ESU-services

fair consulting in sustainability

2018

Pilot-study for the analysis of the environmental impacts of commodities traded in Switzerland

Niels Jungbluth
Christoph Meili

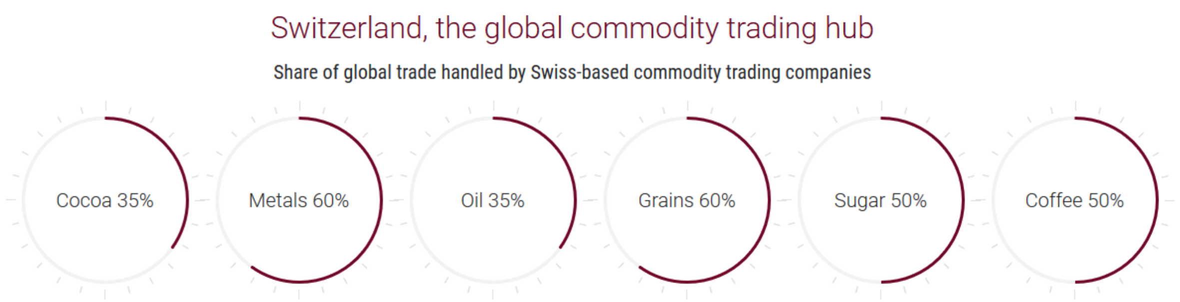
Niels Jungbluth Dr. sc. Techn. Dipl. Ing. TU
ESU-services GmbH
T +41 44 940 61 32

CEO
Vorstadt 14
F +41 44 940 67 94

www.esu-services.ch
CH-8200 Schaffhausen
jungbluth@esu-services.ch

Pilot-study for the analysis of the environmental impacts of commodities traded in Switzerland

Final report



Authors
Niels Jungbluth, Christoph Meili
ESU-services Ltd.
Vorstadt 14
CH-8200 Schaffhausen
jungbluth@esu-services.ch
www.esu-services.ch
Tel. +41 44 940 61 32

Financed by
Swiss Federal Office for the Environment - FOEN, International Affairs Division

Note: The views expressed in this pilot-study are those of the author and do not necessarily represent those of the FOEN

Contents

Imprint

Citation	Niels Jungbluth, Christoph Meili (2018) Pilot-study for the analysis of the environmental impacts of commodities traded in Switzerland. ESU-services Ltd., Schaffhausen, Switzerland, www.esu-services.ch/de/publications/
Financed by	Swiss Federal Office for the Environment - FOEN
Contractor	ESU-services Ltd., fair consulting in sustainability Vorstadt 14, CH-8200 Schaffhausen www.esu-services.ch Phone 0041 44 940 61 32, Fax +41 44 940 67 94 jungbluth@esu-services.ch
About us	ESU-services Ltd. has been founded in 1998. Its core objectives are consulting, coaching, training, and research in the fields of life cycle assessment (LCA), greenhouse gas footprints, water footprint in the sectors energy, civil engineering, basic minerals, chemicals, packaging, telecommunication, food and lifestyles. Fairness, independence, and transparency are substantial characteristics of our consulting philosophy. We work issue-related and accomplish our analyses without prejudice. We document our studies and work transparency and comprehensibly. We offer a fair and competent consultation, which makes it for the clients possible to control and continuously improve their environmental performance. The company worked and works for various national and international companies, associations, and authorities. In some areas, team members of ESU-services performed pioneering work such as development and operation of web based LCA databases or quantifying environmental impacts of food and lifestyles.
Note	The views expressed in this pilot-study are those of the author and do not necessarily represent those of the FOEN
Liability Statement	Information contained herein have been compiled or arrived from sources believed to be reliable. Nevertheless, the authors or their organizations do not accept liability for any loss or damage arising from the use thereof. Using the given information is strictly your own responsibility.
Version	22.08.18 09:39 https://esuservices-my.sharepoint.com/personal/mitarbeiter1_esuservices_onmicrosoft_com/Documents/582 BAFU UmweltwirkungenBranchen/Bericht/jungbluth-2018-LCA-CommoditiesTrade-v5.0.docx

Summary

Commodities such as metals or crude oil, products such as diesel and staple foods are often traded through Switzerland without being physically transported to Switzerland. This means that they are also not included in foreign trade statistics or input-output analyses. For this reason, the associated environmental impacts could not be evaluated in the studies already carried out and planned.

The study at hand is the first analysis that can close this gap in the evaluations already carried out or planned. The focus of this pilot-study is to evaluate the environmental impacts abroad from commodities traded by trading companies located in Switzerland.

Results from the collection of data for the physical amounts of commodities traded and the impact assessment are combined in this study. The conclusions and recommendations according to the goal and scope of the study are summarized in this summary.

What quantities of commodities are traded by companies located in Switzerland?

An estimation of the quantities of 15 commodities traded by Swiss companies has been published for the first time in this study (see chapter 3.1). It is based on several data sources such as literature data, information published by associations and single companies and financial statistics. It has been cross checked e.g. with the global produced and traded amounts of commodities.

An estimated total of about 3 billion tonnes of commodities is traded in 2017 by Swiss companies. Iron ore and crude oil are the most important commodities concerning the mass and make together more than 50% of the total weight. On the third place is coal with a share of 15% and natural gas with 12% share on the mass.

Concerning value of traded products, crude oil is most important and accounts for about 1/3 of the value. This is followed by gold and diesel with 10% each share on the value.

How great are the environmental impacts caused by the production of commodities?

The environmental impacts due to the extraction, production, and transport of 15 commodities traded by Swiss companies are calculated in chapter 4.1. Seven so called footprint indicators are applied in this calculation. The results are about one order of magnitude (ten times) higher than the environmental impacts caused by Swiss production and consumption patterns. Thus, improvements realized during the production of these commodities could in principle be truly relevant to reduce the total impacts caused globally.

Swiss trading companies can play a role through their decisions where and what to buy and sell. They might also be able to influence the production patterns and environmental impacts caused. In classical assessments concerning the environmental impacts being influenced by Swiss production and consumption, these issues are not covered because there are no physical flows of traded commodities crossing Swiss borders in this order of magnitude (with the exception of gold).

What are the most relevant commodities traded by companies based in Switzerland from an environmental point of view?

The most relevant commodities (among the ones under consideration) are identified in chapter 4.3 of this report. The ranking depends very much on the environmental indicator applied. Agricultural products have typically a high influence on biodiversity, eutrophication, and water consumption. The material footprint is defined here only for the extraction of minerals, woody biomass, and energy carriers and thus also more relevant for the production processes of such commodities. Nevertheless, energy, wood and materials are also used for agricultural biomass commodities. Energy carriers are more relevant for the greenhouse gas footprint while the production of some minerals has a specific importance for the air pollution.

The primary extraction of minerals and energy carriers is most relevant for the overall environmental impacts. A critical issue for crude oil extraction is the discharge of produced water and direct methane emissions due to venting and other sources. Air emissions are quite relevant for the mining of copper. For gold mining, water emissions are more relevant.

Which countries of origin are relevant for the global production?

Another question tackled in this study was an assessment of the most important countries of origin for the commodities traded. This is mainly based on an analysis of the most important countries exporting single commodities or in case such information is not available it was based on the most important producing countries. This gives a first idea in which countries environmental impacts are caused.

Local issues are more relevant for biodiversity, eutrophication, and water footprint. These are mainly dominated by agricultural products and here an overall hotspot lies in South-East Asia and Australia. But, some problems for the combination of database and impact assessment method have been identified during the project and thus the mapping of these impacts is not shown any more in this final report.

The location is in principle not relevant for an assessment of the greenhouse gas and material footprint as these are global issues.

From a per-country-perspective, if the ecological scarcity method is applied, exports from Russia, the United States, Saudi Arabia, and Australia are most relevant.

An evaluation by country is interesting for the industry. For individual company representatives, however, the actual supply chains must be looked at. This is not possible within the scope of this study. In addition, the discussion on countries of origin is often only understood from the point of view of transport distances, but these do not play a significant role for most of the commodities investigated in this study. It is mainly relevant for the transport by airplane (which might take place e.g. for gold).

Would it be possible to analyse also which countries are relevant from the perspective of Swiss commodity trade?

During this project only very, limited information has been found concerning the specific relevance of single producing countries for the Swiss commodity trade. There is some indication that a high share of Russian crude oil is traded by Swiss companies. Some information about countries might be available for the company Glencore but has not been evaluated in detail. Thus it was not possible to investigate in more detail the specific relevance of different countries from the perspective of Swiss commodity trade.

Which processes in the supply chain are responsible for the environmental impacts?

In this study, mainly the environmental impacts of extraction and processing of different commodities were investigated. For some commodities also transports to the market were included. All other impacts downstream the trading activity e.g. due to further processing to final products, use or combustion are not included in the analysis.

The importance of distinct stages in the supply chain is evaluated in chapter 4.4. Also, here conclusions depend on the type of environmental indicators. Generally, it can be said that the primary extraction, mining, or farming activity is most relevant. For some minerals (especially iron ore and aluminium) refining is also quite relevant for specific environmental aspects. Transports and storage are only partly covered in the underlying data. They are normally of minor importance according to the assumptions taken in the database. But, a better investigation of these stages in the LCI data seems to be necessary to derive final conclusions.

What type of measures could reduce the identified environmental impacts at the extraction level and/or by trading firms?

Finally, in chapter 5 a non-exhaustive selection of measures is discussed, which might help to reduce the environmental impacts due to the production of traded commodities. A first prerequisite is seen in higher transparency concerning the type and amounts of goods traded and the life cycle behind these commodities. Therefore, production standards or labels might be a clever way to differentiate between products with higher or lower environmental impacts. It is also important to maintain full transparency about the production patterns over the life cycle from extraction over processing until the final consumer. This is often difficult for such commodities which are traded on a global scale and which might go through different hands. New Technologies like blockchain might help improve traceability in the future.

Abbreviations

CDE	centre for development and environment
CH	Switzerland
EE-IOT	environmentally extended input output table
FOEN	Federal Office for the Environment
GLO	Global
KBOB	Koordinationsgremium der Bauorgane des Bundes
KOF	Konjunkturforschungsstelle der ETH Zürich
LCI	life cycle inventory analysis
LCIA	life cycle impact assessment
LPG	liquid petroleum gas
Mt	million tonnes
PDF	potentially damaged fraction
RER	Europe
RME	raw material equivalents
SNB	Swiss national bank
STSA	Swiss trading and shipping association

Acknowledgements

We thank several institutions for the help provided to us during this study:

- KOF Swiss Economic Institute, ETH Zurich
- Public Eye
- CDE-WTI of the University of Berne
- World Resource Forum

1 Background and Objectives

1.1 What is commodity trade?

In merchanting, a company in the domestic economy purchases goods from a supplier abroad and sells these on to a buyer abroad without the goods entering or leaving the domestic economy. Because *merchanting* is common in *commodity trading*, the two terms are often used as synonyms (SNB 2012:34).

In merchanting, goods do not undergo any transformation between purchase and resale and remain in the ownership of the domestic company. About ownership, a distinction is drawn between a merchant and a broker: the latter simply arranges transactions and does not trade, and therefore does not acquire ownership of the goods. The only difference between merchanting and other forms of international trade is the fact that the goods do not physically enter or leave the domestic economy (SNB 2012:34).

Commodity traders do more than buy and sell commodities; they also organise trade-related shipping, insurance against loss and damage to the goods, warehousing at the place of loading and storage, and quality controls of the goods (SNB 2012:34).

Further explanations on commodity trading can be found e.g. in (Bürgi Bonanomi et al. 2015; FDFA 2013).

1.2 What is a company located in Switzerland?

In the context of this study the trade should be investigated for "companies located in Switzerland". The data sources used in this study look at this from different perspectives:

- Associations for which data are investigated in chapter 3.1.1.2 might take a broader perspective and collect data for all company members in this association. Therefore, their figures might also include offices located in Switzerland of a global company with a headquarter in foreign countries.
- For the bottom-up estimation in chapter 3.1.1.3 only companies with a head quarter located in Switzerland are considered. Only with such a definition it can be avoided to include trading activities taking place outside of Switzerland and reported by these companies, which would lead to an overestimation.
- Financial information used in chapter 3.1.1.6 is based on the accounts of the SNB. Data were collected by questionnaires and only a part of the companies with an office in Switzerland answered these questionnaires. Therefore, the scope of this account is uncertain.

With the trade done by companies located in Switzerland all activities taking place from company offices in this country should be considered even if for some parts of the data investigations, a different definition depending on the availability of data had to be taken. For the final estimation for the trade of companies located in Switzerland the most reasonable and complete figures available have been considered to make this estimation.

1.3 Context and motivation for this study

The commodities industry and especially commodities trading continue to be **important for Switzerland's economy**. This is reflected in part in the net receipts from merchanting – largely in commodities trading – which can be used as an approximation for the national economic importance of the commodities trading cluster (trading, shipping, transaction financing and inspection services). The world economic situation, specifically foreign demand for commodities and the prices of traded goods associated with it, is the main driver of revenues from merchanting. Receipts from merchanting in 2015 fell somewhat against 2014 and, according to a Swiss National Bank (SNB) survey, amount to CHF 24.84 billion (2014: CHF 26.55 billion). Since 2010 receipts from merchanting have exceeded receipts from the cross-border commission and services business of the banks in Switzerland (FC 2016).

The commodities sector remains **at the focus of national attention**, as can be seen, for example, in the interest shown by parliament, the media and the launches of various popular initiatives that concern the commodities sector (FC 2016).

The **protection of the environment** is a critical challenge to the commodities sector, particularly in the field of extraction of minerals and energy carriers as well as agricultural products. Environmental impacts occur mainly in resource-exporting countries. Switzerland has strategic, economic and reputational interests in supporting the protection of the environment in the production and processing of commodities traded by Swiss companies. Indeed, commodities are strategic goods and the rising trade in commodities provides a stimulus for the Swiss job market and tax revenues.

At the same time, the commodities industry has a key role to play in meeting the **United Nations Sustainable Development Goals (SDGs) as well as the Paris agreement**. Commodities are for instance an important prerequisite for clean technologies and infrastructure projects which require large amounts of minerals and metals. Metal recycling and technological change contribute to sustaining supply, but studies show that primary metal extraction will cover most of the world's material demand in the coming decades (Dolega, 2016). Trade with agricultural commodities can help to level out local imbalances in food demand and supply. Mining can offer opportunities for jobs and training. The increase in extraction and trade volumes further aggravate the environmental challenge.

The aggravation of environmental challenges entail reputational risks for individual companies and in particular for Switzerland, if the conduct of companies domiciled in Switzerland violates the positions taken and supported by Switzerland in the areas of development policy, peace promotion, human rights, and social and environmental standards.[1] As a location for numerous internationally active companies and one of the world's leading centres for commodities trading, Switzerland has a major responsibility to protect the environment, particularly in countries with inadequate rule of law. The Federal Council expects all companies based in Switzerland operating in or outside of the country to act responsibly, and with integrity in complying with human rights, environmental and social standards, both in Switzerland and abroad (FDFA 2013).

On 27 March 2013, the Federal Council adopted the **Background Report: Commodities** (FDFA 2013). The report shows Switzerland's support to international efforts to deal with the challenges of commodity production, mining and trading. The report's 17 recommendations aim to improve the conditions of the sector and to reduce existing risks. In December 2016, the Federal Council approved the third status report on the implementation of the recommendations

[1] An example for such a violation is e.g. the trade with high-sulphur containing diesel and selling this to African countries (Guéniat et al. 2016).

of the background report on commodities (FC 2016). The Federal Council believes that it continues to make sense to continue to work towards a level playing field at the international level, including fair tax competition and consistent implementation of regulatory standards (FC 2016). It mandated the Federal Administration – the Interdepartmental Platform on Commodities - to carry out an assessment of the situation in the Swiss commodities sector, including any possible need for government action regarding competitiveness, integrity and environmental issues by November 2018.

With the measure 6b of the Report "Green Economy - Federal measures for a resource-conserving, future-proof Switzerland" (Measure 18 of the Green Economy Action Plan 2013, BAFU 2013), the Federal Council intends to strengthen the ecological responsibility and transparency of the commodities sector and to actively engage Switzerland internationally. Within the framework of existing international bodies, Switzerland is working in favour of international rules for the environmentally-safe extraction of commodities and participates in the international dialogue on this topic.

The pilot study at hand is intended to contribute to the work of the Federal Administration aimed at strengthening the global environmental governance of the sector. It is a first analysis that helps for a better understanding of the environmental impacts associated with commodities traded in Switzerland. This is intended to support Switzerland's international engagement in this area. The identification of environmental impacts can also support companies to better target their environmental management and innovation efforts and so, influence production conditions. In line with a study on the supply chains of German companies (Jungmichel et al. 2017), it can be assumed that in order to enable companies to take targeted measures, the identification of the most relevant value-added stages and processes in terms of environmental impact is of crucial importance. When these so-called "environmental hotspots" are known, companies can better target their resource efficiency and innovation efforts.

The study at hand helps trading companies based in Switzerland to learn about the "environmental hotspots" in the supply chains of traded commodities. It further enables them to take concrete, realistic and effective measures to mitigate environmental impacts along the supply chain.

1.4 Relevance of transit trade in Switzerland

Although it is difficult to quantitatively assess the size and relevance of the Swiss commodity trading sector due to the lack of official statistics, two recent estimations can be mentioned. The University of Geneva, in collaboration with the Swiss Association of Commodities and Shipping (STSA), estimated at 496 the number of companies active in trading[2], while the NGO Public Eye, which estimates this number to 544 companies[3]. According to the STSA, the sector employs over 13,000 people directly and generates a further 20,000 jobs indirectly in Switzerland.[4] Another source calculates the number of employees to be only about 7600 (see Tab. 1.1).

The data quality is discussed in chapter 3.3.

Tab. 1.1 compiles key statistical data based on the database published by Public Eye, which is the most detailed source of information known to date.

