Global Assessments and Guidelines for Sustainable
Liquid Biofuel Production in Developing Countries

Biofuels Screening Toolkit

GUIDELINES FOR DECISION MAKERS

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UNITED NATIONS
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Background and introduction

The present *Guidelines for Decision Makers* on the Biofuels Screening Toolkit have been developed to complement the products and results of the research project "Global assessment and guidelines for sustainable liquid biofuel production in developing countries". The project was funded by the Global Environment Facility (GEF) and carried out by three UN agencies (UNEP/DTIE, FAO, UNIDO) in collaboration with several research institutes. The aim was to enable the GEF and other institutions to set clear policies and identify priorities for future work and investments in biofuel-related projects. Furthermore, the project intended to provide guidance to countries with an interest to become involved in the biofuel sector. For these purposes, the project team assessed 74 liquid biofuel pathways for both transport and stationary biofuel applications in developing countries. The assessment covered environmental, social and economic indicators.

The project produced the following results[1]:

- **Final report** – Recommendations to the GEF on sustainable biofuels in developing countries, including a *Biofuels Screening Toolkit* for the assessment of biofuel projects (Franke et al. 2013).
- **Executive summary** – Summary of the *Biofuels Screening Toolkit* to allow for easy use and rapid assessment of biofuel projects.
- **GEF Biofuel Greenhouse Gas Calculator** – Excel-based greenhouse gas (GHG) calculation tool. It was designed as part of the screening toolkit and allows making the GHG emission calculations required for one of the indicators (IFEU 2012).
- **Impacts of Biofuel Production- Case Studies: Mozambique, Argentina and Ukraine** – Environmental and socio-economic impact assessment of biofuel production, applied in three different regions: Argentina, Mozambique and Ukraine (Van der Hilst et al. 2013)
- **Guidelines for decision makers on the Biofuel Screening Toolkit** – These guidelines are intended as an introductory manual to assist decision makers and practitioners when utilising the screening toolkit. The overall purpose of the guidelines is to encourage and promote investment in biofuel production when it is socially and environmentally sustainable, as well as economically viable.

1 All documents can be accessed: http://www.unido.org/en/resources/publications/energy-and-environment/energy-and-climate-change.html and, www.unep.org/bioenergy/Activities/TheGlobalEnvironmentFacilityGEFProject/tabid/79435/Default.aspx

Biofuels in a sustainability context

2

The use of biofuels is currently common in many countries due to a number of positive features and effects. Biofuels effectively substitute and save fossil energy. Thus, they actively decrease the dependence on fossil energy carriers such as coal or crude oil, which frequently have to be imported at high prices. In addition, biofuels help mitigate climate change, i.e. they may lessen the effects of GHG releases in the atmosphere. The reason for this is that in general the production and use of biofuels cause fewer emissions than their fossil counterparts, as they are made from plants that stock emissions from the atmosphere. Biofuels are frequently promoted as a sustainable solution. However, lately an increasingly critical discussion has evolved, and risks associated with biofuels production and utilisation are being analysed.

These risks are connected with two main circumstances. First, biofuels on the current market originate from biomass that is produced on farmland. Second, this biomass could equally be used as livestock feed or human food. The most common types are first-generation biofuels derived from vegetable oils, starch or sugar crops (e.g. soybean, oil palm, wheat, corn, sugar cane). The increasing global demand for biofuels leads to an increased competition for arable land originally cultivated for feed or food purposes. Moreover, existing agricultural systems are facing a significant intensification of cultivation to meet the conflicting demands. The arising competition is one of the factors driving rising food prices and this is most harmful to developing countries. Furthermore, additional land for cultivation is required, thus causing land use changes. These can be either direct, due to the conversion of land for biofuel production, or indirect, when food or feed production is relocated to areas previously not under cultivation. Land use changes in turn may lead to high GHG emissions which potentially negate the positive climate effect of biofuels. Moreover, they may pose considerable risks for biodiversity.

Intensification of cultivation affects the actual features of the land. The use of larger amounts of mineral fertiliser and pesticides, as well as the removal of great residue shares, lead to an overall decrease in soil fertility and water pollution. In consequence, degradation of the soil may be the result. Furthermore biodiversity can also be negatively affected due to longer production periods, the lack or limitation of crop rotations and the elimination of fallow periods. Additionally, a larger need for irrigation may negatively affect water availability within a region.

The negative effects of biofuels production may not only affect the environment. The local population, especially in developing countries, may feel its disadvantages as well. In addition to the risks to food security as described above, cases of land grabbing are increasingly reported. Land use rights are often violated, in particular at large-scale biofuel plantations, where the eviction of landless people is increasingly common. Smallholders are particularly vulnerable to suffer from large-scale projects as competition for space becomes fierce.

On the other hand, biofuels production has been shown to have thoroughly positive effects. When the realisation of biofuels production is carried out with caution and forethought, it may create local jobs and offer income opportunities to alleviate poverty. Moreover, access to modern bioenergy services such as vegetable oil or ethanol for cooking decreases health risks from traditional energy sources, e.g. wood smoke. In this example, modern use of biofuels further saves the time spent on daily wood collection.

Biofuels production striving to be 'sustainable' should be firmly based on sustainability principles. Although the savings of GHG emissions may be vitally important, related negative impacts on environment and society should be avoided during biofuel cultivation, processing and distribution wherever possible. At the same time, the benefits of biofuels as affordable alternatives to fossil fuels, and further in creating jobs and increasing the competitiveness of enterprises have to be considered. A number of the risks discussed above require regulation at the national or higher level (e.g. land grabbing, indirect land use changes). Many of them, however, may be tackled at the individual project level.

Thus, the *Biofuels Screening Toolkit* was developed to assist in designing biofuel projects as well as in assessing and evaluating their sustainability. The toolkit is primarily intended for application to biofuels projects in developing countries. However, it may serve as a universal stimulus for relevant sustainability topics in the context of bioenergy production regardless of the location.

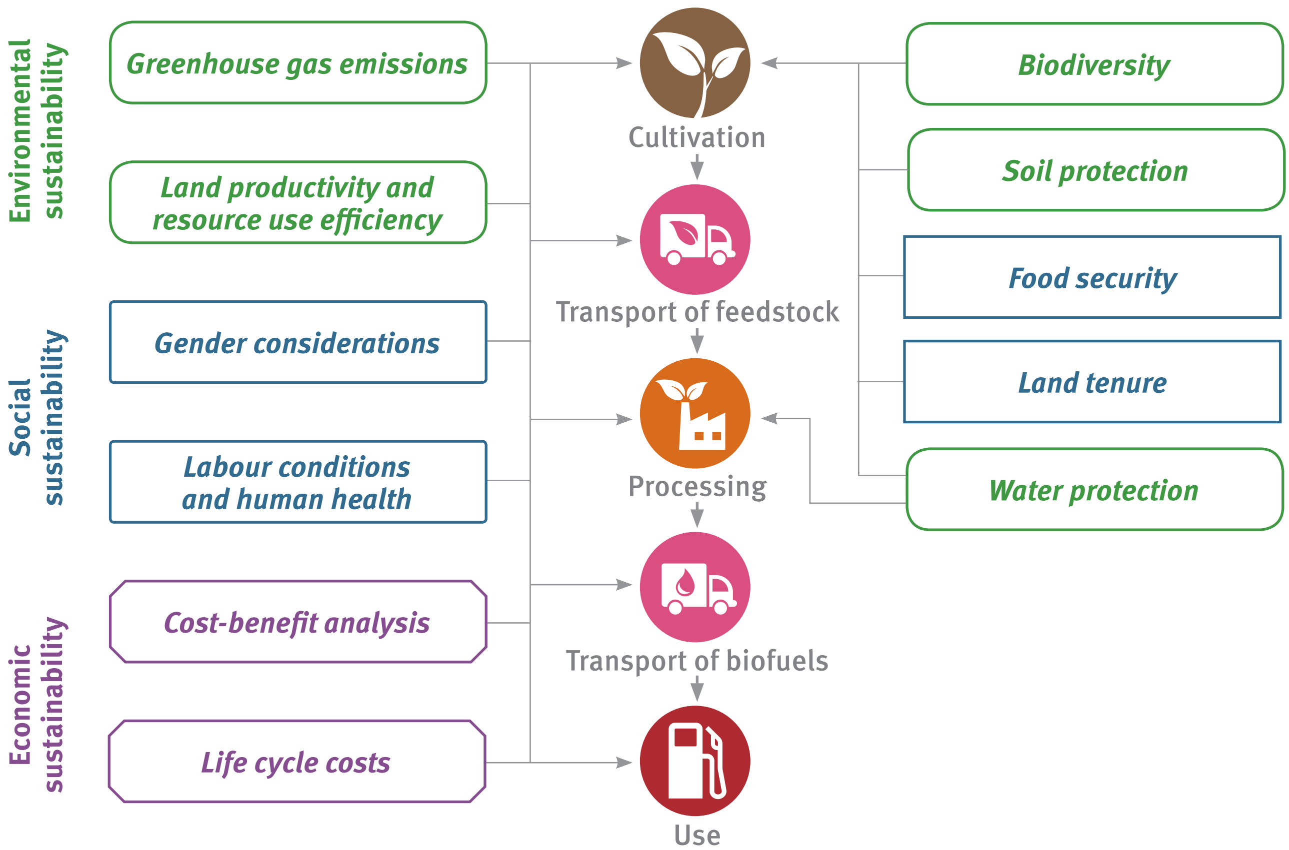
3 The Biofuels Screening Toolkit

3.1 Goal and scope

The *Biofuels Screening Toolkit* was developed to assist in the evaluation of biofuels projects to assess the actual sustainability of the project under investigation. Biofuels are considered sustainable when the entire associated production and supply chain delivers positive environmental, social and economic impacts. However, full analysis of the sustainability issues illustrated in Chapter 2 can be time-consuming and costly. Therefore, the toolkit aims to provide an initial screening tool for biofuel projects. Thus, identification of critical issues becomes easy and convenient.

The *Biofuels Screening Toolkit* introduces eleven sustainability criteria that address the most relevant risks. The biofuel production chain consists of several steps with different risks occurring at each step. Figure 3.1 illustrates the connections between the individual sustainability criteria in the toolkit and the specific biofuel production step involved. All potential impacts related with the first step ('cultivation') may be avoided as soon as waste or residues are used. In case cultivation is performed on non-utilised degraded land, special care has to be taken as it may be high in biodiversity or used informally by the rural poor. Water scarcity may also be a problem. On the other hand land productivity and therefore food security may be raised significantly when such areas are cultivated[2].

Figure 3.1 Application of toolkit sustainability criteria to the individual biofuel production pathway stages



2 For further information on energy crop production on degraded land see Wicke 2011 and Fritsche et al. 2008.

3.2 Target groups

In principal, the toolkit was designed for non-expert users that have no or little formal training in sustainability assessment. The *Biofuel Screening Toolkit* has two main application purposes:

Evaluation of biofuel projects

The toolkit is designed to assess biofuel projects to examine their sustainability performance. In this context, the following user groups might want to use the toolkit:

- ***Financing institutions implementing funding programmes:*** the toolkit may be applied at different stages of the project proposal phase. It may be used both for an ex ante assessment as well as for project evaluation after it has been completed.

- ***Project developers and applicants:*** the toolkit may be used to improve project applications and to identify project weaknesses. Furthermore, it can be used to check indicatively whether the project would meet the requirements of a certification system.

Application for strategic purposes

In addition to checking and evaluating actual projects, the toolkit is able to indicate significant aspects for consideration when developing biofuel strategies. In this context, it may be used by the following target groups:

- ***Policy makers in developing countries:*** when biofuel policies are to be established or further developed, the toolkit may provide an overview of the sustainability aspects to be taken into account[3].

- ***Financing institutions:*** they may use the toolkit as a guideline when implementing biofuel project funding programmes in developing countries.

3.3 Methodology

The *Biofuels Screening Toolkit* uses a traffic light approach for the analysis of a list of eleven sustainability criteria. The specific thresholds signal whether the project is recommended for approval, or whether further assessment is needed to make that decision. For each criterion, the following approach allows identifying individual project conditions:

- **GREEN:** no relevant risks, or adequate project design mitigating such risks **(GO)**.

- **YELLOW:** potential risks which could be mitigated by specific project designs or not enough information to take a decision (**CHECK**); and,

- **RED:** high risks which cannot be mitigated (**STOP**).

3 The Global Bioenergy Partnership (GBEP) has published a set of sustainability indicators particularly addressed at policymakers in order to evaluate national bioenergy policies (GBEP 2011). The GBEP indicators have been reflected while elaborating the indicators comprised within this toolkit, taking into consideration the difference between the national scope and the project level.

Table 3.1 Overview of sustainability criteria covered by the Biofuels Screening Toolkit

Environmental sustainability	Economic sustainability	Social sustainability
Greenhouse gas emissions	*Cost-benefit analysis*	*Food security*
Biodiversity	*Life cycle costs*	*Labour conditions and human health*
Land productivity and resource use efficiency		*Land tenure*
Soil protection		*Gender considerations*
Water protection		

Table 3.1 illustrates the sustainability criteria to be assessed. For each sustainability criterion, the assignment of the final colour of the traffic light depends on qualitative or quantitative thresholds. Qualitative thresholds are defined as yes / no situations that describe the presence or absence of a circumstance. Quantitative thresholds on the other hand are defined as distinct numeric values that have to be achieved to gain a certain colour level. The overall outcome is a colour map that arranges projects into three categories: (a) projects definitely eligible for funding, (b) projects with ambiguous eligibility, and (c) projects not eligible for funding.

3.4 Interpretation of results

The screening of a project with the toolkit will not provide a final score, but rather generate a detailed colour map. This way, users can see their performance across different sustainability areas and learn of areas and elements that may require further analysis and improvement. If the resulting colour map of a proposed project contains one or more indicators scoring red, unsustainable practices in the project design are evident that present significant environmental and social risks, and do not provide sustainability benefits. In light of the key importance of each of the eleven indicator criteria, projects with any red score should not be pursued, unless they are significantly redesigned.

However, assessing sustainability is a complex exercise and not achievable based on “exact science” only. Due to the fact that this toolkit is based on a limited number of relevant indicators, it does not claim to touch and fully incorporate all aspects of sustainability. Therefore, the interpretation of results should identify options to offset burdens with benefits, prioritise and consider trade-offs where applicable. This is permitted as long as risks are reliably accounted for in view of significant hidden advantages.

