

Attribution of impacts to bioenergy production and use for the implementation of the GBEP Sustainability Indica- tors for Bioenergy (GSI)

Technical Paper for the GBEP Task Force on Sustainability

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prepared for



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1 Introduction and purpose

Introduction

The GBEP Task Force on Sustainability (TFS) was reopened in May 2015 with a new scope of work agreed by the GBEP Partners, with the focus to enhance the practicality of the GBEP Sustainability Indicators for Bioenergy (GSI) by producing an implementation guide to complement the “Global Bioenergy Partnership Sustainability Indicators for Bioenergy” report. The GBEP Working Group on Capacity Building (WGCB) elaborated a list of cross-cutting issues where it was regarded as important to provide further guidance to implementation practitioners.

One of these issues, which was encountered in almost all of the GSI implementation projects, addresses the challenge of how to attribute the measurement of the indicators clearly to the production and use of bioenergy in contrast to all other applications. This methodological challenge is referred to as the ‘attribution issue’.

Therefore, it was agreed that a technical paper on attribution should be prepared to provide basic information about this complex matter in order to shed light on the implications of the topic and to give recommendations for practical application.

Purpose of this paper

The content of this paper shall serve as input into the implementation guide on the GSI initiated by TFS, but can also be used as a stand-alone document.

The attribution of impacts to bioenergy production for the use of the GSI consists of many different aspects. For a better understanding, it is necessary to structure the issue and above all provide solutions to the problems that occur in reality.

Therefore, this paper aims to:

- identify the relevant attribution issues;
- structure the underlying attribution issues and identify general solutions to the attribution problems;
- provide specific guidance for the different indicators according to the data situation in the GBEP member countries; and
- report the analysis and guidance in a document as a knowledge base which can be amended in the future as experience will grow.

Structure of the document

In line with the aims identified above, this Attribution Paper will be structured as follows:

- As a first step, the paper identifies the general problems that arise from the attribution to bioenergy of indicator results that have a broader perspective (chapter 2).
- Then some general guidance is presented based on the different underlying aspects of attribution. The structured approach shall help to identify the occurring attribution issues and motivate to find solutions based on these general considerations (chapter 3).
- Special guidance will be given for each one of the 24 GSI. This guidance will be grouped into the three different pillars of GSI:
 - environmental indicators (chapter 4),
 - social indicators (chapter 5), and
 - economic indicators (chapter 6).

Finally, some highlights concerning the attribution issue will be presented.

2 The attribution issue

2.1 The general question

The character of the attribution issue

The GSI deal with the role of bioenergy in respective countries. Like other sectors in a society, the generation and use of bioenergy is part of the entire economy. Focusing on one sector always means to separate it from the whole economy and specify its role within the economic system of a country. The isolation of one sector is connected with the rules and conventions about how to draw the line between the sector of interest and the remainder.

This is also true for bioenergy. Isolation of the sector starts with a definition of the bioenergy system as such but, in the end, involves solving all questions which arise from parting this system from all other systems. This operation will be referred to in this paper as attribution.

There are three main components to this issue:

- Separating bioenergy from other activities
- Coupled processes provide bioenergy
- Assignment of measured effects to bioenergy

Separating bioenergy from other activities

To attribute impacts to bioenergy, the activities in the bioenergy system must be separated by their end use. For instance, besides its application as renewable energy, biomass could be harvested and used as food, animal feed or as material, e.g. in the building sector. So an attribution of the harvest activities of a certain biomass has to be split according to its later use. This may sound simple but often the final uses of biomass are not defined in advance and its final assignment depends on many factors (i.e. seasonal weather conditions, biomass quality, market price, etc.), which are linked to spatial and temporal circumstances.

Additional and detailed information are often needed to address this attribution issue. However, in general, information will never be sufficient to meet the demand for a clear and unambiguous demarcation line between the bioenergy system and other applications. Therefore, rules are needed to deal with the isolation of bioenergy in a feasible but also consistent way. Consistency is important to make results comparable with former numbers or other bioenergy applications. Indicators lose their value if arbitrariness causes doubts in the results or changes them according to an underlying methodology.

Coupled processes provide bioenergy

It is not always the lack of information that causes difficulties for attributing information to the bioenergy system. More fundamental problems arise if a certain process generates different outcomes which feed into the bioenergy system and into other systems, for example, alimentation. Then the fundamental question arises about whether the impacts of a process can be attributed to bioenergy or the foodstuff.

Examples of these coupled processes are manifold. For example, the procedure of growing and harvesting of a crop like wheat which is meant to produce flour while straw is burned for heating purposes. Then questions arise like “does the occupation of land belong entirely to alimentation or also partly to bioenergy” or “is the use of fertilizer or pesticide only caused by the production of good quality and quantity of grains”? Other examples also occur in single production processes like the sugar production, which yields sugar and bagasse as a by-product. If sugar is used as a foodstuff and bagasse as bioenergy then the process itself, and its related upstream activities (sugar cane growing, transportation, etc.), must be assigned to the bioenergy sector and the non-bioenergy sector.

Attribution rules are also needed in these cases to avoid arbitrariness in using GSI. It must be noted that scientific or technical solutions do not necessarily exist to clearly separate bioenergy from the rest of the world. Conventions have to be agreed upon if no straightforward way of attribution exists. Therefore, a procedure to name and solve attribution issues is crucial and helpful for the guidance of practitioners which are confronted with these kinds of questions.

Assignment of measured effects to bioenergy

The above mentioned attribution issues exist for indicators that are based on an outcome due partly to bioenergy and partly to another product systems. In this case, the outcome of economic activities has to be attributed to bioenergy and non-bioenergy. For example, global warming caused by GHG emissions from sugar production has to be assigned to food production and ethanol production (bioenergy) or to bagasse as a bioenergy co-product.

However, the reverse attribution problem also arises, which occurs when the GSI measures an effect that may have different causes. For example, indicator 15 (“change in mortality and burden of disease attributable to indoor smoke”) is based on total mortality and disease figures. In this example, all other reasons which lead to mortality and disease have to be taken into account and be separated from the cause “indoor smoke”.

2.2 Attribution issues raised during implementation

Seventeen GBEP partners or observers have performed or started to perform the measurement of the GSI at national or subnational level, while three further countries have committed to start implementation (see **Fehler! Verweisquelle konnte nicht gefunden werden.**).

COUNTRIES	COMPLETED	IN PROGRESS	PLANNED
Argentina	N		
Brazil	L		
China			L
Colombia	N		
Egypt	L		
Ethiopia		N	
Germany	N1	N2	
Ghana	N		
India			N
Indonesia	N		
Italy		L	
Jamaica	N		
Japan	L		
Kenya		N	
Netherlands	N		
Paraguay	N		
USA		N	
Sudan			L
Uruguay		N	
Vietnam	N		

Table 1 Overview of the implementation of GSI (N stands for national level; L for local level)

Indicator reports have been published by the countries that completed the work. Furthermore, templates have been elaborated under Activity Group 2 (“Raising awareness and sharing of data and experiences from the implementation of the GBEP indicators”) of the WGCB to characterize and document the outcome of each of the accomplished implementation projects. These templates contain a list of the most frequent problems/difficulties identified while measuring the indicators, including attribution issues.

The GSI implementation reports mention many attribution issues and provide solutions where possible. In contrast, the templates were found to be too general to work with further.

The work on the implementation guide was divided into three sub-groups of the Task Force on Sustainability (TFS) for each pillar or sustainability. These three groups held regular teleconferences during 2017 to discuss important issues to be resolved based on implementation experiences, and potential guidance. These reports have been used to determine the most important attribution questions to be dealt with in this report.

Selected implementation reports and the experience of TFS sub-group members are the basis for the evaluation about the need for guidance on the attribution issue. The following countries have been selected for the analysis:

- Columbia
- Germany
- Indonesia
- Paraguay
- Vietnam

Columbia

The assessment is focused on biodiesel made from palm oil and sugarcane ethanol. Ethanol is produced from molasses which is a by-product in sugar production. All sugarcane ethanol is used nationally; there is neither import nor export. Only 45% of the palm oil is used for biodiesel production and all biodiesel is used nationally.

Germany

The assessment is focused on the bioenergy sector as a whole. Usually the crops assessed can be used for all areas, such as bioenergy and food/feed production, and at the cultivation level the later use of the crop is not known in the first place.

Indonesia

The assessment is focused on biodiesel made from palm oil. The majority of the palm oil produced is exported for various purposes (mostly food industry) and only 8 % is used at a national level for biodiesel production.

Paraguay

The assessment is focused on the two priority bioenergy pathways identified in Paraguay – forest biomass for energy, at both household and industrial levels, and ethanol from maize and sugarcane.

Vietnam

The assessment is focused on the two priority energy pathways that were identified for application: cassava-based ethanol and biogas at household, farm and industrial level.

2.3 The way forward for guidance

The analysis of attribution issues for the GSI has shown some fundamental and repeating aspects that should be highlighted (discussed in chapter 2.1), which are categorised into different types. Chapter 3 will provide some general guidance about these overarching aspects that should be considered when tackling a problem, and the guidance will define each category of problem before proposing solutions. Of course, this guidance will not be exhaustive and assistance or exchange of expert knowledge could help further. However, this approach will help the practitioner to understand a newly arising attribution problem which may not have been dealt with in this guidance document.

The chapters 4, 5 and 6 will concentrate on the three areas of sustainability and investigate single indicators. Not all indicators will be assessed in detail; the criteria for inclusion was as follows: if they have been mentioned somewhere in the five reviewed implementation reports or if they have been mentioned by the respective TFS sub-group. Where potential attribution issues are identified for a GSI that is not discussed in detail, reference is made to similar problems and guidance in other indicators.

For each indicator with one or more relevant attribution issues the following structure is applied:

1. Short recapitulation of the indicator and its measurement

The short recap of indicator and its measurement shall facilitate a quick understanding of the indicator without consulting the GBEP indicator report. Nevertheless, it is advised to read into the objectives and scientific background of a specific indicator to fully understand the attribution problem and an appropriate solution to it.

2. Attribution challenges during GSI implementation in some countries

Mentioning the attribution challenges provides a quick insight into which of the five implementation reports have raised a question and maybe also provide a solution. Table 2 shows the approach used. In order to have a quick look into the respective report, the reference cites the page number of that report. (It should be noted that the full implementation report of Paraguay is in Spanish.)

Country	Attribution issue	Used approach	Reference

Table 2: Evaluation scheme of specific attribution issues in country reports

3. Issues highlighted by the TFS sub-group

Short notes on the sub-group report are provided to indicate which issues were discussed and if any guidance was given.

4. Specific guidance for the indicator

Subsequently, single attribution issues are taken up for the selected indicators. Depending on the indicator, more than one issue is addressed.

