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From Chicks to Nuggets: An Assessment of Socio-Economic and Ecological Impacts of Chicken Value Chains from Brazil to Switzerland

Bachelor Thesis

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Abstract

Food value chains are embedded in society and nature and therefore related to environmental, as well as socio-economic impacts. On the one hand, food value chains may provide benefits for society, such as employment opportunities or the provision of safe and sound food. On the other hand, these employment opportunities are not necessarily safe and in compliance with human dignity. Furthermore, food production contributes to environmental problems, such as global warming and degradation of natural habitats. However, in modern global food value chains, production-specific impacts are often shifted to net-exporting countries of agricultural commodities, such as Brazil. In order to prevent or minimize negative impacts and to increase positive impacts of food value chains, a thorough knowledge about implications is necessary. Therefore, the aim of this work was to support the development of sustainable food value chains by assessing ecological and socio-economic impacts of the Brazilian-Swiss chicken value chain. This value chain was selected as a case study of global food value chains, representing the most traded meat worldwide.

In order to assess the impacts, a range of methods was used: in a first step, the structure of the value chain was analyzed by means of a desk research. Then, ecological and socio-economic impacts were assessed by a life cycle assessment and a desk research, respectively. The socio-economic and ecological impacts were further evaluated employing a Sustainable Hotspot Analysis. Interviews with Brazilian stakeholders were conducted to include their perception into the analysis.

The results showed that the value chain consists of the following main processes: breeding and hatching, feed production, rearing, catching and transport, slaughtering and primary processing, distribution, secondary processing, retail and consumption. Broiler farmers are usually integrated into a vertical supply chain. About 50% of the total production in Brazil is controlled by the two largest integrating companies. In total, the value chain generates 3.5 million jobs in Brazil, which are mainly located in urban areas. Socio-economic Hotspots were found in the *rearing stage* (unfair contract conditions between broiler farmers and integrating companies) and in the stages *feed production*, *catching, slaughterhouses* (occupational health and safety). Furthermore, more than 30'000 land conflicts and incidences of human rights violations are related to the *feed production* stage. Environmental hotspots were found to be air pollution through the stages *rearing* and *feed production*. *Feed production* contributes furthermore to global warming, land use and water pollution.

Results indicate that strategies should focus on feed production and the reduction of ammonia during rearing. Feasible farm-level strategies exist already to decrease the amount ammonia emissions. The establishment of improved food compositions or an increase in nitrogen-use efficiency would have far-reaching effects on several environmental problems. To increase social sustainability of the value chain, law enforcement needs to strengthen existing regulatory norms by accurate monitoring and penalties. Furthermore, integrating companies need to assume responsibility for the actions of subcontracting firms and, furthermore, pay fair minimum wages to broiler farmers.

Zusammenfassung

Lebensmittel-Wertschöpfungsketten (LWK) sind in eine natürliche und gesellschaftliche Umgebung eingebunden und haben daher vielfältige Auswirkungen. Einerseits können LWK zum Wohlstand der Gesellschaft beitragen, beispielsweise durch die Schaffung von Arbeitsplätzen oder die Bereitstellung gesunder Nahrungsmittel. Andererseits sind die geschaffenen Arbeitsplätze nicht zwingend sicher und menschenwürdig. Zudem ist die Produktion von Lebensmitteln mit vielfachen Umweltauswirkungen, wie dem Klimawandel und der Zerstörung natürlicher Habitate, verknüpft. In modernen globalen LWK werden die Auswirkungen, die durch die Produktion von Lebensmitteln entstehen, jedoch oftmals auf Netto-Exporteure von Landwirtschaftsprodukten, wie beispielsweise Brasilien, abgewälzt. Um die potentiellen positiven Auswirkungen von globalen Handelsketten zu maximieren und gleichzeitig die negativen Auswirkungen zu minimieren, ist es nötig, diese Effekte zu kennen und zu verstehen. Daher war das Ziel dieser Arbeit die Untersuchung der ökologischen und sozio-ökonomischen Effekte einer globalen Wertschöpfungskette, anhand der brasilianisch-Schweizerischen Poulet-Wertschöpfungskette (WK), um zur Entwicklung nachhaltiger LWK beizutragen.

Um die Effekte zu ermitteln, wurden mehrere Methoden verwendet: Die Struktur der Wertschöpfungskette wurde mittels einer Literaturrecherche untersucht. Für die Ermittlung der Auswirkungen wurden eine Ökobilanzierung und eine Literaturanalyse durchgeführt und diese mit einer Hotspot-Analyse evaluiert. Schliesslich wurden Interviews mit brasilianischen Stakeholdern durchgeführt, um deren Wahrnehmung miteinfliessen zu lassen.

Die Resultate zeigten, dass die Poulet-WK folgende Prozesse durchläuft: Zucht, Futterproduktion, Aufzucht, Einfangen und Transport, Schlachtung, Distribution, Verarbeitung, Verkauf. brasilianische Hühnerbauern meist vertikal in die Wertschöpfungskette integriert sind. Die WK, welche zu über 50% von den zwei grössten Integrationsfirmen kontrolliert wird, generiert in Brasilien 3.5 Millionen Arbeitsplätze, die sich vor allem in urbanen Gebieten finden. Drei von sechs sozialen Hotspots fanden sich in der *Futterproduktion* (Landkonflikte, Arbeitssicherheit, Menschenrechtsverletzungen). Weitere Hotspots fanden sich in der *Aufzucht* (Vertragsbedingungen), beim *Einfangen* der Hühner und in *Schlachthäusern* (beide Arbeitssicherheit). Vier von fünf ökologischen Hotspots fanden sich ebenfalls in der *Futterproduktion*, durch Beiträge zur Klimaerwärmung, Landnutzung, Wasser- und Luftverschmutzung. Die *Hühneraufzucht* selbst steuert den grössten Hotspot zur Luftverschmutzung bei.

Diverse landwirtschaftliche Massnahmen könnten zur Reduktion von Ammoniakemissionen beitragen. Verbesserungen der Futterzusammensetzung hätten weitreichende Folgen. Um die sozialen Missstände in der Wertschöpfungskette zu minimieren, müssten existierende Gesetze durch akkurate Kontrollen und hohe Strafen gestärkt werden. Zudem müssten integrative Firmen ihre Verantwortung gegenüber Angestellten der Sub-Unternehmen wahrnehmen und den Bauern faire ausreichende Minimallöhne gewährleisten.

Content

Glossary

BR	Brazil
BRF	BRF S.A. (formerly Brazil Foods), company
BRICS	Acronym for Brazil, Russia, India, China, South Africa
CH	Switzerland
CO_2	Carbon dioxide
cw.	Carcass-weight
EC	European Commission
FAO	Food and Agriculture Organization of the United Nations
FC	Forest Code
ILCD	LCIA method: International Reference Life Cycle Data System
JBS	JBS S.A. ("José Batista Sobrinho"), company
LCA	Life Cycle Assessment
LCIA	Life Cycle Impact Assessment
LWK	Lebensmittel-Wertschöpfungskette
MERCOSUR	Mercado Común del Sur (Southern common market)
NH_3	Ammonia
OHS	Occupational Health and Safety
SHDB	Social Hotspot Database
SHSA	Sustainable Hotspot Analysis
S-LCA	Social-LCA
SFVCP	Sustainable Food Value Chain Paradigm
WK	Wertschöpfungskette
ZHAW	Zurich University of Applied Sciences

1 Introduction

Food is a vital necessity for every human being. However, food production is associated with a wide variety of impacts on nature and society. Food production is highly dependent on natural inputs, such as land, soil and water (UNEP, 2018a). According to the UNEP (2018b), the food sector accounts for 30% of the global energy consumption and 22% of the greenhouse gas emissions. In developing countries, the relative impact of food production to the ecological impact is assumed to be even higher (Nemecek et al., 2016). Furthermore, value chains are embedded in a socio-economic environment, providing food and employment opportunities to society, underlying a dynamic, which depends on various socio-economic factors, such as urbanization rate, population growth or the economic and political system (Garnett, 2013) (Tendall et al., 2015).

According to estimates of the United Nations, the world population is expected to grow from 7.5 billion people to 9.8 billion people by 2050 (UN, 2017). In order to meet the growing food demand, global food production will have to increase by 60% in the coming decades (Alexandratos, 2012). However, a growing agricultural production will lead to a growth of related impacts, as well. Therefore, the development of sustainable food value chains is considered crucial to ensure food security and to maintain natural resources (UNEP, 2018a).

In order to design sustainable food systems or specific value chains, arising effects on all of these different dimensions have to be considered and understood. However, understanding of modern food systems is not trivial. Traditional, locally oriented subsistence food value chains have been replaced by industrial, global value chains (McCullough, Pingali, & Stamoulis, 2008). In the course of globalization, international trade volumes have increased considerably: according to the Worldbank (2018b), global international merchandise exports have increased from 125 billion US Dollar in 1960 to nearly 18 trillion US Dollar in 2017, driven by a decrease of state interventions, such as trade tariffs (Anderson, 2010). Especially emerging economies increased their share in global trade volumes considerably in the last thirty years (ECB, 2010). However, the effects of global trade or food value chains, in particular, on society and environment are being widely discussed. On the one hand, global trade promotes economic growth of net-exporting countries (Clapp, 2016). On the other hand, production-specific environmental impacts are shifted to these countries at the same time (Clapp, 2016).

Despite the large number of studies existing, analyzing ecological or socio-economic aspects of global trade, only little research was conducted to understand the sum of effects, trade-offs and interactions, based on a specific value chain, in a holistic approach. However, in order to develop sustainable food value chains, comprehensive knowledge about implications of food value chains is necessary for stakeholders and decision-makers. This thesis therefore aims to support the development of sustainable food value chains by investigating the effects of a specific global food value chain in a net-exporting country in all sustainability dimension (environment, social, economic) and to determine the most urgent areas of concern ("hotspots"). The value chain of chicken from Brazil to Switzerland is selected as an example of a global food value chain due to five reasons:

1. Brazil is a typical net-exporter of agricultural goods, with a net-export value of 60 billion US Dollars. Switzerland, on the contrary, is a net-importer with a net-import value of 2 billion US Dollars (FAOSTAT, 2016).
2. Poultry meat is currently the most produced and traded meat worldwide, with 120 million tonnes and 13 million tonnes, respectively. The export amount of chicken meat has increased fiftyfold since the beginning of the 60s (FAOSTAT, 2018a).
3. The consumption of meat products and, in particular, poultry meat, has been constantly increasing. The highest rise in poultry meat consumption can be observed in emerging economies (OECD, 2018). But also in Switzerland, the consumption of poultry meat has steadily increased over the last years (BLW, 2017a).
4. With a production amount of 13 million tonnes, Brazil was the second largest producer and largest exporter of poultry meat, worldwide. Brazil is furthermore the main supplier of import poultry meat in Switzerland (BLW, 2016). Next to coffee and orange juice, poultry meat is among the most important import commodities from Brazil to Switzerland, with about 9% of the total import value (BLW, 2016).
5. The European Union and Switzerland are currently negotiating with the Latin American trade association between Argentina, Brazil, Paraguay, Uruguay and Venezuela (MERCOSUR) about launching a free trade agreement (EC, 2018) (Chavaz, 2018). Mercosur countries are traditionally net-exporters of agricultural goods. With sinking tariffs, an increase of agricultural trade volumes can be assumed (Anderson, 2010).

In order to assess the effects of the chicken value chain, the following research questions are addressed:

I. What is the basic structure of the value chain of chicken produced in Brazil and consumed in Switzerland?
II. What kind of socio-economic benefits arise in the country of production?
III. What kind of socio-economic hotspots arise in the value chain?
IV. What kind of ecological hotspots arise in the value chain?

For the holistic assessment of the value chain, a range of methods is used. For research question 1), the value chain is analyzed, resulting in value chain maps and a qualitative description of main processes, actors and locations. For research question 2) and 3), a desk research, based on scientific knowledge is conducted to assess socio-economic impacts related to a selected set of impact indicators. For research question 4), a life cycle assessment according to ISO 14044 (2006) is conducted. Additionally, impact results of 3) and 4) are evaluated by means of a Sustainable Hotspot Analysis (SHSA) according to Wallbaum & Kummer (2006). Semi-structured and unstructured interviews with stakeholders in Brazil and Switzerland are used to complement the data on the value chain structure of research question 1) and to compare found hotspots of research questions 3) and 4) with opinions from participating value chain actors.

2 Theory

2.1 Sustainability of Food Value Chains

The concept of a value chain was firstly introduced by Porter in 1985 (Porter, 1985). He used the term to describe a firm as a collection of interlinked activities, represented by a value chain. His approach of a value chain analysis was developed as a tool to improve economic performance of companies (Porter, 1985).The concept was later applied for food products (Kaplinsky & Morris, 2000), and sustainability aspects were included by the following definition:

A sustainable food value chain is defined by "*the full range of farms and firms and their successive coordinated value-adding activities that produce particular raw agricultural materials and transform them into particular food products that are sold to final consumers and disposed of after use, in a manner that is profitable throughout, has broad-based benefits for society and does not permanently deplete natural resources"* Neven (2014).

According to the sustainable food value chain paradigm (SFVCP) by Neven (2014), a sustainable value chain contributes to food security by an increase of financial resources and improvements in food supply, e.g. through cost reduction or an increase of nutritional value. Therefore, both aspects should be addressed when strategies for food security are being developed. According to Neven (2014), the benefits generated by a food value chain can be distinguished as follows:

1. Salaries for workers
2. A return on assets for entrepreneurs
3. Tax revenues
4. A better food supply for consumers
5. A net impact on the environment (positive or negative).

M*easurement* of sustainability performance is considered as the first step for the development of sustainable value chains, followed by *understanding* and *improvement* (Neven, 2014). Therefore, the following section will describe already available sustainability measurement / assessment tools and related research results.

2.2 Impacts of Food Value Chains

2.2.1 Impacts of Agricultural Production

In order to assess the impacts of food value chains, a variety of methods was developed. Although attempts exist to combine all dimensions of sustainability in a single assessment method, there is currently no established assessment method covering all aspects of sustainability of value chains (Karimi, Brown, & Hockings, 2015) (Dent, Soosay, & Fearne, 2012) (Jawtusch et al., 2013). The FAO developed a universal framework for Sustainability Assessment of Food and Agriculture Systems (SAFA), defining 60 sustainability objectives, 20 subtopics and four sustainability dimensions (FAO, 2013). The related SAFA tool was developed and tested in three enterprises and on 60 farms in Europe and Mexico (Jawtusch et al., 2013). However, the SAFA tool is considered as resource-demanding and mainly focusing on enterprise level (Jawtusch et al., 2013). Therefore, the use of different methods is still common when assessing different dimensions of sustainability of value chains.

