Progress Report: Methodology of Chilean Food & Agriculture LCI Database

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ABSTRACT

The lack of harmonized and regionally appropriate life cycle inventory databases is one of the main challenges limiting the use of life cycle analysis for decision making on food systems. The food and beverage sector in Chile is important for the country and is strongly focused on exports, where requirements for sustainable practices and value chain transparency are increasing, but there is a lack of technical capacity within companies to analyze and interpret sustainability assessment. In this context, Fundación Chile and Universidad de la Frontera are developing the EcoBase Food project, an environmental information management system for life cycle analysis, through a technological platform, to improve the sustainability and competitiveness of the food and viticulture exports industry. The following document presents a summary of the data collection methodology to create the life cycle inventories for the project, which corresponds to an adaptation from international best practices and is aligned to international initiatives.

Keywords: life cycle analysis, life cycle inventories, Chilean food and viticulture sector, LCI methodology, LCA tools

1. Introduction

The lack of harmonized and regionally appropriate life cycle inventory (LCI) databases is one of the main challenges limiting the use of life cycle analysis (LCA) for decision making on food systems (Heller, Keoleian and Willett, 2013). Several LCA and environmental information initiatives have been developed in recent years, but there is little coordination among them. Some of these initiatives are:

Table 1. Initiatives and sources of information

Type	Initiative	Information
Users of data	The Sustainability Consortium	http://www.sustainabilityconsortium.org/sp/
	Product Environmental Footprint	http://ec.europa.eu/environment/eussd/smgp/product_footprint.htm
	Nordic Swan	http://www.nordic-ecolabel.org/
	Grenelle Law	http://www.developpement-durable.gouv.fr/IMG/pdf/Grenelle_Loi-2_GB_.pdf
Database development initiatives with different methodologies	World Food Database	http://www.fcrn.org.uk/research-library/food-and-its-life-cycle/other-studies/world-food-lca-database
	International Life Cycle Data System (ILCD)	http://eplca.jrc.ec.europa.eu/?page_id=86
	Ecoinvent	http://www.ecoinvent.org/database/
	AusLCI	http://alcas.asn.au/AusLCI/
	AgriBALYSE	http://www2.ademe.fr/servlet/getDoc?id=38480&m=3&cid=96
	LCA Digital Commons	https://www.lcacommons.gov/nrel/search

The food and beverage sector in Chile is an important sector, strongly focused on exports. It is the second largest sector for the Chilean economy and ranks 15th worldwide (US Commercial Service, 2012). Requirements for sustainable practices and value chain transparency are increasing (ProChile, 2012), both from international retailers (Walmart, Tesco, among others) and from within the country as a member of the OECD (OECD, 2005). Along with this, there is a lack of technical capacity within companies in Chile to analyze and interpret sustainability assessment.

In this context, Fundación Chile and Universidad de La Frontera (UFRO) are developing the EcoBase Food project, which has secured funding from a public grant presented with the following title: "Development of an Environmental Information Management System for Life Cycle Analysis, through a Technological Platform, to improve the sustainability and competitiveness of the Food and Viticulture Exports Industry". The project relies on the support and interest of 9 different trade organizations from the food and wine sector, along with the Environment and Agriculture ministries and the Chilean Promotion Bureau (ProChile due to its Spanish initials).

The aim of the project is to increase the competitiveness of food exporters and producers, including small to medium enterprises (SMEs).It is expected that companies will be able to increase their competitiveness by:

- Providing transparent and rigorous product sustainability information (e.g. environmental footprints) to clients.
- Demonstrating positive and competitive sustainability performance.
- Identifying hotspots, evaluating solutions and prioritizing sustainability improvements based on this information.

To achieve this, the project will deliver an environmental information platform, which will provide:

- A methodological framework and guidelines for consistent data collection and impact assessment
- Excel based data collection tool.
- 16 national product category (Table 2) data baseline models, with options to model different production systems per category.
- Instructions for selecting indicators, best practices and improvement opportunities associated with major environmental impacts.