The guidance provided will be methodological guidance (rather than country-specific), since country-specific conditions, existing statistical systems and the quality of data can be very different and demand individual approaches.

3 General guidance for the attribution issue

3.1 Overarching considerations

Before structuring the issues which may arise at an indicator level some overarching considerations shall be made first.

Obeying overarching criteria

The most important criteria that shall be respected for tackling an attribution issue are as follows:

- Plausibility
- Transparency
- Practicability

Plausibility is needed to understand the rationale behind an attribution issue, whilst transparency supports the reproduction of solutions. Practicability ensures the feasibility of an assignment under given circumstances.

Practicability as the main challenge

Practicability is connected to the availability of data and therefore directly linked to the economic effort required to produce data for sector-specific attribution. An idea to bridge the gap is to work with solutions for the attribution issue that require different efforts to achieve data and figures. The TIER approach supports the needs and possibilities for use of indicators under different circumstances¹.

Respecting the objective of an indicator

Every indicator has a purpose. This purpose is formulated in the GSI Report (GBEP, 2011) under the heading “How the indicator will help assess the sustainability of bioenergy at the national level”. The solution of an attribution issue must be in line with the text given under this heading.

¹ The definition of the TIER approach from the IPCC Inventory Guidelines: A tier represents a level of methodological complexity. Usually three tiers are provided. Tier 1 is the basic method, Tier 2 intermediate and Tier 3 most demanding in terms of complexity and data requirements. Tiers 2 and 3 are sometimes referred to as higher tier methods and are generally considered to be more accurate.

For instance, the objective of an indicator may set the system boundaries. According to the objective, the system boundaries related to an indicator could be:

- the entire life cycle (e.g. Indicator 1 – the GHG balance for a bioenergy product)
- the national situation (e.g. Indicator 12 – jobs in the bioenergy sector)
- the national territory (e.g. Indicator 2 – soil quality for bioenergy crops)

The assignment methodology must respect the underlying system boundaries.

3.2 DPSIR - a helpful methodological framework for indicators

Attribution issues of different character and measurement may exist for all 24 GSI. A methodological framework for indicators is regarded as helpful to better analyse and solve attribution issues connected with the indicators. Such a well-established framework was initially developed for environmental indicators by the OECD and subsequently amended by the European Environmental Agency (EEA).

The framework, known as DPSIR, structures indicators along plausible cause-effect-chains and shows how indicator contents are interlinked without judging if it is positive or negative. In the amended version, the components of the framework are defined as follows (complemented by examples of bioenergy use):

- **Driving forces**
Driving forces describe the causes that initiate a change of activities by groups or individuals. Example: enhanced use of bioenergy.
- **Pressure**
Any kind of a change of activity will create a pressure on the society or on the environment. Example: land use change, GHG emissions, creation of jobs.
- **State**
The current state of a socio-economic or environmental situation can be observed or measured. Example: water quality, biodiversity, income from bioenergy production.
- **Impact**
The effect on a current situation caused by a driving force or pressure. Example: increased land occupation, biodiversity loss, GHG reduction, job increase.
- **Response**
Measures being taken to mitigate negative effects or foster positive ef-

fects. Response measures can be chosen to influence any step of the cause-effect-chain. Example: environmental regulations, tax reduction for bioenergy use, trainings.

The framework is used in a broader sense of cause-effect-chains and is not restricted to only environmental indicators as originally meant by the developers. Figure 1 provides an illustration of this approach.

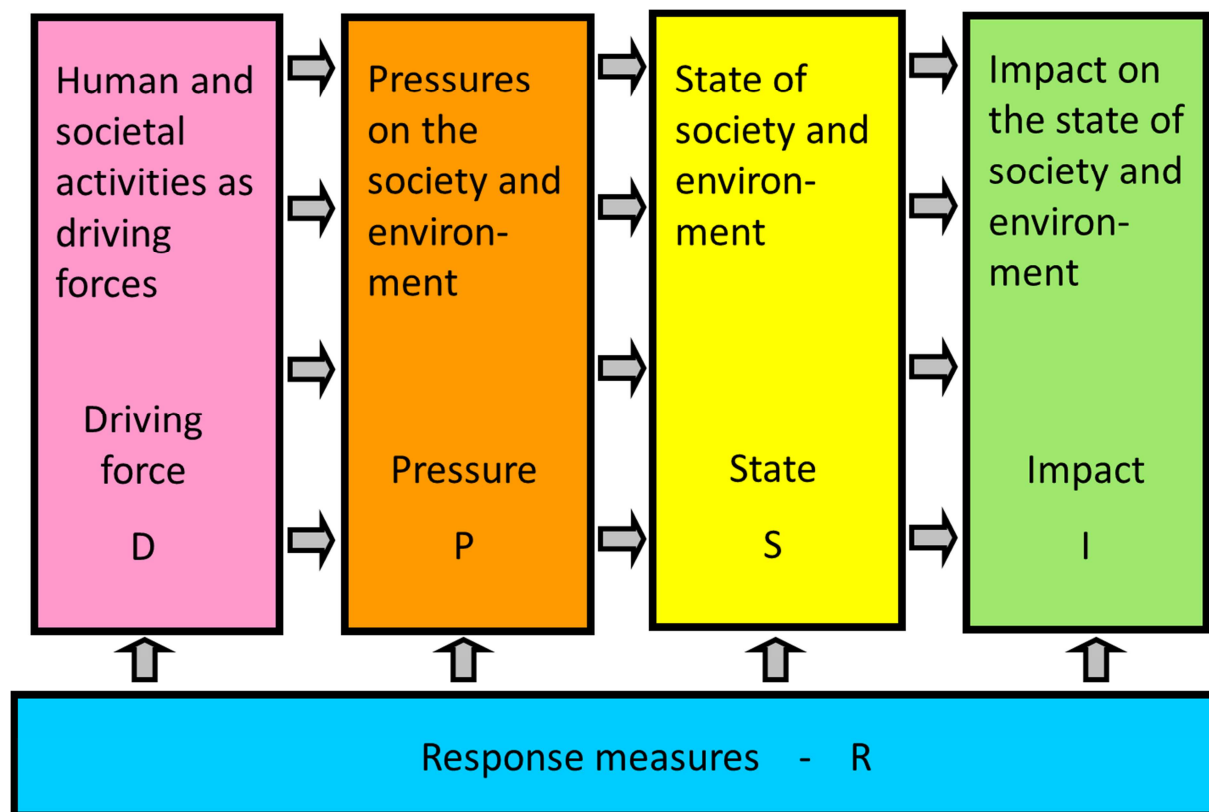


Figure 1: Illustration of the DPSIR indicator framework

The guidance for the attribution issue of the GSI is to identify the character of an indicator according to this framework and reflect how an attribution issue can be better solved by considering the DPSIR framework.

Many GSI are related to driving forces or pressures. As mentioned in chapter 2.1, GHG emissions are pressures which are measured by releases to the environment. If these releases have to be attributed to several process outputs then the assignment has to be done at this level.

This is different to the other issue raised in chapter 2.1, which refers to an attribution issue at the effect level (state or impact). The indicator mentioned was “change in mortality and burden of disease attributable to indoor smoke (indicator 15)”. The impact “change in mortality” must be separated from other mortality causes. This type of attribution issue can be found for the indicators such as water quality (partly), biological diversity, indoor smoke, etc.

3.3 Identification of attribution types and related guidance

A review of attribution issues raised by the implementation reports and the TFS sub-groups reveal different types of questions and problems. They could roughly be classified into the following groups:

- (1) Attribution of statistical data to the bioenergy sector
- (2) Allocation of indicator results related to coupled activities
- (3) Attribution of general effects to bioenergy
- (4) Overlap of several of these types of attribution
- (5) No attribution issue at all – but a general lack of data

1. Attribution of statistical data to the bioenergy sector

Often it is necessary to separate bioenergy from other economic activities. Many indicators address bioenergy as part of the total national economy or as part of the overall land use in a country. With sufficient financial resources, it is generally possible to generate primary data which is directly related to bioenergy only.

For instance, soil quality and land tenure are indicators which might be known for the total land of a country. However, in order to measure these indicators specifically for the use of agricultural land for bioenergy, a reporting scheme may need to be developed that collects sectoral information at every single land area. This is costly and perhaps not appropriate for the intention of the indicator.

A statistical approach which relates the share of bioenergy to the total economy or total land use is a first approximation for an indicator. Figure 2 shows this type of pragmatic **Top-Down-Approach**, which could be applied in many cases and solves the attribution issue of the bioenergy production in comparison to the overall value for a country.

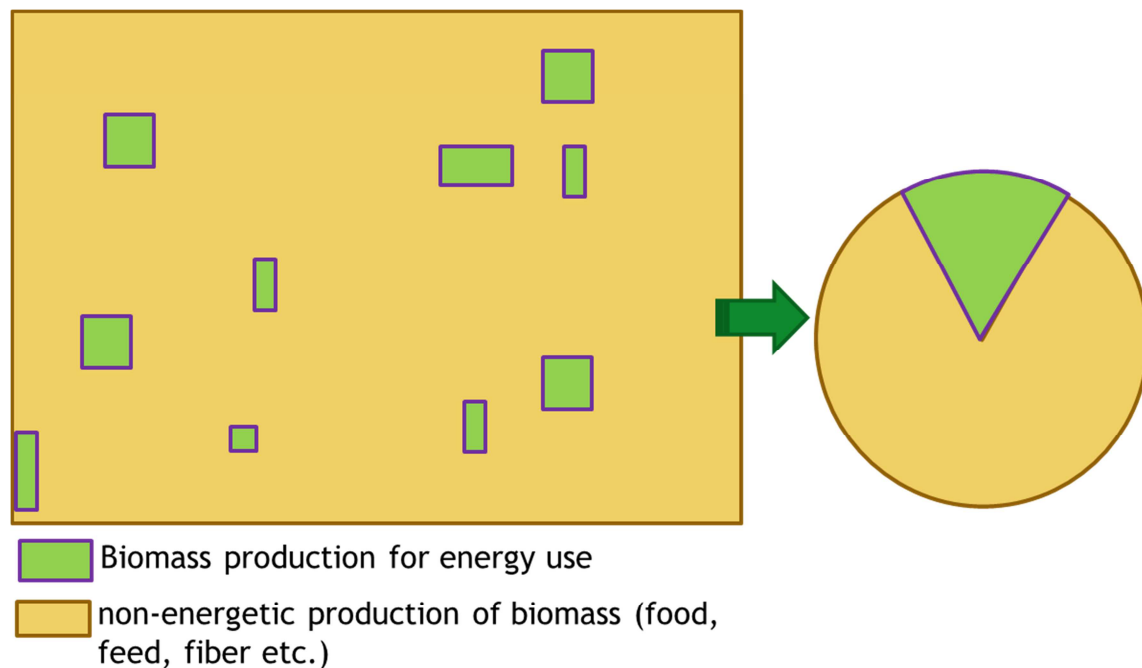


Figure 2: Scheme on how to interpret spatial data for bioenergy as a share of aggregated total figures

In other cases, information may exist for a single unit of the bioenergy sector but not for the entire bioenergy activities of a country. Then a **Bottom-Up-Approach** will be the choice to extrapolate from a unit or a multitude of single units to the totality of the bioenergy sector. The emissions of e.g. biofuel production can be extrapolated from one typical production plant to the overall emissions of the sector by scaling up the production figure of the specific plant to the production of the whole country.