To give an example: a project is identified to provide enormous advancements in rural development, yet it performs poorly in terms of GHG reduction. The toolkit should clearly answer with an overall negative result. However, that should not prevent decision makers from reflecting aspects beyond the toolkit verdict. Conversely, a project could provide major GHG reductions, but would require financial support since the cost-benefit balance would be negative in mid-term. In such cases, the toolkit is meant to provide a clear result. Nevertheless it is the responsibility of the user and decision maker to overrule that result if a strong case can be made in favour of the project. This also applies to the thresholds provided in the following sections. They should be treated as guiding principles rather than for application in the strictest sense.

At the individual project level, the toolkit is intended as a guiding document during the communication process between a project applicant and the financing institution. Yellow and red labels will reveal the need for further adjustments of the project. Only in cases where further modification of the proposed project is definitely unfeasible for whatever reason, a red label should result in stopping a project.

3.5 Relation to other sustainability and legal requirements

Sustainability requirements

For biofuels, numerous sustainability requirements have been developed – either as legal requirements or as voluntary certification systems. Table 3.2 lists the most relevant systems.

Table 3.2 Overview of sustainability systems

Legal requirements	• European Renewable Energy Directive (RED) • Low Carbon Fuel Standard (LCFS, California) • Renewable Fuel Standard (RFS2, USA)
International agreements	• United Nations Framework Convention on Climate Change (UNFCCC) • Global Bioenergy Partnership (GBEP)
Voluntary certification schemes	• Bonsucro • Green Gold Label (GGL) • International Sustainability and Carbon Certification (ISCC) • Roundtable on Sustainable Biomaterials (RSB) • Roundtable on Sustainable Soy (RTRS) • NEN NTA 8080

The toolkit covers the most relevant sustainability criteria which are widely used in the above mentioned schemes. However, application of the toolkit will not give a definitive result on whether a project could meet the criteria of a certain scheme. Instead, it will provide a rough indication. For example, the certification of a project / product requires a much more detailed assessment that cannot be captured by the toolkit. However, every green label indicates a good chance that certification might succeed.

Most large scale projects will require an Environmental and Social Impact Assessment (ESIA) by law which makes the application of the toolkit redundant. In these cases, the toolkit could serve as a framework for summarising the most important findings of an ESIA that is usually associated with a voluminous report. Full toolkit application, however, will be required in more small-scale projects that are not subject to comprehensive prior assessments.

Legal requirements

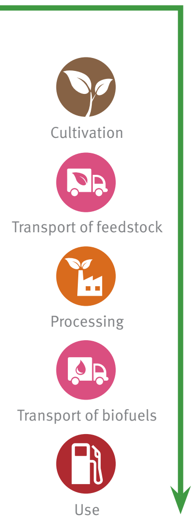
In most countries, legal requirements are in place covering most of the areas mentioned in this document (e.g. environmental regulation, labour law etc.). Often, they may contain thresholds or rules overlapping with those mentioned in the following sections. In some cases this may lead to conflicts requiring a careful consideration of all aspects. It is clear that national legislation should be prioritised. However, in some cases thresholds presented in the toolkit may be stricter than those required by national law. As in most cases, projects should be able to go beyond the requirements of national law voluntarily, it is recommended to align projects with the requirements listed in the toolkit (see also chapter 3.4).

4

Detailed description of the sustainability criteria

The following subchapters present detailed information on the use of the indicators in project assessment. Each section starts with a decision tree. Each tree visualises a sequence of steps that identifies whether a project should be labelled green, yellow or red. Each step may be compared to a question that requires confirmation or rejection, i.e. a ‘yes’ or ‘no’ answer. The decision tree is followed by instructions on the methodology and the description of relevant and useful data sources.

4.1 Greenhouse gas emissions



The mitigation of climate change is one of the main drivers for the implementation of biofuels. Therefore, the actual GHG emission savings in comparison with fossil fuels are of vital interest in biofuel projects. Biofuels may achieve emission savings by (i) replacing fossil fuels and (ii) producing co-products (e.g. soy meal). Co-products derived from a biofuel production pathway may then in turn replace other products (e.g. animal feed). Thus, GHG emissions from the production of the replaced product may be saved. On the other hand, GHGs are emitted during biofuel production and use, e.g. due to the application of fertilisers and pesticides, and the consumption of energy in cultivation and processing. Furthermore, land use changes can cause considerable emissions. These savings and emissions have to be offset against each other in order to come to a final result. The following section describes how to carry out this calculation.

How to calculate GHG emissions

The most common methodology for GHG balances is the life cycle assessment (LCA). It is a structured, comprehensive and internationally standardised (ISO 2006) method. All GHG emissions across the entire life cycle of the biofuel are included in the calculations. The first step calculates emissions generated during biofuel production. Figure 4.1 exemplifies how a palm oil biodiesel pathway is structured, and how the emissions from every single step have to be added up to yield the total emissions. In the second step, the computed emissions total from the biofuel is compared to the total emissions of the fossil fuel equivalent to be replaced. For example, one megajoule of palm oil biodiesel may replace one megajoule of fossil diesel. In consequence, the production and use of biofuels may lead to emission savings, or it may cause additional net emissions in comparison to the fossil fuel.

Figure 4.1 The logic of GHG emission calculation for a palm oil biodiesel pathway

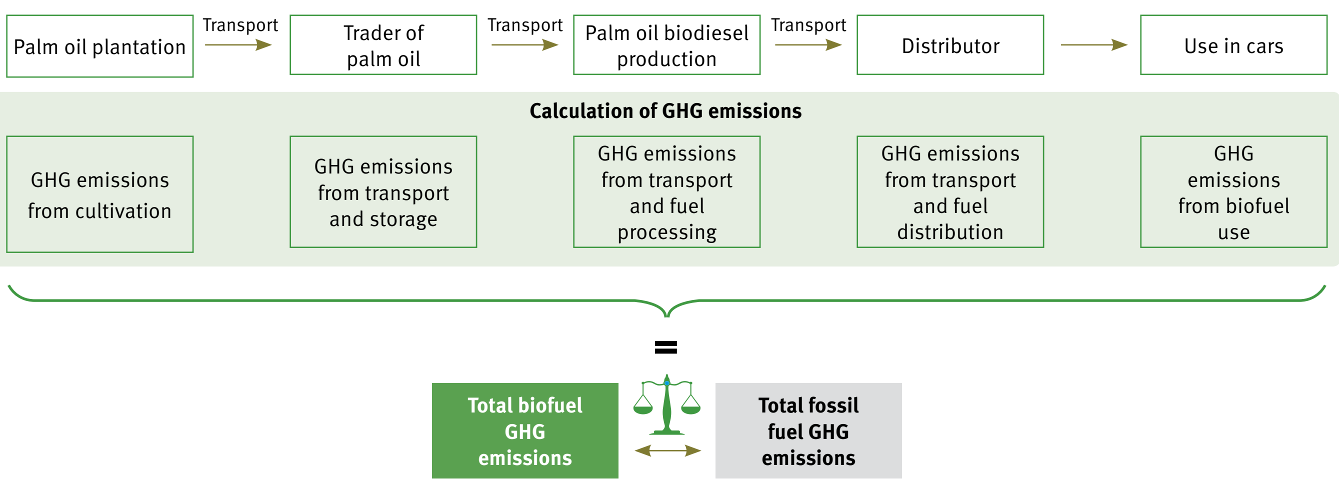
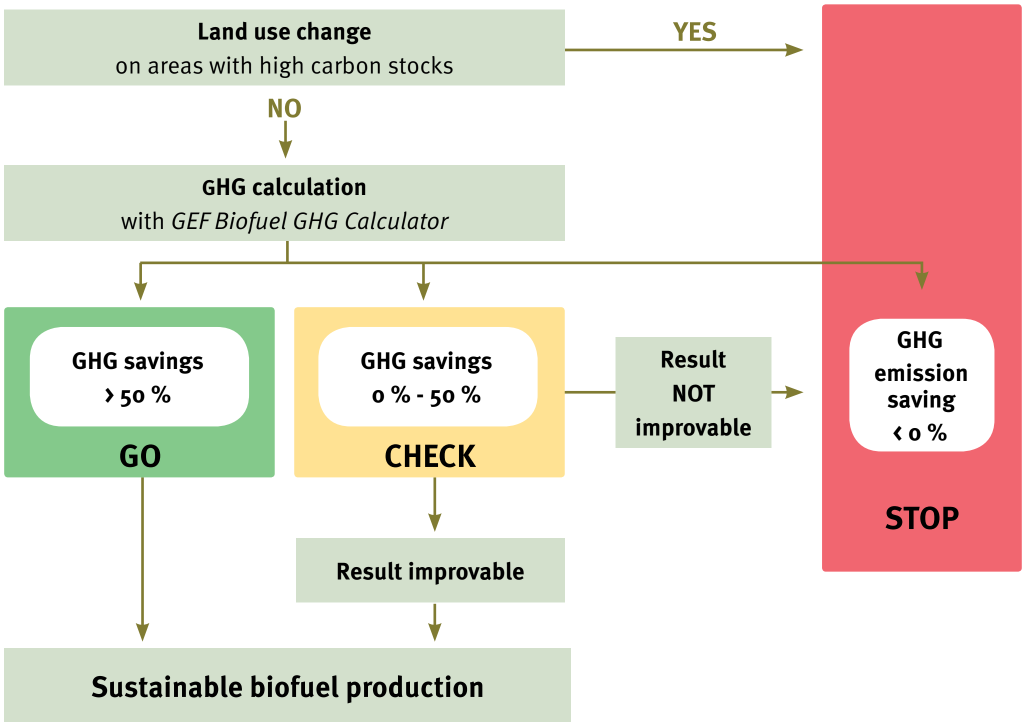


Figure 4.2 illustrates the GHG indicator decision tree. In a first step, it should be assessed whether a biofuel project leads to land use changes (LUC). Depending on the previous vegetation, LUC may lead to significant carbon emissions. In the worst case, these emissions could exceed the emission savings from replacing fossil fuel. Therefore, certain land use types should be excluded from conversion in principal (for further details, see Box 4.1). In a second step, the GHG balance of the biofuel pathway is calculated. If the resulting GHG savings exceed 50 % compared to a fossil fuel, a green label is awarded to the project. If GHG savings are below 50 %, the project plan should be revised to reduce the GHG emissions caused by the project. During revision, the focus should be on production steps that have been identified to cause high emissions. Among these are LUC, nitrogen fertiliser application and crop yields. In addition, energy needs and energy carriers (e.g. coal or natural gas) in the processing plant significantly influence the balance. It further depends on whether surplus electricity generated could be fed into the national electricity grid. If the project design, for whatever reason, may not be improved to achieve a considerable saving, the project design should not be recommended for funding and the project should be stopped. It should be noted here that the thresholds serve as an indication. As written in Chapter 3.4, it may be decided that a project is pursued due to its great advantages even if low emission savings are achieved. However, emission savings should never be below zero as this indicates a possible undesired land use change.

Figure 4.2 Decision tree for the indicator 'Greenhouse gas emissions'



The *GEF Biofuel Greenhouse Gas Calculator*

The modelling of scientifically sound LCAs is laborious and time consuming. The process requires considerable data and has proven difficult for non-experts. For this reason, the *GEF Biofuel Greenhouse Gas Calculator*[4] was developed within the GEF project (IFEU 2012). It is an Excel-based spreadsheet tool that makes the LCA methodology accessible to non-experts.

The calculator has two main purposes:

1. It shows the GHG emission results for 74 biofuel scenarios (called 'settings') in developing countries with transparency, and presents them ready-to-use. The settings cover different fuel types (e.g. ethanol, biodiesel, vegetable oil), different feedstocks (e.g. sugar cane, oil palm, jatropha), various countries (e.g. Mali, Mozambique, Indonesia), various crop management systems (e.g. low or high input of fertiliser,

4 To be accessed here: http://www.unep.org/bioenergy/Activities/TheGlobalEnvironmentFacilityGEFProject/tabid/79435/Default.aspx

field work, irrigation) and includes a range of different time frames (2010, 2020). The results may be used as indicators for the estimation of the impacts of biofuel projects that are carried out in similar circumstances to those covered by the settings.

2. The user can customise the settings mentioned above to reflect his / her own needs using own data (e.g. yields, fertilisers applied).

Structure and function of the calculator

The calculator contains general information sheets (e.g. Directory, About, References) and pathway calculation sheets. Each pathway calculation sheet covers a specific feedstock / fuel combination (e.g. soy / biodiesel, sugarcane / ethanol). Within the sheets calculations are displayed for several settings. The calculation of each setting is presented in a transparent way with all input data clearly listed. In addition, each sheet contains a user-defined column where individual independent calculations may be made. The user may either copy an existing setting and modify the data as appropriate, or he may start with a completely new calculation.

Data requirements and sources

Data requirements

Required data are distinguished between background data and input data. They are used for GHG emission calculation as shown in Figure 4.3.

Figure 4.3 The calculation of greenhouse gas emissions with input data and background data

Input data (e.g. yields, fertiliser)	**X**	**Background data** (e.g. heating values, emission factors)	**=**	**Greenhouse gas emissions**

Input data have to be provided by the user and include, e.g. yields, amounts of fertiliser or pesticides, or amount of process energy consumed. All input data that have been employed for the calculation of the emissions of the predefined settings are reported in the calculator. In the case that the user has access to own individual data, these may be entered in the user-defined column. Background data include emission factors, i.e. emissions that are inherently caused by every single input (e.g. g CO_{2eq} / kg fertiliser). Moreover, they include conversion factors such as heating values that help converting the input data into the required unit. All background data are reported in the sheet 'Background data' of the calculator. The conversion of units and calculation of emissions is done automatically by the calculator. Figure 4.4 illustrates the calculation process in detail, as exemplified by the cultivation step.