For the assessment of *environmental impacts*, the Life Cycle Assessment-methodology (LCA) was developed and is meanwhile an accepted tool to quantify and compare ecological impacts related to value chains (Nemecek et al., 2016). In the last decades, many LCA studies have been conducted to assess the impact of food products (Nemecek et al., 2016). The results indicate that food production is one of the major contributors to environmental impacts associated with consumption, next to housing and transport (Tukker & Jansen, 2006). Together, food, housing and transport account for about 80% of environmental impact for most impact categories (Tukker & Jansen, 2006). Most studies found that the agricultural production stage is the stage most heavily contributing to environmental impacts of food value chains (Foster et al., 2007) (Alig et al., 2012). Due to their use of fertilizers and pesticides, agricultural cultivation is related to several environmental problems, such as water scarcity or the pollution of air and water through acidification or eutrophication (Hanjra & Qureshi, 2010) (N. Anderson, Strader, & Davidson, 2003) (Moss, 2008). Furthermore, agriculture contributes to climate change, ozone depletion and the use of agricultural area for cultivation is directly related to biodiversity loss or soil degradation (Vié, Hilton-Taylor, & Stuart, 2009) (Nemecek et al., 2016). However, studies indicate that the consumption stage of food value chains has a considerable impact on the overall impact of the value chain, as well: improvements in nutrition behavior (decrease of meat consumption) and food waste reduction are considered as important strategies to decrease overall environmental impacts related to food systems (Nemecek et al., 2016) (Garnett, 2013).

Socio-economic effects affect different stakeholders of the value chain in different ways. They are less tangible and therefore more difficult to quantify. In general, agriculture is regarded as a growth promoter for the economy of developing countries. Income creation through employment in the agriculture sector stimulates the demand for non-agricultural products, therefore promoting non-agricultural incomes as well (Pingali, 2007). However, inequalities in society remain, if they are not targeted by social policies to establish smallholder participation or to reduce the poverty (Pingali, 2007).

Currently, there are ongoing attempts to include social aspects into the LCA methodology (Dreyer, Hauschild, & Schierbeck, 2006). The United Nations Environment Program (UNEP) published guidelines for a Social-LCA (S-LCA) in 2009 (Benoît et al., 2009). The Social Hotspot Database (SHDB) is a global database, proposing country- and sector-specific areas of concern (“hotspots”) of value chains, and is used as inventory of S-LCA applications (Benoit-Norris et al., 2012). However, the integration of social aspects still needs standardization and a larger database for a better applicability (Iofrida et al., 2018).

In the following chapters, an overview of scientific results of socio-economic and ecological impact assessments related to the production of agricultural products in Brazil and poultry production, in general, are presented.

2.2.2 Impacts of Agricultural Production in Brazil

Many value chains, such as of chicken meat, originate from Brazil. Brazil is currently the main or one of the main global suppliers of many agricultural commodities, such as soybeans (second largest exporter), beef (main exporter), coffee beans (main exporter) and poultry meat (main exporter) (FAOSTAT, 2018). Brazil's agricultural sector grew considerably during the second half of the 20th century, which is mainly a result of a national development strategy, promoting an expansion of agricultural area, intensification and investments in agricultural technologies (Brainard & Martinez-Diaz, 2009) (USITC, 2012). Currently, about one third of Brazil's area are used for agriculture (FAO, 2014). Brazil's agriculture has meanwhile become furthermore highly industrialized, efficient and export-oriented: 34% of Brazilian exports are food products (FAO, 2014).

Although Brazil's agriculture has a decreasing share in gross domestic product (GDP), agriculture and agribusiness are still considered to be important pillars of the Brazilian economy (Martinelli & Filoso, 2009): 15% of the Brazilian population are employed in the agricultural sector and about 25% of the GDP is related to the agribusiness sector (FAO, 2014) (Desouzart, 1995). Furthermore, the production of some agricultural commodities, such as bioethanol, is considered as driver for rural development (de Ferranti, 2005). Brazil managed to reduce social inequity during the last decade with the introduction of powerful social programs, resulting in a reduction of income inequality: the GINI-index fell from 58.1 to 51.5 (Guinn & Hamrick, 2015) (Worldbank, 2018a). However, globally seen, Brazil is still among the countries with the highest GINI-indices (Worldbank, 2018a).

An unequal land distribution is considered as driver for social problems related to Brazilian agriculture (Martinelli et al, 2010). Agricultural expansion and lacking land titles have promoted unequal land distribution, violence and food security problems in rural areas, especially in the Amazon (CPT, 2010). The land GINI-index (showing inequality in distribution of land) of export-oriented crops, such as sugarcane, soy or maize, is usually higher than the GINI-index of staple foods for domestic consumption (Worldbank, 2007) (Martinelli et al., 2010). The land GINI-index of crops was found to be correlated with growth: the higher the land inequality, the more the crop area was expanded (Martinelli et al., 2010).

Further social aspects related to Brazilian agriculture include sector-specific adverse working conditions, e.g. the exploitation of sugarcane workers (Luiz A. Martinelli & Filoso, 2008). According to the inventory of the SHDB (2018), Brazilian food products show highest hotspot indices (indicating the probability of a problem) in the field "health and safety", followed by "labor rights", "human rights" and "community infrastructure". Figure 1 shows hotspot indices of the SHDB for Brazilian grain, meat and food products. Grain production shows higher hotspot indices than meat production and food production in general, mainly caused by higher probabilities in the categories "labor rights and decent work" and in the category "human rights".

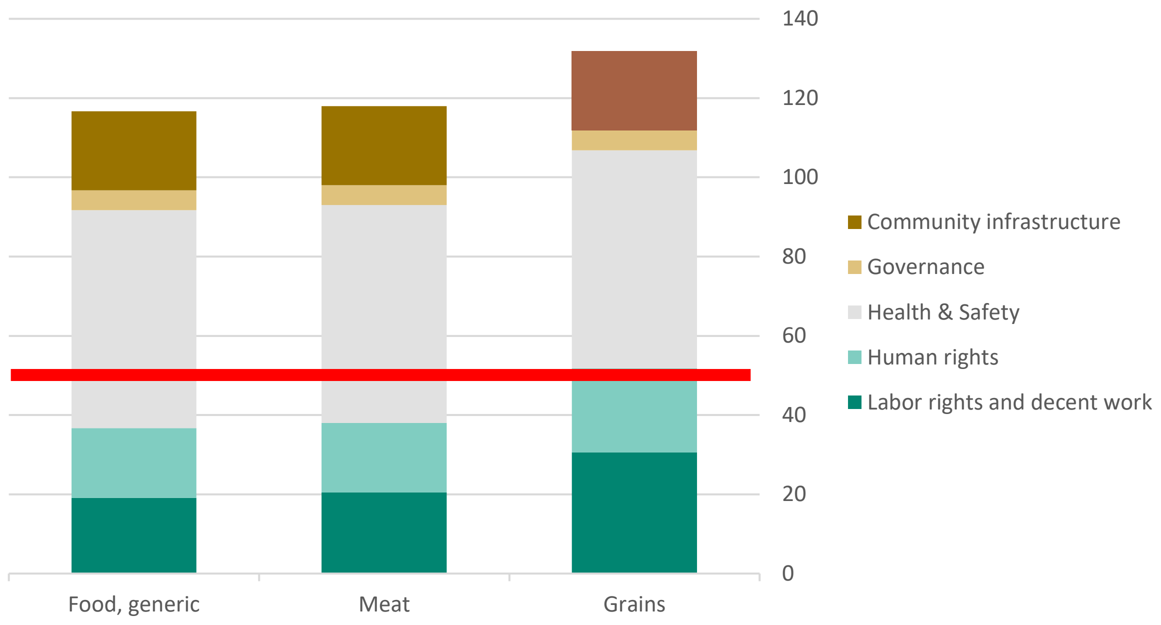

Figure 1: Aggregated social hotspot indices for Brazilian grains, meat and food (generic). Red line: Swiss meat (comparison scenario); Indices separated into categories "labor rights and decent work", "human rights", "health and safety", "governance and community infrastructure". Source: Social hotspot database (SHDB, 2018).

Agricultural production in Brazil has several implications for the natural environment. Enterprise-driven deforestation for the cultivation of export-oriented crops accelerated land use changes in the Brazilian Amazon, which are regarded as main cause for biodiversity loss and furthermore the release of high amounts of sequestrated carbon dioxide (Holly K. Gibbs et al., 2016) (Vié et al., 2009). The Forest Code-regulation was set up in the 1990s, obliging farmers to preserve 80% and 20% of their area in the Amazon and other biomes, respectively. However, enforcement was difficult and deforestation rates rose, especially in the Amazon (Soares-Filho et al., 2014). Pressures from retailers and Non-Governmental organizations (NGOs) led to the assignment of a voluntary agreement, known as *Soy Moratorium*. This agreement between retailers and traders obliged soy traders not to purchase soy grown on lands deforested after July 2006 in the Brazilian Amazon and led successfully to a significant reduction of deforestation rate in this region (Gibbs et al., 2016). However, the *Cerrado* savannah is not affected by the Soy Moratorium, although it is considered as a biodiversity hotspot, providing 30% of the Brazilian biodiversity (Françoso et al., 2015)(Martinelli et al., 2010). Of the natural cover of the *Cerrado*, only 50% remain. Furthermore, intensification of Brazilian agriculture has led to additional ecological pressures on natural ecosystems, such as soil erosion and eutrophication, mainly caused by the use of high fertilizer amounts (Martinelli & Filoso, 2009) (Martinelli & Filoso, 2008).

2.2.3 Impacts of Poultry Production

Poultry production can be divided into several sectors, supplying different channels (Upton, 2007), as is summarized in Table 1.

Table 1: Overview over poultry production sectors, according to Upton (2007)

Sector		Market	Biosecurity standards	Owner poultry production	Future outlook
1	Small-scale / Backyard production	Subsistence, domestic market (rural)	Low	Private	Stable
2	Commercial production, <2000 birds	Domestic market	Low	Private	Decreasing
3	Commercial production, >2000 birds	Domestic market	Moderately high	Company	Decreasing
4	Industrial	Domestic market, export	High	Integrated Farmer	Increasing

Poultry production systems of sector 1 (small-scale production systems) are considered to have a broad range of direct positive effects on society of developing countries. Products, such as meat and eggs, and indirect products, such as chicken dung, may increase food security and financial resources of smallholder farmers (Steinfeld & Mack, 1995). Backyard poultry production is therefore considered to be an important tool to enhance rural development (Mack, Hoffmann, & Otte, 2005) (Mcleod, Thieme, & Mack, 2009).

However, export-oriented poultry production (sector 4) has other impacts on society than small-scale poultry farming. Commercial broiler farmers are usually *vertically integrated* (Upton, 2007). Vertically integrated systems are common around the world for a wide variety of agricultural commodities (FAO, 2001). In vertically integrated systems, all or many of the value chain stages are managed by a single company (Upton, 2007). In the poultry industry, it is common that contract farmers raise chickens to grow-out size and that feed, day-old chicks, medicine and technical assistance is provided by the integrators, which are usually meat processing companies (Upton, 2007). Integrated farming does not directly contribute to food security of farmers, since raised chicken are not consumed by the farmers but only sold via the official distribution channel. Furthermore, net-effects on income of farmers are controversial since considerable financial investments are required (Miele, 2013) (Prowse et al, 2012).

The environmental impact of industrial poultry production was assessed by several LCA studies (Table 2). Meat products are generally associated with higher environmental impacts than animal or vegetal products (Nemecek et al., 2016). However, in comparison to other meat products (beef and pork), the environmental impact per kg of edible protein was found to be lower regarding the contribution to global warming potential, as well as land- and energy use (de Vries & de Boer, 2010) (Nemecek et al., 2016). Industrial chicken production is highly depending on concentrate feed, which is grown on agricultural area (da Silva et al., 2014). Regarding acidification through emissions of ammonia, and eutrophication, studies show generally lower values for poultry meat than for other meat types, as well (de Vries & de

Boer, 2010). However, magnitude of ammonia emissions depend on several factors, such as climatic conditions, management practices, storage and housing facilities and are therefore more difficult to generalize (de Vries & de Boer, 2010). The same is true for eutrophication, since the share of nutrient run-off cannot be generalized. Gerbens-Leenes et al. (2013) calculated the water footprint of several meat products. They showed that poultry has a lower water footprint than beef and pork and that the major contributing value chain stage is the stage of feed production.

Findings of environmental impacts related to poultry production can be summarized as following.

- **Feed as main contributor**: The feed production stage is generally considered to be a major contributor of the value chain to environmental impacts. The contribution of post-farm gate processes are generally considered small in comparison to feed production and rearing stage for all impact categories (da Silva et al., 2014) (Alig et al., 2012). Gerbens-Leenes et al. (2013) concluded that main factors, influencing environmental impacts, are the FCR, feed composition (share of roughages) and the origin of feed.
- **Production-system:** extensive, free-range and organic poultry production systems were found to be related to higher environmental impacts than industrial production due to the use of higher feed amounts and smaller concentrate fractions, such as maize and soy (Gerbens-Leenes et al., 2013) (Alig et al., 2012).
- **Location matters I**: Alig et al. (2012) compared environmental impacts of different meat value chains (beef, pork, chicken) with destination Switzerland for different production systems and locations. They found that Brazilian chicken production is generally related to higher environmental impacts than Swiss or French production systems. Higher impacts for acidification, resource use and aquatic eutrophication were attributed to the use of urea as fertilizer, as well as the higher amounts of phosphoric fertilizer, which are necessary for specific Brazilian soil conditions. Furthermore, higher impacts were found for terrestrial and aquatic ecotoxicity, caused by higher pesticide amounts.
- **Location matters II**: A LCA study on Brazilian poultry production was conducted by da Silva et al. (2014), comparing Southern and Center-West production regions in Brazil. Chicken from the Center-West region in the Brazilian Cerrado showed significantly higher greenhouse gas (GHG) emissions, caused by carbon releases through crop cultivation on deforested areas.

Table 2 shows an overview of LCA results for the production of 1 kg of chicken (at farm gate) with impacts related to global warming, land use, cumulative energy demand and acidification potential.

Table 2: Overview of LCA results for 1 kg chicken (live weight), at farm gate, GWP: Global warming potential, CED: Cumulative Energy Demand; AP: Acidification potential. US: United States of America; EU: European Union; BR: Brazil. Based on Da Silva (2012)

Autor, location	**GWP** kg CO_2-eq.	**Land use** Occup. m^2yr	**CED** MJ	**AP** kg SO_2-eq.
Spies (2003), BR	1.41	-	14.3	0.06
Pelletier (2008), US	1.39	1.40	-	0.015
Leip et al. (2010), EU	3.43	-	-	-
Da Silva (2012), BR South / Center-West	1.45 / 2.10	2.46 / 2.51	19.1 / 18.0	0.034 / 0.031

The approaches of this study to find most urgent areas of concern in the chicken value chain will be presented in the following chapter.

3 Methods and Material

3.1 Research Strategy

The first step of this work was to find relevant information about the structure and actors of the value chain of chicken production. Based on these findings, socio-economic and ecological impacts were assessed for a selected set of indicators. Finally, found effects were evaluated by means of a Sustainable Hotspot Analysis according to Wallbaum & Kummer (2006), resulting in the most important areas of concern ("hotspots") within the value chain. These were compared to statements from stakeholders. A variety of methods were used for the different steps (Figure 2).