2 Eggert N., Ferro-Luzzi G. et Ouyang D. (2017) "Commodity Trading Monitoring Report", Swiss Research Institute on Commodities.

3 Public Eye (2017) "Swiss commodity trading sector", base de données, disponible sous https://www.publiceye.ch/fileadmin/files/documents/Rohstoffe/Public_Eye._Switzerland_Commodity_Trading_Sector.xlsx.

4 https://stsa.swiss/knowledge/center

Fiscal contributions from commodity trading sector companies represent 22% of Geneva's budget, 10% in Zug and approximately 19% of the City of Lugano's income.[5] Both Geneva and Zug have special tax regulations for merchandisers. Nearly half of the companies in this sector are in Geneva (Tab. 1.1).

About 25% of the companies are not only active in the commodity trading, but they have own upstream or downstream production activities (Tab. 1.1).

About half of the companies is active in the energy sector. This is followed by companies active in metals and minerals (38%) and soft commodities (24%).

Most of the companies are SME's with less than 50 employees. Six companies have more than 250 employees each.

Tab. 1.1 Key statistical information for the Swiss commodity trading sector compiled by Public Eye

Location of companies		
Region	*Number of companies*	*Percentages*
Geneva/Vaud	266	48.9
Central CH (BS, ZH, ZG)	165	30.3
Other	63	11.6
Ticino	50	9.2
Total	544	100
Area of activities (Group level)		
Type of activity	*Number of companies*	*Percentages*
Trading	544	100%
Upstream (extraction, exploration, production, mining)	82	15%
Midstream (processing and refining)	25	5%
Downstream (storage, distribution)	24	4%
Commodity family (Group level)		
Type of sector	*Number of companies*	*Percentages*
Energy	242	44%
Metals and Minerals	205	38%
Soft commodities	131	24%
Employment of trading companies (pure extractive not included)		
Size	*Number of companies*	*Total number of employees*
0-10	301	na
11-50	67	na
51-100	15	na
101-249	11	na
250+	6	na
No current employment	124	-
Total	**524**	**7594**
Source: Federal Statistical Office (FSO)		

Before 2003, the sector was dominated by some firms trading in coffee, cotton, grains etc. Between 2001 and 2011, the importance of merchanting for Switzerland has increased enormously. Since 2010, current account receipts from merchanting have exceeded the receipts of banks in Switzerland from financial services abroad. Until then, the latter was always the largest item under exports of services (SNB 2012).

5 https://stsa.swiss/knowledge/center

The increase in receipts from merchanting after 2008 can be explained by new entrants in the Swiss market. Since 2003 the sector is dominated by mining products (e.g. Glencore) and crude oil (Vitol, Trafigura etc.).

In addition, a small part of the growth in receipts from merchanting can be explained by the increase in margins. Most of the increase in receipts growth for merchanting traders' resident in Switzerland prior to the financial crisis is probably the result of increases in commodity prices. Moreover, Swiss-based merchanting traders are likely to have expanded also the volume of their business activities (SNB 2012:39).

According to the KOF at the ETH Zürich, transit trade was important driver of economic growth in 2015 and contributed 4% to the Swiss value creation.[6]

Transit trade data, which in Switzerland consists largely of commodities trade (94% in 2011); provide an approximation of economic importance. The import and export to Switzerland plays a negligible role, apart from precious metals.

For this pilot-study it is also important to define the location of the transit trade. Some companies have their (global) head quarter in Switzerland, while others only have offices located in Switzerland. For the study the focus lies on the trade reported by these companies with headquarters located in Switzerland. The issue of the headquarter is only relevant for the assumptions analysis further described in chapter 3.1.1.3.

1.5 Overview over studies dealing with environmental impacts caused by Swiss production and consumption

In two ground-breaking studies commissioned by the FOEN, greenhouse gas emissions from total consumption in Switzerland were assessed for the first time (Frischknecht & Jungbluth 2000; Jungbluth et al. 2007). In summer 2011, the FOEN then published the pilot study "Environmental Impacts of Swiss Consumption and Production" (Jungbluth et al. 2011b) on the overall environmental impact of consumption and production in Switzerland. Further evaluations on environmental impact and resource consumption of products and services in Switzerland that are important from an environmental point of view were also prepared on the basis of the above-mentioned study (Stucki et al. 2012). This study, together with an evaluation of reduction potential in consumption (Jungbluth et al. 2012), forms the basis for a basic study on the green economy (Kissling-Näf et al. 2013). The assessment in these studies was carried out, among other methods, using the ecological scarcity method 2006 (Frischknecht et al. 2008).

A number of methodological questions on the possible course of action for a time series of environmental impacts were examined in a preparatory study (Nathani & Jungbluth 2012). On this basis, a time series for the total environmental impact of Swiss consumption was drawn up (BAFU 2014) and evaluated using the method of ecological scarcity in 2013 (Frischknecht et al. 2013). Later, a disaggregation of the environmentally extended input output table (EE-IOT) in 96 sectors was carried out and evaluated (Frischknecht et al. 2015). The time series for the Swiss footprints has been updated (Frischknecht et al. 2018), using regionalised inventories for the biodiversity and water footprints.

An analysis on the consumption of important raw materials in Switzerland has also been carried out on behalf of the FOEN (Dubach et al. 2015).

[6] https://www.kof.ethz.ch/news-und-veranstaltungen/news/kof-bulletin/kof-bulletin/2016/10/kof-herbstprognose-2016-langsam-aufwaerts.html and https://www.tagesanzeiger.ch/wirtschaft/konjunktur/transithandel-treibt-schweizer-wirtschaft-an/story/11295253

Recently, a study was started to evaluate the environmental impacts caused by various industries by the FOEN. Only the quantities of goods recorded in the foreign trade statistics are considered for this calculation (Nathani et al. 2018).

In all previous and ongoing studies on the environmental impact of the Swiss economy, commodities trading has not been considered, as the commodities do not cross physically national borders (with a few exceptions). Trading is not a service for third parties but means that traders buy (own or bank financed) and resell the commodities, and storage facilities are not located in Switzerland.

1.6 Consumption, production and trading perspectives on environmental impacts

Environmental impacts caused by a country like Switzerland can be analysed from different perspectives. Thus, it is important to declare from which perspective of investigation the results are shown. The scope of different assessment perspectives has been defined in former studies (Jungbluth et al. 2011b; Jungbluth et al. 2012; Nathani & Jungbluth 2012, Fig. 1.1). The consumption perspective looks at environmental impacts due to the final demand in one country. The production perspective looks at direct environmental impacts caused in one country.

production perspective

induced by:	Domestic final demand	Exports
Domestic environmental impacts	✓	✓
Environmental impacts abroad		

consumption perspective

induced by:	Domestic final demand	Exports
Domestic environmental impacts	✓	
Environmental impacts abroad	✓	

Fig. 1.1 Environmental impacts in consumption and production perspectives

The pilot study at hand adopts a new perspective: the transit trade point of view (Fig. 1.2). The environmental impacts are examined from the point of view of commodity trading companies based in Switzerland. It can be assumed that almost all environmental impacts which are recorded for this study take place outside of Switzerland.

induced by:	Domestic final demand	Exports	Production and transport of traded commodities
Domestic environmental impacts			
Environmental impacts abroad			✓

Fig. 1.2 Environmental impacts in the perspective of commodity trading

1.7 Analysis of environmental impacts of commodities traded by companies based in Switzerland

Commodities such as metals or crude oil, products such as diesel and staple foods are often traded through Switzerland without being physically transported to Switzerland (EvB 2011; FDFA 2013). This means that they are also not included in foreign trade statistics or input-output analyses. For this reason, the associated environmental impacts could not be evaluated in the studies already carried out and planned.

The study at hand is the first analysis that can close this gap in the evaluations already carried out or planned. The focus of this pilot-study is to evaluate the environmental impacts abroad from commodities traded by trading companies located in Switzerland.

To estimate the environmental impacts – or "environmental hotspots" of commodities traded by companies based[7] in Switzerland, the total traded quantities must first be estimated (as further explained in chapter 3.1. All environmental impacts resulting from the extraction and processing of the commodities traded by Swiss companies are considered in the calculation.

It is assumed that trading companies might have a certain influence on production patterns of the commodities e.g. by clearly providing information about origin of commodities, specific qualities (e.g. GMO-free, organic) or managing certificates or labels. The identification of the so-called "environmental hotspots" can support companies to better target their environmental management and innovation efforts and so, influence production conditions. It will also support their risk management, and if existing their supply chain management and investors relations.

Key characteristics for this study are summarized in Tab. 1.2.

[7] The headquarter or branche which reported the trade is based in Switzerland.

Tab. 1.2 Key characteristics of the pilot study

Title	Pilot-study for the analysis of the environmental impacts of commodities traded in Switzerland
Financed by	Swiss Federal Office for the Environment - FOEN
Products and variants investigated	List of 15 products. Trading volumes in physical units according to the data basis investigated for Swiss trading companies.
Scope	Resource extraction and processing of analysed commodities. Transports and storage only included if already assessed in the underlying LCI data. Environmental impacts occurring further downstream along the supply chain (use phase) will not be considered due to the complexity of such analysis and lack of reliable information.
Objectives	The overall objective of the study is to assess the environmental impacts associated with the extraction, preliminary transformation and transport[8] of commodities traded by companies based in Switzerland.
Reference year	Latest annual trade data (2017 or earlier) available at the start of the project.
Functional unit	Quantity of 15 important commodities traded by Swiss companies within one year.
Key questions of the study	What quantities of the chosen commodities are traded in Switzerland? How great are the environmental impacts caused by the extraction, production, transport of commodities traded by companies based in Switzerland? What are the most relevant commodities traded by companies based in Switzerland from an environmental point of view (cradle to gate)? Which countries of origin are relevant for the global production of these commodities? At what stages of the supply chain occur the most important environmental impacts and what processes/products are responsible for the environmental impacts? What type of measures could reduce the identified environmental impacts at the extraction level and/or by trading firms?
Standard to be applied	None
Comparative study	No
Software for calculations	SimaPro 8.5.3
Background database	KBOB v2.2: 2016 and ecoinvent Centre 2017; ESU 2018; Jungbluth et al. 2018a for some products
Foreground data	Traded amounts investigated by literature research
Life cycle impact assessment	Environmental impacts are analysed through a set of seven so-called "footprint indicators.

2 Goal and Scope Definition

2.1 Introduction

In general, the methodology for life cycle assessment is followed in this study. A general description of the way a life cycle assessment (LCA) is elaborated can be found on the website of the authors.[9] The first step is to elaborate and describe the goal and scope of the study. In general, methodological choices are taken in line with the used background data from the ecoinvent database (Frischknecht et al. 2007).

8 Transports to the market are excluded if not already investigated in the used datasets.

9 http://www.esu-services.ch/ourservices/case-studies/

2.2 Key questions of this study

This study aims to support the Federal Offices in analysing the environmental impacts of the commodity sector and to enable Switzerland to be actively involved in this area at the international level.

The key questions to be answered in this study are taken as follows:

- What quantities of the analysed commodities are traded in Switzerland? (chapter 3.1)
- How great are the environmental impacts caused by the extraction, production and transport[10] of commodities traded by companies based in Switzerland? (chapter 4.1)
- What are the most relevant commodities traded by companies based in Switzerland from an environmental point of view (cradle to gate)? (chapter 4.3)
- Which countries of origin are relevant for the global production of the analysed commodities? (chapter 3.1.3 and 3.1.4)
- At what stages of the supply chain occur the most important environmental impacts? What processes/products are responsible for the environmental impacts? (chapter 4.4)
- What type of measures could reduce the identified environmental impacts at the extraction level and/or by trading firms (e.g. sustainable sourcing, labelling, etc.)? (chapter 5).

2.3 Investigated commodities

A large variety of commodities traded globally could in principle be examined. It was not possible at the beginning of the project to estimate for which of these commodities the corresponding quantities can be determined, and which environmental relevance different commodities would have.

Therefore, the analysis in this project is carried out for a pre-selection of 15 commodities. The selected commodities were mentioned e.g. in publications dealing with the Swiss commodity trade. Often at least first information about the share of Swiss companies for the global trade were available at the start of the project. The selected commodities were mentioned by experts consulted in the preparation of the project. The importance of the selected was furthermore confirmed e.g. by the financial information available for the commodity trade (SNB 2017).

As there is not yet comprehensive information about all commodity trading in Switzerland, it is not possible to estimate the share of the selected commodities for the total commodity trade, nor to estimate if anything important is missing. The evaluation of the data quality in chapter 3.3 shows at least that there is not a considerable underestimation in this selection, when cross compared with general financial information.

In chapter 6.2, some indications are given about which commodities might be of interest for future analysis. But, in the check of data quality for this study it is at least confirmed that no major items by mass or value are missing in the balance of traded commodities (see chapter 3.3.1).

[10] Environmental impacts are assessed with datasets readily available in the KBOB database. Transports to market are only included for some commodities.

According to this discussion at the beginning of the project, data on trading for the following commodities were searched:

Energy carriers

- crude oil
- diesel
- petrol
- natural gas
- coal

Ores and metals

- iron ore
- copper
- bauxite
- aluminium
- gold[11]

Agricultural commodities

- coffee
- cocoa
- cereals (wheat)
- sugar
- vegetable oils (palm oil)
- cotton

The following commodities are not considered as they are already being investigated by ongoing work or necessary LCI data are not available:

- electricity (included in former study Jungbluth *et al.* 2011b)
- gemstones[12]
- rare earth (lack of LCI data)

2.4 System boundaries

This study investigates environmental impacts of resource extraction and processing for a list of commodities traded by Swiss companies. Transports and storage are only included if already assessed in the underlying LCI data. Environmental impacts occurring further downstream along the supply chain (use phase) are not considered due to the complexity of such analysis and lack of reliable information. The assessment is made for the trade with commodities during one year (2017 as far as data are available).

11 Swiss refineries process around 2/3 of the annual global gold demand. Gold is physically imported and exported effectively and there are data from the EZV and it is already considered in previous studies.

12 No LCI data available

2.5 Life cycle impact assessment (LCIA) methods (Footprint indicators)

Environmental impacts are analysed through a set of seven so-called footprint indicators also used by Frischknecht *et al.* 2018 for evaluating environmental impacts of consumption.

- Overall environmental footprint, Ecological scarcity method 2013 (Frischknecht et al. 2013). Balance of several environmental indicators and weighting of aspects according to Swiss laws.
- Greenhouse gas footprint (Solomon et al. 2007)[13] Emission CO_2 and other greenhouse gases which can lead to a catastrophic change in global climate.
- Biodiversity footprint (Chaudhary *et al.* 2016). Potential impacts of different types of land occupation and transformation on biodiversity. No country specific characterisation factors could be applied in the LCIA of this project as such information is not available for the elementary flows recorded in the KBOB database.
- Eutrophication footprint (marine eutrophication, Goedkoop et al. 2009). Emissions of nitrogen that is the main cause for eutrophication in sea water.
- Air pollution footprint (particulate matter, Goedkoop et al. 2009). Particles and other emissions having an impact on human health.
- Water footprint (Boulay *et al.* 2018). Evaluation of water uses with regional factors for water scarcity.
- Material footprint (Ores, minerals, fossil energy, biomass) (Schoer *et al.* 2012). Masses moved for the extraction of ores, minerals and energy carriers).

The choice of these indicators has been made to allow for comparability to the most possible extent with parallel studies financed by the FOEN. Further information about the indicators is provided in the annexe chapter 8. The characterisation factors for SimaPro were directly provided by the FOEN and had been prepared for a parallel study (Frischknecht *et al.* 2018). However, in the scope of this study it was not possible to put the regionalisation for the biodiversity and water footprint into practice, nor to apply country specific factors. Hence, a substantial underestimation of these indicators and their share of the total environmental impact can be expected and comparability with other studies commissioned by FOEN is not given.

In this study, a cradle to gate perspective is taken. More specifically it is called trading perspective as described in chapter 1.6. Here the so-called "footprints" only cover the supply chain stages extraction, production and transport. This must be kept in mind when comparing the results with footprints in other publications on behalf of the FOEN that take the entire value chain of goods and services (extraction, transport, production as well as the use and disposal phases) into account (see e.g. FOEN 2016, page 5).

The indicator "cumulative energy demand, total (sum of CED non-renewable and CED renewable)" which is looked at in some of the parallel studies (Nathani *et al.* 2018) in this context is not evaluated for this project due to known overlaps with greenhouse gas and material indicators.

[13] This is not the most recent method for characterising the impacts of different greenhouse gases (IPCC 2013). It has been chosen to be consistent with other studies in this context commissioned by FOEN.

3 Data collection

3.1 Commodity volumes traded by companies located in Switzerland

A key first task in this project was to estimate the amounts of commodities traded by companies located in Switzerland. Such an estimation has not been made before to our knowledge. The approach for data collection is described in this chapter.

Statistical information was searched for different stages as explained below:

- Total amount *produced / consumed globally* during one year. This should be the maximum number that can be considered in the assessment for trade.
- Total amount *traded globally*. A part of the produced amount might be used regionally or within one company, and thus it is not traded through international companies. To avoid possible double counting, the maximum annual trading volume is limited to the global annual production. For most commodities under investigation (except cocoa), global trade data was found in different literature sources.[14]
- Total amount *traded by Swiss companies* (or share of the amount traded globally). This is the key figure that is searched for in this analysis.

3.1.1 Data sources

Various online and literature sources are consulted to estimate the quantities traded by Swiss companies in physical units (kg, Nm3). An overview about these sources and the results of the data collection is given in this chapter. A detailed description of all data sources is available as an annexed Excel document (chapter 12.1).

3.1.1.1 Global trading statistics

Global trading statistics are provided e.g. by Chatham House to enable users to explore the fast-evolving dynamics of international trade in natural resources, the sustainability implications of such trade, and the related interdependencies that emerge between importing and exporting countries and regions.[15] Total annual trading volumes for several commodities in these statistics are much higher than annual production rate of crude product. If this is the case for a certain commodity, the data source is neglected, and traded amounts are estimated based on production data.