All input data are collected on an annual basis in order to provide for a consistent time frame, and to enable summing up of all data. The data needed at each step are:

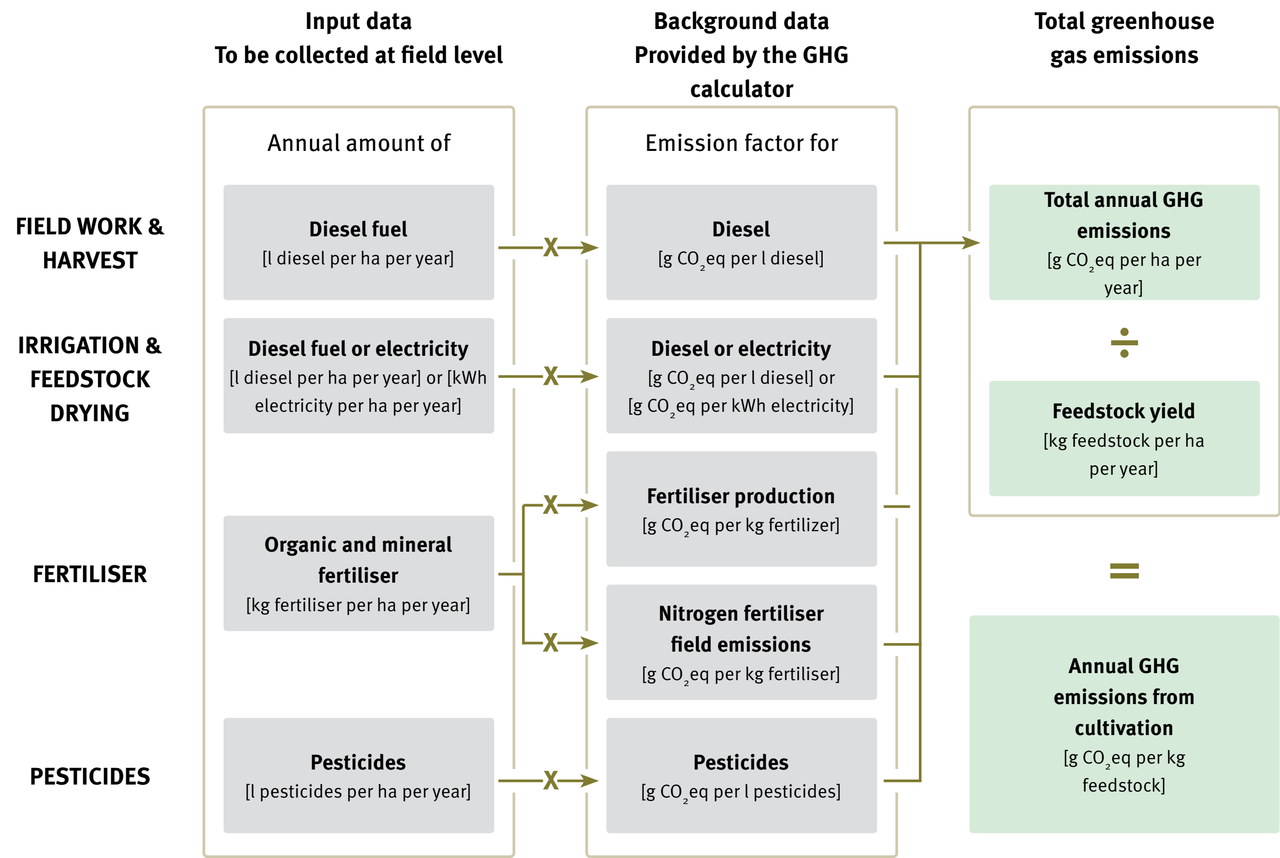
- **Cultivation**: yields, amount of mineral and organic fertiliser (nitrogen, phosphorous, potash, calcium), amount of pesticides, amount of electricity and / or fuel consumed for field management (field preparation, harvesting, fertiliser application), amount of energy consumed for irrigation and drying / storage.

- **Processing** (may include different steps): yields, types and amounts of co-products (e.g. bagasse, rapeseed meal), amount of chemicals used, type and amount of energy carriers used, amount of surplus electricity fed into the grid.

- **Transports**: distances of each transportation step (e.g. from field to processing plant), mode of transport used.

- **Use phase**: in the final step, the emissions of the biofuel production are compared to those from a comparable amount of fossil fuel (called 'fossil fuel comparator'). By default, the tool uses the fossil fuel comparator published in the European Renewable Energy Directive (2009/28/EC) (EU 2009a). If the user intends to use a different factor, he may do so in the user-defined column.

Figure 4.4 Data requirements in the cultivation step



As has been mentioned above, land use change for the establishment of a cultivation area may cause significant GHG emissions. Therefore, this topic must be treated with caution. Box 4.1 describes further details.

Box 4.1 How to handle calculation of direct and indirect LUC

Direct land use change (dLUC): The cultivation of biofuel feedstocks may lead to land use changes, e.g. to the conversion of forests or grasslands into agricultural areas. This conversion causes emissions of the carbon that was previously stored in the soil and vegetation. Depending on the vegetation type, these emissions may be very high, and may result in emissions that siginifcantly exceed the GHG savings from the replacement of fossil fuel. Therefore, the conversion of the following carbon rich vegetation should be avoided in principal: forests, peatland and wetlands.
The emissions from the conversion of other vegetation types have to be considered in the calculation. A specific sheet to calculate those emissions is included in the *GEF Biofuel GHG calculator* (IFEU 2012).

Indirect land use change (iLUC): The cultivation of biofuel feedstocks can lead to the replacement of feed or fodder crops that have been previously cultivated in that area. The cultivation of the replaced crops is shifted to other areas where they may cause undesired land use changes. The resulting emissions can be equally significant as those from direct changes. However, the indirect effects are complex and difficult to quantify. To date, there is no definitive scientifically accepted approach on how to factor iLUC in LCAs. Therefore, emissions from iLUC do not have to be considered for assessing concrete biofuel projects. However, to raise awareness among project developers, and to visualise potential impacts, iLUC factors for different crops are included in the GEF calculator. They have been published in October 2012 by the European Commission in a proposal for the amendment of the Renewable Energy Directive (2009/28/EC) (EU 2009a) and the Fuel Quality Directive (2009/30/EC) (EU 2009b).

Moreover, interested project developers may refer to the Low Indirect Impact Biofuels (LIIB) approach that helps identifying biofuels with low risks of causing indirect impacts (LIIB 2012).

Data sources

Table 4.1 lists data requirements and sources that are useful for using the GEF Biofuel GHG Calculator (IFEU 2012).

Table 4.1 Data sources for performing GHG calculations with the GEF Biofuel GHG Calculator (IFEU 2012)

Data requirement	Data source
Input data (e.g. yields, amount of fertiliser, amount of energy used)	• Collection at field level from all actors involved using questionnaires (sound documentation and verification necessary) • Long term local / regional statistical data • Scientific literature (see also the sheet 'References' in the *GEF Biofuel GHG Calculator*)

Table 4.2 lists data sources for ambitious users who want to perform GHG calculations that go far beyond applying the GEF calculator.

Table 4.2 Information on further data sources

Data requirement	Data source
Emission factors and life cycle inventory data	• ECOINVENT • European reference Life Cycle Database (ELCD) • IPCC NGGIP Emissions Factor Database • US DOE NREL Life Cycle Inventory Database

4.2 Biodiversity

Cultivation

Biofuel feedstock cultivation requires arable land which is available only to a limited extent. As arable land is also needed for food, feed and fibre production, competition for land may be the consequence. The growing demand for biofuel feedstocks adds to the pressure on land, resulting in two developments:

- the **expansion** of arable land to increase the amount of land available
- the **intensification** of existing agriculture to increase the amount of biomass produced

The conversion of land for the expansion of arable land is one of the main drivers of biodiversity loss, and potentially the factor with the highest influence. Impacts are very harmful when forest, peatland, wetland or grassland is converted and replaced by monocultures. Risks are especially high in emerging and developing countries that are known to harbour high amounts of the Earth's biodiversity.

The ultimate impact on the biodiversity of an area depends on the location of that area as well as on agricultural and forestry practices, and the previous land use. The influence on biodiversity from land conversion under different conditions is shown in Table 4.3. It can be clearly seen that all cropping systems, regardless of their location, show strong negative impacts on biodiversity when the cultivation takes place on land with previously undisturbed natural vegetation. On the other hand, when perennial crops are grown on existing crop- or grassland or on marginal / abandoned land, the influence can be comparatively positive.

Table 4.3 Influence on local biodiversity from land conversion

Land use	Climate	Annual crops	Perennial crops		
		e.g. rape seed, cassava	Oil palm	Grass (e.g. miscanthus, sugar cane)	Woody biomass (e.g. eucalyptus)
Undisturbed natural vegetation	Temperate/ tropical	Very negative	Very negative	Very negative	Very negative
Secondary forest	Temperate/ tropical	Negative	Negative	Negative	Negative
Existing cropland/ grassland	Temperate	Neutral to positive	n.a.	Neutral to positive	Neutral to positive
	Tropical	Negative to neutral	Negative to neutral	Negative to neutral	Negative to neutral
Marginal/ abandoned land*	Temperate/ tropical	Negative	Neutral to positive	Neutral to positive	Neutral to positive

Source: adapted from WAB 2007

** Marginal land indicates land with e.g. poor soil quality, low water availability and/ or unfavourable climate conditions (for more detailed information see Chapter 4.3)*

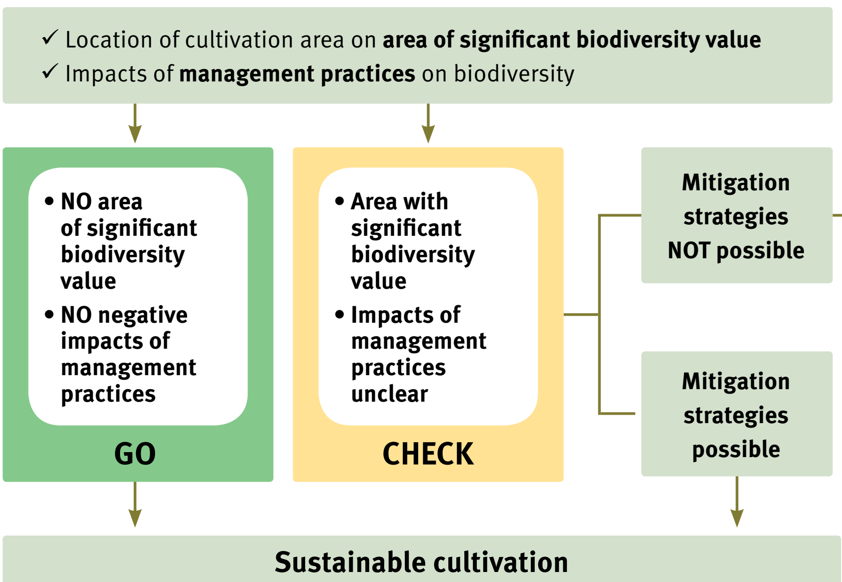
After conversion, the agricultural management system also strongly impacts biodiversity at the site. On the one hand, there are still yield gaps in many areas, i.e. yields are lower than they could be. These areas could benefit from intensification which, however, should be done in a sustainable way. On the other hand, areas with already intensive agriculture could face negative impacts from a further intensification.

Given this background the indicator focuses on the following two key issues:

- conservation of areas of significant biodiversity value, and
- promotion of agricultural and forestry practices with low negative impacts on biodiversity

Figure 4.5 shows the corresponding decision tree. In a first step, it should be assessed whether areas of significant biodiversity value are going to be cultivated, and whether management practices will have negative impacts on biodiversity. If this is not the case, cultivation can start. If risks have been identified regarding one or both issues, the project plan should be adapted and risk mitigation strategies should be applied. If this is not possible for whatever reason, the project should be stopped.

Figure 4.5 Decision tree for the indicator 'Biodiversity'



How to assess and mitigate biodiversity risks

Risk assessment and risk mitigation

The following paragraphs illustrate how biodiversity risks related to the area and the management system can be assessed. A selection of mitigation strategies is summarised in Table 4.4.

(1) Identification of areas of significant biodiversity value

The starting point for identifying areas of significant biodiversity value should be protected areas. They have a legal status and their location is well known in most cases. However, the existing protected areas throughout the world fail to cover all important biodiversity types, and do not fulfil the needs of species and habitats. Thus, established protected areas do not guarantee the sufficient protection of biodiversity and should be seen only as a minimum threshold.

The challenge is to identify those areas that are of importance for biodiversity, but are currently not protected. Many concepts and tools exist to assist in this task. A selection of the most important ones is illustrated in Table 4.5. All protected and biodiversity-relevant areas should be excluded from conversion and additionally, buffer zones should be established around them. The widths of buffer zones depend on the ecosystem, however, values given in studies vary between 20 and 60 m (Fritsche et al. 2010).

Even when complete areas are excluded from cultivation, the remaining land may include natural or semi-natural habitats that may be home to rare, endemic or endangered species. If such habitats or species are identified, their protection should be ensured as well. This can be done with belts or islands of natural vegetation being maintained, or through resettlement / replanting of these species in suitable areas.

(2) Management practices

Risks from agricultural management arise from the intensive use of agro-chemicals such as pesticides and fertilisers. They are not only a threat to biodiversity in a particular area but have a more extensive impact due to leaching into water bodies and spreading into the air. There are strong correlations with the soil and water indicators which are described in Chapters 4.4 and 4.5.

Further risks arise from the type of crop composition. The tendency to monocultures and tight crop rotation systems lower the diversity and make the cropping system more vulnerable to diseases. Also the introduction of non-native species that are possibly invasive as well as genetically modified species can pose risks.

A management system not harmful to biodiversity should be adapted to the local environmental conditions and follows the principles of Integrated Pest Management (IPM), conservation agriculture or organic farming.

More details on concrete measures are given in Table 4.4.

Table 4.4 Risk mitigation options for biodiversity

Protection of areas	• Exclude areas that are protected and of significant value for biodiversity from conversion • Establish buffer zones around those areas • Integrate the protection of rare/ endangered species into the management
Establish sustainable management	• Identify suitable areas for a certain crop based on Agro-Ecological Zones • Adapt the crop choice and the crop rotation system to local environmental conditions • Apply pesticides and fertilisers according to needs • Apply management methods that are not harmful for soil and water (see Chapters 4.4 and 4.5) • Prefer the use of native species and local varieties • Avoid the use of invasive species (carry out a Pest Risk Assessment) • Avoid the use of genetically modified organisms • Include landscape elements (e.g. corridors, buffer zones, etc.)

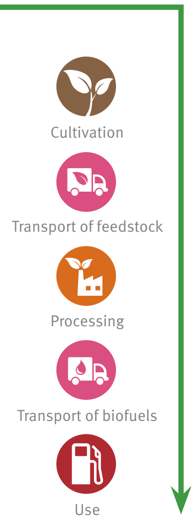
Data sources

Table 4.5 lists data sources that are useful in identifying areas of significant biodiversity value.

