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Trade Liberalisation and Biodiversity

Scoping Study:

Methodologies and Indicators to

Assess the Impact of Trade Liberalisation on

Biodiversity (Ecosystems and Ecosystem Services)

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List of Abbreviations

CBD	Convention on Biological Diversity
CCA	Causal Chain Analysis
CETA	Comprehensive Economic and Trade Agreement
CGE	Computable General Equilibrium
DGVM	Dynamic Global Vegetation Model
EEMRIO	Environmentally-Extended Multi-Regional Input-Output model
EC	European Commission
EU	European Union
EU MS	European Union Member State
FDI	Foreign Direct Investment
FTA	Free Trade Agreement
FAOSTAT	Food and Agriculture Organization Corporate Statistical Database
GEM	General Ecosystem Model
GHG	Greenhouse Gas
IAM	Integrated Assessment Model
IUCN	International Union for Conservation of Nature
LCA	Life cycle assessment
NGO	Non-governmental Organisation
OECD	Organisation for Economic Co-operation and Development
PE	Partial Equilibrium
REDD+	Reducing Emissions from Deforestation and Forest Degradation plus
SDG	Sustainable Development Goal
SIA	Sustainability Impact Assessment
SWOT	Strengths-Weaknesses-Opportunities-Threats
TEEB	The Economics of Ecosystems and Biodiversity
TSIA	Trade Sustainability Impact Assessment
TTIP	Transatlantic Trade and Investment Partnership
UNEP	United Nations Environment Program
UNEP-WCMC	United Nations Environment World Conservation Monitoring Centre
UNSD	United Nations Statistics Division
WAVES	Wealth Accounting and the Valuation of Ecosystem Services
WTO	World Trade Organization

ABSTRACT

The objective of this study is to identify and analyse the use of existing methodologies for assessing biodiversity impacts of trade with a view to assist the Commission in developing a robust methodology and related indicators to assess the impacts of trade liberalisation on biodiversity. The existing approach is not adequate because it does not assess and integrate those impacts in a comprehensive or systematic manner. The study identifies and evaluates a number of qualitative and quantitative methodologies that could be used to improve biodiversity related aspects of Sustainability Impact Assessments (SIAs) of trade agreements. The overall conclusion of this scoping study is that a novel approach building on a) a more systematic use of biodiversity indicators and b) a more synchronized and fit-for-purpose use of different methods is needed. This conclusion is supported by the review of existing knowledge and the views of experts working in the field.

EXECUTIVE SUMMARY

Introduction

The EU 2020 Biodiversity Strategy adopted in 2011 commits the EU to enhance the contribution of trade policy to conserving global biodiversity and address potential negative impacts by systematically including it as part of trade negotiations and dialogues with third countries.

The mid-term review of the Strategy published in 2015, however, found that even though the EU had taken initial steps to reduce indirect drivers of global biodiversity loss and to integrate biodiversity into its trade agreements the progress has been insufficient, including in reducing the impacts of EU consumption patterns on global biodiversity. Consequently, the Council has called on the Commission to increase its efforts in implementing the trade-related aspects of the Biodiversity Strategy, thereby increasing the positive contribution of EU trade policy to biodiversity conservation.

One of the barriers to increasing the effectiveness of EU trade policy as a means to support global biodiversity conservation is that there is currently no robust methodology to assess the impact of trade liberalisation – and associated changes in trade flows and/or foreign investment - on biodiversity, including ecosystems and ecosystem services. More in-depth analysis aiming at developing a standard methodology and related indicators to assess the impact of trade on biodiversity is therefore required.

The objective of this study is to identify and analyse the use of the existing methodologies for assessing biodiversity impacts of trade, including foreign investment covered by trade agreements, with a view to assist the Commission in improving the assessment of the impacts of trade liberalisation on biodiversity.

To achieve the above objective this study focuses on identifying and assessing existing methodologies and indicators available to assess biodiversity impacts of trade. The assessment includes a systematic analysis of the strengths and weaknesses of different methodologies as well as gaps in the overall assessment framework. As a part of the process, relevant experts and research institutes on the field have been engaged with, to support the analysis.

Assessing biodiversity impacts in the context of EU's trade policy

Since 1999, the European Commission has been conducting Sustainability Impact Assessments (SIAs) on all negotiated Free Trade Agreements (FTAs) with non-EU countries. At the core of SIAs is the causal chain analysis (CCA) used to identify the relevant cause-effect links between the trade measures proposed and the economic, social and environmental impacts these measures may have. The CCA requires the development of a baseline scenario outlining what the likely economic, social, human rights and environmental developments are in the absence of the trade agreement and against which the likely impacts of the trade agreement under negotiation will be measured and compared. As such CCA forms the basic framework for identifying and assessing possible biodiversity impacts of FTAs, using both qualitative and quantitative means.

The screening of SIAs carried out in the context of this study revealed that there is no clear preferred or systematic approach for assessing biodiversity impacts within SIAs. While biodiversity is commonly used as one of the core sustainability indicators in the analysis of the baseline conditions the sub-indicators used fall considerably short on providing a comprehensive coverage of the Convention on Biological Diversity (CBD) targets and related indicators. All SIAs base their analysis of the expected effects on a combination of qualitative techniques. There is no common mix of techniques across screened SIAs, however the development of in-depth case studies seems to be the most commonly used methodology. The screening further suggests that the impacts on biodiversity of agreements on foreign investment are only marginally considered in the environmental analyses, building similarly on qualitative methods.

Options to improve the assessment of biodiversity impacts

This study identified "nested" options to improve the assessment of biodiversity impacts in SIAs.

Firstly, it is possible to improve the current approach which, as outlined above, is largely qualitative. This centres on making the current approach more systematic and comprehensive and carrying out a systematic and dynamic assessment of core biodiversity indicators (status and diversity of species, protected areas and ecosystems) across all economic sectors. For example, the SIA of the EU-India FTA is a possible good basis for this 'advanced qualitative approach'.

Further to the above, the advanced qualitative approach can be supported by a number of quantitative methodologies. We identified two broad categories of quantitative methodologies that can be nested within the approach. Both of these categories build on the economic analysis currently used in SIAs to project the likely economic developments of the FTA in comparison to the baseline scenario. The first quantitative methodology called 'industrial ecology approach' directly links changes in production and consumption that are projected by the economic analysis to changes in environmental and biodiversity indicators through information derived from case studies, field experiments and expert opinion. The second quantitative methodology is more nuanced and proceeds in two steps. It first translates the projected changes in production and consumption into consequences for land use and then uses the projected land use changes to assess the final impacts on environmental and biodiversity indicators. This can be carried out either by using 'land use models' and 'biodiversity models' in a consecutive manner in the modelling chain or by using 'integrated assessment models' in which economic models, land use models, and biodiversity models are integrated.

Figure 1 below illustrates how the above options are foreseen to be nested within one another. The figure shows the steps in the analysis (on the left) and methods and models that can assist the steps (on the right).

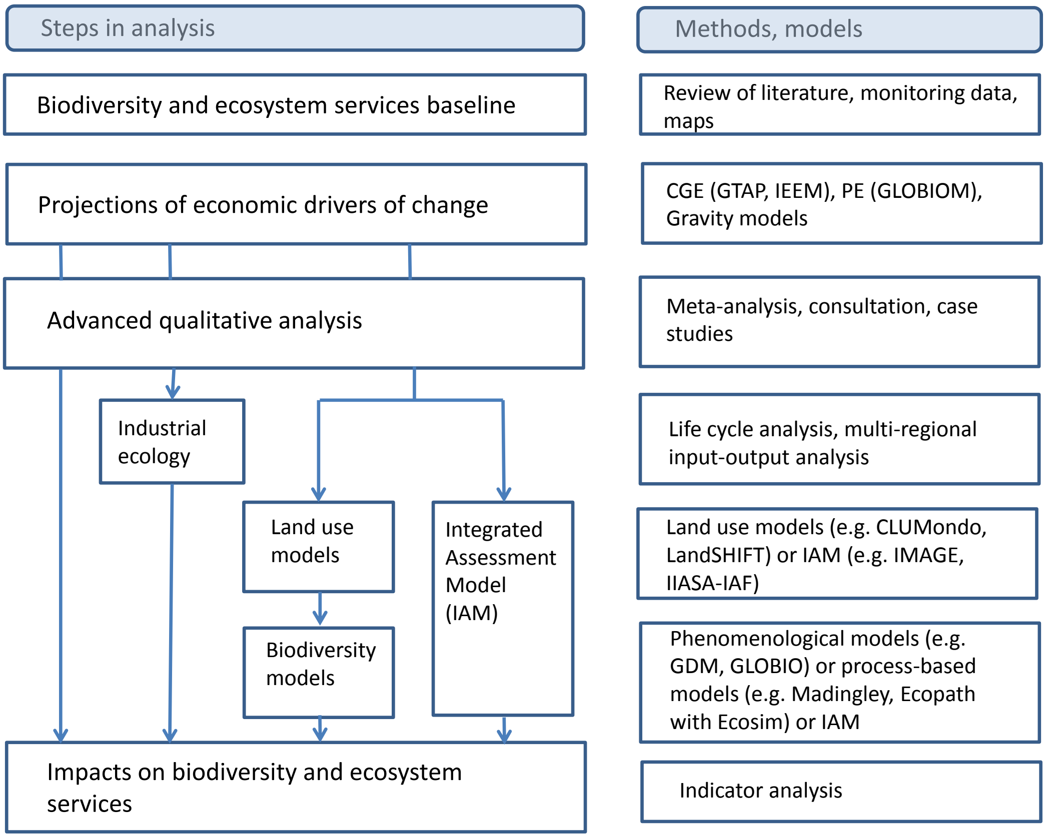

Figure 1: Options for the improvement of the assessment of the impact of trade liberalisation on biodiversity (ecosystems and ecosystem services). On the left side of the figure are the steps in the analysis, starting from the development of a baseline and then proceeding to assessing the possible changes and impacts. For the latter, a range of quantitative methodologies can be nested within a qualitative framework (see text for further details). On the right side of the figure examples of methods and models that could be used in each step of the analysis are shown, with further detail for each method and model provided in Chapter 3 of the report.

Key information and knowledge gaps

The study identified some key knowledge gaps in the assessment of the biodiversity impacts of FTAs. For the assessment of biodiversity impacts it is important to know which economic sectors will expand and which will contract as a consequence of an FTA. According to empirical evidence, the performance of economic models to project sector-level effects of trade reforms remains low. It is likely that the analysis will become even more difficult and the projections more uncertain as new free trade agreements will increasingly focus less on the removal of tariff barriers and more on the removal of non-tariff barriers. Another issue is that the focus of current economic models that are used to project the effects of trade reforms is primarily on energy-intensive sectors of industry and not on land-using sectors. For a robust assessment of the biodiversity impacts a stronger focus on land-using sectors of industry is necessary.

With respect to investment, biodiversity is not consistently considered in the context of SIAs and neither are the impacts on ecosystem functioning and the supply of ecosystem services. If it is considered, the impact of investment on biodiversity is almost exclusively studied for the raw materials extraction sector (i.e. mining). There is little information on possible impacts via other sectors.

In principle, qualitative assessments allow for taking into consideration all biodiversity indicators relevant in the context of FTA impacts. However, none of the existing SIAs provide a comprehensive coverage for impacts per CBD target (i.e. use more than one or two indicators per target). Therefore, even in the qualitative context the current assessment of trade impacts on biodiversity seems not to be comprehensive. Also, the existing assessments do not cover CBD targets and related indicators in any systematic manner, especially across all trade sectors.

Due to data limitations, the application of land-use models in the context of trade impacts remains simplistic focusing on the most predominant land cover only. Such representation ignores a number of aspects that are relevant for biodiversity, such as land use management, land cover composition, and landscape configuration. Recent developments in landscape characterisation for improved land-use modelling, including land systems approaches, aim to overcome these issues, but their use is not yet common practice.

Finally, designing a study that comprehensively assesses the impact of a trade agreement using fine-resolution modelling for a specific country is resource intensive, not available off-the-shelf. Therefore, securing available resources for carrying out robust assessments is a key challenge.

Conclusions and recommendations

No single existing methodology or method can sufficiently address the identified current inadequacies. Therefore, a novel approach building on a) a more systematic use of biodiversity indicators and b) a more synchronized and fit-for-purpose use of different methods is needed. This conclusion is supported both by the review of existing knowledge and the views of experts working in the field.

CCA will continue to form the framework for overall assessments, with qualitative methodologies playing an integral role in identifying and assessing the complex outcomes of trade on biodiversity. However, we recommend that a more advanced qualitative approach, with a comprehensive set and application of biodiversity indicators, reflecting both the possible scope and time scale of impacts, is designed and implemented in the context of the SIA's CCA.

Economic models alone are unfit to assess impacts of FTAs on biodiversity, ecosystems, and ecosystem services. Additional approaches are needed to assess the impacts of economic scenarios on biodiversity. To address this we have, for example, identified quantitative approaches ranging from relatively simple assessment of relationships between economic activity and biodiversity indicators to modelling the causal relationships between drivers for change and impacts on biodiversity. Critical issues are time dimensions and feedback loops, critical thresholds and tipping points, and uncertainty. It is recommended to test some of these more complex approaches for use in SIAs. The testing can probably best be done in retrospective analysis of past FTAs.

A range of indicators already exist to assess the status and changes in biodiversity, however only a handful of these are commonly used in the context of FTA SIAs. Consequently, we recommend the SIA process - and related guidance - to be reviewed with a view to broaden the set of biodiversity indicators included in the assessment. Furthermore, we recommend these indicators to be systematically used across all FTAs. Here we recommend a two-tier approach that includes a) an identification of a set of key indicators to be used across all SIAs complemented by b) a more FTA-specific set of indicators, corresponding to the key trade-related sectors involved. Importantly, we recommend that any assessment of trade impacts on biodiversity starts with the identification of biodiversity concerns and related indicators to match these concerns, with subsequently the most appropriate approaches (methods and models) to cater for these indicators to be selected.

Finally, we recommend dedicated efforts to be taken to provide guidance for and mainstream assessing biodiversity impacts of investment liberalisation in the context of EU trade in the future, building on the broader FTA impact related conclusions and recommendations outlined above.

RESUME ANALYTIQUE

Introduction

L'UE a adopté en 2011 la Stratégie de l'Union Européenne pour la biodiversité afin d'optimiser le rôle des politiques commerciales dans la conservation de la biodiversité mondiale et de diminuer leur potentiel impact négatif en incluant systématiquement cette stratégie dans les négociations et les dialogues commerciaux avec des pays tiers.

Publiée en 2015, l'analyse à mi-parcours de la Stratégie a néanmoins démontré que l'UE avait fait les premiers pas vers une diminution des facteurs indirects de perte de biodiversité et vers l'intégration de la biodiversité dans les accords de commerce mais que les progrès étaient insuffisants, et ce même au niveau de l'atténuation de l'impact du modèle de consommation de l'UE sur la biodiversité. Dans ce contexte, le Conseil en appelle à la Commission à redoubler d'efforts pour l'exécution des aspects commerciaux de la Stratégie pour la biodiversité et à augmenter par-là la contribution positive de la politique commerciale de l'UE sur la préservation de la biodiversité.

L'absence d'une méthodologie efficace pour évaluer l'impact de la libéralisation du commerce (et des changements sur les flux commerciaux et/ou les investissements étrangers qui en découlent) sur la biodiversité, écosystèmes et services écosystémiques compris, est un des obstacles à une politique commerciale efficace de l'UE. Il est donc nécessaire de conduire une analyse plus poussée avec pour objectif la création d'une méthodologie et d'indicateurs permettant d'évaluer l'impact du commerce sur la biodiversité.

L'objectif de cette étude est d'identifier et d'analyser l'utilisation des méthodologies existantes d'évaluation des effets du commerce sur la biodiversité, y compris les effets des investissements étrangers au sein des accords commerciaux, afin de permettre à la Commission d'améliorer son évaluation des impacts de la libéralisation du commerce sur la biodiversité.

En vue d'atteindre l'objectif cité, cette recherche identifie et analyse les méthodologies actuelles et les indicateurs disponibles d'évaluation des effets du commerce sur la biodiversité. Cette évaluation inclut une analyse systématique des forces et des faiblesses des différentes méthodologies ainsi que des lacunes du cadre d'évaluation en général. Au cours du processus, des experts compétents et des centres de recherche sur le terrain ont participé à l'analyse.

Évaluation des effets de la politique commerciale de l'UE sur la biodiversité

Depuis 1999, la Commission européenne réalise des évaluations d'impact sur le développement durable (EID) pour tous les accords de libre-échange (ALE) avec des pays tiers. L'analyse de la chaîne causale (ACC) est au centre des EID, et permet d'identifier les liens de cause à effet entre les mesures commerciales proposées et leur impact social, économique, et environnemental. L'ACC nécessite un scénario de référence précisant quelles seraient, en l'absence d'accords de commerce, les évolutions économiques, sociales, environnementales et en matière de droits de l'homme. Ce scénario permettra de mesurer et de comparer les effets potentiels de l'accord de commerce en cours de négociation. L'ACC en tant que telle forme le cadre de référence d'identification et d'évaluation des impacts potentiels des ALE, en utilisant des méthodes qualitatives et quantitatives.

L'examen des EID mené dans le cadre de cette recherche démontre l'absence d'une approche préférentielle ou systématique d'évaluation des effets sur la biodiversité dans les EID. Tandis que la biodiversité est souvent un des principaux indicateurs de durabilité dans l'analyse de la base de référence, les sous-indicateurs ne suffisent pas à une couverture exhaustive des objectifs et des indicateurs de la Convention sur la diversité biologique (CDB). Toutes les EID centrent leur analyse des effets potentiels sur un ensemble de techniques qualitatives. Il n'y a pas un ensemble commun de techniques parmi les EID examinées, mais il semblerait néanmoins que la méthodologie la plus répandue soit celle des études de cas approfondies. L'examen suggère également que l'impact sur la biodiversité des accords d'investissements étrangers n'est pris en compte que de manière marginale dans les analyses environnementales, qui se construisent de façon similaire, à savoir sur des méthodes qualitatives.

Options pour améliorer l'évaluation des effets sur la biodiversité

Cette recherche identifie des options interdépendantes visant à améliorer l'évaluation des effets sur la biodiversité au sein des EID.

Premièrement, il est possible d'améliorer la méthode actuelle qui, comme cité précédemment, est largement qualitative. Ceci à pour objectif de rendre l'approche actuelle plus systématique et complète, et de mener une évaluation systématique et dynamique des indicateurs fondamentaux de biodiversité (statutnombre d'espèces présentes, aires protégées et écosystèmes) dans tous les secteurs économiques. Par exemple, l'EID de l'ALE UE-Inde pourrait être une bonne base pour cette « approche qualitative poussée ».

Qui plus est, l'approche qualitative poussée peut être appuyée par des méthodologies quantitatives. Nous avons identifié deux amples catégories de méthodologies quantitatives qui peuvent s'imbriquer dans l'approche. Ces deux catégories se construisent sur l'analyse économique actuellement utilisée dans les EID, qui prévoit les possibles développements économiques de l'ALE par rapport au scénario de référence. La première méthodologie quantitative, appelée « approche d'écologie industrielle », établit un lien direct entre les changements de production et de consommation prévus par l'analyse économique et le changement des indicateurs environnementaux et de biodiversité grâce aux informations tirées des études de cas, des expériences sur le terrain et de l'avis des experts. La deuxième méthodologie est plus nuancée et comporte deux parties. Premièrement, elle transforme les prévisions de changement de production et de consommation en conséquences sur l'utilisation des terres. Deuxièmement, grâce aux prévisions de modification d'utilisation des terres, elle évalue les impacts finaux sur les indicateurs environnementaux et de biodiversité. Ceci peut être utilisé soit en utilisant les « modèles d'utilisation des terres » et les « modèles de la biodiversité » de façon consécutive dans la chaîne de modélisation, soit en utilisant des « modèles d'évaluation intégrée », dans lesquels on retrouve les modèles économiques, d'utilisation des terres et de biodiversité.

Le schéma 1 ci-dessous illustre comment les options citées ci-dessus pourraient s'imbriquer les unes dans les autres. Le schéma montre les étapes dans l'analyse (à gauche), et les méthodes et modèles qui viennent en appui (à droite).

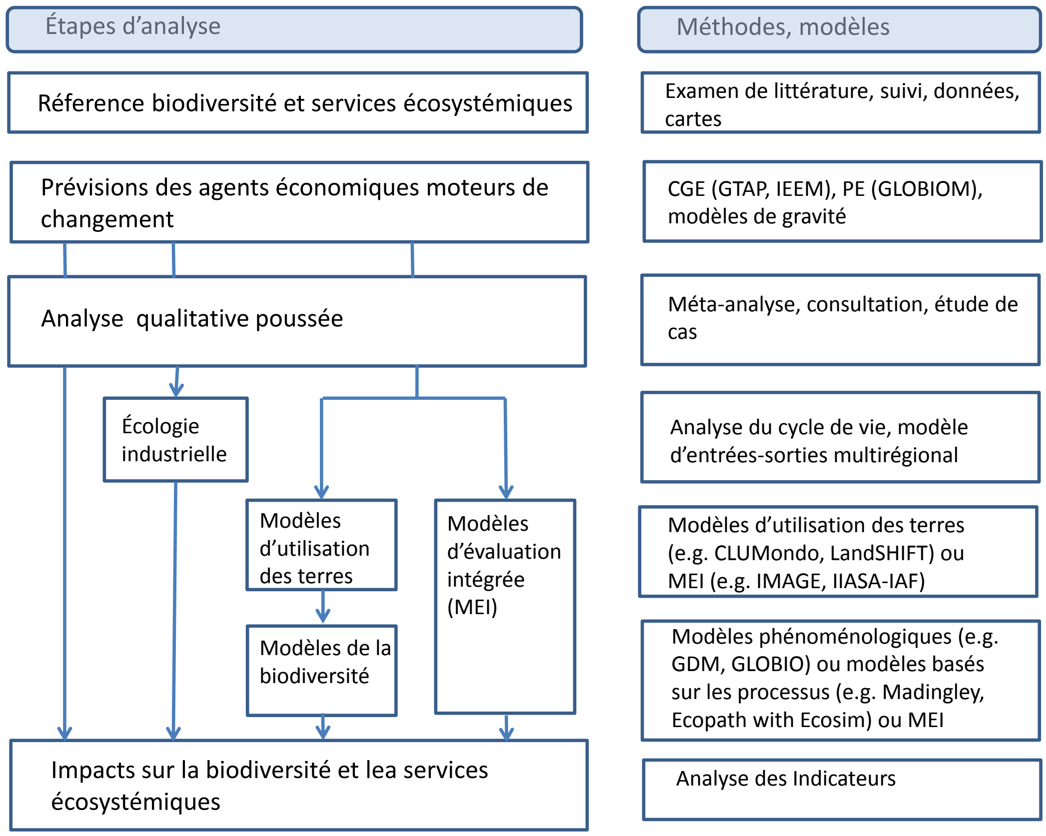

Schéma 1 : Options pour améliorer l'évaluation des effets de la libéralisation du commerce sur la biodiversité (écosystèmes et services écosystémiques). A gauche, les étapes dans l'analyse, en commençant par la création d'un cadre de référence pour ensuite évaluer les changements et les impacts possibles. Pour ces derniers, un éventail de méthodologies quantitatives qui peuvent être intégrées dans un cadre qualitatif (pour plus de détail, voir texte). A droite, des exemples de méthodes et de modèles qui pourraient être utilisées à chaque étape de l'analyse, qui seront détaillées au sein du troisième chapitre du rapport.

Informations clé et lacunes

Cette recherche a identifié certaines lacunes en termes de connaissances dans l'évaluation des impacts des ALE sur la biodiversité. Dans le cadre de l'évaluation des effets sur la biodiversité il est important de savoir quels secteurs économiques vont s'étendre et lesquels vont se contracter suite à un ALE. Selon des preuves empiriques, la capacité des modèles économiques à prévoir les effets des réformes commerciales au niveau sectoriel reste faible. Il est probable que l'analyse devienne encore plus difficile et que les prévisions moins précises, car les nouveaux ALE se centreront de moins en moins sur l'élimination des obstacles tarifaires et de plus en plus sur celle des obstacles non-tarifaires. Autre problème, les modèles économiques actuels utilisés pour prévoir les effets potentiels des réformes commerciales se penchent essentiellement sur les secteurs les plus énergivores de l'industrie, au détriment des secteurs fonciers. Afin d'obtenir une évaluation fiable des impacts sur la biodiversité, il est indispensable de focaliser les recherches sur les secteurs fonciers.

En ce qui concerne les investissements, la biodiversité n'est pas systématiquement prise en compte dans les EID. Il en va de même pour les impacts sur le fonctionnement des écosystèmes et de l'offre des services écosystémiques. S'il est présent, l'impact des investissements sur la biodiversité n'est considéré que pour les secteurs de l'industrie extractive (i.e. le secteur minier). On ne dispose que de très peu d'informations sur les effets potentiels via d'autres secteurs.

En principe, les évaluations qualitatives permettent de prendre en compte tous les indicateurs pertinents en matière d'ALE. Néanmoins, aucune des EID existantes ne propose une couverture complète des impacts par objectif CDB (i.e. utiliser plus d'un ou deux indicateurs par objectif). Par conséquent, même sous un aspect qualitatif, l'évaluation actuelle des effets potentiels du commerce sur la biodiversité ne semble pas être exhaustive. De plus, les évaluations existantes ne couvrent pas les objectifs CDB et leurs indicateurs de façon systématique, ni tous les secteurs d'activité.

Étant donné le manque de données, l'application de modèles d'utilisation des terres dans le cadre des impacts commerciaux reste simpliste, ne prenant en compte que les principales couvertures terrestres. Une telle représentation oublie un certain nombre d'aspects pertinents pour la biodiversité, telles que la gestion de l'utilisation des terres, la composition des sols et la configuration du paysage. Les récentes avancées dans la caractérisation des paysages destinée à l'amélioration de la modélisation de l'usage des terres, y compris des approches topographiques, tentent de contourner ces difficultés. Leur utilisation est néanmoins peu répandue.

Enfin, concevoir une étude qui évalue l'impact d'un accord commercial dans sa totalité en utilisant une modélisation à haute résolution pour un pays en particulier nécessite des ressources considérables et n'est pas immédiatement disponible. Obtenir les ressources requises pour des évaluations fiables est un défi de taille.

Conclusions et recommandations

Aucune des méthodologies ou méthodes actuelles ne peut pallier aux faiblesses identifiées. Par conséquent, une nouvelle approche sur base de a) une utilisation plus systématique des indicateurs de biodiversité et de b) un usage plus synchronisé et sur-mesure des différentes méthodes est nécessaire. Tant l'analyse des connaissances existantes et l'avis des experts sur le terrain appuient cette conclusion.

L'ACC restera le cadre général d'évaluation, au sein duquel les méthodes qualitatives joueront un rôle essentiel dans l'identification des répercussions complexes du commerce sur la biodiversité. Nous recommandons cependant, pour les EID des ACC, la conception et la mise en place d'une approche qualitative plus poussée, avec un ensemble complet d'indicateurs de biodiversité (tant en nombre d'indicateurs qu'en termes d'application de ceux-ci), et qui évalue l'ampleur et l'échelle de temps des impacts.

Les modèles économiques sont à eux seuls incapables d'évaluer les effets potentiels des ALE sur la biodiversité, sur les écosystèmes et sur les services écosystémiques. Il faut des approches complémentaires afin de prévoir les impacts des scénarios économiques sur la biodiversité. En réponse à ceci nous avons, par exemple, identifié des méthodes quantitatives allant d'une évaluation relativement simple des liens entre activité économique et indicateurs de biodiversité pour modéliser le lien causal entre les moteurs de changement et les impact sur la biodiversité. Il est recommandé de tester certaines de ces méthodes plus complexes sur les EID. Les tests pourraient probablement être réalisés lors d'une analyse rétrospective d'ancien ALE.

Il existe déjà une palette d'indicateurs pour évaluer le statut et les changements de la biodiversité. Cependant très peu d'entre eux sont utilisés dans le contexte d'EID d' ALE. Nous recommandons donc que les processus d'EID (et les orientations connexes) soient revus en élargissant le nombre d'indicateurs utilisés. En outre, nous recommandons l'application systématique de ces indicateurs pour tous les ALE. Nous recommandons ici une approche en deux temps : a) identification d'un éventail d'indicateurs clés à utiliser au cours de toutes les EID et b) compléter avec des indicateurs spécifiques aux ALE, correspondants aux secteurs commerciaux concernés. Nous recommandons essentiellement que toute évaluation des effets potentiels du commerce sur la biodiversité commence par l'indentification des préoccupations liées à la biodiversité et les indicateurs qui en découlent, pour ensuite choisir les approches (méthodes et modèles) appropriées.

