



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

Technical Paper for the GBEP Task Force on Sustainability

Draft March 2019

prepared by

Jürgen Giegrich, Susanne Köppen, Horst Fehrenbach, ifeu-Institut
Uwe R. Fritsche, Ulrike Eppler, IINAS

in collaboration with



Heidelberg, Darmstadt, Berlin, March 2019

Acknowledgements

The paper was prepared with funding from the German Ministry for Economy and Energy (BMWi) through a contract with the German Federal Environment Agency (UBA).

The authors would like to thank the GBEP Secretariat for their comments and edits to this paper, as well as the GBEP colleagues who contributed to the validation process.

Any error, misconception or omission remains the responsibility of the authors.

Contents

1	Introduction and purpose	1
2	The attribution issue	3
2.1	The general question	3
2.2	Attribution issues raised during implementation	5
2.3	The way forward for guidance.....	7
3	General guidance for the attribution issue	10
3.1	Overarching considerations.....	10
3.2	Attribution types and related general guidance	11
3.3	Statistical separation of the bioenergy sector.....	12
3.4	Allocation of indicator results from coupled production activities.....	13
3.5	Assignment of general effects to bioenergy	15
4	Guidance for environmental indicators	16
4.1	Overview of the attribution issue for environmental indicators	16
4.2	Indicator 1 Lifecycle GHG emissions.....	17
4.3	Indicator 2: Soil quality.....	20
4.4	Indicator 6: Water quality.....	23
4.5	Indicator 8: Land use and land-use change related to bioenergy feedstock production	26
5	Guidance for social indicators	29
5.1	Overview of the attribution issue for social indicators	29
5.2	Indicator 9: Allocation and tenure of land for new bioenergy production.....	29
5.3	Indicator 11: Change in income.....	32
5.4	Indicator 12: Jobs in the bioenergy sector	35
5.5	Indicator 14: Bioenergy used to expand access to modern energy services	37
5.6	Indicator 15: Change in mortality and burden of disease attributable to indoor smoke.....	39
5.7	Indicator 16: Incidence of occupational injury, illness and fatalities	42
6	Guidance for economic indicators	45
6.1	Overview of the attribution issue for economic indicators	45
6.2	Indicator 17: Productivity	45
6.3	Indicator 19: Gross value added.....	49
6.4	Indicator 20: Change in the consumption of fossil fuels and traditional use of biomass	51
7	Highlights concerning the attribution issue	53

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, encountered in most GSI implementation projects, is the challenge of how to attribute the measurement of the indicators clearly to the production and use of bioenergy in contrast to all other activities. This challenge is referred to as the ‘attribution issue’. Therefore the term attribution issue does not follow a clear-cut methodological definition but is related to various practical problems in applying the GSI.

The TFS agreed that a technical paper on this attribution issue should be prepared

Purpose of this paper

This paper provides basic information on the attribution issue, its potential implications, and gives recommendations for practical application. It aims to serve as input into the implementation guide on the GSI initiated by TFS but can also be used as an independent guidance document. It is based on the methodological report “The Global Bioenergy Partnership Sustainability Indicators for Bioenergy” (FAO/GBEP 2011) with its objective that reads as follows:

“The 24 sustainability indicators for bioenergy and their methodology sheets are intended to provide policy-makers and other stakeholders with a tool that can inform the development of national bioenergy policies and programmes, monitor the impact of these policies and programmes, as well as interpret and respond to the environmental, social and economic impacts of their bioenergy production and use.” (Introductory note of FAO/GBEP 2011)

The attribution of impacts to bioenergy consists of different aspects. For a better understanding, it is necessary to structure the issue and above all provide solutions to the problems that occur in practice while implementing the GSI.

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 this document as a knowledge base which can be amended in the future as experience will grow.

Since the main purpose of this paper is to serve as a practical guidance document, it is intentionally brief and concise. Rather than aiming for completeness, reiterating all possible aspects and details, it provides literature examples and references to scientific publications for further detail.

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 of impacts to bioenergy for the different indicator results (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 adopt solutions based on these general considerations (chapter 3).
- Special guidance will be given for 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 (chapter 7).