This statistical attribution issue can generally be solved by efforts to collect more specific data or use simple methods of allocating available figures to the sector, as described above. Furthermore, statistical data available from national statistical offices may have been aggregated to produce a national figure and perhaps could be easily be separated again for the purpose of the bioenergy sector.

2. Allocation of indicator results related to coupled activities

A different attribution issue arises when a process generates two or more products which serve not only the production of bioenergy but also the production of e.g. food or bio-based material for non-energy purposes. This issue is a common challenge in the method of Life Cycle Assessment (LCA) where environmental impacts have to be allocated to different products from a coupled production process (e.g. chlor-alkali electrolysis producing chlorine, sodium hy-

dioxide and hydrogen at same time). This attribution issue in LCA is referred to as allocation.

Allocation issues of this type arise in many instances while dealing with bioenergy production and use. Some have been mentioned above, such as the coupled production of wheat for food and straw for bioenergy, or the production of sugar for food alongside the co-production of bagasse for energy purposes.

An extended discussion of allocation of environmental impacts to coupled products exists in the LCA community. Principles for dealing with allocation of this type can be found in international standards (ISO 14040, ISO 14044) and many academic publications.

Solutions to the allocation problem are not always straightforward and depend to a large extent on the goal and scope of an underlying question. In the case of the GSI, the objective is to describe the performance of a bioenergy system at a national scale. Therefore, a solution to co-product allocation is needed which supports the accountability of effects from bioenergy production and use which reaches from single processes to a national inventory for the GSI.

Due to the complex nature of allocation, solutions will be necessary on a case-by-case basis, following the general criteria mentioned above.

A potential set of solutions is provided by the annex of the Renewable Energy Directive of the European Union (RED), where normative allocation rules have been established to fulfil the tasks of this Directive. The underlying philosophy for allocation of the RED applies an attribution of greenhouse gas emissions by the **value of energy flows** of the different products. So, for example, the energy content of wheat grains multiplied with its amount and the energy content of straw and its amount are used to attribute the GHG emissions to each product stream. In certain cases, attribution by energy content may not be applicable, and a partitioning of impacts by the **economic value** of both product streams could also be used.

Concerning the GSI, plausible allocation conventions are applied, which can then be adapted to specific indicators and allocation issues. Such common conventions could be (open to further discussion):

- Allocation by energy content shall be the default method when different energy products originate from a coupled production.
- Allocation by energy content shall be the default method when energy products and products for other purposes (e.g. food, animal feed, material use) share the same production processes and have to be allocated. A sensitivity analysis shall be performed using the economic values of the co-products to detect any implausible conclusion for the GSI.

- Provide full transparency and traceability of underlying assumptions and results if co-product allocation has been used in the context of the GSI measurement.

3. Attribution of general effects to bioenergy

Some GSI refer to general effects that may partly be caused by the bioenergy sector. Examples are a change of water quality in rivers or the change of mortality and health effects by indoor smoke. The attribution issue, to what extent this can be assigned to the production and use of bioenergy, can only be solved with the help of cause-effect models or studies.

The use of proxy indicators at the level of driving forces or pressures is another approach to avoid more complex indicators at the state and impact level (see chapter 3.2). Hence, the measurement is shifted from effects to its causes with a loss of accuracy of the desired indicator objective.

4. Overlap of several of these types of attribution

Unfortunately, the attribution issue for GSI can be an overlap of both attribution types described here. Then it is necessary to separate the two types and solve them separately.

5. No attribution issue at all – but a general lack of data

It also should be assessed if an identified attribution issue is not an attribution issue in the first place but a general lack of data. Then the lack of data should be addressed for further revision of implementation studies with an analysis if an attribution issue will be arise with having filled the data gap.

4 Guidance for environmental indicators

4.1 Overview of the attribution issue for environmental indicators

Environmental indicators are the first group of GBEP sustainability indicators and are related to the environmental implications of the bioenergy sector. The indicators encompass emissions to air and water, influence on soil, biodiversity and the use of natural resources like water and wood resources.

From the eight environmental indicators, attribution issues will be addressed for the following indicators:

- Indicator 1 Lifecycle GHG emissions
- Indicator 2 Soil quality
- Indicator 6 Water quality
- Indicator 8 Land use and land-use change related to bioenergy feedstock production

Special guidance about attribution issues are given in this chapter.

Indicators where attribution issues are yet to be raised by the implementation reports have not be addressed in detail. However, practitioners may still encounter attribution problems in the future:

- Indicator 3 Harvest levels of wood resources
Statistical problems have been raised in assigning harvested wood to different uses. The share of harvested wood for bioenergy purposes can only be reported if satisfactory statistics exist.
- Indicator 4 Emissions of non-GHG air pollutants, including air toxics
A discussion was observed if this indicator should be based on a life cycle approach or on the release from single processes. Attribution issues caused by the production of various final products are similar to the co-product problem of indicator 1.
- Indicator 5 Water use and efficiency
Often, no information is available about the amount of the water withdrawn for agriculture and specifically applied to bioenergy crops. This refers to a statistical attribution issue and can be solved with the help of solutions to similar questions discussed for indicator 2 question (2).
- Indicator 7 Biological diversity in the landscape
It has generally been difficult to assess the provisions of this indicator. Therefore attribution issues seemed to be a sub-ordinate problem for the time being. Guidance has to be oriented at the state or impact level (e.g. like indicator 6).

4.2 Indicator 1 Lifecycle GHG emissions

a) Short recapitulation of the indicator

Description:

Lifecycle greenhouse gas emissions from bioenergy production and use, as per the methodology chosen nationally or at community level, and reported using the GBEP Common Methodological Framework for GHG Lifecycle Analysis of Bioenergy 'Version One'

Measurement unit(s):

Grams of CO₂ equivalent per megajoule

b) Attribution challenges during implementation

Country	Attribution issue	Used approach	Reference
Colombia	<p>In Colombia, production of ethanol is integrated within the sugar mills, which produce a number of co-products beside sugar and ethanol, such as panela, bagasse and compost.</p> <p>The Colombian palm oil and biodiesel industries generate several co-products beside crude palm oil and biodiesel, including kernel oil, kernel cake, glycerol, soap and oil-palm cobs.</p>	<p>The priority for long-term monitoring should be mass and energy allocation, but use of economic allocation and substitution methods would also be useful to deepen the understanding of the impacts of biofuel policy and production practices on GHG emissions.</p> <p>It is also recommended to include an allocation factor differentiated by stage of the chain.</p>	<p>p.38 p.42 p.49/50</p>
Indonesia	<p>Among the several co- and by-products generated by the palm oil mills, the palm oil mill effluent (POME) is the liquid waste generated from the oil extraction process in palm oil mills.</p>		<p>p.36</p>
Paraguay	<p>En el caso de caña de azúcar se genera como co-producto el bagazo, el cual según fuentes primarias del sector es empleado en la caldera para obtener energía calorífica que se emplea en el proceso productivo.</p> <p>En el caso de maíz se generan como co-productos los Granos Secos de Destilería y Solubles o DDGS, y Granos Húmedos de Destilería y Solubles o WDGS</p>	<p>No fue por tanto necesario estimar el porcentaje de emisiones asociadas al bagazo, ya que su uso en el proceso productivo se encuentra incluido en las emisiones totales.</p> <p>La metodología empleada para poder estimar el porcentaje de emisiones asociadas al etanol y aquel asociado a los co-productos mencionados fue el poder calorífico inferior (PCI).</p>	<p>p.56 p.59 p.60</p>

Vietnam	Besides ethanol, by-products include Dried Distillers Grains sold for animal feed production, biogas used as supplemental energy, and CO ₂ collected for sale.	The GHG emissions from the ethanol plants are partly balanced by the amount of biogas produced as a co-product that can be used for Combined Heat and Power (CHP) generation. The allocation for dry stillage as another co-product also acts to balance GHG emissions. Liquid CO ₂ is another co-product of the ethanol pathway; the CO ₂ emitted from the fermentation process is collected and sold to third parties. However, it is not taken into consideration. Therefore, the eventual effect is the GHG emissions minus the CO ₂ emitted from the fermentation process.	p.46 p.49 p.50/51
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c) Issues highlighted by the TFS sub-group

None mentioned

d) Specific guidance

1. The issues raised in the implementation reports are mainly referring to co-product allocation using LCA methodology, i.e. *multi-output processes with different (energy) products occur while comparing the GHG emissions from different energy sources at the national level*. Summarizing the above used solutions, the following approach is proposed:
 - TIER 1: Use pre-set default methods and values from a data source (e.g. Biograce)
 - TIER 2: Use economic value of products with original data and consider individual solutions where appropriate (e.g. CO₂ as product).
 - TIER 3: Use energy content (lower heating value) of material flows as allocation factor with original data and consider individual solutions where appropriate (e.g. CO₂ as product).
2. An attribution issue which has not been mentioned in the implementation studies but may arise if statistical data is not satisfactory is *how to separate the aggregated GHG impact of bioenergy at a national level from the overall GHG impact of the country?*

The LCA approach applies the definition of a functional unit which is related to the use phase (e.g. MJ of used energy). According to the intention, the

functional unit can be defined as the total of all energy products (electricity, heat, biofuels) consumed in the respective country in GWh.

The life cycle from cradle to grave with all emissions for all bioenergy products consumed in a country have to be taken into account. Note that the production of bioenergy feedstock which is exported to another country is not included in the system boundaries.

- TIER 1: Estimate the share of energy products from bioenergy against the overall consumption of energy products in a country and combine them with default values for the respective products life cycle.
- TIER 2: Use statistical national consumption data for bioenergy products and combine them with default values for the respective products life cycle.
- TIER 3: Combine all energy products on a one-by-one basis from original national data with statistical national bioenergy consumption data to achieve the national GHG bioenergy level.

