Habituellement, les échanges avec les parties prenantes spécialisées sont avant tout concentrés dans la phase de sélection et de délimitation du champ d’études, afin de limiter le coût en termes de ressources. Or, il serait vraisemblablement bénéfique d’échanger avec ces spécialistes tout au long du processus d’évaluation. Cela permettrait la mise en place d’une référence aussi complète que possible et l’examen par les pairs des résultats de l’évaluation. La consultation des spécialistes – qui a sa place au rang des bonnes pratiques futures – devrait être structurée autour de la chaîne « moteur – pression – impact – réaction », en rassemblant systématiquement des informations sur les différents aspects de l’état de la biodiversité, des tendances et des conséquences possibles liées au commerce. Un simple questionnaire standardisé pourrait être élaboré à cette fin pour les évaluations futures lorsque cela est nécessaire.

1. INTRODUCTION

Trade liberalisation introduces changes to economic sectors, increasing or decreasing demand – and therefore production – in trade partner countries. These changes can have an impact on biodiversity, ecosystems and the services they provide, which needs to be carefully evaluated.

This document provides a dedicated methodological framework for assessing the impact of EU Free Trade Agreements (FTAs) on biodiversity, both in the context of *ex-ante* and *ex-post* evaluations.

It underpins the delivery of the EU Biodiversity Strategy for 2030, in particular the commitment for the Commission to *'better assess the impact of trade agreements on biodiversity, with follow-up action to strengthen the biodiversity provisions of existing and new agreements if relevant.'* This commitment has been explicitly endorsed by the Member States, as part of the Council Conclusions in 2020.

The methodology outlines a stepwise process on how to set up and carry out an assessment of the impacts of trade liberalisation on biodiversity in a structured and consistent manner, with a view to improve the transparency and robustness of the assessment while allowing for better comparability between individual assessments. At the same time, the methodology also provides flexibility to accommodate various types of agreements and partner countries.

The methodology recognises the multifaceted nature of biodiversity and, therefore, the multifaceted ways through which impacts can occur and how they can be measured. Consequently, the methodological framework starts with the identification of trade-related drivers and pressures for ecosystem degradation and biodiversity loss, then goes on to assessing possible consequent changes in the status of ecosystems and species.

This methodology is not a standalone procedure but it is foreseen to be used as part of the Commission's overall trade impact assessment process, both before and/or during the trade negotiations (*ex-ante*) and when trade agreements are in place (*ex-post*). As such, the methodology builds on and works under the chapeau of the official EU guidance, including the Better Regulation Guidelines, Better Regulation Toolbox, and Sustainability Impact Assessment (SIA) handbook [1] that frame the EU trade impact evaluation process. As such, it is to be noted that the methodology is not aimed to be used to capture overall impacts of trade on biodiversity, but that it is explicitly focused on assessing changes in ecosystems and biodiversity linked to the liberalisation of trade as part of EU FTAs.

Finally, while this methodology is designed for assessing the impacts of liberalisation under trade agreements on biodiversity, the overall approach could easily be generalised and applied to the assessment of a broader range of environmental impacts. Applying a systematic approach across environmental impacts is considered

[1] https://trade.ec.europa.eu/doclib/docs/2016/april/tradoc_154464.PDF

important in order to understand the broader environmental and social costs, and benefits associated with EU FTAs.

The document consists of the following elements:

- Chapter 2: Introduction to biodiversity impacts linked to trade
- Chapter 3: Overview of how impacts can be assessed
- Chapter 4: Overview of the methodology
- Chapter 5: Stepwise application of the methodology
- Chapter 6: Practical considerations

- Annex I - II: Examples of applying the methodology
- Annex III: Overview of biodiversity indicators
- Annex IV: Overview of models

2. WHAT ARE BIODIVERSITY IMPACTS?

Biodiversity is a multifaceted concept and therefore there is no single, unique indicator that could be used to assess biodiversity impacts of FTAs. Instead, the status of and pressures on biodiversity are captured through a set of indicators, with each indicator providing a measure for a specific 'facet' of biodiversity.

Biodiversity indicators are commonly classified in a chain of 'drivers – pressures – state – impact – responses' (DPSIR) framework. In this framework, social and economic developments (driving forces, D) exert pressures (P) on the environment causing a change in the state (S) of the environment. This leads to impacts (I) on ecosystems, human health, and society, which may elicit a societal response (R) that feeds back on driving forces, on the state of the environment or on impacts via various mitigation, adaptation or curative actions.

To translate this to the context of this methodology, liberalisation of trade in goods, services and investments can function as a driver of change in different economic sectors, causing changes in the amount of land- and other resource use or in their quality (e.g. pollutants and emissions impacting air, water or soil). The changes in the quantity of land- and other resource use and/or environmental or resource quality can change the pressures on biodiversity, leading to an impact in the state of and trends in biodiversity, ecosystems and the services they provide. Finally, trade impact assessments can also identify possible response(s) to addressing possible foreseen negative impacts and/or help to enhance any positive impacts identified.

In principle, trade-related changes can lead to both increased and reduced pressures on biodiversity, resulting in either negative or positive impacts. In practice, there is ample evidence that the impacts of EU trade agreements on global biodiversity have contributed to net negative rather than positive consequences [2]. These negative impacts are caused by trade liberalisation resulting in a larger and/or faster land clearing in FTA partner countries, many of which important hosts of global biodiversity. As a response to negative impacts, a range of safeguards can be put in place to regulate against such impacts. Alternatively, incentives can be adopted to try to foster positive impacts.

Building on the above, the methodology outlined in this document centres around the identification and application of a set – or rather a chain – of indicators supporting biodiversity assessment that capture the below:

Driver *(changes in economic sectors generated by an FTA) →* ***Pressure*** *(land- / resource use or resource quality change linked to economic change) →* ***Impact*** *(change in biodiversity and ecosystems linked to pressure) →* ***Response*** *(existing or new safeguards to prevent negative impacts or measures to amplify positive impacts).*

[2] E.g. SDSN & IEEP (2019); Bellora et al (2020); Vito, Cicero & IIASA (2013); and Crenna et al (2019)

As a rule, all EU trade impact assessments should cover the above elements of biodiversity impacts, establishing a clear chain of consequences investigated from start to finish of the assessment. The exact indicators selected to capture these impacts will be FTA specific, depending on (a) the partner countries in question and sectors subject to trade liberalisation and (b) the identified impacts and availability of data and other relevant information, and resources.

The 'response' elements often gain less prominence than other elements in the impact chain. However, in the context of this methodology they are considered as an equally important – albeit qualitative – element of the assessment, playing an important role in the 'impact chain' to inform the FTA negotiations and helping to create a 'virtuous' feedback loop to mitigate negative or boost positive outcomes of the agreement.

For a list of possible indicators to assess biodiversity impacts, please see Annex III. For concrete examples of applying indicators in the context of assessment process, please see Annexes I and II.

The indicators listed in Annex III are commonly used in the literature. These indicators are available at a global level, with a possibility to disaggregate them to national level. The listed indicators are currently available (i.e. not experimental) and considered robust and reliable so as to be used in the EU trade impact assessment and evaluation context [3].

The choice of indicators is based on a combination of factors, including which sectoral changes are foreseen to cause an impact and in which ecosystem impact(s) are going to occur. The availability of data can be a factor limiting indicators available to be used in practice. Finally, in the context of quantitative assessments, modelling tools use fixed inputs and outputs and therefore the choice of a model determines the type of indicator(s) used. Stepwise application of the methodology outlined in Chapter 5 guides the reader through the process of indicator selection and application in more concrete terms.

[3] Note: biodiversity indicators are evolving rapidly. The list in Annex I reflects the state of knowledge at the moment of publication of this guidance.

3. HOW CAN BIODIVERSITY IMPACTS BE ASSESSED?

At minimum, biodiversity impacts of FTAs can be assessed in a qualitative manner, using causality between driver, pressure and impact to determine changes brought forward by an FTA. Such qualitative assessments – building on for example existing case studies, expert knowledge and stakeholder interviews – play an important role in situations where the availability of data does not allow for systematic quantitative assessment to be carried out.

However, aiming to quantify (at least some of) these elements is considered preferable and this methodology pays dedicated attention to advise on how biodiversity impacts of trade can be quantified through modelling. In this case, qualitative analysis complements and completes the quantitative analysis, allowing cross-validation and leading to a more robust analysis.

It is helpful to know from the start that no single model is currently available to cover the full driver – pressure – impact chain of changes caused by trade on biodiversity. Consequently, quantitative assessments need to build on the application of two or more models with the outputs of one feeding into the other (so called 'loose coupling' of models).

One of the key challenges for quantitative assessment is to connect changes in the driver (i.e. economic sector changes), that are typically modelled at a national and sectoral levels, to changes in pressures and impacts on biodiversity taking place at spatially explicit levels within a country. Biodiversity is spatially heterogenic, which means that some regions and/or areas are especially valuable for conservation and/or vulnerable to impacts. This also means that the significance of impacts can vary considerably depending on the location. Consequently, spatial understanding of changes linked to an FTA is key for understanding its biodiversity impacts in a meaningful way, including identifying responses to address any negative impacts. As a rule of thumb, being able to increase the spatial specificity of FTAs' economic impacts increases the robustness of assessing biodiversity impacts.

Building on the above, quantitative assessment of biodiversity impacts in the context of this methodology centres around a 'modelling chain' that uses the outputs of the economic modelling (driver) to feed into land or resource use models (pressure) which then can be linked to biodiversity models (impact):

Economic modelling *(changes in economic sector outputs at national level) →* ***Land use modelling*** *(spatially explicit changes in land- / resource use within country) →* ***Biodiversity modelling*** *(changes in ecosystems and/or species links to land- / resource use).*

Variations to the above exist including 'extensions' to the standard economic model that allow linking economic changes to changes in pressures to biodiversity at national level. However, land use modelling is an element required to be able to understand how these pressures get spatially distributed within a country.

Box 3.1 below explains in more details the chain of models for quantifying biodiversity impacts of FTAs whereas Annexes I and II provide concrete examples of applying such a modelling chain in the context of an assessment process.

Note: The above outlined 'theory' of assessing biodiversity impacts and quantifying them through a chain of models applies to all ecosystems, including terrestrial and marine. The advances on this field have, however, largely focused on the terrestrial environment. Consequently, the key focus of this methodology is to illustrate mapping out biodiversity impacts of trade through changes in land use. This should <u>not</u> be interpreted as lack of importance to be given to the impact of trade liberalisation on marine, coastal or inland water resources, ecosystems and biodiversity.

The above also applies to assessing impacts of trade liberalisation on the risk of invasive alien species (IAS). While the development of modelling approaches to assess and predict distributions and impacts of IAS is on the rise, no existing tools are available and 'ready to use' in the trade impact context.

The different steps of the methodology outlined in Chapters 4 and 5 cater equally for all possible effects of trade on biodiversity across all economic sectors, ensuring that all impacts are identified and addressed. Furthermore, a number of the models identified in Chapter 5 are suitable to be used to assess trade related impacts in aquatic ecosystems. However, it is useful to understand already from the start that, due to methodological limitations, the assessment of non-land use related impacts is likely to be based on a more qualitative rather than quantitative analysis.

Box 3-1 Quantifying FTA's biodiversity impacts: a chain of models

Modelling chain consists of the following elements:

Economic models: Computable General Equilibrium (CGE) models form the basis for all EU trade impact assessments. They project changes in economic activities at the national and sectoral levels due to trade liberalisation. In their basic form, <u>CGE models do not model changes in land use or other pressures on biodiversity</u>. CGE analysis for EU trade agreements is typically carried out by DG Trade with the results provided to consultants carrying out further assessment of impacts based on the CGE core economic findings.

Output of the CGE models can be fed into economic models that provide more directly applicable indications of biodiversity pressures. Environmentally-Extended Multi-Regional Input-Output (EEMRIO) models combine standard economic matrices of national economies with natural resources and pollution accounts. The models track the use of both priced and unpriced natural resources (water, air, land) as non-monetary inputs into production. In terms of outputs, EEMRIO models allow making a causal and quantifiable link between changes in economic activity and related changes in land and resource use and pollution levels. However, <u>they typically do not provide spatially explicit information on these pressures within a country</u>.

Land use models: <u>Land use models can be linked to the output of CGE and EEMRIO models to provide *spatially explicit* effects on land use and land cover types</u>. The models as a rule have been peer-reviewed for publication in scientific journals, which enhances their reliability and transparency. A variety of open source and free models is available. To apply such models, knowledge of geographic information systems, statistics, spatial analysis and spatial data are necessary, and data availability may be a barrier for less developed countries/regions. Nevertheless, a vast amount of global or regional spatial data on land use and land cover, and environmental characteristics is now freely available, and can be used in case national data is not accessible, not recent or not of sufficient quality for the purpose. Additionally, hundreds of case studies on different scales have been applied around the world, which can be of help when setting up a new land use model. In terms of output, land use models simulate future land use linked to agriculture, forestry and other land use dependent sectors. This way, they allow identifying which areas are most likely to experience land use change in the future, which enables us to identify locations with biodiversity impacts and the type of impact. Furthermore, advances are being made to couple land use models with climate change models and/or with ecosystem service models. When ready for wider application, such coupled modelling allows to assess changes linked to trade liberalisation together with broader changes taking place simultaneously.

Biodiversity models: Biodiversity models can be linked to land use models. Biodiversity models come in two main types: phenomenological and process-based. The former is based on empirical relationships between the variables whereas the latter models the processes involved in the functioning of the system. Process-based models are more complex to develop and, although their outputs might provide better predications of biodiversity impacts, their practical implementation is limited by the greater technical expertise and data inputs required. In contrast, phenomenological models, that use statistical relationships between cause and effect, are relatively straightforward to understand and apply.

Integrated Assessment Models (IAM) integrate economic, land use and biodiversity models into one tool. They are internally consistent and produce results of high quality. They are, however not easily amendable to changes in regional aggregation (for example to focus on a particular country) or time horizons, and are not accessible to individual consultants that are not working in the institutions that developed the models.

Looking into the future, it is considered that finer level of aggregation and greater access to data can improve CGE simulation results, which then helps to improve the robustness of land use and biodiversity models further down the modelling chain (Nilson, 2019). Further advances can also be made to make MRIO models more spatially and/or commodity specific, thus improving the basis for land use and biodiversity models (e.g. Croft et al. (2019), Green et al. (2019) and Brucker et al. (2019)).

Annex IV provides further information on different types of models, including further advances in the field currently under development.

4. OVERVIEW OF THE METHODOLOGY

The methodology is structured in three stages, as visualised in Figure 4.1.

4.1 Stage I: Preparatory stage

Prior to the impact assessment, a baseline is constructed and impact screening and scoping is performed. This is fundamental to allow focusing the actual assessment on the foreseen key impacts while, at the same time, providing a comprehensive overview of the range of (possible) impacts and mitigating the risk of overlooking any significant impacts.

The baseline and outputs of screening and scoping will be revisited at the final stage of the assessment, when discussing the impact assessment results in the wider context (Stage III).

The preparatory stage will result in the identification of priority impacts and related set of indicators to be used in the context of the assessment. This stage will also be used to determine the relative importance of biodiversity analysis in the overall assessment, including where appropriate reflecting the role of a trade partner country in conserving biodiversity in global context (e.g. as 'host' of biodiversity hotspots).

4.1.1 Baseline

The baseline describes the situation with regards to biodiversity and governance in a country(ies) subject to the impact assessment. 'Performance' refers to a factual description of the historical biodiversity status and trends, unrelated to potential impacts of the FTA. It aims at identifying potential biodiversity threats and opportunities in a country, such as trends in land- and resource use or quality with known negative impacts on biodiversity or markets for biodiversity friendly products. 'Governance' refers to a factual description and also the effectiveness of the policy and legislative framework in place to protect and sustainably use biodiversity in a country. Taken together, 'performance' and 'governance' can offer insight into the likely effectiveness of mitigation measures agreed for the FTA.

The baseline informs non-expert stakeholders on a country's biodiversity status and informs the impact screening and scoping exercise that follows. It also forms the basis for identifying what existing policy responses are in place – or needed to be put in place – to mitigate adverse or enhance positive impacts.

4.1.2 Screening and scoping

Impact screening and scoping aims to canvas possible impacts of trade agreements on biodiversity and lead to the identification of priority impacts which are to be assessed in detail in the actual impact assessment.

4.1.3 Impact screening and scoping is a three-step approach:

Step 1: Screening of FTA impacts – Two impact 'drivers' of an FTA are identified and explored: economic impacts and additional impacts. Economic impacts refer to changes in production and consumption levels in different sectors as result of an FTA, based on the results of economic modelling. Additional impacts refer, amongst others, to possible changes in the (effective implementation of) legislation because of an FTA. These two types of general changes resulting from an FTA can directly or indirectly cause negative or positive impacts on biodiversity.

Step 2: Screening of biodiversity status – This step, which is informed by the biodiversity baseline, provides a broad-brush assessment of biodiversity status and trends (pressures – impacts – responses) across economic sectors covered by the FTA.

Step 3: Scoping of primary biodiversity impacts and related indicators – Based on a joint analysis on the expected economic and additional impacts and biodiversity status and trends, priority impacts are identified. These priority impact areas are to be assessed in detail in the impact assessment stage. The scoping exercise also leads to the identification of indicators available and foreseen to be used to assess the impacts.

4.2 Stage II: Method selection and impact logic

This stage aims to determine the level of ambition of the analytical exercise, if possible, in quantitative terms, and to develop the analytical plan to assess each priority impact.

Step 1: Determining the level of analytical ambition – Step 1 determines the depth of analysis between 'moderate' and 'high' level of ambition, with the former using qualitative means to determine the impacts and the latter assessing impacts in a quantitative manner through modelling. The decision between these two levels of ambition is based on considering the type of priority impact(s), available data on indicators, and resources and expertise required.

Under 'moderate' level of ambition, causal chain analysis is used to assess the impacts of trade agreement on biodiversity. This builds on the use of existing qualitative and quantitative information across the pressure – impact – response chain (i.e. without quantitative modelling), resulting in a (mainly) qualitative assessment.

Under 'high' level of ambition, quantitative modelling is used to determine how changes in economic outputs linked to a trade agreement translate into quantifiable changes in land- or resource use or quality and further changes in the status of biodiversity.

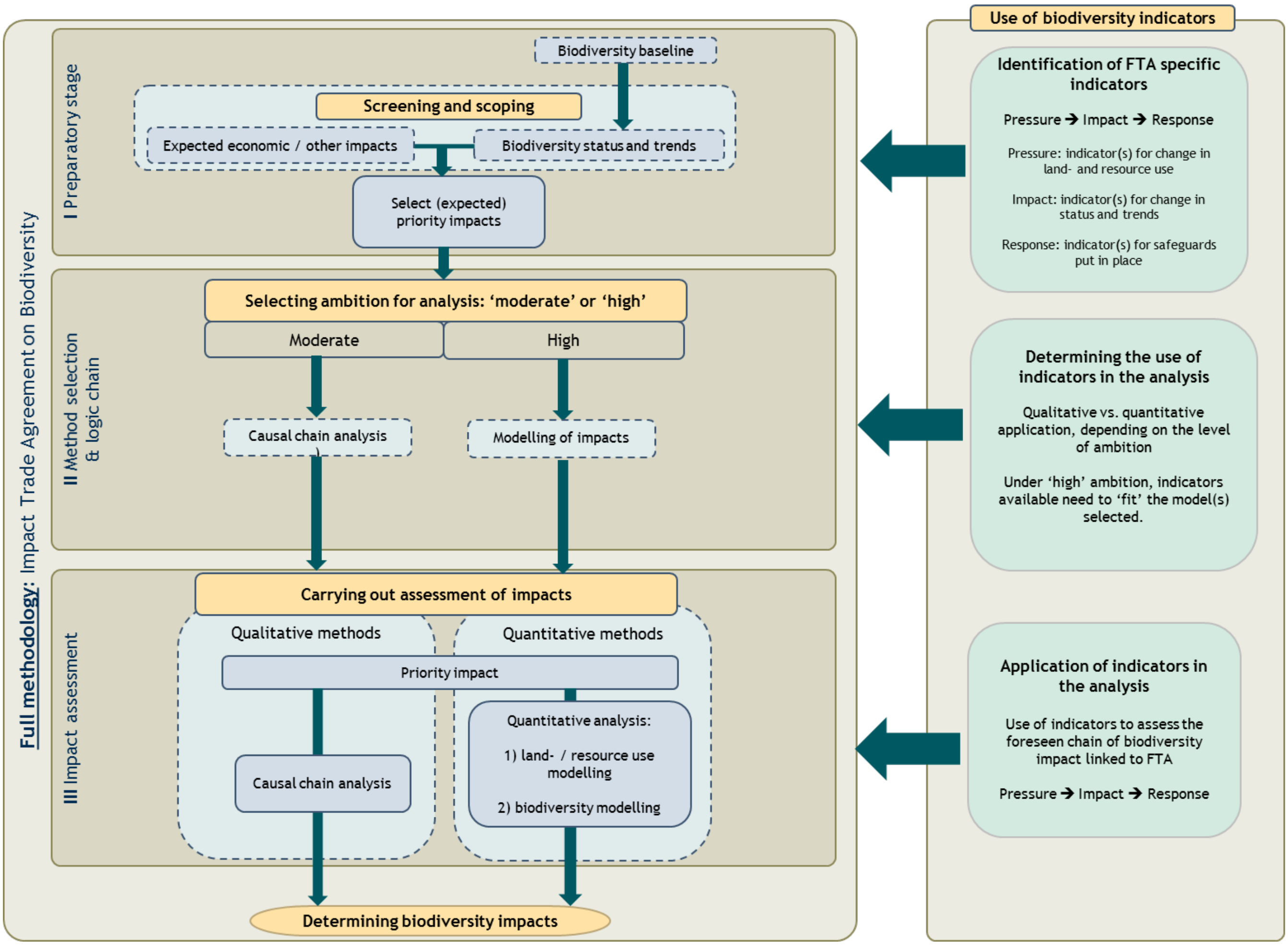
Step 2: Establish the impact logic – For each selected priority impact, impact logic is established to identify the interlinkages between different components of the analysis (pressure – impact – response). Establishing an impact logic is relevant for both 'moderate' and 'high' ambition, however it holds specific importance in the latter context. Establishing impact logic requires describing relationships between each step along the chain, so that causal assumptions are transparent and can be revisited as more information becomes available.