3.1.1.2 Associations

From time to time, the commodity trading association STSA publishes some estimates of market shares via media and only with % figures instead of tonnages. Fig. 3.1 shows the share of Swiss trading companies in total world trade for some key commodities. The figures provided on the homepage of this association were one of the most relevant sources for the assessment of the Swiss share in total world trade.

14 All sources are provided in an annexed Excel document.
15 https://resourcetrade.earth, accessed on 07.06.2018

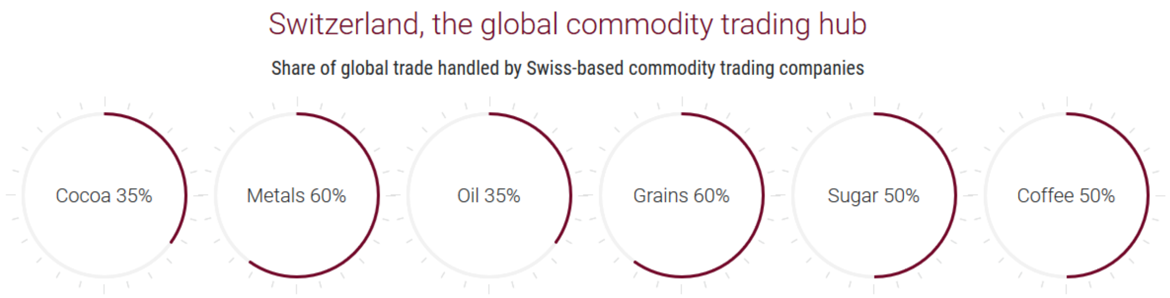


Fig. 3.1 Share of Swiss trading companies in total world trade [16]

3.1.1.3 Single companies (bottom-up estimation)

Physical volume data from the largest market participants can be used to make estimates of volumes traded by companies located in Switzerland. Since the markets for both energy sources and agricultural commodities are strongly dominated by a few large corporations, this indeed needs some effort. Many companies publish figures only cautiously, but such a calculation is possible, e.g. as done for the oil sector (see EvB 2011: 215, Tab. 1).

For 22 companies mentioned in the Swiss context such information has been searched in annual reports or sustainability reports. The companies have e.g. been listed in former publications (e.g. EvB 2011) or they were listed in the database about the Swiss commodity sector[3] with a high turnover or a large number of employees. and evaluated as far as possible:

- ADM
- Alvean
- Ameropa
- Barry Callebaut
- Baytur trade
- Bunge
- Cargill
- ECOM Agroindustrial corporation
- Glencore
- Gunvor
- Kolmar Group
- Litasco
- Louis Dreyfus
- Mercuria
- M.I.S. commodities
- Nestlé[17]
- Sucafina

16 https://stsa.swiss/, Accessed on 24.8.2017.

17 Not a typical commodity trader but very active in buying, processing and selling agricultural products.

- Trafigura[18]
- Trammo
- Unilever
- Vitol

Companies are only considered in the bottom-up estimations of this chapter if the headquarter reporting quantities of traded or produced commodities is in Switzerland (and it can be assumed that the produced amounts were not extracted in Switzerland). This was the case for 15 out of 22 companies. Reports are often only available for the whole company, whose headquarter might be located outside Switzerland. Furthermore, changes of the headquarters location seem to happen on short notice (e.g. for Trafigura). Thus, for about one third (7) of the companies listed above, the headquarters do not seem to be in Switzerland presently. They are therefore excluded from the sum-up. Nevertheless, it can be assumed that a part of the trade reported as worldwide is also carried out in Swiss offices.

Another 5 out of the 15 remaining companies with headquarter in Switzerland looked at do not report any quantitative information. Others only provide information for some of the commodities known to be traded by them. Thus, data for only 10 out of the 22 pre-selected companies could be considered for this bottom-up estimation.

There are almost 550 companies active in the commodities sector in Switzerland. Many of these companies do not even have a webpage. Thus, the sum of the amounts traded by 10 single companies is only a lower limit of the real transit trade activity.

Detailed data about the amounts of commodities were available for one of the most relevant company, Glencore. Besides transit trade, this company is also directly involved in extraction (e.g. mining and crude oil) of commodities. Thus, figures provided by Glencore include other activities besides trading and it was not possible to differentiate between pure trading and other activities. Including these production activities abroad by a company with the headquarter in Switzerland in the analysis would be an extension of the scope of this pilot study. However, in the case of such upstream activities abroad, the company, based Switzerland, has a direct control on extraction condition.

Another example for such a direct involvement by a Swiss company in the global commodity production is Nestlé. This company purchases, processes and sells a huge range of food products. However, it is not a commodity trading company according to the definitions used in this study. Environmental impacts of these activities are neither covered in the present assessments for Swiss production and consumption, as most of these goods are not physically moved in or out Switzerland. However, too little data were available for this company to include it in the data collection for this study.

3.1.1.4 Literature

Another source of information was data from the literature. According to one study (Dubach et al. 2015), 2/3 of the world's coffee production is traded via Switzerland, but only 1.6% of this quantity is actually imported into Switzerland.

[18] Trafigura, the world's third largest commodities trading company, announced it will be moving its legal headquarters from Geneva to Singapore, because of lower taxes and proximity to China. May 2012, https://genevalunch.com/2012/05/23/trafigura-to-move-trading-headquarters-to-singapore/

Other important data sources are the aforementioned publications (Dubach et al. 2015; EvB 2011). We also refer to further studies on this subject (e. g. FDFA 2013).

The fact sheet of the Commission for Research Partnerships with Developing Countries "Switzerland and commodity trade - What do we know? Balance sheet and outlook "[19] has been evaluated. It shows information similar to the one published by the STSA or Swiss authorities (FDFA 2013).

3.1.1.5 Direct contacts

Furthermore, the present study benefited from insights and data from the following organisations, e. g:

- Public Eye
- CDE-WTI of the University of Berne
- World Resource Forum
- KOF Swiss Economic Institute

All organisations answered and provided us with hints on relevant literature sources.

3.1.1.6 Financial information

Financial information is used together with market prices to cross check the estimations in physical units for the trade.

A rough estimate can be made based on the Swiss National Bank's (SNB) transit trade statistics. This statistic records the transactions in which Swiss companies in country A buy a commodity and deliver it - unchanged - to country B (without importing or exporting it to Switzerland).

The flows are reported in monetary terms. Total sales fluctuated in recent years between CHF 500 - 800 billion per year. For the latest available data, which are quarterly reported in 2016-2017, the total value of reported expenses/income was about 625 billion CHF per year.[20]

In 2016 the total net revenue amounted to 26 billion CHF for Swiss companies. The largest share of net revenues from transit trade was found for the energy sources. In the last five years, however, their share has declined from 72% to 60%. The proportion of metals and minerals rose from 15% to 18% between 2012 and 2016, while the proportion of agricultural and forestry products rose from 4% to 10% (SNB 2017).

The SNB asks companies which, according to information in the commercial register, are mainly active in transit trading and whose transactions according to SNB exceed a “certain threshold value”, for information about their income from transit trade (SNB 2017). However, there is no obligation for companies to supply data without request from SNB. It can therefore be assumed that the number of trading companies covered by the SNB statistics constitutes a lower limit.

It is not possible to directly use the available financial information for estimating the volumes traded for different commodities as data are not available for single commodities. But, the account on transit trade can be cross compared with estimations for the commodity trade done in

19 https://naturwissenschaften.ch/organisations/kfpe/about_kfpe/annual_report_2016/58677-die-schweiz-und-der-rohstoffhandel---was-wissen-wir-bilanz-und-ausblick

20 https://data.snb.ch/de/topics/aube#!/cube/bopcurrq?fromDate=2016-Q3&toDate=2017-Q3&dimSel=D0(L0,T0,T4,T7,T9,PMTWV),D1(E,A,S)

this study as given in Tab. 3.1 to verify the assumptions. This is further discussed in chapter 3.3.1.

3.1.2 Information about the share traded by Swiss companies

To estimate the share of Swiss companies in total trade, information provided by associations (c.f. chapter 3.1.1.2) has been used. Therefore, only data by the STSA were available. This has been compared with the sum of data provided by single companies (c.f. chapter 3.1.1.3). Available data are further documented in chapter 12.1.

3.1.3 Information about the origin of traded commodities

For this study it is of interest to know where environmental impacts associated with Swiss trading activities occur. However, it is not possible to answer this question based on the LCA database to be used in this project. Data in the LCA database for most of the commodities are only available for single countries of origin or for Europe but not for a global mix. Wheat, for example, can be produced in about a hundred countries. However, LCI data in ecoinvent are only available for Switzerland and a few other countries. Thus, no representative average for the global production can be modelled based on these databases.

For commodities purchased on the world market, such as metals, it is hardly possible to differentiate exactly where the commodities traded in Switzerland come from. The difficulties of a view on the origin of gold imports, for example, were presented in a study published by GfbV (GfbV 2012).

Information about the countries of origin is rarely available for the specific trade patterns of Switzerland. It is for example known that merchants in Geneva have a specific focus on trading Russian crude oil[21], but more detailed information about the amounts of crude oil traded from different regions of the world is not available.

In general, if available, export data from countries related to commodities under investigation were used to estimate the amount of these commodities traded in Switzerland. If such data was not available, total production data for countries of origin were used as starting point for the calculation.

Information regarding major exporting and/or producing countries for the selected commodities is shown in the following sub-chapters as far as available for each commodity investigated in this study. Full details about the produced volumes per country of production for each commodity are provided in the annexe 12.2. However, a country might be an important producer of a commodity, but a minor exporter of the commodity. Given the importance of Swiss trading globally, key exporting countries provide better indications about the possible location of environmental impacts. Still, it is also possible that environmental impacts also occur further upstream, e.g. in case of processed products like diesel or petrol. But, such an evaluation goes beyond the goal and scope of this study.

3.1.4 Global production and trade data for single commodities

In the following sub-chapters information regarding single commodities or groups of commodities is provided. Fig. 3.2 gives an overview on the total amount of commodities, analysed in this study, and exported in 2016/2017.

21 According to the STSA, about 75% of Russian exports of crude oil and oil products are managed through Geneva. https://stsa.swiss/knowledge/main-players/companies

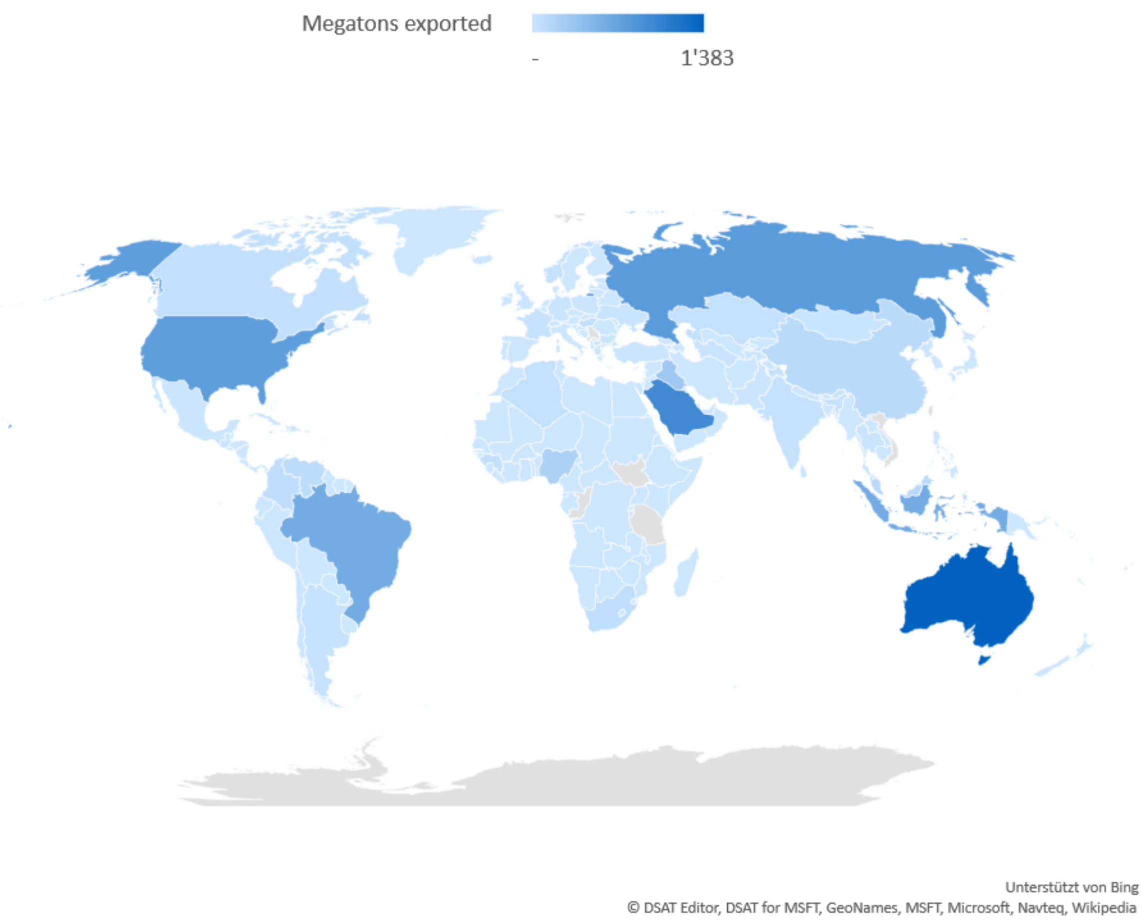


Fig. 3.2 Total amount of all single commodities exported by country of origin (grey background = no data available)

3.1.4.1 *Energy sources and carriers*

Latest statistical data for the global production and consumption of energy sources by origin are available for the year 2016.[22] The average between global production and global consumption reported in this data source is used to estimate the globally produced amount per year. Thus, changes in stocks (which make the difference between the two) are levelled out to a certain extent. Also, stocks might be traded as well as actual production. The difference between the two is in the range of other data uncertainties and thus not relevant for the final conclusions of this study.

Furthermore, data for the amounts of global trade and transport of energy carriers were available in that publication. Where available the exported amounts were used in this model.

3.1.4.1.1 *Crude oil*

BP 2017 provides quite detailed information about the origin and global trade movements of crude oil. Middle East countries are the most important producers and exporters worldwide in terms of volumes (BP 2017). These are also the countries where most crude oil is exported from.[22]

22 https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy/oil/oil-trade-movements.html

3.1.4.1.2 Light distillates

Light distillates consist of liquid petroleum gas (LPG), naphtha and aviation and motor gasolines.[23]

Export and import statistics were found for 2013 with an outlook for 2019. In 2013, countries in Asia, as well as Russia and North America were the main exporters of light distillates. It is assumed that the Middle East will increase the export of refined products until 2019.[24]

3.1.4.1.3 Middle distillates

The term "middle distillates" is assigned to petroleum products obtained in the "middle" boiling ranges from about 180°C–360°C during the process of crude oil distillation. They are also called middle distillates because the products are removed at mid-height in the distillation tower during the multi-stage process of thermal separation.

In Germany, middle distillate is the technical term used for gasoil. Middle distillates, which are hence also known as gasoil, primarily include extra light heating oil (heating oil EL), and diesel fuel, as well as marine diesel oil (MDO) as an intermediate stage between middle distillates and heavy fuel oil, and jet fuel (also called Jet A-1 or kerosene).[25]

Global export statistics were found for 2013.[24] In 2013, countries in Europe, the Former Soviet Union and the Middle East are the main exporters of light distillates. It is assumed that North America East will become a net exporter of refined products until 2019.

3.1.4.1.4 Natural gas

The data source shows quite detailed information about the global origin and trade movements.[22] Most important countries for exports are Russia, North America and countries in the Middle East and Asia/Pacific region.

3.1.4.1.5 Coal

Nearly 1,400 million tonnes (Mt) of coal were traded in 2014, with the majority flowing from the top two exporters: Indonesia (417Mt, worth around $20bn) and Australia (387Mt, about $35bn).[26]

3.1.4.2 Ores and metals

3.1.4.2.1 Iron ore

Iron is the most commonly used metal worldwide. It is primarily used by the construction, engineering, automotive, and machinery industry, often as the main ingredient for steel. Australia and Brazil are some of the largest producers and exporters of usable iron ore in the world. In 2016, Australia produced an estimated 825 million metric tons of iron ore, while Brazil's production came to an estimated 391 million metric tons. Export statistics for iron ore were available and used.[27]

23 http://www.clihouston.com/knowledge-base/oil-refinery-major-products-of-it.html
24 https://www.eia.gov/conference/2014/pdf/presentations/halff.pdf
25 https://www.marquard-bahls.com/en/news-info/glossary/detail/term/middle-distillates.html
26 https://www.carbonbrief.org/mapped-the-global-coal-trade
27 https://www.statista.com/statistics/590231/exports-of-iron-ore-worldwide-by-region/

3.1.4.2.2 Copper

Statistics on trade by country of origin were available.[15] However, the traded volume is much bigger than what is produced annually. Therefore, global production data was used to estimate shares of copper from certain origins traded in Switzerland. Total global copper production from mines amounted to an estimated 20 million metric tons in 2016.[28] Major producing countries include Chile, Peru and China. Chile produces nearly one third of the world's copper.