Enfin, nous recommandons que des efforts considérables soient entrepris afin de systématiquement accorder, à l'avenir, une place aux impacts de la libéralisation des investissements sur la biodiversité dans le commerce de l'UE. Ce, grâce aux conclusions sur l'impact des ALE et aux recommandations citées ci-dessus.

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1 INTRODUCTION

1.1 Background

The EU 2020 Biodiversity Strategy[1] adopted in 2011 commits the EU to enhance the contribution of trade policy to conserving global biodiversity and address potential negative impacts by systematically including it as part of trade negotiations and dialogues with third countries (Target 6, Action 17b).

The mid-term review of the Strategy published in 2015, however, found that even though the EU had taken initial steps to reduce indirect drivers of global biodiversity loss and to integrate biodiversity into its trade agreements the progress has been insufficient, including in reducing the impacts of EU consumption patterns on global biodiversity. Consequently, the Council has called on the Commission to increase its efforts in implementing the trade-related aspects of the Biodiversity Strategy, thereby increasing the positive contribution of EU trade policy to biodiversity conservation.

One of the barriers to increasing the effectiveness of EU trade policy as a means to support global biodiversity conservation is that there is currently no robust methodology to assess the impact of trade liberalisation – and associated changes in trade flows and/or foreign investment - on biodiversity, ecosystems and ecosystem services. More in-depth analysis aiming at developing a standard methodology and related indicators to assess the impact of trade on biodiversity is therefore required.

1.2 Scope and objectives

The purpose of this study is to identify and analyse the use of the existing methodologies for assessing biodiversity impacts of trade, including foreign investment covered by trade agreements, with a view to assist the Commission in developing a robust methodology and related indicators to assess the impact of trade liberalisation on biodiversity.

To achieve the above objective this study focuses on identifying and assessing existing methodologies used or available to assess biodiversity impacts of trade. In this context, it also briefly explores the role of trade related foreign investment and its possible implications on biodiversity. The assessment includes a systematic analysis of the strengths and weaknesses of different methodologies as well as gaps in the overall framework of available methodologies in assessing biodiversity impacts.

As a part of the process, relevant and knowledgeable experts and research institutes on the field have been systematically engaged with, to support the analysis.

Finally, the scoping assessment leads to the development of preliminary suggestions as to potential avenues for future work aimed at developing a robust and comprehensive approach to assess the impact of trade and/or investment liberalisation on biodiversity, ecosystems and ecosystems services in the context of EU free trade agreements (FTAs).

1 http://ec.europa.eu/environment/nature/biodiversity/strategy/index_en.htm

1.3 Approach and methodology

The work was carried out in two stages. In the first stage relevant existing approaches, methodologies, methods and models, including the biodiversity indicators they cover, were identified and assessed. In the second stage the information on different approaches etc. led to a comparative assessment of gaps, opportunities and challenges of the existing frameworks. These two stages of work have been supported by engagement with key stakeholders with a view to complement the review of literature.

Identifying and assessing existing approaches: Dedicated literature searches on the existing approaches, methodologies, methods and models available to assess the impact of trade liberalisation on biodiversity and ecosystems have been carried out. These searches have been conducted through standard and academic search engines (e.g. SCOPUS, Google Scholar, Web of Science, Research Gate, RepEc), including both peer-reviewed and expert literature. The literature search has covered available material that focuses on trade and biodiversity/land use changes/material use directly and material that is not directly related to trade but can be applicable to trade (i.e. impacts of the production of key tradable products on land use / biodiversity).

As the first step of the literature review, the integration of biodiversity into developing the existing EU trade agreements has been reviewed to form a state-of-play backdrop for the assessment. This is based on a review of the existing Sustainability Impact Assessments (SIAs) carried out in the context of EU trade negotiations. As a second step, a range of approaches, methodologies, methods and models available to assess biodiversity impacts in the context of trade have been identified and categorised. Further detail as regards the categorisation of different approaches etc. is provided in section 3.1 of the report, with the following aspects systematically assessed: type of data used; goods, services and financial flows covered; and drivers for change and indicators for status of biodiversity assessed.

Comparative assessment: Based on the analysis of existing approaches, a comparative assessment of the overall framework available to address biodiversity impacts in the context of trade negotiations has been carried out. In this context the complementarities and/or overlaps between different approaches, methodologies, methods and models have been outlined, highlighting the strengths, limitations and opportunities linked to different available means of assessment. Based on this analysis, the gaps in the existing framework have been identified.

Treatment of biodiversity indicators: The study has in particular aimed at systematically analysing the ability of different approaches, methodologies, methods and models used to assess trade related impacts to integrate biodiversity indicators, both in a quantitative and qualitative manner. The global framework of indicators - as agreed in the context of the UN Convention on Biological Diversity (CBD)[2] to assess the progress towards the 2020 biodiversity goals - has formed the basis for this analysis (See Chapter 4).

Stakeholder engagement: The study also identified and engaged with important research institutes, academic experts, international organisations, non-governmental organisations, and private institutions in the area of trade liberalisation and biodiversity. This was carried out through the means of an expert survey aimed at reviewing and complementing the findings of the literature review, including to identify any missing methodologies and to complement the insights on the current status and possible future developments of the framework.

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[2] CBD/COP/DEC/XIII/28

1.4 Structure of the report

This report presents the final results of the study, consisting of the following parts:

Chapter 1 provides an introduction to the study, followed by Chapter 2 that outlines the current state of play in assessing biodiversity impacts in the context of EU's trade policy. Chapter 3 presents the core of the analysis reviewing existing methodologies, methods and models used to estimate the impacts. This review forms the basis for Chapter 4 that divides the existing methodologies etc. into a number of key approaches and carries out a comparative assessment between them. Chapter 5 complements the literature review based analysis with insights gained through a survey of experts in the field. Finally, Chapter 6 concludes with the key insights from the study and discusses the way forward.

In addition to the above, a number of annexes provide more detailed information supporting different stages of the analysis:

- Annex 1: Summary from screening of SIAs
- Annex 2: Expert survey
- Annex 3: Summary database of experts consulted
- Annex 4: Recommended fellow experts and research institutes
- Annex 5: Aichi biodiversity targets and indicators
- Annex 6: Biodiversity in the context of EU Investment Agreements

2 ASSESSING BIODIVERSITY IMPACTS IN THE CONTEXT OF EU'S TRADE POLICY

Sustainability Impact Assessments (SIAs) form the key framework for assessing the impacts of EU trade agreements, with biodiversity identified as one of the key environmental aspects to be considered in both the general and sector specific analyses of SIAs. In this context, the EU has recently gained the competence to also negotiate for possible provisions on investment liberalisation, with SIAs forming the main vehicle to explore related impacts on environment and biodiversity.

This Chapter provides a brief assessment of methodologies used in the context of SIAs to assess the possible impacts of EU trade and/or investment agreements on biodiversity.

The Chapter concludes that there is no clear preferred or systematic approach for assessing biodiversity impacts within the completed EU trade SIAs. A combination of qualitative techniques with the development of in-depth case studies is the most commonly used methodology to assess biodiversity effects. As regards investment agreements, the review of existing SIAs suggests that the impacts on biodiversity are only marginally considered in the environmental analyses and, similar to trade agreement SIAs, largely build on qualitative methods.

2.1 Introduction

The status of biodiversity, ecosystems and ecosystem services is known to be affected by a range of direct drivers such as habitat change, overexploitation, invasive alien species, pollution and climate change, and indirect drivers such as population change, change in economic activity, socio-political factors, cultural factors and technological change. EU trade agreements can affect these drivers - both in third countries as well as the EU - through a number of ways. For example, changes in market access of products can lead to changes in sectoral production, production methods, land use and transport infrastructure, with possible biodiversity consequences. Changes in market access can intensify and encourage trade in an unsustainable or sustainable manner. For example, in the former case the conversion of natural or semi-natural habitats into agriculture might increase aggravating biodiversity loss. In the latter case, market access to products that meet certain environmental standards might encourage mainstreaming of biodiversity-friendly farming practices in the trade partner country.

Investment liberalisation, negotiated as stand-alone agreements or included as a dedicated chapter within the broader trade agreements, plays an increasing role in the context of EU trade. The impacts of these agreements on the environment have been increasingly studied in the last two decades[3] with some sectors, such as the mining industry[4], receiving greater attention than others. Changes in the flows of foreign investment can impact the intensity and/or standards of different business operations

[3] See for instance: WWF (1999)

[4] See for instance OECD (2002)

which in turn can, for example, lead to increased infrastructure development with negative biodiversity impacts. Alternatively, investments by companies with higher sustainability standards or the increasing role of impact investing (i.e. investing with a view to generate social and environmental impact alongside a financial return[5]) can have the potential to deliver environmental benefits (Illes et al. 2017). In principle, EU-wide investment agreements with external countries could ensure a regulatory environment that provides safeguards for biodiversity.

Since 1999, the European Commission - and in particular the Directorate-General for Trade – DG TRADE - has been conducting Sustainability Impact Assessments (SIAs) on all negotiated trade agreements with non-EU countries, including the implications of investment liberalisation.

SIAs are independent assessments produced by external consultants and take place during trade negotiations. These SIAs serve as an important tool to assess the potential economic, social and environmental implications of the trade and/or investment agreement in question and feed into the work of the negotiators (EC 2016a). Following the publication of each SIA, the Commission often publishes position papers that constitute "the [official] response from the Commission Services to the study's findings and recommendations on policy measures" (EC 2014). At the time of writing, 25 SIAs have been conducted and two are currently in process.[6]

Although SIAs vary depending on the type of trade and/or investment deal being negotiated, in the last ten years DG Trade has published two editions of SIA handbooks (EC 2006; EC 2016b) providing guidance on the methodological frameworks used to carry out future SIAs. The latest 2016 edition of the Handbook reiterates the need that all SIAs should assess the likely environmental impacts of the trade agreements in detail. The document suggests a detailed assessment of environmental impacts needs to build on the overall economic modelling using supplementary economic models as well as qualitative analysis and case studies.

In its recommendations, the Commission identifies biodiversity as one of the key environmental aspects that should be considered in both the general and sectoral analyses conducted in the context of SIAs. However, details on the particular mix of techniques or indicators used to assess biodiversity impacts of trade and/or investment within SIAs are left to be determined by the individual SIA and, therefore, not specified within the Handbook's methodological approach.

2.2 Overview of methodologies used in SIAs

As part of the literature review, all 25 of the most recent EU SIAs were assessed in order to identify the different methodologies used and to understand how impacts of the EU agreements on trade and/or investment on biodiversity and ecosystem services are analysed and considered. Table 2-1 further down in this Chapter shows a summary of the

[5] Impact investments are investments made into companies, organizations, and funds with the intention to generate social and environmental impact alongside a financial return. These investments: (i) are intentional, (ii) the investors expect to generate financial return on capital, or at least a return of capital, and (iii) a wide range of return and asset classes are available, such as cash equivalents, fixed income, venture capital, and private equity.

[6] For the full list see: http://ec.europa.eu/trade/policy/policy-making/analysis/policy-evaluation/sustainability-impact-assessments/index_en.htm

"biodiversity screening" of all recent SIAs. The complete table that resulted from the screening of SIAs can be found in Annex 1.

In general, the SIA screening exercise showed that there is great interrelatedness between various methodologies and a wide range of quantitative and qualitative methods SIAs apply. Most SIAs applied a similar overall methodological framework (see Figure 2-1) proposed within Commission Handbooks, with the following steps:

1. Screening and scoping analysis: establishing a baseline scenario on the status of the environment, including on biodiversity in most cases, together with an assessment of the implemented Multilateral Environmental Agreements (MEAs).
2. Scenario analysis and modelling: delivering quantitative economic assessment of impacts from trade liberalisation. Computable General Equilibrium (CGE) modelling exercises (See Chapter 3) are often the basis for the SIA's economic and social analysis. However, the only environmental variables that tend to be assessed within the models are emissions, material use and energy outputs.
3. Overall sustainability assessment, including social and environmental assessment: With regards to the environmental assessment, since CGE models often only apply modelling for GHG emissions, material use and energy outputs, most SIAs apply additional quantitative and qualitative environmental analysis to complement and inform results from modelling. Biodiversity impacts are mostly considered in qualitative analysis using a combination of other methodologies, such as literature review, expert-led assessment of quantitative results and Strengths-Weaknesses-Opportunities-Threats (SWOT) analysis.
4. Sectoral analysis: specific trade-relevant sectors are further analysed and in many SIAs specific case studies are developed to support this analysis. For instance, the impacts of trade liberalisation on biodiversity are often considered in in-depth case studies focused on illegal trade of natural resources.
5. Causal chain analysis (CCA): is a conceptual tool that is used throughout the SIAs to identify the relevant cause-effect links between the trade measures that are being proposed and the economic, social and environmental impacts the specific trade measure may have.
6. Dissemination and consultation with key stakeholders: stakeholder consultation is a parallel and complementary component of most SIAs and runs alongside the overall analysis, particularly after preliminary results from data analysis have been obtained at the Interim Report phase. Most biodiversity-related impacts are developed and/or strengthened when in consultation with relevant stakeholders.

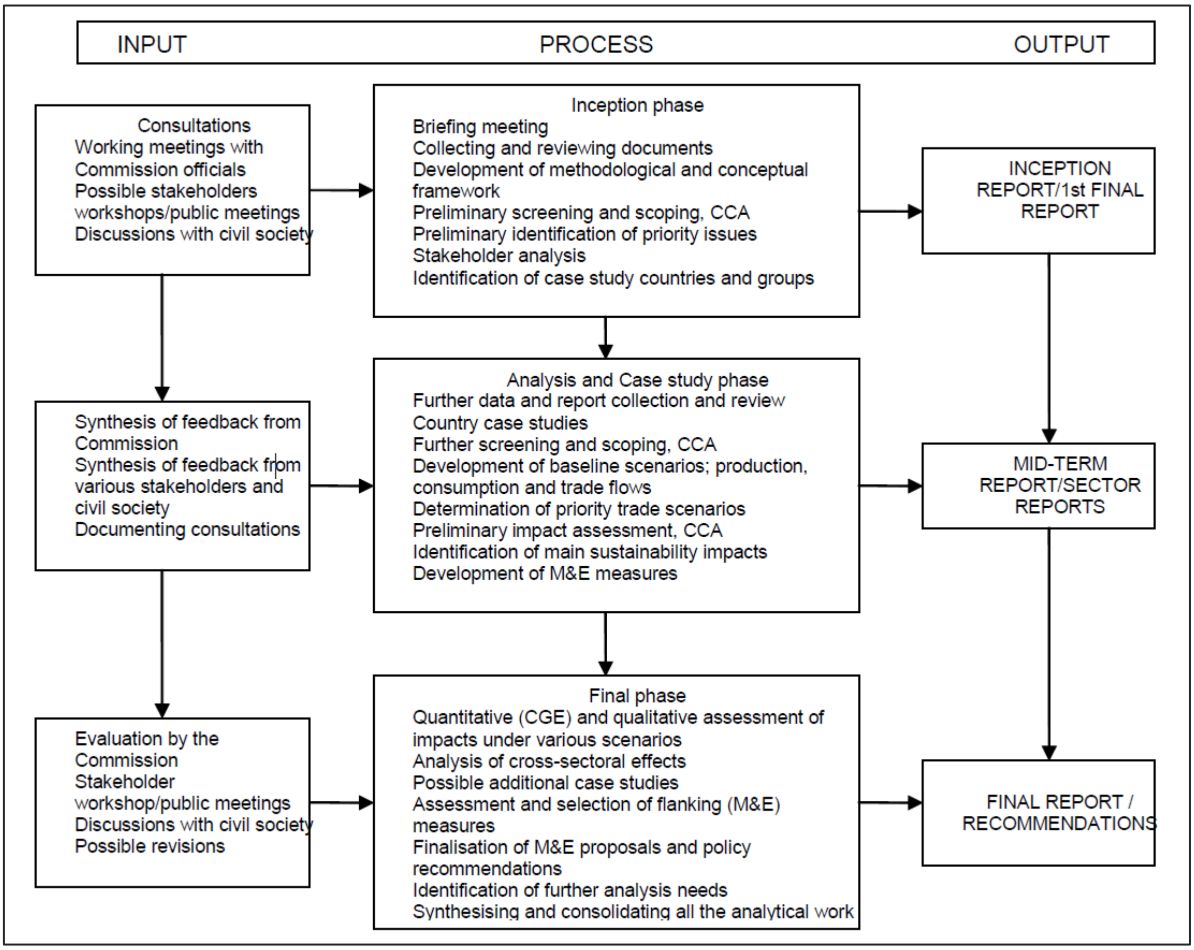


Figure 2-1 Input, process, and output of a Trade SIA

Source: European Commission, 2013 (from European Commission, Trade SIA Handbook, EC 2006, page 12)

2.3 Assessing biodiversity impacts within SIAs

The screening of SIAs shows that there is no clear preferred or systematic approach for assessing biodiversity impacts within SIAs (Table 2-1). As recommended by the Commission Handbooks, biodiversity tends to be used as one of the core sustainability indicators in the analysis of the baseline conditions. Common biodiversity sub-indicators include rate of overall land use of biodiverse areas, number of threatened/endangered species (e.g. Common Bird Index) and rate of change of this number, status of some commercially used species (fish and timber), protected areas coverage (km^2 or %) etc. In a handful of cases (e.g. SIAs for CETA, EU-Mercosur, EU-Armenia), the same core sustainability indicators are also used as the structure to present the final results (for both global and sectoral results). These currently used indicators directly respond to the monitoring of a number of the CBD biodiversity targets - namely Target 4 (species in trade), Target 5 (rate of loss of natural habitats) and Target 12 (status of threatened species) – however they do fall considerably short on providing a comprehensive coverage of the CBD targets and related indicators (see Chapter 4 for further information).

Economic modelling, the basis for the assessment of trade-related impacts within most SIAs, does not account for the potential effects of trade on biodiversity (See Chapter 3 for further detail). Therefore, all SIAs based their analysis of biodiversity effects on a combination of qualitative techniques. Although there is no common mix of techniques across screened SIAs, the development of in-depth case studies seems to be the most commonly used methodology assessing biodiversity effects from the increase in trade liberalisation.

Finally, for 10 of the 19 SIAs that include a position paper from the Commission, biodiversity effects are mentioned and recommendations of flanking measures to mitigate potential negative biodiversity impacts are announced.

As regards impacts of foreign investment, the review of existing relevant EU SIAs suggests that the impacts on biodiversity are only marginally considered in the environmental analyses and largely build on qualitative methods (See Box 2.1 and Annex 6). As above, the few examples of biodiversity indicators used are mainly responding to CBD biodiversity targets 5 and 12 (i.e. rate of loss of natural habitats and status of threatened species) and provide a very limited information on impacts across these targets.

Two examples illustrating the most explicit existing treatment of biodiversity in the context of both trade and investment are provided in Box 2.1 below.

Table 2-1 Summary of SIA Screening of methodologies for assessing trade effects on biodiversity

FTA	Year of SIA completion	Method of SIA (environmental assessment)	Is biodiversity mentioned/assessed?	Position paper mentions Biodiversity?
EU-US (TTIP)	2017	Followed the general methodological framework from EC Handbook[7]. For the overall assessment, no CGE model was applied – quantitative assessment built from recent modelling exercises. For the Sectoral analysis, the Five-Step Ecorys Sector Sustainability Approach (ESSA) was used.	Yes, biodiversity is one of the environmental themes for the Overall Sustainability Impact Analysis. Development of biodiversity case studies	No
EU-Myanmar	2016	Causal Chain Analysis: Quantitative assessments (cross-comparison of indicators) as the basis for qualitative assessment (expert assessment and consultation). Not enough data for modelling	Yes, biodiversity as one of current environmental concerns in Myanmar	No
EU-Japan	2016	Followed the general methodological framework from EC Handbook. The qualitative analysis focused on regulatory effects (maintain level of environmental regulation). Case studies	Yes, biodiversity is one of the environmental indicators for the SIA methodology. Biodiversity case studies	Yes
Green Goods Initiative	2016	Quantitative analysis then applied to case studies. E3ME modelling for sectoral analysis. Case studies, consultations	Biodiversity not directly assessed but as part of Millennium and SDGs.	N/A
EU-Jordan	2014	Followed the general methodological framework from EC Handbook	Yes, qualitative account of main ecosystems and endangered species	Yes
EU-Egypt	2014	Followed the general methodological framework from EC Handbook	Yes, qualitative account of main ecosystems and endangered species	Yes
EU-Tunisia	2013	Followed the general methodological framework from EC Handbook	Yes, qualitative account of main ecosystems and endangered species	No
EU-Morocco	2013	Followed the general methodological framework from EC Handbook	Yes, qualitative account of main ecosystems and endangered species	No
EU-Armenia	2013	Followed the general methodological framework from EC Handbook	Yes, both as part of analysis of the baseline conditions and as one of the aggregate environmental indicators for the SIA methodology	No
EU-Georgia and EU-Moldova	2012	Followed the general methodological framework from EC Handbook	Yes, Quantitative assessments complemented by qualitative analysis	No

[7] Common SIA methodological approach from EC SIA Handbook (2006, 2016b): Screening and scoping analysis; scenario analysis and CGE modelling; additional quantitative and qualitative analysis; sectoral analysis; Casual Chain Analysis; and Dissemination and consultations with key stakeholders.

EU-Canada (CETA)	2011	Followed the general methodological framework from EC Handbook. Case studies	Yes, both as part of analysis of the baseline conditions and as one of the aggregate environmental indicators for the SIA methodology	No
EU-Libya	2009	Followed the general methodological framework from EC Handbook. Qualitative assessment included: Revealed Comparative Advantage and Finger-Kreinin Indices measuring the similarity of the structure of exports between countries.	Very superficially and only qualitatively.	N/A
EU-Andean countries	2009	Followed the general methodological framework from EC Handbook. Case studies	Yes, both as part of analysis of the baseline conditions and as one of the aggregate environmental indicators for the SIA methodology	Yes
EU-Central America	2009	Followed the general methodological framework from EC Handbook.	Yes, biodiversity is one of the aggregate environmental indicators for the SIA methodology	Yes
EU-Mercosur	2009	Followed the general methodological framework from EC Handbook. Additional to CGE modelling, quantitative analysis included SEA, gravity model and Poverty and Social Impacts Analysis (PSIA). Case studies.	Yes, both as part of analysis of the baseline conditions and as one of the aggregate environmental indicators for the SIA methodology	Yes
EU-ASEAN countries	2009	Followed the general methodological framework from EC Handbook. Case studies.	Yes, biodiversity is one of the aggregate environmental indicators for the SIA methodology	Yes
EU-India	2009	Followed the general methodological framework from EC Handbook.	Yes, both as part of analysis of the baseline conditions and as one of the aggregate environmental indicators for the SIA methodology	Yes
EU-China	2008	Followed the general methodological framework from EC Handbook. Additional to CGE modelling, quantitative assessment included TAPES PE Model[8].	Biodiversity is measured as one of the indicators within the impacts table for environmental goods and services. Biodiversity assessed in qualitative methods	No
EU-Korea	2008	Followed the general methodological framework from EC Handbook.	Biodiversity is not one of the 9 core indicators or subindicators.	No
EU-ACP	2007	Followed the general methodological framework from EC Handbook. The first stage of the framework was a priority-setting exercise for the five ACP regions. The second stage in the framework included an approach	Yes, qualitative account of main ecosystems and endangered species	No

[8] Trade Analysis Partial Equilibrium Sussex, suite of PE models developed at The University of Sussex, UK

		for identifying social and environmental impacts of changes in trade and economic activity affected by trade.		
EU-Ukraine	2007	Followed the general methodological framework from EC Handbook.	Yes, both as part of analysis of the baseline conditions and as one of the aggregate environmental indicators for the SIA methodology	Yes
Euro-Mediterranean	2007	Followed the general methodological framework from EC Handbook, both per country and country grouping.	Biodiversity is one of the elements considered for the baseline scenarios and the impacts of the FTA.	Yes
EU-Arab States	2004	CGE Modelling was substituted by bespoke models, indicator cross-comparison, etc.	Biodiversity assessed through Indicator comparison between countries	No
EU-Chile	2002	Followed the general methodological framework from EC Handbook, as then published in 2006.	Yes, both as part of analysis of the baseline conditions and as one of the indicators for the SIA methodology	N/A
WTO Food Crops	2002	Development of Scenarios and assessment of impacts. SIA does not carry out CGE modelling exercise but draws upon desk research from previous work. Case studies	Biodiversity effects are assessed for different countries	N/A
WTO Negotiations	1999	Sector by sector methodology: Scenarios, Significance by assessing indicators, Causal Chain Analysis, Case studies,	Biodiversity is one of the core sustainability indicators measured sector by sector	N/A

Source: Own compilation from EC (2016a)

Box 2-1 Examples of EU trade and investment agreement SIAs including focus on biodiversity

EU-Andean Community Association Agreement

The EU-Andean SIA was conducted in 2009 and provided an independent assessment of the likely economic, social and environmental impacts to inform the negotiations of the multi-party trade agreement between the European Union, and its Member States, and the Andean countries of Colombia, Ecuador and Peru.

The overall methodology of the EU-Andean Trade SIA followed causal chain analysis (CCA) approach to identify the significant cause-effect link between a proposed change in trade policy and its economic, social, and environmental impacts. In the core of this assessment was a quantitative analysis, based on the application of a multi-region computable general equilibrium (CGE) model to obtain the core economic impacts of the trade agreement. The CGE assessment required the establishment of both baseline and two liberalisation scenarios. Quantitative modelling was then complemented by qualitative methods (e.g. literature review, expert in-depth assessment, case studies) to better assess those variables that the applied models were not able to measure. Preliminary results were then complemented by stakeholder consultation and public dissemination of results. As a result of the analysis and consultation, a series of policy recommendations were provided in order to inform the trade agreement negotiations.

The assessment of biodiversity effects was very relevant to this SIA as the Andean region is considered one of the most ecologically diverse areas in the world. With respect to the assessment of biodiversity effects within the SIA, "biodiversity" – together with "environmental quality" and "natural resource stocks" - is one of the nine core sustainability indicators used in the analysis of the baseline conditions. The only environmental variable included in the global model output was an estimate of changes in CO_2 emissions. Therefore, in order to assess biodiversity effects results from the quantitative modelling were complemented by a combination of qualitative methodologies. These included literature review, expert in-depth assessment with the use of biodiversity-related indicators, and stakeholder consultation.

Using biodiversity as one of the core sustainability indicators results in a systematic consideration of possible biodiversity impacts across the SIA, including possible positive impacts of value chains based on the development of biodiverse products. However, the application of the "biodiversity" indicator remains at a very generic level, referring to the loss of or negative impacts on biodiversity without providing any specific indicators for the loss and/or gain.

Of the mix of qualitative methodologies used within this SIA, the development of case studies was one of the key tools for the assessment of biodiversity effects. An example was the case assessing potential impacts of increasing biofuel production as a result of the trade agreement. This case study identified the loss of biodiversity as "the environmental issue of greatest concern".

As a result of the EU-Andean SIA, the Commission's Position Paper[9] raised issues concerning the trade impact on the environment. As one of its final conclusions, the position paper highlighted how "the Trade Agreement might have potentially significant impacts in terms of deforestation and reduced biodiversity, as a result of the predicted expansion of agriculture and timber industries". As a result of these potential impacts, the position paper identified flanking measures (e.g. supporting the design and implementation of biodiversity conservation strategies) in order to mitigate some of the identified negative impacts.

The SIA and its investment chapter of the EU-Canada Comprehensive Economic and Trade Agreement (CETA)[10]

The CETA SIA was conducted in 2011 and at the time negotiations were still ongoing and consultants had to make numerous assumptions in their assessment. In the SIA, for investment modelling gravity modelling was used with the OECD's investment restrictiveness variable to estimate the impacts of liberalisation of investment flows between Canada and the EU on the sectoral level of FDI flow.

The environmental assessment of investment impacts primarily focused on the oil sands and mining sectors given their importance in Canada. The results of the gravity modelling suggested

[9] Commission Services Position Paper on the Trade Sustainability Impact Assessment (SIA) of the Multiparty Trade Agreement with Andean Countries (Nov. 2010), available at http://trade.ec.europa.eu/doclib/docs/2010/november/tradoc_146987.pdf

[10] http://trade.ec.europa.eu/doclib/docs/2011/september/tradoc_148201.pdf

that investment in these sectors could increase, which could lead to increased environmental impacts; nevertheless conclusions on the magnitude of investment increase were not decisive.