Table 4.5 Data sources for biodiversity

Assessment of areas of significant biodiversity value	Remarks
Integrated Biodiversity Assessment Tool (IBAT)	Includes datasets of the World Database of Protected Areas (WDPA), Key Biodiversity Areas (KBA), Alliance for Zero Extinction (AZE), IUCN Red List of Threatened Species and broad scale conservation priorities (biodiversity hot spots, important bird areas etc.)
World Database on Protected Areas (WDPA)	Global dataset on marine and terrestrial protected areas; includes the official set of protected areas submitted by national protected areas authorities and the secretariats of international conventions.
A-Z areas of biodiversity importance	Glossary of systems to assign and protect areas for biodiversity conservation; contains detailed information for a number of recognised systems to prioritise and protect areas of biodiversity importance For each type of area, the guide provides a brief description along with helpful facts on geographical coverage and scale, the criteria and objectives behind their identification, management related information, and links to other sources of information and tools of relevance for each area.
Global Invasive Species Database (GISP)	Focuses on invasive alien species that threaten native biodiversity and natural ecosystems and covers all taxonomic groups from micro-organisms to animals and plants in all ecosystems. For a quick check the worst invasive alien species are listed in the GISP.
Integrated Pest Management (IPM)	Ecosystem approach to crop production and protection that combines different management strategies and practices to grow healthy crops and minimize the use of pesticides. Provides several useful links about how to conduct a IPM and includes useful explanations.

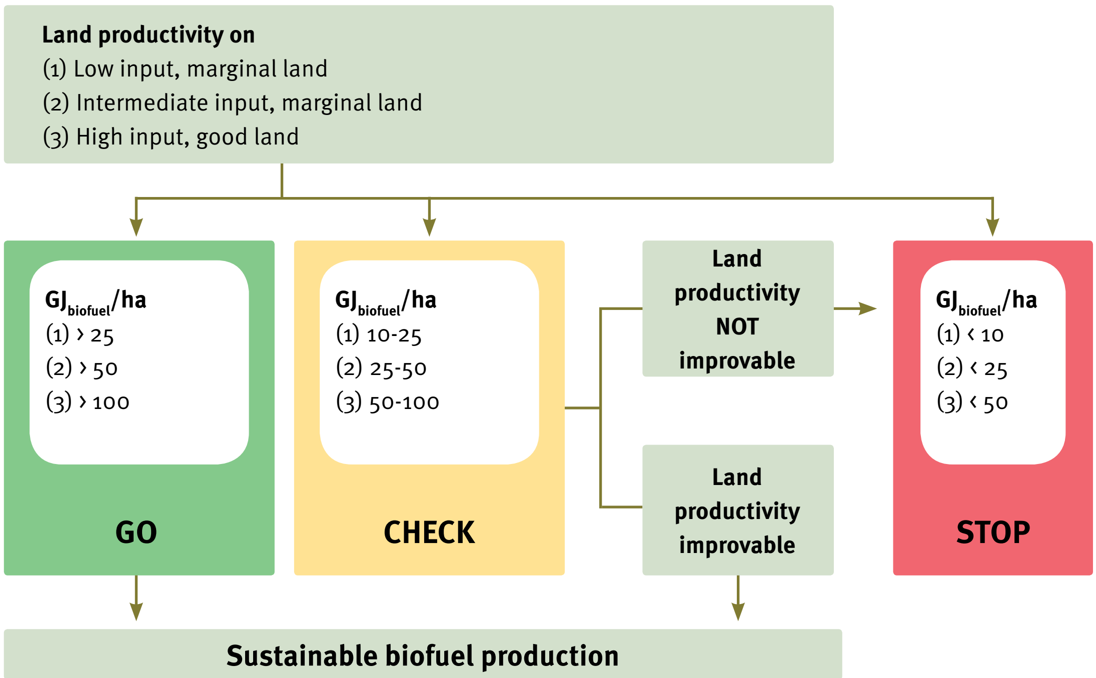
4.3 Land productivity and resource use efficiency



The global availability of land is limited, while at the same time, competition for land is growing. Due to population growth, there is an increasing need for food, feed and fibre production. Additionally, land is needed for nature protection and recreational purposes. The increasing demand for biofuels adds to this development, as most biofuel production relies on energy crops as feedstock. Therefore, land productivity should be maximised wherever possible, i.e. biofuel projects should strive for highest possible outputs of biofuel from one hectare of land without diminishing the soil and water health.

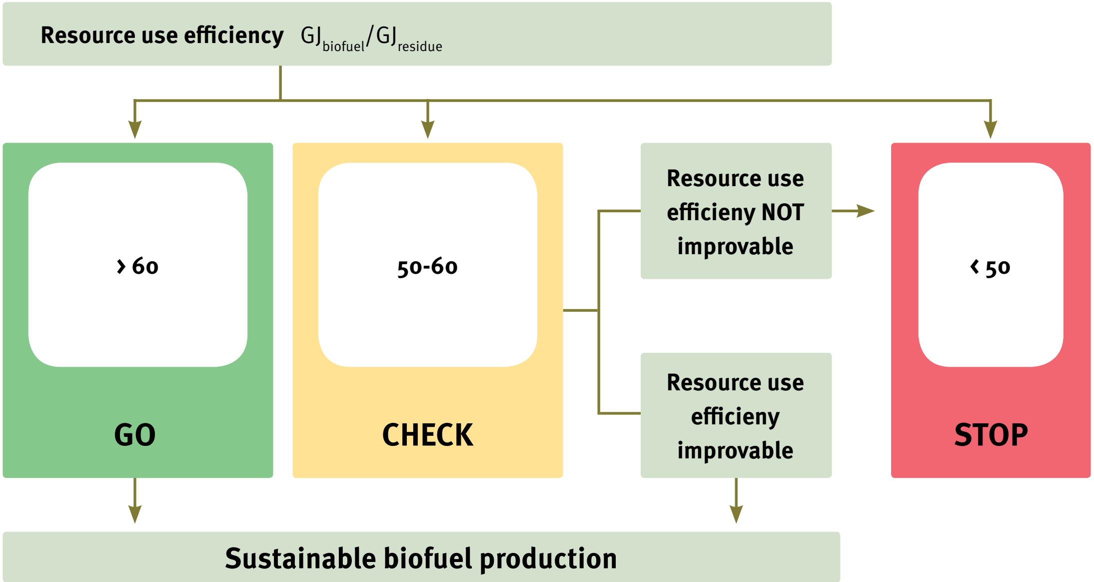
Figure 4.6 illustrates the respective decision tree on land productivity with thresholds on the amount of biofuel produced. In order to take into account different environmental conditions, different thresholds are valid for certain land categories. If the productivity within a certain category is too low, the project plan should be revised in order to increase the output. This may be done by increasing yields and / or conversion efficiencies. If an increase of productivity is not possible, it is advisable to stop the project.

Figure 4.6 Decision tree for the indicator 'Land productivity'



The need for high use efficiencies applies not only to energy crops but also to the use of residues and waste. Although residues and waste do not need land for production and thus do not add to the competition for land, they themselves are a valuable resource for a variety of uses. Here, the increasing demand may also lead to competition. For example, in many countries straw is used as animal feed and wood is needed for many products in the wood industries. The use for energy production may lead to competition. It probably will increase in future when the production of second generation biofuels will come to the market. They allow the use of lignocellulosic residues (e.g. straw, forestry residues) as feedstocks, and thus will fuel demand for these feedstocks. Therefore, the material itself should be used as efficiently as possible, i.e. the highest possible amount of biofuel should be produced from a certain amount of waste or residue. Figure 4.7 shows the respective thresholds.

Figure 4.7 Decision tree for the indicator 'Resource use efficiency'

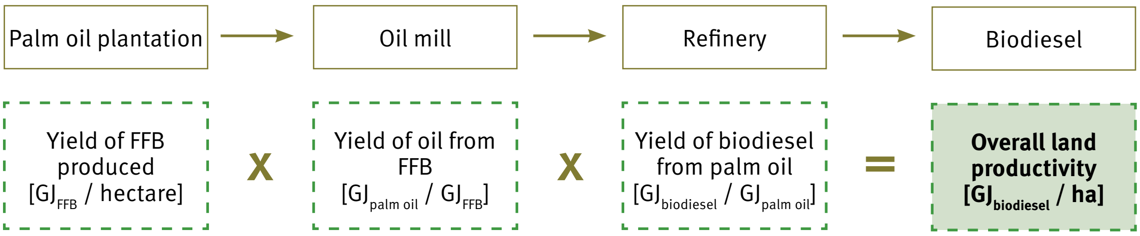


How to calculate land and resource use efficiencies

For **energy crops**, land is used as a reference and the indicator refers to the highest possible output of biofuel per hectare of land (as $GJ_{biofuel}$ / ha). For the calculation, the whole biofuel production chain has to be taken into account, including all conversion steps. Even if a project covers only biofuel cultivation, the efficiencies of subsequent conversion steps are relevant.

An example for the calculation is illustrated in Figure 4.8. One hectare palm oil plantation produces a certain amount of fresh fruit bunches (FFB). The FFBs are used to produce palm oil which is then converted into biodiesel. In the end, the amount of biodiesel from each individual hectare can be calculated.

Figure 4.8 Example for calculating land productivity



Land has different qualities depending on soil types, climate factors and management methods. As a result, different yields can be achieved. This is reflected by distinguishing three categories of land where different land productivity thresholds apply:

1. High input, good land
2. Intermediate input, marginal land
3. Low input, marginal land

The land categories are derived from the settings approach that has been applied in the GEF project. The level of input (low, intermediate, high) refers to management activities that are included or excluded in calculation. They are illustrated in Table 4.6.

Table 4.6 Activities included in the different input systems

	Field clearing	Filed preparation	Planting	Weed control	Pruning	Fertilisation	Pest and disease control	Irrigation	Harvesting	Post-harvest activities
Low inputs	•	•	•	•					•	•
Intermediate inputs	•	•	•	•	•	•	•		•	•
High inputs	•	•	•	• •	•	• •	• •	•	•	•

For marginal land, no clear definition exists, and in the literature different terms are used synonymously (e.g. degraded land, abandoned land, low productivity land, wasteland), although each term has a slightly different meaning (Wicke 2011). For the purpose of this indicator, marginal land is used to describe land where only low productivity can be achieved due to poor soils, low water availability and / or unfavourable climate conditions.

Differences in the categories are reflected by different yields, different amount of fertilisers / pesticides used and different amount of diesel needed for field work. These data are listed for all settings in the *GEF Biofuel GHG Calculator* (IFEU 2012) and can be taken as a reference.

Naturally, the categories may be applied independently from the settings approach. There are no clear definitions, but the application should reflect good, intermediate and bad cultivation conditions. Average and maximum regional and local yields can be taken as reference in order to assess the yields that can be expected.

As **residues and wastes** are produced independently from arable land, the biomass itself is the starting point for the calculation. It follows the same principle as shown in Figure 4.8, yet with residues / wastes being the first input. The overall live cycle efficiency is expressed as the amount of biofuel that is produced from a given residue / waste input (as $GJ_{biofuel}$ / $GJ_{residue}$).

Data requirements and sources

For indication purposes, the yields and conversion data listed in the *GEF Biofuel GHG Calculator* may be taken (IFEU 2012). First, the setting has to be selected that best reflects the project circumstances. The pathway calculation sheets list all information regarding yields and conversion efficiencies. They simply have to be converted into the right units to give results regarding land productivity and resource use efficiency.

Table 4.7 illustrates the data that are needed for calculating land productivity and resource use efficiencies and provides sources where these data can be found.

Table 4.7 Data requirements and sources for land productivity and resource use efficiency

Data type	Data source
Cultivation yields	• Collection at field level using questionnaires (sound documentation and verification necessary) • Long term local / regional statistical data • Scientific literature (see also the sheet 'References' in the *GEF Biofuel GHG Calculator*)
Conversion efficiencies (e.g. oil mills, refineries, ethanol plants)	• Collection at plant operator level using questionnaires (sound documentation and verification necessary) • Regional / national average data • Scientific literature (see also the sheet 'References' in the *GEF Biofuel GHG Calculator*)

Cultivation

4.4 Soil protection

Soil is the basis for feed, food and fibre production. In addition, it is important for water filtering and as a habitat for animals. Soil further stores carbon and nutrients. Therefore, its health is an essential part of sustainable agriculture. At the same time, soil cannot be expanded or multiplied, and new soil is formed at very slow rates. Due to extremely slow generation, soil is treated as a limited and non-renewable resource. The following factors contribute to soil degradation:

- loss of soil organic matter, leading to decreased soil fertility and yields
- soil erosion, leading to soil loss (especially of fertile topsoil)
- accumulation of mineral salts (salinization) in soils, from irrigation water and/or inadequate drainage, with possible adverse effects on plant growth
- soil compaction, i.e. increasing densification of the soil after compression, reducing water flow and storage, and limiting root growth
- loss of crop nutrients

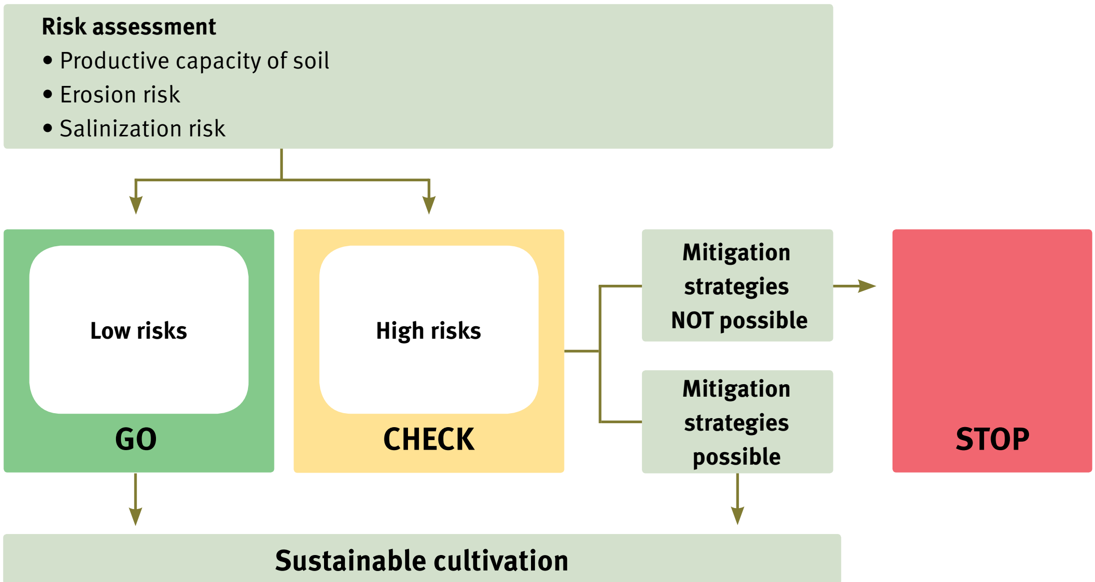
These factors are interlinked and are influenced by different environmental and management factors. For example, soil compaction can increase erosion which in turn leads to the loss of the fertile topsoil and causes that water drains off faster instead of being stored.