3.1.4.2.3 Bauxite

Statistics on trade by country of origin were not easily available. Therefore, global production data was used to estimate shares of bauxite from certain origins traded in Switzerland. About 300 million tons of bauxite was extracted in 2017. Australia and China were the major producers. [29]

3.1.4.2.4 Aluminium

Statistics on trade by country of origin were available.[15] This was used to estimate shares of aluminium from certain origins traded in Switzerland. About 130 million tons of aluminium was sourced in 2017. China was the major producer.[29]

3.1.4.2.5 Gold

Statistics on trade by country of origin were available.[15] However, the traded volume is much bigger than what is produced annually. Therefore, global production data was used to estimate shares of gold from certain origins traded in Switzerland. China was the largest gold producer in the world in 2016, accounting for around 15% of total annual production. Australia and Russia each produce about 9% and the USA about 7% of all newly-mined gold.[30]

3.1.4.3 Agricultural commodities

According to the STSA, Geneva is a world's leading hub for the trade of grains and oil seeds, handling alone one-third or approximately 75 million tons of the global free trade in these commodities.[31]

3.1.4.3.1 Coffee

Global statistics on trade by country of origin were available[15]. However, the traded volume is much bigger than what is produced annually. Therefore, global production data was used to estimate shares of coffee from certain origins traded in Switzerland. The most relevant coffee producing countries and regions are Brazil, Vietnam, and Colombia. [15, 32]

3.1.4.3.2 Cocoa

Statistics on trade by country of origin were available.[15] However, the traded volume is much bigger than what is produced annually. Therefore, global production data was used to estimate shares of cocoa from certain origins traded in Switzerland. Cocoa is mainly produced in Cote d'Ivoire, Ghana, Indonesia and Malaysia. The consumption mainly takes place in Europe and North America..[33]

---

28 https://minerals.usgs.gov/minerals/pubs/commodity/copper/mcs-2018-coppe.pdf
29 https://minerals.usgs.gov/minerals/pubs/commodity/bauxite/mcs-2018-bauxi.pdf
30 https://www.gold.org/about-gold/gold-supply/gold-mining/gold-mining-map
31 https://stsa.swiss/knowledge/main-players/companies

33 https://www.cbi.eu/sites/default/files/market_information/researches/trade

3.1.4.3.3 Cereals (wheat)

Global import and export data for wheat is available.[15] This information is used to assess shares of cereals from certain origins traded in Switzerland. Most important wheat exports are produced in the United States, Argentina, Russia, France and the Ukraine.[34]

3.1.4.3.4 Sugar

Global import and export data for sugar is available.[15] This information is used to assess shares of sugar from certain origins traded in Switzerland. The most important sugar exporting countries are Brazil, Thailand and Australia. In total, sugar is produced in 113 countries around the world. Seventy-one countries produce sugar from sugar cane (79% of production), thirty-five from sugar beets (21% of production), and seven from both plants.[35]

3.1.4.3.5 Vegetable oils (palm oil)

Statistics on trade by country of origin were available.[15] This information is used to assess shares of palm oil from certain origins traded in Switzerland. Global palm oil production has increased from 15.2 million tons in 1995 to 62.6 million tons in 2015. This is the highest production volume of all vegetable oils, exceeding the second biggest oilseed crop by more than 10 million tons. This volume is mainly produced by Indonesia and Malaysia.[36]

3.1.4.3.6 Cotton

Statistics on trade by country of origin were available.[15] This information is used to assess shares of cotton from certain origins traded in Switzerland.

Cotton for export is produced mainly in the United States, India, Brazil, Vietnam and China.[37]

3.1.5 Summary of the data collection on trade by Swiss companies

The results of the data collection are fully documented in an excel table. Various sources of information are compiled in this table. Finally, an estimate of the volumes traded by Swiss companies is made. Tab. 3.1 summarizes the main results of this analysis and shows the estimated amounts of commodities traded by Swiss companies used in further calculations.

All volumes are provided in kg or Nm3 which allows a direct link to LCA data as described in the next chapter. E+06 can be read as "million kg", E+09 as "million tonnes" and E+12 as "billion tonnes".

For readers not familiar with the scientific notion of numbers and SI units, the data are also provided in easier to read units in Tab. 3.1

The columns follow the logic of estimation already described in chapter 3.1.1.1. The first column in Tab. 3.1 "Commodities traded/CH" shows the amounts of commodities assumed to be traded by Swiss companies. This is the starting point for the calculation of environmental impacts due to the production of commodities traded by Swiss companies in chapter 4. The next two columns provide a minimum and maximum estimation to show the possible range of uncertainty of this estimation.

This first column was calculated in three steps as described in chapter 3.1:

34 https://apps.fas.usda.gov/psdonline/circulars/grain-wheat.pdf
35 https://www.suedzucker.de/en/Zucker/Zahlen-zum-Zucker/Welt/
36 https://www.palmoilandfood.eu/en/palm-oil-production
37 https://www.statista.com/statistics/263055/cotton-production-worldwide-by-top-countries/

1. The column on “Total production/consumption/GLO” shows figures investigated in the previous chapters for the global annual production or consumption. This was the first point in the analysis.
2. Only a part of this amount is traded globally. The estimates for this share and the amount of the globally traded commodities is shown in the next two columns. It is also based on the data described in the previous sub-chapters.
3. The “Amount traded/GLO” is then multiplied with the “best guess” for the share traded by Swiss companies in the last column. The estimation for this share is mainly based on information provided by associations (chapter 3.1.1.2) which is cross checked with the sum-up of data for single companies (chapter 3.1.1.3). The result equals than the estimation made in the first column.

An estimated total of about 3 billion tonnes of commodities is traded by Swiss companies. Iron ore and crude oil are the most important commodities based on the mass and make together more than 50% of the total weight. Concerning value of traded products, crude oil is most important and accounts for about 1/3 of the value.

A detailed documentation of the assumptions and data sources for this estimation can be found in the annexe 12.1.

Tab. 3.1 Summary of estimated trading data investigated for this study in easy to read units. (Details explained in above text)

	Unit	Commodities traded	Commodities traded, Min	Commodities traded, Max	Total production /consumption	Share of production traded	Amount traded	Best guess share
		CH	CH	CH	GLO	GLO	GLO	CH
Commodities, energy sources	Mio. t	2'128.69	-	-	20'559.22	0.00	5'856.25	0.0%
· crude oil	Mio. t	744.00	442.71	744.00	4'400.30	0.00	1'900.00	39.2%
· diesel (Middle distillates)	Mio. t	182.69	108.70	182.69	1'768.54	0.00	521.96	35.0%
· petrol (light distillates)	Mio. t	167.31	99.56	167.31	1'619.73	0.00	478.04	35.0%
· natural gas	Mio. Nm3	379.40	18.82	379.40	3'547.24	0.00	1'084.00	35.0%
· coal	Mio. t	466.73	157.60	466.73	7'460.40	0.00	1'333.50	35.0%
Commodities, ores and metals	Mio. t	998.48	-	-	2'639.89	0.00	1'664.14	0.0%
· iron ore	Mio. t	930.00	47.10	930.00	2'280.00	0.00	1'550.00	60.0%
· copper	Mio. t	8.58	3.50	8.58	22.50	0.00	14.30	60.0%
· bauxite	Mio. t	46.00	27.37	46.00	274.00	0.00	76.67	60.0%
· aluminium	Mio. t	13.90	8.27	13.90	63.39	0.00	23.17	60.0%
· gold	Tsd. T	2.10	0.06	2.10	3.15	0.00	3.15	66.7%
Commodities, agricultural goods	Mio. t	137.19	-	-	1'003.46	0.00	304.39	0.0%
· coffee	Mio. t	2.88	0.87	3.24	7.57	0.00	5.40	53.3%
· cocoa	Mio. t	1.11	0.66	1.11	3.97	0.00	3.18	35.0%
· cereals (wheat)	Mio. t	78.25	46.56	109.75	735.30	0.00	182.91	42.8%
· sugar	Mio. t	26.31	0.50	29.60	170.81	0.00	59.20	44.4%
· vegetable oils (palm oil)	Mio. t	27.12	16.07	27.12	62.60	0.00	48.20	56.3%
· cotton	Mio. t	1.52	0.40	1.83	23.21	0.00	5.50	27.6%
Total	Mio. t	3'075.79	978.69	3'111.26	22'439.56	0.00	7'286.03	42.2%
Total, turnover for trade	Mrd. CHF	961.28	426.11	979.43	-	-	-	-

CH – Switzerland
GLO – Global
Min – Minimum of available data
Max – Maximum of available data

3.2 Linking traded amounts to life cycle inventories of commodity production

In this chapter the so-called life cycle inventory analysis (LCI) is described. This is a standardized stage in the LCA methodology. In this step information about the amount of commodities traded by Swiss companies is linked to the underlying data on the production of each commodity in the LCA software SimaPro 8.5.3. Only after this step it is possible to calculate the environmental impacts of the commodity trade. Readers who are not interested in the underlying data for the LCA might skip reading this chapter.

One dataset is created in the software which describes the annual trade with commodities by Swiss companies. Therefore, the quantity for each single commodity traded by Swiss companies is directly linked to a single data set for the extraction and production of the corresponding commodity (Tab. 3.2). E.g. the amount of 744 million tonnes of crude oil is linked to the data set "crude oil, import mix, at long distance transport/RER". This dataset includes the underlying data for calculating the environmental impacts of crude oil imported to Europe.

According to specifications for this project, the LCI is elaborated on the basis of KBOB data (KBOB v2.2: 2016). The nomenclature for the data documentation is also prescribed by this choice.

Presently data for mineral oil products are updated on behalf of FOEN. Updated data for crude oil, diesel and petrol are used from this ongoing study (Jungbluth et al. 2018c).

Data for cocoa and coffee are not available in the KBOB database. Therefore ecoinvent v3 data are used in the LCI (ecoinvent Centre 2017). To allow an easy linking with the imported datasets a simple dataset according to v2.2 naming rules was created.

A correction has been made for the LCI data of iron ore production. A rough estimation has been made to estimate a global market mix for sugar and wheat (Tab. 8.1). Both is shortly described in the Annexe chapter 8. These corrections are considered in the ESU-database which builds on the KBOB database and includes the above-mentioned updates and corrections (ESU 2018).

As one can see in Tab. 3.2 data are not always available for the global (GLO) production of the commodities, but only for Europe (RER, UCTE) or even only for single countries (e.g. MY – Malaysia for palm oil).

Tab. 3.3 shows the scope of the datasets applied in the life cycle inventory analysis. The three columns give a short overview about the coverage of these datasets concerning the investigation of the first extraction/farming, processing and transports to the market.

The first column shows also which countries of origin are covered in the life cycle inventory data based on the abbreviations used in the database.

For 10 datasets the investigations cover all stages until the provision to the European or global market for bulk products. For the other datasets some stages until the delivery to the market are not covered in the underlying data. Storage of products is only included for mineral oil products.

Tab. 3.2 Unit process raw data for the total trade of commodities by companies located in Switzerland

Name	Location	InfrastructureProcess	Unit	total trade of commodities	UncertaintyType	StandardDeviation95%	GeneralComment
Location				CH			
InfrastructureProcess				0			
Unit				a			
crude oil, import mix, at long distance transport	RER	0	kg	744'000'000'000	1	1.40	(3,2,1,3,3,BU:1.3); · crude oil; Estimated amount of trade by companies in Switzerland
diesel, at refinery	RER	0	kg	182'685'757'347	1	1.40	(3,2,1,3,3,BU:1.3); · diesel (Middle distillates); Estimated amount of trade by companies in Switzerland
petrol, at refinery	RER	0	kg	167'314'242'653	1	1.40	(3,2,1,3,3,BU:1.3); · petrol (light distillates); Estimated amount of trade by companies in Switzerland
natural gas, at long-distance pipeline	RER	0	Nm3	379'400'000'000	1	4.55	(3,2,1,3,3,BU:4.49); · natural gas; Estimated amount of trade by companies in Switzerland
hard coal mix, at regional storage	UCTE	0	kg	466'725'000'000	1	1.79	(3,2,1,3,3,BU:1.72); · coal; Estimated amount of trade by companies in Switzerland
iron ore, 65% Fe, at beneficiation	GLO	0	kg	930'000'000'000	1	4.45	(3,2,1,1,1,BU:4.44); · iron ore; Estimated amount of trade by companies in Switzerland
copper, at regional storage	RER	0	kg	8'580'000'000	1	1.64	(3,2,1,3,3,BU:1.57); · copper; Estimated amount of trade by companies in Switzerland
bauxite, at mine	GLO	0	kg	46'000'000'000	1	1.32	(3,2,1,1,1,BU:1.3); · bauxite; Estimated amount of trade by companies in Switzerland
aluminium, production mix, at plant	RER	0	kg	13'900'000'000	1	1.40	(3,2,1,3,3,BU:1.3); · aluminium; Estimated amount of trade by companies in Switzerland
gold, at regional storage	RER	0	kg	2'100'000	1	6.01	(3,2,1,3,3,BU:5.94); · gold; Estimated amount of trade by companies in Switzerland
green coffee, market mix	GLO	0	kg	2'880'000'000	1	1.99	(3,2,1,3,3,BU:1.93); · coffee; Estimated amount of trade by companies in Switzerland
cocoa beans, market mix	GLO	0	kg	1'111'600'000	1	1.40	(3,2,1,3,3,BU:1.3); · cocoa; Estimated amount of trade by companies in Switzerland
wheat grains, at farm	GLO	0	kg	78'246'544'444	1	1.61	(3,2,1,3,3,BU:1.54); · cereals (wheat); Estimated amount of trade by companies in Switzerland
sugar, at sugar refinery	GLO	0	kg	26'311'111'111	1	7.77	(3,2,1,3,3,BU:7.69); · sugar; Estimated amount of trade by companies in Switzerland
palm oil, at oil mill	MY	0	kg	27'120'000'000	1	1.40	(3,2,1,3,3,BU:1.3); · vegetable oils (palm oil); Estimated amount of trade by companies in Switzerland
yarn, cotton, at plant	GLO	0	kg	1'516'666'667	1	2.20	(3,2,1,3,3,BU:2.14); · cotton; Estimated amount of trade by companies in Switzerland

Tab. 3.3 Scope of the datasets applied for the investigation of commodities by companies located in Switzerland

Commodity	extraction/ farming	processing	transport until
· crude oil	RU, NG, KZ, NO, IQ, MX, SA, US	none	European refinery
· diesel (Middle distillates)	RU, NG, KZ, NO, IQ, MX, SA, US	in Europe	European refinery
· petrol (light distillates)	RU, NG, KZ, NO, IQ, MX, SA, US	in Europe	European refinery
· natural gas	DE, GB, NL, NO, RU, NAC, RME, NG	none	European high pressure grid
· coal	AU, CPA, RU, ZA, EEU, WEU, RNA, RLA	none	European power plant
· iron ore	GLO mine	beneficiation to 65%	beneficiation plant
· copper	ID, RLA, RER	refinery, incl. recycling share	European market
· bauxite	GLO mine	none	none
· aluminium	GLO mining and processing in Europe	processing, incl. recycling share	European market
· gold	ZA, US, AU, CA, PG, CL, PE, TZ, SE	refinery, incl. recycling share	European market, incl. aircraft transport
· coffee	BR, CO, HN, ID, IN, VN	none	global market
· cocoa	CL, GH, ID	sun-dried	global market
· cereals (wheat)	FR, ES, DE, CH, US	none	none
· sugar	BR, CH	sugar production from crop	sugar refinery
· vegetable oils (palm oil)	MY	pressing	oil mill
· cotton	CN, US	yarn production	local yarn production plant

3.3 Data quality

In the following the quality of data estimated in chapter 3.1 and 3.2 is critically discussed.

3.3.1 Trade (production, consumption) data

In chapter 3.1 of this study, for the first time, the amounts of several commodities traded by Swiss companies are estimated based on different data sources. There exist no databases or publications that would already provide the necessary statistical data. Therefore, the numbers provided in this study can be considered as the best available estimation possible at this time.

The financial account on transit trade as discussed in chapter 3.1.1.6 can be cross compared with estimations for the commodity trade done in this study as given in Tab. 3.1. This is explained here. First, the price of the commodities must be evaluated.[38] As they are traded mainly in US$ this must be transferred to CHF. Commodities' prices can vary substantially which is a problem for this type of calculation. The price for the most traded commodity, crude oil, fluctuated between 40 US$/bbl. and 115 US$/bbl. in the last seven years. Another example is the price for iron ore which dropped from 150 US$/t in 2013 to 40 US$/t in the end of 2015 and afterwards increased to 70 US$/t in March 2018.[39] It is not known which average price was relevant for the financial accounts.

The value calculated for the estimation of trade of commodities in this study amounts to about 960 billion CHF, compared to the 625 billion CHF reported by the SNB for the Swiss transit trade. Thus at least the order of magnitude can be confirmed. However, there are some gaps in the underlying financial statistic (SNB 2017): intra-group transactions are not included, as well as commodities that will change on the road (e. g. oil that is refined) and the number of companies surveyed by the SNB appear to be anything but complete as reporting to the SNB was not mandatory.

The most relevant data for global production and trade often refer to 2016 and 2017. Thus, they can be considered as up-to-date.

Information regarding the share of Switzerland is sometimes also based on older sources or sources without a clear annual reference. The main source of information is the data published by the STSA association. Not much is known about the background of this information and how reliable it is. It is also not clear if this is more an upper limit estimation to possibly highlight the importance of this sector.

It must be noted that the consideration of crude oil on the one side and diesel and petrol on the other involves a possible double counting of impacts presented in this study as impacts due to crude oil extraction are counted towards both. But, it is not known how much of the crude oil traded by Swiss companies ends up physically in fuels traded by Swiss companies and thus and estimate about the importance of this issue cannot be made.

Some double counting occurs also for bauxite which is the basic resource to produce aluminium. But, this is of low relevance as the overall environmental relevance of bauxite trade is also quite low (as shown in the next chapter).

A way to improve the data quality might be to rely on data directly collected by associations of the commodity trading sector. This would better allow to deal with confidentiality requirements

38 E.g. www.indexmundi.com/commodities/
39 http://www.infomine.com/investment/metal-prices/iron-ore-fines/5-year/

of single companies. Furthermore, it can be expected that the associations have a good overview about new players in the market or trading companies who are not active anymore.

The publishing of information by single trading companies on the type, amount, origin, and – tending to be less relevant for this sort of assessment – the product qualities, would be important for a comprehensive analysis of environmental impacts related to the trading sector.

3.3.2 LCI data

Here the quality of life cycle inventory (LCI) data for the present study is discussed.