3. Another attribution issue arises for GHG balances if land use of bioenergy products has to be set into perspective to the total land use of a country². i.e. *How can GHG emissions from land use and land use change be attributed to specific bioenergy products?*

Since this indicator follows a life cycle approach, the above question does not only apply to the land use change on national territory but for all countries from which nationally used bioenergy is imported (not valid for other indicators).

- TIER 1: In cases where role of bioenergy for the area of land use change is not known it shall be assumed that the land use change for bioenergy relates to the same share of land occupation between different uses as it was before the change. Carbon change data should be used from IPCC.
- TIER 2: Apply original area data of land use change from a land use category into land use for bioenergy products and use the most adequate data for biogenic carbon change from IPCC.
- TIER 3: Apply original data from national administrations or statistical offices regarding land use change from an IPCC land use category to

² This also applies for other indicators like indicator 2 (soil quality), indicator 8 (land use and land use change) and indicator 9 (land tenure).

land use for bioenergy for area and biogenic carbon on this land before and after the change (reference date, period of time to be defined).

4.3 Indicator 2: Soil quality

a) Short recapitulation of the indicator

Description:

Percentage of land for which soil quality, in particular in terms of soil organic carbon, is maintained or improved out of total land on which bioenergy feedstock is cultivated or harvested

Measurement unit(s): Percentage

b) Attribution challenges during implementation

Country	Attribution issue	Used approach	Reference
Colombia	It was not possible to carry out direct soil surveys and consequent analyses of soil organic carbon (SOC) and other parameters related to soil quality (<i>for bioenergy feedstocks</i>).	Therefore, secondary data were retrieved from the relevant institutions in the country. Information available from different governmental reports was found to be, in fact, insufficient to define the percentage of land for which soil quality is maintained or improved out of the total land devoted to bioenergy feedstock cultivation. A mainly qualitative analysis was supplemented with an exemplificative calculation of SOC content, based on information found in the literature. Finally, assuming that the necessary information on soil quality was available, an ideal methodological approach for the Colombian context is proposed.	p.51/52
Germany	Codes of Good Practice for agriculture of which the most relevant in this context is to “preserve the site-typical organic matter content, especially through a sufficient supply of organic matter or the reduction of management intensity”. (<i>for bioenergy feedstocks</i>)	Since there are no definitions or reference values for site-typical organic matter contents, the actual supply status has to be assessed with humus balancing. The Ministry of Agriculture advises to balance humus input and output or that the balance should be posi-	p.19/20

		<p>tive.</p> <p>Area of bioenergy feedstock cultivation: the cultivation of bioenergy feedstocks cannot be located exactly so that an allocation of soil organic carbon contents to certain bioenergy feedstock is not possible</p>	
Indonesia	<p>In 2010, ICALRRD produced maps of predicted soil carbon stocks with a coverage of 84 percent of the surface of the country.</p> <p>However, due to the great variability of the aforementioned parameters and the complexity of soil types found in Indonesia, further studies with a broader coverage are recommended.</p>	<p>For this project, field surveys were performed in plantations to retrieve primary data on soil quality in areas where oil palm is cultivated.</p>	<p>p.52/53</p> <p>p.57</p>

The evaluation of the implementation reports reveals that the indicator lacks of sufficient detailed data for soils in general, including SOC. The attribution issue for providing data for bioenergy feedstock purposes then is a secondary problem.

c) Issues highlighted by the TFS sub-group

The attribution issue concerns how to assign information on the soil organic content (SOC) and respective soil improvement measures to bioenergy production in contrast to other non-energy purposes.

The sub-group proposed as guidance:

- If maps on SOC contents and/or high-risk areas are available, they can be combined with maps of bioenergy production, if available (e.g. SEEMLA approach 6).
- As a proxy, the distribution of crop production that could potentially be used for bioenergy production (e.g. palm oil, sugarcane) could be used.
- Alternatively, information on the indicator can be attributed based on the share of the area covered by bioenergy production. Also, the share of application of good practices could be used as a proxy.

d) Specific guidance

For the indicator 2, the following questions of attribution may arise. Solutions are given using the TIER approach.

(1) How can the soil management and the share of maintained or improved soil quality be attributed unambiguously to the production of bioenergy if the same biomass product is used for food, fodder or non-energy products?

- TIER 1: Via humus balancing spatial or similar approaches shares of degrading, maintaining and improving of soil carbon content can be determined but without differentiating between the final uses of the biomass. Then soil qualities shall be attributed to bioenergy according to its share on the total production of the respective cultivation.
- TIER 2: A clear assignment of agricultural land to bioenergy production can be made (see above) and the change in soil organic content will be estimated via humus balancing for this land with a sufficient spatial differentiation of bioenergy feedstock production.
- TIER 3: Due to a clear assignment of agricultural area to bioenergy feedstock e.g. because of fiscal reasons or unambiguous regional practice the land for bioenergy can be identified. Furthermore soil organic content is analyzed and monitored over a sufficient time period and with sufficient soil sampling in the respective area.

(2) How can soil quality be attributed to bioenergy feedstock management if this material is derived as a co-product from biomass for various purposes (e.g. straw) or as a separate co-product of continuous rotation farming?

It is a prerequisite to have information on the amount and type production of biomass for energy and the other products from combined production by measurement or statistics.

- TIER 1: With the knowledge of SOC or humus balances of a certain combined agricultural production, but without the evidence that it relates to a specific product of the combined production, a simple allocation shall be performed. The allocation factor can be the economic value of the by-products or their energy content (mass * lower heating value).
- TIER 2: Humus balance can be calculated for the combined production of energy biomass and be attributed to bioenergy with the knowledge of management options.
- TIER 3: Soil organic content is measured over a sufficient time period and with sufficient soil sampling in the respective area and findings can be attributed directly to the management of the different parts of biomass (e.g. high yield of straw) or to the bioenergy cultivation in rotation farming (in that case if a net SOC degradation of the overall rotation can be attributed to the bioenergy cultivation only).

The Colombian researchers proposed an ideal methodological approach, assuming that the necessary information on soil quality was available. The indicator measurement should therefore be approached as follows:

- Analysis of soil maps;
- Determination of the relationship between risk-zones and bioenergy zones;
- Estimation of SOC change related to bioenergy zones; and
- Recommendations for maintaining or increasing SOC content.

4.4 Indicator 6: Water quality

a) Short recapitulation of the indicator

Description:

(6.1) Pollutant loadings to waterways and bodies of water attributable to fertilizer and pesticide application for bioenergy feedstock production, and expressed as a percentage of pollutant loadings from total agricultural production in the watershed

(6.2) Pollutant loadings to waterways and bodies of water attributable to bioenergy processing effluents, and expressed as a percentage of pollutant loadings from total agricultural processing effluents in the watershed

Measurement unit(s):

(6.1) Annual nitrogen (N) and phosphorus (P) loadings from fertilizer and pesticide active ingredient loadings attributable to bioenergy feedstock production (per watershed area):

- in kg of N, P and active ingredient per ha per year

- as percentages of total N, P and pesticide active ingredient loadings from agriculture in the watershed

(6.2) Pollutant loadings attributable to bioenergy processing effluent:

- pollutant levels in bioenergy processing effluents in mg/l (for pollutant concentrations and biochemical and chemical oxygen demand – BOD and COD), and (if also measured) °C (for temperature), µS/m (for electrical conductivity) and pH

- total annual pollutant loadings in kg/year or (per watershed area) in kg/ha/year

- as a percentage of total pollutant loadings from agricultural processing in the watershed

b) Attribution challenges during implementation

Country	Attribution issue	Used approach	Reference
Columbia	With regard to indicator component 6.1, data on average fertilizer application rates in the cultivation of sugarcane and oil palm and on the associated pollutant loadings	CUE (2012) reported average fertilizer application rates in sugarcane cultivation and also N and P loadings into the superficial waters of the Cauca watershed. These val-	p. 83/84 p. 85

	into waterways and bodies of water were found in literature.	<p>ues were then allocated to ethanol production, based on the energy content of this fuel out of the total energy content of all products obtained from sugarcane.</p> <p>The attribution to biodiesel production from palm oil was made on the basis of the share of CPO used for biodiesel.</p> <p>Indicator component 6.2 could not be measured.</p>	
Germany	<p>Nutrient and pollutant concentrations in water bodies are measured and reported on a very regular base ensuring a close monitoring of water quality. (indicator 6.1)</p> <p>There is no official and regular data collection on pollutant loadings from bioenergy processing. Data on the amount of treated and untreated waste water are collected by DESTATIS, however, only for the industrial sector as a whole. (indicator 6.2)</p>	<p>Only for rivers the allocation of pollution inputs (nitrogen and phosphorous) to their sources is modelled. This was realised in a project commissioned by UBA where the input of different substances into German water bodies was modelled with MONERIS (UBA 2010).</p> <p>A further exact disaggregation into bioenergy feedstocks is not feasible with the current data base. At one of the expert workshops it was agreed that a linear allocation of environmental impacts based on the share of bioenergy feedstock area is a suitable proxy.</p> <p>For all other water bodies (lakes, groundwater) and for pesticides only concentrations are measured.</p>	<p>p. 38</p> <p>p. 40</p>
Indonesia	<p>For the measurement of this indicator, water quality data were collected in two estate plantations. Twenty one water samples were taken from different sections of the waterbody that flow along the borders of the plantations.</p>	<p>Bottom-up approach; no allocation needed</p>	<p>p. 85</p>
Vietnam	<p>For the measurement of sub-indicator 6.1 for Cassava-based ethanol, 15 water samples were collected from waterways and bodies close to cassava plantation areas. Due to lack of data indicator component 6.2 could not be measured.</p>	<p>Bottom-up approaches; no allocation needed</p>	<p>p.101</p> <p>p. 105</p>

	The Institute of Agricultural Environment (IAE, 2015) implemented a largescale project to investigate the status of biogas effluent quality. The project collected 300 samples of wastewater in 10 provinces of Viet Nam.		
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c) Issues highlighted by the TFS sub-group

The sub-group states that normally national data on pollution loading to water exist but a specific attribution to bioenergy is not available.

d) Specific guidance

The review of the implementation reports reveals a certain uncertainty connected with indicator 6.1. The measurement description includes two approaches. Pollutant loadings to waterways and bodies of water from bioenergy shall be measured:

- in kg of N, P and active ingredient per ha per year
- as percentages of total N, P and pesticide active ingredient loadings from agriculture in the watershed

The first measurement can be achieved from bioenergy feedstock management and is not connected to an attribution issue. The second measurement has several attribution issues because it is related to a state and impact indicator. First, the loadings of the water body have to be known. Then, the share of agriculture has to be derived and next the share of the cultivation of bioenergy crops of the agriculture share has to be determined. This constitutes a double attribution issue, which is not easy to solve.