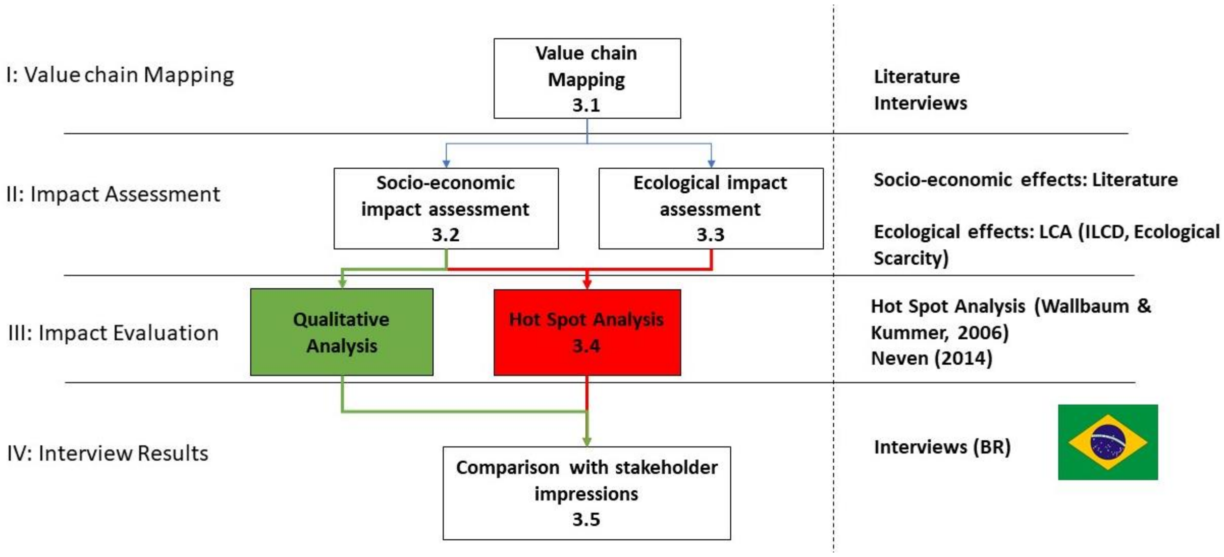

Figure 2: Research strategy in four steps (I-IV). Red (green) boxes and arrows: handling of negative (positive) effects; Right side: methodical approaches for each step. Brazil flag: step conducted in Brazil. .

3.2 Value Chain Mapping

For value chain mapping, the value chain of chicken was analyzed for relevant *processes*, *actors* and *traded amounts*.

The information about processes was used to create a flow chart value chain map, according to Herr & Muzira (2009). Further information on distribution channels and types of relationships between actors were added to form a grid chart (Herr & Muzira, 2009). Additional information was condensed into a synthesis value chain map (appendix A4). Table 3 shows an overview of the main data sources used for several types of information.

Table 3: Types of sources, related target information and main sources.

Type of source	Target information	Sources
Product, registration number	Actors	Retail products - Chicken Nuggets, origin: Brazil, at Retailer Switzerland - Diced chicken meat, origin: Brazil, at Retailer Switzerland
Interviews with industry representatives	Processes Actors	Complete list in section 3.6
Documents of industry associations and companies	Processes Actors Amounts	ABPA (2017) BRF (2017) JBS (2018) Proviande (2017) Aviforum (2016)
Statistics	Amounts Actors	FAOSTAT (2018) OECD (2018) BLW (2018) USITC (2012) IBGE (2018) Embrapa (2018)
Technical literature	Process description	e.g. Gillespie & Flanders (2009)

The value chain maps were used as a basis for the socio-economic and ecological impact assessment, which is described in the following subsections 3.3 and 3.4, respectively.

3.3 Socio-Economic Impact Assessment

In order to assess the socio-economic impacts of the value chain, a desk research was conducted. The impacts were categorized into *positive* and *negative* effects and evaluated, as is shown in Figure 3.

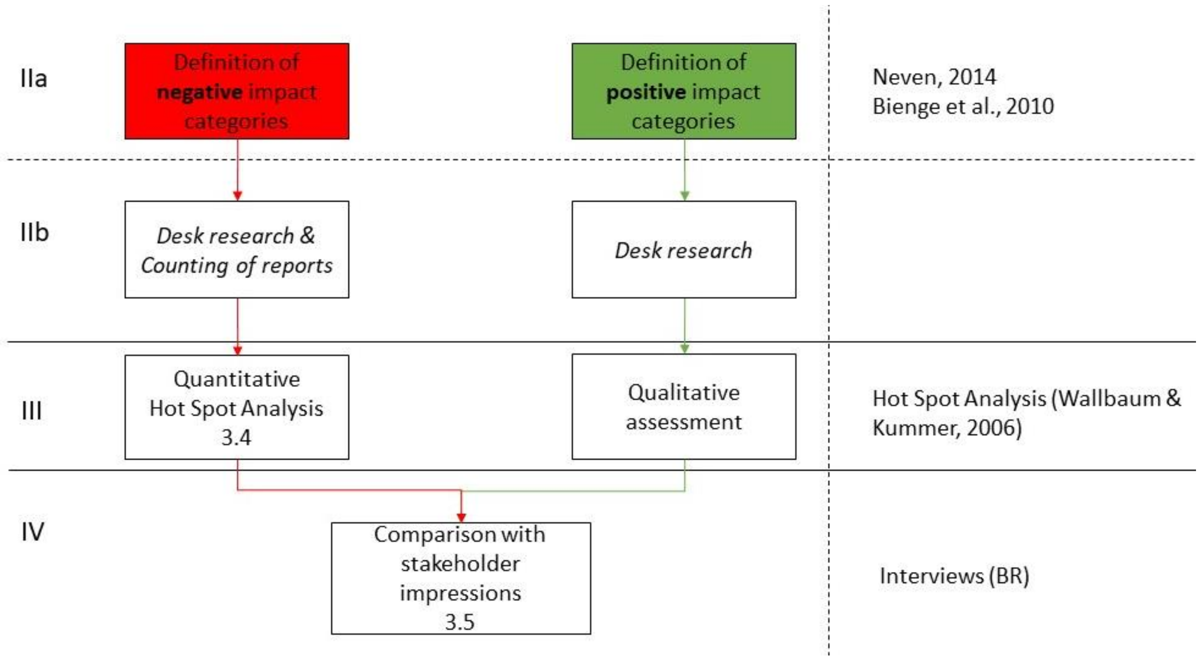

Figure 3: Research strategy for the socio-economic impact assessment (step IIa and IIb). Left side: actions; right side: main sources and methods for related step.

In a first step, positive and negative effects were divided into several subcategories. Table 5 shows the selected subcategories and related Sustainable Development Goals of the United Nations (SDGs) (UN, 2018).

As subcategories for *negative* effects were chosen “working conditions”, “health and safety”, “human rights”, “land conflicts”, “food supply”. First category refers to adverse working conditions, including contract problems. The category “human rights” refers to violations of human rights, “land conflicts” refers to conflicts between companies and local communities, “food supply” comprises adverse effects on food security. These subcategories were derived from existing sustainability indicators for biofuel value chains from Bienge, Geibler, & Lettenmeier (2009) and from(Diaz-Chavez, 2014).

The chosen subcategories for *positive* effects should cover value chain benefits contributing to poverty reduction, according to Neven (2014). Benefiting effects in the subcategories “employment creation”, “improved food supply” and “taxes” were considered (Figure 4). Additionally, Neven’s (2014) category “return on assets”, was replaced by the category “market access for smallholders” to focus on the aspect of inclusiveness of the value chain. Since rural areas in Brazil have considerably higher poverty rates than urban areas (World Bank, 2018), the effect on these areas were investigated additionally (subcategory “rural development”), according to the impact category “contribution to local economy” by Diaz-Chavez (2014).

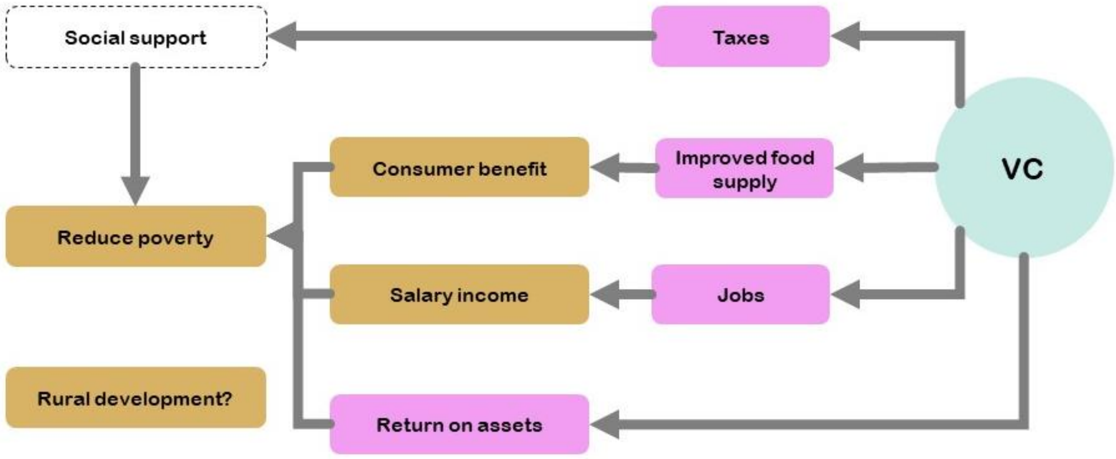

Figure 4: Simplified Food Value Chain Paradigm, showing potential benefits of value chains by Neven (2014). VC: Value chain. Red: benefit aspects covered by impact subcategory. Blue boxes indicate development goals. , based on Neven (2014).

In a second step, a desk research, based on peer-reviewed papers and reports by NGOs was conducted to find impacts of the value chain stages for each category (e.g. human rights). Reports about *negative* effects were counted, resulting in a counting table with quantitative values of numbers of reports for each value chain stage and subcategory (Table 4).

Table 4: Imaginary example of a counting table, indicating the number of found reports related to a specific value chain stage and category (e.g. 8 reports about health & safety issues in value chain stage 1).

	Value Chain Stage 1	Value Chain Stage 2	Value Chain Stage 3
Health & Safety	8	4	1
Human rights	0	0	3
Working conditions	2	3	2

Care was taken to ensure that NGOs were counted only once per phase and category, even if several reports on the same topic (e.g. Working conditions of soy field workers) were published. Reviews were also counted once, even if several studies were listed in them. If other papers were used in addition to reviews, care was taken that they were not already included in the review in order to avoid double counting.

The results of the *negative* impact assessment (counting table) was further evaluated quantitatively by means of a SHSA by Wallbaum & Kummer (2006), described in section 3.5.

For *positive* effects, it was assumed that the number of reports is not correlated with the dimension of a benefit. Therefore, reports on positive effects were not evaluated quantitatively.

Table 5: Socio-economic impact categories, divided by negative (Hotspots) and positive (Benefits) impacts, including related stakeholder groups, a description of indicators, related SDG goals.

Stakeholders	Category	Leading questions	Targeting SDG (Nr.)	Source
		Negative impact categories		
Workers	General working conditions	Problems with contracts, working hours?	Decent work (8)	Bienge (2010)
	Health & Safety	Occurrence of health problems exceeding the national average?	Good health and well-being (3) Decent work (8)	Bienge (2010)
Workers/ Society	Human rights	Occurrence of child labour, discrimination, forced labour, freedom of association, sexual harassment?	Decent work (8) Peace, justice and strong institutions (16)	Bienge (2010)
Society	Land conflicts	Incidences of land disputes?	Peace, justice and strong institutions (16)	Diaz-Chavez (2012)
	Food supply	Decrease in food availability?	Zero hunger (2)	Neven (2014)
Animals	Animal welfare	Legal standards?	-	
		Positive impact categories (Benefits)		
Workers	Employment creation	Jobs created? In which stages of the value chain?	Decent work (8)	Neven (2014)
Asset owners	Return on asset/ Market access for smallholders	Is there a possibility for small family farms to participate in the VC? At which stages?	-	Neven (2014)
Society	Rural development	How are benefits distributed (rural/urban)?	No poverty (1) Zero hunger (2) Decent work (8)	Diaz-Chavez (2012)
Society	Improved food supply	Does the VC generate more valuable or affordable food?	Zero hunger (2)	Neven (2014)
Society	Taxes	Are taxes used for social security programs? Effectiveness?	-	Neven (2014)

3.4 Ecological Impact Assessment

3.4.1 Introduction

For the assessment of ecological impacts of food products, life cycle assessment (LCA) is an established and widely distributed tool (Nemecek et al., 2016). Therefore, an LCA was conducted to assess impacts of the chicken value chain. The result of the life cycle impact assessment (LCIA) was used as basis for the quantitative evaluation and generation of hotspots by means of a SHSA (section 3.5).

According to ISO 14040 and ISO14044 (2006), an LCA is conducted in four steps. In a first step ("goal and scope"), aim, system boundaries, considered processes, a functional unit and the specific method for the impact assessment are defined. In a second step ("life cycle inventory", LCI), emissions and resources arising in all value chain stages are summed up. In the third step ("life cycle impact assessment", LCIA), emissions and resource are assigned to specific environmental problems, referred as "impact categories", e.g. climate change, human toxicity, pesticide use. In a fourth step ("interpretation"), results are analyzed and interpreted.

In this thesis, the four steps of the LCA are integrated into the sections, as shown in Figure 5. Goal and scope, as well as explanations about the LCI, are integrated in this section. However, LCI tables with quantitative values of resource uses and emissions can be found in appendix A1. The LCIA and the interpretation are integrated into the chapter "results" and "discussion", respectively.

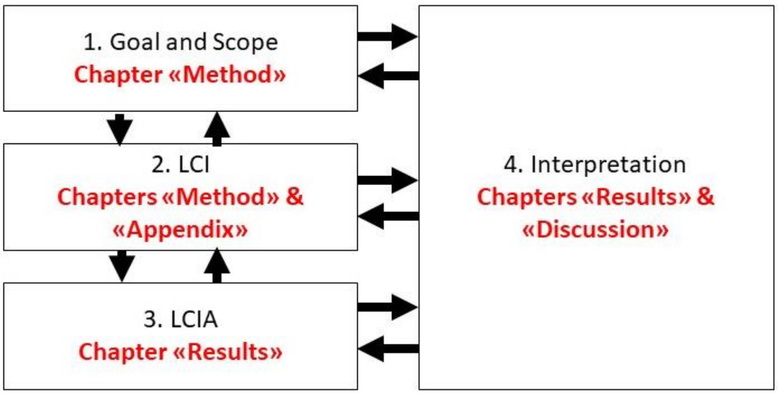

Figure 5: LCA procedure according to ISO 14040 and 14044 (2006) in four steps (Goal&scope, life cycle inventory, life cycle impact assessment, interpretation). The parts are integrated in the chapters of this study, as shown in red.

3.4.2 Goal and Scope

For this work, an LCA was used to estimate the environmental impact of 1 kg of chicken meat (unallocated) produced in Brazil, transported to Switzerland, at retail. The aim of the LCA was to

i) find the contribution of different stages of the value chain to environmental pollution in different damage categories, e.g. to global warming;

ii) establish of a data basis for the further Sustainable Hotspot Analysis according to Wallbaum & Kummer (2006).

The following processes were taken into account (see Figure 6): feed production (including maize and soy cultivation, processing into soybean meal), day-old chick production (including breeding and hatching), chicken rearing and slaughtering. Furthermore, transport processes between farm and slaughterhouse (by truck), as well as from slaughterhouse to port (by truck), from port in Brazil to port in Rotterdam (Netherlands, by ship), from port to distribution center and retail in Switzerland (by truck) have been considered. Not included were: processing in Switzerland, energy consumption at retailer, preparation of food at home or impacts through food waste.