Only publicly available background data is used for the present study as requested by the FOEN. Priority is given to the KBOB data (KBOB v2.2: 2016) in order to have a consistent database which is also used in former or parallel studies (Frischknecht et al. 2018; Nathani et al. 2018). Single agricultural commodities (for which data are not available in the KBOB database) are assessed with LCI data available in ecoinvent v3.4. Thus, no full data consistency could be achieved on this issue.

For future work, it could be more recommendable to use ecoinvent v3.x data for all commodities investigated in such a project as the database includes already global market datasets including the transports involved in providing goods to the market. Also, there would be more data available for agricultural commodities produced in different regions. But, market dataset in the present version v3.4 (ecoinvent Centre 2017) are known to have often errors, thus this version was not chosen for this project.

The coverage of data variation could be further improved by investigating global market mixes also under consideration of further public (Blonk 2014; Koch et al. 2015; Nemecek et al. 2015) or commercial (Jungbluth et al. 2018b) databases. By using this data, it would be possible to use or develop LCI datasets which better reflect the mix of production patterns and locations for commodities. By fitting such new datasets to the mix of products traded, it would also be possible to better investigate the origin of environmental impacts in different countries.

As mentioned before, transports are only partly covered in the underlying data. There might be a specific relevance if commodities are transported by air plane. This could be expected for high value goods like gold.

During the project a problem with emission data recorded for iron ore has been found. The issue is described and corrected in chapter 8.2.

Storage of commodities might also be a part of the trading activity. So far storage of such goods is only partly investigated in the LCI data (e.g. for crude oil and mineral oil products). For other commodities data on storage are missing (e.g. agricultural commodities). Also, high security storage and transports for gold (and other high value metals or gemstones) might be an issue, which so far was not investigated in LCA. The importance of storage for total results is unclear and it would be recommended to include at least rough assumptions in future updates of the market data in ecoinvent.

4 Assessment of environmental impacts

The significance of the environmental impacts is evaluated in the life cycle impact assessment (LCIA) phase of an LCA. First, inputs and outputs (as recorded in the LCI) of the life cycle are cumulated over all process stages considered in the evaluation. For this the LCA software calculates the inputs and outputs of several resources and emissions over the life cycle of the commodities investigated. Environmental impacts of extraction, preliminary transformation (processing) and transport of traded commodities are included.

These cumulative inputs from the environment (resources such as crude oil and water or land occupied) and the cumulative outputs (emissions to air, water and soil) constitute the basis of the impact assessment. Therefore, the total amount of resources or emissions is multiplied with a characterisation factor which is given by the different LCIA methods. The LCIA methods for footprint indicators are mentioned in Tab. 1.2, chapter 2.5 and described in chapter 8.

The environmental impacts are calculated for the reference flow of one-year trade with commodities by Swiss companies. This estimation is made for the year 2017 (as far as possible).

Transports and infrastructures (storage facilities, etc.) used for trading purposes, transports to final customer, as well as use and disposal of the traded commodities are not included in the calculations. Direct environmental impacts caused by trading companies in Switzerland (e.g. office infrastructure, electricity use for computer and lighting, etc.) are not included in the analysis.

It must be noted that the single aspects and indicators are also included in the calculation of the overall environmental footprint, using the Ecological Scarcity Method 2013, a weighting scheme based on environmental goals adopted by Switzerland.

Results for the biodiversity and water footprint were evaluated as well, but they are not shown in this chapter due to problems identified during the project. These are described in an Annexe.

4.1 Environmental impacts of extraction, processing and transport of commodities traded by Swiss companies

Tab. 4.1 shows the results for the calculation of environmental impacts due to the production of commodities traded by Swiss companies. The production of these goods caused about 4 quadrillion (10^{15}) ecological scarcity points and 1.26 trillion (10^{12}) tons of CO2-equivalents. To bring these figures into perspective, they are compared with the annual impacts of Swiss consumption in the next chapter.

Tab. 4.1 Environmental impact of extraction, processing and transport of commodities traded by Swiss companies

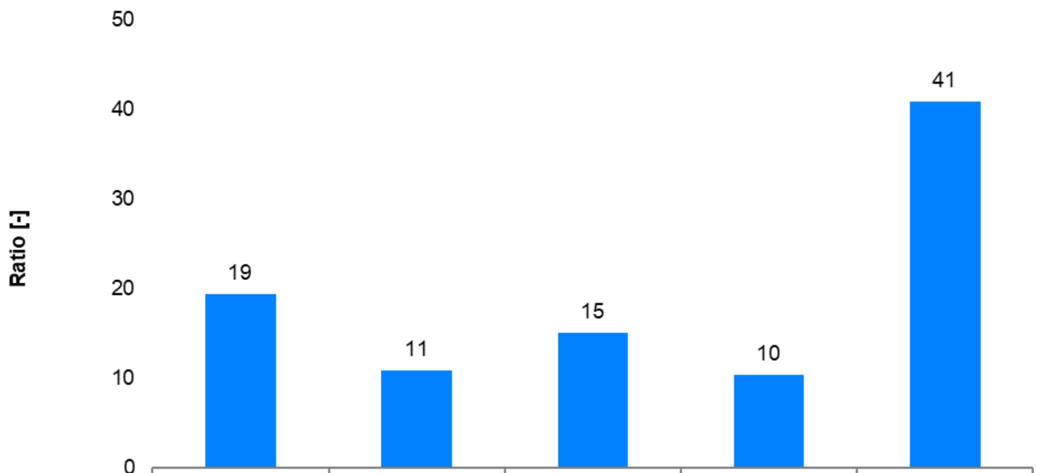
	Overall environmental footprint	Greenhouse gas footprint	Air pollution footprint	Eutrophication footprint	Material footprint
	Trillion UBP'13	Million tons CO2-eq	1000 tons PM10-eq	1000 tons N-eq	Billion RME
Commodities, energy sources	*1'819*	*959*	*1'569*	*390*	*2'696*
· crude oil	918	370	743	165	951
· diesel (Middle distillates)	269	141	232	47	256
· petrol (light distillates)	256	136	240	45	239
· natural gas	207	172	125	16	553
· coal	169	141	228	118	698
Commodities, ores and metals	*905*	*130*	*841*	*121*	*2'899*
· iron ore	91	16	251	14	1'285
· copper	424	16	388	40	664
· bauxite	2	0	5	1	68
· aluminium	90	71	109	24	99
· gold	299	28	88	42	782
Commodities, agricultural goods	*1'023*	*167*	*500*	*757*	*126*
· coffee	118	23	86	201	21
· cocoa	255	22	43	102	4
· cereals (wheat)	488	51	125	242	52
· sugar	34	7	31	37	13
· vegetable oils (palm oil)	88	44	168	144	23
· cotton	40	20	46	31	14
Total	**3'747**	**1'257**	**2'911**	**1'268**	**5'721**

4.2 Comparison with key figures for the environmental impacts of the Swiss economy

In this chapter a comparison with key figures for the total environmental impact caused by the Swiss economy is made. Numbers for the total environmental impacts due to Swiss consumption in Fig. 4.1 were provided by FOEN as calculated in a parallel project for the same footprint indicators[40] as used in this study (Frischknecht *et al.* 2018).

Fig. 4.1 shows that the overall environmental impacts of traded commodities are 19 times higher than the ones caused by total Swiss consumption (not only of the commodities under consideration). They are also 11 times higher for the greenhouse gas footprint.

Most relevant regarding this comparison is the material footprint. This can be explained by the fact that commodities are investigated in this study. During extraction many of these commodities cause a high initial material footprint. But, e.g. global warming emissions due to the use of fossil fuels are not included. Also, for all other indicators impacts to produce commodities traded by Swiss companies are considerable higher than the direct impacts of Swiss production and consumption recorded so far.



	Overall environmental footprint, in Trillion UBP'13	Greenhouse gas footprint, in Million tons CO2-eq	Air pollution footprint, in 1000 tons PM10-eq	Eutrophication footprint, in 1000 tons N-eq	Material footprint, in Billion RME
Ratio traded vs consumed	19	11	15	10	41
Swiss consumption	193	116	193	122	140
Commodities traded by CH	3'747	1'257	2'911	1'268	5'721

Fig. 4.1 Comparison of environmental impacts to produce commodities traded by Swiss companies as calculated in this study with the total results for the impacts of the Swiss final consumption (Frischknecht et al. 2018).

40 Both studies use the ecological scarcity method 2013 to calculate the overall environmental impact. However, there are differences considering country specific data on land and water use. Both studies consider indirect effects of stratospheric emissions by aviation for the carbon footprint.

4.3 Share of single commodities for total footprint results

The share of different commodities for the footprint results is shown in Fig. 4.2. It must be kept in mind that the use phase (where e.g. emissions from fossil fuels are caused) or other life cycle stages taking place after the trade (e.g. metal processing) are not considered. Blue colours are used for energy carriers, grey colours for ores and metals and other colours for agricultural commodities. This is a visualization of the results already shown in Tab. 4.1.

Energy carriers are dominating the results for the mass balance (c.f. Tab. 3.1), environmental air pollution and greenhouse gas footprint. Most relevant is the extraction of crude oil.

Ores and minerals are most relevant for the material footprint. Most relevant is iron ore.

Agricultural commodities are most relevant for eutrophication footprint. Wheat is most important for the eutrophication.

The share of different commodities while evaluating environmental impacts is thus quite dependent on the indicator used to look at such impacts. Different indicators focus on different single environmental themes. For priority setting it is recommended to also consider the results according to the overall environmental footprint which gives the highest share of impacts to crude oil. The second most important commodity is difficult to identify as several ones have shares around 10%.

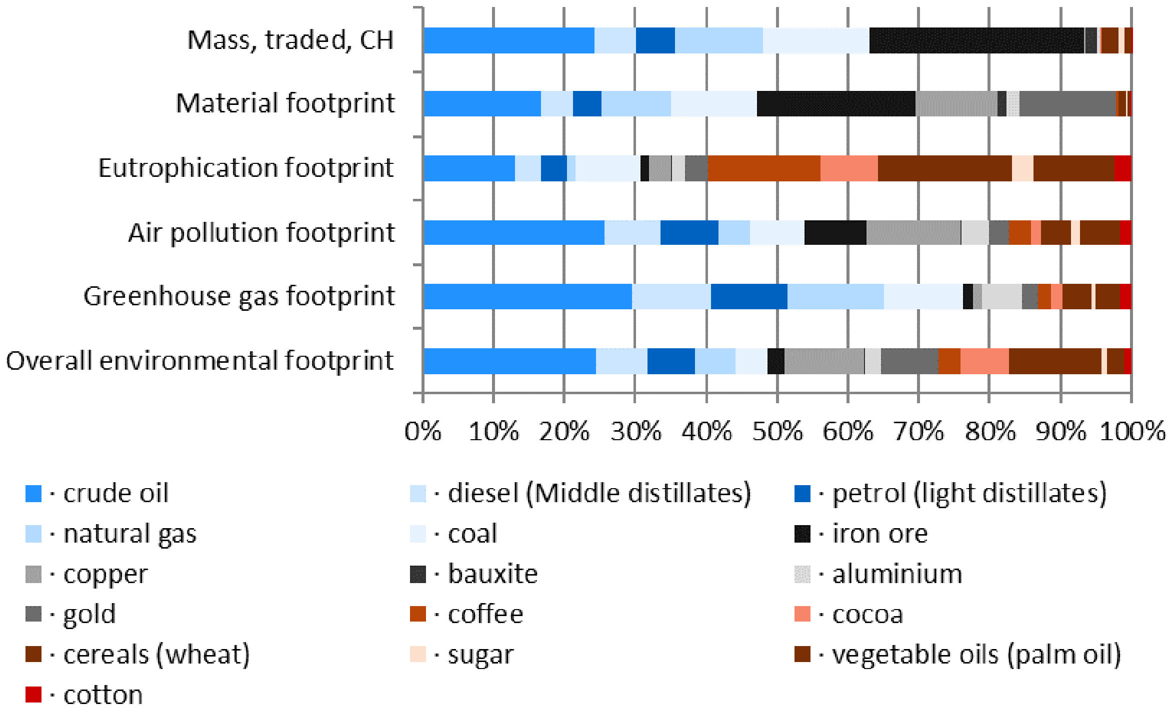


Fig. 4.2 Share of different commodities for the total impacts due to the production of commodities traded by Swiss companies

4.4 Relevance of extraction, transformation, and transport stages

The study only considers the extraction, transformation, and transport when integrated in the background data used (see Tab. 3.3). In this chapter it is investigated at what stages of the supply chain the most important environmental impacts occur, and which processes/products are responsible for these environmental impacts. The main cause of the impact (e.g. chemicals used in that stage, energy required, etc.) is mentioned after analysis of the datasets in SimaPro.

This overview does not include an in-depth evaluation for each commodity and each indicator but gives insights from the perspective of total results for the seven single indicators.

It must be noted that often the underlying data used are not sufficient to cover and investigate the whole global production as data are only available for single countries or regions. Obvious limitations are mentioned in the respective chapter for each single indicator.

4.4.1 Overall environmental footprint

Regarding the trade of commodities, the primary extraction of minerals and energy carriers is most relevant for the overall environmental impacts. A critical issue for crude oil extraction is the discharge of produced water and venting of associated gas. Air emissions are quite relevant for the mining copper. For gold mining, water emissions are more relevant. For agricultural products like wheat land use and heavy metal emissions to water due to the application of fertilizers are most relevant.

4.4.2 Greenhouse gas footprint

Three main sources of emissions are relevant for the greenhouse gas footprint. The key factor are direct emissions of methane during oil extraction (venting). Other relevant factors are the energy consumption in production processes. For agricultural commodities also, emissions due to the applications of fertilizers can be relevant. Electricity consumption in several production stages accounts for more than 7% of the greenhouse gas footprint. But, finally there are a lot of processes contributing to the total result and no single processes or stage can be identified as outstanding relevant.

Emissions due to the combustion of energy commodities (crude oil, oil products, natural gas and coal) traded by Swiss companies are not accounted for in this study. If these emissions would be included ultimate results would be much higher and dominated by these emissions of fossil fuel combustion.

4.4.3 Eutrophication footprint

The eutrophication footprint is mainly caused by emissions during the farming of agricultural commodities. Nitrate emissions to water account for about 60% of this category indicator. They occur because of surplus application of different fertilizers. Some importance is also due to ammonium emissions due to the discharge of water during oil extraction.

4.4.4 Air pollution footprint

Crude oil extraction accounts for about 25% of this indicator. Relevant are the emissions of sulphur dioxide due to combustion of fuels and flaring. Other important emissions are nitrogen oxides and particle emissions which take place in a range of different production stages mainly due to the combustion of fuels. No further outstanding priority stage can be identified for this.

Emissions of particles and sulphur dioxide during crude oil extraction are further important contributors to the air pollution footprint.

4.4.5 Material footprint

The indicator material footprint is calculated based on characterisation factors for minerals and energy carriers extracted as a raw material. Concerning metals, for example, it shows the total quantity of ores extracted in the mining process. Most important for the material footprint is the mining of iron ore and extraction of crude oil which each have a share of about 25%. This is directly due to the characterisation factors applied in this method on the amount of iron or oil extracted. Gold, natural gas and copper extraction are further important processes.

4.4.6 Conclusions

For most footprint indicators the first process stage in the life cycle of the commodity is the most relevant one. Many impacts are related to extraction, mining or agricultural production. It must be noted that transport and storage processes in connection with trade are only partly covered in the underlying background database. Thus, no full picture can be provided regarding such processes under more direct control of merchanting companies. This study did also not evaluate the full life cycle e.g. including the combustion of energy carriers. Thus, it is not suitable to draw overall conclusions on full life cycle or "footprint" of commodities.

5 Options for action for trading companies and politics

This chapter discusses measures that could reduce the identified environmental impacts at the extraction level and/or by trading companies. It provides non-exhaustive indications on what trading companies or public authorities might do.

Most trading companies do not have a direct control over the most relevant production processes. They can directly influence transport or storage processes if this is part of the trading activity, but these stages are of lower environmental relevance. However, by fulfilling a trade, they might also request and pass information (such as through certificates, labels, etc.) about the commodity from supplier to customer, and by doing this, increase the environmental transparency.

A small percentage of Swiss companies, such as Glencore, is also directly involved in upstream activities, which implies a more direct influence on location and production conditions and therefore associated environmental impacts.

5.1 Transparency about the amounts, origin and environmental impacts

An important starting point for improving the environmental performance of traded commodities would be to increase transparency about the *amounts* of commodities traded, the *origin*, *production conditions* and *associated environmental impacts*. It is unclear which information about such issues is already available today for commodity traders and for which information they would have to ask possible suppliers including other trading companies.

As mentioned at the beginning of this study, so far it is not easily possible to give a full picture on the Swiss commodity trading sector including e.g. the amounts of all commodities traded by Swiss companies. Statistics developed by the SNB are a first starting point, but more detailed information would be necessary to follow-up the developments also from an environmental perspective.

Today generally environmental reports of large companies often lack information concerning the real environmental impacts caused, because only relative developments for some indicators are reported. Also, often only a very limited list of emissions and resource uses or direct inputs and outputs is covered. From a political perspective it would be important to report also key figures about the products produced and the total emissions or energy uses caused by these production processes. For trading companies such emissions could be reported under the scope 3 level.

Supply Chain analyses bring transparency for customers and investors. They can help minimise risks by identifying hotspots in the whole supply chain.

For the Food & Agriculture Sector, an assessment tool[41] developed by the Research Institute of Organic Agriculture (FiBL) exists which makes it possible for food companies and agricultural producers to evaluate, report and profit from their sustainability performance.[42] The SMART tool is based on the SAFA-Guidelines. The SAFA – Sustainability Assessment of Food and Agriculture Systems – sustainability guidelines, have been published in December 2013 by the

41 (SMART (Sustainability Monitoring and Assessment RouTine)

42 https://www.sustainable-food-systems.com/en/

Food and Agriculture Organization of the United Nations (FAO). With this holistic interpretation of the major sustainability themes, the SAFA guidelines provide an overarching common sustainability language and framework for the food and agriculture sector.[43]

The Responsible Mining Index[44] (RMI, supported by SECO among others) is another example aiming for transparency in the mining sector. It is an index that asses mining company policies and their practices on economic, environmental, social and governance issues.