4.3 Stage III: Impact assessment and interpretation

This Stage carries out the impact assessment of the priority impacts identified in Stage I, using the method(s) identified in Stage II.

The interpretation of the impact assessment places the results in a broader context and discusses the most significant findings. While focusing on the priority impact areas, the interpretation should also draw from the screening and scoping stage and include any insights related to possible wider or alternate impacts, e.g., if circumstances or assumptions underpinning the assessment to change.

Figure 4-1: Summary of the methodology



5. APPLICATION OF THE METHODOLOGY

This chapter outlines the application of the methodology in a stepwise manner. For each stage of the methodology, this chapter will provide a description, and objective and principles. In addition, relevant background information is provided.

Illustrative examples of applying the methodology in ex-ante and ex-post situations are provided in Annexes I and II.

5.1 Preparatory stage – biodiversity baseline and screening and scoping

The first step in the methodology is the preparatory stage, which is to be done prior to the actual impact assessment as it is designed to bring focus to the impact assessment. It contains two elements: establishment of the baseline, and impact screening and scoping.

5.1.1 Biodiversity baseline

Background and rationale

What is the baseline?

The baseline describes the situation with regards to biodiversity in a certain country. As such, it explores a country's performance in light of delivering its national objectives and international commitments on biodiversity conservation and sustainable use, and a country's governance related to these aspects. It also establishes the relative importance of biodiversity conservation in global context (e.g. identifies any biodiversity hotspots).

The section on 'performance' describes how the status of biodiversity has evolved over the years (e.g. trends). It focuses on identifying potential risks and opportunities in the field of biodiversity. The performance section is a purely factual description of the historical biodiversity situation in a certain country, unrelated to potential impacts of an FTA.

The section of 'governance' explores how biodiversity and related broader environmental governance has evolved over the years and comments on (changes in) the effectiveness of this governance in promoting and protecting biodiversity. Governance relates to a system of management and oversight on conservation and sustainable use of biodiversity and ecosystems and this section includes understanding of key governance structures (such as legislation for environmental protection) and roles and responsibilities of key agencies.

What is the purpose of the baseline?

The objectives of the baseline are threefold. In terms of the assessment logic, the key objective is to inform both the screening and scoping exercise and final conclusions of the assessment. In terms of wider process, the baseline steers the practitioners carrying out FTA evaluations to explore and assess a range of environmental impact areas (including biodiversity) without prejudgement of the situation. Finally, the baseline also serves to inform non-expert stakeholders on the biodiversity status in a certain country.

How to establish the baseline?

The baseline is established based on desk-based research and literature review. Where resources allow, additional research (e.g. targeted stakeholder consultations) help to verify the robustness of the baseline, including in a situation where existing literature is limited and/or dates back to several years. However, the assessors need to remain mindful of avoiding an ineffective allocation of resources; most resources should be allocated to the actual impact assessment, being the focal point of the analysis.

The following three step approach is recommended:

Step 1: Literature review regarding status and trends – In this step, the practitioner should strive to identify the main trends, risks and opportunities regarding the conservation and sustainable use of biodiversity in a country, including any production and resource use patterns than underpin them. It should also help to establish the relative importance of biodiversity conservation in a global context (e.g. identify biodiversity hotspots hosted by a country).

As a source, where available national sources of information (national or regional biodiversity assessments, national reports [4] to the Convention on Biological Diversity etc.) should be used. Practitioners may also consult international literature in which the biodiversity performance of the country of interest is compared to global benchmarks. The Biodiversity Indicator Partnership Dashboard [5] and the United Nations Biodiversity Lab can offer relevant context setting information available across multiple countries.

A dedicated section below provides further advice and resources to guide the identification of information on different biodiversity impacts and related indicators covering pressure, impact and response.

Step 2: Literature review regarding governance – The second step is to explore the situation with regards to governance affecting biodiversity in the country of interest. It is particularly interesting to review literature on the effectiveness of environmental governance. Understanding the rigour of governance is important for two reasons. First, the EU FTAs refer to national legislative and governance frameworks as a key basis for ensuring trade sustainability. The effectiveness of rules-based measures (e.g. prohibition of the use of toxic materials in traded products) depends to a large extent on the rigour of environmental governance in trade partner countries, in particular implementation and enforcement. Secondly, the EU may aim to improve the quality of environmental governance through FTAs, by including specific provisions on environmental regulations and standards in the Trade and Sustainable

[4] https://chm.cbd.int/search/reporting-map?filter=all
[5] https://bipdashboard.natureserve.org/bip/SelectCountry.html

Development (TSD) Chapter. Identified flaws in environmental governance may therefore serve as input for the final TSD Chapter, strengthening the effectiveness and enforceability of the Chapter.

As for information sources, the national reports to the Convention on Biological Diversity (CBD) and the national biodiversity action plans are considered relevant sources for this step. Furthermore, UNECE and OECD Environmental Performance reviews also provide relevant information.

What kind of information to gather and present on biodiversity impacts and related indicators?

The development of a baseline forms a natural starting point for identifying available information 'along' the chain of pressure – impact – response indicators, as described under Chapter 2. This information can be further used as the basis for identifying and determining the FTA specific indicators linked to priority impacts (see 'screening and scoping' phase, below).

In order to support the overall analysis in a systematic manner, the baseline should aim to cover information available across the different types of impacts (i.e. pressure – impact – response) across as many sectors as possible, representing this in a systematic manner (i.e. from pressure, to impact, to response) and identifying commonly available indicators to capture these impacts as used in the existing literature.

Commonly reputable sources, overall robustness of data and length of available time series, should be used as guiding principles for what kind of impact information to gather and analyse.

Annex III provides an overview of biodiversity indicators commonly used and available. It should be used as a basis for identifying FTA specific information on and indicators for biodiversity in the context of EU impact assessments, starting from the baseline.

In general, indicators should be included based on three criteria:

1. Availability: indicators should be available for at least ten years to allow for simple trend identification and accessible for practitioners.
2. Descriptive power: indicators should meaningfully describe the biodiversity status.
3. Interpretability: indicators should be understandable and relatively easy to interpret by (non-expert) stakeholders.

Outcomes

The baseline should result in an accessible and understandable overview of the current situation and the trends with regards to biodiversity performance in a certain country, including its role in conserving biodiversity in the global context. To the extent feasible, an overview of (the effectiveness of) environmental governance should also be established.

Finally, the baseline should also result in the collection of information on biodiversity impacts, covering the pressure – impact – response chain across as many sectors as possible and thereby supporting the later selection of indicators for key impacts.

For a concrete example of a baseline, please see Annex I.

5.1.2 Screening and scoping

Background and rationale

What is impact screening and scoping?

Impact screening and scoping is an exercise in which the existing biodiversity status, expected impacts, characteristics of an FTA, and stakeholder views are jointly scanned to identify the impacts to be assessed in detail by the impact assessment.

The biodiversity screening and scoping exercise builds upon the SIA Handbook and is tailored for the biodiversity assessment. In this context, *screening* is a tool to select the key biodiversity related issues to be assessed in further detail and to explain why a particular focus should be put on these issues. *Scoping* is a tool to identify the driving force of a predicted impact, identified and narrowed down during the screening exercise.

It should be emphasised that impact screening and scoping is only meant to bring focus in the analysis and that expected impacts are not expected to be evaluated in detail during this stage.

What is the purpose/relevance of impact screening and scoping?

The main goal of screening and scoping is to map and understand the major expected and/or potential impacts and biodiversity concerns and opportunities in a country linked to the EU FTA. This leads to the further identification of priority impacts on a well-informed, transparent basis. These priority impacts are then analysed in detail in the impact assessment stage. This approach allows a practitioner to gain an overview of the possible impacts across different economic sectors covered by an FTA and then being able to focus on analysing priority impacts with sufficient depth and robustness. This approach also helps to mitigate the risk of overlooking any possible impacts.

What are the key principles for a successful impact screening and scoping exercise?

The key principles for impact screening and scoping are transparency, consistency and adequate timing.

Transparency and consistency should ensure that all stakeholders involved in the EU FTA negotiations, from the European Commission and country officials to civil society, understand the analytical process upon which priority impacts are identified. Most importantly, stakeholders should be able to understand why a certain potential impact is (or is not) identified as a priority impact and thus assessed (or not) in detail.

Appropriate timing of the process should ensure that impact screening and scoping can be used at its full potential. Impact screening and scoping are crucial to plan and focus the impact assessment on a well-informed basis. Timing is commonly identified as a challenging factor in EU SIAs and ex-post evaluations as the focus of the final analytical exercise is often requested to be established in the inception phase of a project, prior to the finalisation of impact screening and scoping.

To avoid duplication of efforts, this phase is primarily informed by the baseline, highlighting the importance of the baseline's robustness. However, information to support screening and scoping is also commonly acquired through expert and/or stakeholder interviews, to complement the baseline and especially to address any information gaps. In the latter context, interviews should systematically use the pressure – impact – response logic as a basis to further explore foreseen impacts, including explicitly asking the interviewees to point to concrete evidence (indicators) to substantiate insights provided. This will help to ensure that the acquired information is robust and fit for purpose to support the next stages of the assessment process, including identifying FTA specific indicators to assess primary impacts.

How to perform screening and scoping?

Step 1: Develop the impact screening and scoping framework – The first step is to develop the framework for impact screening and scoping by means of a matrix. This matrix serves to structure the screening and scoping exercise. To ensure consistency, the structure shown in Table 5-1 is proposed.

Sectors are shown in the rows and (1) expected market access and rules-based impacts, (2) current biodiversity status ranging from pressures to impacts and responses and (3) judgement of priority impact are shown in the columns.

The sector classification varies depending on FTA in question as does what is covered under the pressure – impact – response columns (e.g. which indicators are available to capture these status related aspects). Each element in this proposed structure will be explained in detail in the next sections.

Ultimately, both the expected market access and rules-based measures impacts, and the observations regarding the biodiversity status should be weighted to determine expected impact on biodiversity, ranging from moderate to significant and from negative to positive. Table 5-2 shows the proposed colouring scheme to weight both elements in the matrix. An example of a populated matrix is shown in Table 5-3 below.

Table 5-1 Impact screening and scoping matrix – structure

		Expected FTA impacts		Biodiversity status			Priority impact
		Market access	*Rules-based measures*	*Pressure (land- or resource use or quality)*	*Impact (ecosystem / species)*	*Response*	
Sectors	**Sector 1** *e.g. agriculture*						
	Sector 2 *e.g. forestry*						
	Sector 3 *e.g. fishing*						
	Sector ...						
Not sector specific							

Table 5-2: Colour scheme to weight expected impacts and biodiversity status

Colour	Meaning
	Significant expected positive impact or biodiversity opportunity
	Moderate expected positive impact or biodiversity opportunity
	Expected significant impact or biodiversity risk, direction unknown
	Moderate expected negative impact or biodiversity risk
	Significant expected negative impact or biodiversity risk

Step 2: Screening – expected impacts of FTA – There are two main elements through which a trade agreement can create economic and environmental impacts: changes related to the access to markets (tariff related measures) and rules-based measures (non-tariff related measures).

Step 2A: Screening – expected market access impacts – Historically, increased market access has been the cornerstone of trade agreements. By means of an FTA, levels of trade and other economic factors (e.g. production and value added) should increase for the trade partners. This remains a critical objective of modern trade agreements. As such, FTAs are naturally expected to affect trade between and production in the countries involved. From a life cycle perspective, changes in production levels will have an impact on the environment, including biodiversity. Consequently, expected market access impacts, focussing on production changes, are considered a crucial element to consider in the screening exercise.

For any EU FTA, the European Commission models the FTA's expected market access impacts through a CGE model. The results of this modelling exercise, the CGE results, serve as the starting point for most SIAs and ex-post evaluations as they represent the FTA induced market access impacts, or the marginal economic changes resulting from the FTA. The reason why the CGE results are usually the starting point of any assessment is that it is essentially one of the few (or even the only) methods that isolates the FTA induced impacts on trade from general trade trends. Isolating the

FTA induced expected impacts from trade trends is challenging as there is no real-life counterfactual to compare against. FTA induced effects are estimated as a difference between a situation with an FTA in place vs. a situation without the FTA in place, for a given variable (e.g. forestry and wood products) in a given year. As such, one side of the comparison is always hypothetical, i.e. in case of an SIA there is no FTA yet in place to compare to and in case of an ex-post evaluation there is no real life situation without the FTA. For this reason, modelling is essentially always required to isolate the FTA induced impacts.

As SIAs and ex-post evaluations should assess the FTA induced impacts, and because FTAs naturally lead to market access and related economic impacts, the CGE results are usually the starting point for any analysis.

CGE results cover various elements, including changes in Gross Domestic Product (GDP), trade flows and production levels. For the environmental analysis, including the biodiversity analysis, the changes in production levels are the most relevant element. The production level results show the (expected) impact on production at sector level, per country. Results are available in relative and absolute terms (the percentage and absolute difference between the situation with an FTA compared the situation without an FTA). Results may come in different units of measure, e.g. production volumes or production values (in market prices).

CGE results are at a rather granular level as they cover roughly 60 different sectors. For that reason, it may be appropriate to perform additional analyses to be able to assess the economic impacts at a more aggregated level (e.g. for forestry or agriculture sectors). This can be done relatively easily as all information is available in relative and absolute terms. If resources allow, it is feasible to carry out some basic further modelling, e.g. partial equilibrium models could be used to generate more aggregated sector specific information (see Annex IV for further information).

Step 2B: Screening – expected impacts linked to rules-based measures – Aside from the expected impacts to market access (tariffs), FTAs may be associated with changes to rules-based (non-tariff) measures.

Rules-based measures refer to changes in legislation or (common) ambitions detailed in an FTA which can generate environmental impacts. Any modern EU trade agreement includes a TSD Chapter through which the signees (re)confirm their commitments to various sustainability goals. In many cases, the TSD Chapter also covers provisions relevant for biodiversity (e.g. confirming the commitments with regards to the Convention of Biological Diversity). Aside from the TSD Chapter, an FTA may cover provisions to limit or prohibit the use of certain (toxic) materials, which may result in relevant biodiversity impacts. Additional expected impacts include, but are not limited to, impacts resulting from rules-based measures.

In addition to the TSD Chapter related measures, other relevant impacts can also be identified based on the baseline literature review or stakeholder inputs. In case practitioners include additional expected impacts based on the literature or stakeholder input, it is important to be aware of the fact that only FTA induced impacts should be included. If feasible, the additional expected impacts should be at sector level. If an expected impact cannot be attributed to a certain sector, it can be included at the bottom part of the matrix.

Step 3: Screening – current biodiversity status and trends – The next step in impact screening and scoping is exploring existing links between the economic sectors identified and biodiversity status. Identifying key sectors that have been identified in literature as key drivers of biodiversity loss (or conversely, improvement) provides an indication as to whether an expansion in economic activity in those sectors is likely to further exacerbate biodiversity loss.

Conversely, if a sector has not been identified as an important driver for biodiversity loss in the partner country, this suggests that an increase in economic activity in that sector is less likely to produce biodiversity loss than if it had been identified in the literature as a key driver of biodiversity loss. However, in this case it is also crucial to consider marginal changes in an output of a sector vis-à-vis the sector baseline. If the marginal change brought forward by an FTA is significant this might present a biodiversity risk even within a sector that has previously been identified as 'biodiversity neutral' (i.e. a sector reaches a threshold where negative impacts start take place).

In general, it is important to explicitly note the screening stage does not yet establish a direct causal link between the status of and trends in biodiversity and economic and/or additional changes caused by the FTA. It simply provides an indication of such a link, guiding the prioritisation and detailed causal assessment that follows.

The way in which the modelling results are linked and the analysis is set up can best be described with a hypothetical example. Based on the analysis in Step 2, an FTA is expected to result in a 3% increase in meat production. This leads to a conclusion that this increase in production could impact biodiversity through land clearing (removing habitat and increasing pollutant loads to waterways). However, before this conclusion can be drawn, the practitioners should (a) identify the 'pathways' from meat production to impacts on biodiversity (e.g. intensification and/or extension of production, extension related land clearing and habitat loss, possible water and soil quality impacts) and (b) identify to what extent these aspects are relevant in the country in question. If it is concluded that land use change has been a significant threat for biodiversity in the trade partner country, the potential impact of meat production on land use change becomes more significant. Furthermore, if it is then concluded that meat production has historically been related with land use change in the partner country, the expected increase in meat production in the country due to the EU FTA becomes more significant in terms of its biodiversity impact.

The biodiversity status is informed by the biodiversity baseline to avoid duplicating effort. In addition, information to support screening is also commonly acquired through expert and/or stakeholder interviews. Please see the beginning of this section for further information on conducting the latter.

Based on the information in the biodiversity baseline, economic modelling and stakeholder interviews, practitioners can include the most pressing biodiversity threats and potential opportunities in the impact screening and scoping matrix, ideally at a sector level. Table 5-3 and shows an example of a screening and scoping matrix after the finalisation of the screening stage (excluding scoping).

Table 5-3 – Indicative populated screening and scoping matrix – includes screening only

Sector				Expected FTA impacts		Biodiversity status		
				Market access	*Rules-based measures*	*Pressure (land- or resource use or quality)*	*Impact (ecosystem / species)*	*Response*
Sectors	*Primary sector*	1	Agriculture - horticulture	++		A		
		2	Agriculture - meat, dairy, wool	+		A		
		3	Agriculture – crop production					
		4	Forestry	/	A	A		
		5	Fishing	++	B		B	
		6	Mining	+		C		
		7	Oil/gas extraction	-				
	Secondary sector	8	Meat and dairy products	/				
		9	Vegetable food products	/				
		10	Beverages and tobacco products	/				
		11	Clothing products	+				
		12	Wood and paper products	+				
		13	Petroleum, coal products	/				
		14	Chemical, rubber, plastic products	/				
		15	Non-metallic mineral products	-				
		16	Metal products	/				
		17	Machinery, electronic equipment and other manufacture	/				
		18	Electricity and gas	/				
		19	Utility	/				
		20	Construction	/				

		21	Transport	/				
Not sector specific								

*Legend: **Dark red** refers to a significant negative expected impact/risk, **light red** refers to a moderate negative expected impact/risk, **dark green** refers to a significant positive expected impact/opportunity, **light green** refers to a moderate positive expected impact/opportunity. The letters (e.g. A and B) refer to specific observations which are further explained in the second part of the table.*

Expected impacts		**Source**
++	Large (>1%) expected increase in production in sectors 1 and 4	CGE
+	Medium (0.5 - 1%) expected increase in production in sectors 2,5,10 and 11	CGE
-	Medium (0.5 - 1%) expected decrease in production in sectors 6 and 14	CGE
/	No changes to sector	CGE
A	Expected improved legislation in partner country on sustainable forestry as a result of a provision in the TSD Chapter	Draft FTA
B	Expected improved legislation in partner country on sustainable fishing as a result of a provision in the TSD Chapter	Draft FTA
Biodiversity status		**Source**
A	Historically, agricultural production and forestry has been linked to land use change (e.g. deforestation) in partner country	Literature
B	The aquatic population has worsened over the past years in partner country	Expert
C	Mining has been linked to water and soil pollution as a result of mercury use in partner country	Literature

Step 4: Scoping – identification of priority impacts and related FTA specific indicators – At this stage, the expected impacts and the biodiversity status and trends have been mapped. The next step is to identify and justify priority impacts based on scoping. Scoping is operationalised by an integral analysis on the expected impacts and the biodiversity status.
There are two ways in which a priority impact can be justified:

1. Horizontally – a significant expected market access and rules-based measure impact coincides with a significant/moderate biodiversity risk or opportunity;
2. Vertically – a significant biodiversity risk or opportunity coincides with moderate expected impacts across several sectors.