2 The attribution issue

2.1 The general question

The character of the attribution issue

The GSI deal with the role of bioenergy in individual countries. The generation and use of bioenergy cuts across multiple sectors and parts of the entire economy. Focusing on this specific subsector always means to separate it from the whole economy and specify its role within the entire economic system of a country. The isolation of one subsector requires clearly defined procedures, 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 sector as such but, in the end, involves solving all questions which arise from parting the bioenergy sector from all other surrounding activities.

In the context of this paper attribution is defined as “the challenge of how to attribute the measurement of the indicators (GSI) to the production and use of bioenergy in contrast to all other activities.”

Three main types of attribution could be identified for the measurement concepts of the 24 GSI and their implementation:

- (1) Statistical separation of impacts from the bioenergy sector from other economic activities
- (2) Allocation of impacts from production activities (coupled processes) that are simultaneously related to bioenergy products and other products (e.g. food products)
- (3) Partial assignment of general effects to the bioenergy sector

(1) Statistical separation of bioenergy from other activities

Activities of the bioenergy sector as measured by GSI may form part of a larger economic system. An attribution issue arises if no detailed information about the bioenergy share as a subsystem exists. With the help of secondary information the share of the bioenergy sector has to be determined.

It can be argued that an attribution issue would not arise if sufficient statistical data exists. But reality shows that the collection of data can be connected with institutional and cost constraints within a country. Consequently indicators may not always be available as desired.

Maybe information never may be considered as 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 as a subsystem in a feasible, transparent, and reasonable manner. Consistency is also important so that results can be tracked and compared over time or to other bioenergy applications. Furthermore, indicators lose their value if arbitrariness causes doubts in the results or changes them according to a modification in the underlying methodology.

Some general approaches that may be helpful to mitigate this type of attribution issue are described in chapter 3.3.

Separation of bioenergy products from coupled processes

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 foodstuffs.

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 grains”? Other examples also occur in production processes like the sugar production, which yields sugar as main product and bagasse as a by-product. If sugar is used for food purposes and bagasse for 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.

But an attribution issue also arises if sugar from sugar cane is used partly for food and partly to produce ethanol for fuel purposes.

Attribution rules are needed to avoid arbitrariness in using GSI. It must be noted that scientific or technical solutions do not necessarily exist to clearly separate bioenergy from other end products. Conventions have to be agreed upon when no straightforward way exists to address attribution. Therefore, a procedure to identify and clarify attribution issues is useful for practitioners when confronted with these kinds of questions.

Some general guidance about this attribution issue is provided in chapter 3.4.

Assignment of measured effects to bioenergy

The above mentioned attribution issues exist for indicators that are caused by activities of the bioenergy system and other product systems. In such cases, the

indicator results like the emission of greenhouse gases have to be determined by attributing the emissions to these different activities.

But also another attribution problem arises if an indicator result may have different causes. Then the impact measured by an indicator must be related to the different underlying activities by analyzing cause-effect-chains.

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”.

Some general guidance about this attribution issue is provided in chapter 3.5.

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 local level (see **Error! Reference source not found.**).

COUNTRIES	COMPLETED	IN PROGRESS
Argentina	N	
Brazil		L
Colombia	N	
Egypt	L1 + L2	
Ethiopia		N
Germany	N1	N2
Ghana	N	
Indonesia	N	
Italy		L
Jamaica	N	
Japan	L	

Kenya		N
Netherlands	N	
Paraguay	N	
USA		N
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 further work with.

Additionally the work on the Implementation Guide of the GSI was taken into account. Three sub-groups of the Task Force on Sustainability (TFS) were formed for each pillar or sustainability. These three groups held regular teleconferences during 2017 and 2018 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 document.

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. (FAO 2014a)

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. (IINAS/IFEU 2014)

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. (FAO 2014b)

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. (FAO 2018a)

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. (FAO 2018b)

2.3 The way forward for guidance

The analysis of attribution issues for the GSI has shown some fundamental and repeating aspects that are categorised into three different types (chapter 2.1). Chapter 3 will provide some general guidance about these overarching aspects that should be considered when tackling a problem and proposing solutions. Of course, this general guidance will not be exhaustive and may serve as an exchange of expert knowledge.