The following document presents a summary of the data collection methodology to create the LCIs for food and wine products in Chile. The methodology is an adaptation from international best practices and aligned to international tools, standards and recognition schemes; balancing the generality and specificity of these to suit the Chilean industry requirements the best. The main sources for the methodology are:

- The International Organization for Standardization's Life Cycle Assessment method (International Organization for Standardization (ISO) 2006a; International Organization for Standardization (ISO) 2006b)
- Ecoinvent Quality Guidelines (Weidema et al., 2012), as an important centre of expertise and support for the project, as well as the potential to provide the Ecoinvent database with information from the project.
- Shonan Guidance Principles (Sonnemann and Vigon, 2011), as a general guide for the methodology structure (Context, Unit process, Aggregation, Documentation, among others).

Along with the above, the methodology has been developed taking into account the different opinions of the trade organizations and ministries involved in the project, and will pass through a critical review before final publishing.

The methodology could be applicable to any food or beverage product, but the project will focus on 16 different product groups (Table 2), which are categorized into: Fruits & Wine, Aquaculture and Meat & Dairy. Collectively, in 2012 the considered product categories represented 62% of Chile's food and beverage exports (Chilean Central Bank, 2012).

Table 2. Product categories in the project

Fruits & Wine	**Aquaculture**	**Meat & Dairy**
• Fresh Apples	• Salmon	• Pork
• Dried Apples	• Mussels	• Chicken
• Table Grapes		• Powdered milk
• Apple Juice		• Gouda cheese
• Wine		
• Avocado		
• Fresh Plums		
• Fresh Blueberries		
• Canned Peaches		
• Frozen Raspberries		

This project is being developed in parallel with the construction sector, in pursuit of a national project that aims to have a coordinated platform of information for relevant industries of the Chilean economy. Having databases which are coordinated and have similar structures facilitates information exchange and allows for improved decision-making at a country level, optimizing and making resource use more efficient. With the objective of having these projects as part of a more harmonized international network, Fundación Chile has become a member of UNEP/SETAC´s Life Cycle Initiative, and is actively participating in international developments.

2. Methodology

The present methodology aims to enable the quantification and reporting of environmental impacts associated with the agricultural/livestock/aquaculture production and processing stages, linked to upstream and downstream data. The project will create “cradle to gate" inventories and offer tool support to model “cradle to retail gate” scenarios.

The document includes:

- A methodological framework providing consistent data collection and impact assessment guidelines;
- Defined product categories (Table 2), with their respective lists of processes, inputs and outputs to facilitate data collection.

2.1. Scope

The goal of the project is to increase the competitiveness of food producers and exporters, including SMEs. It also aims to obtain better understanding of the impacts of the Chilean food and wine supply chains and to introduce and enable the industry to use life cycle thinking.

Therefore, one of the target audiences is exporting companies from the food and wine sector. Another key envisioned target audience for the sustainability information is future retailers at key export markets (e.g. French retailers in coming years). Therefore the functional units and scope need to be appropriate for use by retailers and cradle to retailer gate, which is why the functional unit will be a unit of mass or volume rather than a nutritional unit for example. This is useful from the consumer’s point of view but not from producers and retailers standpoint.

To this end, the methodology aims to generate national LCI baseline models that could be later used as a base for more complex LCA studies. Also, it will try to generate unit process inventories as disaggregated as possible, protecting minimum requirements of confidentiality.

The functional unit will be 1 kg of packaged product, except for wine which will be 0.75 l of packaged wine, since this is the most purchased format. Additionally, the most representative varieties or types of products (e.g. Royal Gala and Granny Smith apple varieties) of the Chilean industry will be employed. These measures will allow having consistent, comparable and representative information.

2.2. System boundaries

The stages covered are: i) raw materials, ii) agriculture, iii) livestock & aquaculture, iv) processing, v) packaging and vi) distribution.

A list of inclusions and exclusion per life cycle stage is given in Table 3.

Table 3. Life cycle stage inclusions and exclusions

Life cycle stage	Inclusions	Exclusions
Raw materials (secondary data)	• Agrochemical production • Other chemical input • Fuel production • Transportation[a]	• Manufacture, transportation, and end-of-life disposal of buildings, transportation and packaging infrastructure, capital equipment and auxiliary machineries • For crop production, it is not necessary to include the production of seeds as the relative contribution to environmental impact is