So the attribution issue suggests to first separate agricultural from non-agricultural uses and then the bioenergy cultivation from the agricultural sector using a TIER approach:

- TIER 1: Possible emission sources for water pollutants shall be identified and the contribution of agriculture to the loadings of the water body shall be estimated with available information. Then the share of the bioenergy sector shall be attributed to the loadings according to the percentage of land for bioenergy to the total agricultural land.
- TIER 2: Total emissions and share of agricultural management emissions shall be assessed with the help of an environmental effluent model. Like before, the share of bioenergy shall be estimated with the share of land for bioenergy to the total agricultural land.

- TIER 3: An effluent model for pollutants from agriculture as a total and with a separate sub-model for types and location of bioenergy crops shall be used.

4.5 Indicator 8: Land use and land-use change related to bioenergy feedstock production

a) Short recapitulation of the indicator

Description:

(8.1) Total area of land for bioenergy feedstock production, and as compared to total national surface and

(8.2) agricultural land and managed forest area

(8.3) Percentages of bioenergy from:

(8.3a) yield increases,

(8.3b) residues,

(8.3c) wastes,

(8.3d) degraded or contaminated land

(8.4) Net annual rates of conversion between land-use types caused directly by bioenergy feedstock production, including the following (amongst others):

- arable land and permanent crops, permanent meadows and pastures, and managed forests;

- natural forests and grasslands (including savannah, excluding natural permanent meadows and pastures), peatlands, and wetlands

Measurement unit(s):

(8.1-2) hectares and percentages

(8.3) percentages

(8.4) hectares per year

b) Attribution challenges during implementation

Country	Attribution issue	Used approach	Reference
Columbia	Yields of sugarcane and oil palm did not increase in recent years. The indicator focus (8.3) was on the use of bagasse, which is a by-product of sugarcane processing, for cogeneration. For indicator component 8.4, the focus was on oil palm, as the expansion has been much more significant.	Bagasse used for co-generation in ethanol distilleries for electricity generation was calculated as share of total energy production. (8.3) Information found in literature regarding oil palm expansion and related land-use changes in selected regions of Colombia was summarized but data was not adequate. The share for bioenergy was correlated to the CPO used for biodiesel	p. 99 p. 102 p. 104

		production. (8.4)	
Germany	Total area of land for bioenergy feedstock production, and as compared to total national surface and (8.2) as compared to agricultural land and managed forest area.	The methodology to derive the indicator values was to determine the total land use for bioenergy feedstock production per year based on national statistics, and to divide these values by the respective data for the national surface, agricultural area, and managed forest area, respectively, which were also taken from national statistics	p. 51
Indonesia	Total area of land for bioenergy feedstock production, and as compared to total national surface and (8.2) as compared to agricultural land and managed forest area.	The total area of land for bioenergy feedstock production and as compared to total national surface and agricultural land was retrieved from both national and international statistics. Satellite images were overlaid with the map of Indonesian soil types in order to assign land use changes taking place on peat versus mineral soils and generate respective information.	p. 101/102
Vietnam	Cassava has many uses in industrial processing such as production of monosodium glutamate (MSG), alcohol, instant noodles, glucose, syrup, candy, cookies, barley sugar, adhesives, food additives, pharmaceutical additives, biofuel and ethanol.	Analysing statistical data suggest that the expansion in the cassava harvested area registered in the period 2007-2015 was not driven primarily by the demand for ethanol.	p. 124

c) Issues highlighted by the TFS sub-group

For this indicator multiple attribution issues have been raised in the sub-group:

1. The first issue is the lack of information on feedstock distribution, i.e. exactly where crops for bioenergy are grown in the country. In some cases, bioenergy-related land-use change has been allocated using an artificial overlay based on the use of bioenergy production from various crops. This artificial exogenous assumption can be used when it is not deemed feasible to determine where land conversion occurs specifically for bioenergy.
2. Where multiple crops are used for the same bioenergy carrier (for example, both sugar cane and cassava for ethanol production in Paraguay) and

the ratio of the crops is not available, calculating the land area required using data from mills on quantity of ethanol produced and conversion efficiency is very difficult.

3. A final difficulty with measuring land use change occurs when the crop used for producing the bioenergy carrier is a secondary crop only used in rotation with the primary crop (and so the attribution of land-use change to the crop grown for bioenergy is complicated by this issue).

For the last bullet the sub-group formulated specific guidance which is presented below (2.).

d) Specific guidance

1. This issue is linked to the attribution issues of land use in general, i.e. *how can land use and land use change be attributed to specific bioenergy products?*

- TIER 1: In cases where the role of bioenergy for land use change is not known it shall be assumed that at least it shall be attributed the same share as of the total land occupation.
- TIER 2: In cases where the role of bioenergy for land use change can be estimated it shall be applied using different estimated shares (lower or higher) as the numerical share of total land occupation suggests.
- TIER 3: Original data of land use change from a land use category into land use for bioenergy products shall be applied.

2. *How to attribute land use change for rotation cropping?*

For attributing land-use change to crops that are used in rotation with other crops, an economic/market-based approach could be used depending on the ratio of the price of the commodity compared with the total. However, this requires an average over a certain number of years, which needs to be made explicit. For the attribution of land-use change to perennial crops (such as palm oil), one needs to ensure that the time period is at least equal to the economic rotation of the specific crop (from planting to harvesting) to ensure that all land-use change is taken into account.

5 Guidance for social indicators

5.1 Overview of the attribution issue for social indicators

The social indicators are the second group of GBEP sustainability indicators and include issues like tenure of land, job creation, income or health aspects related to the bioenergy sector.

The TFS sub-group on social indicators mentioned attribution issues and strive for guidance for the following six indicators:

- Indicator 9 Allocation and tenure of land for new bioenergy production
- Indicator 11 Change in income
- Indicator 12 Jobs in the bioenergy sector
- Indicator 14 Bioenergy used to expand access to modern energy services
- Indicator 15 Change in mortality and burden of disease attributable to indoor smoke
- Indicator 16 Incidence of occupational injury, illness and fatalities

Often the attribution issues are related to the lack of data.

Indicators where attribution issues are yet to be raised by the implementation reports have not been addressed in detail:

- Indicator 10 Price and supply of a national food basket
The indicator is an impact indicator describing the national situation for availability and supply of foodstuff for people under the condition of bioenergy production. It is a safeguard indicator to determine constraints in sufficient access to affordable food. No attribution issue has been raised in the implementation reports but general methodologies for the assessment are needed.
- Indicator 13 Change in unpaid time spent by women and children collecting biomass
Indicator 13 is not related to an attribution issue because it is a direct measurement of time spent for a certain purpose.

5.2 Indicator 9: Allocation and tenure of land for new bioenergy production

a) Short recapitulation of the indicator

Description:

Percentage of land – total and by land-use type – used for new bioenergy production where :

(9.1) a legal instrument or domestic authority establishes title and procedures for change of title; and

(9.2) the current domestic legal system and/or socially accepted practices provide due process and the established procedures are followed for determining legal title.

Measurement unit(s):

Percentages

b) Attribution challenges during implementation

Country	Attribution issue	Used approach	Reference
Columbia	Getting hold of relevant data and information can be extremely challenging, in particular, for areas that have been recently converted to the production of bioenergy feed-stocks such as palm oil.	It was decided to focus on two key aspects related to access to land, namely distribution of land ownership and farm sizes and business models. The Government committed to create an agrarian jurisdiction in order to resolve tenure conflicts and formalize the small land property that still lacks a formal title.	p. 109 p. 111
Germany	All land property is documented in the land title register.	Indicator 9 is not relevant in Germany.	p. 63
Indonesia	Getting hold of relevant data and information can be quite challenging, in particular, for areas that have been recently converted to the production of bioenergy feed-stocks such as palm oil.	Literature on land conflicts associated with oil palm concessions was reviewed and summarized. In addition, an overview of the legislative framework related to land tenure was presented with information about access to land, namely land ownership and business models.	p. 116
Paraguay	El “Tamaño de fincas y propiedad de las tierras destinadas a la producción de caña de azúcar y maíz zafriña” se elaboraron en base a los resultados del Censo Agropecuario	Para analizar el marco legal de tenencia y explotación de tierras y bosques, se revisaron documentos oficiales como el Estatuto Agrario, y publicaciones del Programa ONU-	p. 173

	2008. No existe información más actualizada.	REDD+ Paraguay. Las estimaciones sobre la situación de las tierras dedicadas a la plantación de caña de azúcar, respecto a la titulación, fue obtenida en entrevistas a Asociaciones de Cañicultores y de empresas alcoholeras.	
Vietnam	A quantitative measurement of the indicator was not possible due to lack of data.	An in-depth review of the relevant literature was carried out. In particular, a comprehensive overview and analysis of the regulatory framework related to land tenure was provided together with a description of the main patterns related to land ownership and use for the areas under cassava cultivation. Additionally a survey with cassava-growing households (63 in total) and cassava starch processing plants was carried out in two cassava-producing provinces.	p. 133

c) Summary of main issues highlighted by the TFS sub-group

The sub-group states that for the measurement of indicator 9, it is necessary to define what constitutes ‘new bioenergy production’ based on the specific local circumstances (e.g. features of the local bioenergy sector) and on the objectives of the analysis.

Regardless of how a country/user defines the aforementioned term, it is very difficult to identify the specific land/areas used to grow the feedstock for the production of such ‘new’ bioenergy as compared to land where the same feedstock is grown for non-bioenergy purposes. Furthermore, it might be challenging to establish and monitor the link between land tenure and bioenergy activities, especially in the case of informal transactions, due to the difficulties in separating the effect of bioenergy activities from other factors.

d) Specific guidance

A pragmatic approach could be to focus on areas of recent expansion in the production of the main crops/feedstocks used to produce bioenergy. Then the share of these crops/feedstocks used for bioenergy (vs. other uses) should be considered, in order to attribute the measured impacts to bioenergy.

If – for sub-indicator 9.2 – part of the crops/feedstock cultivated in the aforementioned areas are certified according to sustainability standards that address land tenure in line with Indicator 9, it could be assumed that the established procedures for determining legal title have been followed.

The attribution issue is mainly a matter of insufficient monitoring of tenure of land and insufficient related production figures. The subsequent TIER approach could be applied for these questions:

(1) How can tenure of land be attributed to production of “new bioenergy”?

- TIER 1: With general data about tenure of land and production figures of new bioenergy is shall be estimated which percentage of land for new bioenergy exist at all. Then as a first approximation, the related production can be regarded as equally distributed to the tenure of land.
- TIER 2: With the help of general data about the distribution of land-ownership and general data about farm sizes, business models and production figures of new bioenergy an aggregate of this information can give a fair estimate.
- TIER 3: Original data of tenure of land shall be related to original production figures of new bioenergy. This should be a constant feature of national statistics.