In practice, the justification is based on a multi-criteria assessment, instead of a linear process, involving expert judgement. As a rule of thumb, practitioners should understand that significant expected market access and/or rules-based measure impacts associated with significant biodiversity threats or opportunities qualify as priority impacts. The less significant either the market access / rules-based measure impact or the related impact on biodiversity status becomes, the lower the need for an in-depth assessment.

The selection of each priority impact should be clearly and explicitly justified. In addition, it should also be justified if a moderate expected impact, or a moderate biodiversity risk or opportunity is not selected as priority impact. This is shown Table 5-4. Priority impacts will be assessed in detail in the impact assessment.

Finally, for the identified priority impacts, a set of available indicators foreseen to be used in the following stages of the assessment will be identified. These indicators should, as much as possible, cover the chain of pressure – impact – response, as explained in Chapter 2 and, in practice, they are the same indicators already identified in the baseline and/or screening (e.g. interview process), used as part of the screening phase to substantiate the assessment. This set of indicators will be reviewed and complemented at Stage II when determining the methods for assessing priority impacts in more detail.

Table 5-4 – Indicative populated screening and scoping matrix – includes screening and scoping

Sector				Expected impacts: Market access	Expected impacts: Rules-based measure	Biodiversity status: Pressure (land- or resource use or quality)	Biodiversity status: Impact (ecosystem / species)	Biodiversity status: Response	Priority impact
Sectors	Primary sector	1	Agriculture - horticulture	++		A			A
		2	Agriculture - meat, dairy, wool	+		A			
		3	Agriculture – crop production						
		4	Forestry	/	A	A			B
		5	Fishing	++	B		B		C
		6	Mining	+		C			
		7	Oil/gas extraction	-					
	Secondary sector	8	Meat and dairy products	/					
		9	Vegetable food products	/					
		10	Beverages and tobacco products	/					
		11	Clothing products	+					
		12	Wood and paper products	+					
		13	Petroleum, coal products	/					
		14	Chemical, rubber, plastic products	/					
		15	Non-metallic mineral products	-					
		16	Metal products	/					
		17	Machinery, electronic equipment and other manufacture	/					
		18	Electricity and gas	/					
		19	Utility	/					
		20	Construction	/					
		21	Transport	/					
Not sector specific									

*Legend: **Dark red** refers to a significant negative expected impact/risk, **light red** refers to a moderate negative expected impact/risk, **dark green** refers to a significant positive expected impact/opportunity, **light green** refers to a moderate positive expected impact/opportunity, **yellow** refers to a potential significant impact for which the direction is unknown. The letters (e.g. A and B) refer to specific observations which are further explained in the second part of the table.*

Table 5.4 priority impact column written assessment

A	Potential impact on land use change as a result of increased production in the horticulture sector.
B	Potential impact on the forestry sector as a result of expected improved legislation in the sector, while no major change in the level of production is expected.
C	Potential impacts on fisheries resulting from increased economic output (i.e. Intensified fishing) and expected improved legislation.

Outcomes

Impact screening and scoping should result in identification and justification of priority impacts, based on a transparent, consistent and adequately timed analysis; and justification for not assigning certain expected impacts as 'priority' impacts.

This stage also results in the identification of a (preliminary) set of available indicators to be used in the later stages of the assessment.

For a concrete example of screening and scoping, please see Annex I.

5.2 Method selection and impact logic

Following the preparatory stage of impact screening, a short list of priority impacts for greater analysis will be identified. In the broader context of the ex-ante or ex-post evaluation, these may be addressed through case studies.

The next stage of the methodology is to identify the 'analytical chain' and approach through which to assess these priority impacts.

In general, there are two possible approaches, leading to more qualitative or quantitative outcomes, depending on the route taken. It is possible to (a) use analytical tools involving modelling or (b) use causal chain analysis based on literature and data analysis. The former yields to quantitative outputs. The latter is of qualitative nature, supported by quantified insights where available (e.g. existing studies).

Background and rationale

What is method selection and impact logic?

'Method selection' refers to deciding on the level of ambition and selecting the relevant tool(s) to assess a certain expected impact. 'Impact logic' refers to the identification of each step, and the connections between steps – qualitative or quantitative – required to establish biodiversity impacts caused by the marginal changes induced by the FTA within the selected method.

What is the purpose/relevance of method selection and impact logic?

Method selection and impact logic should provide clarity on the level of ambition in an early stage to increase the effectiveness of the actual impact assessment. It should support practitioners in selecting the best methods by clearly understanding and agreeing on the logic before starting the analysis.

What are the principles for method selection and impact logic?

The key principle for selecting the method(s) and impact logic is that it should be fit for purpose to capture those priority impacts identified through screening and scoping. Therefore, this stage should carefully construct the chain of pressure and impact within a sector specific context, reiteratively identifying suitable indicators to be used either to provide causal evidence or used as inputs into model(s) while also selecting suitable model(s) to be used.

Producing quantitative outputs is desirable wherever data and/or resources so allow. As explained in Chapter 3 and Annex IV, such quantitative outputs are produced through models for which a number of alternatives are available. In this context, it is common to use a chain of two models with the first capturing changes in biodiversity 'pressure' due to an FTA and the second using these outputs to predict related 'impact' at ecosystem and/or species level.

Note: It is preferable to aim for a minimum level of quantitative assessment of the 'pressure' element of the biodiversity impact chain (i.e. impact of FTA on land- or resource use and/or quality) even if there are no resources to link these results to further modelling and the related 'impacts' on ecosystems and/or species need to be assessed with the help of causal chain analysis. Ideally, this quantitative assessment of pressure(s) will be done spatially explicitly within a country – as opposed to a national level analysis – using land use models.

However, it is also understood that carrying out quantitative assessments might be limited by data and/or resources available to conduct a robust assessment. In this case qualitative assessment by the means of causal chain analysis is recognised as acceptable way forward.

How to select the method and construct the impact logic?

Step 1: Determining the level of analytical ambition – Before proceeding with the analysis of biodiversity-related impacts, it is first necessary to consider the level of analytical ambition that is appropriate to pursue in the impact assessment.

This is a judgement call by the practitioner based on:

- *Impact type*: the selection of tools needs to reflect the type of impact being assessed. Land-use models can be readily used for changes that are anticipated to result in land use change, however other impacts may be more difficult to model, such as changes in agricultural practices beyond land use (e.g. intensification or changed practices within an existing location) and changes in aquatic biodiversity due to water quality changes.
- *Impact extent and severity*: as highlighted in Chapter 2, biodiversity is spatially heterogeneous which means that some areas are more biodiversity rich, unique and/or vulnerable than others. Furthermore, the extent to which people directly depend on the benefits provided by biodiversity and well-functioning ecosystems varies, with the poor generally being the most reliant on such

resources. The expected extent and severity of impact should therefore increase the level of analytical ambition.

- *Available data*: data availability is a key factor determining what type of analysis is possible. Causal chain analysis allows for more flexibility in terms of using available data on impacts and related indicators to construct a relationship between trade-related drivers, pressures and impacts. Modelling uses fixed data inputs and outputs and therefore the available data needs to meet these requirements. In some cases, data availability might be the factor limiting quantitative analysis.
- *Budget*: the use of quantitative modelling to produce estimated changes in key biodiversity indicators is more resource-intensive than qualitative assessment, requiring dedicated data inputs and sometimes involving sophisticated models, which can be time-consuming to use. Where insufficient budget is available to allow such modelling, less resource-intensive causal chain analysis to carry out qualitative assessment can be employed.
- *Capabilities:* as with budget, modelling requires specific expertise whereas analytical skills and general knowledge about biodiversity can be used in causal chain analysis.

'Moderate' level of ambition: In case a moderate level of ambition is selected, an expected impact will be assessed using causal chain analysis. This means a qualitatively oriented assessment, supported by quantitative information from existing literature and/or some simple quantitative calculations using existing literature.

'High' level of ambition: If a high level of ambition is selected, an expected impact will be assessed using modelling. Depending on the resources and expertise available, causal chain analysis might need to be used to derive ecosystem and/or species level impacts.

Building on the above, the impact assessment process can also become a combination of high and moderate ambition, with quantitative methods used for those key sectors where data and resources so allow and Causal Chain Analysis (CCA) for the remaining key sectors.

Step 2: Establish the impact logic – For each selected priority impact, the impact logic is to be established. The impact logic follows the driver – pressure – impact chain, now "populating" this chain with dedicated indicators to capture the different impacts. At this stage the FTA induced impact (driver) needs to be causally linked to a biodiversity pressure and then further to impact at ecosystems and/or species level. The step should result in a clear plan to analyse each selected priority impact.

Under 'high' ambition, the indicator(s) need to fit the input requirements of the core CGE model and the following modelling chain. The preliminary set of indicators identified at the screening and scoping phase provides the basis for this consideration and should be reviewed here, based on the selection of model(s) and, if necessary, new more suitable indicators need to be explored to fit the modelling logic. If suitable indicators are not available, this points to the need to carry out the assessment with 'moderate' ambition.

Guiding criteria for selecting robust indicator(s) for the assessment – both under the 'moderate' and 'high' ambition includes the following:

- *Availability*: FTA specific indicator(s) should be available for the respective country and ideally also for other countries (for reasons of comparability). They should be available over multiple years to allow for trend analysis. In case it is expected that a certain indicator may not be produced any more in the near future, other indicators should be prioritised. Also, the indicators should be accessible for practitioners and all stakeholders.
- *Descriptive and impact power:* each FTA specific indicator should be able to meaningfully describe the biodiversity situation in a certain country and it should allow to establish FTA induced biodiversity impacts. In other words, based on FTA induced impacts (e.g. change in production in sector X, or a ban on the use of toxic matter Y) and/or the outcomes of the quantitative method, a quantitative change in the indicator should be established. As such, there should be a clear connection with the FTA induced impacts.
- *Interpretability:* FTA specific indicators should be understandable and relatively easy to interpret by (non-expert) stakeholders.

A list of possible indicators with an assessment of their suitability in the context of trade impact assessments can be found in Annexes I and II.

For this step, active participation of the entire team involved in the biodiversity analysis is crucial. This helps to correctly identify the interlinkages between different components of the analysis. If these are not identified at this stage, it may impede an effective impact assessment.

Under the 'high' ambition approach, consulting experts – within or outside the immediate team – to help to understand foreseen model(s) is also considered good practice. This helps to avoid making inaccurate or too simplified assumptions vis-à-vis model application and outputs, ensuring transparency limitations are clearly understood.

'Moderate' ambition: In case the ambition for analysis for a certain priority impact is moderate, the analysis will be based on the principles of CCA. CCA, or root causes analysis, is an analytical tool, which is intensively used in environmental, human rights and social analyses.

In CCA, the path or chain through which a root cause (i.e. in this case trade liberalisation) ultimately results in an impact is analysed. CCA often includes logic diagrams in which connections between links in the chain are shown.

For a concrete example of a CCA based 'moderate ambition' assessment, please consult Annex II.

'High' ambition: The impact logic for 'high' ambition consists of considering two interrelated elements.

Establish the type of FTA-induced impact (e.g. unit of measure) – The impact assessment analyses the effect of the FTA-induced (marginal) change on biodiversity. As such, this component identifies the type of impact which will serve as an input for the further analysis. This commonly is a change in the level of production in a certain sector (such as timber products, meat or cereal production, or mining output), a prohibition of the use of a toxic material or the introduction of a process or practice) to reduce the biodiversity impacts of certain activities.

Selection of model(s) and ensuring their data requirements – It is crucial to have a complete understanding of the required inputs for the modelling exercise and to understand if these inputs can be established and delivered. Data suitability and/or availability lead to the selection of model(s) for quantitative analysis and the type of output (each) model produces (e.g. unit of measure).

Table 5.5 below provides a summary of the commonly available – and used – models to assess trade related biodiversity impacts, ranging from pressure(s) to impact(s) at ecosystem and species level.

Land use models usually need to be provided with pre-defined amounts of future land use (e.g. crop areas), meaning they can be combined with standard outputs of economic models. To allocate the future land use, an initial land use/land cover map, and a set of environmental characteristics is necessary. These depend on the type of land use effects studied, however usually consist of spatial data on soil and terrain, climate, and human settlements and infrastructure. Data should be as recent and detailed as possible (in terms of spatial detail). Land use models allocate the amounts of land use across the territory of the studied area (country or region) based on the empirically derived relationships between land use and the set of used environmental characteristics. This procedure is different for each model, but mostly consists of statistically studying how land use can be explained with the environmental characteristics. Finally, the future land use is allocated based on pre-defined rules that, for example, define which type of land use can be converted, into what type of land use, where conversions can take place, or other rules. These conversions are region/country specific.

Spatially explicit outputs from land-use models enable the identification of more specific impacts on biodiversity in numerous ways. In most simplistic terms, land use change results can be combined with existing data on high value biodiversity areas and/or areas under threat in studied countries, by overlaying the latter on the former in a geographic information system (See Annex II). For a more specific assessment, land use model outputs can be linked to a biodiversity model, where impacts on biodiversity would be assessed in the most rigorous way, as described in Chapter 3 and Annex IV.

Note: if the resources are not sufficient to model the whole chain from pressure to impact, it is acceptable to only model the 'pressure' element of the biodiversity impact chain (i.e. impact of FTA on land- or resource use and/or quality) and then link these results to related 'impacts' on ecosystems and/or species via causal chain thinking. Such approach is also recommended when the impacts verified through land use modelling are small. In such case, allocating resources to biodiversity modelling may not be justified. Furthermore, modelling biodiversity impacts becomes technically difficult when changes in land use are small, diminishing the accuracy of analysis.

For concrete examples of a 'high-ambition' assessment, please consult Annex I and Annex II.

Table 5-5 Summary of potential models to be used to assess biodiversity impacts (pressure – impact)

Model name	Type of model	What covers?	Spatially explicit?	Sector
Eora	EEMRIO	Pressure: Resource use	No	All sectors
EXIOBASE	EEMRIO	Pressure: Resource use	No	All sectors
TRASE	Material flow account (MFA)	Pressure and impact: Deforestation	Yes	Agriculture (commodities)
DynaCLUE	Land use change model	Pressure: Land use	Yes	Agriculture, forestry
CLUMondo	Land use and land use intensification change model	Pressure: Land use and intensity (changed fertilizer, pesticide and water use)	Yes	Agriculture, forestry
LandSHIFT	Land use change model	Pressure: Land use	Yes	Agriculture, forestry
Dinamica EGO	Land use change model	Pressure: Land use	Yes	Agriculture, forestry
FLUS	Land use change model	Pressure: Land use	Yes	Agriculture, forestry
PREDICTS	Biodiversity model (phenomenological)	Impact: Species abundance and species richness	Yes	Agriculture, forestry
Ecopath with Ecosim	Biodiversity model (process-based)	Impact: Marine ecosystem	Yes	Fisheries

Model name	Type of model	What covers?	Spatially explicit?	Sector
GLOBIO	Integrated Assessment model	Pressures and impacts: Species abundance	Yes	Agriculture, forestry and fisheries

Outcomes

The method selection and impact logic design should result in the following outcomes: timely decision on the level of ambition of the analytical exercise and fully designed impact logic and analytical plan with FTA-specific indicators and, for the 'high' ambition approach, identification of selected model(s).

For concrete examples of method selection and impact logic design, please consult Annexes I and II.

5.3 Impact assessment and related conclusions

What is the impact assessment and related conclusions?

The assessment of is carried out as per outlined in Chapter 5.2.

For a concrete example of a biodiversity impact assessment in the context of EU FTA, please consult Annex I.

The conclusions cover the write-up of the overall analysis. They commonly include a summary of baseline and the selection of priority impacts, discuss the results of the impact assessment and provide the relevant wider context necessary to interpret the results of the impact assessment. This wider context draws from the baseline and also reflects the screening and scoping process.

What is the purpose and relevance of conclusions?

The purpose of the conclusions is twofold. The first objective is to inform the reader about the overall process (e.g. selection of priority impacts) and the second objective is to place the impacts in a wider context, reflecting the baseline.

One important role of the conclusions is to complete the analytical chain of biodiversity impacts by reflecting the 'response' in the light of the impact assessment results, drawing from the information compiled in the baseline and during the screening and scoping process. This results in identifying required measures that need to be (put) in place to mitigate foreseen negative impacts and/or boost positive impacts.

Based on the above, conclusions will identify recommendations that then need to be fed into the overall negotiation (ex-ante) and/or implementation evaluation (ex-post) process.

How to draw and present relevant conclusions?

Conclusions should cover the most significant findings of the assessment. They should clearly draw from and be connected to the evidence base put together during the impact assessment process, including both the baseline and the assessment itself.

Evidence on impacts should be clearly presented with references made to the robustness of the results. The impact logic and, where applicable, its modelling chain should be clearly documented, and key underlying assumptions should be transparently presented. This includes any limitations posed by the underpinning economic analysis provided to the assessors by the Commission.

Visualisation of results is encouraged where possible, including impacts assessed through both 'moderate' and 'high' ambition approaches. For example, CCA-based results could be visualised through a set of flowcharts supported by any quantifying evidence. For modelling results, maps provide a useful tool for communicating foreseen areas of impact.

In addition to discussing the key impacts and related outcomes, the conclusions should also reflect any other impacts identified in the screening and scoping stage but not considered significant enough to merit a detailed analysis (i.e. non-priority impacts). For these impacts, possible future changes that could lead to a currently biodiversity 'neutral' sector to become a risk should be flagged up.

Conclusions should aim to cover the following elements:

- A brief discussion of the biodiversity baseline and the outcomes of the impact screening and scoping exercise to justify the selection of priority impacts.
- A clear statement on the methodological tools used (e.g. CCA, modelling or both).
- A presentation of the results of the impact assessment in such a way that they are understandable by non-expert readers.
- A discussion on the implications of the results.
- Concrete and relevant recommendations on 'response' measures to mitigate expected negative impacts or to intensify expected positive impacts.

Recommendations provided should be as specific as possible, referring to concrete policy responses required to address the identified impacts. They should aim to cover two elements: 1) measures linked to the trade liberalisation itself (e.g. measures to prevent trade in products causing deforestation and/or promote trade in biodiversity-friendly products) and 2) flanking measures that affect the outcomes of trade liberalisation (e.g. domestic legislation and its enforcement). The latter could include, for example, the extent and/or management of protected area networks, species protection measures, sustainable management regimes and/or wider biodiversity governance (resources, capacity building etc.). Annex III provides examples of response measures and related indicators.

Finally, the recommendations could be clearly targeted to the most relevant audiences, both in the EU and trade partner country. For example, in the European Commission context, recommendations linked to trade liberalisation are clearly specific to DG TRADE however recommendations linked to flanking measures can also be supported by other DGs such as DGs ENVIRONMENT and DEVCO.

6. PRACTICAL CONSIDERATIONS

Implementing the methodology for assessing biodiversity impacts involves some practical considerations of best practice linked to expertise, resources, time scale and stakeholder engagement.

These considerations are integrated as part of the above chapters however they merit also to be explicitly identified, with more detailed horizontal guidance provided below.

Expertise of the assessment team: It is evident that the application of the methodology requires explicit expertise on biodiversity, ecosystems and related services. This expertise is two-fold including, at minimum, good understanding of issues linked to biodiversity status, impacts and how to assess them (e.g. biodiversity indicators) and, for the 'high' ambition assessment, dedicated expertise on modelling impacts through the different elements of the modelling chain.

In practice, it is understandable that the teams carrying out assessments and evaluations are more trade impact 'generalist' than biodiversity specialists. It is also recognised that the needs for modelling expertise will only become apparent in the course of the assessment process, i.e. not when the team is put together and/or the work is awarded.

To provide a concrete estimate, the assessment carried out in Annex I was conducted by a team of four trade impact assessment experts with explicit prior experience in biodiversity, supported by an expert on land use modelling.

Reflecting the above, a recommended best practice would be to require a robust basic level of biodiversity expertise in the core team, supported by identified external experts foreseen to be called in if the screening and scoping phase leads to a 'high' ambition approach for assessing biodiversity impacts. To support this, financial frameworks for assessments should include a sufficient earmarked budget to be sourced out to external biodiversity experts if needed (see also 'resources' below).

Finally, quantitative outputs of the impact assessment process are pre-determined by the model used (i.e. indicators used to capture impacts are model specific and 'fixed'). Therefore, teams carrying out trade impact assessments should be clear and transparent from the start with regard to the modelling chain they anticipate to use and/or have access to.

Robust economic information base: The methodology highlights the important role of economic modelling in facilitating and/or enabling the assessment of biodiversity impacts. EU trade impact assessments are commonly underpinned by CGE modelling carried out by the Commission, i.e. not by the team conducting the impact assessments.

To ensure the applicability of economic modelling as a basis for biodiversity assessments, a few aspects should be jointly considered by the Commission and the assessment team.

Firstly, the underlying assumptions of economic modelling should be made transparent and clear to the assessment team. This allows the team to better interpret the outcomes of further analysis.