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 were as follows:

- they have been mentioned somewhere in the five reviewed implementation reports, or

- 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 of other indicators.

For each indicator of the 24 GSI 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 issues 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 scheme that was used for this analysis. In order to have a quick look into the respective country report, the reference cites the page number of that report. (It should be mentioned 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 reports are provided to indicate which issues were discussed and if any guidance was given by the respective sub-group.

4. Specific guidance for the indicator

Subsequently, single attribution issues of the indicators are chosen for proposing specific guidance. Depending on the indicator, more than one issue is addressed.

The guidance provided is concentrated on 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
- Consistency

Plausibility is needed to understand the rationale behind an attribution issue. Transparency supports the reproducibility of results. Practicability ensures the feasibility of an assignment under given circumstance. Consistency ensures that the same methods or procedures are applied to the same kind of attribution issue.

Practicality 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 approaches that require different efforts. The TIER approach supports the needs and possibilities for the 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 sus-

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.

tainability of bioenergy at the national level". The solution of an attribution issue must be in line with the text given under this heading.

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 Attribution types and related general 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 (see above):

- (1) **Statistical separation** of impacts from the bioenergy sector from other economic activities
- (2) **Allocation of impacts from coupled production activities** that are simultaneously related to bioenergy products and other products (e.g. food products)
- (3) Partial **assignment of general effects** to the bioenergy sector

General guidance for these three types of attribution issues are given in the following sub-clauses.

While analyzing the attribution issues other observations have been made:

- Overlap of several types of attribution
- No attribution issue at all – but a general lack of data

Overlap of several of these types of attribution

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

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.

3.3 Statistical separation of the bioenergy sector

Often it is necessary to separate bioenergy from other economic activities. Many indicators of the GSI address bioenergy as part of the total national economy without knowing the exact share of bioenergy. In principle sufficient financial resources as well as favourable legal and institutional conditions may allow generating primary data which is directly related to bioenergy only.

For instance, land tenure is an indicator which might be known for the total land of a country. However, in order to measure the indicator specifically for the use of agricultural land for bioenergy, a reporting scheme may need to be developed that collects sectoral information at every single spot of land.

To attribute impacts to bioenergy, the activities in the bioenergy system must firstly 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.

The separation of bioenergy from other sectors for an indicator based on statistics in the case of insufficient data can be applied by a

- Top-Down-Approach, or a
- Bottom-Up-Approach

The **Top-Down Approach** works with auxiliary information that is available on a national scale for bioenergy as well as for other economic sectors. The relation of bioenergy to a total indicator result for the auxiliary information can be used to assume that the value of the desired indicator behaves in the same way.

For instance, the total revenues for bioenergy are known in relation to the total revenues from agriculture. If this auxiliary information is assumed to be appropriate for the attribution of e.g. the occupation of agricultural land it can be used to calculate the bioenergy indicator result about tenure of land with the same relation.

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. For instance, Indonesia had 608 registered palm oil mills in the year 2012. Specific information from some representative palm oil mills were used to extrapolate to the situation of the entire number of palm oil mills in the country. One precaution for this approach is to assure you use a representative sample before upscaling.

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 easily be separated again for the purpose of the bioenergy sector. Also Systems of National Accounting (SNA) may exist to be used for the statistical separation of the bioenergy sector.

3.4 Allocation of indicator results from coupled production 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 assessment method of Life Cycle Assessment (LCA). In LCA environmental impacts have to be allocated to different products from a coupled production process. 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 production of ethanol 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 at the

basis of single processes which then could be used for an upscaling to the national inventory.

Due to the complex nature of bioenergy systems, choices about allocation need to be made thoughtfully, following the general criteria mentioned above, and should be clearly documented. Once an allocation method is selected for an indicator of the GSI, it should be applied consistently if comparisons are to be made over time, or among project options.