5.3 Indicator 11: Change in income

a) Short recapitulation of the indicator

Description:

Contribution of the following to change in income due to bioenergy production:

(11.1) wages paid for employment in the bioenergy sector in relation to comparable sectors

(11.2) net income from the sale, barter and/or own-consumption of bioenergy products, including feedstocks, by self-employed households/individuals

Measurement unit(s):

(11.1) local currency units per household/individual per year, and percentages (for share or change in total income and comparison)

(11.2) local currency units per household/individual per year, and percentage (for share or change in total income)

b) Attribution challenges during implementation

Country	Attribution issue	Used approach	Reference
Columbia	For the testing of this indicator, only partial data could be found in literature on wages in bioenergy feedstock production and processing, on the price paid to sugar producers, and on the prices paid to ethanol and biodiesel producers, which are set by law. Information was particularly sparse for the palm oil-based biodiesel supply chain.	Given the limited data availability, a quantitative assessment of the two components under this indicator was not possible.	p. 124
Germany	Even though there is data on wages in Germany these data do not differentiate between bioenergy and other activities (e.g. agricultural and forest workers). Similarly, there is no reliable data on sub-indicator 11.2.	Indicator 11 has not been assessed.	p. 71
Indonesia	Disaggregated data on wages in bioenergy feedstock production and processing were found in literature and were cross-checked with up-to-date surveys performed in two locations in North Sumatra, one of the main bioenergy feedstock production areas in Indonesia	Literature and cross-checked with up-to-date surveys performed in two locations. However, information concerning the number of hours worked daily, hourly wages and the incidence of overtime hours and days was not thoroughly and consistently reported by the participants during the survey.	p. 135
Paraguay	La información de los promedios de los salarios en los sectores agrícolas, forestales y manufactureros se obtuvieron de la Encuesta Permanente de Hogares (EPH) del año 2015.	La información para este indicador se obtuvo de las visitas que se hicieron a las principales empresas productoras de etanol, principalmente de una empresa estatal, que tiene salarios por encima de las empresas privadas.	p. 188
Vietnam	For both the Cassava-based ethanol and biogas value chains, secondary data on income per employee and household in the bioenergy value chain were found and used.	These data were validated and complemented through a survey that was carried out in two provinces of Viet Nam:	p. 155

c) Issues highlighted by the TFS sub-group

The sub-group identified two main attribution issues:

- The first is that disaggregated data for the bioenergy sector is often not available. Therefore, for sub-indicator 11.1 (wages paid for employment in the bioenergy sector in relation to comparable sectors), the wages in the bioenergy sector are subsumed by other sectors, making comparison difficult or impossible.
- The second issue arises where there are multiple co-products within one value chain. The income should be attributable to bioenergy and distinct from other non-bioenergy-related income. Especially for complementary products of the same value chain, it is difficult to attribute changes in income to the bioenergy pathway.

d) Specific guidance

The two attribution issues from the TFS sub-group may be approached as follows:

(1) The first question is not an attribution issue *per se* but a matter of lack of sufficient data, i.e. *How can wages paid for employment in the bioenergy sector be assessed in relation to comparable sectors?*

- TIER 1: An estimation could be done by analyzing market prices for other agricultural goods (e.g. foodstuff) in comparison to bioenergy products based on typical annual yields of farms.
- TIER 2: If information exists for the agricultural sector in total, a special (representative) survey could be launched for bioenergy production only and compared to the entire agricultural sector.
- TIER 3: Established statistical data is available and collected frequently with a specific survey about employment in bioenergy.

(2) *How should the income from multiple co-products be attributed to bioenergy and non-bioenergy related income? Especially how can complementary products of the same value chain be attributed to different income levels?*

- TIER 1: An estimation could be done by comparing market prices for products for bioenergy uses to market prices for non-bioenergy uses. This could be a first indication also for the income situation of people working in the sector.
- TIER 2: -

- TIER 3: A representative survey about the income of employees from respective farms and industries could be conducted with different share of bioenergy and non-bioenergy products.

This is a very specific question which is more related to research activities. It will be difficult to observe the incomes based on different crops/feedstocks or even the same crops/feedstocks for bioenergy and non-bioenergy on a regular basis.

5.4 Indicator 12: Jobs in the bioenergy sector

a) Short recapitulation of the indicator

Description:

Net job creation as a result of bioenergy production and use,

(12.1) total and disaggregated (if possible) as follows:

(12.2) skilled/unskilled

(12.3) indefinite/temporary.

(12.4) Total number of jobs in the bioenergy sector; and percentage adhering to nationally recognized labour standards consistent with the principles enumerated in the ILO Declaration on Fundamental Principles and Rights at Work, in relation to comparable sectors (12.5)

Measurement unit(s):

(12.1) number and number per MJ or MW

(12.2) number, number per MJ or MW, and percentage

(12.3) number, number per MJ or MW, and percentage

(12.4) number and as a percentage of (working-age) population

(12.5) percentages

b) Attribution challenges during implementation

Country	Attribution issue	Used approach	Reference
Columbia		Relatively detailed information was found in the literature on the number of direct, indirect and induced jobs associated with the sugarcane and palm oil supply chains. For direct jobs, the figures found refer to feedstock production and to the processing stage. The share of jobs associated with the former and attributable to the production of ethanol and bio-	p. 129

		diesel was estimated.	
Germany		The Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) sponsored several studies on employment effects of renewable energies since 2005 which use statistics published by the Federal Statistical Office. The results are regularly reported by AGEE-Stat and BMUB.	p. 72
Indonesia	To date, no official data on employment in the bioenergy sector specifically is readily available for Indonesia and it is difficult to estimate with accuracy the actual size of the workforce involved in the sector.	The National Labour Survey, which is carried out annually and is also the key source of data on employment status and employment by sector, there is no standalone figure available for employment in agriculture. Different authors attempted estimating the workforce attributable to bioenergy alone. In addition, a survey approach was taken also for the measurement of indicator 12.	p. 141
Paraguay		Además de datos primarios obtenidos directamente de empresas, se utilizaron también datos secundarios provenientes de varios informes.	p. 195
Vietnam	Yearly statistical data on employment for Viet Nam is categorized into three main economic mega-sectors: service, construction and industry; agriculture, forestry and fishing; and special occupation.	At present, no official data on employment in the bioenergy sector are available and it is difficult to estimate with accuracy the actual size of the workforce involved in the sector. The direct employment associated with the supply chains of Cassava-based ethanol and household level biogas was estimated, based on data and information from official statistics and reports.	p. 163

c) Issues highlighted by the TFS sub-group

The attribution challenge is that it may be difficult to determine the exact number of jobs created and lost/displaced as a result of bioenergy production and use (to give net job creation figure).

d) Specific guidance

This attribution issue again is a matter of existing statistical figures.

(1) What is the exact number of jobs created and lost/displaced as a result of bioenergy production and use?

- TIER 1: Estimations can be made by observing the number of total jobs in the agricultural sector compared to the production figures of conventional products and bioenergy products. (This does not include the whole value chain.)
- TIER 2: Surveys about the job creation in bioenergy can be made on an individual basis for research purposes.
- TIER 3: Established statistical data about jobs in the bioenergy sector is available and collected on a regular basis.

5.5 Indicator 14: Bioenergy used to expand access to modern energy services

a) Short recapitulation of the indicator

Description:

(14.1) Total amount and percentage of increased access to modern energy services gained through modern bioenergy (disaggregated by bioenergy type), measured in terms of

(14.1a) energy and

(14.1b) numbers of households and businesses

(14.2) Total number and percentage of households and businesses using bioenergy, disaggregated into modern bioenergy and traditional use of biomass

Measurement unit(s):

(14.1a) Modern energy services can take the form of liquid fuels, gaseous fuels, solid fuels, heating, cooling and electricity. A change in access to each of these forms of modern energy can be measured in MJ per year and this is preferable in order to allow comparison of different forms of energy service, but each may also be measured in appropriate units of volume or mass per year, which may sometimes be more convenient, leading to the following possible units for this indicator component:

Liquid fuels: litres/year or MJ/year and percentage (1)

Gaseous fuels: cubic metres/year or MJ/year and percentage

Solid fuels: tonnes/year or MJ/year and percentage

Heating and cooling: MJ/year and percentage

Electricity: MWh/year or MJ/year (for electricity used), MW/year (if only electricity generation capacity to which new access is deemed to have been gained can be measured), hours/year (for the time either for which electricity is used or for which there is access to a functioning electricity supply) and percentage

(14.1b) number and percentage

(14.2) number and percentage

(1) When converting between litres/year and MJ/year for liquid fuels the Lower Heating Value (LHV) for the given liquid fuel should be used. For example, the energy content (LHV) of anhydrous ethanol is 21.1 MJ/litre. Furthermore, the difference in energy content per litre should be taken into account when comparing different liquid fuels.

b) Attribution challenges during implementation

Country	Attribution issue	Used approach	Reference
Columbia	Modern bioenergy did not have any role in this increase in access to modern energy services that was recorded in Colombia during the past decade.	Hence, this indicator is not relevant for the current Colombian context	p. 137
Germany	Energy services are covering all regions of Germany; access is available by everybody.	This indicator is considered as not relevant in the German context.	p. 74
Indonesia	During the past decade, access to modern energy services increased in Indonesia.	Modern bioenergy did not have any role in the increase in access to modern energy services	p. 152
Paraguay	Las bioenergías no poseen un rol relevante en facilitar y/o incrementar el acceso a servicios energéticos modernos por el desconocimiento de la importancia como fuente económica.	La falta de datos y desactualización de los mismos, reflejó la ausencia de información presente en el sector de la biomasa, debido principalmente a la explotación dispersa e informal.	p. 206
Vietnam	Data needed for calculating the amount of modern energy consumed by the household sector are: total final energy consumption by the household sector; share of households using kerosene for cooking and lighting; share of households using improved cookstoves to burn biomass for cooking; share of households using electricity generated from biomass	The estimated value of number of households using modern bioenergy was obtained by dividing the quantity of energy from bioenergy by the average the energy consumption per household. To disaggregate this figure into modern and traditional use of biomass, the share of households using traditional biomass and total number of Vietnamese households was com-	p. 174

	and biofuels; and share of households using biofuels for transportation and irrigation (data unavailable).	pared.	
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c) Summary of main issues highlighted by the TFS sub-group

The sub-group stated that, excluding the case of decentralized energy production from biomass sources, in all other cases attributing an increase in access to modern energy services to bioenergy poses challenges both in terms of data requirements and methodology.

d) Specific guidance

After revision of the reports, only Vietnam provided extended thoughts and calculations for this indicator. The case of Vietnam shows that specific information is needed to make estimations for the measurement of the indicator.