Feed production, day-old chick production, chicken rearing and slaughtering are processes, which are carried out in Brazil. Whenever available, Brazilian data sets were used, or the data sets were adapted to Brazilian conditions, e.g. global or European data sets for electricity were replaced by Brazilian data sets. Following transport processes were considered: transport by truck between farm and slaughterhouse (Brazil), transport by truck between slaughterhouse and port (Brazil), transport by ship between port (Brazil) and port (Netherlands, Rotterdam), transport by truck between port (NL) and distribution platform (CH), transport by truck between distribution platform (CH) and distribution center and retail (CH).

The output of the system and functional unit is **1kg chicken (carcass weight)**. The carcass weight refers to the weight of chicken after evisceration of offal, heads and feet.

The main source of information was a report by the Swiss agricultural research institute Agroscope (Alig et al., 2012) which is based on Brazilian data of Da Silva et al. (da Silva et al., 2014). The information was used to model the feed composition, transport distances and types. For the processes related with day-old chick production (breeding and hatching), data sets from the Agrifood database were used. These data sets contain data for the production of day-old chicks in the Netherlands. For energy and infrastructure inputs used for chicken rearing, an ecoinvent 3 data set (allocation - cut-off by classification – unit) was used, whereas energy inputs (electricity and heat) were adapted to Brazilian conditions. For the slaughtering process, an adapted data set modelled by the research group Life Cycle Assessment (Zurich University of Applied Sciences, ZHAW) with Brazilian electricity inputs, was used. For all not mentioned background processes, data sets of the ecoinvent database 3 (allocation - cut-off by classification – unit) were applied (Wernet et al., 2016).

For the Life Cycle Impact Assessment (LCIA), two impact assessment methods were applied. ILCD 2011 Midpoint+ (v1.09, 2016) was used for goal i) of the LCA. It is a collection of already existing midpoint methods and was developed by the European Commision in 2010. It covers 16 midpoint impact categories, among them ozone depletion, human toxicity, particulate matter (European Commision, 2010).

The impact assessment method Ecological Scarcity 2013 according to Frischknecht & Büsser Knöpfl (2013) was used for goal ii) of the LCA, as a data basis for SHSA by Wallbaum & Kummer (2006). Ecological Scarcity 2013 is a single-score method, resulting in eco-points, which was used for the comparison of different impact categories in this thesis. Emissions and resources use amounts are converted into eco-points by means of eco-factors which depend on the relation of actual fluxes to tolerated fluxes, defined by legal requirements of Switzerland (distance-to-target principle). The results of different categories can thus be added and compared (e.g. climate change and air pollution), which is a prerequisite for the application of the Sustainable Hotspot Analysis methodology by Wallbaum & Kummer (2006).

By-products, such as chicken excreta or animal residues from slaughtering, have not been considered, assuming their economic value being negligible in comparison to chicken meat. Therefore, no allocation was performed at any stage.

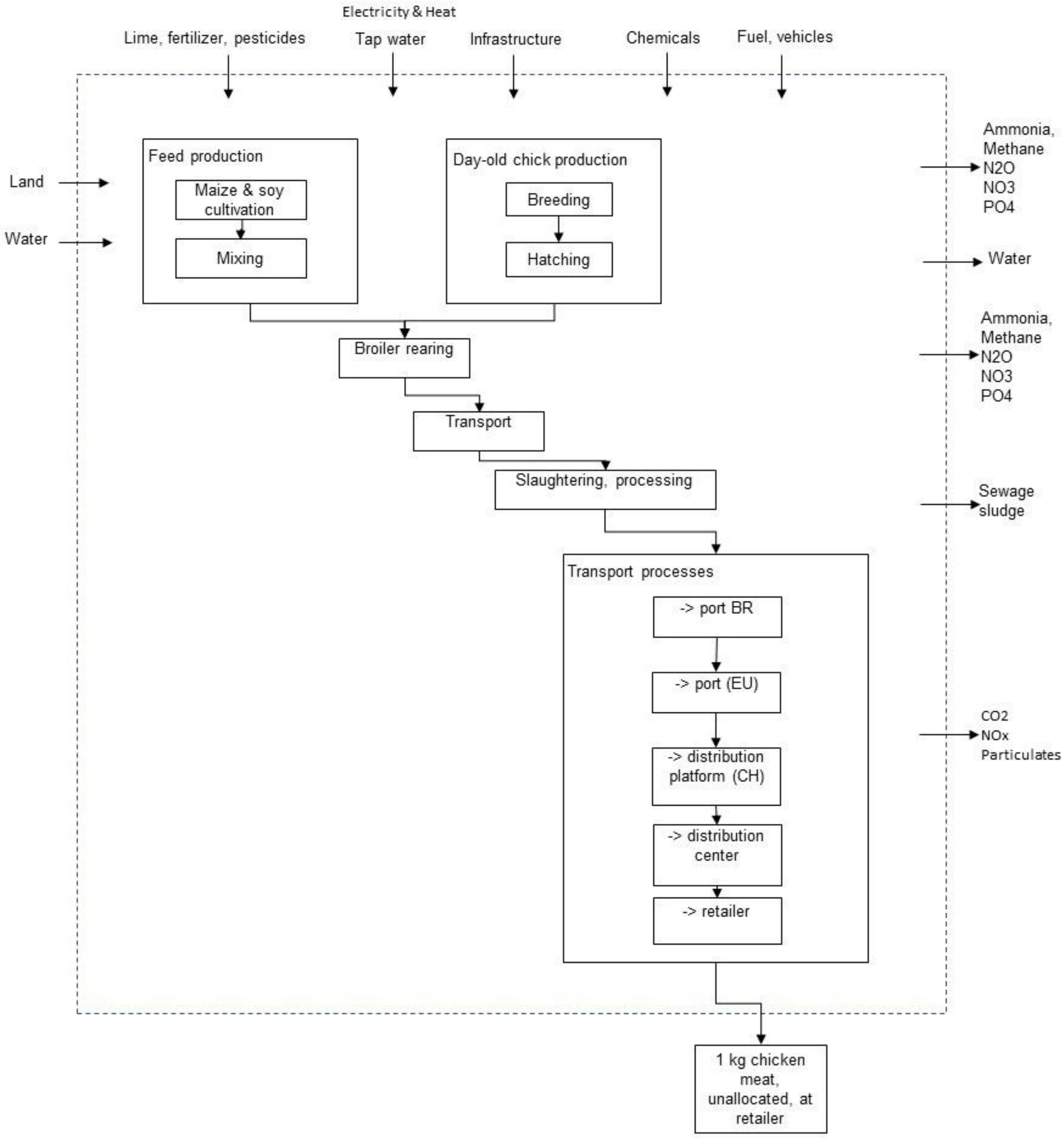

Figure 6: Considered processes for the production of 1 kg of chicken meat (unallocated, at retailer) are within system boundaries (dotted line). Natural inputs (from left), inputs from technosphere (from above) and emissions leaving at the right side. Source: author.

3.4.3 Life Cycle Inventory

The following processes were modelled and analyzed separately: feed production, rearing, slaughtering, transport.

The composition of Brazilian poultry **feed** (34% soy extraction meal, 52% maize grains, 5% soybean oil, minerals and additives) was based on Alig et al. (2012). Assuming an FCR of 1.87 for the chicken breed COBB, which is commonly used in Brazil (Hoffmann et al., 2013), a feed amount of 1.87 kg is used for the production of 1 kg chicken meat (live weight). With an exploitation share of 0.7, a feed amount of 2.8 kg is needed for the production of 1 kg chicken meat (carcass-weight, “cw”) (Hoffman et al., 2013).

For **hatching**, the data set “*Hatching eggs, broiler parents >20 weeks, at farm/NL Economic*” of the Agrifootprint v3.0 database was used (Blonk, 2017), which includes breeding process of broiler breeders as inputs. The amount of day-old chicks per kg meat (cw) was calculated as following: the average live weight of chicken at slaughter age is 2.44 kg (da Silva et al., 2014). Considering an exploitation value of 0.7, each chicken produces 1.78 kg chicken meat (cw). Therefore, for the production of 1 kg of chicken meat (cw), 0.58 chickens are needed. If a mortality rate of 4.3% is considered, an amount of 0.61 chickens are necessary for each kg of chicken meat (cw) (da Silva et al., 2014).

For the modelling of the **rearing** stage, the data set “*Chicken for slaughtering, live weight {GLO}*| *chicken production* | *Alloc Rec, U*“ for chicken growing of the ecoinvent database 3 (Wernet et al., 2016) was used, containing inputs, such as infrastructure, water, heat and electricity. Furthermore, the data set contains emissions into air and water, such as ammonia, methane or nitrate. The data set was adapted by removing feed inputs in order to separate the rearing and the feed stage, and by replacing heat and electricity inputs with Brazilian data sets, if available.

For **slaughtering**, the data set “chicken, meat, carcass (cold) at slaughterhouse/kg/GLO U” from the Agrifood database DBEI3.3 was used, assuming that slaughtering processes in Brazil and Switzerland have similar in- and outputs (Alig et al., 2012). The data set was adapted by replacing heat and electricity inputs by Brazilian data sets, when available.

Transport processes were modelled with average transport distances for Brazilian chicken, according to Alig et al. (2012), shown in Table 6.

The complete LCI tables can be found in the appendix A1.

Table 6: Transport types and distances for Brazilian poultry, according to Alig et al. (2012)

Transport	Type	Distance (km)
Farm -> Slaughterhouse	Truck	250
Slaughterhouse -> port (BR)	Truck, cooling	800
Port (BR) -> port (NL)	Ship	10’000
Port (NL) -> distribution platform (CH)	Truck, cooling	750
Distribution platform (CH) -> center (CH)	Truck, cooling	100
Distribution center (CH) -> retail (CH)	Truck, cooling	25

3.5 Sustainable Hotspot Analysis (SHSA)

According to Bienge et al. (2009), the Sustainable Hotspot Analysis (SHSA) is a useful tool for decision-making to define ecological and socio-economic areas of priority ("hotspots") in complex value chains. SHSA was developed by the Wuppertal Institute (Wallbaum & Kummer, 2006) to identify ecological resource-intensities within a value chain. Meanwhile, the SHSA has been refined and social aspects can be included, as well (Bienge et al., 2009) (Liedtke & Baedeker, 2010) (Rohn & Lukas, 2014).

The SHSA is conducted in three steps (Bienge et al., 2010):

1. Comparison of sustainability performance of categories *within* a life-cycle phase
2. Comparison of sustainability performance *between* life-cycle phases

Figure 7 and Figure 8 show the procedure of steps 1 to 3 for selected socio-economic and ecological impact categories, respectively.

Table 0: Result of negative socio-economic impact analysis (counting table)

Category/Life-cycle phase	Production	Processing	Distribution	End-of-life
Human rights	1	0	2	1
Working conditions	5	11	2	1
Health & Safety	2	2	8	5

Step 1

Table 1: Comparison *within* life-cycle stages

Category/Life-cycle phase	Production	Processing	Distribution	End-of-life
Human rights	1 (min)	1	1	1
Working conditions	3 (max)	3	1	1
Health & Safety	2 (medium)	2	3	3

Step 2

Table 2: Comparison *between* life-cycle stages

Category/Life-cycle phase	Production	Processing	Distribution	End-of-life
Human rights	2 (med)	1 (min)	3 (max)	2 (med)
Working conditions	2	3	2	1
Health & Safety	1	1	3	2

Step 3

Table 3: Synthesis of table 1 and 2 (Multiplication

Category/Life-cycle phase	Production	Processing	Distribution	End-of-life
Human rights	6 (2x3)	1	3	2
Working conditions	2 (2x1)	9 (3x3)	1	2
Health & Safety	3	2	6	2

Figure 7: Illustration of Sustainable Hotspot Analysis procedure (steps 1-3) for selected socio-economic impact categories.

For the HSHA of (negative) socio-economic effects (Figure 7), the result of chapter 4.4 (counting table) was used as a basis for the creation of step 1 and 2. Minimum values within a value chain stage (or subcategory) of the counting table were rated as “1” in table 1 and 2, maximum counting values were rated as “3”, and values in between were rated as “2”.

As data basis for the ecological SHSA (Figure 8), the categories of the chosen life cycle impact assessment (LCIA) method Ecological Scarcity 2013 were chosen. The results of the LCIA table with eco-points were used to create table 1 and 2 of step 1 and 2, respectively. Values smaller than 10% of the sum of the eco-points within / between categories were rated as “1”, values bigger than 40% of the sum of the eco-points within / between were rated as “3”, values in between were rated as “2”.

Table 0: Result of ecological impact analysis (values in eco-points)

Category/Life-cycle phase	Production	Processing	Distribution	End-of-life
Climate change	220	0	15	100
Air pollution	30	23	25	200
Water pollution	90	50	75	25

Step 1

Table 1: Comparison *within* life-cycle stages

Category/Life-cycle phase	Production	Processing	Distribution	End-of-life
Climate change	3 (>40%)	1	2	2
Air pollution	1 (<10%)	2	2	3
Water pollution	2 (>10%, <40%)	3	3	1

Step 2

Table 2: Comparison *between* life-cycle stages

Category/Life-cycle phase	Production	Processing	Distribution	End-of-life
Climate change	3 (>40%)	1 (<10%)	1 (<10%)	2
Air pollution	2	1	1	3
Water pollution	2	2	2	2

Step 3

Table 3: Synthesis of table 1 and 2 (Multiplication

Category/Life-cycle phase	Production	Processing	Distribution	End-of-life
Climate change	9 (3x3)	1	2	4
Air pollution	2 (1x2)	2	2	9
Water pollution	6	6	6	2

Figure 8: Illustration of Sustainable Hotspot Analysis procedure (steps 1-3) for selected ecological impact categories.

With the results in table 3, the socio-economic and ecological hotspots can be identified. According to Wallbaum & Kummer (2006), hotspots are defined as results with a ranking of “6” or “9”.

3.6 Interviews

In Switzerland, two phone interviews with industry representatives of a retail organization and a meat trade association were conducted in May 2018 and September 2018, respectively. The interviews were focusing on information about the value chain (actors, stages, current development). The interviews were conducted as unstructured, qualitative interviews without guidelines.

In Brazil, four face-to face and three phone interviews were conducted between the 1st and 16th of July 2018. The interviews covered several stages of the value chain, as is shown in Figure 9.Among the interviewees were two academic experts, two nutritionists, two sanitary inspectors (slaughterhouse stage), one sanitary inspector (farm stage), one animal welfare specialist and one caipira-farmer (and ex-soy field worker). The interviews were semi-structured, open guideline interviews with open-ended questions. The guidelines for the Brazilian interviewees were covering value-chain structure-aspects, as well as socio-economic and ecological impacts of the value chain. The general structure of the guidelines was as following:

- General questions: Description of personal or company activities
- Poultry industry: What are the main challenges? Estimation of sustainability in general?
- Socio-economic issues: Are there problems? Estimation of situation of broiler farmers, slaughterhouse workers, chicken catchers?
- Ecological issues: Are there problems caused by the value chain?
- Future outlook: Are changes in sight? What changes would be necessary to make the value chain more sustainable?

In all cases, the interview questions were adapted to the interviewee's knowledge and expertise. The Brazilian interviews were recorded and, for the qualitative analysis of the interviews, coded according to the main topics of the guideline. A description of the Brazilian interviews can be found in appendix A3.