Allocation of environmental impacts in LCA – but also other indicator values – for coupled processes can be made by:

- Physical properties, or
- Economic properties.

Physical properties include flows of mass, chemical energy content, exergy values, stoichiometric relations, etc. Economic properties are typically costs or prices to be used for allocation. An allocation of an indicator result of coupled processes always sums up to a 100%. Only the distribution of the share of the result is subject of the chosen allocation factor.

The advantage of using physical properties is their inherent value that does not change over time and regions. Nevertheless they sometimes do not represent the rationale behind a subdivision of an indicator. For instance, mass flows between grains and straw of wheat does not reflect the purpose of cultivating this crop.

An allocation by economic values is more in line with the purpose of running a process that provides coupled products. But the disadvantage is the fluctuation of the economic property in time that leads to different indicator results for a specific co-product. So the indicator result may change not because of a change in environmental or technical performance but by fluctuation in the underlying economic value.

Concerning the GSI, plausible allocation conventions should be applied that allow the comparison of indicator results over time. As their main purpose is to monitor the indicators of bioenergy systems over time physical properties should be applied as a first choice. That does not exclude economic allocation factors per se but their application must be handled with care especially while monitoring the development of an indicator over time.

As dealing with energy systems the following conventions are suggested:

- 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.

It shall be amended that for the context of comparing systems on a macroeconomic scale also the method to calculate a marginal substitution can be chosen. So the comparison of a system with bioenergy production to a reference scenario or counterfactual system without bioenergy production can be an approach to avoid allocation (e.g., Koponen et al., 2018; Efrogmson et al., 2016).

3.5 Assignment 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 along the cause-effect-chain is a pragmatic approach to avoid more complex indicators at the effect level. Hence, the measurement is shifted from effects to its causes with a loss of accuracy of the desired indicator objective.

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>In the case of sugar cane the co-product bagasse is generated, which is used in the boiler for producing heat and applied in the own production process.</p> <p>In the case of corn the co-products Dry Grains of Distillery and Solubles (DDGS) and Wet Grains of Distillery and Solubles (WDGS) are generated.</p>	<p>So far it was not necessary to estimate the percentage of emissions assigned to the bagasse because its use is included in the production process and hence in the total emissions.</p> <p>The method to estimate the percentage of emissions associated with ethanol and with the mentioned co-products is based on the lower heat value.</p>	<p>p.56 p.59 p.60</p>
Vietnam	<p>Besides ethanol, by-products include Dried Distillers Grains sold</p>	<p>The GHG emissions from the ethanol plants are partly balanced by</p>	<p>p.46</p>

	for animal feed production, biogas used as supplemental energy, and CO2 collected for sale.	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 CO2 is another co-product of the ethanol pathway; the CO2 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 CO2 emitted from the fermentation process.	p.49 p.50/51
--	---	---	-----------------

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 imbedded in specific data sources with a consistent allocation approach
 - TIER 2: Use energy content of products and apply other solutions such as exergy or economic allocation factors where appropriate.
 - TIER 3: Use energy content of material flows as allocation factor or appropriate other well defined allocation factors with original data
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 reports of the Intergovernmental Panel on Climate Change (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 land use for bioenergy for area and biogenic carbon on this land be-

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).

fore 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 positive.	p.19/20

		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	
Indonesia	In 2010, ICALRRD produced maps of predicted soil carbon stocks with a coverage of 84 percent of the surface of the country. 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.	For this project, field surveys were performed in plantations to retrieve primary data on soil quality in areas where oil palm is cultivated.	p.52/53 p.57

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), $\mu\text{S}/\text{m}$ (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

	<p>into waterways and bodies of water were found in literature.</p>	<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.		
--	---	--	--

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 an indicator about the state of the environment (total N, P and pesticides in the watershed) and an impact indicator (N, P and pesticides loadings from agriculture). 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 a certain challenge to be solved.