It can be concluded that the possible attribution issue can be addressed by conducting studies which use the basic information available in a country.

5.6 Indicator 15: Change in mortality and burden of disease attributable to indoor smoke

a) Short recapitulation of the indicator

Description:

(15.1) Change in mortality and burden of disease attributable to indoor smoke from solid fuel use.

(15.2) Changes in these as a result of the increased deployment of modern bioenergy services, including improved biomass-based cookstoves.

Measurement unit(s): Percentages

b) Attribution challenges during implementation

Country	Attribution issue	Used approach	Reference
Columbia	A decrease in wood fuel consumption has been reported in Colombia during the past decade. This appears to be linked mainly to the increase in access to natural gas, while modern bioenergy technologies have not played a significant role.	A number of studies include data related to the incidence of Chronic obstructive pulmonary diseases (COPDs) in Colombia and their impact on mortality and burden of disease. In order to measure this indicator in the future, surveys and epidemiological studies on wood-	p. 139

		fuel use and the incidence of COPDs should be conducted among a sample of households in different regions of the country.	
Germany	Even though there is again an increase of wood-stoves in Germany, these mostly pellet-fired systems do not cause indoor smoke at relevant levels.	Therefore, this indicator has not been assessed.	p. 75
Indonesia	Information from the limited national as well as international reports on the matter has been reviewed. A field survey including 43 households was additionally carried out during this project in order to complement the information obtained from the literature. The main energy source for cooking is still LPG, no change in burden of disease was possible to attribute to modern bioenergy deployment.	Within the 25 most important causes of burden, as measured by disability adjusted life years (DALYs), lower respiratory infections showed the largest decrease. Household air pollution was estimated to be the fourth highest risk factor for disease burden in Indonesia in 2010 with a share of 6 percent of the Indonesian DALYs lost.	p. 154
Paraguay	En el contexto de este estudio, se realizó una visita a las comunidades rurales. Además, se consultaron varias fuentes posibles de datos secundarios.	A nivel del Ministerio de Salud Pública y Bienestar Social, no hay información estadística con un nivel de desagregación que permita saber los casos de muertes y enfermedades debido a inhalación de aire contaminado en el hogar. Se pudo obtener información sobre muertes anuales atribuibles a contaminación del aire en los hogares, del informe 2016 de Global Alliance for Clean Cookstoves (GACC).	p. 213
Vietnam	Nationally representative data on health, especially respiratory diseases, are very limited in Viet Nam. Collection of health data is costly.	Detecting the causal effect of smoke on health is almost impossible. It requires a randomized control trial with a long time duration. In this project, a small field survey was implemented to collect data on health status and respiratory diseases of households using biogas.	p. 180

c) Issues highlighted by the TFS sub-group

The measurement of this Indicator has proved problematic during Implementation because of the difficulty of attributing health impacts to indoor smoke. It is very resource intensive to carry out interviews or studies to quantitatively measure this Indicator.

d) Specific guidance

A look at the DPSIR indicator framework (see Chapter 3.2) reveals that “change in mortality and burden of disease attributable to indoor smoke” is an impact indicator. Impacts are at the very end of the cause-effect-chain which makes it difficult to link the final effect (change in mortality) to the driving force, which is “decrease of indoor smoke by using increased deployment of modern bioenergy services”.

In the first place, change in mortality and burden of disease have to be measured by statistics, which might be available in most countries at a general level. Then only epidemiologic studies are able to relate overall mortality and disease figures to single reasons like indoor smoke. Concepts exist like the measurement of disability adjusted life years (DALYs), as mentioned by the Indonesian implementation report. The challenge is to separate health risks of individuals to gain conclusions for a population and a specific risk which is made with the help of epidemiological studies.

Further to this, statistical data is needed about what has changed in households and to what extent. The deployment of modern bioenergy services is one factor of many.

It is possible to implement a measurement of this indicator with the help of primary statistics and supporting scientific knowledge as it was done in some implementation reports. The attribution issue is mixture of having access to statistics and applying scientific evidence to the cause-effect-chain.

Instead of proposing a TIER approach it should be considered if the content of this indicator could be addressed by a driving force or pressure proxy indicator, e.g. “number of households with indoor cooking stoves” or “change in number of households with indoor cooking stoves”.

5.7 Indicator 16: Incidence of occupational injury, illness and fatalities

a) Short recapitulation of the indicator

Description:

Incidences of occupational injury, illness and fatalities in the production of bioenergy in relation to comparable sectors.

Measurement unit(s):

Number/ha (for comparison with other agricultural activities) or number/MJ or MW (for comparison with alternative energy sources).

b) Attribution challenges during implementation

Country	Attribution issue	Used approach	Reference
Columbia	Very limited information could be found on the incidence of occupational injury, illness and fatalities in the domestic bioenergy sector.	The statistics from the federation of Colombian insurance companies (Fasecolda) elucidated information on the two main bioenergy feedstocks used in the country, i.e. sugarcane and palm oil.	p. 140
Germany	Even though there is data on occupational injuries, illness and fatalities in Germany these data do not differentiate between bioenergy and other activities (e.g. agricultural and forest workers). Furthermore, potential occupational health impacts can occur in other countries due to bioenergy imports (especially biofuels) to Germany, but there is no reliable information available on the impacts in exporting countries.	This indicator has not been assessed.	p. 75
Indonesia	Very limited information could be retrieved on the incidence of occupational injury, illness and fatalities in the domestic bioenergy sector in Indonesia.	There is little if any official data concerning occupational injury, illness and fatalities that relate directly to the bioenergy sector in Indonesia, as any relevant data is not disaggregated from other sectors.	p. 158
Paraguay	No se han encontrado estadísticas sobre accidentes y muertes laborales.	A pesar que se ha establecido la obligatoriedad de la comunicación	p. 218

	les a nivel general en el país y menos desagregada por sectores de producción.	de accidentes de trabajo vía web por resolución 835/16 del MTESS, con la finalidad de elaborar políticas y estrategias de prevención de accidentes de trabajo y enfermedades profesionales, no se ha podido acceder a documentos con estos registros.	
Vietnam	In Viet Nam, this indicator ^r was not deemed relevant for the biogas pathway. The analysis focused on the Cassava-based ethanol value chain. There is very limited information available on the incidence of occupational injury, illness and fatalities along this value chain in Viet Nam, as well as for agriculture as a whole and other economic sectors.	Based on available data and statistics (e.g. from the Viet Nam Household Living Standard Survey (VHLSS) and the Viet Nam Enterprise Census), a few estimates were made. Furthermore, a field survey was carried out, with the aim to collect data on occupational injury, illness and fatalities among cassava-growing households as well as ethanol firms.	p. 184

c) Issues highlighted by the TFS sub-group

The sub-group states that better disaggregation of data is required to conduct this analysis specifically for the bioenergy sector.

d) Specific guidance

The availability of satisfactory statistical data is the main shortcoming concerning this indicator. Hence, the attribution issue is a secondary problem if data about occupational injury, illness and fatalities are collected at a general level and have to be assigned to bioenergy activities.

An interesting question was raised by the German implementation report. Germany is importing large amounts of bioenergy feedstock. Therefore, the report considers whether occupational diseases occurring in exporting countries have to be regarded for Germany. It has to be decided if the territorial principle or the responsibility principle should be applied.

(1) How can occupational injuries, illness and fatalities be assigned to the bioenergy sector?

- TIER 1: Use existing occupational health statistic and use given subdivisions such as agricultural operations, forestry, etc. for a first estimate for the bioenergy sector.

- TIER 2: A specific stand-alone survey will give a picture of the situation. It can be combined with the approach described in TIER 1.
- TIER 3: Establish occupational health statistics with a subdivision for workers in the bioenergy sector and collect this information on a regular basis.

6 Guidance for economic indicators

6.1 Overview of the attribution issue for economic indicators

The economic indicators are the third group of GBEP sustainability indicators and are related to the economic performance of the bioenergy sector. The indicators include typical economic aspects like productivity or gross value added but also energy related items and consumption, training and logistics.

The TFS sub-group on economic indicators mentioned attribution issues for three indicators where they strive for guidance on how to address these issues:

- Indicator 17 Productivity
- Indicator 19: Gross value added
- Indicator 20 Change in the consumption of fossil fuels and traditional use of biomass

Indicators without attribution issues explicitly raised by the implementation reports and the TFS sub-group are:

- Indicator 18 Net energy balance
The indicator uses a similar approach as Indicator 17 Productivity. So guidance can be found there. LCA calculations are explicitly mentioned as one sub-indicator for energy efficiency. Hence, all LCA related guidance like for Indicator 1 GHG Balance provide helpful guidance.
- Indicator 21 Training and re-qualification of the workforce
A lack of information is the main constraint for the measurement of this indicator. So an attribution issue is a secondary question. In the DPSIR framework this indicator can be considered a response indicator.
- Indicator 22 Energy diversity
No obvious attribution issue is related to this indicator.
- Indicator 23 Infrastructure and logistics for distribution of bioenergy
No obvious attribution issue is related to this indicator.
- Indicator 24 Capacity and flexibility of use of bioenergy
No obvious attribution issue is related to this indicator.

6.2 Indicator 17: Productivity

a) Short recapitulation of the indicator

Description:

(17.1) Productivity of bioenergy feedstocks by feedstock or by farm/plantation

(17.2) Processing efficiencies by technology and feedstock

(17.3) Amount of bioenergy end product by mass, volume or energy content per hectare per year

(17.4) Production cost per unit of bioenergy

Measurement unit(s):

(17.1) Tonnes/ha per year

(17.2) MJ/tonne

(17.3) Tonnes/ha per year, m³/ha per year or MJ/ha per year

(17.4) USD/MJ

b) Attribution challenges during implementation

Country	Attribution issue	Used approach	Reference
Columbia	It should be considered that in Colombia ethanol is produced from molasses and is only one of many co-products obtained from sugar-cane.	No information was found about how attribution was performed. Maybe some attribution aspects for production costs are implicitly applied by using the FAO's Bioenergy and Food Security (BEFS) Detailed Analysis. The implementation report states that further guidance for taking into account co-products and by-products would be useful without specifying for which issues.	p. 147 p. 152
Germany	No attribution issue addressed		
Indonesia	No attribution issue addressed	The implementation report states that further guidance for taking into account co-products and by-products would be useful without specifying for which issues.	p. 165
Paraguay	Los cálculos presentados fueron desarrollados en base a la producción de etanol; sin considerar otras salidas como vinaza y bagazo para caña de azúcar; y DDGS y WDGS para maíz.	Si la planta es eficiente debe quedar disponible un 20% a 25% del bagazo que puede ser utilizado para cogeneración de energía eléctrica para venderla a la Red, pero como esta posibilidad aún no está	p. 225/226