For the environmental assessment the following two sets of indicators were used: (i) biodiversity, water usage and contamination, toxic contaminants and effluents, air pollution and GHG emissions and (ii) environmental policy space, institutional and regulatory environment. For both areas a baseline analysis was conducted. For the former, the analysis primarily focused on the mining sector and Canada's tar sands, with some impacts of forest-based industries also considered. For biodiversity, the rate of overall land use of biodiverse areas and number of threatened and/or endangered species (e.g. rate of change) were used as indicators for the mining & oil and petroleum sectors and the forestry sector, respectively. The assessment concluded that "a marginal increase in investment inflows driven by CETA and higher oil and mineral prices could lead to an increase in production capacity that would in turn lead to impacts on capital stocks, use of biodiverse areas, water use and contamination, toxic contaminants and effluents, and air pollution and GHG emissions". The gravity modelling also showed that increased investment might take place in the fishing sector which in turn could put more pressure on fish stocks. As such, biodiversity effects were considered but not in great details.

The SIA also analysed the potential environmental impacts of the proposed ISDS mechanisms under CETA, for which it assessed the impacts of other ISDS mechanisms in the North American Free Trade Agreement (NAFTA) and other EU MS BIAs and concluded that it might lead to negative environmental impacts.

3 REVIEW OF EXISTING APPROACHES, METHODOLOGIES, METHODS AND MODELS

This chapter categorises and discusses existing approaches, methodologies, methods and models that are used or are available for assessing the impact of trade liberalisation on biodiversity and ecosystems. Causal chain analysis (CCA) forms the standard conceptual framework for analysis in SIAs. Within CCA, the cause-effect links between trade measures and impacts on biodiversity can be assessed by qualitative and/or quantitative methods. The review in Chapter 2 shows the current practice for carrying out CCAs is a combination of qualitative techniques.

Building on the above, this Chapter first discusses these qualitative techniques in more detail then moving on to discussing potential quantitative techniques that can complement the qualitative analysis.

We conclude from this Chapter that there are opportunities to extend current practice in the assessment of the impacts of trade liberalisation on biodiversity, ecosystems and ecosystem services in both qualitative and quantitative ways, but that there is no single methodology that can address all issues and that a combination of approaches will always be necessary.

3.1 Introduction and categorisation

This Chapter identifies and assesses the existing approaches, methodologies, methods and models used and/or available for assessing the impact of trade liberalisation on biodiversity and ecosystems.

Approaches and methodologies: We consider approaches and related methodologies to be the general distinguishable means towards assessing the relation between trade agreements and biodiversity. We have identified 3 different approaches: qualitative approaches, industrial ecology approaches and modelling approaches (See Table 3-1). We define an approach as a collection of methodologies, methods and/or models (general or specific) that can quantify or describe in a qualitative sense entire pathways between the policy scenario and the impacts on biodiversity, ecosystems and/or ecosystem services.

Causal chain analysis (CCA) (see 3.2 below) is considered to form the basic framework for identifying and assessing possible biodiversity impacts of FTAs, using both qualitative and quantitative means. It is therefore considered separately and not as part of qualitative and/or quantitative approaches.

Methods: Methods are the tools that belong to a specific approach / methodology to establish quantitative or qualitative links between causes and effects in the pathways between trade liberalisation and the final effects on biodiversity, ecosystems and ecosystem services.

Models: Models, in this review, are considered specific instances of methods available for the analysis of quantitative links between causes and effects in the pathways between trade liberalisation and biodiversity. Hence while models are also discussed in a more general sense (e.g. Economic model, Industrial Ecology model), and where appropriate different methods within these general model types (e.g. Computable General Equilibrium models, Multi-Regional Input-Output models), we use the subsections on models to review and discuss specific models (e.g. GTAP, Eora).

For each approach, methodology, method and/or model that is distinguished, we give a short introduction to how it works, what type of data is used, how well it is able to address the goods, services and finance related changes in general and especially linked to biodiversity. Then we briefly assess the drivers for biodiversity change that it covers (or could cover) and, if applicable, the indicators for biodiversity status being used.

Table 3-1 Overview of approaches, methodologies and methods that are used in assessing the impacts of trade liberalisation on biodiversity and ecosystem services. *Note: causal chain analysis (CCA) (see 3.2 below) is considered to form the basic framework for identifying and assessing possible biodiversity impacts of FTAs, using both qualitative and quantitative means and herefore considered separately.*

	Approach	Methodologies / Methods	
Qualitative	**Qualitative approaches (Section 3.3)**	Qualitative data analysis	*Literature review and assessment* *Qualitative meta-analysis* *SWOT analysis* *Use of qualitative indicators* *Expert assessments*
		Stakeholder consultation	*Expert interviews* *Surveys and questionnaires* *Public consultations* *Workshops* *Dissemination of results*
		Case studies	These are often developed using a combination of the above methods (e.g. literature review, expert analysis, complemented with stakeholder engagement.)
Quantitative	**Industrial ecology approaches (Section 3.4)**	Life Cycle Analysis	
		Multi-regional input-output modelling	
	Modelling approaches (Section 3.5)	Economic models	*General equilibrium models, Partial equilibrium models, Gravity models*
		Land use models	-
		Biodiversity models	*Phenomenological models, Process-based models*

3.2 Causal Chain Analysis

The causal chain analysis (CCA) forms the commonly used framework for the assessment of trade impacts on environment (e.g. biodiversity). CCA can be carried out by a combination of qualitative and quantitative means and as such in the context of this study it is considered to form the overarching analytical context for the application of different methods (i.e. not classified as an approach of methodology in itself).

The CCA "requires the development of a baseline scenariooutlining what the likely economic, social, human rights and environmental developments are in the absence of the trade agreement and against which the likely impacts of the trade agreement under negotiation will be measured and compared. " (European Commission, 2016b, p:14)

There is no single conceptual framework for CCA. However, the existing frameworks seem to all address a similar series of questions linked to the production of commodities subject to trade (e.g. management and technology, physical infrastructure), and social organisation and regulatory frameworks in place to govern trade (law and policy) (UNEP 2005). Furthermore, a classic SWOT analysis (strengths, weaknesses, opportunities and threats) and expert assessments are often used to complement CCA.

In the context of biodiversity, UNEP has produced a dedicated guidance as how to systematically integrate biodiversity considerations into assessing the impacts of trade policy within the context of the agricultural sector. This guidance is one of the few documents available providing a common "skeleton" for a biodiversity focused causal chain analysis. The analysis includes a scoping and assessment phase, all framed within a conceptual framework aimed at framing the causal chain analysis (See Box 3-1 below).

One of the key elements within CCAs (e.g. the UNEP framework above) is the identification of priority issues and objectives related to biodiversity and appropriate indicators to assess these. According to the existing guidance, indicators should include a mix of short, medium and long-term measures, to capture the full range of effects (UNEP 2010). Long-term indicators are particularly useful in assessing the irreversibility of environmental change. It may also be appropriate to select a combination of local, national and global indicators, as they may provide information about different points along a chain of related events. Section 3.3.4 below provides further information on biodiversity related indicators in the context of qualitative assessments.

Box 3-1 Conceptual framework for assessing biodiversity-related impacts in the context of agricultural trade policy

Guidance by UNEP provides a detailed structural framework for framing and carrying out a causal chain analysis for biodiversity impacts of trade within the context of the agriculture sector.

One of the key elements within the guidance is the development of a conceptual framework for possible biodiversity impacts, with a view to operationalise this framework within the context of a broader impact assessment. The first step to develop a conceptual framework is to identify the main issues to be assessed, such as the trade policy, aspects relating to agriculture, biodiversity, ecosystem services, farm livelihoods, and/or the national economy. The framework can be developed with increasing levels of detail for each component and the linkages between them. It is an iterative process, and the conceptual framework should build on the earlier steps in the integrated assessment process and should be refined in the steps that follow.

For the development of contextual framework, the following questions are identified to be addressed to assess the causal chain(s):

1. Which specific trade policy and commodity are you looking at? Indicate one specific policy measure (e.g. changes in levels of tariff, non-tariff barriers and subsidies).
2. How would the selected policy measures affect the demand for and supply of the targeted commodity? Indicate the direction of change in the level of production.
3. What would be the change in land use due to the change in production (e.g. intensification, changing to another commodity, abandoning the land)? Who would be the winners and losers from the change in land use?
4. Given the likely change in land use, what would be the change in biodiversity and ecosystem services?
5. Given the likely change (positive or negative) in biodiversity and ecosystem services, what major dimensions of human wellbeing would be affected? Who would be the winners and losers from the possible change in aspects of human well-being?

6. What kind of information is required for such an assessment?

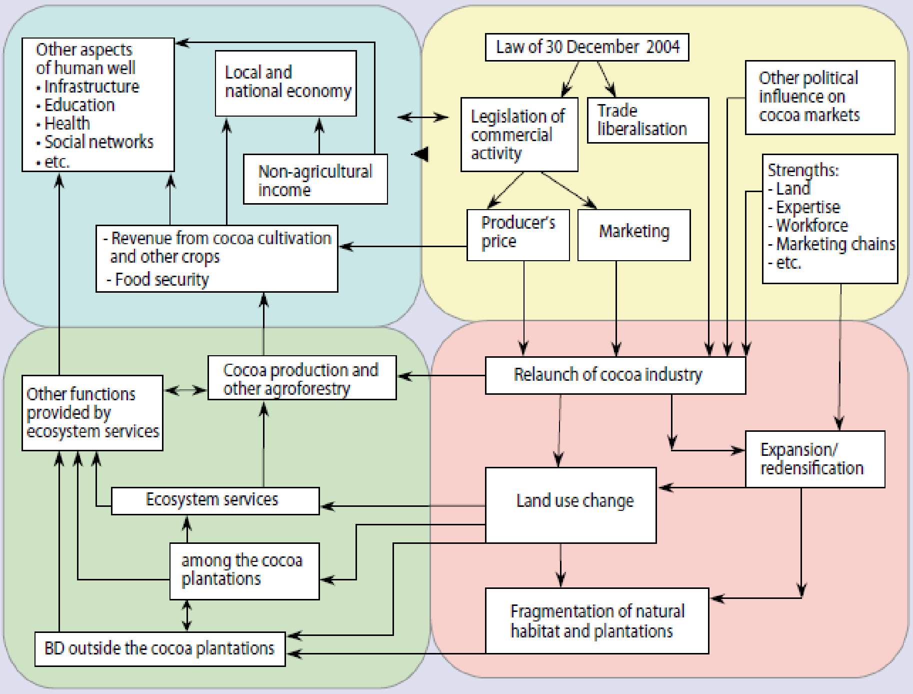
Then a step-by-step approach is recommended to facilitating the development of a conceptual framework, including:

1. Bring together stakeholders.
2. Identify issues or the elements (including economic, social and environment issues/elements) that need to be considered within the policy context and parameters of impact assessment and link them to the use of questions identified above. Determine the appropriate scale (e.g., global, regional, national and long term vs. short term).
3. Place the issues in 'boxes' - starting with broadest scale.
4. Identify likely linkages between the boxes.
5. Review the conceptual framework with stakeholders and experts.
6. Amend conceptual framework to include comments from review and increase the detail of the analysis.

The Figure below provides an example of a conceptual framework used in the context of assessing the impacts of trade in cocoa on biodiversity in Cameroon.

Box 4.4 Adapted conceptual frameworks (2)

Cameroon's conceptual framework highlights the relevant legislation prominently. This 2004 law and other policies have helped to regulate commercial activity and to liberalize trade in cocoa, which resulted among other outcomes, in the recovery and growth of the cocoa industry.



Sources: UNEP (2010)

3.3 Qualitative approaches

In general, three types of qualitative methodologies used to assess biodiversity impacts of trade can be identified: stakeholder consultations, case studies and qualitative data analysis.

It is important to note that the different qualitative methodologies and methods are not exclusive but rather complementary to one another, for example with different methods for stakeholder consultation "nesting" within a broader framework for qualitative analysis. Similarly, case studies assessing the impacts of trade on biodiversity, commonly by exploring trade within a certain sector or a commodity, consist of qualitative (or quantitative) data analysis often complemented by engagement with stakeholders.

3.3.1 Stakeholder consultations

The review of existing EU SIAs and other trade related assessments reveals that different stakeholder consultations form an integral part of the existing trade impact assessments with a range of different methods applied during the course of the process including stakeholder workshops, expert interviews, field surveys, questionnaires and appraisals, and public consultations (See Box 3-2 below).

Regardless of the method used, environmental impacts of trade are explicitly addressed in the context of the contemporary, trade agreement related stakeholder engagement processes. However, there are differences in the current practices as to which level of detail impacts on biodiversity are identified and explored (see section 3.3.4).

Box 3-2 Assessing the environment impacts of rice production and trade in Vietnam

An integrated assessment of the impacts of trade liberalisation on the rice sector in Vietnam was carried out in 2003 (UNEP 2005). This assessment was linked to the broader context of trade liberalisation in Vietnamese agriculture ongoing since the 1980s.

The assessment process included a number of qualitative methods focusing on the engagement with stakeholders. The use of these methods reflected the general approach later on outlined in the UNEP 2010 guidance for addressing biodiversity impacts in the context of trade and agriculture (see Box 3-1 above).

Stakeholder workshop: A stakeholder workshop was organised at the beginning of the integrated assessment to undertake a strategic screening and build up awareness of the impact of trade liberalisation in the rice sector. The workshop also functioned as a means for specifying and designing the broader assessment process. It included stakeholders from research institutes, universities, local officers, extension workers, food and rice processing companies, rice traders, and representatives from rice farmers' unions. Six thematic areas on the environmental impacts of rice production and rice trade were discussed: soil management and fertilization, pesticide use, plant breeding and change in cropping system, traded goods in the rice sector, rice technology transfer and economic structure and environmental laws. The overall impression was that the impact of rice trade liberalisation was generally positive in terms of socio-economic impacts but negative in terms of environmental impacts. See Table 3-2 below.

Table 3-2 Stakeholder assessment of the environmental impacts of the growth of rice production and trade in Vietnam (UNEP 2005)

Impact determinant	Factors	Environmental impact	Function/ process/ explanation
Nature of goods	Increased rice production Increased rice export Increased chemical fertilizer use Increased pesticide use	-- -- -- --	Increased tradable goods involve processing, transport, and delivery of the harmful inputs e.g. pesticides and agro-chemicals
Technology transfer	Increased rice cropping Replaced rice varieties Changed fertilization New plant protection measures Increased machine operations Fields converted to aquaculture Fields converted to urban areas	- - ++ + - -- --	This was the nature of the new technologies adopted, among which only the improved fertilization and plant protection (e.g. IPM) was perceived as having mitigation effects
Economic scale	Competed water sources	-	Large economic scale
Large	Decreased efficiency of resources Invested to environment projects	-- ++	consumes resources and impacts negatively on environment except environmentally friendly projects
Economic structure	Increased rice share in agriculture Decreased share of agriculture	++ --	Urbanization and industry produced negative environmental impacts
Environment standards	Changed environmental laws Env. standards of technology Env. standard of agri. goods	+++ + +	Liberalization embedded international standards with national laws

Note: (---/+++)negative/positive very important, (--/++) important, (-/+) not significant, (0) not clear
Source: Study data (2002).

Participatory Rural Appraisal (PRA): A Participatory Rural Appraisal exercise was conducted in the Mekong Delta to study rice farmers' knowledge, perceptions and actions with respect to the impacts of trade liberalisation on rice production and the opportunities to produce rice using less pesticides and chemical fertilisers. The PRA indicated that farmers perceived environmental impacts mainly through the increased use of agrochemicals. According to participatory scoring results, most farmers agreed there has been a negative impact on soil fertility, water quality of rivers and canals, and wild fish resources due to the intensification of rice cultivation.

Field survey: A field survey was conducted in the Red River Delta and the Central Coast area. Results of the field survey showed that farmers agreed there were some positive impacts on soil fertility, human water resources and the living environment from rice intensification within their settlement areas. However, the study notes that this contradictory result to the above might be caused by the fact that the farmers may not have perceived that increased rice productivity may be due to continuously increasing rates of fertilizer application.

In general, the assessment concluded that rice expansion and intensification have negative environmental impacts, including on biodiversity. For example, the increase in the price of rice and the decrease in the price of agrochemicals resulted in higher total levels of agrochemical use. This contributed to soil degradation, water pollution, loss of agrobiodiversity, and a decline in aquatic habitat and freshwater fishery harvests. The expansion of rice cultivation posed a risk to remaining forests and wetlands that are particularly rich in biodiversity. Finally, rice intensification has documented to have led to the replacement of traditional rice varieties with modern varieties.

Source: UNEP (2005)

3.3.2 Case studies

Case studies are commonly used as an analytical input within trade impact assessments. In general, case studies allow for a wide set of conclusions to be drawn on the likely sustainability impacts of trade, this way offering an opportunity for a focused CCA of certain specific trade sectors (e.g. sectors or sub-sectors with identified possible impacts on the environment and biodiversity).

In context of the EU SIAs (see section 2.22 above), the preliminary assessment by this study indicates that using case studies as one of the SIA methodologies seems to result in a more comprehensive and contextualised assessment of biodiversity impacts within the overall rhetoric. In comparison, the biodiversity related impacts of trade seemed to lack context and desired detail in all the SIAs that did not use case studies. Box 3-3 and Box 3-4 provide concrete examples of recent SIA case studies addressing biodiversity impacts in the context of the TTIP and the FTA with Japan respectively.

Box 3-3 Case study on the impacts of trade in illegal natural resources in the context of TTIP

In the context of the SIA for the Transatlantic Trade and Investment Partnership (TTIP) between the EU and the US, a dedicated thematic case study was carried out to assess the potential effect that the agreement might have on addressing the trade in illegally harvested wildlife (e.g. fisheries) and timber products.

The case study builds on a number of elements: 1) identifying the existing relevant regulatory framework for trade in wildlife and timber, 2) establishing the baseline for the current scale of illegally harvested trade (timber, fish and CITES[1] listed wildlife), and 3) based on the above, assessing the possible impacts of the TTIP agreement at bi- and multilateral levels.

The case study concluded that illegally harvested trade between, through and destined for the EU and US markets is significant. For (potentially) endangered species, the illegally harvested trade flow from the US to the EU was assessed particularly significant, with the highest number of CITES seizures in the EU originating from the US. Illegal timber was concluded to represent approximately 2-3% of total EU and US timber imports while illegal, unreported and unregulated (IUU) fishing activities were estimated to be the largest scale of illegal activity for the EU and the US. Consequently, the case study concluded that through the significance of bilateral trade flows, potential trade provisions in TTIP could trigger substantial impacts on the sustainability of these natural resources globally, with the area of IUU fishing considered as the most significantly (positively) impacted by TTIP. Joint warnings or import bans (such as through 'yellow carding') could potentially be very effective in addressing illegal flows of wildlife, fish and timber based on the combined sizes of their markets.

Source: European Commission (2017)

[1] Convention on International Trade in Endangered Species of Wild Fauna and Flora

Box 3-4 Case Study on the fisheries trade in the context of the FTA with Japan

In the context of a trade and investment agreement between the EU and Japan, a dedicated thematic case study was carried out to assess the potential effect of the agreement on fisheries.

The case study consisted of the following elements: 1) developing a baseline, including outlining the frameworks for fisheries management in the EU (e.g. all relevant EU Member States) and Japan and establishing the level of international trade of fisheries products in both countries; 2) assessing the possible outcome of the agreement and its impact on fisheries trade.

The case study concluded that tariff liberalisation was foreseen to be unlikely to result in tangible increases of fishery trade between the EU and Japan against the baseline. Relevant conservation measures were assessed to be in place on both sides and no substantial impact of the agreement was foreseeable on fisheries resources or vulnerable fishing societies from the FTA. Finally, the case study concluded that there would be few risks that illegal fish products would be re-exported.

Furthermore, specific trade aspects could be put in place to help in restricting illegal trade. For example, the customs schedules in Japan could be adopted to provide additional information that could assist in traceability of fish.

Source: European Commission (2016c)

3.3.3 Qualitative data analysis

Some examples exist for vigorous qualitative meta-analytical approaches to assess impacts of trade on biodiversity. The global environmental changes syndromes approach is a method that allows a systematic analysis of qualitative information to untangle complex causal chains. Instead of focusing on a single sectoral element of a change (e.g. declining stocks, social inequities among fisheries actors), it allows for assessing more complex "bundles" of change - so called social–ecological syndromes of change - and the interacting factors contributing to them. This approach has been used to identify social–ecological syndromes of change related to international seafood trade and then examine the most likely causal factors contributing to the observed syndromes around the world (Crona et al. 2015, Box 3-5 below). While the study by Crona et al. (2015) focused on analysing the effects on local systems, it could be used as a starting point for further developing the assessment of trade-related causal chains within key biodiversity sectors also at the national or regional scales.

Box 3-5 Global environmental change syndromes approach: impacts of international seafood trade on small-scale fisheries

The global environmental change syndromes approach has been used to identify social–ecological syndromes of change related to international seafood trade and then examine the most likely causal factors contributing to the observed syndromes around the world.

Data and analysis: the analysis proceeded in four steps outlined below.

Literature search / sampling: Literature search, based on a set of relevant key word combinations, was carried out to identify relevant studies that would form the basis of the analysis. Altogether 18 cases documenting impacts of seafood trade on small-scale fisheries were identified.

Identification of factors and outcomes: Based on the broader literature, five aspects of seafood trade were identified as potentially important factors affecting the impact of trade (i.e. the nature of change). These included: nature of the demand for a seafood product, market system structure, socio-economic and institutional characteristics of the local fishery, and ecological characteristics of target species. In parallel, based on the case studies (18), different possible local-level outcomes related to the international trade of seafood were identified. This resulted in the identification of 12 outcomes including: declining fish stocks, sustained or increasing fish stocks, high levels of debt among fishers, declining fishers' income, sustained / increased fishers' income, reduced employment opportunities in fisheries, wealth accumulation among traders, increasing conflicts among fisheries actors, destructive fishing practices, declining food security, fishing related health issues, and increasing local fisheries governance.

Identifying social–ecological syndromes: A case-by-outcome matrix was created (using 18 case studies and 12 identified outcomes) where each case received a 1 or 0, respectively, if it exhibited a particular outcome or not. This matrix was then used to carry out a linkage cluster analysis to determine the final clusters of change (i.e. syndromes). This analysis led to the development of three different syndromes (see syndromes A-C below).

Analysis of factors contributing to observed change: Qualitative comparative analysis (QCA) - building on a case-by-factor matrix - was then carried out to each of the three syndromes, to determine the combination of factors that explain the observed change(s). For each of the three analyses, the outcome variables were dichotomized so that an individual case either exhibited the syndrome in focus (1) or not (0).

Outcomes: Syndrome A includes six cases and is characterized by sustained or recovered fish stocks. Syndrome B consists of five cases and is characterized by decreasing fish stocks, either in combination with increasing conflicts between fisheries actors or increasing levels of debt among fishers. The seven cases comprising syndrome C share similar outcomes to syndrome B such as declining fish stocks and high levels of debt among fishers. In addition, this syndrome is associated with decreasing incomes for fishers and an accumulation of wealth among traders. Each syndrome exhibited multiple causal pathways (i.e. combinations of causal factors leading to a specific outcome).

The analysis suggests that the presence of strong and well-enforced institutions is the principal factor contributing to sustaining or recovering fish stocks in the context of international seafood trade. However, even when institutions are in place they can become overwhelmed by a combination of other factors such as strong market demand for products, strong patron–client relations and trade focusing on highly vulnerable species.

The study also identified a number of aspects requiring to be addressed in the future, including lack of data on environmental impacts and poor documentation of case studies (i.e. focus on providing data on only one or a few of the many dimensions of trade impacts).

Source: Crona et al. (2015)

3.3.4 Qualitative methodologies and biodiversity

Assessing impacts of trade on biodiversity is complex due to two reasons: there is generally a lack of data available on biodiversity and cause-effect chains tend to be complex. Impacts of trade on biodiversity – both negative and positive - are often indirect, cumulative and difficult to predict. Therefore, qualitative assessments are often used to provide detailed information on the biodiversity issues in question, insight in cause-effect chains, and appropriate policy oriented biodiversity objectives and indicators. As such, qualitative assessments are complementary to quantitative assessments, rather than a replacement.

Data

The qualitative methodologies and methods for assessing trade and/or investment impacts on biodiversity can – and have been known to - apply a range of different types of biodiversity data to develop biodiversity base line and assess foreseen impacts.

The most commonly accessed data sources in the existing assessments include national and regional data on land use and land cover and/or resource use which, linked to the status and development of different economic sectors, is used as an indirect proxy to predict changes in biodiversity in a qualitative manner.

In addition, national and regional monitoring data on the status of and trends in biodiversity is commonly used, in particular to establish the baseline situation. When possible, the latter is linked to specific economic sectors (e.g. in the case of EU agri-environment indicators).

Scope

In principle, qualitative assessment methods allow assessing the impacts of trade and/or investment on biodiversity across all economic sectors. In practice, however, the availability of such sector-specific assessments varies, with only a very few existing assessments (e.g. EU and India FTA) providing a systematic qualitative account of possible biodiversity impacts across all sectors. Most commonly, the sector-specific qualitative assessments of impacts seem to focus on certain priority sectors (e.g. fisheries and forestry) as identified in the context of developing the trade agreement specific biodiversity baseline.

Drivers of biodiversity change and indicators for biodiversity status/change

The review of existing assessments and literature reveals that qualitative assessments can use a range of different indicators for biodiversity, both in terms of assessing the baseline situation and them moving on to exploring possible changes due to trade and/or investment.

Drivers: Changes in trade flows within economic sectors are used as key direct drivers, first affecting the pressures on the use of natural resources and further on impacting biodiversity via changes in land- or resource use. In the latter case, the most commonly included drivers are, for example, changes in land cover (type or area), water quality, waste discharge, use of fertiliser or pesticides etc. The identified indirect drivers considered (e.g. demographic changes, population density) are similar to the quantitative assessments. However, the role of biodiversity in the causal chains for indirect drivers often remains implicit.

Indicators: Biodiversity indicators used in the context of qualitative assessments include a range of indicators, used to either assess the baseline situation and/or changes in biodiversity status. Both direct and indirect indicators are used.

Direct indicators most commonly used in the existing assessments include the coverage of protected areas, status of species and ecosystems, species diversity and existence of biodiversity hot spots and status of threatened species. An example of a tool that can be used to create maps of ecological values across landscapes is the Local Ecosystem Footprinting Tool (LEFT) (Willis et al., 2012). Some assessments have also attempted to include invasive alien species as an indicator.

Indirect indicators used to qualitatively assess biodiversity impacts – in particular possible changes in the status of biodiversity – are linked to the drivers above and include changes in forest and land cover (e.g. land degradation), water sources and their quality, and changes in natural resource use (e.g. fisheries and wildlife). In the latter context, status and trends in illegally obtained resources associated with biodiversity (e.g. illegal unreported & unregulated fisheries or illegal timber logging) have been used in recent years to more explicitly assess trade and/or investment implications for biodiversity, especially in the context of case studies.

In general, the review of existing material reveals that the current use of drivers and indicators linked to the status of and changes in biodiversity is not systematic and it fails to cover a range of the indicators identified by the CBD framework (see Chapter 4). Beyond the general indicator (i.e. "biodiversity"), the existing assessments seem to all use a slightly different set of indicators, with varying depth and detail in terms of documenting the foreseen changes in the different elements of biodiversity (genetic, species and ecosystem level). In the context of the EU SIAs, the EU level assessment of the FTA between EU and India provides a unique example of a systematic qualitative treatment of a set of core biodiversity indicators (species, protected areas and ecosystems) across all economic sectors (Ecorys 2008).

Reflecting these insights in the context of the CBD biodiversity targets, the most commonly used indicators in the context of qualitative assessments seem to correspond to a range of CBD targets including Target 4 (status of traded species), Target 5 (rate of loss of natural habitats), Target 6 (sustainable fisheries), Target 8 (pollution), Target 12 (status of threatened species) and Target 14 (ecosystems that provide essential services, including services related to water). However, in all the cases the indicators used fail to provide a comprehensive coverage of the CBD targets, as per the identified list of indicators recommended to be used for a comprehensive assessment (see Chapter 4 for further information).

3.4 Quantitative: Industrial ecology approaches

Industrial Ecology is the study of material and energy flows through industrial systems. Industrial ecology is a multidisciplinary field of research which combines aspects of engineering, economics, sociology, toxicology and the natural sciences (Garner 1995).