		small. The exception to this is where seed production would be expected to be, or shown to, represent more than 1% of the impact to any impact category (for example where small organic farms may be studied).
Agriculture	• Water use • Land use • Soil carbon sequestration • Agrochemical and fertilizers use • Fuels combustion and electricity • Machinery • Waste management • Transportation[a]	• Manufacture, transportation, and end-of-life disposal of buildings, transportation and packaging infrastructure, capital equipment and auxiliary machineries • Consumables • Staff transport • Noise and vibration, radiation, odor and waste heat
Livestock & Aquaculture	• Feed • Fuels combustion and electricity • Chemicals • Fugitive emissions • Water use • Land use • Soil carbon sequestration • Agrochemical use • Waste management • Transportation[a]	• Manufacture, transportation, and end-of-life disposal of buildings, transportation and packaging infrastructure, capital equipment and auxiliary machineries • Consumables • Staff transport • Animal welfare • Noise and vibration, radiation, odor and waste heat
Processing	• Fuels combustion and electricity • Chemicals • Fugitive emissions • Water use • Waste management • Transportation[a]	• Manufacture, transportation, and end-of-life disposal of buildings, transportation and packaging infrastructure, capital equipment and auxiliary machineries • Consumables • Staff transport • Noise and vibration, radiation, odor and waste heat
Packaging	• Source of plastics, paper, glass, aluminium, metals, etc. • Recycled content • Primary, secondary & tertiary packaging • Transportation[a]	• Manufacture, transportation, and end-of-life disposal of buildings, transportation and packaging infrastructure, capital equipment and auxiliary machineries • Consumables • Staff transport • Noise and vibration, radiation, odor and waste heat
Distribution	• Storage; • Distribution to retail outlets; • Transportation to retail outlets; • Cold storage and preservation processes	• Manufacture, transportation, and end-of-life disposal of buildings, transportation and packaging infrastructure, capital equipment and auxiliary machineries • Noise and vibration, radiation, odor and waste heat

[a]Transportation shall include all modes (road, rail, air, and by ship) occurring in-between the life cycle stages.

2.3. Allocation procedure

In LCA, environmental impacts and benefits are calculated for different materials, products, assemblies and services. These products are produced by a large diversity of production systems that make up a modern industrial economy. Whenever a single process produces more than one product or service (e.g. beef being produced as a co-product in the production of milk), an approach is needed to determine how the environmental impacts of the single process should be assigned to each of the products or services. This is commonly referred to as the allocation problem.

For the EcoBase project, sufficient data shall be collected to enable flexibility with regards to allocation between co-products. This includes co-product price information, mass/volume, etc. Where allocation between co-products cannot be avoided or based on direct causality, economic allocation will be used, in order to allocate inputs and outputs between the products and functions in a way which reflect their value. This is in line with the Handbook on LCA, which advises economic allocation as baseline method for most situations (Guinée et al., 2002).

This approach also allows allocating impacts between recycled products and waste-derived fuels.

2.4. Cut-off rules

No strict quantitative cut-off rule is followed in the project. The database shall be as complete as the knowledge of the data providers allow. In principle, all known inputs and outputs are recorded as such. All input and outputs within the assessment scope shall be included as far as practical and reasonable. However, for the purpose of prioritizing efforts, the following threshold can be applied:

- Strong efforts to collect high quality data shall be held when inputs are anticipated to make a material contribution (more than 1% normalized impact in the priority impact categories) to the total life cycle inventory per functional unit.
- Otherwise, data can be collected from conservative estimates.
- Where a single source of energy and water use and emissions accounts for more than 50% of the likely total life cycle inventory per functional unit, the above threshold rule (inclusion of at least 95%) shall apply to the remaining life cycle inventory.

Further information on data sources is given in section 2.5 below.

2.5. Data collection guidelines and tool design

For this project, one of the goals is to obtain data that represents the various realities (production technologies, raw materials, etc.) of each product. It will work with the principle of collecting the best available information, prioritizing completeness of systems, and basing the data collection efforts according to the following hierarchy of sources of information (adapted from Howard & Sharpe, 2010):

1. Primary information: Information obtained directly from companies
2. Secondary information:
   - Studies and other national projects related to each category.
   - Information available from the Clean Production Agreements from the National Council of Clean Production
   - Information available in the Chilean national environmental impact assessment database (e-SEIA).
   - Documented estimates from national experts.
   - International studies or other projects related to each category which could be complemented with international experts' contributions.
   - LCA databases internationally recognized, with the necessary and feasible adjustments to adapt them to the Chilean reality (energy matrix, transport distances, etc.).