Secondly, the link between the economic and environmental analysis (e.g. biodiversity) could be improved by considering the following:

- Ensuring that the CGE modelling does not 'lose' sectors with possible environmental and biodiversity impacts by grouping together sectors with less economic 'weight'. While such grouping make sense from an economic impact perspective it can result in lack of detail – and therefore a lack of further detailed analysis – for some smaller sectors with relatively large environmental and/or biodiversity footprints or posing specific pressure on the environment and biodiversity.
- Taking up best practice to link CGE modelling to specific environmental and resource satellite accounts that can help to underpin biodiversity analysis. It is feasible for the CGE model to be linked to global datasets on greenhouse gas emissions, air pollution, and resource and land use.

Adequate resources: Expert consultations carried out as part of the development of this methodology have systematically identified that the lack of resources is the key reason limiting the extent and depth of biodiversity – and other sustainability – assessment as part of trade impact evaluation.

No clarification on minimum resources or budget is provided in the existing official SIA guidance by the Commission. However, experts carrying out trade impact assessments indicate that the budget allocated to the environmental aspects of EU trade evaluations – including climate change, greenhouse gas emissions, air quality, use of energy, water and soil quality, land use, waste management, biodiversity or ecosystems and protected areas – takes a minor share of total budget, with resources for biodiversity specific assessment commonly being in the order of magnitude €1000 to €3000 per evaluation. This scale of resourcing does not allow for a detailed analysis to be carried out.

Consequently, a successful uptake and implementation of the methodology requires adequate resources to be made available by the Commission to carry out the assessment in practice. It could be envisaged, for instance, to clearly earmark these resources for the environmental element of any given assessment (%) with an indicative (minimum) share for the biodiversity analysis (e.g. based on prior knowledge of partner country). The use of resource within these envelopes should remain somewhat flexible, reflecting the findings and needs of the assessment as the work progresses, including any need to outsource work to carry out modelling.

To provide a concrete estimate, the assessment carried out in Annex I took around 20 expert days to complete.

Adequate time scale: Understandably, upgrading the rigour of biodiversity and/or broader environmental components of trade impact assessments and evaluations has implications on the time scale within which they can be performed. This needs to be carefully reflected within the FTA negotiation or implementation framework, in order to feed into the broader process in a timely manner.

To provide a concrete estimate, the assessment carried out in Annex I took around 8 weeks to complete.

As future best practice, the Commission should ensure that an adequate timeframe vis-à-vis the policy process is provided for trade impact assessments and evaluation to be carried out.

Stakeholder consultation: Stakeholder consultation is an existing core element of EU trade impact assessment procedures and it also plays an important role in delivering robust biodiversity assessments, especially when it comes to consulting experts in the trade partner countries.

Traditionally, reaching out to expert stakeholders takes place during the screening and scoping phase, to limit the burden on resource use. Arguably – and resources and timescale permitting – engagement with expert stakeholders would be beneficial throughout the assessment process, supporting the development of an as comprehensive as possible baseline and helping to peer-review the outcomes of the assessment process (e.g., verify assumptions underpinning CCA and/or modelling).

As highlighted in Chapter 5, the consultation of expert stakeholders should be structured around the 'driver – pressure – impact – response' chain, seeking to gather information across these different aspects of biodiversity status, trends and possible trade-related impacts in a systematic manner, including aiming to assess data availability. A simple standardised questionnaire could be developed to be used in this context across all future assessments and evaluations where appropriate.

ANNEX I EXAMPLE I – EX-POST ASSESSMENT OF EU FTA WITH COLOMBIA

Note: *This example is based on the application of the methodology in the context of the EU – Andean ex-post assessment, carried out in 2020 - 2021.*

1. BASELINE

1.1 Introduction

Colombia is known for the abundance and diversity of their habitats and species resulting from the variety in geographical characteristics and climate. It holds important ecosystems such as forest systems (e.g., the Amazon forest, mountain forest of the Andes, and the Chocó region), freshwater and coastal wetlands (including mangroves), grasslands and mountains (CEPF, 2015). These serve as natural carbon sinks and generate unique conditions for rich biodiversity. Colombia is among the 17 megadiverse countries in the word [6]. Yet, various pressures are present, such as agricultural activities, (illegal) mining and logging practices, deforestation and forest degradation, wildlife trading, overfishing, urbanization, and climate change. These pressures are putting Colombia's rich biodiversity at risk.

1.2 Governance framework

Colombia signed and ratified the Convention on Biological Diversity (CBD) [7], the Cartagena Protocol [8], the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) [9], and the Nagoya Protocol [10]. In December 2020, Colombia, Bolivia, Ecuador and Peru signed the Andean environmental charter, an instrument to facilitate co-operation in efforts to protect local ecosystems and tackle the climate crisis, as well as to establish shared goals for sustainable development (Republic of Colombia, 2020; LatinNews, 2020).

The National Policy for the Comprehensive Management of Biodiversity and its Ecosystem Services (PNGIBSE) was launched in July 2012 and introduced a new way of addressing biodiversity in the country (CBD, n.d.). PNGIBSE recognises the intrinsic value of species and ecosystems and the functions derived from them, and links biodiversity to human well-being and social viability of local communities. In 2016, the Ministry of Environment and Sustainable Development launched the Biodiversity Action Plan 2016-2030 (PAB), an instrument that guides the implementation of

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[6] In July 2000, the World Conservation Monitoring Centre recognised 17 'megadiverse countries', most located in the tropics. Together, these 17 countries harbour more than 70% of the earth's species (Mittermeier et al. 1997).

[7] The Convention on Biological Diversity aims to 1) conserve the biological diversity, 2) sustainably use of the components of biological diversity and 3) fair and share equitably and fairly the benefits arising out of the utilisation of genetic resources.

[8] The Cartagena Protocol on Biosafety to the Convention on Biological. The Cartagena Protocol on Biosafety to the Convention on Biological Diversity was adopted by the Conference of the Parties to the Convention on 29 January 2000.

[9] CITES aims is to ensure that international trade in specimens of wild animals and plants does not threaten their survival.

[10] The Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization to the Convention on Biological Diversity. The protocol was adopted by the Conference of the Parties to the Convention on Biological Diversity at its tenth meeting on 29 October 2010 in Nagoya, Japan.

PNGIBSE (Minambiente, 2017b). In the CBD's Sixth National Report, Colombia reported the implementation of various important management improvements driven by PAB, which have resulted in progress of the Strategic Plan 2011-2020 and its Aichi Targets (Minambiente, 2019a).

As part of the PAB, Colombia is expanding its protected areas which are managed by the National System of Protected Areas (SINAP). Forest protection started with the introduction of Law 2 of 1959, which created seven large (national) Forest Reserves Zones (RFZ) for developing the economy and protecting water resources, soils, and wildlife (Mes, 2008). There are a variety of schemes targeting the conservation of Colombia's natural and cultural wealth, such as Ramsar sites, biosphere reserves, and Peasant Reserve Areas[11], Zero Deforestation Agreement (Minambiente, 2017b and 2020a). Despite these institutional and regulatory frameworks, the PAB reports that there are several factors[12] preventing the effective implementation of forestry and biodiversity protection measures (Minambiente, 2017b).

1.3 Performance

Table A1E1.1 shows the Environmental Performance Index (EPI). The EPI is based on 32 underlying performance indicators (including biodiversity & habitat) covering 11 categories. All scores are scaled from 100 to 0 (Wendling et al., 2020).

Table A1E1.1 EPI scores for Colombia in 2020

Country	EPI score	Global Rank	EPI score for biodiversity & habitat	Ecosystem services
Colombia	52.9	50th	76.8 (regionally [13] ranked. 7 (Reg. 7))	36.4 (Reg. 11)

Source: Wendling, et al. (2020).

Protected areas: Ecosystem-based adaptation practices, such as the establishment of protected areas [14] and their effective management, are important measures to protect biodiversity (Magrin et al., 2014). The CBD Secretariat (n.d.) defines protected area drivers and pressures as any human activity or related process that has a negative impact on key biodiversity features, ecological processes, or cultural assets within a protected area. Several key drivers are (illegal) exploitation of resources, deforestation, transportation (i.e., roads and ship lanes) and human intrusions, including inappropriate recreational activities. The associated pressures are modification of natural ecosystems, such as altered hydrological and fire regimes, invasive alien species, pollution, and climate change-related threats, such as coral bleaching. A more

[11] Zones that were established to support small scale farmers. It prevents the expansion of the agricultural frontier and neutralize the concentration of ownership.
12 These factors are: i) institutional weakness, reflected in poor implementation of enforcement mechanisms (especially related to illegal logging) and ii) conflicts related to land-use planning (i.e. conflicts between human settlement, production activities, (legal and illegal) and extraction of renewable and non-renewable natural resources (Minambiente, 2017b).
[13] The region includes Latin America & Caribbean
[14] According to the IUCN definition of 2008, a protected area is a clearly defined geographical space, recognised, dedicated, and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values.

indirect pressure is the low awareness in society about the importance of protected areas (Crofts et al., 2020). Drivers and pressures to protected areas can be addressed by effective management of protected areas, as well the evaluation of management effectiveness (Hockings et al., 2006).

In Colombia**,** there is **strong growth of protected areas since 2005** (UNEP-WCMC, 2020) because of the SINAP and other conservation strategies (see governance section). In 2018, a total of 1,093 areas were protected, of which 58 via the Forest Reserves Zones (RFZ), 59 via System of National Natural Parks (PNN) (Ibid.). The other protected areas fall under regional and private [15] protected areas. **Colombia is close to meeting Aichi Target 11** [16] with 15.9% of protected coastal and marine areas and 13.7% terrestrial protected areas (Ibid.). However, the effectiveness of protected areas needs to be assessed for the actual conservation of biodiversity and ecosystem services. Currently, 12.9% of terrestrial protected areas and 4.4% of coastal and marine protected areas are evaluated on their effectiveness (Ibid). Due to a gap in legislation for protected areas, **only a very small proportion of protected areas is truly protected** (Aldana and Mitchley, 2013). Deforestation, mining, and oil exploration affects the protected areas (Minambiente, 2019a). In the BAP (2017), it was reported that 44 mining areas were granted in the PNNs and 57 areas in ZRFs, including highly biodiverse areas of the Amazon, Orinoco and Chocó (Minambiente, 2017b).

Deforestation: Deforestation is among the main pressures to the conservation of biodiversity in Colombia. The principal drivers of deforestation in the Colombian forests are mining, (illegal) logging, agricultural production including oil crops (e.g., palm oil) and illicit crops, and population growth (Minambiente, 2017b). Moreover, deforestation in the Amazon region is closely related to drivers such as poverty, social inequality, the lack of opportunities and armed conflict in the region (FAO, 2020). Associated pressures are land use conversion (forest encroachment), infrastructure projects, urbanisation, and overgrazing (Boucher et al., 2011).

Colombia lost 5.3% of its forest cover between 2001 and 2019, of which 36% of the tree cover loss happened in area of humid primary forests (Global Forest Watch, 2021). The total area of humid primary forest in Colombia decreased by 2.7% (Ibid.). It is estimated that 10% of forest loss was reported in the jurisdiction of indigenous reservations (20,713 hectares) (Minambiente, 2019a). In 2014, deforestation was mainly concentrated in the region of the Amazon rainforest, representing 45% of the total tree cover loss, followed by the Andean region with 24%, and the Caribbean with 17,5% and Pacific with 13.5% (Minambiente, 2017b). It is estimated that 75% of the annual timber production in Colombia comes from natural forests and 25% from commercial plantations. About **42% of this production is illegal**, contributing 480 km^2 of annual forest degradation and overexploitation of 21 tree species (Minambiente, 2017b). In 2018, 70% of the national deforestation was generated in the Amazon region (IDEAM, 2018). Agricultural expansion is also a

[15] Civil society nature reserve (RNSC)

[16] Aichi Biodiversity Target 11 calls for the conservation of "at least 17% of terrestrial and inland water areas and 10% of coastal and marine areas

main **driver** of deforestation in Colombia. Especially crops as cocoa and avocados showed a notable increase in area planted of 88% and 127% between 2012 and 2016 respectively (IDEAM, 2019).

Box A1E1.1 Transformed ecosystems

In **Colombia, land-based and insular ecosystems have changed most over the past years**, while those that are aquatic and coastal ecosystems seem to be preserved in greater proportion (Minambiente, 2017b). Colombia contains 91 types of general ecosystems (marine, aquatic, coastal, terrestrial, and insular), of which 70 corresponds to natural ecosystems and 21 to transformed ones. Between 2005-2009 and 2010-2012 33.5% and 35.1% of the terrestrial ecosystems were transformed, respectively. For island areas, the proportion of changed area is 46.2% between 2010-2012 (IDEAM et al., 2017). **Habitat loss has been related to extensive agriculture for traditional export products and bioenergy crops** (Minambiente, 2019a).

Species: Drivers of biodiversity loss are similar to the drivers to deforestation and threats to protected areas. Pressures are habitat loss resulting from ecosystem transformation driven by e.g., forestry, agriculture and mining activities. Other drivers and pressures to biodiversity are, for instance, illegal trafficking of wildlife species, introduction of exotic species and climate change (Minambiente, 2020b).

The number species have been declining – amphibian species in particular. In total, Colombia contains 54,871 species of which 1,203 are at various threat levels as identified by the International Union for Conservation of Nature (IUCN). More specifically, 173 species are identified as critically endangered, 390 species as endangered and 640 species are categorized vulnerable (Ibid.). **The proportion of threatened species in the critically endangered category and the threatened category lowered since 2005 and has been stable since 2014, whilst the proportion of species in the vulnerable category grew since 2005 and remained stable since** (von Humboldt, n.d.).

1.4 Overview

The detailed baselines described in the previous sections have been used to set the scene, and to inform the impact screening and scoping exercise. Table A1E1.2 schematically summarises the key results.

Table A1E1.2 Drivers, pressures, impacts and responses across environmental impact areas

	Drivers	Pressures	Impacts	Responses
Terrestrial biodiversity	Mining & logging, agricultural production (incl. the harmful use of pesticides), population growth, (illegal) wildlife trafficking, poverty, armed conflicts	Land use change (deforestation and forest degradation) resulting in ecosystem transformation and habitat loss. Invasive alien species, pollution, and climate change-related threats, infrastructure projects, urbanisation, and overgrazing	Loss/degradation of ecosystems and associated biodiversity loss	National/regional biodiversity strategies, including protected areas, sustainable forestry, measures for wildlife trading, sustainable agriculture practices
Marine biodiversity	Fishing, aqua- and agriculture, population growth	Unsustainable fishing practices (e.g., overfishing, IUU fishing), climate change, pollution (e.g., plastic litter and chemicals), deforestation (mangrove areas)	Loss/degradation of ecosystems and associated biodiversity loss	Sustainable fishery policies, IUU fishing regulation, marine protected areas, improve monitoring and surveillance practices

References used in the baseline

Aldana, A., & Mitchley, J. (2013). Protected Areas legislation and the conservation of the Colombian Orinoco Basin natural ecosystems. Nature Conservation, 4, 15.

Boucher, D., Elias, P., Lininger, K., May-Tobin, C., Roquemore, S., & Saxon, E. (2011). The root of the problem: what's driving tropical deforestation today? The root of the problem: what's driving tropical deforestation today?

CEPF. (2015). Ecosystem Profile: Tropical Andes Biodiversity Hotspot. Available here.

Crofts, R.*, Gordon, J.E., Brilha, J., Gray, M., Gunn, J., Larwood, J., Santucci, V.L., Tormey, D., and Worboys, G.L. (2020). Guidelines for geoconservation in protected and conserved areas. Best Practice Protected Area Guidelines Series No. 31. Gland, Switzerland: IUCN.

FAO. (2020). Proyecto REDD+ de Pago por Resultados para Colombia. Available here.

Global Forest Watch. (2021). Deforestation Rates & Statistics for Colombia, Ecuador and Peru | Global Forest Watch [WWW Document]. Available here. Accessed on 14 Jan 2021.

Hockings, M., Stolton, S., Leverington, F., Dudley, N. and Courrau, J. (2006). Evaluating Effectiveness: A framework for assessing management effectiveness of protected areas. 2nd edition. IUCN, Gland, Switzerland and Cambridge, UK. xiv + 105 pp.

IDEAM. (2018). Resultados Monitoreo de la Deforestación 2018. Bogotá, D.C. Available here.

IDEAM. (2019). Estudio Nacional del Agua. Bogotá. 452pp. Available here.

LatinNews. (2020). In brief: Andean countries sign new environmental agreement. Available here.

Magrin, G.O., J.A. Marengo, J.-P. Boulanger, M.S. Buckeridge, E. Castellanos, G. Poveda, F.R. Scarano, and S. Vicuña. (2014). Central and South America. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Barros, V.R., C.B. Field, D.J. Dokken, M.D. Mastrandrea, K.J. Mach, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N.

Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1499-1566

Mes, G. (2008). Colombia: A Country Study within the Framework of the Evaluation of the Netherlands Government's Policy on Tropical Rainforests. Available here.

Minambiente. (2017b). PAB: Biodiversity Action Plan 2016-2030. Available here.

Minambiente. (2019a). CBD's Sixth National Report of Colombia. Available here.

Minambiente. (2020a). Acuerdos Cero Deforestación. Available here.

Minambiente. (2020b). Especies amenazadas en Colombia. Available here. Accessed on 1 Dec 2020.

Mittermeier, R.A., Robles-Gil, P., Mittermeier, C.G. (Eds). (1997). Megadiversity. Earth's Biologically Wealthiest Nations. CEMEX/Agrupaciaon Sierra Madre, Mexico City.

Republic of Colombia. (2020). MIL-OSI Translation: Andean Environmental Chartervia MIL OSI - ForeignAffairs.co.nz. Available here.

UNEP-WCMC. (2020). Protected Area Profile for Colombia from the World Database of Protected Areas, November 2020. Available here.

Von Humboldt, A. (n.d.). Biological Resources Research Institute. Porcentaje de población que vive por debajo del umbral internacional de pobreza extrema. Available here.

Wendling, Z.A., Emerson, J.W., de Sherbinin, A., Esty, D.C., et al. (2020). 2020 Environmental Performance Index. New Haven, CT: Yale Center for Environmental Law & Policy. epi.yale.edu

2. SCOPING AND SCREENING

Scoping and screening of the potential impacts of the FTA in Colombia concluded that impact of the FTA through the horticulture sector on land conversion (related to climate change and biodiversity) is considered a priority impact based on the FTA's positive impact on output in the horticulture sector, especially for the products under the categories 'vegetables, fruits' and 'other crops' (e.g., etc., flowers), and the existing environmental pressures within the sector, related to land conversion, and the country's megadiverse ecosystems.

Pressures due to mining as a result of coal and minerals extraction are not considered priority impacts since no economic impact of the FTA on the extraction of coal or minerals has been observed.

Tables A1E1.3 and A1E1.4 below provide details of the analysis, following the steps outlined in Chapter 5 of this document.

Table A1E1.3 Final impact screening and scoping matrix Colombia

Sectors			Tariff reduction impact	Non-tariff related impact	Biodiversity and natural resources			Priority Impact
	CGE Sector				Pressure	Impact	Response	
Cropland	1	Paddy rice		1	1			Yes
	2	Wheat						
	3	Cereal grains						
	4	Vegetables, fruit	+					
	5	Oils seeds						
	6	Sugar cane/beet						
	7	Plant-based fibres						
	8	Crops	+					
Grazing	9	Cattle, sheep, goats						
	10	Animal products	-					
	11	Wool	--					
[redacted]	12	Forestry		3	3			No
	13	Fishing		4	4			
	14	Coal		2	2			
	15	Oil		2	2			
	16	Minerals		2	2			

++ refers to large positive impact on output, + refers to moderate impact on output,
-- refers to large impact on output, - refers to moderate impact on output.
The numbers shown in the matrix refer to the numbers in the table below

Table A1E1.4 Final impact screening & scoping matrix Colombia (details)

#	Topic		Issue
1	Potential impacts of horticultural sector		Potential positive impact on the production of and trade in **sustainable and organic products** (e.g., coffee, cocoa). A recent study showed that the import of sustainable palm oil from Colombia to the EU increased from 23% to 31% between 2014-2018, and that a growing trend of certified biofuels has been observed (using the ISCC certification) (from 7% in 2017 to 26% in 2018) (Solidaridad, 2019).
			Increased agricultural production may have resulted in **land use conversion** (e.g., deforestation), which may impact Colombia's megadiverse ecosystems (Development Solutions, CEPR, and University of Manchester 2009).
2	Pressures resulting from mining		In general, trade agreements may have supported initiatives and **certification standards** towards sustainable mining (e.g. Better Gold Initiative, Fairtrade and Fairmined). In Colombia, the FTA may have helped in advancing environmental legislation for the mining sector. For instance, in March 2018, the Congress of Colombia approved Colombia's joining of MINAMata Convention on Mercury (EPRS and ICEI, 2018). Furthermore, co-founded by the European Union, the Colombian government signed an agreement in 2018 to take stronger action to implement OECD Due Diligence Guidance

		Green	in Colombian gold supply chains, including a better mining registry, monitoring mechanisms to assess risk, and support capacity building for industry and government (OECD, 2017).
		Red	The mining sector (both legal and illegal mining) has historically been related to negative environmental impacts in Colombia, such as deforestation, soil depletion, and water pollution. If the FTA increased mining activities, these pressures may have been intensified. In some regions of Colombia, mining exploitation is driving the increase in the discharge of untreated water considerably (IDEAM, 2019). In the Colombian Amazon, for example, mining is reported to have increased in the last years due to the extraction of minerals such as gold, cobalt, copper, among others (Ibid).
3	Forestry	Green	As per the TSD Chapter, the parties commit to improve forest law enforcement and the effective implementation of **CITES** for endangered timber species (see chapter IX of the FTA).
		Red	At the same time, the impact on the forestry sector may also have been negative in case the improvements of the **institutional environmental** frameworks have not kept pace with the potential increased export of forest products (CEPR, and University of Manchester 2009; Cantaurias Salaverry, et al., 2015). In Colombia in particular, experts flag deforestation (e.g. in the Amazon) as a major issue.
4	Fish resources	Green	The FTA may have led to **improved cooperation** in the context of Regional Fisheries Management Organisations (RFMO) & combat IUU (Development Solutions, CEPR, and University of Manchester 2009).