Retail associate (industry representative, CH)

The phone interview with a Swiss retail associate was used to gain more information about suppliers of Swiss retail stores.

Meat trader associate (industry representative, CH)

The phone interview with an associate of a Swiss meat trading organization was conducted with the goal to find details about the Swiss import market.

Academic experts (BR)

Both academic experts work as researchers at university institutes. One has his expertise in the promotion of protected communities, the other works in the field of pig and poultry nutrition. The interviews with the academic experts had the goal to find more details about the value chain and to thematize socio-economic and ecological hotspot issues. One of the academic experts was met on a farm, where he explained the cropping system of a *Caipira*-farmer.

Nutritionists (industry representative, BR)

Both nutritionists work in the feed industry. One of them for a supplier of amino acids, the other in a premix company. The interviews with the nutritionists served to explore further value chain details, primarily. One of the nutritionists also discussed several hotspots.

Sanitary inspectors (slaughterhouse stage, industry representative, BR)

The sanitary inspectors were asked about food-safety issues, in particular. Furthermore, they were asked about socio-economic and ecological hotspots.

Sanitary inspectors (farm stage, industry representative, BR)

The sanitary inspector was met at a commercial broiler farm (dark house). There, he gave an insight into technical details of dark house systems.

Animal welfare specialist (industry representative, BR)

The animal welfare specialist works as a consultant of meat-processing companies and farmers. He gives trainings to chicken catchers and transport teams. Main topic of the interview were animal welfare issues, in particular.

Caipira-Farmer (ex-soy field farmer, BR)

The *caipira*-farmer was accompanying the interview with one of the academic experts on his farm. He showed his cultivation techniques. Furthermore, he gave brief insight into his life as a *caipira*-farmer and past experiences as a worker on soy fields.

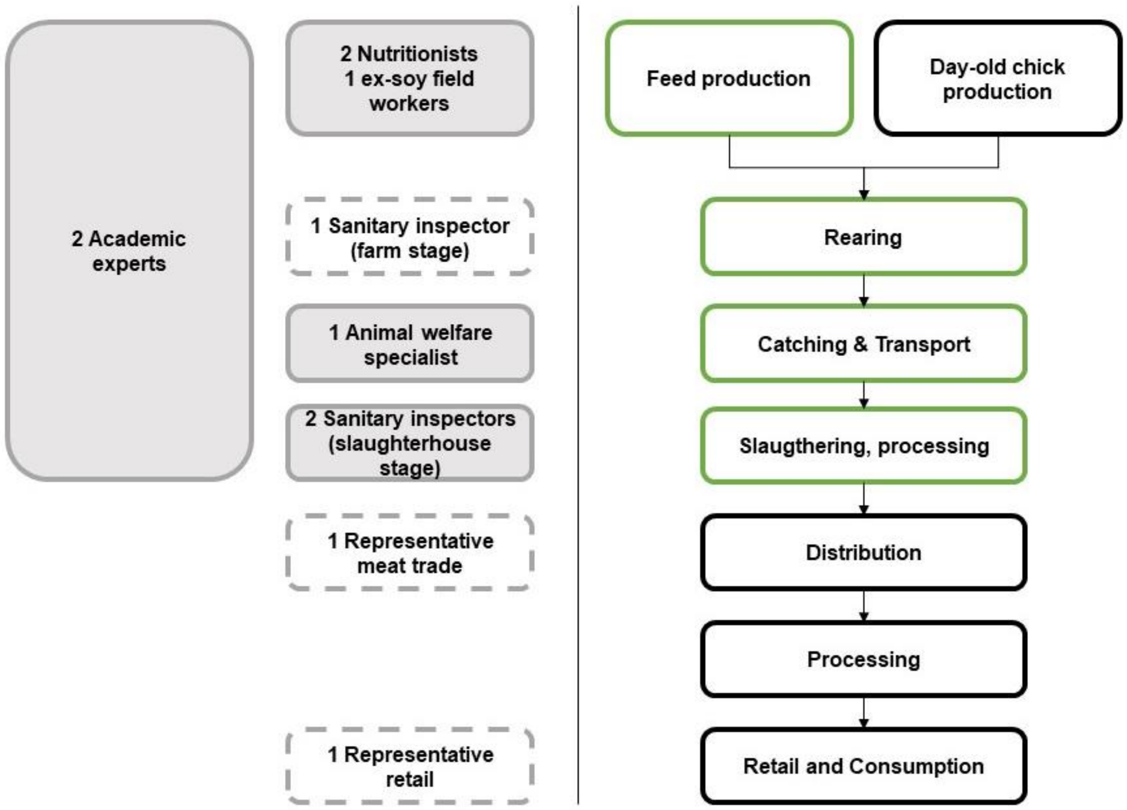

Figure 9: Interview sample (left side) and related value chain stage (right side). Green processes: value chain stage represented by at least one interviewee's expertise. Dotted lines: informal interviews.

4 Results

4.1 Summary

Figure 10 shows an overview of the main value chain stages, their related ecological and socio-economic hotspots and discussed benefits, which are presented in section 4.2 to 4.5.

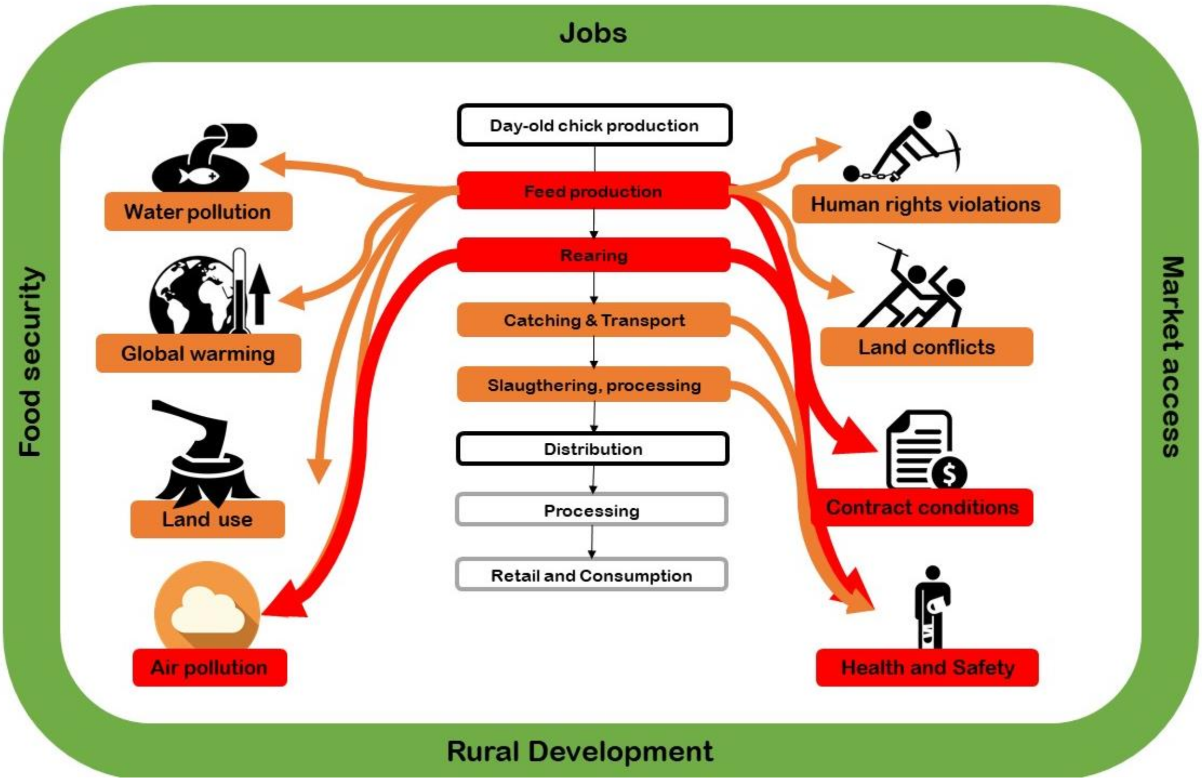

Figure 10: Summary of main findings, indicating value chain stages and related hotspots. Orange: ranting "6"; red: rating "9". Green frame indicates benefits by the value chain.

4.2 Value Chain Structure

4.2.1 Overview

Swiss people consume in average about 12 kg poultry meat per year, whereby 42% of this amount are imported (BLW, 2017a. From the import amount, 39% are imported from Brazil, resulting in a yearly consumption of 1.9 kg Brazilian poultry meat per Swiss capita (BLW, 2017a). In the following part, the way of the chicken, from the production in Brazil to the Swiss consumer is described.

The main production stages of the chicken value chain are feed production, day-old chick production, rearing of broilers, catching and transport of broilers, distribution, processing and consumption. **Value chain map 1** (flow chart map according to Herr & Muzira, 2009) shows these main processes and related products in Figure 11. The production of genetic stock for the broiler breeders is produced in the

United States or Europe. The chickens are bred, reared and slaughtered in Brazil. Then, they are transported to Europe, respectively Switzerland, where they are processed in a second step.

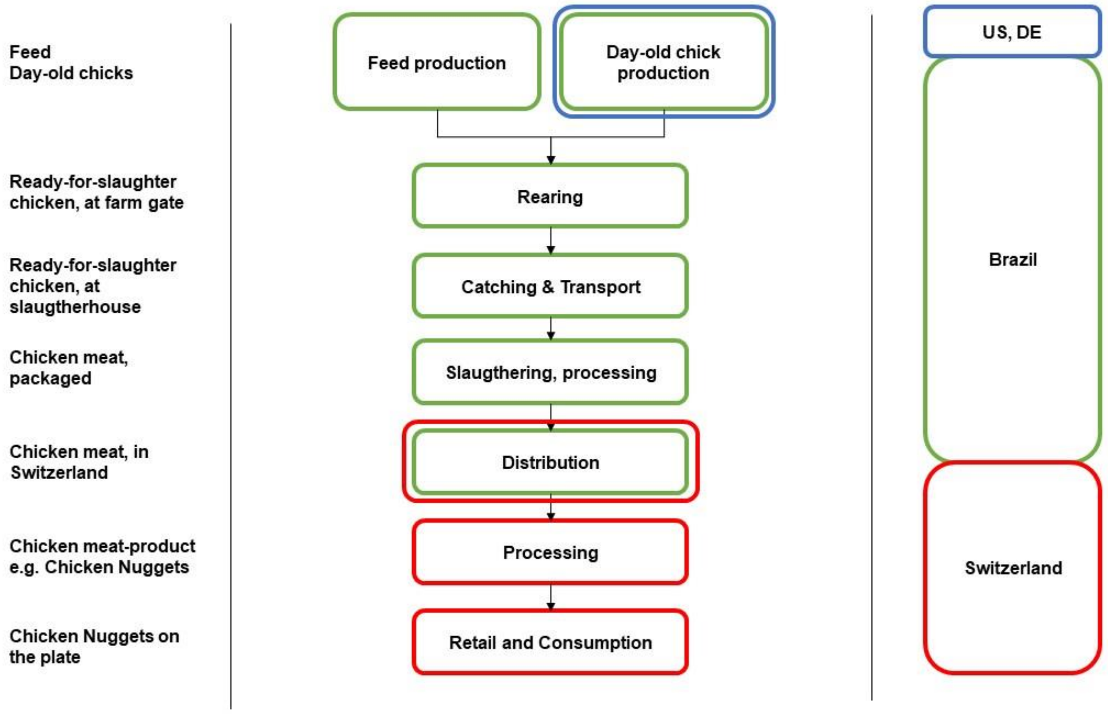

Figure 11: Value chain map 1. Flow chart value chain map according to Herr & Muzira (2009) of main processes (middle). Left side: Products of associated processes. Right side: Countries, where associated processes are conducted.

An overview over separate market channels and actors is shown in **value chain map 2** (grid chart map according to Herr & Muzira, 2009) in Figure 12. Most of the production channels in Brazil are vertically integrated: about 90% of the total Brazilian poultry production is produced by contract farmers (ABPA, 2017). The domestic market is supplied by integrated and non-integrated suppliers. However, export-oriented poultry production has strict food safety requirements and is completely supplied by large integrating companies (personal information, industry representative).

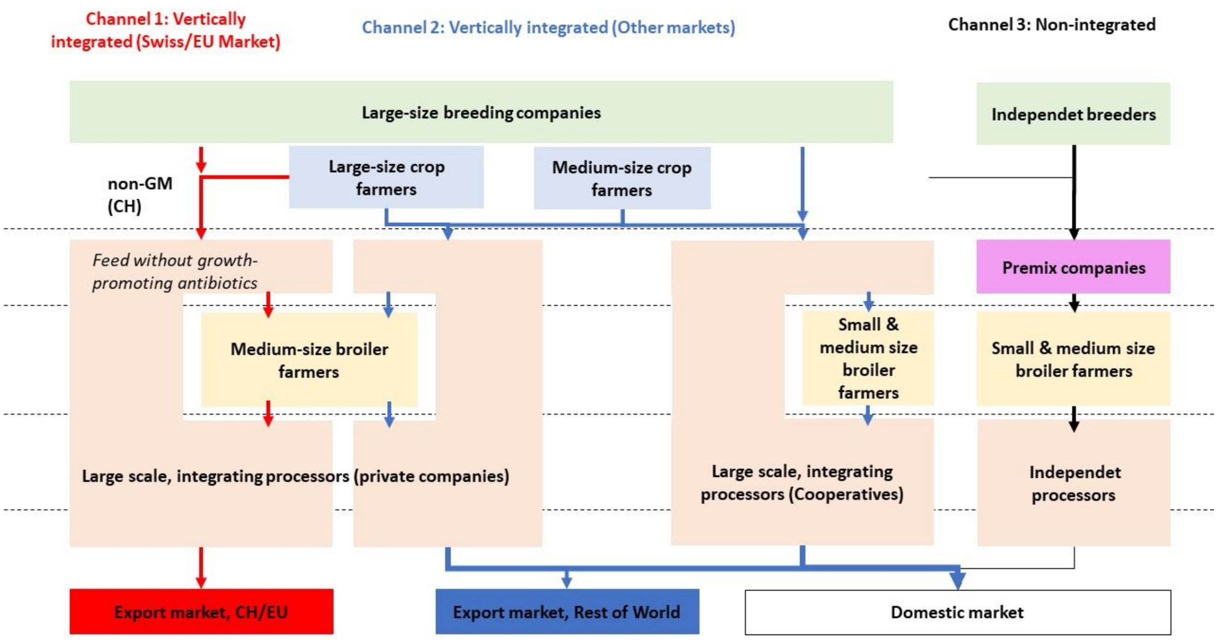

Figure 12: Value chain map 2. Grid chart according to Herr & Muzira (2009), showing main distribution channels and related size characteristics of value chain actors.

Organic chicken is produced without growth-promoting antibiotics (Filho & do Valle Pereira, o. J.). The market for organic food has been continuously growing in Brazil (Fonseca, 2013). However, with 10'336 producers, cultivating on 0.3% of the total agricultural area in Brazil, organic farming is still considered to be an underdeveloped niche market with a low presence of organic products in Brazilian retailers (Willer & Lernoud, 2018) (Fonseca, 2013). According to Filho & do Valle Pereira (o. J.), infrastructure costs for organic chicken are four times higher than for conventional chicken, which may contribute to low market shares.