The soil protection indicator summarises the complexity by covering three main parameters:

1. productive capacity of soil defining the quality of soil
2. soil erosion determining the quantity of soil
3. salinization

Figure 4.9 shows the procedure of applying the soil protection indicator. It follows a two-step approach: an initial risk assessment is followed by the identification and application of mitigation strategies. If there are no or low risks with regard to the three parameters, the cultivation is labelled green. If risk factors occur at any of the parameters, it should be examined if mitigation strategies are feasible. These remedial strategies should be listed in the project proposal. If mitigation efforts are unfeasible, or if the project applicant is not willing to implement them, the project should be labelled red and stopped.

Figure 4.9 Decision tree for the indicator 'Soil protection'



How to assess and mitigate soil risks

Risk assessment

The following paragraphs list which elements are important in a risk assessment regarding the three parameters introduced above. Additional risk factors are illustrated in Table 4.8.

- **Productive capacity of soil** depends to a large extent on the amount of organic carbon in the soil, which in turn serves several functions. Therefore, soil organic carbon (SOC) is taken as a proxy. The amount of SOC available is influenced both by environmental conditions (e.g. soil type, climate) and soil management. There are certain soil types, such as sandy soils, that have a lower carbon content naturally. In principle, the cultivation of annual crops poses a higher risk, as more field work is needed and the soil is left uncovered for longer periods of time than in the cultivation of perennial crops. Both lead to high nutrient and SOC losses. The removal of residues lowers the organic carbon content further.

- **Soil erosion** can be caused by wind or by water, and is influenced by soil type, landscape and management systems. Both types lead to the loss of topsoil. Steep slopes are generally more prone to soil erosion, as is soil that is subject to the production of annual crops and the use of heavy machinery.

- **Salinization** leads to an excessive increase of water-soluble salts in the soil. It can be caused by inefficient irrigation systems or inappropriate drainage management.

In the risk assessment it is advisable to first focus on local or national assessments or thresholds (e.g. as defined in legal regulations).

Table 4.8 Risk factors for soil protection

Decline in productive capacity of soils	• Certain soil types (e.g. soils with high organic content, soils with permanent / temporary wetness, shallow / weakly developed soils, sandy soils, man-made soils) • Management practices (e.g. annual crops, intensive tillage, removal of large amounts of residues) • Cultivation area that has been converted from grassland, wetland or forest • Draining of wet soils
Soil erosion	• Exposed and large open fields • Steep slopes • Certain soil types (e.g. soils with low organic carbon content) • Management practices (e.g. annual crops, intensive tillage, use of heavy machinery, reduced soil cover) • Areas with strong rainfalls and winds • Cultivation area that has been converted from grassland, wetland or forest
Salinization	• High soil salinity • Irrigation with salt-rich water • Negative water balance at least at some periods of the year (see also Chapter 4.5) • Insufficient drainage to wash away excess salt

Risk mitigation

An extensive risk assessment is data-intensive and time-consuming. Therefore, it may not be feasible during the project preparation period. In order to minimise risks, the focus should be put on soil conservation management methods. They can, and should be, applied in all biofuel projects as they usually have a multitude of positive effects. Appropriate management options are listed in Table 4.9.

The final choice of the mitigation strategy has to be adapted to climatic and soil conditions, as well as to the project scope and size. In principal, traditional farming methods should be taken into account, although they may have to be modified to reflect modern farming requirements.

Table 4.9 Risk mitigation options

Increasing the productive capacity of soil	• Recycle organic matter (residues left in the field, mulching, use of organic fertiliser) • Adapt extraction rates of residues (more residues should be left on poor soils) • Apply conservation tillage (reduced till, no-till) • Plant perennial or permanent crops to reduce management • Adapt crop rotation
Minimising soil erosion	• Enhance soil cover (vegetative or residue soil cover; crop choice, mulching) • Plant perennial crops to reduce management • Plant row cultures / wind break; terracing • Do not use exceedingly heavy machinery • Adapt sowing and field work to weather conditions
Avoiding salinization	• Do not apply irrigation on soils with high salinity • Use water with low salt content for irrigation • Use effective drainage systems

Data sources

Due to the strong correlation with local conditions and locally applied soil management methods, few data sources exist. For the identification of risk sites, high-resolution spatial data are needed, and these are presently not available at a global scale. If a project is to be planned, the existence of such data sources should be investigated at a local level. Table 4.10 lists some sources that may be of help at the project level.

Table 4.10 Data sources to be applied at project level

Soil risk assessment	Remarks
Common criteria for risk area identification according to soil threats (Eckelmann et al. 2006)	Overview of risk factors for single threat categories; lists factors that have to be evaluated; focus on Europe
Land Degradation Assessment in Dryland (LADA)	Provides manuals for national and local assessment of land degradation in combination with toolboxes.
Soil Impact Assessment Guideline (RSB 2011)	In-depth guideline to assist in the identification, assessment and mitigation of impacts on soil resulting from soil erosion and the application of fertilizers.
Visual Soil Assessment for Annual Crops (FAO 2008)	Quick and simple method to assess soil condition and plant performance. It can also be used to assess the suitability and limitations of a soil for annual crops
A Handbook for the Field Assessment of Land Degradation (Stocking & Murnaghan 2001)	Rapid and non-technical methods for measuring and assessing land degradation in the field
Sustainable Land Management Practice in Sub-Saharan Africa (Liniger et al. 2011)	Guideline for sustainable land management

For strategic assessments, like at national scale, lower resolution data are sufficient. They are listed in Table 4.11.

Table 4.11 Data sources for further reading

Data source	Remarks
Harmonized World Soil Database (HWSD)	Database with over 16 000 soil mapping units that combines regional and national soil information (SOTER, ESD, Soil Map of China, WISE) with the information contained within the FAO-UNESCO Soil Map of the World Allows to query the location of soil units regarding selected soil parameters
United Nations Convention to Combat Desertification (UNCCD)	Established in 1994, it addresses specifically the arid, semi-arid and dry sub-humid areas.
ISRIC World Soil Information	Independent, science-based foundation; provides access to a data download facility for datasets and maps on local, national and global scale and at various resolutions

4.5 Water protection

Cultivation

Processing

Only about 1% of the global water resources are accessible as freshwater. Due to population growth, industrial development, pollution and climate change, freshwater is scarce in some regions of the world. This causes impacts on human health and may lead to malnutrition. Therefore, the sustainable management of water resources is a key global environmental challenge and urgently needed. As water cannot be globally distributed without enormous effort, water scarcity and pollution should be assessed at regional and local scales.

In addition to water scarcity, water pollution due to pesticides or fertiliser application, for instance, may lead to a decrease of water quality. Low water quality in turn may result in water scarcity within the project area. With regard to ecosystem quality, water scarcity may also affect biodiversity. Water demands for irrigation and industry compete with water for the environment. This may have negative impacts on the aquatic biodiversity but also, for example, on the health of riparian residents.

Therefore, two key factors need to be considered to ensure a sustainable treatment of the world's water resources during the cultivation and production of biofuels:

1. regional and local water scarcity
2. water contamination during cultivation and processing

How to assess and mitigate water risks

The indicator follows a two-step approach: a risk assessment is followed by the identification and application of mitigation strategies. The following paragraphs describe the risk assessment separately for both aspects of the water protection indicator, followed by a proposal of mitigation measures.

Risk assessment

(1) *Regional and local water scarcity*

Figure 4.10 illustrates the procedure of applying the water protection indicator in order to examine regional and local water scarcity. When assessing the regional and local water availability within the project area, a water scarcity assessment should be conducted. If the proposed project intends to implement a rainfed farming system for the production of biofuels within this area, the cultivation may be labelled green. If the proposed project includes irrigation of the crops, the availability of water resources within the project area has to be assessed to decide whether the irrigation would increase the regional and local water scarcity. However, rainfed-cultivation should be preferred over any irrigation in principal. Thus, withdrawal of local water resources is avoided, and existing resources are available for other purposes, e.g. to be used as drinking water.

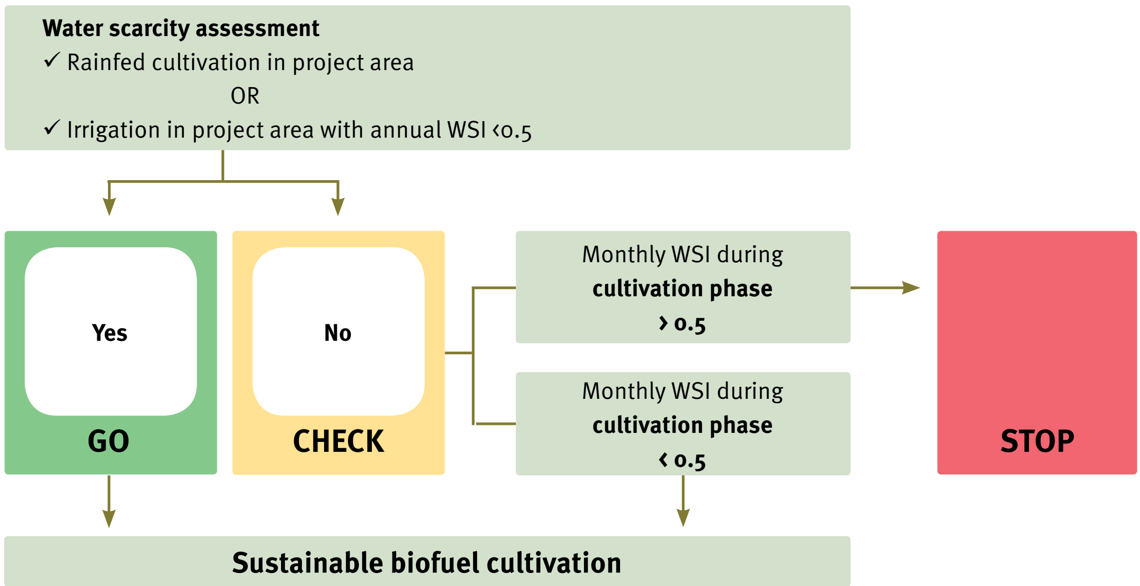
One assessment approach to determine the water scarcity within the project area is the application of the so-called "Water Stress Index" – the WSI. The WSI was originally developed for the assessment of water consumption in a life cycle assessment, and is currently widely applied in this context. However, it may also serve as a screening indicator, ranging between 0 and 1. It considers the local water availability as well as the annual water withdrawal on watershed level. It further includes additional parameters such as precipitation distribution. A watershed is the entire geographical area drained by a water course and its tributaries.

The higher the WSI, the higher the water scarcity in the respective region and therefore, more action is needed to reduce water deprivation. Generally, water resources experts define the threshold between moderate and severe water stress at a WSI of 0.5. Therefore, this value is proposed to serve as threshold for labelling a project region as being water-scarce.

The determination of the annual WSI on watershed level is possible via the freely accessible Google Earth layer under the Enhanced EcoIndicator-99 method for water and land use (EI99+) (ETH 2013). Within this layer, the annual WSIs of all watersheds in the world are represented. By clicking into your project area, you receive the regional water scarcity index of your cultivation area.

If the annual water scarcity index is determined to be lower than 0.5, a sustainable biofuel cultivation is ensured, and may therefore be labelled green. If the annual WSI is higher than 0.5, the project applicant should check the seasonal variability of the water scarcity, as in some regions such as large parts of Europe the WSI is highly variable for different months. The crop growing period may have a considerable influence on the local water availability and therefore, shifting crop planting dates may help to avoid additional water stress within the project area. The monthly WSI for each watershed is available via a free accessible Google Earth layer as well at ETH 2013a. If the monthly WSIs during the intended cultivation phase are expected to be lower than 0.5, the cultivation may be labelled green. If the WSI is expected to be higher than 0.5 the project applicant should apply risk mitigation measures. If this is not possible, the project should be labelled red and stopped.

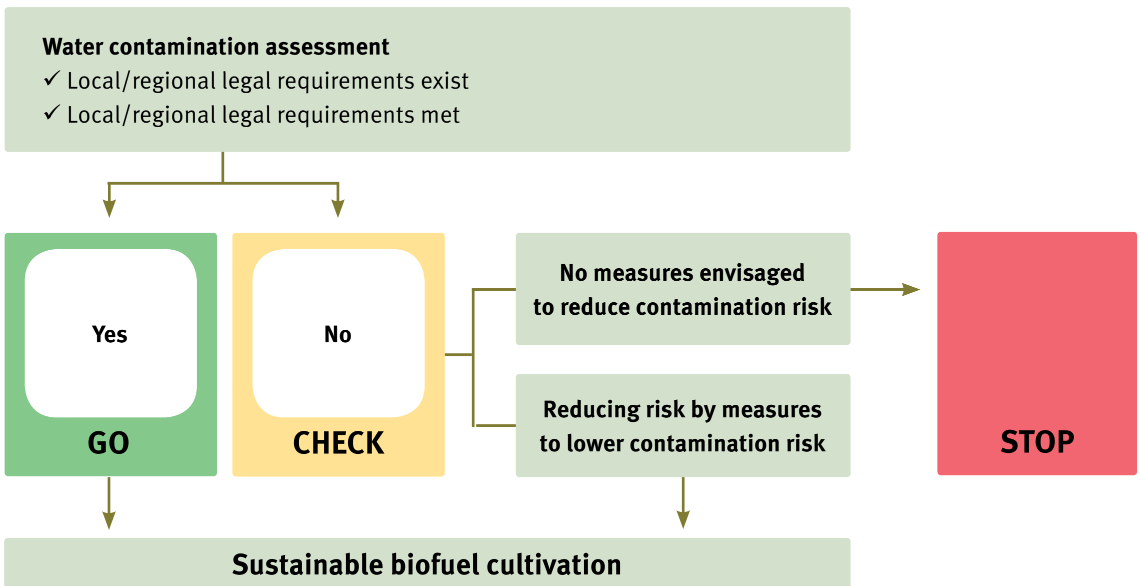
Figure 4.10 Decision tree for the indicator 'Water protection' – water scarcity



(2) *Water contamination during cultivation and processing*

Figure 4.11 illustrates the procedure of applying the water protection indicator in order to examine water contamination during cultivation and processing of biofuels. To evaluate the influence of the production of biofuels on the local water resources, the applicant should check if local and regional requirements regarding

Figure 4.11 Decision tree for the indicator 'Water protection' – water contamination



water pollution exist (see further chapter 3.5) and related threshold values are met. If both conditions are fulfilled, the project may be labelled as green. If legal thresholds are exceeded, the project applicant should investigate available measures to reduce the risk of water contamination. For example, efficient waste water treatment plants within the project area may significantly lessen water contamination. If no legal requirements and legal thresholds exist, all available measures that aimed at reducing the risk of water contamination should be considered as well. If the project applicant is unable or unwilling to supply sufficient waste water treatment plants, the project should be labelled red and stopped.