Green=potential positive impact, red=potential negative impact

3. METHOD SELECTION AND IMPACT ASSESSMENT

3.1 Introduction and summary

Estimating the spatial extent and distribution of deforestation due to the Andean FTA in Colombia is a complex task, unavoidably requiring the use of certain assumptions. All assumptions are based on best and most detailed data, and state of the art scientific advances on forests, agriculture, and other land use for Colombia. This section explains the methodological steps and summarises the key results.

3.1.1 Step 1: Transposing CGE data on output changes induced by the FTA

This methodology uses the results of the CGE model as inputs to estimate the extent to which the FTA-induced output change resulted in permanent deforestation. The CGE modelling results are used because they provide the most (and only) reliable estimate of *FTA-induced changes* by calculating the difference between the actual observed situation and the modelled (hypothetical) situation without the FTA. As such, the results of the CGE model show the FTA-induced economic changes in 2020. The CGE results cannot be directly used to assess the impact on land use change and deforestation as the results are in monetary units (millions of USD). The first step therefore aims to transpose the CGE results on FTA-induced output changes per sector into a spatial metric (hectares of land).

The following steps are followed to get to the result of step 1 (as shown in Flowchart A1E1.1):

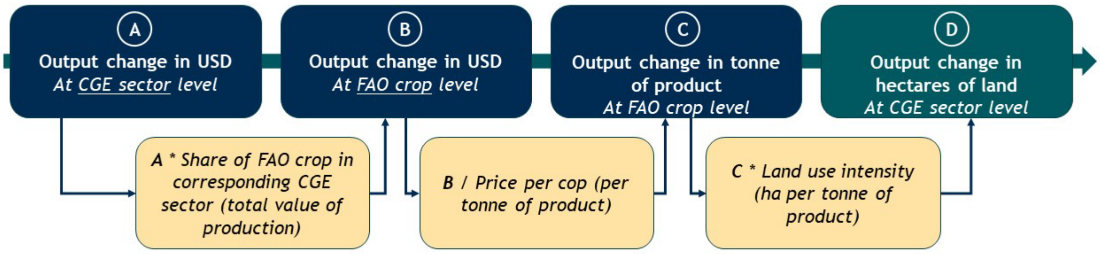
A. The first step is to extract the **FTA-induced output changes per sector (in million USD)** from the CGE model. The output changes at sector level are then disaggregated to output changes at crop level (B). This is done by multiplying the output changes at sector level by the relative share (%) of the total value of production of a certain crop in the total value of production from the overarching sector. This is a necessary step as both the price information and land use intensity are only available at crop level.

B. Now that the **FTA-induced output changes per crop are estimated (in million USD)**, the output change per crop in terms of tonne of product can be calculated. To do this, the output change in million USD per crop is divided by the price of that crop.

C. This results in the estimated **FTA-induced output change at crop level (in tonne of product)**. The output change at crop level is multiplied by the average land use intensity of that crop, to estimate the hectares of land corresponding with the FTA-induced output change.

D. The last step is to aggregate the data again to estimate the **FTA-induced output change in hectares of land per sector**.

Flowchart A1E1.1: Estimating the hectares of land corresponding with the FTA-induced output change in the agricultural sector

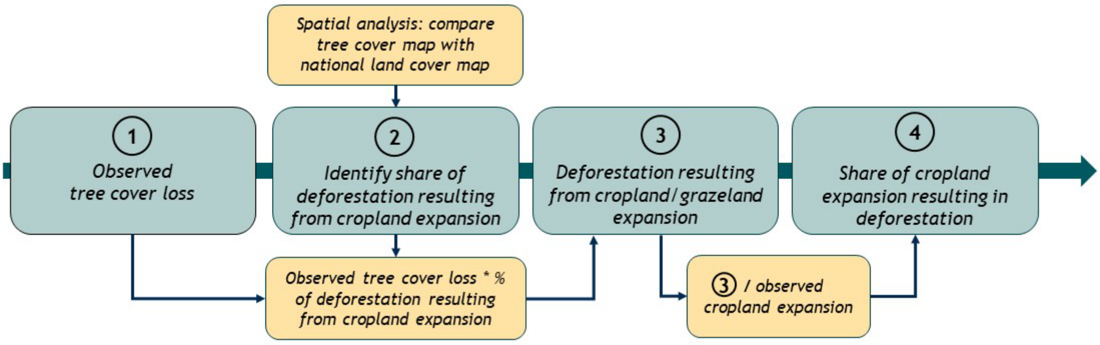


3.1.2 Step 2: Land use change analysis for the Colombia

To deliver the second step, the context of Colombia regarding land use conversion is incorporated in the analysis. The following steps have been used to estimate the share of deforestation resulting from cropland and grazing activities (as shown in Flowchart A1E1.2):

1. The first step is to extract **tree cover loss** data (based on satellite images).
2. In the next step, the spatial analysis commences. By laying a map of Colombia's land cover over the tree cover map, **the share of deforestation resulting from cropland expansion is estimated**.
3. Based on the results of Step 1, the amount (hectares) of deforestation resulting from cropland is calculated for the period 2012-2016 (by multiplying the results from both steps).
4. The last step is to divide the results from step 2 by the actual (observed) cropland increase over the same period, to estimate the **share of cropland expansion resulting in deforestation**.

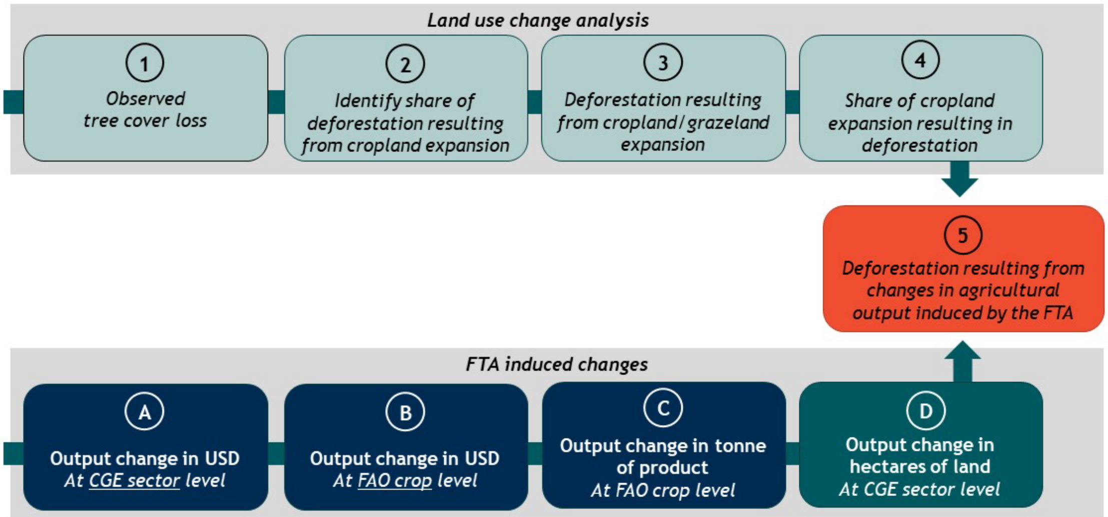
Flowchart A1E1.2: Estimating the share of deforestation resulting from cropland and grazing activities



3.1.3 Step 3: Estimating deforestation resulting from output changes in the agricultural sector caused by the FTA

In Step 3, the outcomes of the previous steps are combined to estimate the deforestation resulting from changes in the agricultural sector induced by the FTA, as shown in Flowchart A1E1.3.

Flowchart A1E1.3: Overall approach



3.1.4 Summary of the results

Based on the analysis, the following conclusions are drawn regarding the impact of the FTA through FTA-induced output changes in the agricultural sectors in Colombia on permanent deforestation and biodiversity:

Thus far it is estimated that the FTA resulted in a *net* increase in cropland areas in Colombia (considering *all* crops produced). It is estimated that this increase resulted in 3,500 to 4,000 hectares of land being permanently deforested. This corresponds to roughly 0.5% of total deforestation observed over the period of the FTA.

Based on the spatial modelling exercise, it appears unlikely that this deforestation occurred in the most (biodiverse) intact areas in Colombia.

3.2 Detailed methodology

This methodology uses the results of the CGE model as inputs to estimate the extent to which the FTA-induced output change resulted in permanent deforestation. The CGE modelling results are used because they provide the most (and only) reliable estimate of *FTA-induced changes* by calculating the difference between the actual observed situation and the modelled (hypothetical) situation without the FTA. As such, the results of the CGE model show the FTA-induced economic changes in 2020. The CGE results cannot be directly used to assess the impact on land use change and deforestation as the results are in monetary units (millions of USD). The first step therefore aims to transpose the CGE results on FTA-induced output changes per sector into a spatial metric (hectares of land). This section explains these steps in detail.

3.2.1 Estimating the land footprint of the FTA based on output changes (CGE)

Output change in USD at CGE sector level

As explained above, the FTA-induced change in output at sector level serves as the basis for this analysis. This data results from the (economic) modelling exercise performed by DG Trade to assess the impacts of this FTA. Although the CGE results cover 59 sectors in total, only the (nine) sectors related to agriculture are included in this analysis, as the objective is to analyse the biodiversity impacts related to changes in the agricultural sector as the agricultural sector is responsible for most deforestation [17]. The first two columns in Table A1E1.5 show the relevant sectors from the CGE model and columns 3-5 show the estimated FTA-induced output change in 2020 per sector.

Output change in USD at FAO crop level

To estimate the corresponding hectares of land associated with economic activity changes, the output changes in USD are first transformed to output change in volumes of product (based on price data) and then to hectares of land (based on land use intensity data). In these steps, FAO data on prices and land use intensity at crop level is used. As the CGE results on output change are not at crop level, the CGE data is distributed over crops using share (%) of the total value of production of a certain crop in the total value of production in the corresponding CGE sector. Data on the total value of production was extracted from FAO and the average shares between 2012-2018 (to correct for yearly differences).

Lastly, the CGE results on output per sector are multiplied with the calculated share (%) of the total value of production of a certain crop in the total value of production in the corresponding CGE sector, to estimate the CGE results at crop level.

Output change in tonne of product/crop

In the next step, the output change in million USD at crop level is divided by the price per tonne of product to estimate the output change per crop in tonne of product. For

[17] We exclude the potential of illegal deforestation that we cannot accurately estimate in this analysis.

this analysis, producer price data[18] from FAO has been used (the average price between 2012-2018 has been used).

Output change in hectares of land

The output change in tonnes of product at crop level was then multiplied by land use intensity per crop to estimate the corresponding area of land. For land use intensity data, FAO statistics at national level have been used (average value between 2012-2018).

The final step was to aggregate the results (from crop level to CGE sector level), which resulted in estimates of FTA-induced output change in hectares of land at CGE level. As shown TableA1E1.5, the *vegetables, fruits nuts* sector experiences the largest FTA-induced output change (in USD). The second largest in output change (in USD) the *crops nec* sector, which includes cocoa and coffee production. It is also noted that the FTA-induced output change in the sector related to grazing (*bovine cattle, sheep, and goats*) is negative. As such, it is considered very unlikely that the FTA contributed to deforestation through grazing activities. For that reason, the analysis focusses on estimating the impacts through the FTA-induced changes in cropland area.

Table A1E1.5 FTA-induced output change in 2020 (in mln USD) and corresponding hectares of land

<table>
<tr><th>#</th><th>Sector</th><th>FTA-induced output change in 2020 (in mln USD)</th><th>Sector</th><th colspan="3">Estimated land use change (in ha)</th></tr>
<tr><td>1</td><td>Paddy rice</td><td>0.0</td><td rowspan="8">Cropland</td><td rowspan="8" colspan="3">10,766</td></tr>
<tr><td>2</td><td>Wheat</td><td>0.0</td></tr>
<tr><td>3</td><td>Cereal grains nec</td><td>- 0.5</td></tr>
<tr><td>4</td><td>Vegetables, fruit, nuts</td><td>45.9</td></tr>
<tr><td>5</td><td>Oil seeds</td><td>- 1.4</td></tr>
<tr><td>6</td><td>Sugar cane, sugar beet</td><td>- 2.3</td></tr>
<tr><td>7</td><td>Plant-based fibers</td><td>0.0</td></tr>
<tr><td>8</td><td>Crops nec</td><td>8.3</td></tr>
<tr><td>9</td><td>Bovine cattle, sheep and goats</td><td>- 5.9</td><td>Grazing</td><td>n/a</td><td>n/a</td><td>n/a</td></tr>
</table>

3.2.2 Estimating deforestation due to agricultural activities between 2012-2019

Increased agricultural output can be achieved in various ways. As such, the relation between output change in the agricultural sector and deforestation is a not given. The

[18] Producer prices are considered the relevant price to estimate volumes of production. The CGE results show the output change in the agricultural sector, dominated by agricultural producers. Ultimately, producers receive a production price. Output change (USD) divided by the production price is considered the most accurate way to estimate production volumes.

first step to assess this was to extract data on observed **tree cover loss** from Global Forest Watch data [19] (GFW, 2021).

Next, estimates on the share of tree cover loss due to commercial agriculture activities resulting in permanent deforestation from Curtis et al. (2018) were consulted, as shown in Table A1E1.6.

The table shows the observed tree cover loss between 2012 and 2019, the share of tree cover loss due to commercial agriculture activities resulting in permanent deforestation, and the multiplication of these numbers to show the estimated amount of deforested areas due to commercial agriculture. Note that, except for the data on observed tree cover loss, these values are not used in the next parts of the analysis.

Table A1E1.6 Role of commercial agriculture in deforestation between 2012 and 2019

Observed tree cover loss ('12-'19)	**% of deforestation due to commercial agriculture ('12-'19)**	**Deforested areas due to commercial agriculture ('12-'19)**
2,026,000 ha [20]	35.2%	713,000 ha

Source: Global Forest Watch data (2021) & Curtis et al. (2018)

3.2.3 Share of deforestation resulting from and livestock grazing

No reliable data exists to distinguish the share of deforestation caused by cropland and livestock grazing in Colombia over the analysis time period. Spatial land *use* data, combined with regularly updated tree cover loss data from Hansen et al. (2013), has therefore been used to identify this relation.

Most recent national land use data has been used, available from the Colombian national authority (IDEAM, 2020). It is noted that, even though this data is the most up-to-date data available, a time lag remains.

Based on a geographic information system (QGIS Development Team, 2020), it was then estimated to what extent deforestation could be attributed to cropland and livestock grazing. **The tree cover loss data for the period 2000-2015 was overlaid with the national land cover maps to identify what the forests were converted to.** An example is provided in Figure A1E1.1.

Based on this spatial analysis, it is concluded that livestock grazing is the main driver for deforestation in Colombia (as shown in Table A1E1.7). This conclusion has been validated using academic literature on deforestation drivers in Colombia. This literature confirmed that livestock grazing (in the form or extensive ranching systems) is the predominant deforestation driver due to it being relatively inexpensive (see for example Armenteras et al., 2013; Clerici et al., 2020).

[19] The GFW data is available for the period 2012-2019, which we used for our estimates.
[20] Data after 2016 was considered unreliable for Colombia. The analysis is therefore based on the data between 2012 and 2016. Observed tree cover loss in Colombia between 2012 and 2016 is equal to 942,900 ha.

As noted earlier, it is unlikely that the FTA resulted in increased grazing activities in Colombia. For that reason – and because the FTA does not cover illicit crops, which are important deforestation drivers in the wider Central American and Andes region (Armenteras et al., 2013; Quintero-Gallego et al., 2018; Tellman et al., 2020) – the focal point of the analysis is deforestation due to cropland activities.

Figure A1E1.1 Overlaying observed deforestation (red locations) with a land cover map

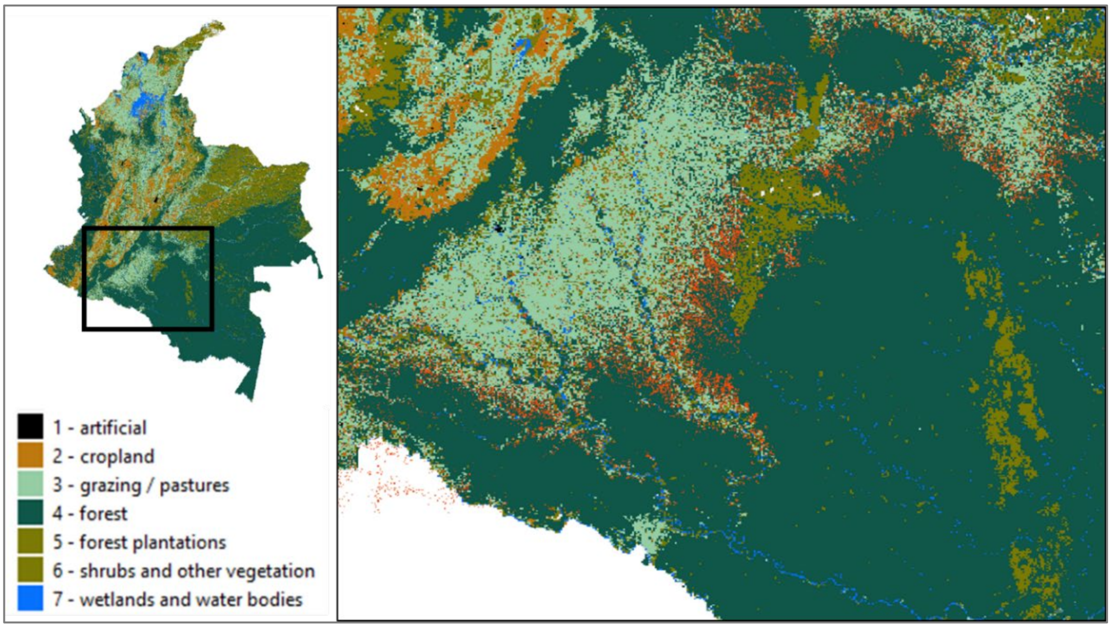


Table A1E1.7 Estimated shares of cropland and livestock grazing in deforestation due to agricultural activities (in %), based on data between the period 2000-2015

Estimated % of cropland in deforestation due to agricultural activities	Estimated % of livestock grazing in deforestation due to agricultural activities
10.2%	89.8%

3.2.4 Cropland change resulting in deforestation

The next step was to identify the **share of cropland expansion resulting in deforestation**. The numerator in the share is equal to the observed tree cover loss multiplied by the share of deforestation caused by cropland expansion (10.2%). Due to lack of certain data after the year 2016 in Colombia, it was decided to base the estimates for the period 2012-2016. The observed tree cover loss in this period in Colombia was equal to 942,900 ha. The denominator is based on FAO statistics (FAO, 2021) on observed **change in cropland area** for Colombia over the same period (273,200 ha). The result of this calculation shows the share of cropland expansion resulting in deforestation in Colombia between 2012 and 2016, equalling 34.5%.

Table A1E1.8 Final calculation to estimate the share of cropland change resulting in deforestation (2012-2016)

Country	Observed tree cover loss	% deforestation caused by cropland expansion	Observed change in cropland area	% cropland expansion resulting in deforestation
Colombia	942,900 ha	10.2%	272,300 ha	34.5%

Source: Calculations Trinomics & IVM

3.2.5 Deforestation resulting from FTA-induced changes in agricultural output

The final step is to multiply the cropland area corresponding with the FTA-induced output change in the agricultural sector by the share of cropland resulting in deforestation. Table A1E1.9 summarises the results.

It is estimated that the FTA-induced output change in the agricultural sector resulted in 3,500 to 4,000 hectares of land being permanently deforested, which corresponds to roughly 0.5% of observed deforestation driven by com-mercial agriculture. Overall, it is estimated that the FTA resulted in a *net* increase in cropland area in Colombia, compared to the hypothetical situation without an FTA (based on the estimated cropland area corresponding with the CGE results, as calcu-lated earlier). This increase is driven by the *vegetables fruits and nuts* sector, in which the FTA-induced output change equals +46 million USD and the *crops nec sector* (+8 million USD). The corresponding estimated amount of cropland area equals roughly 11,000 ha of crop land. Using the share from section 2.4 on the % of cropland ex-pansion resulting in deforestation, it is estimated that the FTA-induced output change in the agricultural sector is related to 3,500 to 4,000 ha of permanent deforested area.