Industrial ecologists have developed and applied a number of tools that directly map the correlation between economic activities and biodiversity, by examining local, regional and global material and energy uses, flows and stocks in products, processes, life cycles, industrial sectors and economies. It focuses on the environmental burdens associated with the consumption of goods throughout the product life cycle from the extraction of raw materials, to the production of goods, to the use of those goods and to the management of the resulting wastes. While the focus of Industrial Ecology was and is predominantly on materials, energy, and wastes, recently interesting attempts have been made to extend the methods of industrial ecology towards the inclusion of product lifecycle effects on biodiversity. We discuss recent developments in the life cycle assessment of individual products and in global biodiversity footprints of nations.

3.4.1 Life cycle assessment

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 (Curran 2006). 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.[11]

The methodology of Life Cycle Assessment is highly standardized and very complex, but it basically consists of grouping and quantifying resource use and emissions of a product life cycle into a limited number of impact categories which may then be weighted for importance. Detailed guidelines for carrying out an LCA are provided by European Commission (2010) and by UNEP (Frischknecht and Jolliet 2016).

While LCA traditionally focused on materials, energy, and wastes, recently attention also focused on methods and means to include impacts on biodiversity and ecosystem services into LCAs (e.g., Koellner et al. 2013; de Souza et al. 2013; de Baan et al. 2015; Curran et al. 2016). Important questions that are addressed in this literature are indicators and data, reference situation, non-linearity of impacts, interaction among different drivers,

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[11] http://www.lifecycleinitiative.org/

spatial resolution, reversibility of impacts, regeneration time, and accounting for uncertainty (Koellner et al. 2013).

Data

With their rigorous calculation methodology, LCAs usually require an enormous amount of input data that have to be manipulated. Manual manipulation is almost impossible: LCA depends on commercial software packages. These software packages, that have to be purchased or licensed, have their own pre-loaded or linked databases.

Goods, services and financial flows

LCAs are carried out at the level of well-defined products or product groups. This is called the 'functional unit of a product system'. A difference can be made between attributional and consequential LCAs. An attributional LCA attributes impacts to the functional unit according to a normative rule, while a consequential LCA examines the way that the impacts are expected to change as a consequence of the change in demand for the functional unit.[12] Examining the impact of the change in demand for a functional unit on biodiversity due to trade liberalisation would require the use of a consequential LCA method.

Drivers of biodiversity change

In LCA, the drivers of biodiversity change are land occupation and land transformation (these are called 'interventions'). The effects on biodiversity are assessed through the use of species-area relationships (species richness, SR) (e.g., de Baan et al. 2015) or by functional diversity (FD) (de Souza et al. 2013). The species richness indicator (implicitly) assumes that all species are equal, while the functional diversity indicator does not.

Indicators for biodiversity status/change

LCA methods use indicators at various levels of aggregation, often a distinction is made between mid-point indicators and end-point indicators. End-point indicators are Biodiversity Damage Potential and Ecosystem Services Damage Potential (Koellner et al., 2013). At the mid-point level, a wider variety of indicators is used. For biodiversity indicators such as Species Diversity/Richness and Functional Diversity are used. For ecosystem services, indicators such as Biotic production, Climate regulation, Water purification, Freshwater regulation, Erosion regulation, and Functional diversity are used. In terms of CBD generic indicators, LCA can, depending on the specific application, 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).

3.4.2 Environmentally-Extended Multi-Regional Input-Output Analysis

With the advent of large, global environmental-economic datasets, the so-called Environmentally-Extended Multi-Regional Input-Output (EEMRIO) datasets, research has focused on calculating Ecological Footprints of the consumption of goods and services and the effects of Global Supply Chains on biodiversity and ecosystem services. Input-Output matrices of national economies trace the multiple inputs required by sectors or industries to produce their outputs to satisfy final demand (consumption, investment and exports). Standard economic Input-Output matrices are recorded in monetary values. By extending such economic Input-Output matrices with natural resource and pollution flows, the Input-Output methodology can be used to trace the total use of natural resources and the

[12] Consequential-LCA (2015). Why and when?. Last updated: 2015-10-27. www.consequential-lca.org.

emissions of pollutants through the economy to produce output for final demand. A specific characteristic of EEMRIO models, that they share with all Input-Output models, is that they assume a fixed relationship between economic output and input, including environmental 'inputs' and all associated environmental variables. Hence, they assume a linear relationship between economic output (volume of production) and environmental pressure.

A relative simple use of EEMRIO models is the construction of Ecological Footprints (Wackernagel and Rees 1996; Lazarus et al. 2015). The Ecological Footprint method uses fixed factors to convert all flows of energy and matter to and from a specific economy or activity, into a corresponding land and water area needed to support these flows. This required area is called the Ecological Footprint. The land and water area that is available within a country or globally is called Biocapacity. Lazarus et al. (2015) use the Ecological Footprint methodology to calculate the Ecological Footprint of international trade. They argue that the Ecological Footprint is a widely used metric for natural capital and ecosystem accounting and that it offers potential for tracking human-induced pressures on ecosystems and biodiversity, including pressures through trade.

This approach has in a number of cases been used to assess the global footprint of the consumption and trade of food and timber products (Chaudhary and Kastner 2016; Chaudhary et al. 2017; Sandström et al. 2017). EEMRIO has also been used to test the so-called 'Ecologically Unequal Exchange' hypothesis. This hypothesis asserts that low and middle income developing nations maintain an ecological deficit with wealthy developed nations, exporting natural resources and high impact commodities thereby allowing wealthy economies to avoid operating ecologically impactful industries at home. Moran et al. (2013) claim to have falsified an important element of this hypothesis (that developed nations would be net-importers of biophysical resources), but Dorninger and Hornborg (2015) question the theoretical conclusions and the empirical basis of their claim.

Lenzen et al. (2012) use EEMRIO to link detailed threat causes to threatened Red list species recorded by the International Union for Conservation of Nature (IUCN) and Bird Life International to commercially traded goods and services. For example, the spider monkey is endangered by habitat loss linked to coffee and cocoa plantations in Mexico and Central America. This can then be linked through the international trade of coffee and cocoa to, for example, coffee and chocolate consumption in the U.S. Moran and Kanemoto (2017) refined this methodology by also identifying the spatial distribution of the threatened species and thus identifying 'hotspots' of biodiversity threats. Other applications of the EEMRIO methodology are both in the academic domain (for example Wilting et al. 2017; Wilting and van Oorschot 2017) as well as in the commercial domain (for example the software tool BioScope that, as explained on its website, can give an approximation of the biodiversity impact resulting from the supply chain of the commodities purchased by businesses.[13]

Data

There are two major EEMRIO datasets and models: Eora (Lenzen et al. 2012) and EXIOBASE (Wood et al. 2015) that can be used to project impacts of trade to biodiversity or to ecosystem services. 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

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[13] https://www.bioscope.info/

and five aggregate regions for the base year 2007. It contains data of 200 products and 163 industries. It contains data on 15 land use types, 48 types of raw materials, and 172 types of water uses.

Goods, services and financial flows

EEMRIO models usually have relatively detailed sector classifications. EXIOBASE has global data on demand and supply of 48 types of raw materials, which can be very useful for biodiversity assessments. EEMRIO models do not assess financial flows.

Drivers of biodiversity change

The major drivers in EEMRIO models are land conversion, changes in industry activity (e.g. fisheries), pollution, resource use, and climate change.

Indicators for biodiversity status/change

The EEMRIO models produce indicators such as Ecological Footprint, Number of species threats, and Mean Species Abundance. They can also produce indicators on specific ecosystems and ecosystem services such as fresh water use, forest cover, climate regulation, etc. In terms of CBD generic indicators, 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).

3.5 Quantitative: modelling approaches

A large number of models have been used to simulate one or several steps that relate trade-agreements to biodiversity. These steps typically include consequences for different economic sectors (especially with respect to agriculture and forestry), the impacts of economic changes on (the location of) agriculture, forestry and other land use activities, which subsequently affect land cover, biodiversity habitat and a number of other ecosystem properties. In other words, the relation between trade-agreements and biodiversity is one that includes a chain of cause-effect relations. Therefore, model-based assessments of this relation implicitly or explicitly include each cause-effect relation explained above. Combining models for these steps is currently done using either loose-coupling or integrated modelling, which are described and compared in Section 3.5.4.

On the basis of the preliminary review of literature (e.g. Pereira et al. 2010; Meyfroidt et al. 2013), we have subdivided quantitative model approaches into economic models, land use models, and biodiversity models (see Table 3-3). We have checked the appropriateness of this classification with the experts that participated in our survey (see Chapter 5 of this report). Based on the literature review, no quantitative methodologies have been identified that would fully correspond to the definition under section 3.1, i.e. being able to model all cause-effect links on the pathways between the initial trade liberalisation events and the final effects on biodiversity, ecosystems and ecosystem services. However, we have been able to identify a range of potentially useful models which can function as 'elements' for methodologies and, as a combination of two or more models, could qualify as a methodology.

Table 3-3 Overview of the methodologies and methods used in modelling approaches to assess the impacts of trade liberalisation on biodiversity and ecosystem services.

Methodologies / Methods		Specific models (examples)	References
Economic models	*General Equilibrium models*	GTAP, CETM, E3ME, MAGNET	Villoria and Hertel, 2011;Golub et al. 2013;Cambridge Econometrics 2014
	Partial Equilibrium models	GLOBIOM, MAgPIE	Schmitz et al. 2012
	Gravity models	--	Kohl et al. 2016; Oomes et al. 2017; Besedes and Cole 2017
Land use models	-	CLUMondo, LandSHIFT, FORE-SCE	Van Asselen and Verburg 2013; Dezécache et al. 2017; Schaldach et al., 2011, Sohl et al., 2012
Biodiversity models	*Phenomenological models*	Species-area models, Niche-based models, Dose-response models	PBL 2014; Alkemade et al. 2009.
	Process-based models	Dynamic global vegetation models (LPJmL), Marine trophic models	Sitch et al. 2008; Christensen and Walters 2004, Bondeau et al., 2007.

3.5.1 Economic models

An important element in assessing the impacts of trade liberalisation on biodiversity and ecosystem services is to assess the impacts of trade liberalisation on international trade and investment flows and changes in economic activities. For such assessments, economic models of different levels of complexity can be used. Examples are Computable General Equilibrium (CGE) models, Partial Equilibrium (PE) models, and Gravity models of international trade.

Computable General Equilibrium (CGE) models

Introduction

Computable General Equilibrium (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. One example of such a CGE model is the GTAP model (see Box 3-6).

Box 3-6: The GTAP model

The Global Trade Analysis Project (GTAP) model is a widely used, comparative static, multisector, multiregion CGE model. It employs a detailed benchmark equilibrium dataset with a broad coverage of (trade) distortions and explicit statistics on transport margins. The model assumes a global bank to mediate between world savings and investments, and a region specific set of equations for consumer demand that allows for different responses to price and income changes across regions.

GTAP distinguishes between three types of commodities: 1) endowments or factors of production, 2) goods and services that are internationally traded, and 3) capital goods. GTAP has an aggregation facility that allows the user to specify the desired aggregation of endowments, goods and services and regions for a specific model application. At the most disaggregated level, the most recent benchmark equilibrium dataset (version 9) contains information on five endowment commodities, 57 goods and services, and 140 regions, benchmarked at the years 2004, 2007 and 2011 (Aguiar et al. 2016).

The quality of predictions by the standard GTAP model of industry-level effects of past FTAs has recently been investigated by Kehoe et al. (2017). Kehoe et al (2017) compared predicted and actual industry-level effects of four FTAs, and found that the correlations between predicted and actual changes were rather low. They suggest some options for improvement, especially taking into account that FTAs do not only affect existing trade flows, but also stimulate the entrance of new firms and new products in import and export activities.

Over time many extensions of the basic GTAP model have been developed, including GTAP-E that is used to evaluate costs of GHG abatement and to assess the spill-over effects of GHG abatement policies via international trade and sectoral interaction; GTAP-AEZ that incorporates different types of land (Agro Ecological Zones) and forestry data; and GDyn and GDynE that are recursively-dynamic versions of GTAP and GTAP-E, respectively.

In general equilibrium theory, the economy is considered as a set of interrelated markets, where market agents (consumers and producers) freely buy and sell commodities in the form of final and intermediate goods and services and factors of production. There is a market for each commodity traded in the economy. Consumers own resources, from the sale of which, at given market prices, they earn an income. This income determines their consumption opportunities. Given this income, they choose the consumption bundle that maximizes their utilities. Firms transform inputs into outputs in a way that maximizes their profits, given market prices and the firms' technological possibilities. In equilibrium, market prices are such that demand equals supply for all commodities. If firms operate with constant returns to scale technologies, they earn zero excess profits in equilibrium (Shoven and Whalley 1992).

In a multi-region CGE model, economic agents exchange goods and services across regions. The fundamental assumption with respect to international trade is that goods and services from different regions are less than perfect substitutes for each other, i.e., they are different 'varieties'. This is a common assumption in applied international trade modelling, as it allows for 'cross-hauling' of similar goods and services and avoids extreme specialisation effects due to trade liberalisation. In the so-called Armington approach to import demand, economic agents make a two-step decision on the import demand for each good. First, they decide on the optimal (least-cost) sourcing of imports; then, based on the composite import price, they decide on the optimal mix of domestically-produced and imported goods (Armington, 1969). This assumption has been challenged on empirical and theoretical grounds, but as yet remains dominant in CGE modelling (Hertel, 1997, Kehoe et al. 2017).

Ex post analysis suggests that the performance of economic (CGE) models that project the sector-level effects of trade reforms has not been very good in at least a number of occasions (Kehoe et al. 2017). It is likely that the analysis will become even more difficult and the projections more uncertain as new free trade agreements will increasingly focus less on the removal of tariff barriers and more on the removal of non-tariff barriers.

Data

CGE models employ economic data (production, consumption, and trade) on a national or regional level. The data are typically expressed as monetary value flows, except some energy, pollution, or GHG variables that are expressed in physical quantities. The output data that are generated by CGE models are also expressed in monetary value flows.

Goods, services and financial flows

While CGE models provide an internally consistent assessment of broad macroeconomic impacts, they are as a rule not very detailed at the sectoral level. The most recent applications of the GTAP model, for example, can distinguish between 57 economic sectors (industries) at maximum, with 18 primary sectors at maximum (Aguiar et al. 2016). In actual applications of the model, usually fewer sectors, including less primary sectors, are distinguished. For example, in the EU-Andean Trade Sustainability Assessment all primary products were aggregated into seven sectors,[14] while in the SIA of the Free Trade Agreement between the EU and Japan all primary products were aggregated into only two sectors "agricultural primary products, fisheries, forestry" and "other primary sectors". There are some CGE models that model international financial flows such as portfolio or foreign direct investments (FDI). Examples are the FTAP model (Hanslow et al. 2000), the Michigan model (Brown and Stern 2001) and WorldScan (Lejour et al. 2008). A dedicated CGE model was used to assess the impacts on FDI of the EU-China investment agreement (Copenhagen Economics 2012; European Commission 2013).

Drivers of biodiversity change

Since CGE models have limitations as to how nuanced their sector specific impacts can be, this limits how well these indirect drivers can be translated into biodiversity impacts. Most CGE models compute only a very limited number of environmental variables that may have (indirect) impacts on biodiversity, ecosystems and ecosystem services. Some specific CGE models go further than others in projecting land use changes and biodiversity indicators as a result of economic pressures, for example GTAP-AEZ (Hertel et al. 2008), that projects changes in the demand for land across agro-ecological zones and MAGNET (Woltjers and Kuiper 2014) that can account for the expansion of cultivated land (See Box 3-7). A recent interesting approach is the attempt to integrate Natural Capital Accounting into a CGE model by Banerjee et al. (2016). The authors make use of the fact that natural resource data that are collected and organized under the System of Environmental-Economic Accounting (SEEA) are, from an accounting perspective, fully compatible with the economic data in a CGE framework. In their CGE model the natural resources act as non-produced factor of production.

Box 3-7: Land supply in the MAGNET model

In the MAGNET CGE model (which is built on the GTAP model), land supply is endogenous, meaning that new land can be brought into agriculture and forestry production when the demand for agricultural and forestry products increases. Agricultural and forestry land supply is modelled using a land supply curve that specifies the relation between land supply and the land rental rate. The supply curve assures that the most productive land is taken into production first. The potential for bringing additional land into agriculture production is limited to the maximum potentially available land. That maximum is defined on the basis of regional data on land use (arable land, forestry, pasture areas, fallow land, etc.) and the available land is arranged in order of diminishing productivity.

[14] Grains; vegetables, fruits, nuts; other primary foods; other agriculture; forestry; primary fishing; and primary mining.

Indicators for biodiversity status/change

CGE models do not directly compute many indicators relevant for predicting changes in the status of biodiversity, except sometimes trends in the emissions of particular pollutants (CBD Target 8), and fishing effort (CBD Target 6). The strength of a CGE model is mainly that it can be used as the first model in a modelling chain that ultimately calculates or at the very least supports the qualitative assessment of biodiversity indicators (see also Chapter 4).

Partial Equilibrium (PE) models

Introduction

In order to provide more detail on the impact of trade liberalisation on particular segments of the economy, PE models can be used alongside or in lieu of CGE models. Previous EU SIAs have particularly focused on PE models that provide more detail on the energy sector and associated emissions of pollutants and CO_2, such as E3ME.[15] In some cases, PE models with a focus on agriculture have been used. For example, in the SIA of the EU-Japan comprehensive trade and investment agreement, the relatively simple PE model GSIM (Francois and Hall 2002) has been used for the agricultural sector (food and feed) and for additional calculations in the motor vehicles sector. There are dozens of global agricultural PE models, including GCAM, GLOBIOM, IMPACT and MagPIE (for an overview, see von Lampe et al. 2014).

Box 3-8: The GLOBIOM model*

The Global Biosphere Management Model (GLOBIOM) is a partial equilibrium model that covers the agricultural and forestry sectors, including the bioenergy sector. It is used for analysing medium- to long-term land use change scenarios. In GLOBIOM, the world is divided into 30 economic regions. The spatial resolution of the supply side relies on the concept of Simulation Units, which are aggregates of 5 to 30 arcminute pixels belonging to the same altitude, slope, and soil class, and also the same country. For crops, grass, and forest products, Leontief production functions covering alternative production systems are calibrated based on biophysical models like EPIC. GLOBIOM distinguishes between 31 primary land-using sectors and six processed agricultural products.

* note that the GLOBIOM model also contains a land use module. This is further discussed in Section 3.5.4 and Box 3-16.

Data

PE models employ economic data (production, consumption, and trade) on a national or regional level. The data are typically expressed as monetary value flows, but PE models usually use more physical constraints, such as for example altitude, slope, and soil class (see Box 3-8), than CGE models. The output data that are generated by PE models are expressed in monetary value flows but often also in physical quantities.

[15] E3ME is a global sectoral econometric model used to analyze long-term energy and environment interactions within the global economy and to assess short- and long-term impacts of climate change policy.

Goods, services and financial flows

By focusing on specific sectors, PE models *can* have richer sets of sectors, goods and services than CGE models (but this is not necessary). Some agricultural trade models are very detailed in terms of goods (see von Lampe et al. 2014).

Drivers of biodiversity change

In comparison to CGE models, PE models often have a finer sectoral classification. Often these models can also model land use and land cover changes at the subnational level, which brings them closer to assessing land-based drivers of impacts on biodiversity, ecosystems and ecosystem services.

Indicators for biodiversity status/change

PE models do not compute many indicators relevant for predicting changes in the status of biodiversity, except sometimes trends in the emissions of particular pollutants (CBD Target 8), and fishing effort (CBD Target 6). Similar to CGEs, the strength of a PE model is mainly that it can be used as the first model in a modelling chain that ultimately calculates or at the very least supports the qualitative assessment of biodiversity indicators.

The Gravity Model of International Trade

Introduction

Unlike CGE and PE models that calibrate economic flows on the basis of data of a particular year, Gravity Models of international trade directly estimate bilateral trade flows on the basis of a number of variables, sometimes including trade tariffs and changes therein. Econometric estimation is more data driven and less assumption driven than CGE and, to a lesser extent, PE models.

The gravity model of international trade is often called the 'workhorse' of the applied international trade literature (Shepherd 2013, Head et al. 2014), used in thousands of studies, mostly investigating the impact of policies like tariffs and regional agreements on trade. The importance of geography and national borders in trade gives empirical strength to this model. First developed by Tinbergen (1962) as an intuitive explanation of bilateral trade flows, the gravity model was dismissed for a long time for lacking theoretical foundations (Bergstrand 1985), whereas it was providing robust empirical findings (Leamer and Levinsohn 1995). It was only in the early 2000s that the gravity model was acknowledged as theoretically-grounded (Eaton and Kortum 2002; Anderson and Van Wincoop 2003). Recent applications include Hoekman and Nicita (2011), Besedes and Cole (2017), and Oomes et al. (2017).

In SIAs, the gravity model has mainly been used to simulate the impacts of investment liberalisation. An early application can be found in Kirkpartrick et al. (2011). More recently, the gravity model was used in the SIA of the EU-China investment agreement (Copenhagen Economics 2012; European Commission 2013) to estimate the effect of lowering barriers to Foreign Direct Investment (FDI)[16] on investment flows.

[16] Bilateral barriers to FDI were measured by the Copenhagen Economics index of perceived FDI restrictiveness (Copenhagen Economics 2012).

Data

Gravity models estimate bilateral international trade and investment flows based on economic and other data. The data are typically expressed as monetary value flows. The output data that are generated by gravity models are also expressed in monetary value flows.

Goods, services and financial flows

Gravity models of international trade usually do not have a very detailed set of goods and services. Their major quality in the context of our study is their ability to estimate changes in foreign direct investment (FDI) flows as a result of an investment agreement or a trade and investment agreement.

Drivers of biodiversity change

Gravity models can assess the impact of FTAs on FDI as an indirect economic driver of biodiversity change, but they are not capable of modelling land use and land cover changes and final impacts on biodiversity, ecosystems and ecosystem services.

Indicators for biodiversity status/change

Gravity models do not compute indicators for biodiversity.

3.5.2 Land use models

Land use and land use changes are an important interface between economic changes and their impact on biodiversity. In a modelling chain, land use models are placed consistently after economic models, i.e. to downscale economic developments provided by economic models to pixels with a specific land use. Here, land <u>use</u> describes what (economic) activities the land is used for, such as livestock grazing and crop production, while land <u>cover</u> describes what is physically present in a location, such as forests, grasslands, or croplands. Although land use and land cover are frequently related, this is not necessarily the case: while croplands are typically used for crop production, grasslands include both natural grasslands and managed pastures. Therefore, trade agreements, and more generally economic activities, primarily affect land use, which in turn could lead to land cover changes. Land use intensity describes the intensity with which land is used, which could include the number of harvests per year, or the livestock density. An increased demand for land-based products could lead to land use conversions, land use intensification, or a combination of both.

While land use models differ in many important and less important details, they generally form one family of models. These models essentially use an exogenous input[17], often called ‘demand’ for land use activities, and allocate this on a spatial grid. Therefore these models are essentially land use allocation models, and their results are spatially explicit. Such models have also been presented as ‘land change models’ or ‘land system models’. In this report we will use the term ‘land use models’.

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[17] Some models exist that do not need an exogenous demand, as land use change is modelled as a purely endogenous process. Yet, this limits their use in combination with economic models and thus renders them unsuitable to assess the consequences of trade-agreements on biodiversity, hence they are not further considered here.

Data

Land use models typically start from a raster map showing the predominant land use in a location. As such maps are often derived from remote sensing data, many land use maps effectively show land cover. A number of recent applications also include more information on land use intensity, i.e. livestock density and crop productions (see Schaldach et al. 2011; van Asselen and Verburg, 2012). In addition, a number of raster maps representing the location characteristics are typically used in the allocation process, for example elevation, slope, accessibility, and precipitation. While the exact selection of maps differs from one model to the other, and often from one application to the other, these typically include both biophysical conditions, socioeconomic conditions and spatial plans and policies. Obviously the examples here are by no means exhaustive, as many other spatial characteristics could affect the allocation of land changes at a local scale.

Land use models differ widely in the thematic and spatial resolution with which the terrestrial biosphere is represented. While small scale models can have anywhere between 2 and 30 different classes (van Vliet et al. 2016), most global models represent only the main land cover types, e.g. croplands, pastures, forests, and occasionally urban land (Prestele et al. 2016). Similarly, small scale applications, say of regions or countries, use spatial resolutions of 30 to 1000 meter, often reflecting the spatial resolution of the remote sensing imagery that was used to generate these maps. Global models, on the other hand, typically apply a 0.5 degree resolution, which corresponds to the resolution of global climate models, while only a few go down to a 5 arcminute resolution (Prestele et al. 2016). The spatial and thematic resolution has important consequences both for the link with economic models and for the link with biodiversity and ecosystem models (Verburg et al. 2011). These resolutions provide the smallest unit of information that is available to assess biodiversity impacts of economic developments. The number of classes used to represent the terrestrial biosphere can have implications for the assessment of biodiversity impacts, as this determines what type of change can be simulated (intensification, or only land conversion), and the focus on agricultural or natural systems.

In addition to the spatial data, land use models typically use time series of demand related to specific land use types as input. These time series could for example include the total cropland area in a region per year, or the total area used as pasture. More advanced models do not use area demands, but instead product demands, such as tons of crop production, or head of livestock. These demands are exogenous to the model, and often come from economic models. It should be noted that the term “demand” could be confusing, as it is in fact the supply of these land uses or products that the model will allocate, economically. Yet, from the model’s perspective, it is a demand to be allocated, and this term prevails in land use modelling literature.

Box 3-9: The LandSHIFT model

LandSHIFT (Land Simulation to Harmonize and Integrate Freshwater availability and the Terrestrial environment) is a spatially explicit land use change model that has been applied to areas ranging from large regions to global. The main application is for projecting land use change scenarios defined by exogenously defined demands for population growth and agricultural production, in combination with planning and policy measures (Schaldach et al. 2011). Land use changes follow a hierarchical model structure, where the macro level units are represented by countries and the micro level by grid cells, using a spatial resolution between 1km2 and 5 arcminutes.

The model uses so-called land-use systems, which combine both the biophysical and the anthropogenic components of the terrestrial biosphere. Specifically, these denote the predominant land use type, as well as its population density, livestock density and crop production. Changes in land use systems are simulated in dedicated modules for crop production, livestock grazing, and settlements, in order to describe these processes specifically. Model outcomes are a time series of maps with livestock density, population density, and land-use types.

LandSHIFT has been applied on the scale of large countries and world regions, such as an assessment of grazing management on land use systems in the Middle-East (Koch et al. 2008), and the consequences of indirect land use changes from biofuels in Brazil (Lapola et al. 2010). In these model applications, links with hydrological models as well as carbon impacts have already been established.

Drivers of change

Ultimately, land use change is driven by changes in the (exogenous) demand for various land use activities. The allocation of these changes is generally driven by a combination of the suitability of a location, the characteristics of specific land uses, and planning and policy measures. Suitability, sometimes referred to as potential, indicates the combined effect of local (pixel) biophysical and socioeconomic conditions on a specific land use. For example, it could indicate that locations that are relatively flat, with sufficient amount of annual precipitation, and that are accessible for transport are suitable for cropland. The selection and parameterization of such models is done in multiple ways ranging from expert-based selection and calibration (van Delden et al. 2010), to machine learning algorithms (Terando et al. 2014), and logistic regression analyses (Sohl et al. 2012).

Land use specific characteristics are typically used in combination with location specific factors, and represent the behaviour of a specific land use type irrespective of its location. Such characteristics include the resistance of a particular land use type towards change, which could be the result of economic investments as well as the effort that would be required for a land use conversion. In addition, many models explicitly indicate what types of conversions are possible at all, for example to indicate that urban areas are highly unlikely to disappear, while cropland areas are relatively easy to convert. Similar to location factors, the range of approaches to parameterize land use type specific behaviour includes expert-based calibration, machine learning, and empirical estimation (for example in the form of conversion probabilities in a Markov Chain). One additional effect that is often included is a 'neighbourhood effect', representing the attraction or repulsion that one land use can exert on another land use in the vicinity (Verburg et al. 2004; van Vliet et al. 2013). Neighbourhood effects are most commonly applied to allocate urban land uses. Yet, a similar effect has been used to simulate the effect of land availability, as a shortage of cropland is often a stimulus for land use intensification (van Asselen and Verburg, 2013).

Indicators of biodiversity

The result of a land use model is a raster map showing the land use at some point in the future, and often also a time series of land use maps for years or periods in between the start and the end of a simulation. The following CBD generic indicators can be derived directly from the results of most land use models:

- Target 5: Trends in extent of forest
- Target 5: Trends in extent of natural habitat other than forests

In addition, the following CBD generic indicator can be derived rather directly from the resulting land use map, without the need for specialized biodiversity models:

- Target 5: Trends in fragmentation of forests and other natural habitat

Box 3-10: The CLUMondo model

CLUMondo is a spatially explicit land use model that can simulate changes in land use in response to exogenous demands for goods and services. Land use is defined by the land cover composition, as well as the land use intensity, hence changes in demand can yield a combination of area changes and intensity changes, depending on the local conditions. This typical combination of land cover and land use intensity is named 'land system'. The model can be applied at multiple spatial scales, from province and country to global coverage.