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 sig-	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.	p. 99 p. 102 p. 104

	nificant.	The share for bioenergy was correlated to the CPO used for biodiesel 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 be 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 feedstocks 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 feedstocks 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	The size of farms and the tenure of land dedicated to the production of sugar cane and sweet corn was elaborated based on the Censo Agropecuario 2008. More up-to-date information does not exist.	Official documents like the Estatuto Agrario and publications of the UN program REDD+ Paraguay were searched for analysing the legal framework for land tenure and exploitation of soil and forests. Estimations about the situation of land ownership for land used for sugar cane plantations were obtained by interviews of the sugar cane associations and the alcohol industry.	p. 173
Vietnam	A quantitative measurement of the	An in-depth review of the relevant	p. 133

	indicator was not possible due to lack of data.	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.	
--	---	--	--

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.

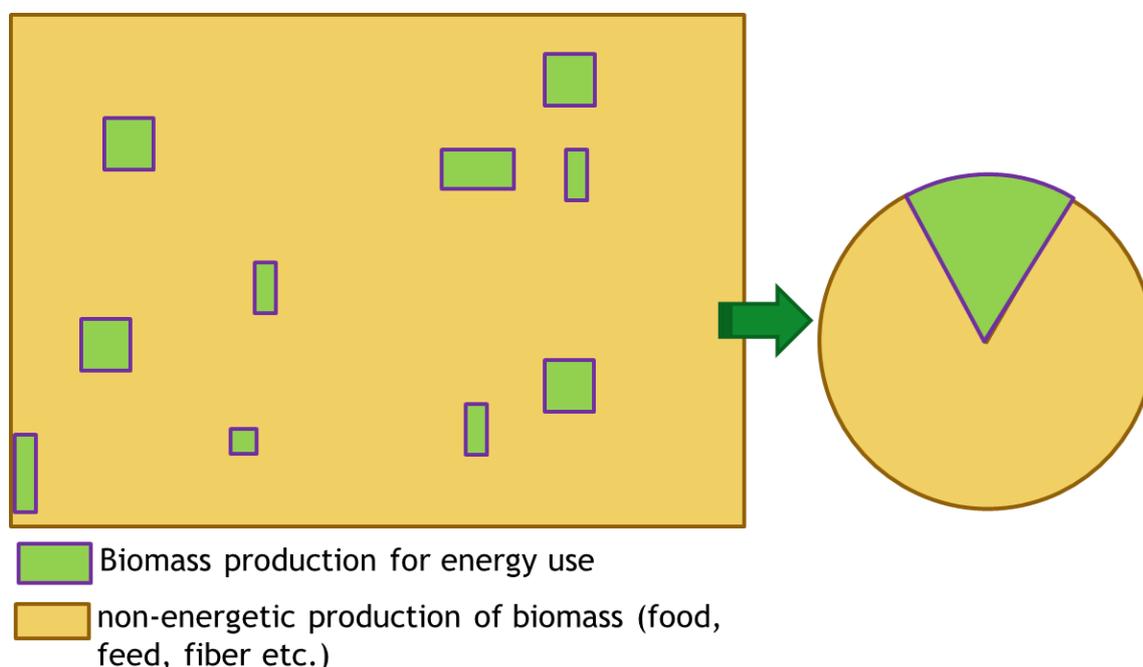


Figure 1: Scheme of the attribution issue about how to attribute land tenure to the bioenergy sector

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	Information about the average income of the agrarian, forest and related manufacturing sectors were taken from the Permanent Survey of Homes (Encuesta Permanente de Hogares - EPH) of the year 2015.	The information for this indicator was collected during the visits at the main producers of ethanol – mainly from one state enterprise that has salaries above private industries.	p. 188
Vietnam	For both the Cassava-based etha-	These data were validated and	p. 155

	<p>mol and biogas value chains, secondary data on income per employee and household in the bioenergy value chain were found and used.</p>	<p>complemented through a survey that was carried out in two provinces of Viet Nam:</p>	
--	---	---	--

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 proxy indication for the income situation of people working in the sector.