The largest integrating companies in the Brazilian poultry industry are the Brazilian companies BRF and JBS, which account for about 50% of the poultry meat production and about 70% of the exported poultry meat (Repórter Brasil, 2016). Further exporting companies are the cooperatives Aurora Alimentos (3rd rank in exports) and C. Vale (4th rank in exports) (ABPA, 2017). Considering chicken with Switzerland as destination market, BRF is the main supplier (personal information, industry representative).

The poultry industry is traditionally located in the South of Brazil, with a production share of 58% (IBGE, 2018). Reasons are colder climatic conditions, the availability of specialized workforce, infrastructure conditions, shorter distances to export ports, which are also located in the South and Southeast of Brazil (USITC, 2012). Since the production of the feed components maize and soy expanded in the Center-west region, the production of poultry has shifted towards Center-west in the last decades to reduce transport costs. However, the lack of specialized workforce and poor infrastructure are major drawbacks of this production region.

Especially for the Swiss market, but also for parts of the European market, non-GM soy is demanded as feed for poultry production (personal information, industry representative). About 80% of soy production in Brazil is genetically modified (USITC, 2012). In order to guarantee separate market channels for GM and non-GM-soy, specialized non-GM farms of very large size provide the segregated market. These large-size farms are mainly located in the Center-West region, where climate is more favorable than in the South region (USITC, 2012). Smaller, GM-soy-producing farms supply poultry production channels without GM-restrictions.

4.2.2 Feed supply

The exact composition of poultry feed varies for different age stages and generations. In average, Brazilian poultry feed consists to about 96% of processed corn and soy products (Alig et al., 2012). Figure 13 shows an overview of the processes related to feed production.

Corn and soy are mainly cultivated in the hotter Center-west region of Brazil. Soybean farmers work independent or vertically integrated. Integrating meat-companies, such as BRF or JBS, buy their feed components, process and mix them in their own feed processing facilities. BRF works together with 3640 suppliers of grain meal and oil, whereby 3000 of them are rural farmers (BRF, 2017). Independent farmers sell their harvest to trades. The main trading companies are the *ABCD*-traders (Archer Daniels Midland ADM, Bunge, Cargill and Louis Dreyfuss), as well as the Amaggi group (Trase.earth, 2017) (USITC, 2012). According to data portal trase (Trase.earth, 2017), these companies account for 57% of the Brazilian soy trade.

Soybean farms in the Center-West region are modern, efficient and large-scale: two-thirds of the farms in the Center-West are bigger than 2'500 ha, some even bigger than 20'000 ha (USITC, 2012). Southern soy and corn farmers united in cooperatives to increase their bargain power and to profit from economies of scale. Cooperatives act as integrators, providing inputs and guaranteeing selling channels to broiler farmers.

Harvested maize grains are usually dried (less than 15% moisture), but not necessarily processed further (INRA et al., 2018). In contrast to corn, soya must be processed further in order to be used as animal feed. About 40% of the harvested soybeans in Brazil are processed into soymeal (32%) and soy oil (8%) (USITC, 2012). Poultry industry alone uses one quarter of the Brazilian soybean meal production as feed input (USITC, 2012). In a first step, soybeans are crushed, dehusked, and then, the oil is extracted mechanically or with solvents. The remaining part is then toasted and milled to soybean meal (INRA, 2017). By-products of the soybean production are lecithin, which is used in feed or food industry (e.g. in chocolate), and soy molasse, which is used as energy additive in cattle feed (Nordic Soya, 2013).

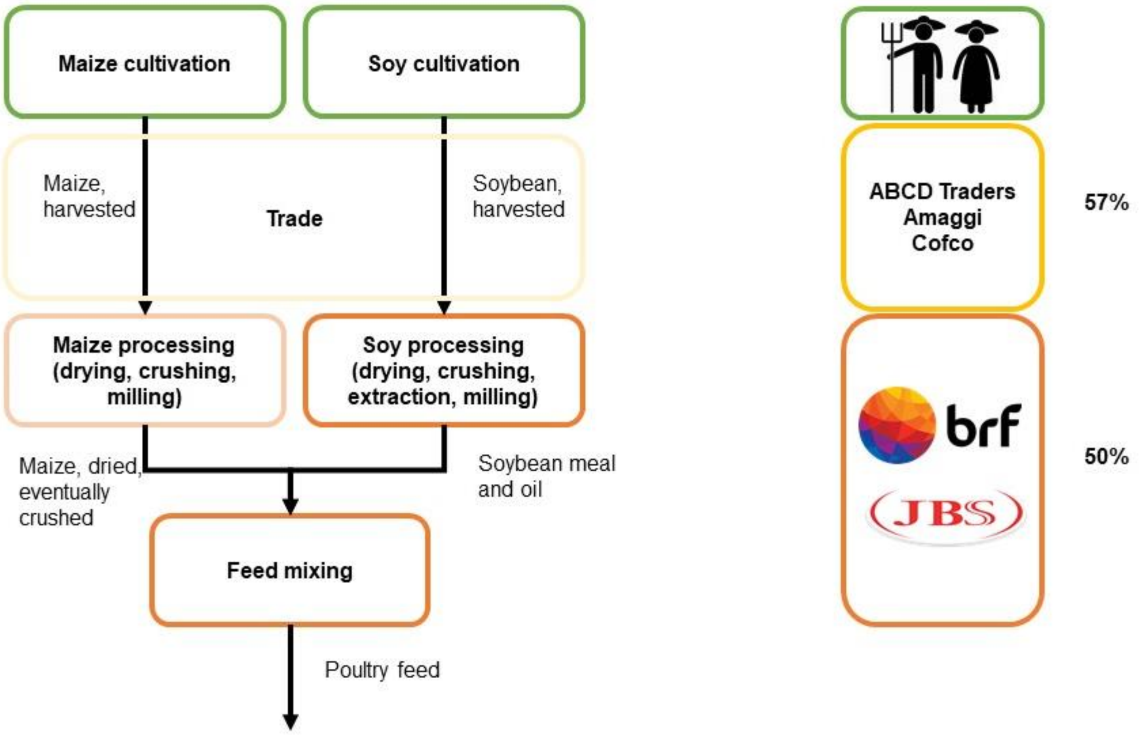

Figure 13: Subprocesses of poultry feed production. Source: author; brf.br; jbs.com.br.

Additives, such as minerals and amino acids are added to match with the precise physical needs of growing broilers. In Brazil and the United States, antibiotics are added as growth promoters. This procedure was developed in the 1950s to increase growth rate of broilers. However, the European Union and Switzerland banned antibiotics as growth promoters in 2006 and 1999, respectively (EC, 2005) (Schweizer Parlament, 2012). The EU-market and Switzerland conduct food safety controls together. Chicken, which is exported to the EU-market or Switzerland, has to be fed without growth-promoting antibiotics (Castanon, 2007). Furthermore, chicken for the Swiss market is fed with GMO-free components (personal information, industry representative).

4.2.3 Day-old chick supply

A basic input supply of broiler farmers are day-old chicks. Modern broiler hybrid-chicks are the result of time-consuming breeding programs.

Pedigree stock with suitable genetics is selected by searching for a wide variety of traits such as feed conversion ratio, heat tolerance, breast meat yield, skeletal quality, heart and lung function (FAO, 2012). In comparison to indigenous chicken, which need twenty week to reach a live weight of 1 kg, modern hybrids grow much faster, reaching a live weight of 2 kg within five week (FAO, 2010). As a consequence, much less feed is needed to rear the chicken: McKay (2009) estimates, that the feed amount to produce one ton of chicken meat decreased from 20 to 8.5 tons during the last 30 years. Pedigree stock is highly valuable: one rooster of the pedigree selection might produce 150 chicken of the GGP generation (grand-grandparent). These 150 chicken could produce 7500 chicken of the grandparent generation (GP), resulting in 375’000 chicken in the parent generation stock (PS) and finally 48’750’000 broilers (Figure 14) (Laughlin, 2007).

At the moment, there are only two suppliers of pedigree stock left, dominating the world market (Hiemstra & Napel, 2013): Aviagen and Cobb-Vantress. It is assumed that these two companies provide between 75% and 90% of the global commercial poultry production (Poultry world, 2017). Aviagen is owned by the German EW Group GmbH (formerly known as Erich Wesjohann GmbH&Co) and provides the breeding lines Ross, Hubbard and Arbor Acres; Cobb-Vantress provides the brand Cobb and Avian among others. Cobb-Vantress is owned by the U.S. company Tyson Foods, Inc., which is the largest meat processor worldwide, followed by JBS (National provisioner, 2018).

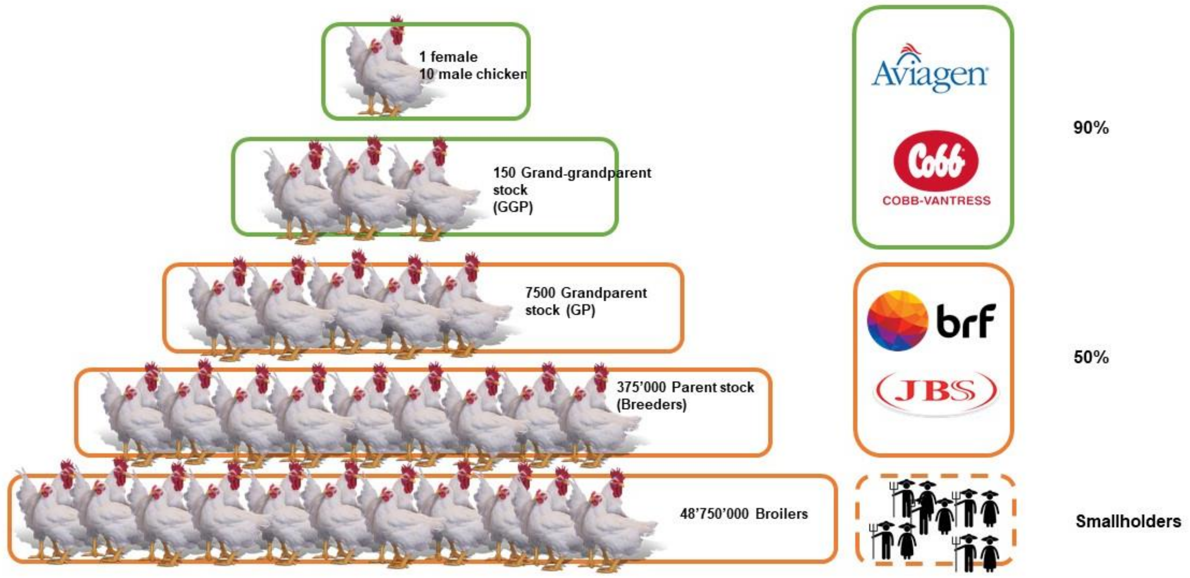

Figure 14: Overview over number of individuals in a generation stock. At the right side: main actors. Green: processes managed by breeding companies (Aviagen and Cobb-Vantress); orange: processes managed by Brazilian integrators (BRF and JBS); dotted line: individual but contracted actors.

Grandparent eggs are imported by Brazilian integrators and hatched in specialized breeding farms. Breeding farms rear chicken of the grandparent and parent generation. Usually, they go through the following processes: brooding, growing, housing, mating, collection, incubation and hatching. At the first stage, the brooding, male and female chicks are held separately until their 5th week of age. Later, at the growing stage (4th to 20th week), they are held together. During this non-reproductive phase, feed is restricted to avoid overweight which would decrease breeding capabilities. At the following housing phase (18th to 22th week), the chicks are placed in sheds with nests. In order to achieve optimal results, about 10% cockerels are added for mating. Fertile eggs are collected regularly and fumigated by formaldehyde gas for disinfection purposes (Poultryhub, 2018). Each hen lays about 150 to 160 eggs during a laying cycle of 34 to 36 weeks (CHEP, 2018). At the end of the laying period, broiler breeders have a weight of about 4-5kg of live weight (CHEP, 2018.

In specialized hatcheries, the fertilized broiler eggs are incubated for 21 days. “Day-old chicks” are defined as chicks being younger than 72 hours. They need a warm environment (32°C-35°C) and high humidity (60%-70%) (CIWF, 2013). The hatched chicks are inspected for diseases. Healthy chicks are then vaccinated (e.g. *Salmonella*, Newcastle disease, bronchitis virus, avian pneumovirus). The vaccine is sprayed on or delivered by drinking water (CIWF, 2013). After vaccination, the chicks are placed in boxes, separated by sex. Sick chicks are being disposed. The chick boxes are then transported to the Broiler farms (CHEP, 2018).

4.2.4 Rearing

Broiler rearing is carried out by farmers who are under contract with the integrating companies (meat processors). They receive the chicks, feed, medical and technical support, as well as facilitated access to financial credits. However, they are contracted to sell the broilers to the respective meat processor only via the official channel and to comply with safety regulations. According to the ABPA, there are about 130’000 broiler farmers in Brazil. Figure 15 shows an overview of the rearing stage and participating actors.

Broiler farmers in Brazil get usually paid with a basic price per kg live weight and an additional bonus, depending on their performance in relation to their competitors (Miele, 2013). Farmers using less feed (lower FCR) get a higher ranking than others. The FCR depends on several management factors, such as temperature or ammonia concentration inside the broiler shed (Cooper & Washburn, 1998) (Naseem & King, 2018).