The global application of CLUMondo represents space in pixels of 5 arcminutes (roughly 9 by 9 kilometres), using cropland, forest land, grassland, built-up land and bare land, complemented with crop production and livestock density for ruminants and monogastrics. The map differentiates between 30 different land systems (which is reduced to 24 when monogastrics are omitted (Eitelberg et al. 2016)). This application is parameterized to start in the year 2000 and simulate changes until 2040 (van Asselen and Verburg, 2013). In addition to standard scenario runs driven by demand for crops and livestock, CLUMondo has also been applied to assess effects of biodiversity demands globally. Specifically, the model was applied to test the effect of a demand for aboveground biomass, and the effect of an explicit demand for biodiversity habitat (Eitelberg et al. 2016). An example of national application for Laos, with a thematic and spatial resolution adjusted to the national scale, can be found in Ornetsmüller et al (2016). Such national scale applications could be used to assess impacts of trade-agreements in specific, targeted, countries.

3.5.3 Biodiversity models

Biodiversity models, like many other computational models, can be characterized as phenomenological models or process-based models. Phenomenological models, including statistical models, are based on hypothesized relationships between variables in a data set, where the relationship seeks only to best describe the data. Process-based models, also known as mechanistic models, are models based on hypothesized relationships between the variables, where the nature of the relationship is specified in terms of the biological processes that are thought to have given rise to the data. Yet, in reality, most models fall somewhere in between, as they can be placed along the continuum from phenomenological to process-based (Dormann et al. 2012). Biodiversity has been operationalised in many different ways in these models, covering different geographical as well as temporal scales. This is also reflected in the list of indicators provided by the CBD.

Phenomenological models

Introduction

In the context of biodiversity impacts of trade agreements, these models typically map biodiversity impacts based on the land use or land cover they are related with. For example, the occurrence of species is related to the type of land cover or land use in a location. Assuming that these observed relations between species ranges and land use or land cover remain valid, land use changes can thus be used to calculate changes in species ranges. Similar phenomenological models have been applied to map the changes in ecosystem services, biomass, and a number of other biodiversity indicators. While phenomenological models do not aim to describe causal mechanisms, the selection of explaining variables (land use or land cover) and explained variables (biodiversity or related indicators) is typically based on an assumed causal relation between both. Only the mechanisms are not described per se.

Data

Phenomenological models basically require (a series of) land use or land cover maps, and a quantification of the relation between land use or land cover, and the mapped biodiversity indicator. For many indicators, a single map suffices to calculate the current state of a particular indicator, while a time series (or at least maps at two different points in time) are required to assess changes in a particular indicator.

Parameters required to describe the relation between land uses or land cover and the specific biodiversity indicator are typically the result of calibration, and thus no data strictly is needed. In some cases, such data is derived from case studies, field experiments, and other measurements, which are collected and synthesized for such modelling. For example, the PREDICTS database is based on more than 1 million records of species abundance and more than 0.3 million records of species richness, both in relation to the local land use or land cover (Newbold et al. 2015). For ecosystem services and other indicators, such extensive databases are not typically available, especially when the operationalization of this ecosystem service is not generally agreed upon or even arbitrary. In these cases relations are frequently based on expert-opinion (Burkhard et al. 2012; Schulp et al. 2014; Maes et al. 2013).

Drivers of change

Changes in biodiversity models are primarily driven by changes in land use and related land cover. Due to the many different biodiversity aspects and the range of different indicators available, additional drivers are frequently included, such as changes in climate, and associated changes in biome or ecosystem properties (See for example Titeux et al. 2016).

Indicators of biodiversity

The following CBD indicators are listed and can be calculated using currently available computational tools:

- Target 5: Trends in degradation of forests and other habitats
- Target 5: Trends in extinction risk, per habitat type
- Target 8: Trends in nutrient levels
- Target 8: Trends in (some) pollutants
- Target 12: Trends in number of extinctions
- Target 12: Trends in extinction risks and population of species.
- Target 14: Trends in benefits from ecosystem services
- Target 15: Trends in carbon stocks

Box 3-11: Generalised Dissimilarity Modelling (GDM)

GDM is a statistical technique to analyse and predict spatial patterns of turnover in community composition (beta diversity) across large regions (Ferrier et al. 2007; Laidlaw et al. 2016). The approach can be adapted to accommodate special types of biological and environmental data such as information on phylogenetic relationships between species, and information on barriers to dispersal between geographical locations. GDM can be applied to a wide range of assessments including visualization of spatial patterns in community composition, constrained environmental classification, distributional modelling of species or community types, survey gap analysis, conservation assessment, and climate-change impact assessment. GDM approaches have been applied for a while, but they have not been applied very often to predict biodiversity changes.

Box 3-12: GLOBIO

GLOBIO (Alkemade et al. 2009) has been developed by the Netherlands Environmental Assessment Agency, PBL, to calculate the impact of environmental drivers on biodiversity for past, present and future, based on cause-effect relationships using spatial information on environmental drivers and their changes as input. The indicator for biodiversity is the mean species abundance (MSA) of original species relative to their abundance in undisturbed ecosystems. Drivers considered are land-cover change, land-use intensity, fragmentation, climate change, atmospheric nitrogen deposition, and infrastructure development. GLOBIO typically feeds from the IMAGE integrated Assessment Model, which produces these drivers as results (see Box 3-15 below), and as such it is capable of addressing the impacts of environmental changes as well as socio-economic scenarios. The GLOBIO modelling framework consists of a model for terrestrial ecosystems and a model for the freshwater environment. The model employs basic statistical relationships between environmental drivers and biodiversity, therefore it is not possible to investigate mechanisms that relate to biodiversity and ecosystem services. The model has wide uptake in global assessments.

Process-based models

Introduction

Process-based models are models based on hypothesized relationships between the variables, expressed in terms of the biological processes that are assumed to have given rise to these variables. An example of a group of process models are Dynamic Global Vegetation Models (DGVMs) (Sitch et al. 2008). DGVMs originate from the climate science community and are primarily applied to simulate the effects of climate change on the global vegetation and subsequently the global nutrient and water cycles. A number of different DGVMs are currently operational, including LPJ (Smith et al. 2008), IBIS (Kucharik et al. 2000), and CCSM (Hurrell et al. 2013). However, the representation of land uses, which is what is typically affected by trade-agreements, is rather simplistic. The exception is a model named LPJmL, where 'mL' stands for 'managed Land' (Bondeau et al. 2007).

Data

The explained variables of process-based models are the same or similar to those of phenomenological models. However, process-based models typically have more requirements for explaining variables and other model parameters, because all processes leading to the explained variable need to be included. Consistently, parameters in process based models all have biological definitions (and units) and so they can be measured independently of the variables of the model. Because processes are described using physical units, these can be derived from other experiments. For example, the FAO maintains a database that expresses carbon stocks in the terrestrial biosphere, which could be used for such models (Tubiello et al. 2013).

Drivers of change

Process-based models are driven by the (biological) processes that ultimately lead to the outcome of interest. These are typically fundamental ecosystem processes including photosynthesis, fluxes of nutrients, and food-web structures. Land use and land cover change are typical exogenous drivers, as is climate change.

Indicators

Process-based models can basically yield the same indicators (explained variables) as phenomenological models, as these models only differ in the computational model describing the relation between land use and these indicators. However, it should be noticed that process-based models are inherently more suitable to assess those indicators that have a biophysical unit, such as nutrients and carbon stocks. For the same reason, indicators with non-biophysical units, such as ecosystem services, are not applicable. The following CBD indicators are therefore available:

- Target 5: Trends in degradation of forests and other habitats
- Target 8: Trends in nutrient levels
- Target 8: Trends in ecosystems affected by pollution
- Target 8: Trends in (some) pollutants
- Target 15: Trends in carbon stocks within ecosystems

In addition, a number of indicators are listed that can be applied for marine biodiversity. While these cannot be derived from processing land use model results, they are potentially affected by international trade agreements. In addition, several biodiversity models also include modules for marine biodiversity (see for example Box 3-14), therefore they are included here as well:

- Target 6: Trends in proportions of depleted target and bycatch species
- Target 6: Trends in proportion of fish stocks outside safe biological limits

Box 3-13*:* The Madingley Model

The Madingley model (Bartlett et al. 2016; Harfoot et al. 2014) is developed principally by UNEP-WCMC and Microsoft Research at Cambridge University. The Madingley model aims to calculate the impacts of policy decisions on biodiversity and ecosystem services, and changes therein. It is a so-called General Ecosystem Model (GEM), based on similar principles as Ecopath with Ecosim (see Box 3-14). It is a process-based model that simulates flows of biomass (organic carbon) and collections of species (cohorts), using fundamental ecological processes like primary production for autotrophs, and eating, metabolism, growth, reproduction, dispersal, and mortality for heterotrophs. The Madingley model is a relatively new model, and as such it is still in its experimental phase for the analysis of anthropogenic impacts on ecosystems.

Box 3-14: Ecopath with Ecosim

Ecopath with Ecosim (EwE) is a process-based model that represents energy flows through marine and aquatic ecosystems dynamically (Christensen and Walters 2004). The model is primarily designed to explore fishing scenarios and their implications for the exploited ecosystems and fisheries catches. EwE describes a static mass-balances of the stocks and flows of energy (usually biomass) in a marine ecosystem at discrete points in time. The food web is modelled by functional groups that include one or multiple species with similar characteristics. Trophic ecology and biomass removal by fishing is explicitly represented. Ecopath uses a system of differential equations to describe the changes in biomass and flow of biomass within the system over time, by accounting for changes in predation, consumption and fishing rates. Space is represented implicitly by the resource use of predators and preys. EwE allows users to explore the effects of spatial fisheries management policies such as Marine Protected Areas, in addition to changes in environmental conditions. The model has been used widely to generate scenarios of changes in or the management of fishing effort on flows of ecosystem services from marine ecosystems through fishing. It is one of the few biodiversity models that explicitly represents both species and specific groups of beneficiaries. However, it can only assess limited fisheries-related impacts.

3.5.4 Model coupling and integrated assessment models

Analysing the impact of trade agreements on biodiversity through models inevitably requires a series of models, each covering their part of the causal chain from trade agreement, through economy and land use to the relevant biodiversity indicators. Such a combination can be made using loose-coupled models or integrated assessment models (IAMs). Although sometimes presented as opposites, both essentially comprise a series of models that are interlinked through model input and model output. The difference between both is the extent to which linkages between models have been established. While loose-coupling typically refers to a series of models that have been combined for a one-off assessment, IAMs refer to groups of models that are typically run together and for which the interlinkages have been developed and implemented earlier. However, inclusion of a model in an IAM doesn't preclude its application elsewhere. Consistently, some models have been used as part of an integrated assessment model, as well as in other loose-coupled combinations of models. For example, the GLOBIO model is a stand-alone model, which has been applied in many different settings, but it is designed to fit well with the outcomes of the IMAGE IAM.

Loose-coupled models

Loose-coupled model assessments typically comprise a collection of models that have been brought together for a specific question. Models are selected to cover the entire causal chain, where the output of one model is again used as the input for another model. For the analysis of the relation between trade agreements and biodiversity, this series of models could comprise a general equilibrium model, a land use model, and a biodiversity model. The general equilibrium model can calculate the impact of the trade agreement on the distribution of economic activities over countries or regions (typically the smallest spatial unit of analysis). This distribution of economic activities, in particular those activities that are relevant for land use and land cover changes, such as agriculture and forestry related activities, subsequently serves as an input for the land use model. This land use model allocates land use activities to grid cells, and thus simulates land use changes over time. In some cases these land use changes directly yield relevant indicators, such as change in the forest extent, but in most cases these land use maps serve as input for biodiversity models that further calculate a number of relevant indicators.

The chain of models as described here is relatively simple, including three models. However, often a larger number of models is required, depending on the research question. For example, Lotze-Campen et al. (2017) use a series of models to assess impacts of nature protection policies on European landscapes. Although this assessment is not strictly comparable with the assessment of the impacts of trade agreements on biodiversity, it follows a similar structure: first economic scenarios are calculated, the results for agricultural and forestry sectors are subsequently fed into a land use model, and the resulting land use map is used to calculate the consequences expressed in a number of ecosystem services indicators. However, the implementation required a large number of models to cover the whole chain from economic scenarios down to biodiversity indicators. Specifically, a number of sector specific models were required in between the global macro-economic model and the land use allocation model, covering the forestry and agricultural sectors specifically (see Figure 3-1).

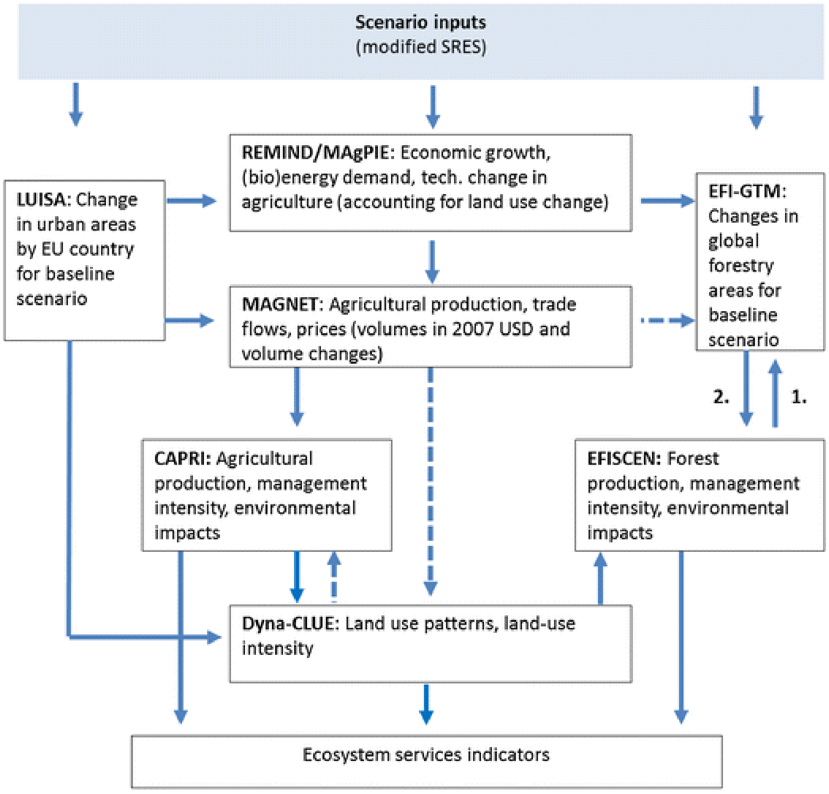

Figure 3-1: Data flow and modelling chain applied to assess the impact of nature protection policies on ecosystem services (Lotze-Campen et al. 2017).

Models combined in a loose-coupled chain of models are normally developed and run independently, oftentimes even at different institutes. Their integration exists as series of data files, including tables, maps, and time series that are sent from one model to another. Consistently, most loose-coupled models are only coupled in one direction, without considering potential feedback. For example, global macroeconomic scenarios feed into a dedicated agricultural economic model, but results of this agricultural economic model do not feed back into the macroeconomic model. Moreover, as models are not designed to be coupled in any specific combination of models, the output from one model might not necessarily fit as input for another model. For example, an agricultural economic model might yield harvested area of wheat, maize and rice separately, while a land use model only includes one class of cropland. Therefore, often, conversions of data are required in order to integrate multiple models in a biodiversity assessment. One advantage is the transparency that is inherent to loose-coupled models, as all intermediate results are by definition available, as are the conversions between datasets and models.

Integrated Assessment Models (IAMs)

Integrated Assessment Models are often viewed as large comprehensive tools that cover all or many relevant aspects for an assessment of environmental change projections. As such they could be considered the "one tool to solve them all". However, it is important to realize that IAMs also consist of multiple models, such as land use models, biodiversity models, and economic models. Yet, in comparison to loose-coupled models IAMs typically have a higher degree of integration.

Individual IAM components are similar to a chain of loose-coupled models. IAMs were originally designed to analyse global environmental change, with a focus on climatic aspects. They typically integrate both socioeconomic and biophysical processes. Accounting for the global context is important, as local and regional demands can be met in spatially disconnected regions through international trade (Lofdahl 1998; Lotze-Campen et al. 2010). While these models have proven capable of addressing land change (van Meijl et al. 2006) the inclusiveness approach towards the modelled processes has come at a cost of process detail. Therefore, detailed processes of land system changes are largely ignored due to this higher level of simplification. IMAGE and the IIASA IAF are two of the IAMs that are frequently featured in global assessments and that include or relate to biodiversity changes (See Boxes 3-15 and 3-16 below).

The integration in IAMs can affect multiple different model properties. First, because models in an IAM are specifically designed or adjusted to be applied in combination, their input and output data is typically more consistent, i.e. the output of one model normally fits as input into another (even though conversion tables or factors are still often required here). Second, a tighter integration, potentially even within the same software framework, might allow for feedback loops between different models or model components. For example, a model could use yearly time steps, and each time step the land use model could be affected by a climate model, while the climate could be affected by simulated land-use change. Nonetheless, such feedback loops are certainly not always implemented, and might be prohibited or at least complicated due to underlying modelling concepts. For example, many economic models calculate equilibria over longer time spans. In addition, due to the integrated nature, IAMs are typically considered black-boxes as intermediate results are not always available. As a result of the ambitious goals of IAMs to cover global environmental change, IAMs often include a large number of models, including those that cover aspects that are not relevant for the relation between global trade and biodiversity.

Box 3-15: IMAGE Integrated Assessment Model

IMAGE (Stehfest et al. 2014) is an IAM developed to analyse the dynamics of global, long-term environmental change and sustainability problems. The modelling framework contains an ecosystem service module that quantifies the supply of eight ecosystem services including for example water availability and carbon sequestration. Estimation of other ecosystem services, such as pollination and pest control requires additional environmental variables and relationships (Schulp et al. 2012). Specifically, this would need fine-scale land-use intensity data from the GLOBIO biodiversity model (Alkemade et al. 2009) (see also Box 3-12).

Box 3-16 IIASA Integrated Assessment Framework

The International Institute for Applied Systems Analysis developed and maintains a number of models that together act as a framework for integrated assessment, the IIASA-IAF. This IIASA-IAF includes the MESAGE macro-economic model, the G4M forestry model, GLOBIOM, and models that represent the climate system. The Global Biosphere Management Model (GLOBIOM) is used to analyse the competition for land between the main land-based production sectors, i.e. agriculture, forestry, and bioenergy (Havlík et al. 2011; Obersteiner et al. 2016). The model allows to assess the production of food, forest, fibre, and bioenergy, and thus also the economic impact on this production and its location. The GLOBIOM model includes a global partial equilibrium model that allocates land uses to 57 world regions, given the objective of maximising consumer/producer surpluses according to scenario definitions. The model aggregates spatial environmental heterogeneity to a small number of simulation units and six land cover types, and therefore, the representation of biodiversity is rather limited.

4 IDENTIFICATION AND COMPARATIVE ASSESSMENT OF EXISTING APPROACHES AND METHODOLOGIES

In this chapter we will synthesize the existing methodologies, methods and models into approaches that can provide a more robust and comprehensive assessment of biodiversity impacts of EU trade agreements. Starting from the status quo the Chapter moves on to introducing more advanced qualitative or quantitative assessment approaches. These approaches are then assessed against a number of criteria with a key criterion being the current or potential ability of the approaches to assess the impacts of FTAs on specific indicators of biodiversity and ecosystem services.

The Chapter concludes that practical assessment will need a combination of approaches, based on the characteristics of the FTA. Most commonly a combination of systematic qualitative analysis with some level of quantitative modelling will be required. If there is an a priori belief that biodiversity impacts might be limited, a relatively simple quantitative assessment could be done by an Industrial Ecology (EEMRIO) approach. For assessment where biodiversity impacts are a priori believed to be more important, research funds could be invested in the services of Integrated Assessment Models (IAMs) or loose-coupled models. Even in the latter case, case studies will remain indispensable for impacts that are more difficult to quantify in spatial models, such as for example, the possible effects of FTA on invasive species or the effects on particular biological elements such as coral reefs.

4.1 Assessment criteria

To develop a more robust and comprehensive way for assessing the impacts of FTAs on biodiversity and ecosystem services, the large number of methodologies, methods and models reviewed in Chapter 3 need to be combined into more synthesised approaches. In order to evaluate the choices in approaches that are possible, a fit-for-purpose set of assessment criteria is required. For the purposes of carrying out an SIA, the criteria should both reflect **practicality**, **comprehensiveness and detail**, and **transparency/credibility**. An ideal approach would be cheap and fast to execute, comprehensive and detailed in the assessment of various dimensions of biodiversity and ecosystem services, and transparent and credible in order for stakeholders to accept the assessment. The **potential for improvement** of the approach with regard to said criteria over time is also an important criterion.

Practicality: Required resources in terms of time and manpower to successfully complete a biodiversity assessment for an SIA. Also important is the availability of data and models for a particular approach.

Comprehensiveness and detail: The number of dimensions of biodiversity and ecosystem services that can be addressed and the thematic, spatial and temporal resolution of the assessment (short term-long term). Of key interest is what indicators can be calculated or included by a particular approach. For this assessment, the list of indicators as selected by the Convention on Biological Diversity (CBD) is used as a starting point. This list contains indicators grouped by target, and subsequently lists one or more generic indicators per target. Table 4-1 below lists the targets. A more detailed list of targets and indicators can be found in Annex 5.

Transparency and credibility: Transparency and credibility are not the same thing, but both help to make the assessment acceptable to stakeholders. The usefulness of an SIA in trade negotiations is foreseen to critically depend on its credibility.

Potential for improvement: In the evaluation of the approaches it is also important to weigh-in the potential for improvement of the approaches. Is the approach mature and therefore not much improvement can be expected, or is the approach relatively new and does it offer scope for improvement in the future? The latter might be a key determinant for improving the 'biodiversity sensitivity' of a given approach.

Table 4-1: Aichi Biodiversity Targets.

#	Description of target
1	By 2020, at the latest, people are aware of the values of biodiversity and the steps they can take to conserve and use it sustainably.
2	By 2020, at the latest, biodiversity values have been integrated into national and local development and poverty reduction strategies and planning processes and are being incorporated into national accounting, as appropriate, and reporting systems.
3	By 2020, at the latest, incentives, including subsidies, harmful to biodiversity are eliminated, phased out or reformed in order to minimize or avoid negative impacts, and positive incentives for the conservation and sustainable use of biodiversity are developed and applied, consistent and in harmony with the Convention and other relevant international obligations, taking into account national socioeconomic conditions.
4	By 2020, at the latest, Governments, business and stakeholders at all levels have taken steps to achieve or have implemented plans for sustainable production and consumption and have kept the impacts of use of natural resources well within safe ecological limits.
5	By 2020, the rate of loss of all natural habitats, including forests, is at least halved and where feasible brought close to zero, and degradation and fragmentation is significantly reduced.
6	By 2020 all fish and invertebrate stocks and aquatic plants are managed and harvested sustainably, legally and applying ecosystem based approaches, so that overfishing is avoided, recovery plans and measures are in place for all depleted species, fisheries have no significant adverse impacts on threatened species and vulnerable ecosystems and the impacts of fisheries on stocks, species and ecosystems are within safe ecological limits.
7	By 2020 areas under agriculture, aquaculture and forestry are managed sustainably, ensuring conservation of biodiversity.
8	By 2020, pollution, including from excess nutrients, has been brought to levels that are not detrimental to ecosystem function and biodiversity.
9	By 2020, invasive alien species and pathways are identified and prioritized, priority species are controlled or eradicated, and measures are in place to manage pathways to prevent their introduction and establishment.
10	By 2015, the multiple anthropogenic pressures on coral reefs, and other vulnerable ecosystems impacted by climate change or ocean acidification are minimized, so as to maintain their integrity and functioning.
11	By 2020, at least 17 per cent of terrestrial and inland water, and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes.

12	By 2020 the extinction of known threatened species has been prevented and their conservation status, particularly of those most in decline, has been improved and sustained.
13	By 2020, the genetic diversity of cultivated plants and farmed and domesticated animals and of wild relatives, including other socio-economically as well as culturally valuable species, is maintained, and strategies have been developed and implemented for minimizing genetic erosion and safeguarding their genetic diversity.
14	By 2020, ecosystems that provide essential services, including services related to water, and contribute to health, livelihoods and well-being, are restored and safeguarded, taking into account the needs of women, indigenous and local communities, and the poor and vulnerable.
15	By 2020, ecosystem resilience and the contribution of biodiversity to carbon stocks has been enhanced, through conservation and restoration, including restoration of at least 15 per cent of degraded ecosystems, thereby contributing to climate change mitigation and adaptation and to combating desertification.
16	By 2015, the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization is in force and operational, consistent with national legislation.
17	By 2015 each Party has developed, adopted as a policy instrument, and has commenced implementing an effective, participatory and updated national biodiversity strategy and action plan.
18	By 2020, the traditional knowledge, innovations and practices of indigenous and local communities relevant for the conservation and sustainable use of biodiversity, and their customary use of biological resources, are respected, subject to national legislation and relevant international obligations, and fully integrated and reflected in the implementation of the Convention with the full and effective participation of indigenous and local communities, at all relevant levels.
19	By 2020, knowledge, the science base and technologies relating to biodiversity, its values, functioning, status and trends, and the consequences of its loss, are improved, widely shared and transferred, and applied.
20	By 2020, at the latest, the mobilization of financial resources for effectively implementing the Strategic Plan for Biodiversity 2011-2020 from all sources, and in accordance with the consolidated and agreed process in the Strategy for Resource Mobilization, should increase substantially from the current levels. This target will be subject to changes contingent to resource needs assessments to be developed and reported by Parties.

Source: CBD 2016

4.2 Identification and evaluation of approaches

Five approaches can be distinguished from the review carried out in Chapters 2 and 3. All of these approaches build on and are are carried out within the overarching analytical framework of causal chain analysis (CCA) that forms the backbone for all EU SIAs (see 3.2 and Figure 4.1).

Status quo approach: As a starting point, in Chapter 2 we screened the methodologies that have been used to address biodiversity in recent EU SIAs. While there are differences between the individual SIAs, we summarise the dominant methodology as the (1) 'Status quo approach'. This is a largely qualitative approach building on the results of scenario analysis and modelling with economic models in combination with stakeholder consultation and a limited number of case studies.

Qualitative approach: In Chapter 3 we identified and reviewed available methodologies, methods and models that could be used to improve this qualitative approach by making it systematic and comprehensive, taking account of the UNEP conceptual framework for assessing the biodiversity-related impacts in the context of agricultural trade policy, and carrying out a systematic assessment of core biodiversity indicators (species, protected areas and ecosystems) across all economic sectors. We highlighted the SIA of the EU-India FTA as a possible good basis for what we call an (2) 'Advanced qualitative approach'. This advanced qualitative approach, foreseen to take place within the CCA framework (see below), can be supported by a number of quantitative methodologies.

Quantitative approaches: Based on the review of quantitative methodologies in Chapter 3, we identify three broad approaches. (3) 'Industrial Ecology approaches' could support the advanced qualitative analysis by a quantitative EEMRIO analysis that links threat causes to threatened Red list species to projected changes in trade flows of goods and services and it could also quantify projected changes in a number of ecosystems and ecosystem services, as described in Section 3.4. In addition, Life Cycle Analysis could be applied to some products whose production and trade have been identified by the advanced qualitative approach as especially critical with respect to biodiversity and ecosystems. In particular, Life Cycle Analysis could support case studies that are an integral part of the qualitative approach. Alternatively, the qualitative analysis could be supported by modelling approaches by means of an (4) 'Integrated Assessment Model (IAM)' or by a chain of two or more (5) 'Loose-coupled models', including land use and biodiversity and ecosystem services models to assess a variety of indicators of biodiversity and ecosystem services associated with the economic scenarios (see Sections 3.5.3 and 3.5.4).

Figure 4-1 below provides a graphical illustration of the different approaches and their interconnections. The basic framework for assessment follows the causal chain analysis (CCA) where first a baseline of biodiversity and ecosystem services is established and where projections of economic drivers of change (the FTA scenario or scenarios) establish a counterfactual through advanced qualitative analysis. This advanced qualitative analysis can be supported by quantitative approaches, including industrial ecology approaches, loose-coupled land use and biodiversity models, or IAMs. Special attention is needed to define a comprehensive set of biodiversity indicators ('indicator analysis').