Based on feedback by the trade associations supporting the project, the data collection tools developed have been designed to increase usability by the data providers. For each of the products in the database, a process list, with its inputs and outputs listed has been generated to guide the data collection process. These process lists are

included within the data collection tools to facilitate the navigation and filling of the spreadsheets. Also, when information is available from literature review, some values are pre-filled to assist the data providers in case they don't have certain fields of information, or if they feel that the pre-filled values represent their production process; validating them. The data collection tools will be sent to private companies, through their respective trade association, with the project teams assisting the filling of the spreadsheets through visits to the facilities or farms, online workshops or other ways of more informal interaction.

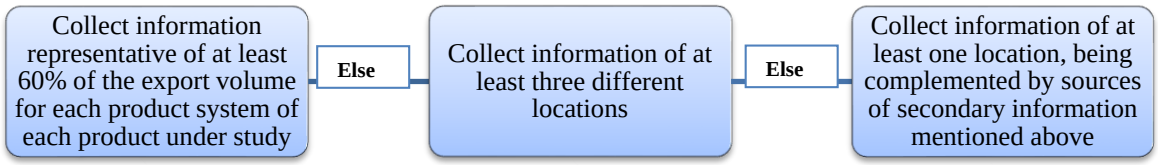
Data collection guidelines for each impact category have been developed and prioritized, based on literature and contribution analysis for several of the product categories. Data collection efforts will be focused according to the representativeness goals given in section 2.5.1 and the hierarchy of sources of information.

2.5.1. Representativeness

In order to maximize the usefulness of the LCI developed, a key aspect is representativeness (from a geographic, technological and productive point of view) of the most important product systems in term of market share exports.

Therefore, a hierarchy of objectives was defined and it is presented below

Figure 1: Hierarchy of objectives



For all cases, the export volume and relevance of the productive systems for national exports will be considered for selecting each location.

2.5.2. Averaging, aggregation and data confidentiality.

As one of the objectives of the project is to provide national baseline LCIs for the products under study, it is necessary to appropriately average and aggregate data from different companies.

In order to protect the confidentiality of individual company's data, the Project will allow for data to be published as aggregated from several sources into anonymous generic averages that are nonetheless representative of the Chilean industry. In general, inputs and outputs of several distinct unit processes are aggregated only if a) data is not available on a detailed unit process level, or b) unit process data is confidential.

The project will average data horizontally. This means that average inventory for each of the individual subprocesses in an inventory are weightily averaged and the sum of these then represents the inventory for the whole. This is preferred because it preserves data richness and it can be used to compare between similar processes from different industries. Also, it can even be used as a proxy process in another sector to fill a non-critical data gap. Maintaining data richness provides advantages such as the ability to see which parts of the processes contribute more to the impacts of their products. This can further help understand how to innovate to mitigate those impacts.

Two particular cases need special attention:

- Only one surveyed company: When only one company is surveyed in a product category, confidentiality will be ensured by combining their data with information from other national or international databases that are considered suitable.
- Various production locations per company: If a company has more than one productive location, LCI averages for each location will be weighted according to the percentage of production of the whole company. Special care will be held when different productive technologies exist inside one company.

The Project will estimate and document the extent to which data are representative of a market or a process, but will not exclude data that cannot achieve any particular threshold level of representativeness. The data used should derive from the most recent annual production data that it is feasible to compile. The data should represent the mean of Chilean production, reflecting differing efficiencies from production at different ages and scales of production.

2.6. Data quality

Data quality is one of the main aspects in the construction of a national LCI database. For this project, an adapted version of the Pedigree Matrix (Weidema et al., 2012) will be used, evaluating the aspects in Table 4.

Table 4. Data quality indicators. Adapted from Weidema et al., 2012.

Indicator	**1**	**2**	**3**	**4**	**5**
Reliability	Verified data based on measurement	Verified data partly based on assumptions or non-verified data based on measurements	Non-verified data partly based on assumptions	Qualified estimate (e.g. by industry expert)	Non-qualified estimate or unknown origin
Completeness	Representative data from a sufficient sample of sites over an adequate period to even out normal fluctuations	Representative data from >50% of the sites relevant for the market considered, over an adequate period to even out normal fluctuations	Representative data from only some sites (<<50%) relevant for the market considered or >50% of sites but from shorter periods	Representative data from only one site relevant for the market considered or some sites but from shorter periods	Representativeness unknown or data from a small number of sites and from shorter periods
Temporal correlation	Less than 3 years of difference to the time period of the dataset	Less than 6 years of difference to the time period of the dataset	Less than 10 years of difference to the time period of the dataset	Less than 15 years of difference to the time period of the dataset	Age of data unknown or more than 15 years of difference to the time period of the data set
Geographical correlation	Data from area under study (e.g. O'Higgins)	Average data from larger area in which the study is included (e.g. Central Valley Region)	Data from area with similar conditions (e.g. Chile or Argentina)	Data from area with slightly similar conditions (e.g. South Africa)	Data from unknown or distinctly different area (North America in- stead of Middle East, OECD-Europe instead of Russia)
Further technological correlation	Data from enterprise, processes, and materials under study	Data from processes and materials under study (i.e. identical technology) but from different enterprises	Data from processes and materials under study but from different technology	Data on related processes or materials	Data on related processes or materials but different technology