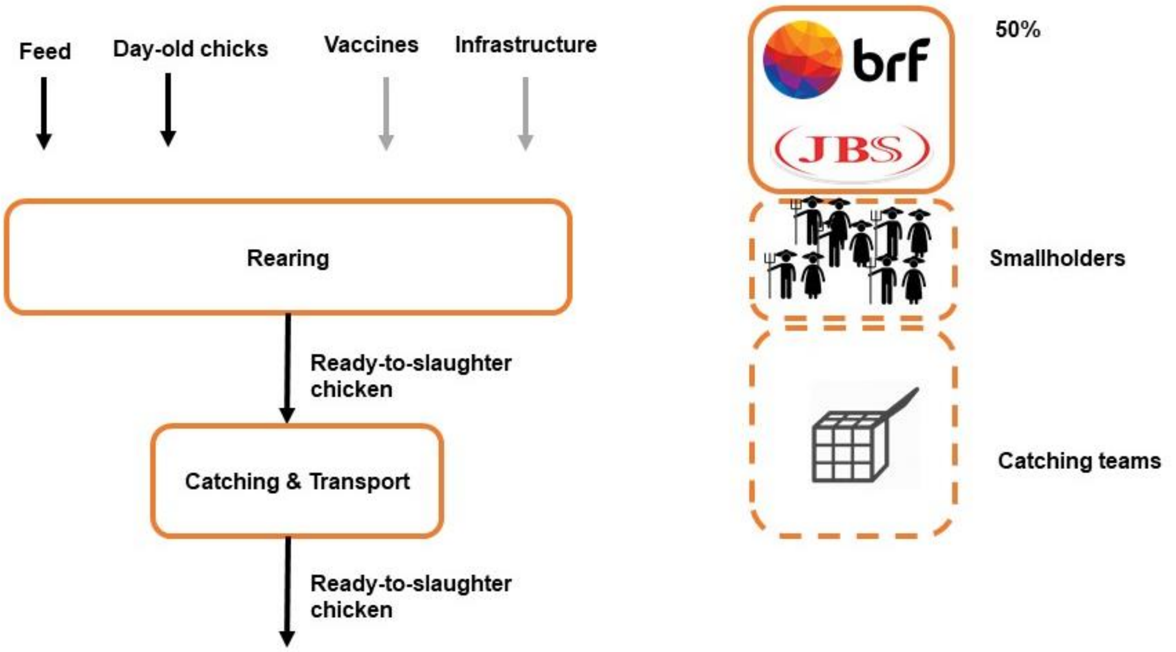

Figure 15: Overview over rearing and catching process. Right side: actors. Dotted lines: contracted actors. Source: author,

In specialized broiler farms, day-old chicks are reared until they reach their final slaughter weight of about 2.4 kg within 42 days (da Silva et al., 2014). The duration and the final weight may differ, depending on the demanded size of the chicken: some final markets demand smaller bodies (e.g. Saudi Arabia), others prefer bigger ones (USDA, 2018). The average rearing time has reduced substantially in the last century, from 112 days to 42 days, and the feed conversion ratio (FCR) improved from 4.7 to 1.85 kg feed per kg live weight (Nationalchickencouncil, 2017). Chicken are usually held freely in flocks of about 10'000 to 20'000 birds on the floor of roofed housings. The floor is covered with litter, made of peanut shells or rice hulls. Water and food are provided automatically and unlimited. Many grow out houses have an air ventilation system (CIWF, 2013). There is no maximum stocking density in Brazil. However, according to the Brazilian Association for Export and Trade, the average stocking density of broilers is 34kg/m^2 in Brazilian farms (Caspari & Oliver, 2010). In comparison, the Swiss upper limit (30 kg/m^2) is lower and the German and EU limit is considerably higher (39 kg/m^2 and 42 kg/m^2) (Proviande, 2016). Traditionally, industrial farms in hotter countries (e.g. Brazil) have open sheds, whereas in temperate climate zones (e.g. European countries), the sheds are closed, climate controlled and operated with artificial lighting (CIWF, 2013). However, Brazil has introduced closed sheds with controlled atmosphere and negative pressure, known as "dark houses", in the last years. Studies indicate that broilers in closed sheds with artificial lightning program and controlled atmosphere, known as "dark house systems", show better FCR, feed intake, final weight and reduced mortality in comparison to the "conventional" Brazilian rearing systems (Rovaris et al., 2014). In Switzerland, artificial light is not allowed as only light source (Proviande, 2016).

4.2.5 Catching and Transport

When chickens have achieved their slaughter weight, they are caught and transported to the slaughtering facility in boxes. For these actions, catching teams ("Chicken catchers") are called by the integrating companies and sent to the broiler farms. The catching teams are usually hired by small, subcontracted companies (Repórter Brasil, 2016). The "catchers" take the birds, put them alive in boxes and stack these boxes on the transportation trucks (Repórter Brasil, 2016). Travel distances of birds from farms to slaughterhouses are not statutory limited in Brazil (Cassuto & Eckhardt, 2016).

4.2.6 Slaughtering and processing

A total of 275 slaughtering facilities were registered in Brazil, with a total slaughter amount of approximately 4.2 Million chicken per year, whereby the largest 25% of the abattoirs supply the market with over 70% of the chicken (IBGE, 2018).

Before slaughtering, the chickens are "stunned" (immobilized, rendered unconscious and insensible) by electricity or gas (Figure 16). Electrical stunning is done through an electrified water bath. Gas methods use atmospheres with low oxygen levels to render the chicken unconscious. The unconscious animals are then slaughtered with automated knifes or by increased CO_2-levels (CIWF, 2013). After killing, the following processes are: removal of the head, removal of feet, removal of internal organs, washing to remove blood, chilling in cold water to prevent bacterial growth, draining. According to the final market's demands, the carcass is cut into pieces, deboned and processed and packed (Poultryhub, 2018). Brazilian slaughterhouses tend to be labor-intensive in comparison to other countries e.g. the United States, where a lot of work is automated. Low labor-costs allow Brazil to supply certain markets with highly adapted chicken meat products. The use of chlorine rinses or other pathogen reduction treatments (PRTs) is forbidden in Brazil (in contrast to the United States). Therefore, exports to the EU-27 market and Russia are possible (USITC, 2012).

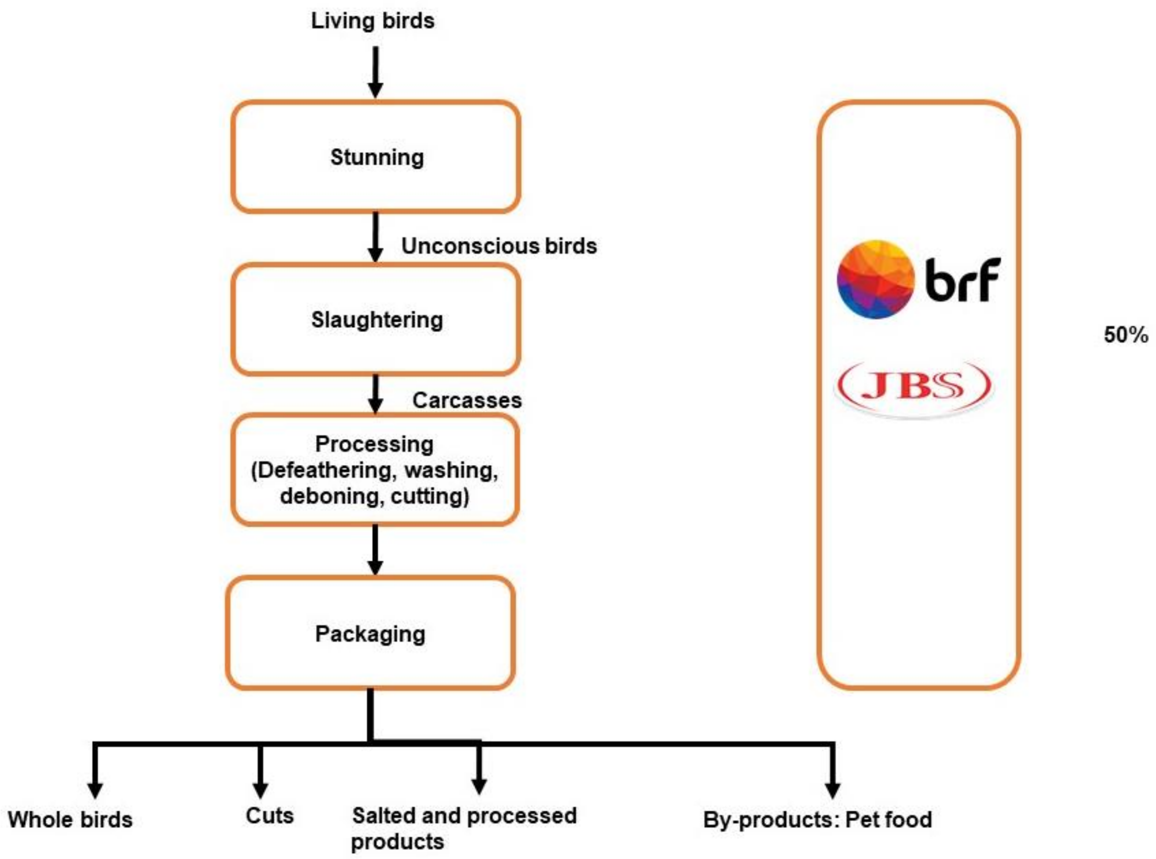

Figure 16: Overview of main slaughtering processes and products. Right side: actors. Source: author.

4.2.7 Distribution

One third of the Brazilian poultry production is exported, whereas the rest is sold in the domestic market (ABPA, 2017). Processed and packed poultry products are distributed worldwide by the integrating and meat-processing companies. Before 2017, the most important destination regions of Brazilian chicken products were the Middle East (36%) and Asia (33%). In 2016, the European Union and Switzerland imported about 9% and 0.45% (17’000 tonnes) of the Brazilian poultry meat exports (ABPA, 2017), as is shown in (Figure 17).

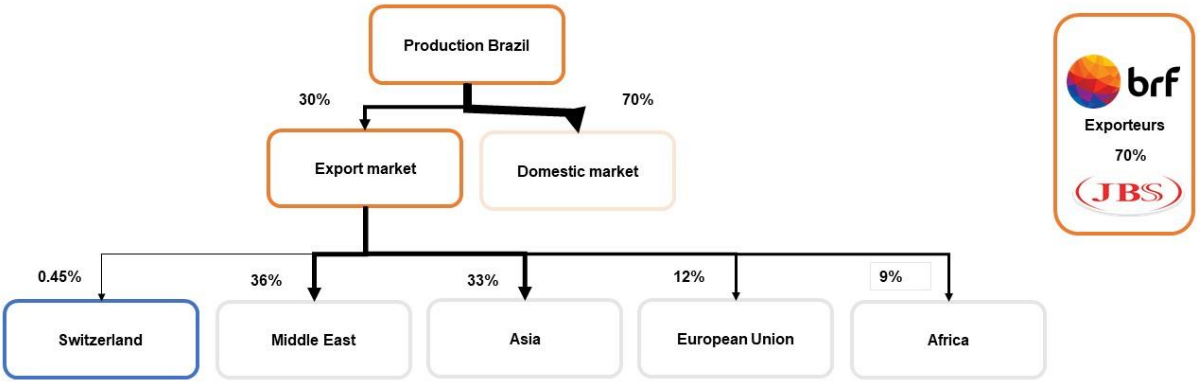

Figure 17: Distribution of Brazilian poultry to export markets (world regions). Data source: ABPA (2017). .

Main export products are cuts (59%), followed by whole chicken (31%). While some importing markets prefer whole chicken (e.g. Middle Eastern Markets), other markets prefer special cuts, processed or salted chicken products (e.g. European Union). Switzerland imports to over 90% cuts. Chicken products for export are transported from the slaughterhouse facilities in a frozen condition to the port, from where on they are shipped to other continents. The ports are mainly located in the South of Brazil, near or in the production states. About one third of the chicken exports leaves from the port Itajaí (Santa Catarina), another third from the port in Paranaguá, in the main production state Paraná. Other ports lie in the cities Sao Francisco do Sul (13%, Santa Catarina) and Santos (9%, São Paulo) (ABPA, 2017). Frozen poultry is transported from the slaughterhouse and processing facilities by truck to the ports. From there, it is shipped to their final destinations. Brazilian poultry reaches the European market through the port of Rotterdam (NL), where meat inspections are conducted for the EU-27 countries and Switzerland (Industry Representative 1, 2018). The inspections search for bacterial diseases such as *E.coli*, *Salmonella*, *Campylobacter* or contaminations by chemical substances such as steroids or veterinary drug residues (EFSA, 2018). After the inspections, the frozen poultry is transported to Switzerland by truck.

4.2.8 Import, Processing, Retail and Consumption in Switzerland

In 2016, Switzerland imported 45’237 tonnes of poultry meat, whereby 39% (17’6500 tonnes) originated from Brazil (BLW, 2017a). Figure 18 shows an overview of the import stages and related actors. Brazilian poultry meat reaches the Swiss market through the Swiss cooperative for cattle and meat import (GVFI International AG) with headquarter in Basel (CH) and subsidiaries in Rotterdam and London (Industry Representative 2, 2018). The company GVFI logistically manages the imports for their customers and furthermore holds their contingent shares in trust (GVFI, 2012). These contingents are annually set by the Swiss Federal Customs Authority for the import amounts of several agricultural products, among them poultry meat (EZV, 2018). In 2017, a total of 46’216 tons chicken meat were imported by Switzerland, whereby about 17’000 tons of Brazilian poultry meat were from Brazil (BLW, 2017a) (BLW, 2017c). Swiss importers have to participate in regular auction procedures, conducted by the Swiss Federal Office of Agriculture, to buy import shares. Important buyers of contingents are the companies

Micarna SA, Bell International/Schweiz AG and Prime Meat Swiss AG. The company GVFI also buys shares in the name of some clients. In the current period 2018, Bell, Micarna and GVFI imported about 20%, 10% and 15%, respectively (BLW, 2018a) (BLW, 2017b) (BLW, 2018b) (BLW, 2018c). However, it should be noted that these numbers refer to the total import amount of poultry meat, not only the amounts from Brazil.

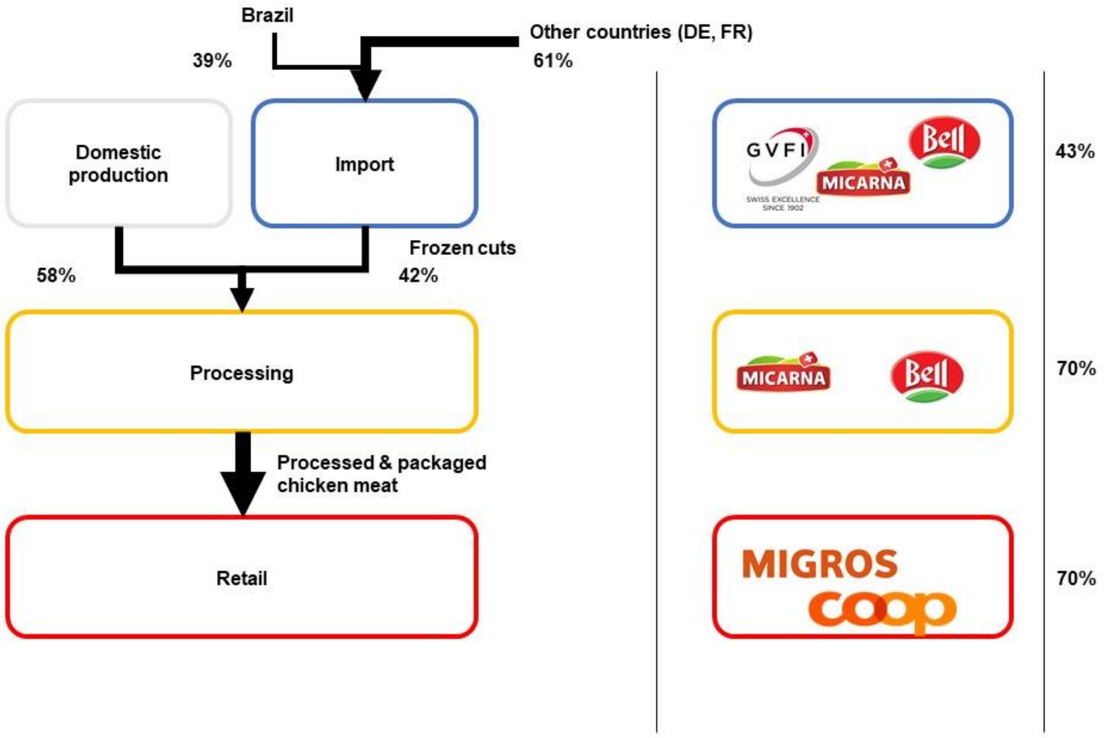

Figure 18: Processes in Switzerland. Left side: Processes and mass flows. Right side: Actors and related market shares.