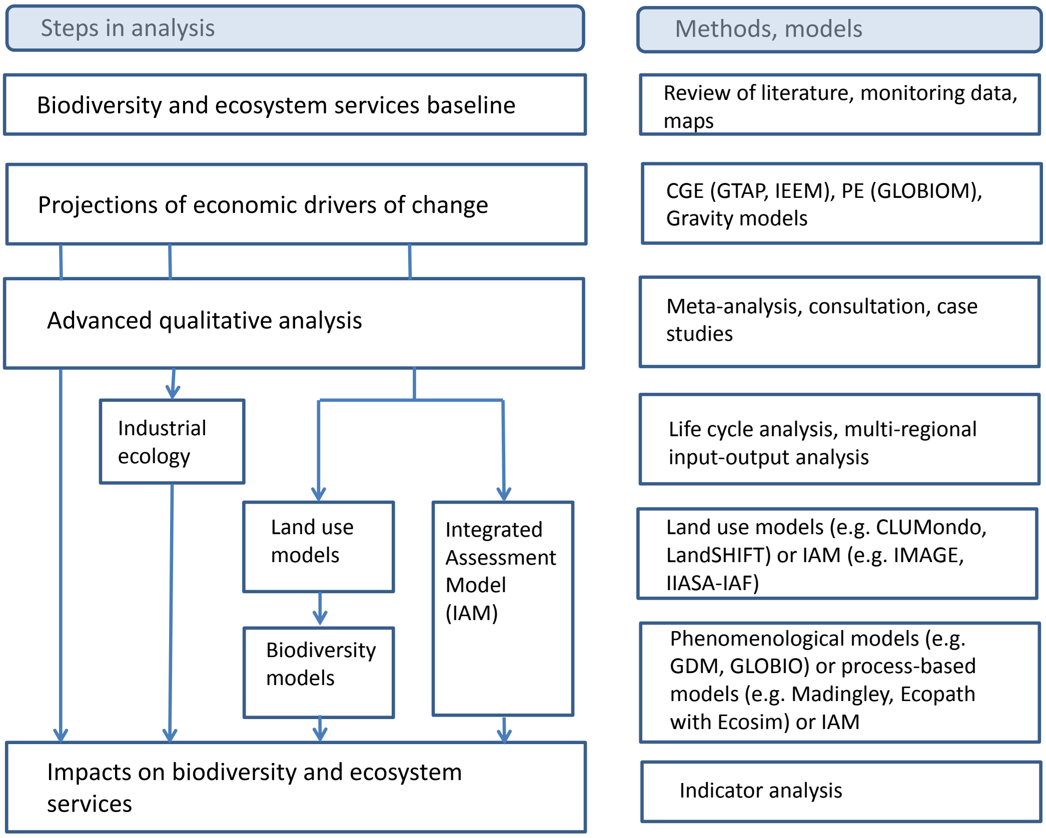

Figure 4-1: Approaches for the assessment of the impact of trade liberalisation on biodiversity (ecosystems and ecosystem services).

The figure shows the steps in the analysis (on the left) and methods and models that can assist the steps (on the right). After the assessment of the baseline and the projection of economic drivers of change, the impacts on biodiversity and ecosystem services are assessed through a systematic and comprehensive qualitative analysis. The qualitative analysis can be supported by a quantitative analysis using an industrial ecology approach (life cycle analysis, environmentally extended multi-regional input-output analysis) and/or by modelling approaches via loose-coupled land use and biodiversity models or by an integrated assessment model.

We can evaluate the approaches against the assessment criteria we introduced above in Section 4.1. As was explained in the introduction of this report, the Status Quo approach has been assessed as insufficient to assess the impact of trade liberalisation – and associated changes in trade flows and/or foreign investment - on biodiversity, ecosystems and ecosystems services. Since the Status Quo approach no longer suffices, we will not explicitly evaluate the approach here. A brief evaluation of the remaining approaches is given below in bullet points.

Advanced qualitative analysis:

- This approach is practical, and probably only slightly more time consuming than the status quo approach. The availability of data may be a problem.
- Comprehensiveness and detail is improved in comparison to the Status Quo approach, but spatial and temporal resolution remains a problem. Quantification of the impacts is not possible, except in case studies and therefore trade-offs with other social and economic impacts are difficult to assess.

- The approach will in principle allow the assessment of most of the CBD indicators. Yet, case studies for some indicators will be relatively straightforward, while others would be rather complicated, for example, when time-lags are involved or when the chain from cause to effect is mixed with other processes. An example of the former would be indicators related to Target 5: the rate of loss of natural habitat (see Table 4-1). Effects on extinction rates, however, would require time-spans that are practically not achievable within a case study and before the potential implementation of a trade-agreement. Case studies can also be valuable to assess some rather specific indicators that are more difficult to quantify in spatial models, such as
    - Invasive species pathways, related to Target 9 (see Table 4-1), as typically quite unique in a way that hampers quantitative analysis with spatial models, while case studies could build on existing examples, to establish such information.
    - Indicators related to Target 10 (see Table 4-1), anthropogenic pressures on coral reefs, also cover quite specific chains of causation that are difficult to establish in quantitative spatial models, while case studies could provide very valuable qualitative information on such relations.
- The approach is well-defined and transparent and should therefore be credible.
- The approach is relatively new (only tested in few cases such as the SIA EU-India) and therefore offers the potential for improvement.

Industrial Ecology:

- The practicality of the approach very much depends on the availability of the appropriate datasets. The EXIOBASE data seem to be in the public domain. Much of the Eora data are also in the public domain. The IUCN data on 'potential threats' are freely accessible. Given the appropriate datasets, the approach is relatively simple and straightforward and can be done in a relatively short period of time.
- The comprehensiveness and detail is limited in biodiversity dimensions (potential impact on threatened species) but large in species and sectoral detail. The approaches report 'potential' impacts, which is a rather unprecise metric. Both models also address a number of ecosystem services. The spatial resolution is either country or region, or 'biodiversity hotspot'.
- The coverage of CBD indicators depends on the availability of pre-existing knowledge on the relations between the outcomes of the EEMRIO model and biodiversity indicators. Such pre-existing knowledge could come from case studies for example, yet a large number of case studies is required for such parameterization. Developing and parameterizing such indicators from scratch would take a prohibitively long time in the context of an ex-ante assessment of trade agreements. As of yet such relations have been established for the impact on threatened species and for a number of ecosystem services including greenhouse gas emissions and air pollution, water use, nutrients and minerals.
- The Industrial Ecology approach is relatively transparent as the 'functions' of the EEMRIO model are basically mapping functions. The credibility of the approach is good as the methods have been described in prestigious academic journals. A weaker point of the approach is the subjective nature of the mapping functions used, especially in the Eora model.
- The approach is relatively new and offers scope for improvement.

Loose-coupled models:

- There are lots of land use models and the European Commission (JRC) operates its own (suite of) global land use models. The correct parametrization and the implementation of the economic scenarios as exogenous 'shocks' to the model may take some time but this would not be excessive. From a practical perspective, the approach of 'coupling' biodiversity/ecosystem services models to land use models can be problematic because it is relatively experimental and will probably need the close cooperation of different institutions.
- The comprehensiveness and detail, both spatially, temporally, and with respect to various dimensions of biodiversity and ecosystem services can be as high as the primary data allow. A chain of loose-coupled models can be developed and assembled with specific biodiversity indicators in mind, and are therefore flexible in addressing specific indicators. In addition, this flexibility allows selecting spatial units (countries) and spatial and thematic resolutions (i.e. pixel size and land cover types) that are required for the analysis of specific biodiversity consequences of trade-agreements. Similarly, loose-coupled models are not restricted to specific indicator models, as long as these can build on results from land use models. Therefore, chains of loose-coupled models can calculate a relatively wide range of biodiversity indicators:
    - Indicators related to Target 5 (see Table 4-1) mostly follow directly from the results of a land use model, and depend on the number and type of land use and land cover classes included.
    - Several models exist that assess the trends in (genetic) biodiversity, as included in Target 13 (see Table 4-1), as a function of land use and land cover changes.
    - Indicators for ecosystem services, such as related to Target 14 (see Table 4-1), have frequently been used to assess consequences of land-use and related land cover changes, and inclusion in a chain of loose-coupled models is relatively straightforward.
- While the transparency of these coupled models will be low (because of the complexities of the models), their credibility can be high, especially if the models and modellers have cooperated before in projects.
- This experimental approach offers enormous possibilities for improvement, both conceptually and data-wise.

Integrated Assessment Model:

- A disadvantage of IAMs is that they can typically not be operated outside the institution that developed them. An advantage is that IAMs typically contain all necessary data and that connections between modules are well-fixed.
- There are some IAMs that can do a comprehensive analysis from economic scenario to biodiversity impact (see Section 3.5.4).
- The exact number and type of indicators that are included in IAMs can differ considerably form one model to the other. In most IAMs, land use is a core result, therefore, indicator 5.1: Trends in forest extent, can be calculated by all IAMs. Trends in other types of natural habitat are typically more difficult as the number of land use and land cover types included in IAMs is generally limited. Biogeochemical cycles are represented with much detail in all IAMs, therefore, indicators related to nutrients flow, greenhouse gases, and carbon stock can be calculated. Several IAMs are equipped with specific indicator models that allow the

calculation of other key biodiversity variables. For example, the IMAGE IAM is equipped with the GLOBIO model, which calculates mean species abundances (an indicator that can be used for Target 13). One limitation of IAMs for the calculation of specific biodiversity indicators is the spatial resolution or granularity. First, in order to address the economic impacts on land-use activities, it is required that all parties included in the trade agreement (e.g. EU and the country with which the agreement is made) are represented specifically. Yet, some economic models use larger spatial units. Moreover, in order to analyse the consequences of these land-use activities on biodiversity, it is essential that the spatial resolution of land use and land cover change mapping is sufficiently fine to assess such effects. Most IAMs currently use 0.5 degrees or 5 arcminutes, both of which are relatively coarse for the assessment of specific consequences for habitat types.

- While the transparency of IAMs is extremely limited (due to their complexity), their credibility in academic and policy communities may be high because of publications in prestigious academic journals and their prior use in important projects.
- Existing IAMs usually offer limited scope for improvement. Due to their complexity, a change of data or internal processing is a major operation that is not easily attempted and that will carry big risks.

4.3 Gaps

In carrying out this scoping study, we have identified a number of gaps in SIAs and/or existing methodologies. Below we present a number of gaps.

Trade/Economic models

- Ex post analysis suggests that the performance of economic (CGE) models that project the sector-level effects of trade reforms has not been very good in at least a number of occasions. It is likely that the analysis will become even more difficult and the projections more uncertain as new free trade agreements will increasingly focus less on the removal of tariff barriers and more on the removal of non-tariff barriers.
- Currently, the focus of CGE models that are used to project the effects of trade reforms is primarily on energy-intensive industries and not on land-using industries. For a good assessment of the biodiversity impacts a stronger focus to land-using industries would seem necessary.

Investments

- With respect to investment, the key gap is that biodiversity is not consistently considered in the SIAs of the stand-alone investment agreements or those FTAs which have a specific investment chapter.
- In those SIAs in which biodiversity was considered the analysis was building on qualitative methods, with in many cases the lack of quantitative data explicitly emphasised.
- At the moment, the impact of investment on biodiversity is almost exclusively studied for the raw materials extraction sector (i.e. mining). There is little information on possible impacts via other sectors.

Qualitative analysis

- In principle, the framework for qualitative assessments allows for taking into consideration all relevant biodiversity indicators for trade impacts. However, while the indicators currently used linked to a range of relevant CBD targets, none of the existing examples provide a comprehensive coverage for impacts per target (i.e. use more than one or two indicators per target as per the CBD list of ideal indicator coverage). Therefore, even in the qualitative context the assessment of trade impacts on biodiversity seems not to be comprehensive enough.

- Also, the existing assessments do not cover CBD targets and related indicators in any systematic manner, especially across all trade sectors. In the context of the EU FTAs, the EU level assessment of the FTA between EU and India provides a unique example of a systematic qualitative treatment of a set of core biodiversity indicators (species, protected areas and ecosystems) across all economic sectors.

Land use and biodiversity models

- Land use models often represent land use relatively simplistically, using land uses related to the predominant land cover in a location. This representation reflects the source of much land-use data, which is remote sensing imagery. However, such representation ignores a number of aspects that are relevant for biodiversity, such as land use management, land cover composition, and landscape configuration. Both IAMs and loose-coupled models will be constrained by these issues, and its importance increases as the resolution decreases, as more information will become sub-pixel, and thus effectively lost. Recent developments in landscape characterization for improved land use modelling, including land systems approaches, aim to overcome these issues. These approaches have been applied on national, regional, and global scale (van Asselen and Verburg 2013; Ornetsmüller et al. 2016; Malek and Verburg 2017), in stand-alone applications as well as in combination with IAMs (Eitelberg et al. 2016), but are certainly not standard.
- A large number of methods have been used to calculate and express biodiversity strictly, i.e. the diversity in species. These include for example species abundance, extinction rates, species diversity, and several related measurements. Yet, results of these metrics might be contradicting and in general it is does not seem clear what quantifications are the most crucial and/or relevant for assessing the biodiversity impacts of trade agreements. Critical in this respect is the ability of methods to consider time dimensions and feedback loops, critical thresholds and tipping points, and uncertainty.
- Perhaps one of the largest challenges is a resource-gap: designing a study that comprehensively assesses the impact of a trade agreement using fine-resolution modelling for a specific country is quite resource intensive, and not available off-the-shelf.

4.4 Conclusions of the comparative assessment

In this chapter we distinguished between five approaches that could be taken to assess the impacts of FTAs on biodiversity and ecosystem services and evaluated them against a set of assessment criteria and specifically assessed their actual or potential capacity to assess the biodiversity indicators that have been selected by the CBD. The five approaches include the Status Quo, Qualitative analysis, Industrial Ecology approaches, Integrated Assessment Models, and Loose-coupled models.

The Status Quo methodology is practical and relatively cheap, but is limited in its ability to assess impacts on biodiversity, except in very broad terms. Moreover, as we discussed at the start of this report, the Status Quo methodology has been assessed as insufficient to assess the impact of trade liberalisation – and associated changes in trade flows and/or foreign investment - on biodiversity, ecosystems and ecosystem services. The rationale for this report is that the European Commission wants to advance impact assessment beyond the Status Quo.

Qualitative analysis beyond the Status Quo is a practical option. Advanced qualitative analysis should be systematic and comprehensive, based on a well-established conceptual framework. We mentioned the UNEP conceptual framework for assessing the biodiversity-related impacts of agricultural trade policy as an example. Qualitative analysis can in principle address any of the CBD indicators, and may be transparent, but will be of limited value in addressing complex cause-effect chains (and may not be very credible in such cases) and will not be able to assess effect-sizes. We see a prominent role for qualitative analysis to assess specific indicators that are more difficult to quantify in spatial models.

Industrial Ecology approaches have gained popularity in recent years. While the approaches are relatively transparent and offer promises for the future, at present their outputs in terms of biodiversity indicators is still limited. Moreover, the use of subjective mapping between economic activities and potential threats to species may render the approaches less credible or at least subject to criticism. Life cycle analysis could be applied to some products whose production and trade have been identified by the advanced qualitative approach as especially critical with respect to biodiversity and ecosystems. There is considerable scope for improvement in these approaches.

Loose-coupled models, e.g. land use change and biodiversity/ecosystem services models offer great flexibility to address a relatively large suit of biodiversity indicators at the required spatial and temporal resolutions. The downside of loose-coupled models is that they will be relatively expensive and risky to employ as their integration will necessarily involve some development. Also transparency may be an issue.

Integrated Assessment Models can be very useful in assessing entire cause-effect chains between economic (trade liberalisation) scenario to selected biodiversity impacts. IAMs contain all necessary data to do the assessment rather fast. The downside to IAMs is that they are typically not very transparent and that they are not flexible in changing regional aggregation or spatial resolution. Most IAMs were developed for climate change policy analysis for which a rather coarse resolution was appropriate. There is some evidence that IAMs will develop in a way that would better suit the needs of biodiversity policies in the future.

Any practical assessment will need a combination of approaches, based on the characteristics of the case at hand. Usually some combination of a systematic qualitative analysis with some quantitative model will be required. If there is an a priori belief that biodiversity impacts might be limited, a relatively simple quantitative assessment for some core indicators could be done by an Industrial Ecology (EEMRIO) approach. For assessment where biodiversity impacts are a priori believed to be more important, research funds could be invested in the services of IAMs or loose-coupled models. Even in the latter case, case studies will remain indispensable for indicators that are more difficult to quantify in spatial models, such as for example, the effects on invasive species or the effects on particular biological elements such as coral reefs.

5 SURVEY OF EXPERTS

This Chapter presents the results of a survey among experts in the field of biodiversity and trade that was used to complement the literature review that was carried out for this study.

The Chapter concludes that due to lack of comprehensive data, no single methodology was identified by the experts that could effectively assess the impacts of trade on biodiversity. Therefore, the experts agreed that using a mix of methods will help to get to a balanced analysis and go beyond a simple sum of results.

5.1 Introduction

The literature review carried out in the context of this study was complemented by gathering the views of key experts in the field of biodiversity and trade. This was carried out in a form of a questionnaire, designed to facilitate the gathering of opinions from the relevant stakeholders in a standard format to enable comparability (see Annex 2).

The questionnaire was disseminated to a number of key experts in the field of trade and biodiversity who have been identified during the initial stages of the study in discussion with the Commission. The selected experts include relevant stakeholders from International Organisations, EU level organisations, NGOs, scientists and private organisations such as consultancies, all from EU MS as well as from developed and developing countries outside the EU. Five experts were selected for their specific expertise in specific methodology/methodologies. All experts are listed in Annex 3.

In total, 51 experts were contacted with the request to fill out the Expert Questionnaire with altogether 10 of these experts providing responses (Table 5-1).

The following sections provide a synthesis of expert responses for each of the standardised questions in the questionnaire.

Table 5-1 Summary of questionnaire responses

Type of stakeholder	Number of stakeholders contacted	Number of responses received
EU-Expert	7	1
External Expert	39	5
Specific External Expert*	5	4
List of organisations responding to the questionnaire OECD - Organisation for Economic Co-operation and Development Joint Research Centre - European Commission Lund University ETH Zurich PBL Netherlands Environmental Assessment Agency Transport and Environment Earthmind Norwegian University of Science and Technology Cambridge Econometrics Ecorys		

* The specific external experts have expertise in specific methodology/methodologies.

5.2 Existing methodologies for assessing the impacts

One of the common reflections from the respondents was the acknowledgment that we are in the early days of biodiversity footprint accounting. Respondents highlighted how this is mainly due to the lack of consensus regarding both an impact metric on biodiversity and, consequently, of a method to attribute that impact to downstream agents.

Although widely used, some respondents noted how economic models alone might not provide an accurate representation of the impacts of trade liberalisation on biodiversity because:

- they are best at measuring economic impacts, from which the other impacts might follow;
- their results tend to be rather general even though they are often based on detailed data (e.g. land use and land cover masses that show changes in biodiversity);
- most models identify land use as the proxy for assessing biodiversity pressure. However, using actual observations of biodiversity pressure (ie the Red List) would be better;
- they often do not give country specific results but results per world region, something that is not very useful for assessing impacts on local biodiversity; and
- results seem to be estimated only for one or two CBD-biodiversity indicators. There are no well-known approaches that show effects on the full suite of the CBD-biodiversity indicators.

In terms of the classification of methodologies and methods in the Questionnaire, a respondent suggested that it would be interesting to make a distinction between retrospective accounts and forward-looking predictions.

One respondent also noted the importance of unpacking the term 'trade liberalisation' and rather more explicitly exploring trades in different types of services. Another respondent highlighted how the assessment should not be about trade impact but rather the impact of effective regulatory or domestic measures in place to help preserve the environment or biodiversity. According to this respondent, in understanding the policy implications it is thus important that a simple outcome/inference (e.g. demand effect on environment) is not taken from the analysis as this could be false (i.e. there are other forms of not trade related demand increases that may also result in negative environmental impacts such as population growth).

Finally, respondents also noted that all existing methodologies have their limitations, often related to the lack of data. In addition, it was highlighted that assumptions needed always to be made, which do not always completely reflect reality. As these disadvantages cannot be avoided, the respondents noted that combining and complementing a mix of methods helps to get to a balanced analysis and go beyond a simple sum of results.

5.3 Methodologies possibly overlooked or missing

Most respondents agreed with the study team's overview and categorisation of instruments, stating that it reflected comprehensively the methods available and most commonly used.

Some respondents included the following examples for further examination and potential inclusion within the next phase of the study[18]:

- Transport modelling;
- Ecologically Unequal Exchange;
- LC-IMPACT method, which adds potentially disappeared fraction of species as an endpoint measure in LCA;
- The use of mapping, such as Local Ecosystem Footprinting Tool (LEFT);
- New CGE models that are taking into account recent developments in Natural Capital Accounting. An example is the IEEM model (Banerjee et al. 2016);
- Methodologies for assessing the impact of products on biodiversity, approaches that can be then linked with global food consumption and trade databases (e.g. FAOSTAT) to then calculate the impacts exported and imported between nations (see Frischknecht & Jolliet 2016; Chaudhary et al. (2016); Chaudhary & Kastner (2016); and Chaudhary et al. (2017);
- Scenario building and biodiversity assessments (see the IPBES work programme);
- Review of biodiversity-relevant standards for FDI such as IFC PS6 which should ensure no-net-loss or net positive gain from trade flows;
- Fishery/open access models to explore the impact of demand and production systems on the environment. Fish trade and biodiversity would be an interesting area to explore and one where the complexities of getting the right domestic regulatory settings would be highlighted as the role of trade per se may be obscure over the open access problem.

5.4 Key gaps, weaknesses and challenges in current knowledge

There seemed to be a general consensus that current indicators and methodologies on biodiversity and biodiversity impacts of trade are unsatisfactory. As discussed above, respondents tend to agree that mainstream economic theory remains highly problematic when applied to the "real world" situations. Related to this problem, a respondent highlighted how although site and product specific issues are the main concern of the stakeholders, these are currently difficult to take into consideration in the existing trade models and therefore most of the models end up discarding them from the analysis. There needs to be better integration between issues raised by stakeholders and models / methods. Finally, and since the impact of a trade agreement on biodiversity assessment is hard to be captured directly from modelling, respondents suggested that having a more detailed overview of best practices in qualitative case studies would be a benefit from this study.

Another identified weakness of the current knowledge is the difficulty of better linking between economic sectors, land use and biodiversity. There are clear gaps in data collection, evidenced in the difficulties for mapping species occurrence or type of production system for a particular commodity. Respondents identified the early stages of ecosystem accounts as one of the main reasons for the lack of success on this kind of integrated analysis. Although they noted how both EU and Member States are investing on this (e.g. programmes such as WAVES, UNSD, and TEEB), respondents believe there is still a lot to do before we move forward from the current experimental phase. A step in the right direction might require considering the attribution of biodiversity pressure to specific industries or human activities. Threats tend to be currently classified by direct pressure rather than by industry/activity. However, a respondent believed that continuing the use of economic models (which are used commonly in business, government, etc.) would require to be able to link biodiversity pressure to economic activities (e.g. through

[18] Please note that most of these suggestions have already been added to the evaluation of methodologies in Chapter 3.

supply chains and scenarios). Another suggestion involves that the future knowledge should focus on identifying the structural economic drivers of biodiversity loss (e.g. economic incentives governing production as well as the demand for inexpensive food and forest products) rather than trying to monitor the processes through methodologies. For example, a respondent highlighted how EU trade policy could make a positive contribution to biodiversity if it identified and banned the various agri- and silvicultural practices that have negative consequences for biodiversity. A respondent also pointed out how environmental impacts are context and location specific. As a result, untangling shifts in demand and shifts in possible production locations is complex. In order to avoid a simplification of issues that might result in simple transitional-only solutions, research needs to explore the differing regulatory/control responses in order to see if there were synergies with trade based solutions (such as the imposition of technical barriers to trade to ensure compliance with certain production standards).

Conceptually, some respondents agreed that more clarity on key definitions is needed. One respondent raised the issue of what is meant by the term 'biodiversity' in any of the approaches presented and wondered why biodiversity and ecosystems are considered as separate when ecosystem services are a subset of biodiversity like services from species and genetic resources. Another conceptual issue that a respondent believes still requires agreement is how to frame the wildlife trade based economy and how trade liberalisation impacts the production and use of wildlife related goods and services.

Finally, respondents also highlighted how there is still a lack of knowledge of cause and effect relations on how different drivers – or sets of drivers - impact biodiversity. They highlighted that there are often various forces at play, some contributing to enhanced biodiversity and some to reduced biodiversity. A respondent with experience in the development of TSIAs argued that because of a lack of well-defined quantitative estimates this often leads to an ambiguous result.

5.5 Pathways with most impact on biodiversity conservation

Most of our respondents did not choose one of the three pathways presented (changes in market access, changes in foreign investment and changes in environmental provisions for trade) but discussed their views on what are the elements that in their opinion have most impact on biodiversity conservation.

In general, respondents acknowledged that all pathways are relevant and that it is hard to determine which has the most impacts as it will depend on the exact provisions for each of those pathways, and on the extent to which provisions are enforceable. The interplay of various factors is what results in global biodiversity loss, with the current model of development based on economic growth identified as the main underlying cause.

More specifically, a respondent believed that domestic policies are more important than the effect of a trade agreement. For example, if the trade agreement includes an increase in foreign investment but the country has at the same time a strong framework to avoid potential negative impacts of economic sectors (e.g. illegal logging), the effects will be very different than when it does not have such a framework in place. Also, the respondent noted that the role of MEAs helping to mitigate possible negative effects on biodiversity could be hindered by the fact that MEA provisions are usually not directly enforceable and that ratification does not automatically imply proper implementation. Consequently, the respondent believed the existence of MEA related clauses in the trade agreement may not automatically have the desired implications for the biodiversity situation in a country.

Regarding specific notes made in relation to the three specific pathways, some respondents noted how market access has the most impact on biodiversity. On the one hand, one respondent pointed out how increase in market access for particular goods/services could be the main driver on trade-related biodiversity loss when corrective measures do not take place. On the other hand, another respondent highlighted how market access to biodiversity assets at both the ecosystem and species level provides standards, codes of good business, etc., which in turn could translate to more responsible and sustainable utilisation of living natural resources. The respondent believes that without market access, legal and transparent international trade and foreign direct investment (FDI) are limited. Finally, one respondent highlighted how the use of market access restrictions is not recommended as they are removed from the ultimate objective to be an effective and efficient response, particular when explored over a longer time horizon. According to this respondent, the pathways that are most important are those which can engender a better environmental management approach. This is more likely to be found in environmental provisions for trade and also market based solutions that target production processes or direct FDI into certain environmentally sustainable activities.

Other respondents noted how policy interlinkages (e.g. climate policy affecting biodiversity conservation through programmes like REDD+) and foreign investment (biodiversity considerations as an element taken into account when assessing the granting of loans) need to be further considered as they also have biodiversity effects.

5.6 Insights as regards specific methodologies

An additional question was added to the group of external experts for those stakeholders that were selected for their specific expertise in specific methodology/methodologies. The following is a summary of the respondents' experiences using and/or combining quantitative and qualitative methodologies in order to assess impacts of trade liberalisation on biodiversity.

PBL Netherlands Environmental Assessment Agency: At the respondent's institute they are currently working on international supply chains and investigating how business decisions can better include biodiversity effects. They are also using input-output (IO) analysis to better understand the linkage between consumption, production and biodiversity. For the work for the Global Land Outlook, they also look at degradation (an important driver for biodiversity loss), but results show that the relation with trade, and especially trade liberalisation, is small.

Independent Expert in the field of Political Ecology: The relation between trade liberalisation and biodiversity has been amply theorised in political ecology, Ecologically Unequal Exchange (EUE), and eco-Marxist literature. This literature and the empirical findings forthcoming from research attempting to monitor processes of biodiversity loss tend to confirm that the relation is negative. A historical perspective shows how the integration of the world market over the past few centuries has ubiquitously resulted in biodiversity loss both on land and in the sea.

Cambridge Econometrics: From their experience with assessments of trade impacts on the environment, respondents from this Institute believe modelling should play a relatively small role in the assessment of impacts from trade liberalisation on biodiversity. They recommend this assessment should be strongly complemented by either ad hoc quantitative analysis or a more qualitative assessment.

Ecorys: The Institute's experience follows the step-processes outlined in this study:

- Assess the baseline situation;
- identify if there are specific severe pressures;

- use the outcomes of the CGE model, together with results of the environmental modelling, and apply causal chain analysis; and
- qualitative analysis is added to get a balanced overall picture.