Risk mitigation

A risk assessment of the impact on water resources to avoid extensive water depletion and water pollution may not feasible during the project preparation period. It requires considerable efforts to determine the detailed impact pathways on the resource. However, to mitigate risk, project developers should focus on the management options for the four key areas listed in Table 4.12.

Table 4.12 Risk mitigation measures

Promotion of rainfed cropping systems	• Select production systems that increase cover crops, low tillage and soil formation • Prefer the use of hedges and intercropping • Protect riparian areas
Good management of irrigation	• Reduce irrigation losses by a high efficiency of irrigation • Regulate withdrawal by other non-agricultural users within project area • Installation of retention basins to utilise rainwater
Mitigation of water pollution from cultivation	• Avoid and/or reduce the use of pesticides • Minimise application of fertilisers • Minimise risk of leaching by erosion (see Chapter 4.4) • Use only an adequate amount of waste water for irrigation and ensure an adequate quality of the waste water
Mitigation of water pollution from production	• Recycle water within production processes (e.g. for cooling) • Install less polluting production and waste water treatment technologies

Data requirements and sources

Currently, several data sources reporting water scarcity on different levels exist. The approach to determine the Water Stress Index at watershed level (see above) is one of several approaches which may be applied to evaluate the regional and local impact on water resources. Table 4.13 lists the proposed approach and some additional sources that provide decision support at project level.

Table 4.13 Data sources to be applied at project level

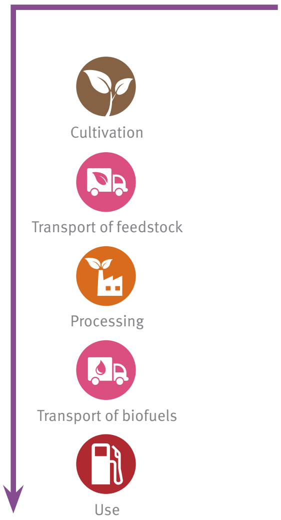
Water scarcity	Remarks
Annual **Water Stress Index (WSI)** according to Pfister et al. 2009	Provides annual water stress indices on watershed and country level for the evaluation of the water scarcity in a specific region
Monthly **Water Stress Index (WSI)** according to Pfister & Baumann 2012	Provides monthly water stress indices on watershed level for the evaluation of the water scarcity of a specific region by considering seasonal variability in regional and local water scarcity
Water management	**Remarks**
AQUASTAT	FAO's global water information system, developed by the Land and Water Division. The main mandate of the programme is to collect, analyse and disseminate information on water resources, water uses, and agricultural water management, with an emphasis on countries in Africa, Asia, Latin America and the Caribbean. This allows interested users to find comprehensive and regularly updated information at global, regional, and national levels.
AQUACROP 4.0 (published in June 2012)	It is a tool for evaluating crop production under different water-management conditions (including rainfed and supplementary, deficit and full irrigation) under present and future climate change conditions, and investigating different management strategies, under present and future climate change conditions. It can be applied at all locations; agricultural sector; site-specific, but can be extrapolated to larger scale by GIS applications.

In addition, sources of guidelines for a sustainable water stewardship are provided in Table 4.14, which may promote broader insights into water related issues and may be applied for strategic purposes.

Table 4.14 Data sources to be applied for strategic purposes

Data source	Remarks
UNESCO International Hydrological programme (IHP)	UNESCO's international scientific cooperative programme in water research, water resources management, education and capacity-building. Among its primary objectives are the development of techniques, methodologies and approaches to better define hydrological phenomena and to assess the sustainable development of vulnerable water resources. Programme may be used to research case studies related to water management experiences.
Alliance for Water Stewardship (AWS)	Represents the vision that water users and managers are responsible water stewards, who protect and enhance freshwater resources for people and nature. Currently in the process of developing a standard with the overall objective to minimise the negative impacts and maximise the positive impacts of social, environmental and economic water use. *Standard to be released in April 2014*

4.6 Cost-benefit analysis



Biofuel projects should be financially viable in order to guarantee their long-term continuation. This is the case if the revenues are higher than the costs. The comparison and summing up of costs and revenues, however, is difficult for two reasons. First, costs and revenues occur at different points in time. For example, when a new plantation is established, high costs may initially occur for the establishment of the plantation, for planting and for maintenance. In contrast, revenues are earned only when a crop is harvested and sold. This may be at the end of a year or even after a period of several years, e.g. for oil palms. Second, money is likely to have a different value in the future. This is due to inflation, and due to the fact that funds could earn interests if deposited at a bank instead of being invested in the project. In order to enable a comparison of future cash flows within a biofuel project, the Net Present Value (NPV) is calculated. The NPV is defined as the sum of the present values of all future costs and revenues, i.e. all projected expenses of the proposed biofuel project, as well as all expected revenues. To calculate the NPV, all future costs and revenues have to be transformed to their present values. These present values may then be summed up to result in an overall positive, negative or neutral result. The NPV is an important tool in the assessment of the financial viability of projects.

Figure 4.12 Decision tree for the indicator 'Cost benefit analysis'

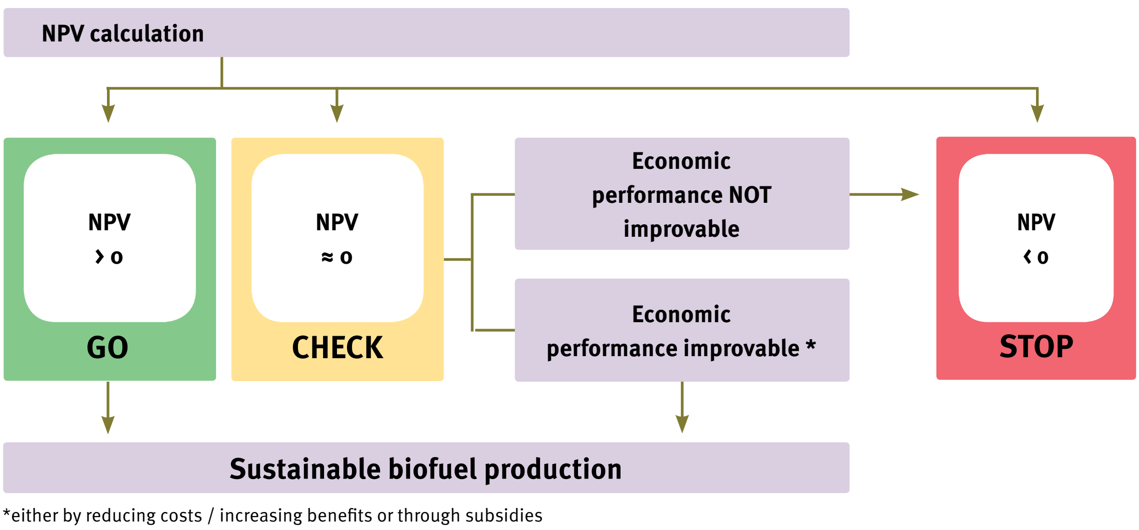


Figure 4.12 shows the decision tree for the cost-benefit analysis. If the result of the NPV calculation is close to zero, the project is at risk of becoming unprofitable if any unexpected development occurs. In this case, the project plan should be revised concerning options to improve the economic performance. These can be savings on the one hand (reducing inputs of fertilisers, energy, labour), or higher benefits due to higher prices that can be achieved at the market or by obtaining increased yields. The same should be done if the NPV is negative (see also chapter 3.4). If a project still leads to a negative NPV after revision, a subsidising scheme for the project could be taken into consideration to ensure its viability. This may be an appropriate solution if the project has so many positive effects, e.g. in terms of income generation or greenhouse gas savings, that it should be implemented regardless of its economic performance.

When looking at the results, not only the NPV of the actual proposed feedstock / project should be taken into consideration. Instead, the projected performance should be compared to similar feedstocks or projects realised in the region. Depending on the outcome of the comparison, it might be advisable to switch to a different feedstock or technology that is more profitable.

How to make a cost-benefit analysis: Calculating the NPV

Calculating the NPV uses the following formula:

$$NPV = \sum_{i=0}^{n} \frac{B_i - C_i}{(1 + r)^i}$$

NPV	*Net Present Value [national currency]*
B_i	*benefits in year i [national currency]*
C_i	*costs in year i [national currency]*
r	*discount rate [%]*
n	*lifetime of project [years]*

In a first step for every single year of a project life cycle the annual costs and benefits have to be identified. In a second step, they are converted into their present value. An example is given in Figure 4.13. It shows a fictitious project with a lifetime of 5 years and a discount rate of 8 %. For each year of the project lifetime the costs and revenues are discounted. The summing up of the discounted costs and benefits (NPV) results in a net benefit of around 11 000 US $. This means that the project is profitable. The detailed numbers are shown in Table 4.15.

Figure 4.13 Example for calculating the NPV of a project

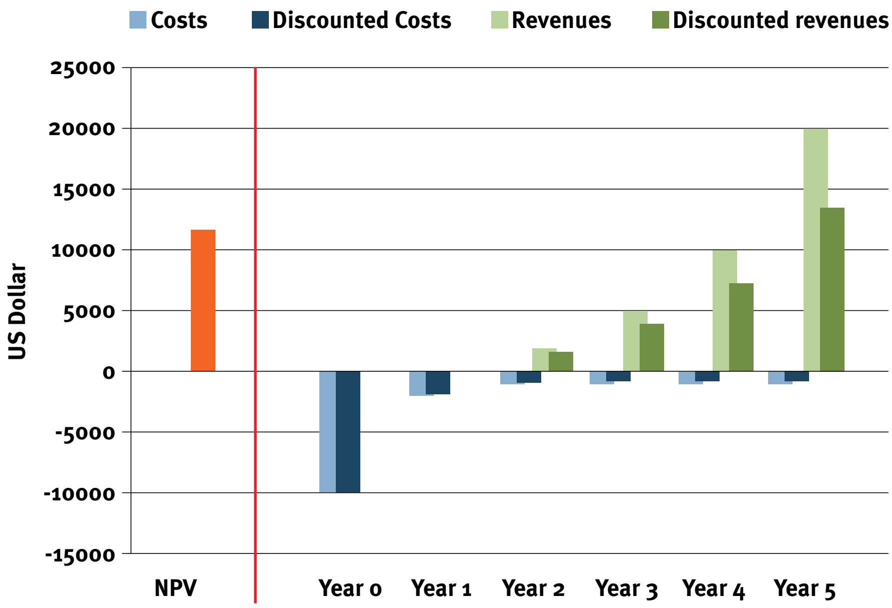


Table 4.15 Costs and benefits of an exemplary project

	Costs	Discounted costs	Revenues	Discounted revenues
Year 0	-10 000	-10 000	0	0
Year 1	-2 000	-1 852	0	0
Year 2	-1 000	-857	2 000	1 715
Year 3	-1 000	-794	5 000	3 969
Year 4	-1 000	-735	10 000	7 350
Year 5	-1 000	-681	20 000	13 612

Data requirements and sources

Costs and benefits to be taken into account

All costs and benefits occurring at the life cycle step of interest have to be taken into account. For example, if the finances of the cultivation of a biofuel feedstock are considered, only costs and benefits occurring at the cultivation stage are to be taken into account. If the planning of a biofuel conversion plant is to be supported, this will be in the focus of interest. In the case that a whole production chain is to be established, all individual costs and benefits from all stages have to be summed up. Table 4.16 lists all costs and benefits that may occur at the different steps.

Table 4.16 Costs and benefits to be taken into account

	Costs	Benefits
Cultivation	seeds, land rental / tax, labour costs, fertiliser and pesticides, machinery, transports	Revenues from feedstock sale Revenues from co-products sale
Processing	feedstock, transport, production costs (labour, energy, machinery, auxiliary materials)	biofuel price, revenues for any co-products sold (e.g. rapeseed meal)

Discount rate

Projects are usually financed with credits. Therefore, the discount rate should be the long term lending rate of a country. Further, the influence of inflation has to be taken into account. The following formula can be used to calculate the discount rate:

$$r = \frac{1+i}{1+p} - 1 * 100\%$$

r real discount rate (long term lending rate)
i nominal interest rate (long term lending rate)
p annual inflation rate

For example, if the long-term lending rate in a country is 16 % and the average inflation of the last years was 10 % this would result in a real discount rate of around 5.5 %.

Project lifetime

The lifetime taken into account for the cost benefit analysis should be adapted to the project duration. For example, if a bioenergy plant is to be established, the lifetime of this plant should be considered. If bioenergy cultivation is to be established, the time until the project ends is the minimum life time. If an annual crop is to be compared with a perennial crop, the later should be the reference.

Data sources

Table 4.17 lists data sources that can be taken into account in cost-benefit analyses.