		<p>permitida en el Paraguay, al bagazo sobrante se le da otros usos, como fabricación de briquetas, etc.</p> <p>Los costos de producción de etanol se realizan asignando los gastos a cada producto, etanol o azúcar, conforme a los datos operativos.</p> <p>La Vinaza, que es otro coproducto, se debe considerar el precio de venta de estos productos y deducir del costo de producción de etanol.</p> <p>En muchas Plantas del Paraguay se pueden procesar ambas materias primas, caña de azúcar y maíz; por lo cual la asignación de costos de producción al etanol sea como Destilería Anexa a la producción de azúcar o como coproducto de los DDGS/WDGS, es compleja y se debe realizar con especial atención.</p>	
Vietnam	No attribution issue addressed		

c) Issues highlighted by the TFS sub-group

Attribution is an issue identified by the economic sub-group in two main cases, namely:

- When a feedstock (e.g. soybean, sugarcane, etc.) has a number of different uses; and
- When by-products are used together with the main feedstock (as with sugarcane bagasse and molasses both used for ethanol production).

d) Specific guidance

Attribution issues for productivity have many aspects to be considered. Three main aspects shall be mentioned:

(1) The attribution issue for the productivity indicator as it is defined in the GSI relates to three different types of productivity:

- productivity per area of land (indicator 17.1 and 17.3)
- productivity related to the energy output of the feedstock (indicator 17.2 – MJ output per tonne input; indicator 17.4 – USD revenue per MJ output)

(2) The productivity indicator may be used at different spatial levels:

- at the farm level,
- at the level of a landscape or region,
- at the national level

(3) Co-product allocation with a production process having providing several products:

- a feedstock input (e.g. soybean, sugarcane, etc.) lead to a number of different uses
- co-products are used together with the main feedstock (as with sugarcane bagasse and molasses both used for ethanol production)

According to these aspects different attribution issues will come up. They have to be solved differently because they have different objectives and the necessary data will be different.

Unfortunately, the reviewed implementation reports – besides the report from Paraguay – do not address explicitly which attribution issues occurred and had to be solved. The Paraguay report considers the attribution issue of co-product allocation and is provides a solution (cost allocation for ethanol and sugar from sugar cane; reduction of cost by selling mash).

For the attribution issue related to the co-product allocation guidance will be given having in mind the two types of productivity of the indicator:

(1) Multi-output processes with different amounts of (bioenergy) products or co-products have an influence on the productivity. The productivity indicators (17.1) and (17.3) refer to a productivity per area (feedstock productivity). How can the hectare-productivity be assigned to a given bioenergy feedstock at farm level?

- TIER 1: Use allocation factors determined for a specific case e.g. nutrition content, carbon content, etc. as specifically determined for a country and a type of plant production.
- TIER 2: Use economic value of products with original data from a farm (value of products at the point of sale from the farm)
- TIER 3: Use energy content (lower heating value) of material flows as allocation factor with original data from a farm.

(2) Multi-output processes with different amounts of (bioenergy) products or co-products have an influence on the productivity. The productivity indicator (17.2. MJ/Tonne) refer to energy input to produce feedstock output. How can this productivity be assigned to an amount of a specific feedstock output at farm level ?

- TIER 1: Avoid allocation by measuring the energy input related to the output of total biomass (gives no specific information for bioenergy feedstock but for the efficiency of total biomass production)
- TIER 2: Use economic value of products with original data.
- TIER 3: Use energy content (lower heating value) of material flows as allocation factor with original data.

The GSI report (GBEP 2011) provides further guidance to the attribution issues under “Scientific Basis” and “Methodological Approach”.

6.3 Indicator 19: Gross value added

a) Short recapitulation of the indicator

Description
Gross value added per unit of bioenergy produced and as a percentage of gross domestic product
Measurement unit(s): US\$/MJ and percentage

b) Attribution challenges during implementation

Country	Attribution issue	Used approach	Reference
Columbia	The gross value added could be expressed both per unit of bioenergy produced and as a percentage of gross domestic product. Interesting data was also found on the indirect and induced effects of the sugarcane industry on the Colombian economy, and on the share of the various intermediate inputs used in the production of sugarcane-based products.	In 2010, Arbeláez et al. (2010) conducted a comprehensive study on the socio-economic impact of the Colombian sugarcane industry on the national and regional economy. With regard to palm oil based biodiesel production, data on the gross value added could not be found.	p. 157/158
Germany	National statistical data on investments and operational costs for bioenergy exist, but this information does not allow deriving gross value added due, as the GDP calculation in Germany is possible only for whole industry sectors - and bioenergy is part of several sectors.	Therefore, this indicator has not been assessed. As a proxy for this indicator, investments and annual turnover for bioenergy can be used, as these are the monetary inputs to economic sectors which generate additional value.	p. 80
Indonesia	In Indonesia bioenergy is a relatively new sector and consequently	For the measurement of this indicator a case study approach was	P 171

	comprehensive economic data on gross value added by these energy sources are scarce.	taken in order to provide experimental data gathered from a major biodiesel company.	
Paraguay	Los datos económicos completos sobre el Valor Agregado Bruto (VAB) son escasos a partir del año 1999 cuando comenzó a mezclarse etanol con los combustibles fósiles.	En la actualidad existe información aun así para la implementación de este indicador se tomó el estudio de casos con el fin de proporcionar datos experimentales obtenidos de las empresas más relevantes del año 2016.	p. 246
Vietnam	For measuring this indicator, a survey was submitted to 21 cassava-growing households from the Tay Ninh Province that sell fresh cassava to local traders and starch production factories.	Due to lack of data related to the ethanol processing stage, a detailed analysis could be conducted only for the cassava starch value chain. However, an estimate of the gross value added was made for Cassava-based ethanol as well.	p. 214

c) Issues highlighted by the TFS sub-group

There is a problem of attribution as bioenergy, in several cases, is not included as a single economic sector in the System of National Accounting. Alternative data could be used as a proxy in this case, but attribution to bioenergy should be considered.

d) Specific guidance

The indicator can be measured at both plant and national level. In the latter case, the utilization of official statistics should be applied. The System of National Accounts (SNA) is the most anticipated data source at national level. Gross value added can be broken down by industry. However, in many cases, bioenergy sector is not disaggregated as a single sector in the SNA. In this case, attribution issues arise and may be solved with the help of economic allocation because this is the underlying attribution principle for SNA. But this work can only be done by national statistical offices.

When measuring the indicator at plant level, one has to think of the representativeness of the plant or company selected as a case. Gross value added depends heavily on the operation system (e.g. feedstock, scale, conversion technology, etc.) applied to the plant. The reason why the plant represents the whole national bioenergy sector should clearly be explained. For example – the production of the plant represents a high percentage of total production in the country.

The implementation reports apply case studies and use existing research reports for providing information for this indicator. As long as the national statistical offices cannot analyse the bioenergy sector separately within the System of National Accounting only case studies can be used for the indicator. Therefore, not an attribution issue is the main constraint but the availability of data.

(1) What is the gross value added per unit of bioenergy?

- TIER 1: Conduct case studies and extrapolate to the national level.
- TIER 2: -
- TIER 3: The System of National Accounting shall be used for a subdivision for bioenergy. SNA applies economic allocation of the sector.

6.4 Indicator 20: Change in the consumption of fossil fuels and traditional use of biomass

a) Short recapitulation of the indicator

Description:

(20.1) Substitution of fossil fuels with domestic bioenergy measured by energy content (20.1a) and in annual savings of convertible currency from reduced purchases of fossil fuels (20.1b).

(20.2) Substitution of traditional use of biomass with modern domestic bioenergy measured by energy content.

Measurement unit(s):

(20.1a) MJ per year and/or MW per year

(20.1b) USD per year

(20.2) MJ per year and/or MW per year

b) Attribution challenges during implementation

Country	Attribution issue	Used approach	Reference
Columbia	No attribution issue addressed		
Germany	No attribution issue addressed		
Indonesia	No attribution issue addressed		
Paraguay	No attribution issue addressed		
Vietnam	No attribution issue addressed		

c) Issues highlighted by the TFS sub-group

As the main focus of the indicators is the contribution of domestic bioenergy production to energy security and to the balance of payments, consumption of imported bioenergy should not be considered. For the same reason, exports of bioenergy produced in the country should be considered when estimating indicator 20.1b (annual savings (or earnings) from reduced purchased of fossil fuels (or increased sales of bioenergy)).

d) Specific guidance

Reviewing the five Implementation Reports no attribution issue could be found. Also the issue highlighted by the TFS sub-group is not an attribution issue. Recommendation: delete this chapter.

7 Highlights concerning the attribution issue

(1) Understand the **character of the attribution issue**. This will help to find similar attribution challenges and related guidance.

The following types of attribution can be found:

- Insufficient statistical data for the bioenergy sector
- Allocation of a pressure indicator to bioenergy sector
- Assignment of a general effect to the bioenergy sector

Identify if an overlap of different attribution issues exist.

Check if the attribution issue is just a lack of sufficient data.

(2) The **attribution of land** to bioenergy appears for various indicators (1, 2, 8, 9). On the one hand they comprise issues of attribution of bioenergy activities at the background of insufficient statistical data. On the other hand the allocation of land have to be addressed if a coupled product system results in a bioenergy feedstock product and products for other purposes.

Literature

to be completed; provisional list:

- GBEP indicator report 2011
- Colombia GSI implementation report 2014
- Germany GSI implementation report 2014
- Indonesia GSI implementation report 2014
- Paraguay GSI implementation report 2018
- Vietnam GSI implementation report 2018
- IPCC guidelines for TIER approach and land occupation 2006
- OECD and EEA for DPSIR approach 1993 and 2001
- ISO 14040, ISO 14044, Life Cycle Assessment 2006
- Renewable Energy Directive, EU, 2009
- BioGrace tool 2015

Additional literature:

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- 3) “Incorporating bioenergy into sustainable landscape designs” by Virginia Dale et al.
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- 9) "Net primary production in three bioenergy crop systems following land conversion" by Michael W. Deal
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 - a. URL: https://www.google.it/url?sa=t&rct=j&q=&esrc=s&source=web&cd=101&cad=rja&uact=8&ved=0ahUKEwjz5qv18YPNAhUCNxQKHVgQB2s4ZBAWCBswAA&url=http%3A%2F%2Fwww.pinchot.org%2Fuploads%2Fdownload%3FfileId%3D1384&usg=AFQjCNF7jaSgyGCtRkG02xuuhL4iF_SAxw&sig2=KCK9yhqKs6aQWHYQqRxIVg&bvm=bv.123325700,d.d24
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 - a. <http://biotechnologyforbiofuels.biomedcentral.com/articles/10.1186/1754-6834-7-35>