In the sector analysis, the researchers apply a similar approach but usually go in more detail, as the analysis is more specific.

5.7 Conclusion

The detailed questionnaire responses provided interesting insights with the following key conclusions. In general, these conclusions supported the study team's findings presented in Chapters 2 – 4 above.

The series of methodologies and indicators identified by the project team were considered as a good reflection of the current knowledge regarding the assessment of impacts of trade liberalisation on biodiversity and ecosystems.

Due to lack of comprehensive data, no single methodology was identified by the experts that could effectively assess the impacts of trade on biodiversity. Therefore, the experts agreed that using a mix of methods will help to get to a balanced analysis and go beyond a simple sum of results.

Economic models alone might not provide an accurate representation of the impacts of trade liberalisation on biodiversity. Furthermore, the assessment of biodiversity effects cannot rely on the use of economic models alone, and therefore a more detailed overview of best practices in qualitative case studies would be a benefit from this study.

Key gaps, weaknesses and challenges in current knowledge regarding the assessment of biodiversity effects include the difficulty of better linking between economic sectors, land use and biodiversity; and lack of both clarity in key definitions and knowledge of cause and effect relations.

In general, market access and environmental provisions for trade in general have been identified as the key elements influencing biodiversity outcomes (both positive and negative) from trade liberalisation.

6 CONCLUSIONS AND RECOMMENDATIONS

This Chapter discusses the main findings of the study and presents the recommendations that we have drawn from it.

The scoping study reveals that the existing approach (i.e. Status Quo approach) for assessing the impacts of EU Free Trade Agreements (FTAs) on biodiversity (including ecosystems and ecosystem services) is not adequate because it does not assess those impacts in a comprehensive or systematic manner. While biodiversity is commonly used as one of the core FTA SIA sustainability indicators, the present use of more detailed indicators to substantiate this generic "biodiversity" indicator – both in qualitative and quantitative terms - is incomprehensive and inconsistent.

The use of indicators to capture possible impacts in a more specific and meaningful manner is limited, focusing mainly on the trends in species in trade, loss of natural habitats and/or status of threatened species. The use of such specific indicators varies between SIAs, e.g. in some cases these types of indicators remain unidentified. Furthermore, the existing SIAs commonly focus on assessing the biodiversity impacts of a limited number of sectors, failing to consider biodiversity impacts systematically across all trade-relevant sectors. These conclusions apply both in the context of assessing the FTA induced impacts on trade in goods and services and, to an even greater extent, the impacts of FTA related changes in foreign investment. Consequently, the aspirations for improving the EU approach to assessing biodiversity impacts of trade is well justified.

The overall conclusion of this scoping study is that no single existing methodology or method exists that would sufficiently address the identified current inadequacies. Therefore, a novel approach building on a) a more systematic use of biodiversity indicators and b) a more synchronized and fit-for-purpose use of different methods is needed. This conclusion seems to be supported both by the review of existing knowledge and the views of experts working in the field. More detailed recommendations on how to achieve this are provided below.

6.1 The underpinning role of qualitative methodologies

Causal chain analysis (CCA) forms the basic framework for identifying and assessing possible biodiversity impacts of FTAs, using both qualitative and quantitative means. The cause-effect chains of trade impacts on biodiversity are complex, with limited quantitative information foreseen to be available to unpick every nuance and address every relevant aspect. Not every aspect is measureable and even fewer aspects are measured. Therefore, qualitative methodologies – implemented within the overall CCA framework - will continue to play an important role in assessing trade impacts on biodiversity, both in terms of framing the overall analysis and providing information on sectoral and/or stakeholder impacts. In this context, qualitative assessment is foreseen to be the key in providing information to interpret the outcomes of quantitative analysis, for example by explicitly recognising potential biases linked to what cannot be measured.

Qualitative approaches will play an integral role in identifying and assessing the complex outcomes of trade on biodiversity, with stakeholder consultations and case studies complementing the assessment of impacts across different (key) sectors. However, the review of existing application of CCA (e.g. in the context of EU FTAs) reveals a need for more comprehensive and systematic application of biodiversity indicators across trade relevant sectors (see also section 6.4). Therefore, we recommend to design and implement an 'Advanced qualitative approach'. Agreeing on a more comprehensive set and application of biodiversity indicators, reflecting both the possible scope and time scale of impacts (i.e. short and long term), should be in the core of this approach (see section 6.4).

6.2 Understanding the limitations of economic models

Assessing the impacts of an FTA on biodiversity, ecosystems and ecosystem services typically centres on the assessment of the economic effects of the FTA in terms of trade flows, patterns of investments and production. Typically, Computable General Equilibrium (CGE) models are used to simulate changes in tariff and non-tariff barriers on trade flows, on the changes in 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 CO2 emissions. To assess the economic effects of investment liberalisation, gravity models of international trade have been used, sometimes in combination with a CGE model. To provide more detail for particular sectors, Partial Equilibrium (PE) models have been used. Although we identified recent attempts to integrate a wider set of environmental variables into CGE models, most CGE models compute only a very limited number of environmental variables that may have (indirect) impacts on biodiversity, ecosystems and ecosystem services.

Our review concludes that economic models alone are unfit to assess impacts of FTAs on biodiversity, ecosystems, and ecosystem services. Therefore, additional qualitative or quantitative approaches are needed to assess the impacts of economic scenarios on biodiversity, ecosystems and ecosystem services.

Research has also suggested that past performance of CGE models to project the sector-level effects of trade reforms has been rather poor. It is likely that the analysis will become even more difficult and the projections more uncertain as new FTAs will increasingly move away from focusing on the removal of tariff barriers to the removal of non-tariff barriers. This is important as being able to determine the sector-level effects of FTAs is the most important factor in assessing qualitative or quantitative effects on biodiversity. Trade economists have argued that the gravity model of international trade has more predictive power in assessing the impacts of 'deep' FTAs, i.e. free trade agreements that go beyond the reduction of tariffs, on trade flows within sectors. They have also argued for the combination of gravity and CGE models to assess the full economic impacts of FTAs (i.e. on sector-specific trade flows, production and consumption, income, and welfare). It is also important that CGE models that are used in SIAs to project free-trade scenarios provide more detail on land-using economic sectors, as these sectors are likely to have the most impact on biodiversity indicators.

The predictive power of traditional CGE models in assessing sector-level effects of trade reforms is limited and uncertainty is likely to increase because of the nature of modern 'deep' FTAs. It is recommended to examine possibilities to combine gravity and CGE models for future assessments, to retain a meaningful level of sector-specific predictability that allows assessing impacts on biodiversity.

6.3 Improving the performance of economic models through additional quantitative approaches

To link the predicted economic impacts of trade to possible impacts on biodiversity, ecosystems and ecosystem services, we have identified a number of quantitative approaches. These quantitative approaches are foreseen to be applied within a qualitative

CCA assessment framework (see above) and complemented by a number of qualitative approaches as appropriate (case studies and stakeholder interviews). In the quantitative context, we distinguish between Industrial Ecology approaches and Modelling approaches. Industrial Ecology approaches, such as Life Cycle Analysis and Environmentally-Extended Multi-Regional Input-Output Analysis, assume a linear relationship between economic output (volume of production) and environmental pressure. For the assessment of biodiversity these approaches assume a fixed, linear relationship between the production of certain products ('threat causes') and biodiversity indicators, such as changes in land cover, use of natural resources, emissions of pollutants, or threats to endangered species.

In comparison to the Industrial Ecology approach, modelling approaches aim to provide more detail on the cause-effect chain. With a land use model, it is possible to assess where production would expand and whether this expansion would be realized through intensification of production on existing plantations or through the creation of new plantations that may or may not endanger the natural habitat of an endangered species (e.g. the spider monkey). Yet, not all land use models are equally suited, and some ignore a number of aspects that are relevant for biodiversity, such as land use management, land cover composition and landscape configuration. With a suitable land use model, the effects on biodiversity indicators such as the population of target species can be assessed with biodiversity models that either use fixed relationships in phenomenological models (for example a fixed relationship between the area of a particular habitat and the population of a specific species), or through process-based models that model the key biological processes (including photosynthesis, fluxes of nutrients and food-web structures) that ultimately lead to effects on the biodiversity indicators such as for example the population of the target species. However, designing a study that comprehensively assesses the impact of an FTA, using fine-resolution modelling for a specific country can be quite resource-intensive, and is typically not available off-the-shelf.

We have identified quantitative approaches ranging from relatively simple 'fixed relationships' between economic activity and biodiversity indicators to more complex modelling approaches that better capture the causal relationships between drivers for change and impacts on biodiversity. Critical issues are time dimensions and feedback loops, critical thresholds and tipping points, and uncertainty. It is recommended to test some of these more complex approaches for use in SIAs. The testing can probably best be done in retrospective analysis of past FTAs.

6.4 More systematic use of biodiversity indicators

A range of indicators exist that can be used to assess the status of and changes in biodiversity. In the global context, the Convention on Biological Diversity (CBD) has identified a comprehensive list of indicators recommended to be used to assess the progress towards achieving the 2020 biodiversity goals (see Annex 5). However, as highlighted above, only a handful of these indicators are currently used in assessing biodiversity impacts of trade. Furthermore, the current application of biodiversity indicators in the trade context does not systematically differentiate between the possible short and long term impacts, critical trends and critical thresholds, therefore risking providing an insufficient basis for the identification of protective measures within the different timescales of a given agreement.

While for practical and methodological reasons it is not foreseen feasible to integrate all CBD biodiversity indicators (or similar) into FTA SIAs, there is a need to systematically broaden the coverage of biodiversity indicators in order to gain more meaningful and comprehensive insights into the possible impacts of trade on biodiversity – and finally appropriately address these impacts. Consequently, dedicated discussion and further assessment seems to be necessary to identify an 'extended set' of key biodiversity indicators to be used across all FTAs while minimising the risk of both oversimplifying or -complicating the analysis (e.g. the inclusion of too many indicators into the assessment is likely to start providing mixed results, due to overlap between some indicators such as 'changes in mean species abundance' and 'changes in species extinction rates').

Both qualitative and quantitative approaches to assessing trade impacts can be used to integrate the above additional indicators; however no single approach alone can provide information on all indicators. With respect to quantitative approaches, loose-coupled models provided the greatest flexibility in terms of the number and type of indicators included in the model as they can be tailored to any specific area, and as the desired indicator models can be selected based on the relevance for this area and this FTA. However, this approach is also the most resource intensive. Integrated Assessment Models, as well as Environmentally Extended MRIO models might provide suitable alternatives, as these can build on existing tools and databases. Yet these approaches are constrained by the limited number of indicators included and the relative coarse spatial resolution on which they typically operate. Life Cycle Analysis models could be used to assess impacts for a limited number of traded products that were identified as critical in earlier stages of the assessment.

We recommend the SIA process - and related guidance - to be reviewed with a view to broaden the set of biodiversity indicators included in the assessment. Furthermore, we recommend these indicators to be systematically used across all FTAs. Here we recommend a two-tier approach that includes a) an identification of a set of key indicators to be used across all SIAs complemented by b) a more FTA-specific set of indicators, corresponding to the key trade-related sectors involved. Importantly, we recommend that any assessment of trade impacts on biodiversity starts with the identification of biodiversity concerns and related indicators to match these concerns, with subsequently the most appropriate approaches (methods and models) to cater for these indicators to be selected.

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ANNEX 1: LITERATURE REVIEW: SUMMARY FROM SIA SCREENING

Below is a summary table of the database created for the screening of completed EU SIAs. All SIAs and related material can be accessed here.

FTA	Year of SIA completion	Method of SIA	Is BD mentioned or assessed?	Notes	Position paper mentions Biodiversity?
EU-US (TTIP)	2017	The TSIA has two main phases: an overall sustainability impact assessment (for the three main components - economy, social, and environmental) and an in-depth impact analysis at sectoral level. For the first phase, the TSIA conducts a combination of several methodologies with impacts assessed for 5 environmental themes (one being Land Use, Ecosystems, and Biodiversity). These themes are assessed by three channels: 1. CGE modelling for CC, energy, air pollution and material use; qualitative analysis of the quantitative results for possible indirect env. effects (e.g. ecosystems). 2. Trade channel, bio-related impacts assessed by case studies. 3. Regulatory effects (no bio-related theme assessed). For the Sectoral analysis, SIA conducts the Five-Steph Ecorys Sector Sustainability Approach (ESSA) which combines economic modelling for certain aspects and qualitative analysis (lit review and expert interviews for other)	Biodiversity one of the five environmental themes for the Overall Sustainability Impact specific provisions on (illegal) trade in natural resources. Cases for illegal trade of natural resources		No

EU-Myanmar	2016	Combination of quantitative and qualitative analysis (based on statistical data) and qualitative (based on indicator comparison and stakeholder consultation). Not enough data for modelling	Current environmental concerns in Myanmar divided into 7 categories: one being biodiversity	Data for quantitative analysis of environmental impacts is largely unavailable, so the analysis in this section is primarily based on qualitative research inputs and stakeholders.	No
EU-Japan	2016	The environmental analysis builds on both quantitative and qualitative elements. The quantitative analysis uses CGE and the construction of statistics using data from other sources. The qualitative analysis focuses on regulatory effects (maintain level of environmental regulation). Two case studies in fisheries and timber. In addition: stakeholder consultation.	Ecosystems and biodiversity was one of the four environmental topics the overall environmental analysis focused on; biodiversity being studied in the qualitative section.	The actual reports are not quite detailed in terms of how biodiversity impacts are quantified.	Yes, biodiversity impacts from increased output in food and feed sectors highlighted as only area with limited concern.
Green Goods Initiative	2016	Quantitative analysis applied to case studies. E3ME modelling for sectoral analysis. Case studies, consultations	Biodiversity is not one of the core indicators included. Millennium and SDGs are though		No position paper yet

EU-Jordan	2014	First, a Computable General Equilibrium (CGE) model is applied to determine the general effects of trade agreement. For the environmental analysis, CGE results are combined with environmental data to assess FTA effects on air pollution. The qualitative environmental analysis addresses wider environmental effects (e.g. water pollution and use, waste generation and treatment, use of land and land degradation, biodiversity, etc. as well as the implementation of multilateral environmental agreements). The first step is baseline scenario and identification of issues (for this the Yale Environmental Performance Index is used). The second step consists of a pre-analysis of how the FTA could affect the state of the environment both in general and for each of the identified issues. The third and final part looks at the likely impacts of the DCFTA on the environmental aspects described. The main methods applied for these qualitative analyses are literature reviews, consultations with relevant stakeholders, review of official reporting schemes inscribed on respective international conventions and causal chain reasoning.	Qualitative account of main ecosystems and endangered species, causal chain analysis of indirect impact due to water, air pollution etc.	There are two environmental output indicators resulting from the GCE model: 1) emissions and 2) land use intensity.	Position paper states that effects on ecosystems and biodiversity will be mixed, but does not elaborate more.
EU-Egypt	2014	The SIA was done alongside the EU-Jordan SIA and thus applies almost the same methodology. The CGE model is applied and for the quantitative environmental analysis effects on air pollution are looked into, which is complemented with a qualitative environmental analysis.	Idem	Idem	Idem

EU-Tunisia	2013	First, a computable general equilibrium model (CGE model) is used to determine general equilibrium effects of the potential DCFTA between the EU and Tunisia (the 57 original GTAP sectors have been aggregated into 37 economic sectors). Second, in addition to the CGE model, via complementary social quantitative impact analysis, more detailed insight is gained into the social impact of the DCFTA, focusing especially on poverty and inequality. Third, additional quantitative analysis is carried out to have more insights into the overall environmental impact of the DCFTA (airborne pollutants and greenhouse gases). Finally, additional qualitative analysis is crucial to assess the impact of the DCFTA, as not all impacts can be assessed quantitatively. The environmental analysis addresses the situation of the natural environment beyond air pollution – e.g. water pollution, waste generation and treatment, use of land and land degradation, biodiversity, etc. as well as the implementation of multilateral environmental agreements.	Yes	There are two environmental output indicators resulting from the GCE model: 1) emissions and 2) land use intensity.	No
EU-Armenia	2013	Environmental analysis based on quantitative (results of the CGE modelling; an index-based statistical decomposition analysis, and external costs assessment based on the impact pathway approach); air emissions. Qualitative analysis (Critical interpretation of CGE results at the sectoral level; Extensive literature review focusing on issues that are directly applicable to the Armenian situation; Selective analysis of official reporting schemes and commitments under international environmental agreements; consultations with all interested stakeholders).	The quantification of air emissions is complemented by qualitative analysis covering issues such as potential DCFTA impact on biodiversity, land and water pollution, resource efficiency, etc.	Biodiversity is only assessed qualitatively as a potential to be improved if environmental standards in Armenia improve as a result of the FTA	No
EU-Morocco	2013	The SIA was done alongside the EU-Tunisia SIA and thus applies almost the same methodology. The CGE model is applied and for the quantitative environmental analysis	Yes	Idem	No

		effects on air pollution are looked into, which is complemented with a qualitative environmental analysis.			
EU-Georgia and EU-Moldova	2012	Six pillar methodology: Screening and scoping; scenario analysis and CGE modelling; additional quantitative and qualitative analysis, sectoral analysis, Casual Chain analysis, consultation. Environmental quantitative analysis focuses on emissions. The main elements of the qualitative analysis for other elements are: literature review, analysis of official reporting schemes on international conventions, and interviews with key informants.	CGE model results on land use intensity are used to inform potential impacts on biodiversity		No
EU-Canada (CETA)	2011	Multi-region Computable General Equilibrium (CGE) model based on the framework of the Global Trade Analysis Project (GTAP). In addition to the CGE model, the study employed an E3MG (An Energy-Environment- Economy Model at the Global level) macro-econometric model. It also used several gravity models. Finally, to complement the quantitative assessment, the SIA used qualitative approaches in performing the impact assessment, all of which nvolve application of key TSIA sustainability indicators. Finally the methodology includes stakeholder consultation.	Biodiversity = one of 10 core environmental indicators, with two sub-indicators (Rate of overall land use of biodiverse areas -Common Bird Index - Number of threatened/endangered species/rate of change of this number).		No
EU-Libya	2009	According to the inception report quantitative analysis of a trade agreement with Libya poses unique challenges since Libya is not in the standard databases for model-based analysis involving computable general equilibrium models. The quantitative analysis therefore undertook a partial equilibrium modelling within a basic GISM framework. In contrast, the final report says that the Computable General Equilibrium (CGE) model has been employed (with GTAP) with two scenarios. As part of the qualitative analysis, first the analysis of sustainability issues is done, which specifically makes use of Revealed Comparative Advantage and the Finger-Kreinin Indices, as well as of the extent of intra-	Very superficially and only qualitatively.	The inception report states that three aggregate environmental indicator themes of the SIA methodology (biodiversity, environmental quality and	No position paper found

		industry trade (both vertical and horizontal) and the presence of NTBs to trade. The outcomes of the quantitative modelling formed a baseline for further environmental assessment. Further, the baseline environmental study for the EU-Libya Trade SIA outlines Libya's range of geographical, climatic and other environmental characteristics, as well as variations in biodiversity value in many areas, and varying degrees of pressure on natural habitats, land degradation, water resources and pollution levels, with considerable differences between rural and urban areas.		natural resource stocks) will be used but the results on these are not presented in the final report.	
EU-Andean countries	2009	Multi-region computable general equilibrium (CGE) model + qualitative assessment (expert assessment and consultation). Results from the quantitative equilibrium modelling identify the expected magnitude of the increase or decrease in production in each economic sector. In turn, this provides the basis for the environmental and social assessment of liberalisation of trade	Biodiversity is one of the 9 core sustainability indicators used in the analysis of the baseline conditions. At the methodological level, three aggregate environmental indicator themes of the SIA methodology - biodiversity, environmental quality and natural resource stocks capture the principal impacts of the trade sector.	Not able to find the key (sub)indicators within the Biodiversity component of the modelling	Yes, and recommendations for flanking measures are provided
EU-Central America	2009	Quantitative computable general equilibrium (CGE) model measures impact of trade agreement at macro scale and by key sectors using certain environmental (and other) variables (e.g. Change in CO_2 emissions, change in land use, change in agricultural output, biodiversity) and in-depth qualitative analysis by experts on the potential effects of the trade	Biodiversity is a core indicator within the Environmental Area of the Sustainability Impact Indicator for the quantitative modelling done for each of the key sectors (e.g. forestry,	The model is based on Francois, Van Meijl, and Van	Yes, the position paper does highlight the negative impact of trade on biodiversity

		agreement on the environment (e.g. biodiversity) - Casual Chain Analysis	textile, etc.). Also, specific indicators used within the biodiversity qualitative analysis include number of species, protected areas and ecosystem.	Tongeren (FMT 2005)[19]	
EU-Mercosur	2009	CCA. This includes several sub-methodologies, including Multi-region computable general equilibrium (CGE) model (namely the Copenhagen Economic Trade Model (CETM)). It also included Econometric estimation (gravity model); Strategic Environmental Impact Assessment (SEA); and Poverty and Social Input Assessment (PSIA).	The overall SIA incorporates 9 core sustainability indicators to assess impact of trade liberalisation, including three environmental ones (one of them being biodiversity)	Agriculture, manufacturing and services are the three key sectors fully assessed	Very briefly, it doesn't develop further on the main impacts to biodiversity
EU-ASEAN countries	2009	Combination of quantitative and qualitative analysis (based on CGE modelling) and qualitative (based on casual chain analysis and stakeholder consultation). Key outputs are case studies	Biodiversity is one of the core sustainability indicators measured in both the overall Impact Assessment and sectoral assessment. Biodiversity is specifically considered with qualitative methodologies, mainly through CCA, informed by stakeholder engagement		Yes, briefly

[19] http://siteresources.worldbank.org/INTRANETTRADE/Resources/WBI-Training/288464-1120851320801/ModelSims_vanTongeren.pdf

EU-India	2009	The environmental variables are partially covered in the CGE model (e.g. CO2-emissions). In addition to the CGE variables, the TSIA uses causal chain analysis, in-depth analysis through consultations with civil society and interviews with sector experts to get more insights into air quality, forestry effects, land use in agriculture, ecosystem, waste management, water quality and access to safe drinking water, desertification. Several of these issues are impossible to analyse quantitatively, but a structured approach is aimed for: lit review, define core aspects that influence the variable, go through the effects, and discuss them with experts.	SIA focused on impact of the FTA on forests, notably the spread of invasive alien species.. Biodiversity specific indicators for baseline scenarios include: number of species, protected areas, ecosystem.		Yes, No biodiversity effects in EU but indirect negative effect on biodiversity in India identified
EU-China	2008	Quantitative analysis through Globe Regional CGE Model, complemented by stakeholder consultation.	Biodiversity is measured as one of the indicators within the impacts table for environmental goods and services		No, it just mentions environmental protections in general.

EU-Korea	2008	Causal chain effects by combining quantitative and qualitative methodologies for nine core indicators.	Not clear; biodiversity is not one of the 9 core indicators or sub indicators.		No, it just mentions that both countries have adequate FWCs for env regulation.
EU-ACP	2007	The first stage of the framework was **a priority-setting exercise** for the five ACP regions. The second stage in the framework included an approach for identifying social and environmental impacts of changes in trade and economic activity affected by trade. Overall, **the approach adopted involved a combination of quantitative techniques (CGE modelling) and qualitative techniques (causal chain analysis, SWOT analysis).** The SIA was undertaken over four years and involved developing a methodology, undertaking **case studies in key sectors** throughout the ACP (in total 6 areas were analysed: fisheries in Pacific, tourism in Caribbean, agribusiness in West Africa, horticulture in ESA, financial services in CEMAC, rules of origin in SADC), and undertaking **extensive consultation** with negotiators, experts, and relevant stakeholders in civil society in the EU and in the ACP regions. Experience applying the framework confirms that there is no "one size fits all" approach that can be used to analyse the range of issues involved in a SIA. The **choice of techniques selected varied from sector to sector and among the regions**, and depended on the scope of the sector being studied, its economic weight, available data, and the required human	Yes	A set of environmental indicators, including biodiversity indicators were suggested within the initial phase of the SIA and were used to a different extent in all six sectoral analyses	No

		and financial resources weighed against expected value-added of the output.			
EU-Ukraine	2007	Core methodological components are: Causal Chain Analysis (CCA); Scenario analysis and CGE modelling; Sector case study methodology; Consultation and dissemination strategy.	There is a whole section on Biodiversity impacts in the final report. Sub indicators for this are: number of species, protected areas and ecosystems.		Yes, Trade expansion of industrial sectors expected to create a burden to air quality and biodiversity

Euro-Mediterranean	2007	Causal Chain Analysis is used to identify and evaluate potential linkages. Economic models (CGE), CCA, lit reviews and case studies.	Biodiversity is one of the elements considered for the baseline scenarios and the impacts of the FTA.		Yes, biodiversity is one of the negative impacts in areas of high existing stress.
EU-Arab States	2004	Causal Chain Analysis (CCA): consideration of economic and regulatory impacts, traces these changes through sustainability impacts on environmental and social issues: impacts assessed using subjective analytical techniques.	In the final report there is a section on the unsustainable consumption of natural resources and the impact on biodiversity. Indicator comparison between countries		Not specifically. It mentions potential degradation of some ecosystems like the marine environment.
EU-Chile	2002	Multi-region computable general equilibrium (CGE) model (namely the General Trade Analysis Project (GTAP) model) + qualitative assessment (expert assessment and consultation), informing further in-depth sector studies. Causal Chain Analysis.	In the environmental area of the SIA, Core indicators (and secondary indicators) include: Biological diversity (designated eco-systems, endangered species)		No position paper found
WTO Food Crops	2002	Development of scenarios and assessment of impacts. Case studies	Biodiversity is assessed for different countries		No Position paper
WTO Negotiations	1999	Sector by sector methodology: Scenarios, Significance by assessing indicators, CCA, Case studies.	Biodiversity is one of the core sustainability indicators measured.	The assessment varies from	No Position paper

			Second tier indicators for forestry: deforestation rate, changes in the protected ecosystems, number of endangered species…	sector to sector	

ANNEX 2: FINAL VERSION OF THE QUESTIONNAIRE

Institute for European Environmental Policy

Spring 2017

Scoping study:

Methodologies and Indicators to Assess the Impact of Trade Liberalisation on Biodiversity, Ecosystems and Ecosystem Services

Expert Questionnaire

Contract ENV.F.1/FRA/2014/0063

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Introduction

The EU 2020 Biodiversity Strategy adopted in 2011 commits the EU to enhance the contribution of trade policy to conserving global biodiversity and address potential negative impacts by systematically including it as part of trade negotiations and dialogues with third countries (Target 6, Action 17b).

The mid-term review of the Strategy published in 2015, however, found that even though the EU had taken initial steps to reduce indirect drivers of global biodiversity loss and to integrate biodiversity into its trade agreements the progress has been insufficient, including in reducing the impacts of EU consumption patterns on global biodiversity. Consequently, the Council has called the Commission to increase its efforts in implementing the trade-related aspects of the Biodiversity Strategy thereby increasing the positive contribution of EU trade policy to biodiversity conservation[20].

One of the barriers to increasing the effectiveness of EU trade policy as a means to support global biodiversity conservation is that there is currently no robust methodology to assess the impact of trade liberalisation – and associated changes in trade flows - on biodiversity, ecosystems and ecosystems services. More in-depth analysis aiming at developing a standard methodology and related indicators to assess the impact of trade on biodiversity is therefore required.

IVM and IEEP are carrying out a project for the European Commission to identify and assess the existing methodologies for biodiversity impacts of trade. Based on a detailed analysis of their strengths, as well as their gaps and weaknesses, we'll develop suggestions as to potential avenues for future work aimed at developing a robust and comprehensive methodology to assess the impact of trade liberalisation on biodiversity (ecosystems and ecosystems services).

State of play: methodologies and indicators identified based on a literature review

Methodologies and models

There is a vast and growing body of research on the impacts of global supply chains and consumption patterns on land use changes, biodiversity, and ecosystem services. A well-known methodological framework that links the impacts of changes in global supply chains and consumption patterns on land use changes, biodiversity, and ecosystem services is presented by Pereira et al. (2010). It distinguishes between scenarios of socioeconomic development pathways, projections of direct drivers, impacts on biodiversity, and impacts on ecosystem services. Meyfroidt et al. (2013) recently reviewed a number of independent streams of literature on the 'distant drivers' of land use change, interconnections between social-ecological systems that are separated geographically, with a focus on deforestation. They distinguish between approaches from economics, political ecology, land change science,

[20] Environment Council Conclusions, 16 December 2015; §52, 55, 58, 59 & 61

and industrial ecology. To assess the entire cause-and-effect chain between trade liberalisation and impacts on biodiversity and ecosystem services, a combination of methods and models is often required, although Pereira et al. (2010) note that some models include several components (PBL 2014; Alder et al. 2007).