The project will have no strict data quality goals, and the LCI will be as complete as possible, having in mind completeness over depth of them. Therefore, all data will be reported with their respective quality indicators. These indicators will be available for the users, so they can judge how useful the information is in order to use it.

2.7. Life cycle impact assessment

Impact assessment models that are used to interpret LCIA data are still emerging and evolving internationally. Since the early 1990s, numerous LCIA methodologies have been developed. The widespread use of several different methodologies creates confusion over which methodology to use, and criticism arises when the use of LCA gives different results depending on the methodology chosen (European Commission – Joint Research Centre 2008)

ISO 14044, section 4.4.2.2.3.c, recommends minimizing value-choices and assumptions during the selection of impact categories, category indicators and characterization models for the LCIA method, which is why this project includes a recommended LCIA method to be used.

The recommended LCIA method is proposed based on the research documented in:

- A Life Cycle Impact Assessment Method for Use in Australia – Classification, Characterization and Research Needs (Bengtsson et al. 2010):
- Identifying best existing practice for characterization modeling in life cycle impact assessment (Hauschild et al., 2013):

In essence the key considerations are:

- Whether the impact assessment is conducted at mid-point, end-point, or both.
- Whether the impact assessment should be based on best practice scientific methods per impact category (i.e. the BP LCI and AgAusLCI approach in Australia and the ILCD work in Hauschild et al., (2013)) or to adopt a ready-made LCIA method such as World Impact +, ReCiPe or CML.
- Which approach offers the most regionally appropriate impact assessment method.

The interim preference is to adopt ReCiPe on the basis that it:

- Has the flexibility to calculate impacts at both mid-point and end-point,
- Includes global characterization and normalization factors which are deemed by the project team to have higher degree of acceptance by the intended audience than European or US-centric LCIA methods.
- Aligns in terms of impact category selection with the best practice research for the BP LCI and ILCD
- Is actively maintained and updated.

The ReCiPe impact for water depletion and toxicity shall be replaced with the consumptive water use method developed by Ruidoutt and Pfister (2012) and USE Tox (Rosenbaum et al, 2008), respectively. The latter, including minor adaptations to Chile based on contribution analysis and known used substances.

Ionizing radiation will not be covered, as it was deemed not to be relevant for Chile, based on a contribution analysis made for avocado, table grapes, wine and chicken where it represented less than 1% of the normalized impact. In addition, there is no nuclear energy in Chile.

3. Summary and next steps

A data collection and life cycle impact assessment methodology has been developed for the Chilean LCI food and wine database project EcoBase, built upon international best practices and considering several stakeholders' inputs. The methodology will be submitted for critical review to achieve scientific validation before final publishing. This review will be by the Chilean LCA Network nationally and Quantis internationally, with the interest of seeking alignment with the World Food LCA Database.

It is expected that after the initial stage, these developed guidelines will allow more and better databases and products to be incorporated into the database.

Currently, the project is in data collection stage, following the methodology covered in this document. Secondary data collection has mostly been completed, while primary data collection is in progress. As mentioned in section 2.5, the data collection tool has been sent to several companies through trade organizations that are part of the project, and workshops to facilitate navigation and learning of the tool are being carried out with companies for most of the product categories. By mid-2014, data collection will be finalized, and by the end of the same year, a first draft of the LCI and calculators for the 16 selected product categories will be ready. After a critical revision by project partners, a final version of the LCI and the calculators will aim to be ready by early

2015 following which, the process of dissemination will begin until August 2015, which is when the project is expected to finalize.

It is important to mention that all project deliverables including methodology, life cycle inventories, calculators etc. will be publicly available on an online platform operated by project partners.