It is difficult to single out individual crops responsible for most deforestation in Colombia. Evidence suggests, that deforestation patterns from similar countries in the vicinity (Brazil, Peru), where soybean and oil palm are major deforestation drivers, have not yet fully emerged in Colombia, also due to the lack of road infrastructure, high poverty levels in the forested areas and overall earlier stage of colonization processes (Armenteras et al., 2013). Nevertheless, cocoa and coffee could have resulted in deforestation in Colombia as well, and in the Caribbean part of the country also banana (Blanco et al., 2012). For all these reasons, we treated all cropland as potential deforestation driver.

Table A1E1.9 Estimated shares of cropland expansion resulting in deforestation

FTA driven cropland change (ha)	Cropland change resulting in deforestation (%)	FTA induced deforestation (ha)	Total (net) cropland change (ha)	% of total net cropland change resulting from FTA
10,766	34.5%*	3,500-4,000 ha	+273,200	1.4%

** This estimate is based on 2012-2016 data (post 2016 data fluctuates considerably and is too uncertain to use)*

3.2.6 Estimating the biodiversity impact using spatial allocation modelling

Spatial allocation of the impacts

To estimate the related biodiversity impact of deforestation related to FTA-induced output changes in the agricultural sector, the estimated deforestation in Colombia was allocated across a 1 km by 1 km grid with a spatially explicit land use change model. Land use maps for Colombia served as the initial year (pre-FTA) and the result was the land use in the year 2020 because of the FTA. The CLUE (Conversion of Land Use and its Effects; Verburg et al., 2008, 1999; Verburg and Overmars, 2009a) modelling framework was used to spatially allocate changes to cropland areas.

The Dyna-CLUE model is sub-divided into two parts: a non-spatial demand module and a spatially explicit allocation procedure. The non-spatial part calculates the area of land use change at the aggregate level (the whole territory of Colombia) is in this study derived from the CGE model and the assumptions explained in the previous sections. The second part of the CLUE model translates the FTA land use demands into land use changes at different locations within Colombia using a raster-based system (spatially explicit data developed using geographic information systems).

To allocate the cropland area resulting from the previous sections, we used empirically quantified relationships between land use and location factors, in combination with the dynamic modelling of competition between land use types. Location factors consist of socio-economic, soil, and climate and terrain characteristics [21]. In this way, CLUE allocates land use change (e.g., cropland expansion) in areas most suitable for cropland activities (based on combinations of accessibility, soil and climate).

Due to the marginal impacts of the FTA on land use activities so far, the impacts on biodiversity (compared to a no-FTA situation) could be marginal as well and difficult to observe on a national scale (as shown in Figure A1E1.2). However, having spatially explicit results, the areas where the model allocated deforestation can be observed in detail (Figure A1E1.3). The model was also validated, by comparing the results to actual observed deforestation in the same period (Hansen et al., 2013). As shown in Figure A1E1.4, much more deforestation has been observed in the same period. Yet, one can observe that the locations in which the model predicted deforestation are in line with the location where deforestation has been observed [22].

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[21] Socio-economic: Distance to cities, distance to roads, market accessibility. Soil: E.g., soil clay and sand, soil depth, soil organic content, soil pH. Climate/terrain characteristics: precipitation and temperature, elevation, and slope.

[22] It is noted that the model's spatial resolution (1 km) and the observed data (30 km) cannot be directly compared. The observed data presents a much finer spatial distribution, to the extent that actual patterns of how deforestation looked like on the field. The model identified landscapes, where deforestation could have occurred, and should therefore be used to identify the context of where deforestation due to an FTA could have occurred.

Biodiversity impact of land use change resulting from FTA-induced output change

It is concluded that it is unlikely that the FTA resulted in deforestation in the most (biodiverse) intact areas in Colombia. This conclusion is based on two observations (1) the overall estimated FTA-induced land use change is marginal in terms of scale, and (2) the spatial modelling exercise shows that most of the projected deforestation was close to existing cropland, cities, and road infrastructure, and very likely in forests that had already been subject to human influence in the past decades. Additionally, none of it seems to have resulted in large scale deforestation and local disappearance of forests. Nevertheless, locally, the FTA could have resulted in forest fragmentation and an overall increase of human influence in areas with high biodiversity, for example in the Central Andean and Caribbean region.

Figure A1E1.2: Allocated deforestation in Colombia due to the FTA

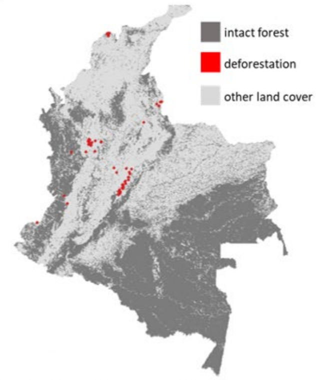


Figure A1E1.3: Allocated deforestation (red colour) in central Colombia

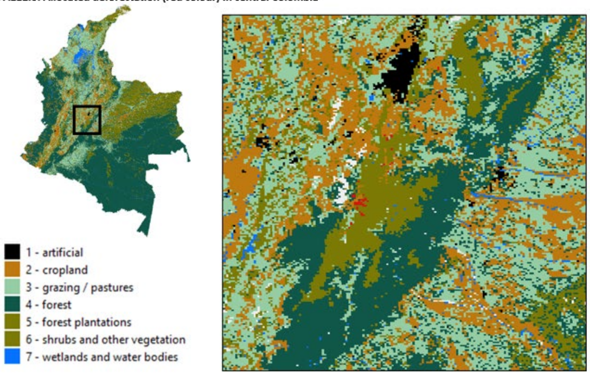
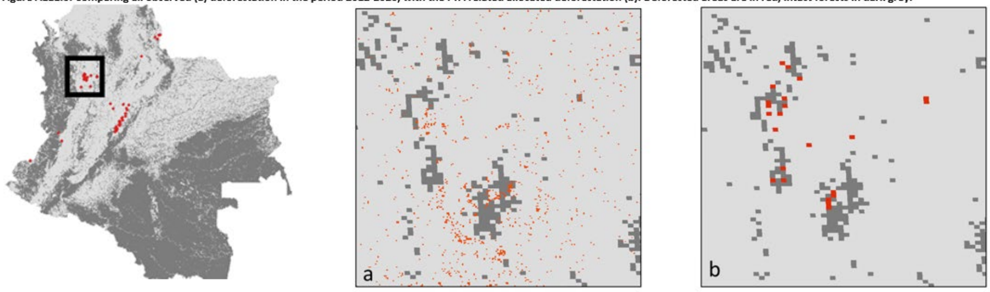


Figure A1E1.3: Comparing all observed (a) deforestation in the period 2012-2020, with the FTA related allocated deforestation (b). Deforested areas are in red, intact forests in dark grey.



References used in the assessment

Armenteras, D., Cabrera, E., Rodríguez, N. & Retana, J. (2013). National and regional determinants of tropical deforestation in Colombia. Reg. Environ. Change 13, 1181–1193. Available here.

Avelino, J., Cristancho, M., Georgiou, S., Imbach, P., Aguilar, L., Bornemann, G., Läderach, P., Anzueto, F., Hruska, A.J. & Morales, C. (2015). The coffee rust crises in Colombia and Central America (2008–2013): impacts, plausible causes and proposed solutions. Food Secur. 7, 303–321. Available here.

Blanco, J.F., Estrada, E.A., Ortiz, L.F. & Urrego, L.E. (2012). Ecosystem-Wide Impacts of Deforestation in Mangroves: The Urabá Gulf (Colombian Caribbean) Case Study. ISRN Ecol. 2012, 1–14. Available here.

Chazdon, R.L., Brancalion, P.H.S., Laestadius, L. et al. (2016). When is a forest a forest? Forest concepts and definitions in the era of forest and landscape restoration. Ambio 45, 538–550. Available here.

Clerici, N., Armenteras, D., Kareiva, P., Botero, R., Ramírez-Delgado, J.P., Forero-Medina, G., Ochoa, J., Pedraza, C., Schneider, L., Lora, C., Gómez, C., Linares, M., Hirashiki, C. & Biggs, D. (2020). Deforestation in Colombian protected areas increased during post-conflict periods. Sci. Rep. 10, 4971. Available here.

Curtis, P.G., Slay, C.M., Harris, N.L., Tyukavina, A. & Hansen, M.C. (2018). Classifying drivers of global forest loss. Science 361, 1108–1111. Available here.

FAO. (2021). FAOSTAT - Food and agriculture data [WWW Document]. Available here.

GFW. (2021). Deforestation Rates & Statistics for Colombia, Ecuador and Peru| Global Forest Watch [WWW Document]. Available here. Accessed on 14 Jan 2021.

Hansen, M.C., Potapov, P.V., Moore, R., Hancher, M., Turubanova, S.A., Tyukavina, A., Thau, D., Stehman, S.V., Goetz, S.J., Loveland, T.R., Kommareddy, A., Egorov, A., Chini, L., Justice, C.O. & Townshend, J.R.G. (2013). High-Resolution Global Maps of 21st-Century Forest Cover Change. Science 342, 850–853. Available here.

Maddela, N.R., Kakarla, D., García, L.C., Chakraborty, S., Venkateswarlu, K. & Megharaj, M. (2020). Cocoa-laden cadmium threatens human health and cacao economy: A critical view. Sci. Total Environ. 720, 137645. Available here.

QGIS Development Team. (2020). QGIS Geographic Information System. Open Source Geospatial Foundation Project.

Quintero-Gallego, M.E., Quintero-Angel, M. & Vila-Ortega, J.J. (2018). Exploring land use/land cover change and drivers in Andean mountains in Colombia: A case in rural Quindío. Sci. Total Environ. 634, 1288–1299. Available here.

Tellman, B., Sesnie, S.E., Magliocca, N.R., Nielsen, E.A., Devine, J.A., McSweeney, K., Jain, M., Wrathall, D.J., Dávila, A., Benessaiah, K. & Aguilar-Gonzalez, B. (2020). Illicit Drivers of Land Use Change: Narco-trafficking and Forest Loss in Central America. Glob. Environ. Change 63, 102092. Available here.

Verburg, P.H., de Koning, G.H.J., Kok, K., Veldkamp, A. & Bouma, J. (1999). A spatial explicit allocation procedure for modelling the pattern of land use change based upon actual land use. Ecol. Model. 116, 45–61. Available here.

Verburg, P.H., Eickhout, B. & van Meijl, H. (2008). A multi-scale, multi-model approach for analyzing the future dynamics of European land use. Ann. Reg. Sci. 42, 57–77. Available here.

Verburg, P.H. & Overmars, K.P. (2009). Combining top-down and bottom-up dynamics in land use modeling: exploring the future of abandoned farmlands in Europe with the Dyna-CLUE model. Landsc. Ecol. 24, 1167. Available here.

Vijay, V., Pimm, S.L., Jenkins, C.N. & Smith, S.J., (2016). The Impacts of Oil Palm on Recent Deforestation and Biodiversity Loss. PLOS ONE 11, e0159668. Avaiable here.

Zambrano, A.M.A., Broadbent, E.N., Schmink, M., Perz, S.G. & Asner, G.P. (2021). Deforestation Drivers in Southwest Amazonia 15.

ANNEX II EXAMPLE II – EX-ANTE ASSESSMENT OF TRADE LIBERALISATION IMPACTS IN BOLIVIA

Note: *This is a theoretical example demonstrating the application of the methodology in an ex-ante context, namely as regards the method selection and final impact assessment. It is not based on any existing or planned EU FTA.*

1. INTRODUCTION

The below provides an example of method selection and final impact assessment developed in the context of overall trade liberalisation for Bolivia.

The example is based on a theoretical full liberalisation of trade of Bolivian agricultural commodities, realising the full potential of the Bolivian cropland and livestock sector. This full liberalisation scenario included a wide variety of FTAs with different partners in the Latin American region but also with the USA and EU. The scenario analyses environmental impacts of trade liberalisation in the period 2020-2035 and presents a 'moderate' and 'high' ambition approach, as per outlined in Chapter 5 of this document.

Both 'moderate' and 'high' ambition approaches start with identifying the drivers: the increased demand for crops and livestock products due to trade liberalisation. This increased demand is calculated by a CGE model and, in the case of this example, resulted in an increase in the amount of new cropland and grazing land necessary to produce these products.

Under both ambitions there is a need to estimate how much of the additional agricultural activities take place in areas with high biodiversity levels. In the case of Bolivia, high biodiversity is primarily associated with tropical forests. Agricultural activities in Bolivia have in the last decades resulted in deforestation and the objective of this assessment is therefore to identify the impact of trade liberalisation on deforestation.

2. MODERATE AMBITION

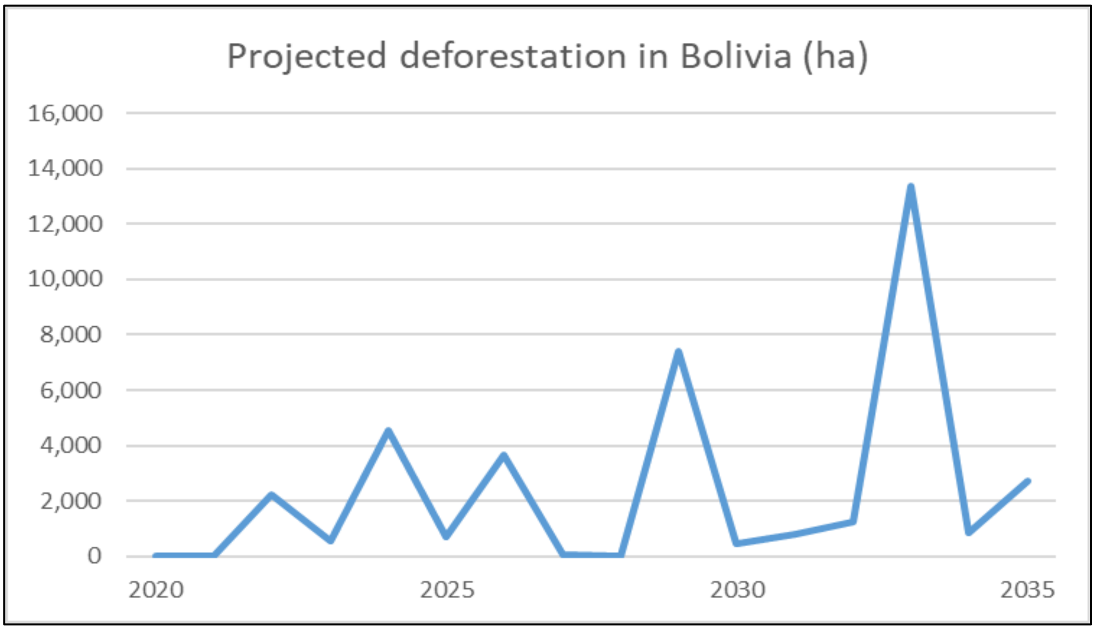
In the moderate ambition, the new land use demands are linked to deforestation by first looking at the past trends. This is based on looking at statistics on past land use change and deforestation. If possible, they can also look at any possible spatial data available.

When it comes to deforestation, publicly available data on forest loss is relatively good, and the consultants need to establish the relationship between past changes to cropland and grazing and deforestation. In Bolivia, evidence shows that in the past decade 77% of all deforestation was due to commercial agriculture, and a majority of it (75 to 80%) was due to livestock grazing, and the rest due to cropland activities (GFW, 2020; Curtis et al. 2018).

By observing past trends, the consultants can identify potential future deforestation in case of trade liberalisation. In the case of Bolivia, it was identified that until 2035, 30,850 ha of additional deforestation would be on the account of full liberalisation (3.2% of total deforestation projected in the same period).

The amount of forest loss can be used in biodiversity assessments. However, the lack of information on the potential locations of deforestation *within* the country means that it is not possible to identify where biodiversity might be particularly impacted due to trade liberalisation. This means that potential biodiversity impacts could be underestimated as forest loss could occur in areas with particularly high biodiversity levels, or in areas that serve as habitats for key species. Figure A2E2.1 shows the difference between the business as usual and trade liberalisation scenario until 2035 in terms of additional deforestation for Bolivia.

Figure A2E2.1: Additional deforestation (in hectares) due to trade liberalisation in Bolivia

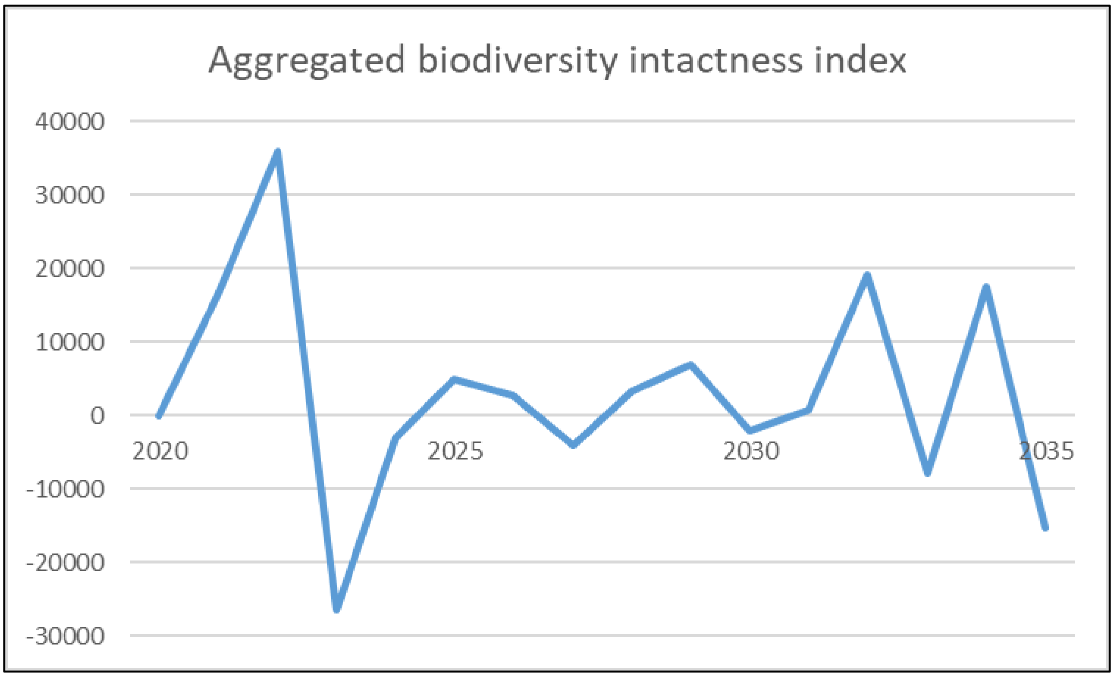


Such non-spatial estimates can also be used for biodiversity assessments, for example, used in combination with the biodiversity intactness index – BII (see Annex III for a description of the indicator). The index is calculated by using the PREDICTS database of studies that quantify the relationship between land use change and biodiversity change. Every land use/cover type receives a coefficient between 0 and 1, which characterises the land use in terms of how intact it is compared to an intact land cover or ecosystem (in the case of Bolivia, for example tropical forest). The aggregated biodiversity intactness index (Figure A2E2.2) can be calculated by multiplying the coefficients of each land use/cover type with the amount of change, where change is defined as a conversion from a more natural or intact land cover type. In this demonstration case, the loss of the aggregated biodiversity intactness index was derived by calculating potential intactness loss of deforestation in the trade liberalisation and no liberalisation scenario. The BII accounts for differences in land use/cover types.

For example, in the Andean case, cropland is 49% less intact than a tropical forest (e.g. Echeverría-Londoño et al., 2016).

Nevertheless, such simplistic biodiversity assessments do not account for location and the spatial variation in biodiversity. Simply put, some areas have higher biodiversity than others, which is why identifying the location of future land use change is of highest importance.

Figure A2E2.2: Future difference in change to biodiversity intactness due to trade liberalisation in Bolivia



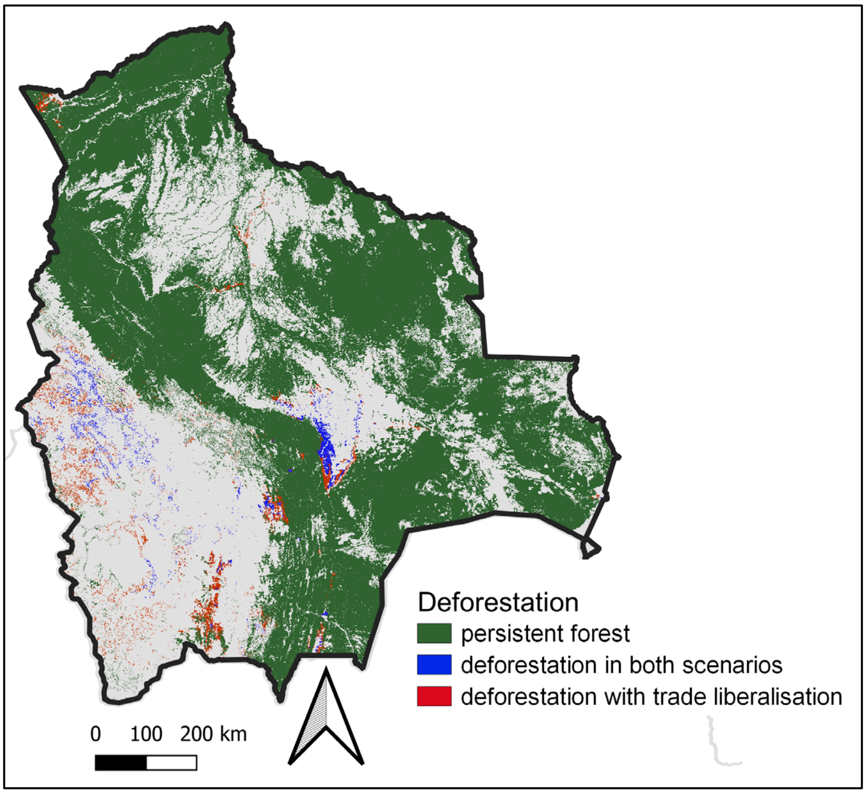
3. HIGH AMBITION

In the high ambition case, a land use model was developed and applied using Dyna-CLUE (Verburg et al., 2009). The model application built on the moderate ambition (above) and used the estimated deforestation due to trade liberalisation.