5.2 International sustainability standards, initiatives and labels

International standards are an important prerequisite to extend the information available within the trade of such commodities. The development of such international environmental standards would be recommended (if not yet available) also for other commodities (e.g. sugar, cereals, metals, energy carriers). This is seen as an important prerequisite to better differentiate products with higher or lower environmental relevance. Furthermore, this would help to pass on information about the production conditions in the first process stages down to the final consumers. Complying with international environmental standards enable companies to be competitive by selling better quality products, and so are not put at a disadvantage in highly globalized markets. This involves working towards their consistent implementation.

In the following some examples of relevant standards, labels or other initiatives for the selected commodities are mentioned (non-exhaustive list):

- International standard for the environmental indicators to be used in the trade of bioenergy products (ISO 13065 2015)
- Round table for sustainable palm oil (RSPO)
- Roundtable on Sustainable Biomaterials (RSB) https://rsb.org/
- Round table on responsible soy, http://www.responsiblesoy.org
- Better Gold Association, http://www.swissbettergold.ch
- Fair-mined Label, http://www.fairmined.org
- Organic farming labels, e.g. www.ifoam.org
- Max Havelaar, Fair trade label, www.maxhavelaar.ch

Further information about the use of labels and environmental product declarations for providing information about environmental impacts of products is provided in the annexe chapter 11.

5.3 Show externalised costs

It can be assumed, that monetary units and systems are most relevant for traders. Therefore, if traders do not have certain environmental standards at hand to access if a certain commodity bears a high environmental burden, traders might find it useful to know about estimates on externalised costs[45] associated with the extraction and use of certain commodities.

Externalised costs occur when producing or consuming a good or service imposes costs upon a third party, e.g. driving a car imposes a private cost on the driver (cost of petrol, tax and buying car). However, driving a car creates costs to other people in society. These can include:

- *Greater congestion and slower journey times for other drivers.*

43 http://www.fibl.org/en/themes/smart-en/safa-guidelines.html
44 https://responsibleminingindex.org/
45 https://www.economicshelp.org/blog/glossary/external-costs/

- *Cause of death for pedestrians, cyclists and other road users.*
- *Pollution, health related problems.*
- *Noise pollution.*

Pollution of air, water and soil and health related problems also occur during the extraction or farming of the commodities under study. Therefore, also for the use of these commodities, there are hidden costs that are paid by people in the society instead of the direct consumer.

If estimates for such externalised costs were integrated in the commodity description or internalised in the price, a trader might choose the environmentally preferable option presuming the price is the same or he can profit from a price premium when reselling. If traders have no interest to show these hidden costs maybe investors might have. Investors might be sensitized for this and request such information from the traders.

A reason why fossil energy sources and other products with high environmental impacts are still competitive is due to high externalised costs. However, so far it was politically not feasible to pose steering fees e.g. on fossil fuels to change that. It seems that this only would be possible with a global agreement and/or environmentally preferable options available for a competitive price.

Methodological recommendations for quantifying external costs based on LCA data could be developed, bearing in mind that monetary valuations result in considerable differences depending on the methods applied, the localisation of effects and critical assumptions taken.

5.4 Setting environmental targets

Companies active in commodity trading should also develop environmental targets including the impacts of the traded commodities (Daub *et al.* 2016).

5.5 Best practices

If trading certified products works well for a trading company, it could also profit from presenting and selling their knowledge about sustainable practices to other companies and customers. Governments or international organizations could collect best practices and make them easily available for companies. A collection of best practices, could help the sector to develop, strengthen and implement its codes of conduct, concerning environmental due diligence and environmental management. An idea could be for governments to support best practices, high performing companies, e.g. by providing awards to companies or considering such issues in the tax negotiations.

Without external pressure (NGO/societal pressure, regulations, etc.), companies might be reluctant to change their business conduct, because this can involve costs without having a clear security about the benefits. If they want to change, they might learn from examples of best practice. If such examples are available, this could create a positive reinforcement effect, as more environmentally preferable products would be demanded.

5.6 Governance of the commodity sector

Governments should foster the dialogue with the private sector and strengthen the implementation of sustainability standards, and gradually strengthen framework conditions, e.g. on environmental due diligence, at national and international levels. International and national developments points to that direction e.g. France's loi de vigilance. In Switzerland, the popular initiative for responsible business also points to that direction. [46]

At the national level, the idea to set up a specific authority for the sector has been advanced by Public Eye. The proposed ROHMA[47] (Swiss Commodity Market Supervisory Authority) would look at this sector in a way comparable to the existing authority for the financial market. As an independent authority, ROHMA could contribute to reducing the problem of the resource curse and to mobilizing resources for development and poverty reduction in commodity-rich developing countries through the supervision and regulation of commodity production and trading companies, as well as of gold refineries and importers.

6 Recommendations for further analysis

6.1 Choice of indicators and database

The choice of indicators and background database for this study was chosen to ensure to the extent possible a comparability with other studies commissioned by FOEN.

The footprint indicators for biodiversity and water can only be used if regionalized flows for land occupation and transformation and water use are available in the database used. Furthermore, missing characterisation factors for several types of land occupation must be integrated in LCIA method for biodiversity (see chapters 3.3.2 and 9).

In the scope of this study it was not foreseen to integrate regionalised information for all datasets present in the KBOB database or use a database that can supply such information (e.g. ecoinvent v3.4). Furthermore, characterisation factors are missing in the LCIA method provided by FOEN for many water flows present in the KBOB database or ecoinvent v3.4 data. Thus, they would have to be complemented for such a study in the LCIA method. It is not recommendable to make evaluations with this indicator under these pre-conditions of using the existing KBOB database.

For the regionalisation of the two indicators the study Frischknecht et al. (2018) will provide a description in the technical report and a manual for implementation in LCI, but this was not yet available for conducting the study at hand.

The data for particle emissions of iron ore in the KBOB database seem to be too high. An update of these LCI data as done for this study is recommended.

It must be noted that almost all issues covered in the single-issue footprint indicators are also covered in the overall environmental footprint method.

6.2 Further commodities to be investigated

Research done for this project indicate that the following commodities also seem to be of importance for the trade in Switzerland.[48] It would be recommended to include them in a future study. However, without knowing the global production nor any quantities traded by Swiss companies, yet it is not possible to forecast how important they will be for the total picture.

46 See: https://www.bk.admin.ch/ch/f/pore/vi/vis462.html and http://konzern-initiative.ch/downloads/
47 http://www.rohma.ch/en/
48 https://www.thebalance.com/the-most-actively-traded-commodities-809314

- Corn
- Ethanol[49]
- Rice
- Soy beans
- Soy bean oil
- Alumina[50]
- Lead
- Nickel
- Platinum
- Silver
- Zinc
- Gemstones
- Fertilizer[51]

6.3 Operational emissions of Swiss companies

The company Glencore reports total greenhouse gas emissions of 36.5 million tonnes CO_2-eq in Scope 1 and 2 (direct emissions e.g. from burning fuels plus emissions from electricity use but excluding purchased or traded goods).[52] This is more than half of the 50 million tonnes reported as direct Swiss emissions.[53] This example alone shows that the previous and ongoing studies on Swiss production and consumption do not cover all emissions caused by Swiss companies, because important parts of these direct emissions will take place at locations outside Switzerland. This concerns also other global companies controlled from a Swiss head office (e.g. Nestle).

This aspect is not fully considered in the present study and further research about emissions that can be associated to Swiss companies would be necessary. But, so far information for other companies in the transit trade sector was not found. And this issue might also be relevant for other sectors were companies are controlled from a Swiss head office, but major production activities take place abroad.

6.4 Inclusion of paper trading for hedging purposes

Besides the physical trading activity, one could think about adding the “paper trading” used for hedging purposes in the analysis. A hedge is a risk management technique used to reduce any substantial losses or gains suffered by an individual or an organization. In this case the trade is entered in a system but only executed under certain conditions. For oil trading, the paper trading for hedging is estimated to be 10 to 15 times the size of the physical market.[54] But, including

49 Four major players on the ethanol market (industrial, edible, bio-fuels) are based in Geneva or surroundings.
50 Intermediate product between bauxite and aluminium. So far no LCI data in ecoinvent.
51 http://www.keytrade.ch/en/ and www.ameropa.com
52 http://www.glencore.com/assets/investors/doc/reports_and_results/2016/GLEN-2016-Annual-Report.pdf
53 https://www.bafu.admin.ch/bafu/de/home/themen/klima/daten-indikatoren-karten/daten/treibhausgasinventar.html
54 https://stsa.swiss/knowledge/main-players/companies

this factor in the analysis would clearly include a double counting as the physical trading already amounts to about 1/3 of the global market. Also, more quantitative information about paper trading for single commodities was not found. Thus, a factor for paper trading was not included in the analysis. It can be assumed that with the paper trading the upper limit of the global annual production (or physical trade) as described in chapter 3.1.1.1 could be met even by Swiss companies.

Finally, besides commodity derivatives, freight also has its derivative[55] market (FFAs) which is actively traded in Geneva. Thus, it might be interesting to look on the activities on this market for freight derivates as well. But, this might be even more complex than the investigation done in the study at hand.

6.5 Inclusion of production activities controlled by Swiss companies

A further extension of the scope of such a study would be the inclusion of production activities abroad controlled by Swiss companies. Two examples are given in chapter 3.1.1.3. On the one hand Swiss companies might be directly involved in extraction and production of commodities such as crude oil. On the other hand, Swiss companies are also controlling global production chains e.g. of food products. Environmental impacts of such activities are not yet covered in studies dealing with Swiss production and consumption because factory locations are outside Switzerland and thus the physical movements of the commodities produced, processed and sold are not covered in the Swiss foreign trade statistics.

6.6 Further use of products traded

From an environmental point of view, the use phase is very important and relatively easy to determine for certain individual products (e.g. fuels, fertilisers) and is therefore already included in the previous study on products (Stucki *et al.* 2012). For other products, the use is rather insignificant from an environmental point of view and/or difficult to determine (e.g. foodstuffs) and is therefore not taken into account there (Jungbluth et al. 2011a; Stucki et al. 2012).

Trade can also be responsible for significant environmental impacts in other countries when it comes to the use of products. For example, Swiss companies are involved in trading in particularly high-sulphur-containing diesel, which is burned in Africa (Guéniat et al. 2016).[56,57] In addition to the production of the traded commodities, their use may also be relevant (in this case SO_x emissions during diesel combustion).

6.7 Comparison with environmental impacts reported in other studies and in the present study

It must be noted that because of the different system boundaries (trade, consumption, production; see figures 1.1. and 1.2) there might be overlaps between the environmental impacts reported in the present study and in other studies cited in chapter 1.5. According to the systematic

55 In finance, a derivative is a contract that *derives* its value from the performance of an underlying entity. Derivatives can be used for a number of purposes, including insuring against price movements (hedging), increasing exposure to price movements for speculation or getting access to otherwise hard-to-trade assets or markets. https://en.wikipedia.org/wiki/Derivative_(finance)

56 http://www.ccacoalition.org/sites/default/files/resources/New%20Factsheet%20-%20Diesel%201.4%20web.pdf, online 24.08.2017

57 http://www.unep.org/transport/pcfv/sulphur-campaign, online 24.08.2017

approach followed in other studies, all environmental impacts from commodity trading are ultimately attributed to consumer products. Since consumption of the commodities examined here often takes place abroad, this results in double counts when looking at studies for Swiss or foreign consumption and the study at hand looking at the trading activities of Swiss companies.

Thus, results presented in this study should not be added-up with results from other studies e.g. to further "increase" environmental impacts by Swiss production and consumption.

Double counting can occur if the same commodities are traded several times by Swiss companies, e. g. if a Swiss company sells the commodity to another Swiss company and it is only used afterwards.

It cannot be determined what percentage of commodities traded by Swiss companies is finally imported to Switzerland. Therefore, an addition of the environmental impacts calculated in this study to the contribution to the Swiss overall environmental impact is not directly possible.

A comparison with the environmental footprints of Swiss consumption (BAFU, 2018) can be found in figure 4.1. Like this, the dimensions can be illustrated but the different system boundaries must be kept in mind (trade vs. consumption perspective). A brief discussion concerning differences with the water and biodiversity footprint methods used in Frischknecht et al. (2018) and Nathani et al. (2018) can be found in the annex and chapter 6.1. Also concerning the material use comparability is not given, since some types of biomass have not been included in this method. Therefore, it would be necessary to apply a factor on the elementary flow for "Energy, gross calorific value, in biomass" to account for the biomass harvested with agricultural crops.

Overlaps with the ongoing study on environmental hotspots (Nathani *et al.* 2018) occur if commodities investigated here finally end up in products imported to Switzerland. Furthermore, the amounts recorded here for gold trade are also covered in this parallel and former studies on Swiss production and consumption because gold is imported to Switzerland.

Possible overlapping and double counting cannot be fully avoided, but they must be kept in mind for the interpretation of results.

7 Bibliography

BAFU 2013 BAFU (2013) Grüne Wirtschaft: Berichterstattung und Aktionsplan - Bericht an den Bundesrat. Bundesamt für Umwelt,, Bern, retrieved from: www.bafu.admin.ch/wirtschaft/11350/12928/index.html?lang=de.

BAFU 2014 BAFU (2014) Entwicklung der weltweiten Umweltauswirkungen der Schweiz: Umweltbelastung von Konsum und Produktion von 1996 bis 2011, retrieved from: http://www.bafu.admin.ch/publikationen/publikation/01771/index.html?lang=de.

BFS 2015 BFS (2015) Der Material-Fussabdruck der Schweiz, retrieved from: https://www.bfs.admin.ch/bfs/de/home/statistiken/raum-umwelt/umweltgesamtrechnung/materialfluesse.assetdetail.350078.html.

Blonk 2014 Blonk (2014) Agri-footprint: Methodology and basic principles. Blonk Agri-footprint BV, Gouda, The Netherlands, retrieved from: www.agri-footprint.com.

Boulay et al. 2018 Boulay A.-M., Bare J., Benini L., Berger M., Lathuillière M. J., Manzardo A., Margni M., Motoshita M., Núñez M., Valerie-Pastor A., Ridoutt B., Oki T., Worbe S. and Pfister S. (2018) The WULCA consensus characterization model for water scarcity footprints: assessing impacts of water consumption based on available water remaining (AWARE). *In: Int J LCA*, **23**(2), pp. 368–378.

BP 2017 BP (2017) BP Statistical Review of World Energy June 2017. BP, London, retrieved from: bp.com/statisticalreview.

Bürgi Bonanomi et al. 2015 Bürgi Bonanomi E., Wehrli J., Bucher D., Rist S., Giger M., Espa I., Franzi S., Elsig M., Gelb S. R., Holzgang M., Dey P. and Wettstein F. (2015) The Commodity Sector and Related Governance Challenges from a Sustainable Development Perspective: The Example of Switzerland Current Research Gaps, retrieved from: www.cde.unibe.ch/research/projects/policy_coherence_for_sustainable_development/commodity_trading_in_switzerland_and_related_research_needs/index_eng.html.

Chaudhary et al. 2015 Chaudhary A., Verones F., de Baan L. and Hellweg S. (2015) Quantifying Land Use Impacts on Biodiversity: Combining Species–Area Models and Vulnerability Indicators. *In: Environmental Science & Technology*, **49**(16), pp. 9987-9995.

Chaudhary et al. 2016 Chaudhary A., Pfister S. and Hellweg S. (2016) Spatially Explicit Analysis of Biodiversity Loss due to Global Agriculture, Pasture and Forest Land Use from a Producer and Consumer Perspective. *In: Environmental Science & Technology*, **50**, pp. 9987-9995.

Daub et al. 2016 Daub C.-H., Winistörfer H. and Weber M.-C. (2016) Environmental Targets of Companies in Switzerland. Commissioned by the Federal Office for the Environment (FOEN).

Dubach et al. 2015 Dubach B., Eva Tabernig, Zah R., Faist-Emmenegger M. and Masson P. (2015) Analyse zu in der Schweiz verarbeiteten Rohstoffen: Relevanzanalyse zu vierzehn in der Schweiz verarbeiteten Rohstoffen mittels ökologischer, sozialer und marktspezifischer Kriterien. engageability, Zürich, Quantis, Zürich, CSD Ingenieure AG, Bern, Switzerland. .

ecoinvent Centre 2017 ecoinvent Centre (2017) ecoinvent data v3.4, ecoinvent reports No. 1-25. Swiss Centre for Life Cycle Inventories, Zurich, Switzerland, retrieved from: www.ecoinvent.org.

ESU 2018 ESU (2018) The ESU database 2018. ESU-services Ltd., Schaffhausen, retrieved from: www.esu-services.ch/data/database/.

EvB 2011 EvB (2011) Rohstoff: Das gefährliche Geschäft der Schweiz. (ed. Erklärung von Bern (Hg.)). Salis Verlag AG, Zürich.

FC 2016 FC (2016) Background report: Commodities - Third status report on the implementation of the recommendations. Federal Council FC, retrieved from: https://www.newsd.admin.ch/newsd/message/attachments/46475.pdf.

FDFA 2013 FDFA (2013) Background Report: Commodities. Report of the interdepartemental plattform on commodities to the Federal Council, retrieved from: www.news.admin.ch/NSBSubscriber/message/attachments/30136.pdf.

Frischknecht et al. 1996 Frischknecht R., Bollens U., Bosshart S., Ciot M., Ciseri L., Doka G., Dones R., Gantner U., Hischier R. and Martin A. (1996) Ökoinventare von Energiesystemen: Grundlagen für den ökologischen Vergleich von Energiesystemen und den Einbezug von Energiesystemen in Ökobilanzen für die Schweiz. 3. Gruppe Energie - Stoffe - Umwelt (ESU), Eidgenössische Technische Hochschule Zürich und Sektion Ganzheitliche Systemanalysen, Paul Scherrer Institut, Villigen, Bundesamt für Energie (Hrsg.), Bern, CH, retrieved from: www.energieforschung.ch.