Indicators

In the literature several indicators for biodiversity and ecosystem services have been proposed, but the lack of a consistent and adequate set of indicators has been highlighted as one of the key problems in this field of research (Hertwich 2012). Recently, the Parties to the Convention on Biological Diversity (CBD) have agreed on a set of indicators for the Strategic Plan for Biodiversity 2011-2020 and the Aichi Biodiversity Targets (CBD 2016). This set of indicators should guide further development of methodologies and models.

Sustainability Impact Assessments

Since 1999, the European Commission (and in particular the Directorate-General for Trade – DG TRADE) has been conducting Sustainability Impact Assessments (SIAs) on all negotiated trade agreements with non-EU countries. These SIAs serve as an important tool to assess the potential economic, social and environmental implications of the trade agreement in question and feed into the work of the negotiators (EC 2016). As of today, 25 SIAs has been conducted and 2 are currently in process.[21] As part of the literature review, a large share of the most recent SIAs (12 out of the 25[22]) were assessed in order to understand how impacts of the trade agreements on biodiversity and ecosystem services are analysed and considered within them.

The SIAs showed that there is a great interrelatedness between various methodologies and a wide range of quantitative and qualitative methods are applied. The SIAs in general applied a similar methodological approach with the following steps:

1. Screening and scoping analysis: establishing a baseline scenario on the status of the environment, including on biodiversity in most cases, together with an assessment of the implemented Multilateral Environmental Agreements (MEAs).
2. Scenario analysis and Computable General Equilibrium (CGE) modelling: delivering quantitative economic modelling.
3. Overall sustainability assessment, including social and environmental assessment: With regards to the environmental assessment, since CGE models often only apply modelling for GHG emissions, material use, and energy outputs, most SIAs apply additional quantitative and qualitative environmental analysis to complement and inform results from modelling. Biodiversity impacts are mostly considered in qualitative analysis using

[21] For the full list see: http://ec.europa.eu/trade/policy/policy-making/analysis/policy-evaluation/sustainability-impact-assessments/index_en.htm

[22] The following trade agreements' SIAs were analysed: EU-Jordan and EU-Egypt, EU-Tunisia and EU-Morocco, EU-Libya, EU-ACP, EU-US (TTIP), EU-Canada (CETA), EU-Andean countries, EU-Central America, EU-Mecorsur, EU-Chile, EU-Myanmar, and EU-ASEAN countries.

a combination of other methodologies, such as literature review, expert-led assessment of quantitative results, SWOT analysis and stakeholder consultation.

4. Sectoral analysis: specific sectors are further analysed and in many SIAs specific case studies are developed. For instance, the impacts of trade liberalisation on biodiversity are often considered in in-depth case studies on illegal trade of natural resources.
5. Causal chain analysis: is a conceptual tool that is used to identify the relevant cause-effect links between the trade measures that are being proposed and the economic, social and environmental impacts the specific trade measure may have.
6. Dissemination and consultation with key stakeholders: stakeholders are a parallel and complementary component of SIAs and run alongside the overall analysis.

Based on the literature and current SIA practice, Table 1 lists a number of methodologies and methods that are and could potentially be used in assessing the impacts of trade liberalisation on biodiversity and ecosystems services. As a rule, a number of methodologies and methods should be linked to assess the entire cause-and-effect chain.

Table 1 Methodologies and methods that are and could be used in assessing the impacts of trade liberalisation on biodiversity and ecosystem services

Methodology	Method	Models	References
I. QUANTITATIVE ANALYSIS			
Economics	General Equilibrium models	GTAP, CETM, E3ME, E3MG	Villoria and Hertel, 2011;Golub et al. 2013;Cambridge Econometrics 2014
	Partial Equilibrium models/Integrated Assessment Models	GLOBIOM, MAgPIE, IMAGE 3.0/GLOBIO	Schmitz et al. 2012; PBL 2010,2014
	Gravity models		Kohl et al. 2016; Oomes et al. 2017; Besedes and Cole 2017
Land system science	Land use change models	CLUMondo, LPJmL	Van Asselen and Verburg 2013; Dézecache et al. 2017; Bondeau et al. 2007
Industrial ecology	Multi-regional Input-Output models	EORA, EXIOBASE, WIOD	Lenzen et al. 2012; Moran and Kanemoto 2017; Marques et al. 2015; Wilting et al. 2017
	Life cycle assessment	--	de Baan et al. 2015
	Supply chain analysis	--	PBL 2016
Biodiversity science	Phenomenological models	Species-area models Niche-based models Dose-response models	PBL 2014; Alkemade et al. 2009.
	Process-based models	Dynamic global vegetation models Marine trophic models	Sitch et al. 2008; Christensen and Walters 2004.
II. QUALITATIVE ANALYSIS			
Qualitative data analysis	Literature review, expert analysis, SWOT analysis, use of qualitative indicators etc.	--	Several example of the use of qualitative methods for the assessment of trade impacts on biodiversity can be found within the Trade Sustainability Impacts Assessments (TSIAs) commissioned by the European Commission. All recent SIA-related documents are listed here: http://ec.europa.eu/trade/policy/policy-making/analysis/policy-evaluation/sustainability-impact-assessments/index_en.htm#_SIAs
Case studies/field research	Case studies are often developed using a combination of literature review, expert analysis, complemented with stakeholder engagement.	--	
Stakeholder consultation	Expert interviews, surveys, questionnaires, public consultations, workshops and dissemination of results	--	

Source: authors' own assessment based on references indicated in the table

Economics

The first step into assessing the impacts of trade liberalisation on biodiversity and ecosystem services is to assess the impacts of trade liberalisation on international trade flows and changes in economic activities. This is the case for both ex-ante and ex-post assessment.

For such assessments, economic models of different levels of complexity can be used. Examples are Computable General Equilibrium (CGE) models, Partial Equilibrium (PE) models, and Gravity models of international trade. These models can be stand-alone or built-in into Integrated Assessment (IA) models or Land Use Change (LUC) models.

Land system science

Land use change models typically operate on a finer scale than economic models, some global models have begun disaggregating land use to the grid cell (Meyfroidt et al. 2013). Land use change models typically employ the output of economic models to provide them with information on the drivers of land use change. Land use change models differ in the way they represent and integrate human behavior.

Industrial ecology

Environmentally-Extended Multi-Regional Input-Output (EE-MRIO) models link changes in global demand for products to an extensive series of global environmental effects, including effects on biodiversity and ecosystem services. Lenzen et al. (2012) and Moran and Kanemoto (2017) study the impact of the global demand for products on local threats on species that are considered vulnerable, endangered or critically endangered by IUCN and BirdLife International.

Biodiversity science

The links between drivers and impacts on biodiversity can be assessed by phenomenological models, that make use of statistical relationships between drivers (land use change, climate change, etc.) and biodiversity outcomes and process-based models that model the entire chain between driver and biodiversity outcome. Phenomenological models include species-area models, that use empirical relationships between area and species number to estimate extinction after habitat loss, and various other dose-response models. Process-based models include dynamic global vegetation models that integrate natural processes such as photosynthesis, respiration, plant competition and biogeochemical cycles.

Qualitative analysis

A wide range of qualitative methods can be used to assess the implications of trade liberalisation on biodiversity and ecosystem services, which can complement the above detailed quantitative methods.. These qualitative methods are not specific to biodiversity impacts per se and therefore should be tailored to the specific characteristics of the trade agreement in question, as well as to the environmental and biodiversity issues present in the specific country. For the purposes of this study and building on the review of the SIAs, we have grouped the types of qualitative analysis into three categories: i) qualitative data analysis, ii) conducting case studies and field research, and iii) consulting stakeholders.

Expert questionnaire

Please complete the questions below by adding your responses directly into the green boxes.

Q1 Do you have any comments as regards the existing methodologies for assessing the impacts (robustness, appropriateness, feasibility etc.)?

Q2 Are there any methodologies we might have overlooked that should be included on the list?

Q3 In general, in your view what are the key gaps, weaknesses and challenges in current knowledge?

Q4 In your view, which are the pathways that have most impact on biodiversity conservation, and why? (Changes in market access, changes in foreign investment and/or changes in environmental provisions for trade?)

Q5 Can you recommend any relevant fellow experts and research institutes?

Thank you for completing the questionnaire !

Please send the completed questionnaire to Alejandro Colsa (Acolsa@ieep.eu), preferably by Friday, 09 June 2017.

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ANNEX 3: SUMMARY DATABASE OF EXPERTS CONSULTED

Summary Database of experts contacted for questionnaire

Category	Name	Last name	Organisation
Expert	Manfred	Lenzen	University of Sydney
Tailored	Joan	Martinez-Alier	Universitat Autonoma de Barcelona
Tailored	Alf	Hornborg	Lund University
Expert	Carlos	Murillo	International Centre of Economic Policy for Sustainable Development
Expert	Abhishek	Chaudhary	ETH Zurich
Expert	Thomas	Kastner	Institute of Social Ecology Vienna
Expert	Anne-Célia	Disdier	INRA
Expert	Yann	Laurans	IDDRI
Expert	Elias	Lazarus	Global Footprint Network
Expert	Jussi	Viitanen	EU FLEGT Facility / European Forest Institute
Expert	Claire	Brown	UNEP-WCMC
Expert	Eva	Mayerhofer	European Investment Bank (EIB)
Expert	Jared	Greenville	OECD
Expert	Hussein	Abaza	UNEP - Economics and Trade Unit
Expert	Dan	Challender	IUCN Global Species Programme
Expert	Gretchen	Stanton	WTO - Agriculture and Commodities Division
Expert	Karsten	Steinfatt	WTO - Trade and Environment Division
Expert	Damon	Vis-Dunbar	IISD
Expert	Bill	Vorley	IIED
Expert	Dilys	Roe	IIED
Expert	Alexander	Kasterine	International Trade Centre
Tailored	Arjan	Ruijs	PBL
Expert	Ilana	Solomon	Sierra Club

Expert	Christophe	Bellmann	ICTSD
Expert	Francis	Vorhies	Earthmind
Expert	Crawford	Allan	WWF
Expert	Rachel	Kramer	WWF
Expert	Cécile	Toubeau	Transport and Environment
Expert	Laura	Buffet	Transport and Environment
Expert	Ivan	Ramirez	BirdLife International
Expert	Duncan	Brack	Associate at Chatham House and FERN
Expert	Antoine	Bouet	IFPRI - International Food Policy Research Institute
Expert	Sigrid	Ekman	CIFOR - Center for International Forestry Research
Expert	Robert	Hoft	CBD
EU	Luca	Montanarella	IPBES
EU	Carlo	Lavalle	JRC
EU	Joaquim	Maes	JRC
EU	Gael	de Rotalier	EC DG ENV
EU	Luca	Perez	EC DG ENV
EU	Anna	Balance	EC DG ENV
Expert	Dicky	Simorangkir	ASEAN Centre for Biodiversity (ACB)
Expert	Daniel	Moran	Norwegian University of Science and Technology
Expert	Keiichiro	Kanemoto	Shinshu University
Expert	Sino	Savilaakso	Center for International Forestry Research
Expert	Yogesh	Gokhale	The Energy and Resources Institute (TERI)
Expert	Lucia	Gallardo	Accion Ecologica
Tailored	Hector	Pollitt	Cambridge Econometrics
Tailored	Nora	Plaisier	Ecorys
Tailored	Paul Hubert	Jenart	Ecorys
Expert	Hans	Van Meijl	WUR
EU	Jesus	Barreiro-Hurle	JRC

ANNEX 4: RECOMMENDED FELLOW EXPERTS AND RESEARCH INSTITUTES

Respondents to our survey suggested additional relevant experts to consult in the next phases of the study. The suggestions are included in the table below.

Specific expert or general stakeholder group
Cambridge Centre for Environment, Energy and Natural Resource Governance
Lawyers
Institut de Ciència i Tecnologia Ambientals – Universitat Autonoma Barcelona
Ecological Marxists such as John Bellamy Foster, Brett Clark, Richard York, Christophe Bonneuil and Jean-Baptiste Fressoz
World Bank
IFC
LEI Institute at WUR University (Andrzej Tabeau)
The Institute for Prospective Technological Studies
PBL (Mark Thissen, regionalised model for Europe showing trade relationships between European Regions)
International Trade Center (Alex Kasterine)
International Centre for Trade and Sustainable Development (Deborah Vorhies)
Smith School of Enterprise and the Environment at Oxford University

ANNEX 5: AICHI BIODIVERSITY TARGETS AND INDICATORS

Table A5-1: Selection of relevant generic indicators to assess the influence of trade agreements on biodiversity. A large number of indicators are possible to assess, using qualitative analysis of case studies, industrial ecology approaches, integrated assessment models, or loose-coupled models. The columns Available and Potentially possible indicate whether these indicators are currently available in the methodologies that we have distinguished, or potentially available (i.e. the relationship can be established, but this hasn't been applied yet). QA, IE, IAM, LC indicate Advanced Qualitative assessment, Industrial Ecology, Integrated Assessment models, and Loose-coupled models, respectively. Note that these results are not a judgement about what can be calculated, but a reflection of the current availability of indicator models only.

Aichi Biodiversity Target	Selected Generic indicators	Available	Potentially possible
Target 1: By 2020, at latest, people are aware of the values of biodiversity and the steps they can take to conserve and use it sustainably	Policy target		
Target 2: By 2020, at the latest, biodiversity values have been integrated into national and local development and poverty reduction strategies and planning processes and are being incorporated into national accounting, as appropriate, and reporting systems.	Policy target		
Target 3 - By 2020, at the latest, incentives, including subsidies, harmful to biodiversity are eliminated, phased out or reformed in order to minimize or avoid negative impacts, and positive incentives for the conservation and sustainable use of biodiversity are developed and applied, consistent and in harmony with the Convention and other relevant international obligations, taking into account national socioeconomic conditions.	Policy target		
Target 4 - By 2020, at the latest, Governments, business and stakeholders at all levels have taken steps to achieve or have implemented plans for sustainable production and consumption and have kept the impacts of use of natural resources well within safe ecological limits	Policy target		
Target 5 - By 2020, the rate of loss of all natural habitats, including forests, is at least halved and where feasible brought close to zero, and degradation and fragmentation is significantly reduced	Indicator 5.1 - Trends in extent of forest	IAM, LC	QA, IE
	Indicator 5.2 - Trends in extent of natural habitats other than forest		QA, IE, IAM, LC

	Indicator 5.3 - Trends in fragmentation of forest and other natural habitats		QA, IE, IAM, LC
	Indicator 5.4 - Trends in degradation of forest and other natural habitats		QA, IE, IAM, LC
	Indicator 5.5 - Trends in extinction risk and populations of habitat specialist species in each major habitat type		QA, IE, IAM, LC
Target 6 - By 2020 all fish and invertebrate stocks and aquatic plants are managed and harvested sustainably, legally and applying ecosystem based approaches, so that overfishing is avoided, recovery plans and measures are in place for all depleted species, fisheries have no significant adverse impacts on threatened species and vulnerable ecosystems and the impacts of fisheries on stocks, species and ecosystems are within safe ecological limits	Indicator 6.3 - Trends in population and extinction risk in target and bycatch species		QA, IE, LC
	Indicator 6.4 - Trends in fishing practices		QA, IE,LC
	Indicator 6.5 – Trends in proportion of fish stocks outside biological limits		QA, IE, LC
	Indicator 6.6 - Trends in catch per unit effort		QA, IE, LC
Target 7 - By 2020 areas under agriculture, aquaculture and forestry are managed sustainably, ensuring conservation of biodiversity	Management target		
Target 8 - By 2020, pollution, including from excess nutrients, has been brought to levels that are not detrimental to ecosystem function and biodiversity	Indicator 8.1 – Trends in pollutants		QA, IAM, LC
	Indicator 8.2 - Trends in extinction risk and populations driven by pollution		?
	Indicators 8.3 - Trends in ecosystems affected by pollution		IAM, LC
	Indicator 8.4 - Trends in nutrient levels	IAM	QA, LC
Target 9 - By 2020, invasive alien species and pathways are identified and prioritized, priority species are controlled or eradicated, and measures are in place	Indicator 9.2 - Trends in the distribution and		QA

to manage pathways to prevent their introduction and establishment	populations of invasive alien species		
	Indicator 9.3 - Trends in eradication of priority invasive alien species		QA
	Indicator 9.4 - Trends in extinction risk and populations driven by invasive alien species impacts		QA
	Indicator 9.5 - Trends in impacts of invasive alien species on ecosystems		QA
	Indicator 9.6 - Trends in the numbers of invasive alien species introduction and establishment events		QA
Target 10 - By 2015, the multiple anthropogenic pressures on coral reefs, and other vulnerable ecosystems impacted by climate change or ocean acidification are minimized, so as to maintain their integrity and functioning	Indicator 10.1 - Trends in extent and condition of coral reefs		QA
	Indicator 10.2 - Trends in extinction risk and populations of coral and coral-reef dependent species		QA
	Indicator 10.3 - Trends in pressures on coral reefs		QA
	Indicator 10.4 - Trends in responses to reduce pressures on coral reefs		QA
	Indicator 10.5 - Trends in extent and condition of other vulnerable ecosystems impacted by climate change or ocean acidification		QA
	Indicator 10.6 - Trends in species extinction risk and populations or condition of other vulnerable ecosystems impacted by climate change or ocean acidification		QA
	Indicator 10.7 - Trends in pressures on other vulnerable ecosystems impacted by climate change or ocean acidification		QA

Target 11 - By 2020, at least 17 per cent of terrestrial and inland water, and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes	Policy target		
Target 12 - By 2020 the extinction of known threatened species has been prevented and their conservation status, particularly of those most in decline, has been improved and sustained	Indicator 12.1 - Trends in number of extinctions		IAM, LC
	Indicator 12.2 - Trends in extinctions prevented		IAM, LC
	Indicator 12.3 - Trends in extinction risk and populations of species		IAM, LC
Target 13 - By 2020, the genetic diversity of cultivated plants and farmed and domesticated animals and of wild relatives, including other socio-economically as well as culturally valuable species, is maintained, and strategies have been developed and implemented for minimizing genetic erosion and safeguarding their genetic diversity	Indicator 13.1 - Trends in genetic diversity of cultivated plants		IAM, LC
	Indicator 13.2 - Trends in genetic diversity of farmed and domesticated animals		?
	Indicator 13.3 - Trends in extinction risk and populations of wild relatives		IAM, LC
	Indicator 13.5 - Trends in genetic diversity of socio-economically as well as culturally valuable species		IAM, LC
Target 14 - By 2020, ecosystems that provide essential services, including services related to water, and contribute to health, livelihoods and well-being, are restored and safeguarded, taking into account the needs of women, indigenous and local communities, and the poor and vulnerable	Indicator 14.1 - Trends in safeguarded ecosystems that provide essential services	LC	IAM
	Indicator 14.2 - Trends in extinction risk and populations of species		IAM, LC

	that provide essential services		
	Indicator 14.3 - Trends in benefits from ecosystem services	LC	IAM
	Indicator 14.5 - Trends in the degree to which ecosystem services provides for the needs of women, indigenous and local communities, and the poor and vulnerable		QA
Target 15 - By 2020, ecosystem resilience and the contribution of biodiversity to carbon stocks has been enhanced, through conservation and restoration, including restoration of at least 15 per cent of degraded ecosystems, thereby contributing to climate change mitigation and adaptation and to combating desertification	Indicator 15.1 - Trends in ecosystem resilience		IAM, LC
	Indicator 15.2 - Trends in carbon stocks within ecosystems	IAM	LC
Target 16 - By 2015, the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization is in force and operational, consistent with national legislation	Policy target		
Target 17 - By 2015 each Party has developed, adopted as a policy instrument, and has commenced implementing an effective, participatory and updated national biodiversity strategy and action plan	Policy target		
Target 18 - By 2020, the traditional knowledge, innovations and practices of indigenous and local communities relevant for the conservation and sustainable use of biodiversity, and their customary use of biological resources, are respected, subject to national legislation and relevant international obligations, and fully integrated and reflected in the implementation of the Convention with the full and effective participation of indigenous and local communities, at all relevant levels	Management target		
Target 19 - By 2020, knowledge, the science base and technologies relating to biodiversity, its values, functioning, status and trends, and the consequences of its loss, are improved, widely shared and transferred, and applied	Policy target		

Target 20 - By 2020, at the latest, the mobilization of financial resources for effectively implementing the Strategic Plan for Biodiversity 2011-2020 from all sources, and in accordance with the consolidated and agreed process in the Strategy for Resource Mobilization, should increase substantially from the current levels. This target will be subject to changes contingent to resource needs assessments to be developed and reported by Parties	Policy target		

***Note**: Most model-based approaches are constrained to the terrestrial biosphere, only few available tools allow to directly relate the consequences of trade-agreements on marine ecosystems and biodiversity. A number of marine biodiversity models and ecosystem models exist (e.g. Madingley model, Ecopath with Ecosim, including EcoOcean), but these have not been linked to land use models and economic models, to our knowledge.*

ANNEX 6: BIODIVERSITY IN THE CONTEXT OF EU INVESTMENT AGREEMENTS

The European Commission negotiates with trading partners on behalf of the EU. Trade policy is an exclusive competence of the EU and in this area Member States can do nothing on their own. The Lisbon Treaty added foreign direct investment (FDI)[23] to the competence of the EU's common trade policy[24] and thus the European Commission now negotiates on behalf of the EU on both foreign direct investment protection and investment liberalisation.

In 2010, the Commission has adopted its Communication "Towards a comprehensive European international investment policy" (COM (2010) 343)[25] which sets out the EU's future investment policy. In the short-term, the policy called for the need to gradually negotiate about investment provisions in certain Free Trade Agreements (FTAs), while in the longer-term it suggested that in certain circumstances stand-alone investment agreements should be negotiated.

In 2014, the EU-Canada negotiations on the Comprehensive Economic and Trade Agreement (CETA) were concluded and this was the first occasion where EU-wide rules on investment formed a part of a broad trade agreement. Furthermore, investment chapters are being negotiated in the context of FTAs with India, Singapore, Japan, Egypt, Tunisia, Morocco, Jordan, Malaysia, Vietnam and Thailand. With regards to the self-standing investment agreements, in 2016 the EU-Myanmar investor protection agreement was concluded and the Commission is currently in the process of negotiating a specific investment agreement with China.

With the gradual introduction of this new investment policy the EU foresees to replace the almost 1200 Bilateral Investment Agreements (BIAs) of Member States with non-EU countries that currently cover investment protection with an EU agreement. The EU Regulation No. 1219/2012[26] ensures legal security for the BIAs until they are replaced by the EU-wide investment agreements.

An important part of the new provisions on investment is to set up a legally binding regime of protection for investment, which are accompanied by the so-called investor-to-state dispute settlement (ISDS) mechanisms. With these mechanisms investors can bring claims against governments in case they believe the investment protection obligations have been breached. Given the controversies around the ISDS mechanisms, which formed an important part of the EU-US TTIP negotiations, in 2015 the Commission has reformed its approach and the new policy envisages the establishment of Investment Court Systems (ICS), which would deliver clearer rules on investment protection. While ISDS mechanisms or the ICS can have implications on environmental policies, for instance via the effect of

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[23] "Foreign direct investment (FDI) is generally considered to include any foreign investment which serves to establish lasting and direct links with the undertaking to which capital is made available in order to carry out an economic activity" (EC Communication "Towards a comprehensive European international investment policy" (COM(2010) 343))

[24] Foreign direct investment being an exclusive external competence for the EU was further clarified through the European Court of Justice Advocate General's Opinion (2/15) in 2017 (https://curia.europa.eu/jcms/upload/docs/application/pdf/2016-12/cp160147en.pdf)

[25] http://trade.ec.europa.eu/doclib/docs/2011/may/tradoc_147884.pdf

[26] Regulation No. 1219/2012 on establishing transitional arrangements for bilateral investment agreements between Member States and third countries. http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32012R1219&from=EN

regulatory chill[27], this area is not in the scope of this study and as such not analysed in further details.

Similar to other trade provisions, investment under the investment chapters/ agreements can have important implications on the environment and biodiversity. The Commission's Communication specifically indicates that "investment agreements should be consistent with the other policies of the Union and its Member States, including policies on the protection of the environment, decent work, health and safety at work, consumer protection, cultural diversity, development policy and competition policy." In addition, the principle of sustainable development is also emphasised.

The SIA of the EU-Myanmar investor protection agreement[28]

The SIA, which was completed in 2016, applied both quantitative and qualitative methods for the assessment and also conducted an extensive stakeholder consultation (interviews, questionnaire, website, workshops). The analysis followed a two-step approach where first a baseline scenario was developed, which was followed by an investment protection agreement scenario. As negotiations were still ongoing during the SIA the consultants have used other negotiating texts, such as the CETA, as reference. The potential environmental impacts were assessed utilising a causal chain analysis with the use of the most relevant indicators.

As quantitative data was lacking for the environmental analysis it was primarily based on qualitative assessment, which included desk-based research and extensive stakeholder consultation. Biodiversity was specifically although very briefly assessed: the current situation was presented with potential future predictions building on the available literature. While overall impacts will largely depend on the direction of investors the SIA suggests that an increase of investment from companies applying sustainability standards and engaging in sustainable practices has the potential to positively impact the protection of biodiversity in Myanmar. In addition, impacts on forest resources, land degradation and water resources are also assessed. Finally, a sectoral environmental analysis was conducted, including on fisheries and the agriculture sector.

Overall, the environmental impact assessment concluded that the potential impacts of the agreement cannot be reliably estimated given the uncertainty around environmental management related to the future investments and as such impacts could be both negative and positive. A key question is whether environmental legislation and governance will improve in Myanmar in the future, in particularly linked to corruption and mismanagement in areas such as illegal logging and mining.

The SIA of the EU-China investment agreement

The SIA focusing on the EU-China investment agreement has not been finalised yet; so far only the SIA inception[29] and interim[30] reports have been published in 2016 and 2017. This Inception Report provides an overview of the planned methodology of the SIA, including on the environmental analysis. For the initial screening exercise the use of the Better Regulation Toolbox (#16: Identification/screening of impacts) is suggested, which will be complemented with the use of OECD Key environmental indicators and the EEA's environmental indicators. Biodiversity,

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[27] In the case of ISDS/ICS the argument for regulatory chill stems from the risk that national governments may become more cautious in introducing new environmental (or other) policies because of the fear that such new policies could lead to expensive ISDS/ICS procedures against them.

[28] http://trade.ec.europa.eu/doclib/docs/2016/december/tradoc_155121.pdf

[29] http://trade.ec.europa.eu/doclib/docs/2016/july/tradoc_154778.pdf

[30] http://trade.ec.europa.eu/doclib/docs/2017/june/tradoc_155638.pdf

flora, fauna and landscapes are listed as one of the seven key areas where indicators are planned to be used. The environmental analysis also suggests paying particular attention to the potential impacts of the investment agreement on sustainability issues covered by multilateral environmental agreements.

With regards to biodiversity, the SIA formulates the following two questions it will aim to answer:

- Does the investment agreement reduce the number of species/varieties/races in any area (i.e. reduce biological diversity) or increase the range of species (e.g. by promoting conservation)?
- Does it affect protected or endangered species or their habitats or ecologically sensitive areas?

In order to answer these questions, the sole use of qualitative analysis is suggested and as such no specific biodiversity indicators are proposed. The qualitative analysis will be based on the results of the Commission's Impact Assessment (see below) and the results of the SIA's economic analysis and will be complemented with literature review, desk-based research and stakeholder consultation.

The SIA specifically states that the assessment of the potential environmental challenges will be based on the 2012 Copenhagen Economics[31] study, which served as a background study for the Commission's Impact Assessment Report on the EU China Investment Relations[32]. The Copenhagen Economics study used a gravity model to assess the economic effect of FDI stocks where investment barriers were measured by the Copenhagen Economics index of perceived restrictiveness. This was complemented by GCE modelling of the macroeconomic effects. The Copenhagen Economics study also assessed the potential environmental impacts. An empirical assessment was completed on pollution intensities of various manufacturing and services sectors. This analysis was complemented by the assessment of potential changes in CO_2 emissions. While the study indicates that the most important environmental impacts were assessed by these two methods further environmental aspects should be considered, including the potential impacts on biodiversity. Nevertheless, the study does not go into further details.

31 https://www.copenhageneconomics.com/dyn/resources/Publication/publicationPDF/3/313/1435826144/44-24-eu-china-final-report-11jun2012.pdf

32 Commission Staff Working Document (2013) Impact assessment report on the EU-China investment relations, SWD (2013) 185, Brussels

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