The modelling started by processing a set of environmental data (explanatory variables) on soil and terrain, climate and infrastructure, to statistically study the relationship between the spatial distribution of different land use/land cover types and these variables. Using these empirically derived relationships and the land use demands from the CGE model, future land use was spatially allocated based on the business as usual and trade agreement scenarios, using the national land use map of Bolivia as the initial year to allocate the changes to.

The resulting land use map for the year 2035 enabled to identify locations which will be likely subject to deforestation as a result of trade liberalisation and increased agricultural activities.

Figure A2E2.3: Identifying deforestation due to trade liberalisation using a spatially explicit land use change model



Having such spatially explicit output enables an identification of more accurate impacts on biodiversity in numerous ways. First, existing data on key habitats in studied countries could simply be overlaid on the land use change results in a geographic information system. While this is not the best approach, due to uncertainties in both the land use and habitat data, it presents a good first step.

Secondly, data on threatened species distribution, importance or intactness could be used (Figures A2E2.4 and A2E2.5, Annex III for more biodiversity indicators). The land use model outputs would ideally be linked to a biodiversity model, where impacts on biodiversity would be assessed in the most rigorous way. Finally, the outputs could be shared with local biodiversity experts that could provide information on potential biodiversity impacts.

Below figures demonstrate how using spatially explicit outputs can be used to identify change to a biodiversity indicator, by using spatially explicit species richness data (Figure A2E2.4) and biodiversity intactness (Figure A2E2.5). Although such data is subject to uncertainties, it can help identify key areas where future trade liberalisation agreements could lead to biodiversity loss.

Figure A2E2.4 concludes that some regions host considerably more mammal species. Identifying which areas are subject to future land use change is therefore important to be able to provide better estimates on potential biodiversity loss. The figure marks areas where future deforestation due to trade liberalisation, as per Figure A2E2.3, was projected to take place, possibly threatening species-rich areas.

Figure A2E2.5 shows that some regions in Bolivia are considerably more intact than others. Identifying which areas are subject to future land use change is therefore important to be able to provide better estimates on how many intact areas remain. The figure marks areas where future deforestation due to trade liberalisation, as per Figure A2E2.3, was projected, possibly threatening intactness.

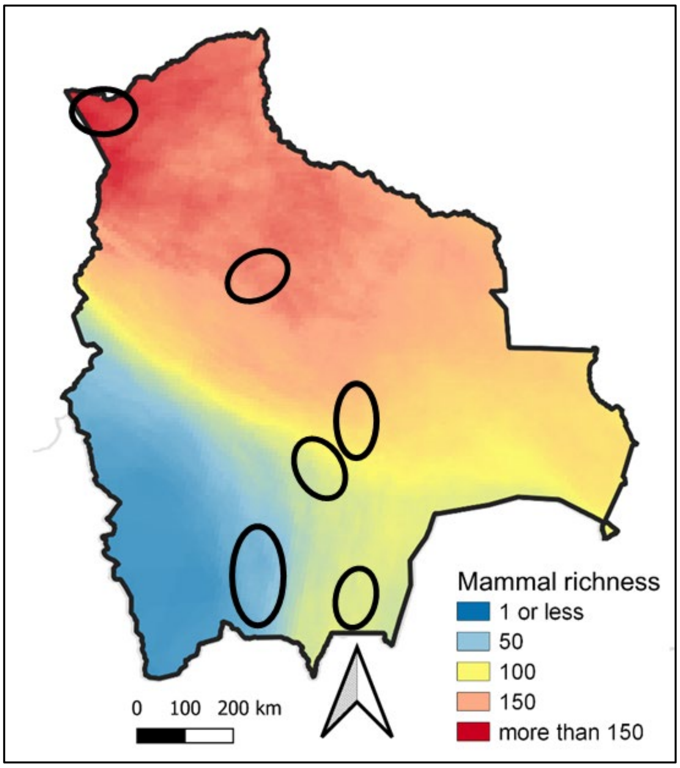


Figure A2E2.4: Spatially explicit data on mammal richness for Bolivia (number of unique mammal species)

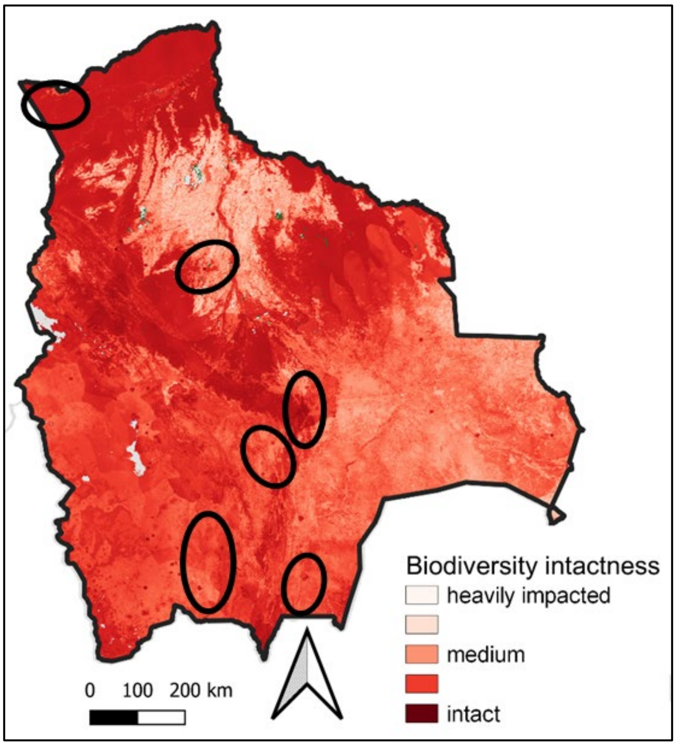


Figure A2E2.5: Spatially explicit data on biodiversity intactness for Bolivia (biodiversity intactness)

References used in the assessment

Curtis, P.G., Slay, C.M., Harris, N.L., Tyukavina, A. and Hansen, M.C., 2018. Classifying drivers of global forest loss. Science, 361(6407), pp.1108-1111.

Echeverría-Londoño, S., Newbold, T., Hudson, L.N., Contu, S., Hill, S.L., Lysenko, I., Arbeláez-Cortés, E., Armbrecht, I., Boekhout, T., Cabra-García, J. and Dominguez-Haydar, Y., 2016. Modelling and projecting the response of local assemblage composition to land use change across Colombia. Diversity and Distributions, 22(11), pp.1099-1111.

GFW, 2020. Global forest watch - Deforestation Maps, Rates & Statistics globally and for individual countries. World Resources Institute, Washington, DC Available from http://www. globalforest-watch.org (accessed December 2020).

Verburg, P.H., Van De Steeg, J., Veldkamp, A. and Willemen, L., 2009. From land cover change to land function dynamics: a major challenge to improve land characterization. Journal of environmental management, 90(3), pp.1327-1335.

ANNEX III – OVERVIEW OF INDICATORS

All indicators included here have data available at the global level, with a possibility to disaggregate the data to national level.

Note: biodiversity indicators are evolving rapidly. The information provided in this Annex reflects the state of knowledge at the moment of publication of this guidance.

Indicator type *(As used in the context of this guidance)*	**Indicator name**	**Indicator producer**	**Year of last update**	**Time series and frequency of updates** *(e.g. 1985-2019, annually)*	**Indicator description**	**Reference**
Pressure	**Trends in potentially environmentally harmful elements of government support to agriculture (producer support estimate)**	OECD	2020	1990- 2019	The data provides an indication on the trends in potentially environmentally harmful elements of government support to producers, as measured by the Producer Support Estimates (PSE). Government support refers to payments made to farmers to manage the supply of agricultural commodities, influence their cost, supplement producers' income and achieve other social and environmental aims. This support to farmers, estimated in terms of the OECD PSE, can be ranked according to its potential impacts on the environment.	Link
Pressure	**Human Appropriation of Net Primary Production (HANPP)**	Institute of Social Ecology, University of Natural Resources and Life Sciences, Vienna	2005	1960-2005	HANPP is an indicator that assesses the extent to which human activities affect flows of trophic energy (biomass) in ecosystems, namely net primary production (NPP), which is a key process in the Earth system. HANPP, measured in units of carbon per year, is the sum of two subcategories: HANPPluc and HANPPharv. HANPPharv is the quantity of carbon in biomass extracted (harvested) by humans or consumed by their livestock per year, including crops, timber, harvested crop residues, forest slash, forages grazed by livestock, and also biomass lost to human-induced fires. HANPPluc denotes alterations in NPP resulting from human-induced land use change, such as the conversion of forest to cropland or infrastructure land. HANPP and its components can be expressed as annual flow of carbon or as percentage of the potential NPP (NPPpot), i.e., the NPP that would prevail in the absence of land use.	Link

Indicator type *(As used in the context of this guidance)*	**Indicator name**	**Indicator producer**	**Year of last update**	**Time series and frequency of updates** *(e.g. 1985-2019, annually)*	**Indicator description**	**Reference**
Pressure	**Change in water use efficiency over time**	FAO (AQUASTAT)	2019	2000-2017	The change in the ratio of the value added to the volume of water use, over time.	Link
Pressure	**Human appropriation of fresh water (water footprint)**	Water Footprint Network			The water footprint measures the amount of water used to produce each of the goods and services we use. It can be measured for a single process, such as growing rice, for a product, such as a pair of jeans, for the fuel we put in our car, or for an entire multi-national company. The water footprint can also tell us how much water is being consumed by a particular country – or globally – in a specific river basin or from an aquifer.	Link
Pressure	**Change in cropland extent**	USGS, FAO			The proportion of an area of interest with land-use devoted to agriculture	
Pressure	**Nitrogen + Phosphate Fertilizers (N+P205 total nutrients)**	FAO			The weight (in tonnes) of three kinds of fertiliser (N,P,K) used in agriculture by countries	
Pressure	**Forest area as a proportion of total land area**	FAO	2020	1990 - 2020 (1990, 2000, 2010, 2015, then annually to 2020)	A measurement of the state of forest cover in a given country	Link
Pressure	**Trends in forest extent (tree cover)**	Hansen et al., 2013			A measurement of how much forest cover has been lost in areas of interest	Link
Impact / Response	**Protected area coverage**	UNEP-WCMC	2020	1900-2020, monthly	This indicator represents how much land in an area of interest is covered by protected areas	Link
Impact	**Proportion of traded wildlife that was poached or illicitly trafficked**	UNODC CITES	2017	2017-annually	The share of all trade in wildlife detected as being illegal	Link

Indicator type *(As used in the context of this guidance)*	**Indicator name**	**Indicator producer**	**Year of last update**	**Time series and frequency of updates** *(e.g. 1985-2019, annually)*	**Indicator description**	**Reference**
Impact	**Biodiversity Habitat Index**	CSIRO	2015	2005- 2015 (every 5 years)	Indicates the impacts of habitat loss, degradation and fragmentation using macroecological modelling	Link
Impact	**Human Footprint**	WCS/UQ/UNBC/NGS	2020	1993-2009 & anticipated 2020, annually	The human footprint map measures the cumulative impact of direct pressures on nature from human activities. It includes eight inputs: the extent of built environments, crop land, pastureland, human population density, night-time lights, railways, roads, and navigable waterways.	Link
Impact	**Marine Trophic Index**	Sea Around Us	2016	1999-	Measures the mean trophic level for all Large Marine Ecosystems and hence indicates the extent of “fishing down the food webs”. This provides a measure of whether fish stocks, especially of large-bodied fish, are being overexploited and fisheries are being sustainably managed.	Link
Impact	**Red List Index (impacts of fisheries)**	IUCN / BirdLife International	2020	1993 – 2020	This version of the Red List Index (RLI) shows trends in the status of birds and mammals worldwide driven only by the negative impacts of fisheries or the positive impacts of measures to control or manage fisheries sustainably.	Link
Impact	**Protected Area Connectedness Index (PARC-Connectedness)**	CSIRO	N/A	2005-2019	Represents how connected terrestrial protected areas are.	Link
Impact	**Species Habitat Index**	MOL, Yale University, NGS	2020	2001-2018 annually	Quantifies the average loss (relative to a baseline year, currently 2001) in suitable habitat that species in a given region (e.g. country) are incurring, weighted by the region’s stewardship for these species.	Link
Impact	**Wetland Extent Trends Index**	Ramsar	2020	1970-2015	Measures trends in wetland area over time, enabling the rate of loss (or growth) of wetland areas to be estimated and gives an indication of the status of wetlands globally.	Link

Indicator type *(As used in the context of this guidance)*	**Indicator name**	**Indicator producer**	**Year of last update**	**Time series and frequency of updates** *(e.g. 1985-2019, annually)*	**Indicator description**	**Reference**
Impact	**Living Planet Index (trends in target and bycatch species)**	ZSL	N/A	1970, annually	Aggregated and summarised trend of the sizes of populations of wildlife species. Used to showcase overall trends of species abundance in target and bycatch species	Link Link
Impact	**Living Planet Index (farmland specialists)**	ZSL			Aggregated and summarised trend of the sizes of populations of wildlife species, fixed at 1 in 1970 as a reference year. Used to showcase overall trends of species abundance in farmland specialist species	Link Link
Impact	**Protected Connected (ProtConn)**	European commission	N/A	2010-2018	A measure of how well protected area networks benefit wildlife species by considering that better-connected PAs provide better protection than poorly connected ones	Link
Impact	**Ocean Health Index**	National Centre for Ecological Analysis and Synthesis (NCEAS)	2019	2012-2019, annually	A scientist-reviewed metric made up of the status, trend, pressures on and resilience of ecological and socio-political systems which contribute to "ocean health"	Link
Impact	**Living Planet Index**	ZSL/ WWF	2020	1970 – 2020, annually (reported every two years	Aggregated and summarised trend of the sizes of populations of wildlife species, fixed at 1 in 1970 as a reference year. Used to showcase overall trends of species abundance	Link Link
Impact	**Proportion of land that is degraded over total land area**	UNCCD	2018	2000-2018, Reported every four years, updated annually	This indicator is defined as the amount of land area that is degraded. The measurement unit for this indicator is the spatial extent (hectares or km2) expressed as the proportion (percentage or %) of land that is degraded over total land area.	Link
Impact	**Biodiversity Intactness Index**	Natural History Museum London			Composite measure of mean abundance/species richness and community similarity to that of primary land - measures the relative "intactness" of nature in different land-use types around the world, based on categorical and continuous factors	Link
Impact	**Global Biodiversity Score**	CDC Biodiversité	2018	Yearly	Assesses impacts of economic activities across their supply chain. Metric= MSA km2- expresses the % intactness of ecosystems.	Link

Indicator type *(As used in the context of this guidance)*	Indicator name	Indicator producer	Year of last update	Time series and frequency of updates *(e.g. 1985-2019, annually)*	Indicator description	Reference
Impact	**Biodiversity Impact Metric**	University of Cambridge Institute for Sustainability Leadership	NA		The Biodiversity Impact Metric, a practical risk-screening tool for supply chain businesses that source agricultural commodities. The approach allows businesses to proactively manage risks relating to the degradation of biodiversity and its wider societal impacts. By highlighting potential high-risk commodities, contexts or practices, businesses can prioritise where to act.	Link
Impact	**Species Threat and Abatement & Recovery**	Pilot availability through IBAT (which is maintained by BirdLife, CI, IUCN, UNEP-WCMC) - in development and not yet fully functional (roll-out in 2021)	2019	2021, annually	The STAR* measures the contribution that investments can make to reducing species extinction. STAR can be used to assess ex-ante (potential) and ex-post (achieved) impacts of investments at a range of scales and over a range of timeframes.	
Impact	**Continuous Global Mangrove Forest Cover for the 21st Century**	Salisbury University	2020	2000-2014, every 5 years	The indicator measures mangrove forest cover on many differing scales	Link
Response	**Number of countries with biodiversity-relevant taxes**	OECD	2020	1980-2020, annually	Environmentally related taxes increase the cost of polluting products or activities, and as a consequence discourage their consumption and production, regardless of whether this was the intended purpose of the tax or not.	Link
Response	**Number of countries with biodiversity-relevant tradable permit schemes**	OECD	2020	1980-2020, annually	Tradable permits are used to allocate emission or resource exploitation rights. They are increasingly used around the world to help achieve policy objectives in mitigating climate change, air pollution, water scarcity or over-harvesting of fisheries.	Link

Indicator type *(As used in the context of this guidance)*	**Indicator name**	**Indicator producer**	**Year of last update**	**Time series and frequency of updates** *(e.g. 1985-2019, annually)*	**Indicator description**	**Reference**
Response	**Number of countries developing, adopting or implementing policy instruments aimed at supporting the shift to sustainable consumption and production**	UNEP	2018	2018, every 2 years	Countries with sustainable consumption and production (SCP) national action plans or SCP mainstreamed as a priority or target into national policies.	Link
Response	**MSC Certified Catch**	Marine Stewardship Council	2019	2000-2019	Measures the green weight catch of fisheries certified by the Marine Stewardship Council and compares this to total wild capture production as reported by the FAO. Certified catch as a percentage of total catch is an indication of the share of global seafood that is caught in an ecologically sustainable manner, and also illustrates commitment from fishers, seafood companies, and governments to achieving and demonstrating sustainability.	Link
Response	**Area of forest under sustainable management: total FSC and PEFC forest management certification**	Forest Stewardship Council (FSC); Programme for the Endorsement of Forest Certification (PEFC)	PEFC: 2020	1995-2017; PEFC: 1999-2010: annually 2011-2020 quarterly	Measures the area certified as responsibly managed forests, including natural or semi-natural forests that are used to produce timber and non-timber forest products, and forest plantations.	Link
Response	**Areas of agricultural land under conservation agriculture**	FAO	N/A	N/A	Measures progress in the global adoption of conservation agriculture, expressed in terms of area	
Response	**Proportion of agricultural area under productive and sustainable agriculture**	FAO	2020	2000-2015, every 3 years	Measures progress towards achieving productive & sustainable agriculture; produced from multiple sub-indicators	Link

Indicator type *(As used in the context of this guidance)*	Indicator name	Indicator producer	Year of last update	Time series and frequency of updates *(e.g. 1985-2019, annually)*	Indicator description	Reference
Response	**Legislation for prevention and control of invasive alien species (IAS)**	IUCN	2018	1967 – 2016	Represents whether or not a country, or the total proportion of countries which have enacted legislation concerning the control of invasive species, or preventative legislation.	Link
Response	**Coverage of protected areas in relation to marine areas**	UNEP-WCMC, IUCN, Birdlife international	2019	1900-2020, annually	Measures how well marine protected areas cover areas identified as marine key biodiversity areas	Link
Response	**Protected Area Coverage of marine Key Biodiversity Areas**	BirdLife International, UNEP-WCMC & IUCN	N/A	1900-2020, annually	This indicator describes the spatial extent to which designated protected areas cover regions of the world which have been identified as Marine Key Biodiversity Areas	Link
Response	**Protected area coverage of ecoregions**	UNEP-WCMC			This indicator is an ecoregion-focused coverage index of how well ecoregions are covered by protected areas	Link
Response	**Average proportion of KBAs covered by protected areas**	BirdLife International, UNEP-WCMC & IUCN	N/A	1900-2020, annually	This indicator describes the spatial extent to which designated protected areas cover regions of the world which have been identified as Key Biodiversity Areas	Link
Response	**Protected Area Representativeness Index (PARC-Representativeness)**	CSIRO	N/A	1970 to 2010: decadal 2010 onwards: biennial	Measures the extent to which terrestrial protected areas are "ecologically representative". This assessment is performed at a much finer ecological and spatial resolution than that typically employed in other assessments of protected-area representativeness. The PARC-representativeness indicator is therefore intended to complement existing indicators of ecological representativeness such as Protected Area Coverage of Ecoregions.	Link
Response	**Coverage by protected areas of important sites**	BirdLife International, UNEP-WCMC & IUCN	N/A	1900-2020, annually	This indicator describes the spatial extent to which designated protected areas cover mountainous regions of the world which have been identified as Key Biodiversity Areas	Link

Indicator type *(As used in the context of this guidance)*	Indicator name	Indicator producer	Year of last update	Time series and frequency of updates *(e.g. 1985-2019, annually)*	Indicator description	Reference
	for mountain biodiversity					
Response	**Proportion of important sites for terrestrial and freshwater biodiversity that are covered by protected areas, by ecosystem type**	BirdLife International, UNEP-WCMC & IUCN	N/A	1900 – 2020, annually	The proportion of sites identified as "important" for biodiversity which are covered by a form of recognised protection, split by ecosystem type	Link
Response	**Number of countries with biodiversity-relevant charges and fees**	OECD	2020	1980-2020, annually	A charge is a requited payment to general government, meaning that the taxpayer gets something in return, more or less in proportion to the payment made whereas a tax is a compulsory unrequited payment. In the database, the terms “fees” and “charges” are used interchangeably.	Link

ANNEX IV – OVERVIEW OF METHODS

1. ECONOMIC MODELS

An important first step in the causal chain analysis (CCA) for assessing the impacts of trade liberalisation on biodiversity and ecosystem services is the assessment of the impacts of trade liberalisation on the volume of international trade and investment flows and on changes in economic activities. As a rule, the macroeconomic impacts of a number of alternative "scenarios" of trade negotiating outcomes are assessed by European Commission services. At the moment, the model of choice for this assessment seems to be the Computable General Equilibrium (CGE) model.