Table 4.17 Data sources for cost-benefit calculation

	Data sources	Remarks
Amount of inputs (e.g. yields, amount of fertiliser and fuel used)	Producer; expert judgements based on local / regional statistics, literature	May have to adapted during project life cycle and verified with real data
Prices • Costs for above mentioned inputs, wages • Revenues for products sold	Local / regional markets, statistics	Long-term averages should be taken to level out seasonal and annual fluctuations which are common in agricultural production
Interest rates (e.g. lending rate, inflation rate)	National banks	Long-term average should be taken

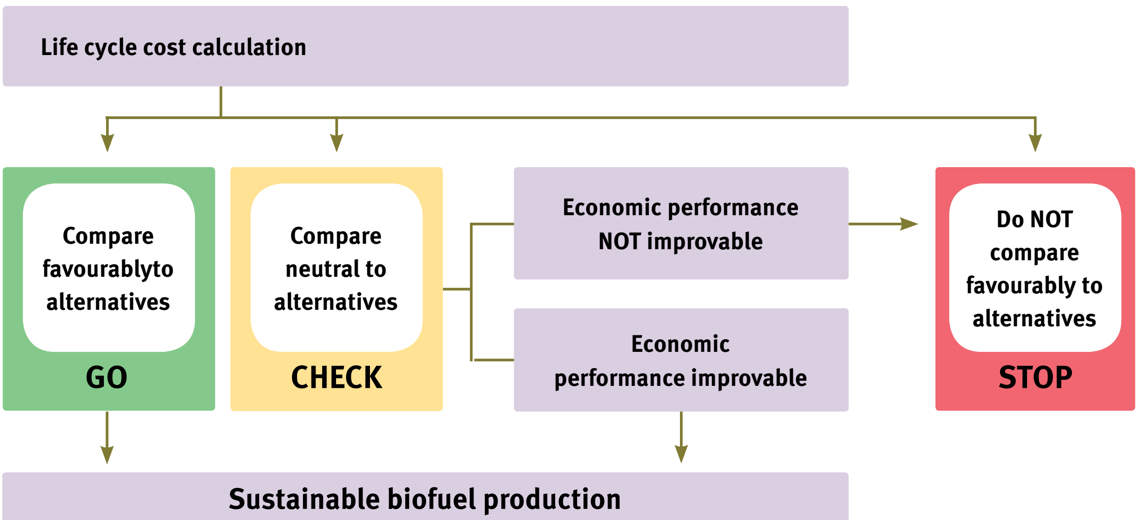
4.7 Life cycle costs

The calculation of life cycle costs covers a small part of the cost-benefit analysis that has been described in the previous chapter. Life cycle costs are defined as the costs that occur at a certain life cycle step, or along the whole life cycle. This allows the comparison with the costs of alternatives. For example, the costs of a biofuel feedstock may be compared with common market prices or with those of an alternative feedstock. Likewise, the costs of biofuel production could be compared with biofuel costs that are already established at the market or with costs for fossil fuels. This allows drawing conclusions on whether the product is likely to survive on the market. The product can only be sold successfully on the market and generate revenues if costs are competitive.

Figure 4.14 illustrates the decision tree to be applied for this indicator. If the product compares favourably to alternatives, the project is labelled green. If it compares neutrally or even negatively, the project should undergo a revision. If the costs cannot be reduced, the project should be stopped.

As for the cost-benefit analysis, subsidies should be considered as a solution for high-expense projects if there are sufficient added benefits potentially outweighing the costs.

Figure 4.14 Decision tree for the indicator 'Life cycle costs'



How to calculate life cycle costs

For the costs occurring along a biofuel life cycle, the same rules apply as for the cost-benefit analysis: in order to be comparable, the Net Present Value (NPV) has to be calculated. This is the only available method to ensure that the costs may be summed up to total costs. The methodology of discounting is described in detail in Chapter 4.6. Exactly the same methodology is to be applied here, however, revenues are ignored for this calculation. Only the costs are taken into account (see Table 4.18). The relevant data sources may be found Chapter 4.6.

Table 4.18 Costs to be taken into account for the life cycle cost analysis

	Costs
Cultivation	seeds, land rental / tax, labour costs, fertiliser and pesticides, machinery, transports
Processing	feedstock, transport, production costs (labour, energy, machinery, auxiliary material)

Table 4.19 presents some examples for possible alternative systems that may be compared with the product of a proposed project. Note that for the comparison of feedstock or biofuel alternatives an appropriate measurement unit has to be chosen. For example, for oil crops, the comparison can be the output of oil (in litres or kg). For sugar or starch crops that can be used for ethanol production, the amount of feedstock (in kg) can be taken into account. This represents the amount of feedstock needed for one litre of ethanol production. But the comparison of different biofuels should be done on an energy basis (e.g. one megajoule).

Table 4.19 Possible alternatives to each product along the life cycle

	Product	Alternatives
Cultivation	Biofuel feedstock (e.g. palm oil, sugar cane, rapeseeds, jatropha capsules)	• Different feedstock that could replace the feedstock under consideration (e.g. cassava instead of sugar cane, jatropha oil instead of Castor oil)
Processing	Biofuel (e.g. vegetable oil, biodiesel, bioethanol)	• Biofuel from above mentioned alternative feedstock • Fossil fuel that is supposed to be replaced by the biofuel • Traditional energy source (e.g. fire wood) that is to be replaced by the biofuel

4.8 Food security

Cultivation

Food security as a key element of social sustainability is defined by FAO as follows: *"Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life"* (WFS 1996). Still, the reality for more than one billion people is food insecurity (FAO 2010), and hunger is the unfortunate reality for several hundred million people, especially in Africa. In that context, potential food security impacts of biofuel development are not only important, but concern a basic human right (UNGA 2010).

The impact of biofuel policies on food prices and thus food security is discussed intensely in the scientific world. The links are complex and multi-faceted. Many scientific studies have been carried out to assess whether the increased demand for bioenergy feedstocks contributes to the increase of food prices. The High Level Panel of Experts on Food Security and Nutrition (HLPE) concluded from a literature review that a link between bioenergy production and food prices exists, although it cannot be quantified (HLPE 2013).

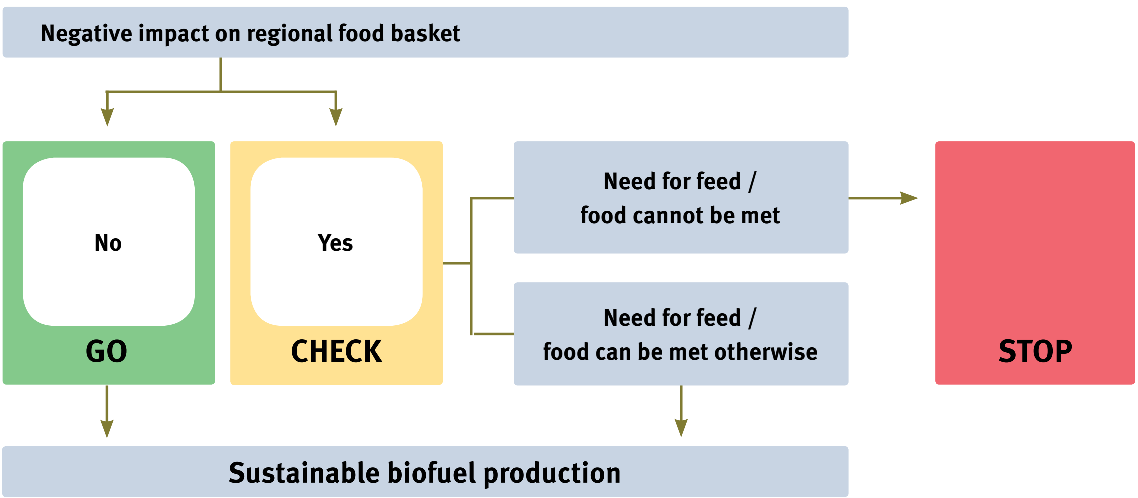
More important than impacts at the global level are those that appear at local level in areas adjacent to biofuel projects. Only at this level the availability of food at affordable prices can be influenced by project developers. The extent of impact depends on the specific design of the biofuel cultivation (e.g. crop types, type of land used), and how it is integrated into the existing agricultural, social, and economic system. The influence in terms of positive or negative impacts on households depends on the local and national circumstances, such as the level of poverty and the vulnerability of households. It affects different actors in different ways, e.g. net crop buying or net crop selling households, rural and urban population. On the one hand, rural households can benefit from investments in and improvements of agricultural systems as the production of food, feed and fibre may be increased. Valuable additional income opportunities may be created in rural areas and stimulating demand and price increases may be of benefit for those households selling biofuel feedstocks.

On the other hand, price increases can reduce access to affordable food and feed for households that depend on buying these commodities. Moreover, biofuel production uses resources – in terms of land, fertilisers and water – that could otherwise be used for food and feed production. Large scale biofuel projects can reduce access to land for the rural poor and thus reduce income opportunities.

Food security is not only a matter of the direct availability of food at affordable prices, but is also influenced by changes in the availability of and access to resources (e.g. land, water). Biofuel projects could potentially displace local residents, yet they may also act as a new source of income. Most of these factors are covered by other indicators ('Water protection', 'Land tenure', 'Gender considerations'). This indicator will focus on changes of food supply to the regional food market which is expressed in the regional food basket.

The respective procedure is illustrated in the decision tree in Figure 4.15. If a biofuel project does not have a negative impact on the local food basket, the project is labelled green. If there is a possible negative impact, compensation measures should be undertaken. If compensation obligations are ignored or not feasible, the project should be stopped.

Figu1re 4.15 Decision tree for the indicator 'Food security'



How to assess food security

Risk assessment

In order to assess risks regarding food security in a particular locality, it is necessary to first determine whether the region (or country) is prone to, or at risk of, food insecurity. Second, the likelihood of the biofuel operation leading to negative impacts in the locality and surrounding area should be examined. The assessment involves three steps:

1. The determination of the food basket and its main staple crops

2. The assessment of changes in the price and / or supply of the food basket and / or of its components expected in the context of biofuel development

3. A "causal descriptive assessment" of the role of biofuels in those expected changes

The food basket is a collection of representative foodstuffs, including main staple crops. It can be either defined nationally, regionally, locally or at household level. The reference area depends on the size of the biofuel project and the connection of the project region with regional / national food markets. The smaller the project and / or the lower the connection with regional / national markets, the lower the level for food basket definition should be. For example, for biofuel projects carried out in regions where food crops are not sold at distant markets but mainly used for subsistence, the area immediately adjacent to the project area is of most importance.

After the main components of the food basket have been identified[5], it should be assessed whether and in which way their availability and prices may be influenced by the bioenergy project. It will be difficult to exactly quantify this influence, and therefore the assessment should follow a causal descriptive approach. Furthermore, national statistics regarding price developments during the last years, as well as the development of the yearly demand and consumption of staple crops may serve as indications as well if available.

The following questions shall guide this process:

- Does the biofuel project take place in a food insecure region?
- What was the previous land use in the project area (e.g. food / feed production, cattle grazing, fallow, natural vegetation)?
- If prior land use was for food / feed production, did the production contribute significantly to the regional supply?
- What will be the level of food / feed production once the project has started?

Risk mitigation

If a negative impact on food security in an area is identified, it should be guaranteed that the need for feed / food can be met otherwise. The following measures can be taken:

- Integration of the production of food / feed crops in the biofuel plantation area
- Provision of alternative areas outside of the project area for food / feed production
- Capacity building in the area regarding a more efficient agriculture
- Generation of income opportunities in the project areas so that food / feed can be bought

Data sources

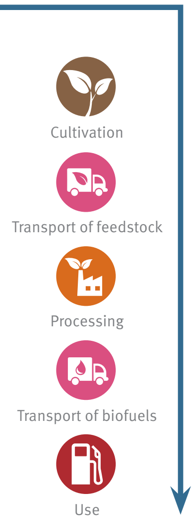
Table 4.20 lists data sources and information that could be helpful for the identification of food security risks at project level.

Table 4.20 Data sources for the food security indicator

Data source	Remarks
FAOSTAT – Food Balance Sheets 2009	Provides Food Balance Sheets for each country. The sheets include the domestic supply and supply per capita differentiated by staple crops. The latest available data refer to the year 2009. The database enables the project developer to determine the relevant main staple crops to be considered within the respective country and by conducting the risk assessment.
Bioenergy and Food Security (BEFS) Operator Level Food Security Tool Version 2	Web-based tool that can provide a preliminary indication of potential risks and benefits for food security from agricultural / bioenergy investments. Amongst other purposes it enables the user to determine the change in the supply of food to the domestic market.
RSB food security guidelines (RSB 2012)	Detailed and extensive guideline on how to assess food security at project level

5 For a first orientation data from FAOSTAT can be taken that provide information on the food consumption at national level (see section on data sources).

4.9 Labour conditions and human health

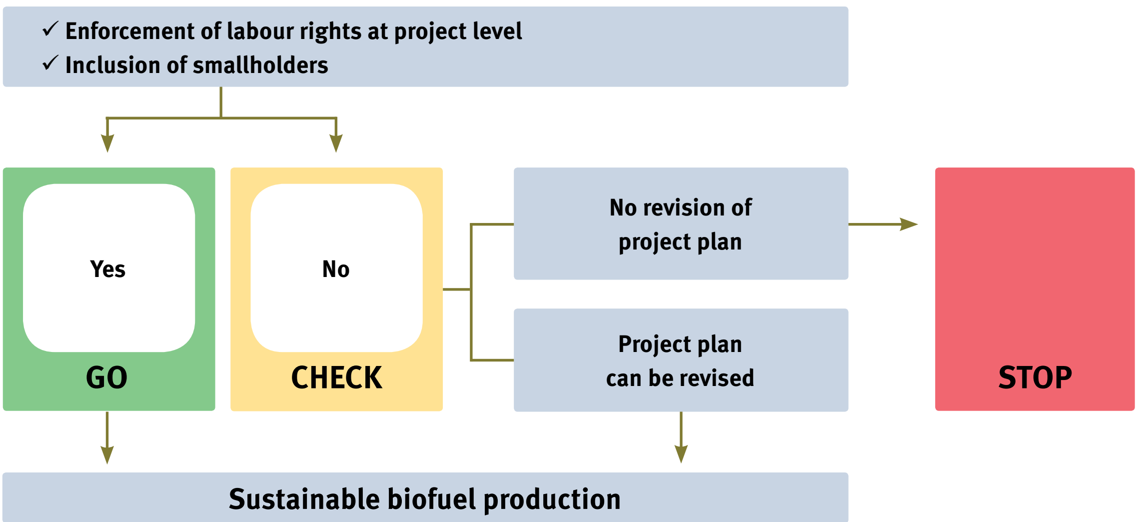


Biofuel implementation may create new employment opportunities. Especially in a developing country context, additional income in rural areas can improve livelihoods substantially. However, not only the number of jobs is critical, but also their quality. Labour conditions may affect who has access to employment, and in which way workers benefit from the employment. Human health is closely related to labour conditions, as workers occupied during cultivation, harvesting and processing may be exposed to human health risks from pesticides, occupational accidents or chemicals.

Furthermore, the groups of people benefiting from biofuel projects have to be taken into consideration. Smallholder farmers are a particularly vulnerable group. They cultivate only small patches of land (often less than one hectare), or manage a small herd of livestock. Often, they have different small sources of income. However, they are still vulnerable to economic shocks. Biofuel projects may be able to offer chances due to income and job creation. Moreover, biofuels may improve the availability of modern energy in rural areas replacing firewood as the only energy source. On the other hand, biofuel projects may present a risk for smallholders when they are developed at large scale. This may lead to a concentration in feedstock cultivation in large plantations. As smallholders have less access to land and transport opportunities, they are excluded from commercial biofuel markets. Sustainable biofuel projects should strive for the integration of smallholders whenever possible in order to support poverty alleviation in rural areas.