Frischknecht & Jungbluth 2000 Frischknecht R. and Jungbluth N. (2000) Graue Treibhausgas-Emissionen des Energie- und des Ernährungssektors der Schweiz: 1990 und 1998. Umwelt-Materialien No. 128. ESU-services, Uster, im Auftrag des Bundesamtes für Umwelt, Wald und Landschaft (BUWAL), Bern, CH, retrieved from: www.umwelt-schweiz.ch.

Frischknecht et al. 2007 Frischknecht R., Jungbluth N., Althaus H.-J., Doka G., Dones R., Heck T., Hellweg S., Hischier R., Nemecek T., Rebitzer G. and Spielmann M. (2007) Overview and Methodology. ecoinvent report No. 1, v2.0. Swiss Centre for Life Cycle Inventories, Dübendorf, CH, retrieved from: www.ecoinvent.org.

Frischknecht et al. 2008 Frischknecht R., Steiner R. and Jungbluth N. (2008) Methode der ökologischen Knappheit - Ökofaktoren 2006. Umwelt-Wissen Nr. 0906. ESU-services GmbH im Auftrag des Bundesamt für Umwelt (BAFU), Bern, retrieved from: www.bafu.admin.ch/publikationen/publikation/01031/index.html?lang=de.

Frischknecht et al. 2013 Frischknecht R., Büsser Knöpfel S., Flury K. and Stucki M. (2013) Ökofaktoren Schweiz 2013 gemäss der Methode der ökologischen Knappheit: Methodische Grundlagen und Anwendung auf die Schweiz. Umwelt-Wissen Nr. 1330. treeze und ESU-services GmbH im Auftrag des Bundesamt für Umwelt (BAFU), Bern, retrieved from: www.bafu.admin.ch/uw-1330-d.

Frischknecht et al. 2015 Frischknecht R., Nathani C., Stolz P., Wyss F. and Itten R. (2015) Extension of a Disaggregated Input-Output Table with Environmental Data for the Year 2008. Treeze im Auftrag Bundesamtes für Umwelt (BAFU), Uster, CH.

Frischknecht & Jolliet 2017 Frischknecht R. and Jolliet O. (2017) Global Guidance on Environmental Life Cycle Impact Assessment Indicators. Volume 1. United Nations Environment Programme, UNEP, Paris.

Frischknecht et al. 2018 Frischknecht R., Nathani C., Alig M., Stolz P., Tschümperlin L. and Hellmüller P. (2018) Umweltfussabdrücke des Schweizer Konsums: Entwicklung der globalen Umweltauswirkungen von Konsum und Produktion in der Schweiz von 1996 bis 2015. Technischer Bericht. treeze Ltd / Rütter Soceco AG, Uster / Rüschlikon, commissioned by the Swiss Federal Office for the Environment (FOEN). Berne.

GfbV 2012 GfbV (2012) Gold: Die Rolle der Schweiz in einem schmutzigen Geschäft. Gesellschaft für bedrohte Völker GfbV, Ostermundigen, retrieved from: www.gfbv.ch.

Goedkoop et al. 2009 Goedkoop M., Heijungs R., Huijbregts M. A. J., De Schryver A., Struijs J. and van Zelm R. (2009) ReCiPe 2008 - A life cycle impact assessment method which comprises harmonised category indicators at the midpoint and the endpoint level. First edition. Report I: Characterisation, NL, retrieved from: lcia-recipe.net/.

Guéniat et al. 2016 Guéniat M., Harjono M., Missbach A. and Viredaz G.-V. (2016) Dirty Diesel. How Swiss Traders Flood Africa with Toxic Fuels. Public Eye, Avenue Charles-Dickens 4, CH-1006 Lausanne.

IPCC 2007 IPCC (2007) The IPCC fourth Assessment Report. Cambridge University Press., Cambridge.

IPCC 2013 IPCC (2013) Climate Change 2013: The Physical Science Basis, Cambridge, United Kingdom and New York, NY, USA, retrieved from: http://www.ipcc.ch/report/ar5/wg1/.

ISO 13065 2015 ISO 13065 (2015) Sustainability criteria for bioenergy. International Organization for Standardization (ISO),, Geneva.

Jungbluth et al. 2007 Jungbluth N., Steiner R. and Frischknecht R. (2007) Graue Treibhausgas-Emissionen der Schweiz: 1990 bis 2004: Erweiterte und aktualisierte Bilanz. UW-0711. ESU-services, Uster, im Auftrag des Bundesamtes für Umwelt (BAFU), Bern, CH, retrieved from: www.umwelt-schweiz.ch/uw-0711-d, www.esu-services.ch/projects/graue-emissionen/.

Jungbluth et al. 2011a Jungbluth N., Büsser S., Frischknecht R., Leuenberger M. and Stucki M. (2011a) Feasibility study for environmental product information based on life cycle approaches. ESU-services GmbH, im Auftrag des Bundesamtes für Umwelt (BAFU), Uster, CH, retrieved from: www.esu-services.ch/publications/methodology/.

Jungbluth et al. 2011b Jungbluth N., Nathani C., Stucki M. and Leuenberger M. (2011b) Environmental impacts of Swiss consumption and production: a combination of input-output analysis with life cycle assessment. Environmental studies no. 1111. ESU-services Ltd. & Rütter+Partner, commissioned by the Swiss Federal Office for the Environment (FOEN), Bern, CH, retrieved from: www.esu-services.ch/projects/ioa/ or www.umwelt-schweiz.ch.

Jungbluth et al. 2012 Jungbluth N., Itten R. and Stucki M. (2012) Umweltbelastungen des privaten Konsums und Reduktionspotenziale. ESU-services Ltd. im Auftrag des BAFU, Uster, CH, retrieved from: www.esu-services.ch/projects/lifestyle/.

Jungbluth et al. 2018a Jungbluth N., Meili C. and Wenzel P. (2018a) Life cycle inventories of oil refinery processing and products. ESU-services Ltd. commissioned by BFE, BAFU, Erdöl-Vereinigung, Schaffhausen, Switzerland, retrieved from: www.lc-inventories.ch.

Jungbluth et al. 2018b Jungbluth N., Meili C., Keller R., Eggenberger S., König A., Doublet G., Flury K., Büsser S., Stucki M., Schori S., Itten R., Leuenberger M. and Steiner R. (2018b) ESU World Food LCA Database - LCI for food production and consumption. ESU-services Ltd., Schaffhausen, CH, retrieved from: www.esu-services.ch/data/data-on-demand/.

Jungbluth et al. 2018c Jungbluth N., Meili C. and Wenzel P. (2018c) Update of LCI data for crude oil and mineral oil products (ongoing). ESU-services Ltd. commissioned by BFE, BAFU, Erdöl-Vereinigung, Schaffhausen, Switzerland, retrieved from: www.lc-inventories.ch.

Jungmichel et al. 2017 Jungmichel N., Schampel C. and Weiss D. (2017) Umweltatlas Lieferketten – Umweltwirkungen und Hot-Spots in der Lieferkette. adelphi/Systain, Berlin/Hamburg.

KBOB v2.2: 2016 KBOB v2.2: (2016) Datenbestand KBOB v2.2:2016. Bundesamt für Umwelt BAFU, Switzerland, retrieved from: www.ecoinvent.org.

Kissling-Näf et al. 2013 Kissling-Näf I., Bernath K., Seyler C., Fussen D., Jungbluth N. and Stucki M. (2013) RessourcenEFFizienz Schweiz REFF: Grundlagenbericht zur Ressourceneffizienz und Rohstoffnutzung. Ernst Basler+ Partner AG und ESU-services GmbH im Auftrag Bundesamt für Umwelt (BAFU), Abteilung Abfall und Rohstoffe, Bern, retrieved from: www.bafu.admin.ch/abfall/10743/index.html?lang=de.

Koch et al. 2015 Koch P., Salou T., Colomb V., Payen S., Perret S., Tailleur A. and Willmann S. (2015) AGRIBALYSE 1.2, retrieved from: www.ademe.fr.

Kounina et al. 2013 Kounina A., Margni M., Bayart J.-B., Boulay A.-M., Berger M., Bulle C., Frischknecht R., Koehler A., Milà i Canals L., Motoshita M., Núñez M., Peters G., Pfister S., Ridoutt B., van Zelm R., Verones F. and Humbert S. (2013) Review of methods addressing freshwater use in life cycle inventory and impact assessment. *In: Int J LCA*, **18**(3), pp. 707-721.

Nathani & Jungbluth 2012 Nathani C. and Jungbluth N. (2012) Zeitreihen für die Gesamtumweltbelastung der Schweizer Endnachfrage: Vorstudie. Rütter+Partner und ESU-services im Auftrag des Bundesamtes für Umwelt, Bern, Rüschlikon, Uster.

Nathani et al. 2018 Nathani C., Frischknecht R., Hellmüller P., Alig M., Stolz P. and Tschümperlin L. (2018) Environmental hotspots in the supply chain of Swiss companies (publication pending). Rütter Soceco AG & treeze Ltd., Rüschlikon & Uster commissioned by FOEN.

Nemecek et al. 2015 Nemecek T., Bengoa X., Lansche J., Mouron P., Riedener E., Rossi V. and Humbert S. (2015) Methodological Guidelines for the Life Cycle Inventory of Agricultural Products. World Food LCA Database (WFLDB). Quantis and Agroscope, Lausanne and Zurich, Switzerland. .

Schoer et al. 2012 Schoer K., Giegrich J., Kovanda J., Lauwigi C., Liebich A., Buyny S. and Matthias J. (2012) Conversion of European product flows into raw material equivalents. . ifeu - Institut für Energie- und Umweltforschung, Heidelberg, Heidelberg, DE.

SimaPro 8.5.3 SimaPro (8.5.3) SimaPro 8.5.3 (2018) LCA software package. PRé Consultants, Amersfoort, NL, retrieved from: www.simapro.ch.

SNB 2012 SNB (2012) Swiss Balance of Payments 2011. Schweizerische Nationalbank, Zürich, retrieved from: https://www.snb.ch/en/iabout/stat/statrep/statpubdis/id/statpub_bop_arch.

SNB 2017 SNB (2017) Zahlungsbilanz der Schweiz 2016. Schweizerische Nationalbank, Zürich, retrieved from: www.snb.ch/d/publikationen/zahlung/zahlung.html.

Solomon et al. 2007 Solomon S., Qin D., Manning M., Alley R. B., Berntsen T., Bindoff N. L., Chen Z., Chidthaisong A., Gregory J. M., Hegerl G. C., Heimann M., Hewitson B., Hoskins B. J., Joos F., Jouzel J., Kattsov V., Lohmann U., Matsuno T., Molina M., Nicholls N., Overpeck J., Raga G., Ramaswamy V., Ren J., Rusticucci M., Somerville R., Stocker T. F., Whetton P., Wood R. A. and Wratt D. (2007) Technical Summary. In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC)*, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Stucki et al. 2012 Stucki M., Schori S., Itten R. and Jungbluth N. (2012) Umweltbelastung und Ressourcenverbrauch von Produkten: Aus Umweltsicht wichtige Produkte und Dienstleistungen in der Schweiz. ESU-services GmbH, Uster, im Auftrag des Bundesamtes für Umwelt (BAFU) (unpublished), Uster, CH.

Wood et al. 2015 Wood R., Stadler K., T. B., S. L. and Giljum S., de Koning, A., Kuenen, J., Schütz, H., Acosta-Fernández, J., Usubiaga, A., Simas, M., Ivanova, O., Weinzettel, J., Schmidt, J.H., Merciai, S., Tukker, A. (2015) Global sustainability accounting-developing EXIOBASE for multi-regional footprint analysis. *In: Sustainability (Switzerland)*, **7**(1), pp. 138-163.

8 Annexe: Changes to LCI data

8.1 Market mix for sugar and wheat

Tab. 8.1 shows the market mixes for wheat grains and sugar applied in this study, which are based on the regional differentiation available in the KBOB database.

Tab. 8.1 Unit process raw data for the global production mix for wheat grains and sugar

Name	Location	Infrastru	Unit	wheat grains, at farm	sugar, at sugar refinery	UncertaintyType	StandardDeviation95%	GeneralComment
Location				GLO	GLO			
InfrastructureProcess				0	0			
Unit				kg	kg			
wheat grains, at farm	GLO	0	kg	1	0			
sugar, at sugar refinery	GLO	0	kg	0	1			
sugar, from sugar beet, at sugar refinery	CH	0	kg		21.35%	1	1.21	(1,1,1,1,3,BU:1.05); Annual production; https://www.suedzucker.de/en/Zucker/Zahlen-zum-Zucker/Welt/
sugar, from sugarcane, at sugar refinery	BR	0	kg		78.65%	1	1.21	(1,1,1,1,3,BU:1.05); Annual production; https://www.suedzucker.de/en/Zucker/Zahlen-zum-Zucker/Welt/
wheat grains conventional, Barrois, at farm	FR	0	kg	26.9%		1	1.21	(1,1,1,1,3,BU:1.05); Annual production; https://en.wikipedia.org/wiki/International_wheat_production_statistics
wheat grains conventional, Castilla-y-Leon, at farm	ES	0	kg	4.5%		1	1.21	(1,1,1,1,3,BU:1.05); Annual production; https://en.wikipedia.org/wiki/International_wheat_production_statistics
wheat grains conventional, Saxony-Anhalt, at farm	DE	0	kg	19.2%		1	1.21	(1,1,1,1,3,BU:1.05); Annual production; https://en.wikipedia.org/wiki/International_wheat_production_statistics
wheat grains extensive, at farm	CH	0	kg	0.0%		1	1.21	(1,1,1,1,3,BU:1.05); Annual production; https://en.wikipedia.org/wiki/International_wheat_production_statistics
wheat grains IP, at farm	CH	0	kg	0.4%		1	1.21	(1,1,1,1,3,BU:1.05); Annual production; https://en.wikipedia.org/wiki/International_wheat_production_statistics
wheat grains organic, at farm	CH	0	kg	0.0%		1	1.21	(1,1,1,1,3,BU:1.05); Annual production; https://en.wikipedia.org/wiki/International_wheat_production_statistics
wheat grains, at farm	US	0	kg	49.1%		1	1.21	(1,1,1,1,3,BU:1.05); Annual production; https://apps.fas.usda.gov/psdonline/circulars/grain-wheat.pdf

8.2 Iron ore

In a draft evaluation of the air pollution footprint emissions of particles in the iron ore processes turned out to dominate the results. The emissions of particles are recorded with 1.3 g/kg iron ore at mine in the KBOB database. No corrections have been made to this figure in ecoinvent v3.4, thus data are still the same in this latest version. The results calculated with other databases (e.g. Frischknecht et al. 1996; Wood et al. 2015, US EE-IOT in SimaPro) for iron ore are considerably (50% to 95%) lower.

Most up-to-date seem to be data for steel published by the World Steel Association,[58] But, in SimaPro only cumulative data are available for steel products. For steel they also show considerable lower results than the ecoinvent data. Results for steel are in the range of 1g particles per kg compared 3 to 10 times higher figures calculated with ecoinvent data. The world steel data does not seem to record all flows for the material footprint (iron ore resource) and thus these data available in SimaPro are not a suitable replacement in this study.

It must be noted that differences in the assignment of the size of particles might limit the comparability. Only small sizes are evaluated with the LCIA method in this study.

In conclusion, the present data in the KBOB database seem to overestimate these impacts. The choice of datasets (iron ore 46%, iron ore 65% or steel) is quite crucial for results.

We received an updated estimate for particle emissions in iron ore production by World Steel as shown in Tab. 8.2.[59] A correction for the "iron ore" dataset has been made according to these emission factors and it was applied to the ESU-database (ESU 2018).

We are unable to share the full Iron Ore process that we have from thinkstep. But, we can extract the particulates to air emissions. Below are the emissions (in kg) from the process for 1 kg Iron Ore, where the top line is the sum of the flows below. It appears to be over 10 times smaller than the data you have found in Ecoinvent, which would be why you find such a large impact for iron ore mining compared with other studies.

58 www.worldsteel.org

59 We received information by Clare Broadbent and Iain Millar in April 2018.

Tab. 8.2 Data received by Worldsteel for particle emissions during iron ore production

	kg/kg iron ore
Particles to air	0.000117
Aluminium oxide (dust)	-4.47E-13
Dust (> PM10)	1.08E-06
Dust (PM10)	1.34E-09
Dust (PM2,5 - PM10)	2.67E-06
Dust (PM2.5)	0.000113
Metals (unspecified)	1.18E-12
Silicon dioxide (silica)	6.47E-13

9 Annexe: Description of LCIA (life cycle impact assessment) methods for environmental indicators

Overview:

- Overall environmental footprint. Ecological scarcity method 2013 (Frischknecht et al. 2013)
- Greenhouse gas footprint (Solomon et al. 2007)
- Biodiversity footprint (Chaudhary et al. 2015; Chaudhary et al. 2016)
- Eutrophication footprint (Marine eutrophication, Goedkoop et al. 2009)
- Air pollution footprint (particulate matter, Goedkoop et al. 2009)
- Water footprint (Kounina et al. 2013)
- Material footprint (Ores, minerals, fossil energy, (woody) biomass) (Schoer *et al.* 2012).

Description of LCIA methods are provided for this study by the FOEN (Frischknecht *et al.* 2018). The methods have been provided as a CSV file for SimaPro and were imported for calculating the final indicator results.

Overall environmental footprint according to the Ecological scarcity method 2013 (Frischknecht *et al.* 2013, No specific description available).

Climate change (**greenhouse gas footprint**): The climate impact of greenhouse gases is expressed in terms of global warming potential (GWP) according to the 4th Assessment Report of the Intergovernmental Panel on Climate Change (CO2 equivalents according to IPCC 2007). The additional heating effects of stratospheric emissions from aircraft are considered. The calculation of the corresponding characterization factors is described in the technical report (Frischknecht *et al.* 2018). These emissions are also covered in the overall environmental footprint.