In some SIAs, consultants have *complemented* this core economic assessment with economic assessments of certain individual sectors (e.g. agriculture) in more detail and certain elements under negotiation that have not been assessed in the core economic analysis (e.g. the impact on foreign investments). In these complementary analyses, use has been made of Partial Equilibrium (PE) models and the Gravity model of international trade.

Computable General Equilibrium (CGE) model: CGE models can be used to simulate the impact of changes in tariff and non-tariff barriers on trade flows, on the output of selected industries in the countries involved and third countries, other economic variables at sectoral or national level, and sometimes on a number of environmental variables, such as energy use and CO_2 emissions. In terms of the CCA approach described above, a CGE model can be used to first projecting a baseline scenario of the relevant economies (i.e. current situation without trade agreement) and then to assess the foreseen impacts of the trade agreement under different trade liberalisation scenarios.

The typical CGE model that is used for trade policy analysis does not result in assessing changes in land use or other indicators that are of relevance for the assessment of possible impacts on biodiversity and ecosystems, except sometimes simulating trends in the emissions of particular pollutants and fishing effort under different scenarios (e.g. through satellite accounts, see below).

CGE modelling does, however, provide important information on the expected changes in volumes of economic activities, such as mining, fisheries, forestry, animal husbandry, crop production, and manufacturing that are key inputs in land use and biodiversity models and, in general, can be causally linked with changes in biodiversity.

Output of the CGE models can be linked to satellite accounts fed into economic models that provide more directly applicable indication of biodiversity pressures. The work on satellite accounts has taken flight in the past five years and allows the CGE model to link to global datasets on greenhouse gas emissions, air pollution and resource use (e.g. forest, grazing, agricultural and mining land use intensity).

Partial Equilibrium (PE) model: PE models can be used to provide more detail on the impact of trade liberalisation on particular sectors of the economy, such as the energy sector or agriculture. Given the importance of agriculture on biodiversity, PE analysis of the agricultural sector may be a useful complement of the core CGE analysis. As described in the 2018 scoping study, there are dozens of global agricultural PE models. Some of these models assess land use and land cover changes at the subnational level that are important drivers of impacts on biodiversity and ecosystems.

Table below presents a number of key characteristics of the above-mentioned global PE models, including their accessibility and ease of use.

Table A4.1: Key characteristics of a number of PE models

PE model	Ecosystems	Sectors	Regions	Accessibility	Ease of use	URL
CGAM	Land (pasture, crops, forests, grass and shrubs), water	Food, non-food, feed (20 crops), livestock, forestry, bio-energy	32 geopolitical regions, including EU15, EU12, and large countries such as USA, Canada, Brazil, China, India.	Full accessibility to model and data via github. It is a 'community model' and well-documented. There is an active 'user community'.	Medium, knowledge of data management (XML) and computing required.	jgcri.github.io/gcam-doc/ overview.html
MagPIE	Land (arable, pasture, forest), water	20 crops, 3 livestock	10 world regions, no individual countries	Full accessibility to model and data via github. Good documentation	High, knowledge of GAMS programming language	https://www.pik-potsdam.de/research/projects /activities/land-use-modelling/magpie
GLOBIOM	Land (arable, pasture, forest), water	Food, non-food, feed (18 crops), livestock, forestry, bio-energy	30 regions, including EU, and large countries	No accessibility without help of IIASA staff	High, knowledge of GAMS programming language	https://www.globiom.org/
IMPACT	Land (arable, pasture, forest), water	39 crops, 6 livestock, 17 processed	159 countries, 154 water basins, 320 food production units	Low/no (need to check)	High, knowledge of GAMS programming language	https://www.ifpri.org/project/global-futures-and-strategic-foresight

Gravity models: Gravity models have been called the 'workhorse' of the applied international trade analysis. In some SIAs, they have complemented the core CGE model for the assessment of trade liberalisation on investment flows (e.g. CETA, EU-China investment agreement). Given the increased focus on new trade agreements on investments, the Gravity model is a useful complement of the core CGE analysis. Investment flows may be an important indirect driver of impacts on biodiversity and ecosystems. Apart from this, Gravity models do not provide additional information that is of use for the assessment of impacts on biodiversity and ecosystems.

2. EXTENDED ECONOMIC MODELS

Output of the economic models above, can be directly fed into Environmentally-Extended Multi-Regional Input-Output (EEMRIO) models. The models combine standard economic Input-Output matrices of national economies with natural resources and pollution accounts. These EEMRIO models track the use of both priced and unpriced natural resources (water, air, land) as non-monetary inputs into production. In terms of outputs, they simulate pollution linked to production.

As such EEMRIO models allow making a causal and quantifiable link between changes in economic activity and related changes in a) land and resource use and b) pollution levels. However, they do not typically provide a spatially explicit assessment of this pressure within the country.

There are two key global EEMRIO datasets and models: Eora and EXIOBASE. Eora contains economic and environmental data of 187 individual countries over the period 1990-2012. The sector classification differs per country, but in total the dataset contains 15,909 sectors across the 187 countries. Eora contains 35 types of environmental indicators covering air pollution, energy use, greenhouse gas emissions, water use, land occupation, nitrogen and phosphorus emissions, crop areas, and the Human Appropriation of Net Primary Productivity. EXIOBASE contains data of 43 countries and five aggregate regions for the base year 2007. It contains data of 200 products and 163 industries as well as data on 15 land use types, 48 types of raw materials, and 172 types of water uses. Between these two datasets and models, Eora is commonly seen as a more 'experimental' resource due to its non-harmonised treatment of sectors within the model (i.e. different countries can have more sectors than others).

The EEMRIO models can produce indicators such as changes in ecological footprint, and changes in the number of threatened species. They can also produce indicators on specific ecosystems and ecosystem services such as freshwater use, forest cover, climate regulation, etc. In terms of indicators that are currently used to monitor progress towards the CBD Aichi Biodiversity Targets, EEMRIO models can assess several indicators relating to Target 5 (rate of loss of natural habitats), Target 6 (sustainable fisheries), Target 8 (pollution), and Target 14 (ecosystems that provide essential services, including services related to water). What the EEMRIO models cannot do, however, is to specify how these changes take place spatially at a local level (i.e. in which specific region or area in trade partner country they are likely to occur).

In the *ex-ante* impact assessment of the possible modernisation of the EU-Chile Association Agreement, the Eora model was used to assess the impact on 27 natural resources and pollution flows, including various greenhouse gas emissions, conventional air pollutants, water use, material use, energy use, and nitrogen emissions for both Chile and the EU.

Further advances are also taking place to make EEMRIO models more spatially and/or commodity specific, this way improving the basis for land use and biodiversity models (e.g. Croft et al. (2019), Green et al. (2019) and Brucker et al. (2019)). In addition, some countries do have regional (e.g. state level) MRIO tables, which could theoretically be explored to be applied in future trade impact assessment contexts.

It has been proposed that a combination of EEMRIO and Life Cycle Analysis for "representative" products could be used to assess the environmental footprint of EU trade between the years 2000 and 2010. When fully developed, this method could increase the "granularity" of current EEMRIO analysis and unveil the specific impacts of *products* traded (instead of sector aggregates). While still in an experimental phase, this combination of methods may offer future possibilities for a more "granular" assessment of impacts of trade agreements on biodiversity and ecosystems.

3. LIFE CYCLE ASSESSMENT AND SUPPLY-CHAIN MODELS

Life cycle assessment (LCA) is a "cradle-to-grave" approach for assessing industrial systems. LCA assesses the cumulative environmental impacts resulting from all stages in the product life cycle, often including impacts not considered in more traditional analyses (e.g., raw material extraction, material transportation, ultimate product disposal, etc.). By including the impacts throughout the product life cycle, LCA provides a comprehensive view of the environmental aspects of the product or process and an indication of the true environmental trade-offs in product and process selection. Life cycle analysis is widely used by companies and firms and is promoted by governments and international organisations such as the United Nations' Environment Program and the Society of Environmental Toxicology and Chemistry in their Life Cycle Initiative.

While most LCA models are expensive commercial products, an interesting and free alternative is the TRASE model/database, an initiative of the Stockholm Environment Institute and the NGO Global Canopy that includes detailed information on the supply chains of 13 agricultural commodities and associated deforestation in six South American countries and Indonesia. Whilst not an LCA model in the traditional sense – it contains material flow information based on trading relationships between countries, connected to sub-national locations of production – results from TRASE can provide 'LCA-like' factors to assess the supply mix of importing countries and associated environmental risks.

4. LAND USE MODELS

Land use and land use changes are a reflection of socio-economic conditions of a location, and are an interplay between socio-economic characteristics, economic opportunities and limitations, and biophysical conditions. Land use models are used to explore future land use change dynamics, by spatially allocating externally modelled (i.e. through economic models) economic developments throughout a given landscape.

There are several land use models, however all spatially explicit models have similar data requirements and outputs (in the form of spatial distribution of future land use, that can be used in all geographic information systems software). Some of the most common land use models used (and easiest to set-up) are CLUMondo (van Asselen & Verburg, 2013), Land-SHIFT (Schaldach et al., 2011) and Dinamica-EGO (Ferreira et al., 2019).

In the land use models, land use changes caused by economic developments are allocated across landscapes by considering a number of characteristics known to determine land use patterns, including local socio-economic conditions (e.g. distance to markets), soil quality (e.g. organic content), suitability of the terrain (e.g. slope), and climate characteristics (e.g. precipitation). Within a modelling framework, land use models usually follow economic models (receiving input on future crop, livestock and timber production), and result in an updated (new) land use situation for a given year in the future.

Land use describes the way human use the land, and the economic activities on such land, for example livestock grazing, crop production and high intensity farming. Land cover on the other hand, describes the physical characteristics of a location, such as grasslands, croplands or forests. The two terms are often used interchangeably, although not always correctly. Grasslands as land cover can, for example, present both natural grasslands with high levels of biodiversity, and high grazing intensity pastures with low biodiversity values. This difference is therefore of highest importance when looking at the effects of trade liberalisation in biodiversity, ecosystems and ecosystem services.

Land use models do not only simulate the changes from one land cover type to the other (e.g. forest to cropland), but also changes within land use and land use intensity (such as change from low grazing intensity grassland to high grazing intensity grassland).

Land use models can link the results of economic modelling to specific geographic areas, for example identifying the extent to which areas of high biodiversity (e.g. by looking at species distribution, significant ecosystems such as primary forests, or the amount of ecosystem services lost) are impacted by a trade agreement. However, outputs of land use models need to be combined with biodiversity models or other similar approaches to identify more explicit impacts on biodiversity, ecosystems and ecosystem services.

5. BIODIVERSITY MODELS

There are two types of biodiversity models: phenomenological and process-based. Phenomenological models are based on hypothesized (statistical) relationships between different variables. In process-based models on the other hand, the relationships between variables are specified based on hypothesized biological processes.

Phenomenological models: Phenomenological models usually map changes in biodiversity due to changes in land cover and land use, commonly as per land use models described above. This works in two ways. Firstly, the observed relationships between species ranges and land cover (e.g. species living in forests) remain the same and, building on that relationship, the future land cover map can inform us on the changes to the species range. Secondly, we can link observations in biodiversity response to the change in land use (e.g. by increased intensity of cropland or forestry activities) and use this statistical relationship to estimate biodiversity change due to land use change. The extent of land use and land cover changes can therefore be used to assess the effect of trade agreements on biodiversity, but also on ecosystem services, biomass, carbon stocks, nutrients, etc.

In the phenomenological models, the relationships between land use and land cover and biodiversity are based on a causal relationship between the two, without describing the mechanisms. For example, natural grasslands are associated with a high value for hosting pollinators, and converting them to high-intensity cropland would lead to changes of the pollinator population at the location. These established relationships can be based on case studies, field experiments, and other measurements collected by large meta-analyses, reviews or research projects. One such example is the PREDICTS database, where over 1.3 million records on species abundance and richness are related to local land use and land cover. In case of missing observations, which can be the case for a specific region or country in relation to the trade agreement, or the type of ecosystem services, expert opinion is usually applied to derive such relationships.

Process-based models: Process-based models are based on hypothesized relationships, which can be based on empirical evidence, between different biophysical variables and biological processes. The biological processes considered in such models, describe fundamental ecosystem processes, such as photosynthesis, nutrient cycling, and food web. The models are usually developed and run by climate and vegetation scientists, however coupling with trade models was, until now, rare.

Changes to biodiversity, ecosystems and ecosystem services can be considered in process-based models, similarly as in the phenomenological models, by "updating" the land use and land cover after a trade agreement. While this is valid conceptually, coupling process-based models with land use has not been applied widely. Compared to phenomenological models, process-based models are more suitable to assess indicators with a biophysical unit, such as carbon stocks or nutrient flow. Ecosystem characteristics and services with non-biophysical units (e.g. species range or cultural services) cannot be assessed using these models. Note, that land use is usually taken into account in a simplistic way in such models, or they are operating on such a scale that smaller changes due to trade agreements might not be possible to assess (e.g. local scale deforestation).

6. INTEGRATED ASSESSMENT MODELS

Linking – or coupling – different models is possible and is commonly applied when assessing the effects of economic changes through land and resource use on biodiversity, in the trade context and more broadly. Models mentioned in the previous sections have so been applied in sequence (serving as input to other models). Such linkages are however loose couplings, where a researcher (or researchers from different institutes), run a set of different models independently.

Integrated assessment models (IAM) are comprehensive toolsets that cover several relevant aspects of future environmental change. They usually consist of a chain of different models (e.g. economic, land use, biodiversity), however they frequently have a high degree of integration rather than just running a set of different models in sequence. Integrated assessment models integrate socio-economic and biophysical processes, meaning they are rather large, complex tools, where some processes – among them, land use change – have to be generalized or simplified. Being fully integrated, different models in an IAM are usually internally consistent, also leading to consistent data and a possibility of internal feedbacks.

Being a toolset where different models are integrated (coupled), IAMs offer studying a wide variety of different aspects of environmental change (not all of them relevant for impacts of trade liberalisation). Nevertheless, some of them (e.g. IMAGE, Stehfest et al., 2014; GLOBIOM, Valin et al., 2014) enable the quantification of biodiversity and different ecosystem services, together with an assessment of their change, such as species abundance, water availability and carbon sequestration. Other IAMs are coupled with biodiversity models, for example by looking at the land use and land cover changes and the effects on the Biodiversity Intactness Index (BII, Newbold et al., 2016; Purvis et al., 2018). Usually, IAMs operate on a coarse spatial and thematic scale (e.g. small number of land use types), meaning that not all effects on biodiversity and ecosystems can be studied. Such examples are fine scale effects, such as changes in land use intensity, changes in pollination, or changes in species distribution.

7. SPECIES AREA RELATIONSHIPS MODELS

Species Area Relationships (SAR) models have been frequently used to assess biodiversity loss due to land use change on a regional and global scale. Species richness in such models is defined as a function of the natural habitats and other areas possible to host biodiversity in a region, and the coefficients of natural areas and human land use describing the potential to serve as habitats for a number of species. SARs are used to identify the number of species lost within an area by looking at the converted and remaining natural habitat in the region.

Although the approach considers land use (both current and potential future), land use is simplified in such approaches, usually consisting of a few broad categories without accounting for intensity of management. SARs have been used globally and in different regions for numerous traded goods (e.g. wood, see Chaudhary et al., 2017), most notably within LCAs of land use (e.g. de Baan et al., 2013).

Combined with land use projections, and trade data of different commodities (crops, wood) within LCAs, SARs are used to identify how changes to trade could result in species extinction of different taxa. Other impacts on ecosystems are usually not taken into account, although it has been demonstrated that the impact on ecosystem services can also be assessed by combining it with ecosystem service models or data on ecosystem service values (e.g. Chaudhary et al., 2017).

8. REFERENCES

Bruckner, M., Wood, R., Moran, D., Kuschnig, N., Wieland, H., Maus, V. & Börner, J. (2019). FABIO—The Construction of the Food and Agriculture Biomass Input–Output Model. Environ. Sci. Technol. 53, 11302–11312. Available here.

Chaudhary, A., Carrasco, L.R. & Kastner, T. (2017). Linking national wood consumption with global biodiversity and ecosystem service losses. Sci. Total Environ. 586, 985–994. Available here.

Croft, S.A., West, C.D. & Green, J.M.H. (2018). Capturing the heterogeneity of sub-national production in global trade flows. J. Clean. Prod. 203, 1106–1118. Available here.

de Baan, L., Alkemade, R. & Koellner, T. (2013). Land use impacts on biodiversity in LCA: a global approach. Int. J. Life Cycle Assess. 18, 1216–1230. Available here.

Ferreira, B.M., Soares-Filho, B.S. & Pereira, F.M.Q. (2019). The Dinamica EGO virtual machine. Sci. Comput. Program., Brazilian Symposium on Programming Languages (SBLP '15+16) 173, 3–20. Available here.

Green, J.M.H., Croft, S.A., Durán, A.P., Balmford, A.P., Burgess, N.D., Fick, S., Gardner, T.A., Godar, J., Suavet, C., Virah-Sawmy, M., Young, L.E. & West, C.D. (2019). Linking global drivers of agricultural trade to on-the-ground impacts on biodiversity. Proc. Natl. Acad. Sci. 116, 23202–23208. Available here.

Newbold, T., Hudson, L.N., Arnell, A.P., Contu, S., De Palma, A., Ferrier, S., Hill, S.L.L., Hoskins, A.J., Lysenko, I., Phillips, H.R.P., Burton, V.J., Chng, C.W.T., Emerson, S., Gao, D., Pask-Hale, G., Hutton, J., Jung, M., Sanchez-Ortiz, K., Simmons, B.I., Whitmee, S., Zhang, H., Scharlemann, J.P.W. & Purvis, A. (2016). Has land use pushed terrestrial biodiversity beyond the planetary boundary? A global assessment. Science 353, 288–291. Available here.

Purvis, A., Newbold, T., De Palma, A., Contu, S., Hill, S.L.L., Sanchez-Ortiz, K., Phillips, H.R.P., Hudson, L.N., Lysenko, I., Börger, L. & Scharlemann, J.P.W. (2018). Chapter Five - Modelling and Projecting the Response of Local Terrestrial Biodiversity Worldwide to Land Use and Related Pressures: The PREDICTS Project, in: Bohan, D.A., Dumbrell, A.J., Woodward, G., Jackson, M. (Eds.), Advances in Ecological Research, Next Generation Biomonitoring: Part 1. Academic Press, pp. 201–241. Available here.

Schaldach, R., Alcamo, J., Koch, J., Kölking, C., Lapola, D.M., Schüngel, J. & Priess, J.A. (2011). An integrated approach to modelling land-use change on continental and global scales. Environ. Model. Softw. 26, 1041–1051. Available here.

Stehfest, E., Vuuren, D.P. van, Kram, T., Bouwman, L., Alkemade, R., Bakkenes, M., Biemans, H., Bouwman, A., Elzen, M., Janse, J.H., Lucas, P., Minnen, J., Muller, M. & Prins, A. (2014). Integrated Assessment of Global Environmental Change with IMAGE 3.0 – Model Description and Policy Applications. PBL Netherlands Environmental Assessment Agency, the Hague.

Valin, H., Sands, R.D., van der Mensbrugghe, D., Nelson, G.C., Ahammad, H., Blanc, E., Bodirsky, B., Fujimori, S., Hasegawa, T., Havlik, P., Heyhoe, E., Kyle, P., Mason-D'Croz, D., Paltsev, S., Rolinski, S., Tabeau, A., van Meijl, H., von Lampe, M. & Willenbockel, D. (2014). The future of food demand: understanding differences in global economic models. Agric. Econ. 45, 51–67. Available here.

van Asselen, S. & Verburg, P.H. (2013). Land cover change or land-use intensification: simulating land system change with a global-scale land change model. Glob. Change Biol. 19, 3648–3667. Available here.