Figure 4.16 displays the decision tree recommended for application. Labour conditions (including human health) and the inclusion of smallholders both have to be assessed. Only if both conditions are fulfilled the project should be labelled green. If one of them is not met, the project plan should undergo a revision.

Figure 4.16 Decision tree for the indicator 'Labour conditions and human health'



How to assess labour conditions

Regarding **labour rights,** the principles of the International Labour Organization Declaration on Fundamental Principles and Rights of Work (ILO 1998) are most commonly accepted and applied. The core labour standards to be applied in biofuel projects are:

- Freedom of association, right to organise and collective bargaining (No. 87, No. 98)
- Elimination of forced and compulsory labour and abolition of child labour (No. 29, No. 105, No. 182)
- Elimination of discrimination in respect of employment and occupation (No. 111)

Many countries have ratified the conventions and implemented related national regulations. For biofuel projects, the existence of such regulations should be reviewed and confirmed first. Of prime importance, however, is the implementation of these principles and regulations in the actual projects. The commitment to core labour standards should be clearly evident from the project plan.

Additionally, the following aspects should be respected:

- Health and safety
- Working conditions and wages

For both aspects, national regulations and international conventions should be referred to, as well as relevant collective agreements. In cases where a government regulated minimum wage is in place for the specific industrial sector, this should be applied. Otherwise, the wage should be negotiated and agreed on annually with the workers.

Wherever applicable and possible, **smallholders** should be included in biofuel projects. This first requires the assessment of small scale farmers in existence in a project area. As their characteristics differ by country and farming systems, the assessment has to consider local circumstances. The assessment should prove whether small scale farmers surrounding a project area are negatively influenced by a project. If this is the case, their inclusion should be attempted. This may be done via outgrower schemes, for instance. The labour conditions mentioned above should be applied equally to outgrowers and employees.

4.10 Land tenure

Cultivation

Land use is not only a key issue in terms of environmental effects, but also has direct social implications. Secure access to land is necessary for rural households to ensure their sustainable livelihoods. Having access to land means also having access to the resources provided by this land, i.e. to water, trees and to feed / food production. Therefore, access to land provides income opportunities and food / energy security. In many developing countries, however, no land market has been established. As a result, the local population in rural areas often grows agro-products without any legal title or formal endorsement. The same is true for meadows and pasture land that is commonly used by communities for livestock breeding, or forests which are used to collect fruits and other products. Often, access to land for the rural poor is based on custom that has its origin in the distant past. Such customary rights result in a low security of land tenure. Consequently, in cases of specific challenges the right to use the land is not recognised by law or official systems, and therefore not protected. Thus, the people face the risk that their rights to land will be threatened by competing claims, and even lost as a result of eviction.

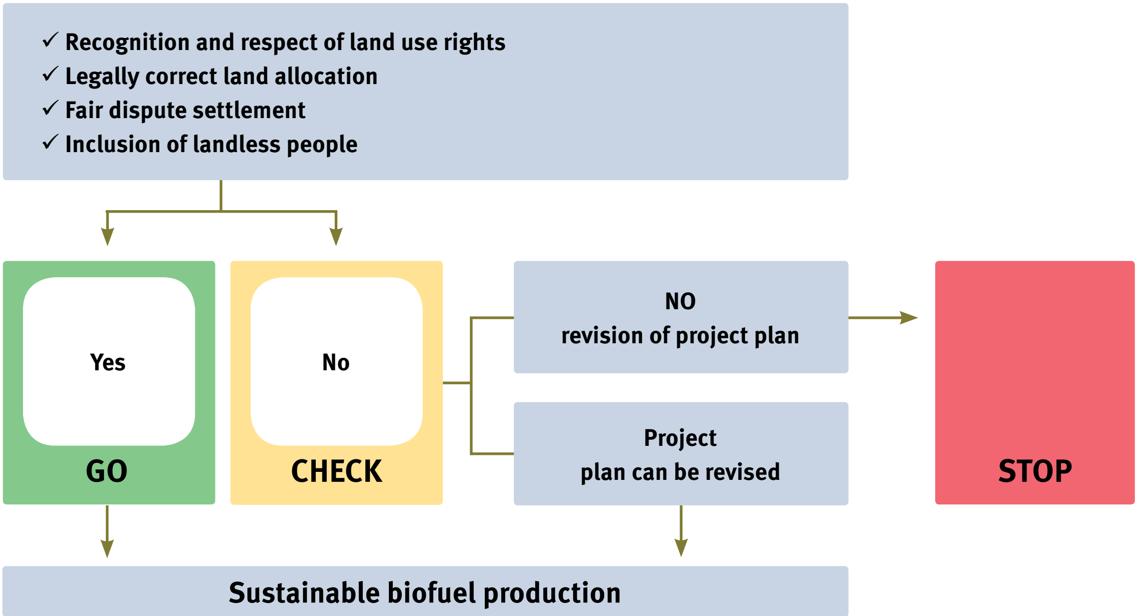
Biofuel development can affect access to land in various ways. Land use change and the conversion of forest or pasture land leads to a reduced access to land. The same holds true for the re-allocation of land, i.e. the allocation of cropland, pastures and forest areas to bioenergy-related investments through concessions or leasing. As a consequence, the local poor population may be deprived of the means to ensure their life subsistence. Furthermore, large scale biofuel projects may increase the land value, so that it may become unaffordable for the local population.

Respect for land tenure rights, whether customary rights or rights derived from formal legal mechanisms, is essential for a fair and equitable allocation of land resources. Furthermore, the following conditions should be fulfilled:

- Recognition and respect of land use rights
- Legally correct land allocation
- Fair dispute settlements
- Inclusion of landless people

Figure 4.17 displays the decision tree that is to be applied. All conditions have to be fulfilled in a project for achieving a green label. If one condition is not met, the project plan should undergo a revision. If such a revision cannot be undertaken, the project should be stopped.

Figure 4.17 Decision tree for the indicator 'Land tenure'



How to assess land tenure

The following sections detail how the four elements of the land tenure indicator are to be assessed.

Recognition and respect of land use rights

In a first step, the land rights in the project area have to be assessed. This includes identification of the legal right-holders and users of the land. Further, it has to be examined to what extent they use the land, including the issue of overlaps with the project area, and the question of the cultural value of the land. In this process, participatory mapping methods should be applied where the local population controls and participates in the development of maps. Often areas are not adequately registered, and it has to be ascertained that all parties concerned are taken into account, including women and marginal groups of the communities such as landless people. If the assessment is done accurately and with due caution, disputes and conflicts at later stages are avoided.

The assessment should include formal and informal land rights which are defined as follows:

- **Formal rights** are secured by the state through laws and regulations or by legal contracts with the owners. Titles, contracts, formal certificates of use, certificates of occupancy or other formal registration are filed, and available, in a national or local registry.

- **Informal rights** are not officially recognised by the authorities. Often they are customary rights that are derived from traditional ownership or uses. These rights are held and supervised by different institutions such as communities, chiefs, families or individuals. In many societies, customary courts or equivalent bodies exist to allocate rights. Customary rights and customary courts may be recognised in national laws and constitutions, by local ordinances and through court decisions.

In addition to mapping the land rights, all state regulation and laws connected to land right matters should be reviewed. It has to be noted that the process of recognising informal land rights may go beyond the requirements formulated in national laws.

The assessment is not necessary in cases of a regular land market, where tenures are legalised and recorded in a formal cadastre, where landowners are not considered poor, or when land acquisition is not opposed by local communities.

Legally correct land allocation

If land use rights have been assessed and clarified, the land allocation may take place (i.e. land acquisition through sale or lease). This should follow due process, including the following elements:

- Prior to land acquisition, formal and informal land use rights have to be identified and recognised. All relevant stakeholders (national / regional / local authorities, representatives of all stakeholders concerned) have been identified and are involved in the process.

- The process should respect the right to Free, Prior and Informed Consent (FPIC), which means that land should be acquired voluntarily and not against the will of prior rights-holders and land users.

- All relevant information on the project (e.g. project area, project type, risks, benefits, responsibilities) has to be communicated to all parties concerned in an understandable way.

- Appropriate compensation measures should be implemented.

- Correct sale or lease contracts should be issued.

Fair dispute settlement

Even if the assessment of land rights is carried out in an appropriate way and if land acquisition follows due process, there may always be conflicts. The project should establish measures for the settlement of disputes.

Generally, all parties involved in the process should have access to fair adjudication. This could mean the access to a court system or other dispute settlement processes. Depending on the situation, different dispute settlement mechanisms could be applied starting from joint fact finding to negotiation, mediation, arbitration and judicial settlement. Some of the mechanisms require third party involvement. One important distinction is the legal outcome: whereas joint fact finding, negotiation and mediation are non-binding measures, arbitration and judicial settlement are legally binding.

Inclusion of landless people

Where applicable, a special focus should be put on landless people. They have neither formal nor informal land use rights, and thus run the risk of being marginalised and ignored in the above mentioned process. At the same time, they are especially vulnerable to the loss of access to land as they do not own any other resources. If landless people are identified as residents in a project area, both their access to and their use of the land should be further guaranteed or, in case a resettlement becomes necessary, they should be appropriately compensated.

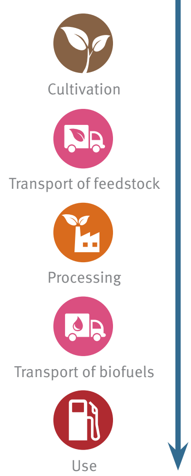
Data sources

For the assessment of land rights it is important to take into account all relevant information sources to guarantee that all right-holders and land users are identified. The sources are listed in Table 4.21.

Table 4.21 Data sources for the assessment of land use rights

Official sources	• Official maps and surveys • Land cadastres • Land tax records • Land use planning and land management maps • Laws and regulations as well as relevant court judgments
Unofficial sources	• Ethnographic surveys • Local, regional, national academic research • Local NGOs

4.11 Gender considerations



The implementation of biofuel projects affects men and women in developing countries in different ways. This reflects their different roles and responsibilities within rural economies. Particularly in developing countries, there is a gender-based inequality between men and women. Women often have less access to land and its resources, to agricultural support and to markets, and thus face a higher risk with regard to food security. For example, women are often allocated low quality lands by their husbands where they cultivate crops for household consumption. With regard to job opportunities and employment conditions, they are also frequently disadvantaged. The nature of the actual impact will depend on the project type and on the socio-economic context where a project takes place.

Traditionally, there is a substantial gender gap in land ownership, with women having reduced access to land and resources needed for agricultural production (water, agro-chemicals). Thus, women have fewer opportunities to participate in the market. As a result, biofuel projects may benefit men more than women. The situation is aggravated when the implementation of biofuel projects reduces the access to land. Furthermore, if energy crop cultivation causes a displacement of women towards marginal lands, this may have negative impacts on women's ability to meet household obligations like food security.

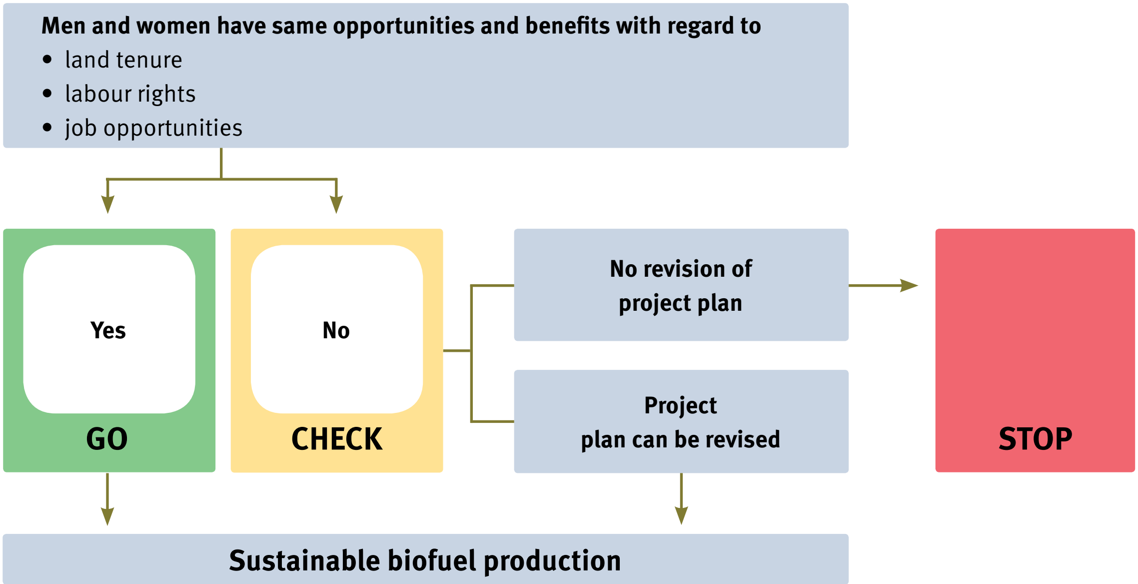
On the other hand, the establishment of biofuel projects can have substantial benefits for women if undertaken in the right way. Besides creating job opportunities, the shift from traditional firewood use to modern fuels has significant health and time implications. Usually, the collection of firewood is a task for women and children, an extremely time- and energy-intensive activity. Moreover, wood collection exposes women and girls to potential health and safety hazards. Switching to modern biofuels for cooking and lighting means saving considerable time that can be used for other economic activities, or for education. It also leads to a considerable improvement of health. Air pollution from the indoor use of open fires and simple stoves affects all members of the family, however, above all women and children.

Therefore, in biofuel projects it should be ensured that women and female-headed households have the same opportunities as men and male-headed households to engage in and benefit from biofuel production. Especially in food insecure countries, the access of women to land must be ensured.

The corresponding decision tree is illustrated in Figure 4.18. The indicator is linked to the social indicators 'Labour conditions' and 'Land tenure'. The same methods and data sets can be applied as presented in Chapters 4.9. and 4.10. Additionally, the creation of income opportunities is mentioned as a criterion. Many jobs in energy crop cultivation and harvesting have to be done my men. However, whenever possible, women should be given priority in selection for employment.

It should be made clear in the project proposal that women are treated with explicit focus regarding the aspects mentioned above. In many countries, respective legal requirements may be in place that should be referred to. However, it should be guaranteed that they are implemented in the specific project in order to be labelled green.

Figure 4.18 Decision tree for the indicator 'Gender considerations'



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