- TIER 2: National statistics about the income situation of different employments comparable to the bioenergy and non-bioenergy farms and industries could be analyzed and used.
- 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	p. 129

		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-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		Besides primary data provided directly by enterprises also secondary data were used from various reports.	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	Bioenergy does not play a major role in facilitating or expanding access to modern energy services because of ignoring its importance as an economic source.	Missing or out-dated data reflect the absence of information in the biomass sector which is mainly due to the disperse and informal use of this kind of energy.	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.	
--	--	--------	--

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

<p>Description:</p> <p>(15.1) Change in mortality and burden of disease attributable to indoor smoke from solid fuel use.</p> <p>(15.2) Changes in these as a result of the increased deployment of modern bioenergy services, including improved biomass-based cookstoves.</p> <p>Measurement unit(s): Percentages</p>

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	In the context of this study visits were made to rural communities. Additionally various sources were consulted for secondary data.	At the Ministry for Public Health and Social Welfare (Ministerio de Salud Pública y Bienestar Social) no statistical information is available at a level of disaggregation necessary to learn about casualties and diseases connected with inhaling contaminated air in homes. Information about the annual death rate of air pollution in homes was retrieved from the 2016 report of the 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 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

<p>Description:</p> <p>Incidences of occupational injury, illness and fatalities in the production of bioenergy in relation to comparable sectors.</p> <p>Measurement unit(s):</p> <p>Number/ha (for comparison with other agricultural activities) or number/MJ or MW (for comparison with alternative energy sources).</p>
--

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 on 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	Statistics about work accidents and deaths could not be found on a na-	An obligation has been established to communicate work accidents via	p. 218

	tional level and disaggregated into production sectors.	web with the resolution 835/16 of MTESS with the objective to develop politics and strategies to prevent work accidents and diseases. But it was not possible to get access to documents in those registers.	
Vietnam	In Viet Nam, this indicator 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.
- 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 sugarcane.	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	The calculations had been developed based on the production of ethanol without regarding the other outputs like (vinaza) and bagasse for sugarcane and DDGS and WDGS for corn.	If the production plant for ethanol is efficient about 20% to 25% of the bagasse could be used for cogeneration of electricity and sold to the national grid. But since this possibility is still not permitted in Paraguay the remaining bagasse is used for other purposes like the production of briquettes, etc. The production costs of ethanol are assigned to the expenditures of each product ethanol or sugar in	p. 225/226

		<p>line with operation data.</p> <p>For (vinaza) which is another co-product the price for sale should be considered and hence the production cost of ethanol should be reduced.</p> <p>In many plants in Paraguay it is possible to process both raw materials, sugar and corn. Then the attribution of production costs to the ethanol should be like the adjacent distillery to the production of sugar or as co-product of DDGS/WDGS. This is complex and should be carried out with special attention.</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 two 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 comprehensive economic data on gross value added by these energy sources are scarce.	For the measurement of this indicator a case study approach was taken in order to provide experimental data gathered from a major biodiesel company.	P 171

Paraguay	Complete economic data about the Gross Value Added are scarce after 1999 when the admixing of ethanol to fossil fuels started.	Currently information is still available for the implementation of this indicator which was retrieved from case studies with the objective to produce experimental data from the most important enterprises in 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: 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.
- TIER 3: The System of National Accounting shall be used for a sub-division 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.

7 Highlights concerning the attribution issue

(1) Understand the **character of the attribution issue**. This will help to identify similar attribution issues if they occur and find the related guidance.

The following types of attribution can be found:

- Insufficient statistical data for the bioenergy sector
- Allocation of an indicator the o bioenergy sector caused by coupled processes
- Assignment of an impact to the bioenergy sector

Identify if an overlap of different attribution issues exist.

(2) If insufficient statistical data exist to determine the share of bioenergy in comparison to all other sectors a top-down approach and bottom-up approach can be used. The top-down approach applies known auxiliary information to determine the share of bioenergy and the bottom-up approach extrapolates the knowledge of single units to the overall value for bioenergy.

(3) The allocation of indicator results of the GSI due to coupled processes should be solved with the help of physical properties of the co-products like the energy content in the first place to assure comparability over time. Other allocation factors like economic values can be helpful but must be handled with care to avoid misinterpretations of indicators over time.