EcoBase Food is one step towards a more transparent and sustainable food sector in Chile, but there is still a long way to go in this direction. While currently the project includes 16 products, the aim is to expand the scope in future both in terms of increasing the number of products and industries involved, as well as improving the quality of the results as and when additional information and/or methods become available. Another future step currently being evaluated is better communication of these results to consumers, possibly under an eco-labelling program or a similar initiative.

4. References

Bengtsson J and Howard N (2010) A Life Cycle Impact Assessment Method for Use in Australia -Classification, Characterization and Research Needs. http://edgeenvironment.com.au/wordpress/wp-content/uploads/A-Life-Cycle-Impact-Assessment-Method-for-Australia.pdf. Accessed 9 December 2013

Chilean Central Bank, 2013. International trade indicators, third trimester, 2013.

European Commission – Joint Research Centre (2008) Recommendation of methods for LCIA, Working Draft 0.7. http://lct.jrc.ec.europa.eu/. Accessed 11 January 2014

Guinée J, Gorrée M, Heijungs R, Huppes G, Kleijn R, de Koning A, van Oers L, Wegener A, Suh S, Udo de Haes H, De Brujin H, van Duin R, Huijbregts M (2002) Handbook on Life Cycle Assessment: Operational Guide to the ISO Standards. http://www.isa.utl.pt/der/ASAmb/DocumentosAulas/Recipe/Handbook%20on%20Life%20Cycle%20Assessment.pdf. Accessed 10 July 2014.

Hauschild MZ, Goedkoop M, Guinée J, Heijungs R, Huijbregts M, Jolliet O, Margni M, De Schryver A, Humbert S, Laurent A, Sala Sand Pant R (2013) Identifying best existing practice for characterization modelling in life cycle impact assessment. Int J Life Cycle Assess 18:683–697.

Heller M, KeoleianG, andWillettW (2013) Toward a life cycle-based, diet-level framework for food environmental impact and nutritional quality assessment: A critical review. Environmental Science and Technology. 47(22):12632-12647.

Howard N and Sharp D (2010) Methodology guidelines for the Materials and Building Products Life Cycle Inventory Database.BPIC Australia.http://www.bpic.asn.au/_literature_79923/LCI_Methodology_Guidelines. Accessed 11 January 2014

International Organization for Standardization (ISO) (2006a) Environmental management - Life cycle assessment - Principles and framework. ISO 14040:2006.Second Edition 2006-06, Geneva.

International Organization for Standardization (ISO) (2006b) Environmental management - Life cycle assessment - Requirements and guidelines. ISO 14044:2006.First edition 2006-07-01, Geneva.

OECD (2005) Environmental Performance Review. http://www.oecd.org/env/country-reviews/34856244.pdf. Accessed 9 April 2014

ProChile (2012) Estado del Arte en Materias de Sustentabilidad a Nivel Nacional e Internacional para Sectores Exportadores Seleccionados. Fundación Chile.

Ridoutt BG and Pfister S (2012) A new water footprint calculation method integrating consumptive and degradative water use into a single stand-alone weighted indicator. Int J Life Cycle Assess 18:204-307

Rosenbaum RK, Bachmann TM, Gold LS, Huijbregts MA, Jolliet O, Juraske R, Koehler A, Larsen H, MacLeod M, Margni M, McKone T, Payet J, Schuhmacher M, van de Meent D and Hauschild, MZ (2008) USEtox—the UNEP-SETAC toxicity model: recommended characterisation factors for human toxicity and freshwater ecotoxicity in life cycle impact assessment. The International Journal of Life Cycle Assessment 13(7):532-546

Sonnemann, G., &Vigon, B (2011) Global guidance principles for life cycle assessment databases. A basis for greener processes and products. UNEP/SETAC Life Cycle Initiative. United Nations Environment Programme (UNEP), Paris.

US Commercial Service (2012) Doing Business in Chile. US Embassy.http://export.gov/chile/static/CCG%20Chile%202012_Latest_eg_cl_050006.pdf. Accessed 9 April 2014

Weidema BP, Bauer C, Hischier R, Mutel C, Nemecek T, Reinhard J, Vadenbo CO and Wernet G (2012) Overview and methodology. Data quality guideline for the ecoinvent database version 3.Ecoinvent Report 1(v.3). St. Gallen: the ecoinvent Centre.

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