Loss of biodiversity through land occupation (**biodiversity footprint**): Land occupation has a major impact on biodiversity and species loss. The indicator for the species loss potential (Chaudhary *et al.* 2016) quantifies the potential damage of land use in relation to biodiversity. The indicator quantifies the loss of species in amphibians, reptiles, birds, mammals and plants by using an area as farmland, permanent crop, pasture, intensively used forest, extensively used forest or settlement area. The indicator weighted endemic species higher than species that are common. The loss of species is determined in relation to the biodiversity of the natural state of the area in the region concerned. This indicator was recommended by the UNEP SETAC Life Cycle Initiative as currently the best available indicator for a transitional period ("interim recommendation", Chaudhary et al. 2015; Chaudhary et al. 2016; Frischknecht & Jolliet 2017). Within this study this indicator can only be applied without regionalization of land occupation flows as such a differentiation is not part of the KBOB background database. Hence, a substantial underestimation of this indicator can be expected. Impacts on biodiversity are covered also in the overall environmental footprint with several different factors (land occupation, water use, eutrophication, pesticides, acidification, etc.).

Overfertilization (**eutrophication footprint**): The introduction of nitrogen into the environment causes a wide range of problems. The most obvious of these is marine eutrophication ("overfertilization"): This indicator quantifies the amount of nitrogen that potentially enters the oceans via the emission of nitrogen compounds into water, air and soil and contributes to overfertilization there (Goedkoop *et al.* 2009). The quantities of nitrogen are considered according to their marine eutrophication potential (kg N equivalents). These emissions are also covered in the overall environmental footprint.

Particulate matter (**air pollution footprint**): The extent of air pollution has a major influence on the health and thus the well-being of the population. Air pollution is described with primary and secondary particles and the associated effects on human health, such as respiratory diseases (Goedkoop *et al.* 2009). The emissions of the fine dust precursors NOX, SO2 and NH3 are added to the direct emissions of fine dust according to their potential to form fine dust (kg PM10 equivalents). These emissions are also covered in the overall environmental footprint.

Water use (**water footprint**): Describes how much Switzerland uses the global resource (fresh) water, considering the water shortage in the production regions. This is illustrated by the water scarcity indicator AWARE recommended by the UNEP SETAC Life Cycle Initiative (Boulay *et al.* 2018). Specifications: consuming water use, non-specific activity. Within this study water flows are only partly regionalized in the underlying background database. Thus, most water flows are characterised with the average global or European factor. It is not clear if this over or underestimates the impacts (or shows the same results as with a regionalized database. These resource uses are also covered in the overall environmental footprint.

Raw materials (**material footprint**, RMC): The material footprint quantifies the consumption of raw materials at home and abroad caused by a country's domestic final demand. The Swiss material footprint is collected by the FSO according to the method of the Statistical Office of the European Union (Eurostat) and divided into the categories ores, minerals, fossil fuels and biomass (BFS 2015). In this study, the material footprint is modelled with the data used here to determine the influence of method and data basis on the results. For the quantification of the material footprint, the total amount of materials required for the manufacture of a product is considered, not just the product itself. Each raw material extraction is multiplied accordingly by one raw material equivalent (RÄ, quantity ore per kg metal, 95.8 kg ore per kg copper). The RÄ factors for ores are based on data from Schoer et al (2012). Only woody biomass is considered with the implementation of this method provided by FOEN and the KBOB database. No elementary flows concerning the production of agricultural biomass are recorded in the KBOB database that could be used with the factors provided for fish, fodder, etc. No extensions have been made to the background database for this indicator. These resource uses are also covered in the overall environmental footprint.

10 Annexe: Further results

10.1 All environmental impacts of extraction, processing and transport of commodities traded by Swiss companies

Tab. 10.1shows the results for the calculation of environmental impacts due to the production of commodities traded by Swiss companies.

The ratio for biodiversity footprint and water footprint to total impacts in Fig. 4.1 would be quite low, which is a first indication of a possible underestimation, which is further analysed in the following chapters.

Tab. 10.1 Environmental impact of extraction, processing and transport of commodities traded by Swiss companies, including biodiversity and water footprint.

	Overall environmental footprint	Greenhouse gas footprint	Biodiversity footprint	Water footprint	Air pollution footprint	Eutrophication footprint	Material footprint
	UBP'13	kg CO2 eq	PDF*a	m3-eq	kg PM10 eq	kg N eq	RME
Commodities, energy sources	*1.82E+15*	*9.59E+11*	*7.57E-05*	*3.60E+10*	*1.57E+09*	*3.90E+08*	*2.70E+12*
· crude oil	9.18E+14	3.70E+11	1.67E-05	1.23E+10	7.43E+08	1.65E+08	9.51E+11
· diesel (Middle distillates)	2.69E+14	1.41E+11	4.55E-06	3.99E+09	2.32E+08	4.70E+07	2.56E+11
· petrol (light distillates)	2.56E+14	1.36E+11	4.26E-06	4.29E+09	2.40E+08	4.52E+07	2.39E+11
· natural gas	2.07E+14	1.72E+11	1.48E-06	2.21E+09	1.25E+08	1.59E+07	5.53E+11
· coal	1.69E+14	1.41E+11	4.87E-05	1.32E+10	2.28E+08	1.18E+08	6.98E+11
Commodities, ores and metals	*9.05E+14*	*1.30E+11*	*1.61E-05*	*3.21E+10*	*8.41E+08*	*1.21E+08*	*2.90E+12*
· iron ore	9.08E+13	1.60E+10	8.34E-07	7.54E+09	2.51E+08	1.42E+07	1.29E+12
· copper	4.24E+14	1.59E+10	4.24E-06	2.83E+09	3.88E+08	3.98E+07	6.64E+11
· bauxite	1.50E+12	2.42E+08	4.32E-08	8.18E+08	5.33E+06	9.56E+05	6.83E+10
· aluminium	9.04E+13	7.07E+10	2.02E-06	1.67E+10	1.09E+08	2.40E+07	9.91E+10
· gold	2.99E+14	2.75E+10	9.01E-06	4.22E+09	8.76E+07	4.19E+07	7.82E+11
Commodities, agricultural goods	*1.02E+15*	*1.67E+11*	*5.99E-05*	*4.24E+10*	*5.00E+08*	*7.57E+08*	*1.26E+11*
· coffee	1.18E+14	2.33E+10	4.71E-06	0.00E+00	8.63E+07	2.01E+08	2.06E+10
· cocoa	2.55E+14	2.24E+10	3.41E-07	0.00E+00	4.30E+07	1.02E+08	4.46E+09
· cereals (wheat)	4.88E+14	5.10E+10	2.49E-06	1.92E+09	1.25E+08	2.42E+08	5.17E+10
· sugar	3.36E+13	6.90E+09	3.66E-07	5.62E+09	3.13E+07	3.68E+07	1.29E+10
· vegetable oils (palm oil)	8.83E+13	4.39E+10	5.08E-05	3.00E+09	1.68E+08	1.44E+08	2.25E+10
· cotton	3.98E+13	1.95E+10	1.14E-06	3.18E+10	4.65E+07	3.14E+07	1.36E+10
Total	**3.75E+15**	**1.26E+12**	**1.52E-04**	**1.11E+11**	**2.91E+09**	**1.27E+09**	**5.72E+12**

10.2 Biodiversity footprint

Coal has a relevant impact on biodiversity footprint due to the wood used in coal underground mining. However, it is likely that the impact of agricultural commodities is heavily underestimated (see later discussion on shortcomings of the results).

About one third of total estimated biodiversity footprint is due to land occupation for palm oil production. About one quarter of total biodiversity footprint is due to the use of wood in underground coal mining. This high importance of this single process is somewhat surprising and might also be due to an error in underlying LCI data recording the amount of wood used in the underground mine. Or it might be due to incorrect data for the share of underground mines vs. open cast mines. A short internet research did reveal slightly lower figures for the wood use in underground mines (2kg/t instead of 7kg/t) but not a major error here. An in-depth controlling of the background database was not foreseen during this project.

The LCIA method provided for this study does not include characterisation factors for land occupation of “annual crops”, “pastures, manmade” or “arable land, unspecified use” (as recorded in the KBOB database). This is the reason why agricultural commodities with the exception of palm oil do not show up in this analysis.

In conclusion, the results underestimate the impact on biodiversity, especially for other agricultural products besides palm oil. They can only be seen as a pilot calculation. Future work is needed and can depart from the recommendations in chapter 3.3.2 and the biodiversity footprints as presented by the BAFU (Frischknecht et al. 2018).

It must be noted that country specific characterisation factors for land occupation cannot be applied with the database agreed on for this project because of a lack of such specific information in the KBOB database. Future work must integrate regionalised flows in the database together with country specific characterisation factors in the LCIA method.

10.3 Water footprint

According to the evaluation of available data, the most relevant issue for the water footprint would be the irrigation for cotton production in China. But, it must be noted that only data for cotton production in this country are applied in the life cycle inventory for this study. However, cotton for trade is produced in different countries and the water use and characterisation factors for water footprint can be quite different from country to country. Thus, these data are not fully representative for the global situation and they should not be used to justify a specific focus on China.

The rest of the water footprint is assigned to several processes such as hydro power production or tap water. No clear priority regarding process stages or products can be identified.

11 Annexe: Environmental labels, standards and product information

Extract from a former study on environmental product information (Jungbluth *et al.* 2011a).

11.1 ISO standard 14020ff for labels and product declarations

The most important standard for environmental labels and declarations is the ISO 14020 (International Organization for Standardization (ISO) 2000). This document provides guidance on the goals and principles that should frame all environmental labelling programmes and efforts, including practitioner programmes and self-declaration. There are three types of environmental labels defined by ISO.

Type I, described in ISO 14024, are environmental labels with criteria set by third parties (not the manufacturer). They are in theory based on life cycle impacts and are typically based on pass/fail criteria. ISO 14024 provides the principles and protocols that third-party labelling, "seal" or "practitioner" programmes should follow when developing environmental criteria for a particular product. The intention is to standardise the criteria used by a multitude of such programmes worldwide and to generate greater agreement among stakeholders.

Type II, described in ISO 14021, are environmental labels based on the manufacturers’ or retailers’ own declarations.

Type III, described in ISO 14025, are declarations that provide quantitative details of the impact of the product based on its life cycle. Sometimes known as EPDs (Environmental Product

Declarations), these labels are based on an independent environmental assessment of the life cycle of the product. The data supplied by the manufacturing companies are also independently reviewed.

In ISO 14020, 9 principles are declared that should be followed by Type I, II, and III labels:

Environmental labels and declarations shall be accurate, relevant and not misleading.
Procedures and requirements for environmental labels and declarations shall not be prepared, adopted, or applied with a view to, or with the effect of, creating unnecessary obstacles to international trade.
Environmental labels and declarations shall be based on scientific methodology that is sufficiently thorough and comprehensive to support the claim and that produces results that are accurate and reproducible.
Information concerning the procedure, methodology, and criteria used to support environmental labels and declarations shall be available and provided to all interested parties.
The development of environmental labels and declarations shall take into consideration all relevant aspects of the life cycle of the product.
Environmental labels and declaration shall not inhibit innovation, which maintains or has potential to improve environmental performance.
Any administrative requirements or information demands related to environmental labels and declarations shall be limited to those necessary to establish conformance with applicable criteria and standards of the labels and declarations.
The process of developing environmental labels and declarations should include an open, participatory consultation with interested parties. Reasonable efforts should be made to achieve a consensus throughout the process.
Information on the environmental aspects of products and services relevant to an environmental label or declaration shall be available to purchaser and potential purchaser from the party making the environmental label or declaration.

Furthermore, ISO states that environmental labels and declarations including those developed or operated in a government-sponsored way shall be voluntary in nature and they shall demonstrate transparency through all stages of their development and operation. Labelling programmes shall be able to demonstrate that sources of funding do not create a conflict of interest. Labels should follow one ISO Type and Type I and Type II labels should not be merged during communication together with a Type III environmental declaration.

The ISO standard can clarify the basic principles of good environmental declarations. It can be an important normative basis for any approach developed for environmental product information.

11.2 Environmental Product Declaration (EPD)

Environmental Product Declaration (EPD) is a voluntary tool to communicate the environmental performance of a company’s product. The overall goal of an EPD is to provide relevant, third party verified, and comparable information to meet various customer and market needs. The international EPD®system is one possible approach. It has the ambition to help and support organisations to communicate the environmental performance of their products (goods and services) in a credible, transparent, and understandable way.

The system has developed general methodological instructions (EPD 2008). The methodology for a particular product group is than defined in product category rules (PCR, e.g. PCR CPC 17 2007 for electricity, stem, etc.). Different producers or associations openly discuss the PCR for a specific product group. So far about 130 such PCRs have been developed or initiated in this system. They cover groups such as mineral water, milk, sparkling wine, windows, fertiliser, etc.

For the specific product, environmental impacts for a list of impact categories are evaluated in an LCA from cradle to gate. There is no one-score weighting system, but a declaration of certain pollutants and resource uses (e.g. water consumption, energy carriers, wastes) as well as results for LCIA impact categories such as climate change, resource use, acidification, eutrophication, etc. as defined in the PCR. An own list of characterisation factors has been published (annexe B to EPD 2008) and is available in LCA software such as SimaPro.

The underlying data used in the LCA need to be externally verified. EPDs are mainly set up for business-to-business communication. However, communication to end consumer is also possible. The producer is responsible for the LCA calculations, which are documented in a report and approved by a technical committee linked to the International EPD Consortium. The EPD documents for single products and producers are publicly available on the homepage of the EPD®system (e.g. Electrolux 1997).

The EPD®system is a non-profit organisation that was founded based on a cooperation between interested parties from any country wanting to join the activities. So far partners seem to stem mainly companies and research institutes from Sweden and Italy and include the European Commission's Joint Research Centre.

Sources: EPD®system: www.environdec.com. Other approaches for EPDs are carried out in Norway (www.epd-norge.no), Japan (www.jemai.or.jp), USA (www.scscertified.com), and South Korea (www.scscertified.com).

12 Annexe: Publication of newly investigated data

In addition to the reports, the data newly compiled during the project and the results are made available in Excel tables for further use (by the contractor, the FOEN or third parties). The data are prepared in such a way that it can be easily traced and used by the FOEN or third parties. The level of detail is as high as analysed in this study.

The Open Data FOEN competence centre is currently developing a concept for Open Data. At the current time "ypst-Server" or "opendata. suisse" are possible. The data for this study are available on the ypst server.

The use of proprietary data had to be limited as far as possible. If proprietary data records are used, this should be listed in the report and the data records should be listed as system tempo processes in the appendix or made available to the FOEN as csv. Therefore, no such data have been used in this study.

In this project some unit processes were newly investigated and imported to SimaPro. This links the traded amounts to background data used for this project.

12.1 Annexe: Excel table with detailed information about data sources and results

Shown in a separate PDF file which will be added here to the final document.

Tab. 12.1 Summary of estimated trading data investigated for this study and used for calculations. (Details explained in above text)

	Unit	**Commodities traded**	Commodities traded, Min	Commodities traded, Max	Total production /consumption	Share of production traded	Amount traded	Best guess share
		CH	CH	CH	GLO	GLO	GLO	CH
Commodities, energy sources	kg	*2.13E+12*			*2.06E+13*	28%	*5.86E+12*	
· crude oil	kg	**7.44E+11**	4.43E+11	7.44E+11	4.40E+12	43%	1.90E+12	39%
· diesel (Middle distillates)	kg	**1.83E+11**	1.09E+11	1.83E+11	1.77E+12	30%	5.22E+11	35%
· petrol (light distillates)	kg	**1.67E+11**	9.96E+10	1.67E+11	1.62E+12	30%	4.78E+11	35%
· natural gas	Nm3	**3.79E+11**	1.88E+10	3.79E+11	3.55E+12	31%	1.08E+12	35%
· coal	kg	**4.67E+11**	1.58E+11	4.67E+11	7.46E+12	18%	1.33E+12	35%
Commodities, ores and metals	kg	*9.98E+11*			*2.64E+12*	63%	*1.66E+12*	
· iron ore	kg	**9.30E+11**	4.71E+10	9.30E+11	2.28E+12	68%	1.55E+12	60%
· copper	kg	**8.58E+09**	3.50E+09	8.58E+09	2.25E+10	64%	1.43E+10	60%
· bauxite	kg	**4.60E+10**	2.74E+10	4.60E+10	2.74E+11	28%	7.67E+10	60%
· aluminium	kg	**1.39E+10**	8.27E+09	1.39E+10	6.34E+10	37%	2.32E+10	60%
· gold	kg	**2.10E+06**	5.95E+04	2.10E+06	3.15E+06	100%	3.15E+06	67%
Commodities, agricultural goods	kg	*1.37E+11*			*1.00E+12*	30%	*3.04E+11*	
· coffee	kg	**2.88E+09**	8.73E+08	3.24E+09	7.57E+09	71%	5.40E+09	53%
· cocoa	kg	**1.11E+09**	6.61E+08	1.11E+09	3.97E+09	80%	3.18E+09	35%
· cereals (wheat)	kg	**7.82E+10**	4.66E+10	1.10E+11	7.35E+11	25%	1.83E+11	43%
· sugar	kg	**2.63E+10**	5.00E+08	2.96E+10	1.71E+11	35%	5.92E+10	44%
· vegetable oils (palm oil)	kg	**2.71E+10**	1.61E+10	2.71E+10	6.26E+10	77%	4.82E+10	56%
· cotton	kg	**1.52E+09**	4.00E+08	1.83E+09	2.32E+10	24%	5.50E+09	28%
Total	kg	3.08E+12	9.79E+11	3.11E+12	2.24E+13	32%	7.29E+12	42%
Total, turnover for trade	CHF	9.61E+11	4.26E+11	9.79E+11				

12.2 Annexe: Produced volumes per country

Shown in a separate PDF file which will be added here to the final document.