(4) The attribution of an indicator based on a general effect (e.g. contamination of a water body) should be assigned to bioenergy by meaningful cause-effect models. If this not feasible a proxy indicator along the cause-effect chain shall be selected as substitute.

Literature

- BioGrace 2012; Publishable final report for Grant Agreement IEE/09/736 BioGrace, Harmonised Calculations of Biofuel Greenhouse Gas Emissions in Europe, John Neeft, Simone te Buck, Timo Gerlagh (Agency NL), Bruno Gagnepain (ADEME), Dina Bacovsky, Nikolaus Ludwiczek (Bioenergy 2020+), Perrine Lavelle, Grégoire Thonier (Bio IS), Yolanda Lechón, Carmen Lago, Israel Herrera (CIEMAT), Konstantinos Georgakopoulos, Niki Komioti (EXERGIA), Horst Fehrenbach, Anna Hennecke (IFEU), Matti Parikka, Lina Kinning and Per Wollin (STEM); www.BioGrace.net, Brussels, 2012
- Efroymsen RA, Kline KL, Angelsen A, Verburg PH, Dale VH, Langeveld JWA, McBride A, 2016; A causal analysis framework for land-use change and the potential role of bioenergy policy. *Land Use Policy* (59) 31 (Dec 2016) 516–527; 2016
- EU 2009; Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC; Brussels, 2009
- FAO/GBEP 2011; The Global Bioenergy Partnership Sustainability Indicators for Bioenergy, First edition, GBEP Secretariat at Food and Agriculture Organization of the United Nations (FAO), Rome, December 2011
- FAO 2014a; Pilot Testing of GBEP Sustainability Indicators for Bioenergy in Colombia, Environment and Natural Resources Management Working Paper No. 59, a contribution to the GBEP programme of work, Rome, September 2014
- FAO 2014b; Pilot Testing of GBEP Sustainability Indicators for Bioenergy in Indonesia; Environment and Natural Resources Management Working Paper No. 60, a contribution to the GBEP programme of work, Rome, September 2014
- FAO 2018a; Sustainability of Forest Biomass for Energy and of Ethanol from Maize and Sugarcane in Paraguay, Results and recommendations from the implementation of the Global Bioenergy Partnership Indicators, Environment and Natural Resources Management Working Paper No. 70 (in Spanish), Edited by Tiziana Pirelli and Andrea Rossi; Rome, 2018
- FAO 2018b; Sustainability of Biogas and Cassava-based Ethanol Value Chains in Viet Nam, Results and recommendations from the implementation of the Global Bioenergy Partnership Indicators, Environment and Natural Resources Management Working Paper No. 69, Edited by Tiziana Pirelli, Andrea Rossi and Constance Miller; Rome, 2018

- IINAS/IFEU 2014; Implementing the GBEP Indicators for Sustainable Bioenergy in Germany, German contribution to the Global Bioenergy Partnership (GBEP) on behalf of the Federal Ministry for Economic Affairs and Energy (BMWi), Susanne Köppen, Horst Fehrenbach, Stefanie Markwardt, Anna Hennecke, Ulrike Eppler, Uwe R. Fritsche; Heidelberg, Darmstadt, Berlin, October 2014
- IPCC 2006; IPCC Guidelines for National Greenhouse Gas Inventories Volume 4, Agriculture, Forestry and Other Land Use; Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds.); Keith Paustian (USA), N.H. Ravindranath (India), and Andre van Amstel (Netherlands) (lead authors), Japan, 2006
- ISO 14040, 2006; Environmental management – Life cycle assessment – Principles and framework (ISO 14040:2006); German and English version EN ISO 14040, 2006
- ISO 14044, 2006; Environmental management – Life cycle assessment – Requirements and guidelines (ISO 14044:2006); German and English version EN ISO 14044, 2006
- Koponen K, Soimakallio S, Kline KL, Cowie A, Brandão M, 2018; Quantifying the climate effects of bioenergy - choice of reference system. *Renewable & Sustainable Energy Reviews* 81:2, 2271-2280. 2018