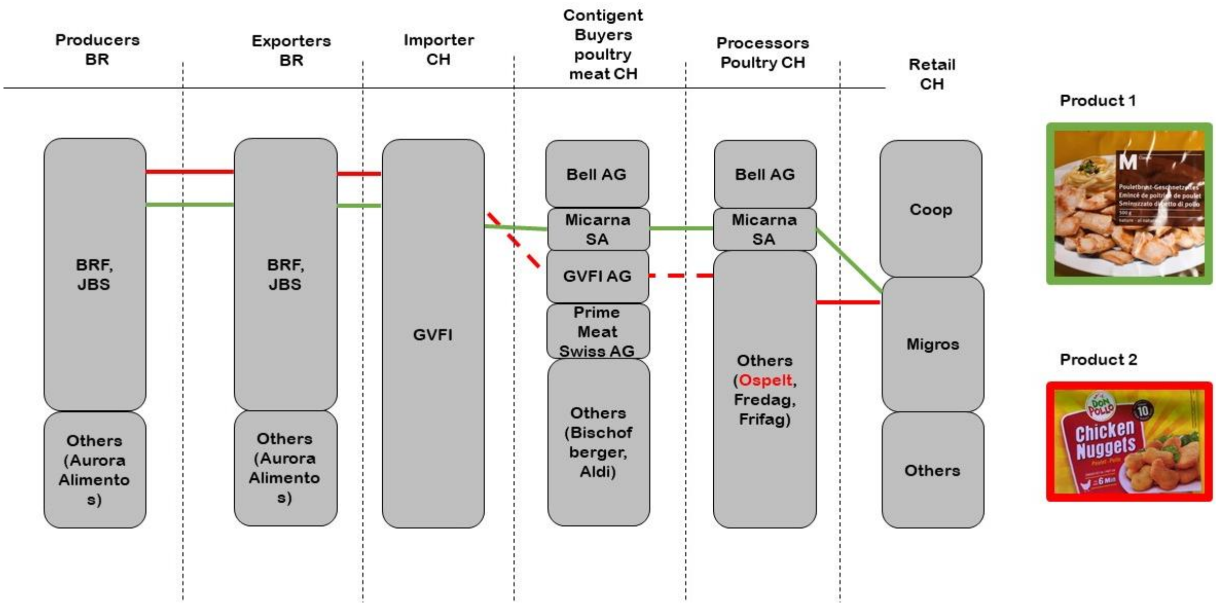

Figure 19: Distribution ways of two products from production to retail. Overview over distribution actors in Brazil and Switzerland, indicating their market share. Information based on 2017-2018.

In a second processing step, the imported poultry meat (mainly cuts) is processed further into final products and packaged for the end consumer. At this processing stage, the main actors in the Swiss market are Micarna and Bell. Micarna S.A. is a meat processing company with headquarter in Courtepin, owned by the retail group Migros, and supplies 40% of the Swiss poultry market with chicken meat products (Micarna, 2018). Bell AG is a European meat processing company with headquarter in Basel (CH) and over 10'000 employees. The retail cooperative group Coop is majority shareholder of Bell (Bell Food Group, 2018). Bell holds a market share of 30 % of poultry production in Switzerland (Aviforum, 2017) . Bell and Micarna sell their meat products to the linked retailers Coop and Migros, respectively. Other meat processors, such as Bischofberger, Fredag or Ospelt sell to different retail channels.

Retailers purchase processed and ready-to-sell packaged meat either from their own processing facilities (e.g. Migros from Micarna, Coop from Bell) or from external processors, e.g. *Don Pollo Chicken Nuggets*, which is currently processed by Ospelt (Figure 19) (personal information, industry representative). At the retail stage, two companies (Coop and Migros) account for 70% of the market share in Switzerland (EDA, 2017).

General remark

A corruption and food-safety affair in 2017, known as “carne fraca” or “weak meat”-affair, led to import bans of several countries, among them the EU-27. Twelve processing facilities of BRF, which before was the main supplier of import poultry meat in Switzerland, were banned this year by the European Union (Industry Representative 1, 2018) (Fortune, 2018). According to the IBGE (2018), a decrease in export amounts of 19 % happened between 2017 and 2018. All descriptions in this section refered to the years 2016 and 2017, before the introduction of the import ban.

4.3 Socio-economic Benefits

In this section, the results of the qualitative assessment of positive, socio-economic effects of the value chain are presented. Figure 20 summarizes the results of the benefit evaluation.

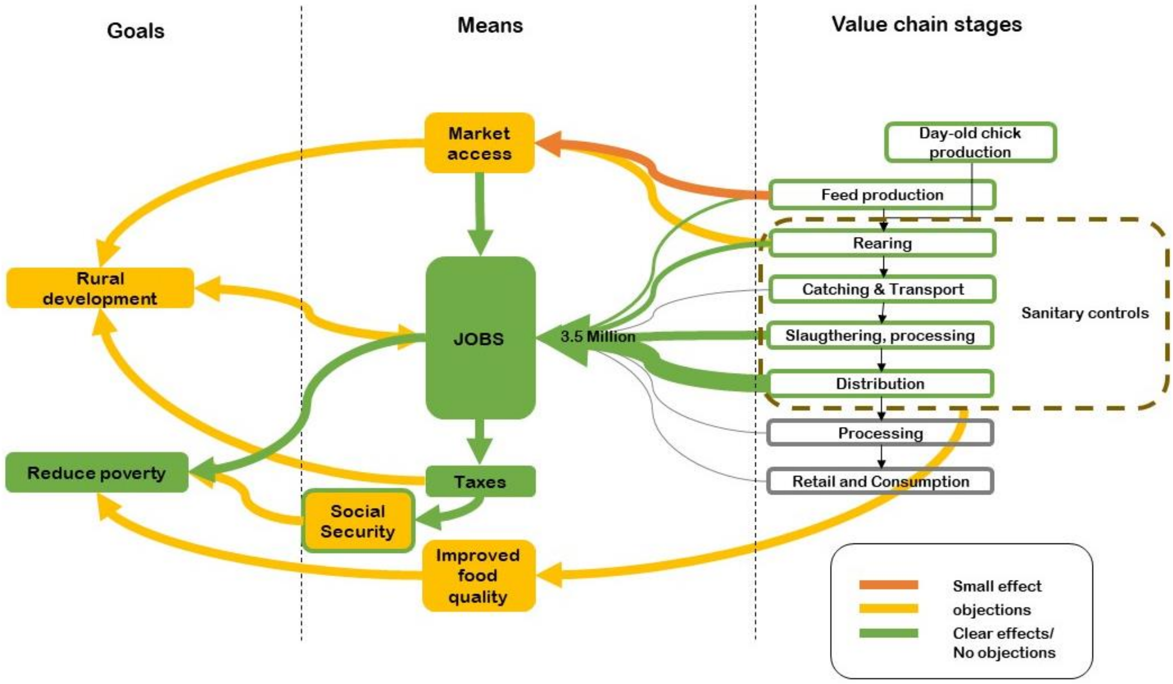

Figure 20: Summary of qualitative benefit evaluation. Value chain stages (right) and related effects on the impact categories.

Employment creation

A direct benefit of the value chain arises through employment creation in all value chain stages. Although a high share of the jobs in the poultry industry is considered to be "low-wage" (USITC, 2014), the resulting income from these jobs leads to a net-improvement of financial resources and therefore to a reduction of poverty (Neven, 2014). Together, the value chain provides about 3.5 million jobs directly and indirectly. Therefore, nearly 2% of the Brazilian population work related to the poultry production sector. According to the ABPA (2017), 130'000 integrated broiler farms exist in Brazil (3.7% of created jobs per employee) and 350'000 people are employed in slaughterhouses (10% of the jobs). This suggests that a high share of employment opportunities can be found in other stages of the supply chain (e.g. distribution, administration).

Market access for smallholders

Value chain stages involving farming activities, such as *broiler farming* and *soy* or *maize cultivation* have the potential to provide market access for smallholders.

In Brazil, about 50% of the poultry producers are family-farms (Embrapa, 2018). In the main production region, the South of Brazil, even more than 80% of the broiler farms are defined as small family-farms (Miele, 2013). This suggests that smallholders have access to the poultry value chain.

However, considering the fact that BRF, the main provider of poultry meat for Switzerland, provides more than 25% of the domestic poultry production and 35% of the export market with 7800 broiler farmers (6% of all Brazilian poultry farmers) (Repórter Brasil, 2016) (BRF, 2017), it can be assumed that there is rather a tendency to work with above-average size farms. Table 7 shows production amounts of poultry meat, as well as number of farms for Brazil and BRF, respectively, showing that farm productivity is at least four times higher for BRF-integrated broiler farms than for average broiler farms. These findings indicate that the integrating company BRF works not primarily with smallholder farmers.

Table 7: Production amounts of poultry meat (live weight, tonnes) and farm numbers for Brazil and exporting company BRF, assuming that BRF is market leader in exports. Source: ABPA (2017), IEG (2018)

	Amount (tonnes)	Farms	Amount (tonnes) / Farm
Total Brazilian production	13’250’939	130’000	102
BRF production	> 3’312’735	7’883	> 420

There are several findings which indicate that also regarding feed production, smallholders have low access opportunities to access the market for export-oriented poultry production:

i) According to Embrapa (2018), 84% of the Brazilian soy production and the majority of corn production is non-familiar;

ii) A study by the Stockholm Environment Institute (Trase.earth, 2018) indicates that nearly 70% of the soy production for domestic consumption and feed production is produced in municipalities with very low smallholder farms (0-20% of the farms);

iii) Most of the non-GMO feed, which is needed for the Swiss and European Market is cultivated by large-size farms (USITC, 2012).

Food security

Some findings suggest that industrialized poultry production may contribute to improvements in food quality / security: chicken meat is more affordable than other animal protein sources in Brazil and is furthermore considered as healthy (FAO, 2018b) (Murphy & Allen, 2003).

However, to make a final judgement on the net-effect on food security of the population, other factors would also have to be taken into account, e.g. an emerging food competition through feed components corn and soya. In addition, there are reports of indigenous population communities that have lost their livelihoods due to the expansion of soybean cultivation areas and related ecosystem damages (Glass, 2012). It might therefore be assumed that the effect on food security varies between population groups. Additionally, trust in the food safety of the Brazilian poultry industry has suffered under the carne-fraca affair, where spoiled meat was systematically chemically treated and sold as sold as fresh meat (Romero, 2017).

Taxes

Brazil is known for having high taxes on citizens and companies (Nes, 2016). Part of these taxes was used in the last decade by the Brazilian government for social programs to combat poverty and to decrease inequality, by far exceeding the social spendings of other emerging economies-countries (Guinn & Hamrick, 2015). Among these programs, which are considered as powerful, are the Zero-hunger-program ("Fome zero*")* or *PNAE*, which support poor families with direct payments or the inclusion of smallholders, respectively. However, newest developments indicate that the political environment has big influence on the execution of the programs: more than 1 million people were reported to having lost their access to the security net program "Bolsa famila*"* (TeleSUR, 2017) and that extreme poverty had risen 11% from 2015 to 2016 (Dolce, 2018). Furthermore, Higgins & Perreira (2014) found that a large percentage of the recipients of social benefits paid by taxes are non-poor and that the poorest pay higher amounts for indirect taxes than they receive with subsidies.

Rural Development

Findings about the distribution of employment opportunities along the value chain suggest most of the jobs are generated in urban areas. The company BRF, the main supplier of Brazilian poultry meat for Switzerland until 2017, employs 7800 broiler farmers and 5170 suppliers (grain, meal) (BRF, 2017). These rural employment opportunities make up for 12% of the total employment opportunities of BRF (BRF, 2017). About 33% of the jobs are assumed to be found in the slaughterhouses, which are usually located in semi-urban areas. More than 50% of the jobs can therefore be assumed in other stages, such as the distribution stage (BRF, 2017).

The results indicate that poverty-reducing employment opportunities are created along the value chain. However, although vertically integrated farming systems could provide market access opportunities for farmers, the inclusiveness of the value chain seems to be lower than national average. Furthermore, the effectiveness of the tax expenditures on social welfare can be questioned. Results suggest that especially urban areas profit from the value chain, since most jobs are not located in rural, farming areas.

4.4 Socio-economic Impacts

4.4.1 Overview

In this section, the results of the quantitative evaluation of negative socio-economic effects by means of a Sustainable Hotspot Analysis are presented. Table 8 shows a summary of the results, indicating areas of concern ("hotspots") of the value chain. These are a result of the hotspot evaluation (see section 3.5) combining the evaluation of reports *within* value chain stages and the evaluation *between* value chain stages (Table 9).

Table 8: Summary of socio-economic hotspots based on Sustainable Hotspot Analysis. FP: Feed production; BF: Broiler farming; BR: Breeding; CT: Catching and transport; SL: Slaughtering

Rating	VC Stage	Subcategory	Topic
9	FP	Health & safety	Health implications through Pesticide use
9	BF	Working conditions	Unfavorable contract conditions
6	FP	Human Rights	Forced labor in soy fields
6	FP	Land conflicts	Land conflicts due to expansion of cultivation areas
6	SL	Health and Safety	Injuries and illnesses in slaughterhouses
6	CT	Health and safety	Health problems of chicken catchers

The results indicate that most socio-economic hotspots (3 of 6) arise in the feed production stage of the value chain. The two most severe hotspots (rating "9") were found in the feed production stage (category "Health and safety") and in the rearing stage (category "General working condition"). The latter problem refers mainly to unfavorable contract conditions for broiler farmers. Health and safety-issues in the feed production stage refer to pesticide health implications of field workers. The results indicate that health-and-safety issues are the most distributed socio-economic problematic impact subcategory (3 of 6 hotspots). The hotspots will be explained in the following sections. A detailed overview over the literature for each value chain stage/category and the SHSA can be found in appendix A2.

*Table 9: Evaluation of **counting table (above)** with hotspots analysis **within value chain stages (middle above)** and **between value chain stages (middle down).** 3: most reports found; 1: Fewest reports found; 2: others. **Hotspot result table (down)** from multiplication of fields entries in table 1 and 2. Red (9) and orange (6) fields indicate hotspots at certain value chain stages and impact categories. WC: Working conditions; HS; Health and safety; HR: Human rights; LC: land conflicts; FS: Food supply*

	WC	HS	HR	LC	FS
Feed	3	9	6	4	2
Breeding	0	0	0	0	0
Rearing	6	1	0	0	2
Slaughtering	2	6	2	0	0
Catching	3	6	2	0	0

Feed	2	3	2	2	1
Breeding	1	1	1	1	1
Rearing	3	1	1	1	2
Slaughtering	2	3	2	1	1
Catching	2	3	2	1	1

Feed	2	3	3	3	2
Breeding	1	1	1	1	1
Rearing	3	2	1	1	2
Slaughtering	1	2	2	1	1
Catching	1	2	2	1	1

Feed	4	9	6	6	2
Breeding	1	1	1	1	1
Rearing	9	2	1	1	4
Slaughtering	2	6	4	1	1
Catching	2	6	4	1	1

4.4.2 Socio-economic Hotspots

Feed Production Stage - Health and Safety (Pesticide implications)

Most reports and studies were found in the feed production stage and the category “health and safety”. The majority of studies suggest that there is a strong correlation between regular contact with pesticides and several health problems, among them neuronal degeneration, neurotic disorders, reproductive disorders (e.g. fetal death), genotoxic effects (chromosome aberriations), brain and prostate cancer (Sanborn et al., 2007) (Bassil et al., 2007). Brazil currently has one of the highest pesticide consumption rates in the world (Caldas, 2016). About 80% of these are used for the cultivation of soy, corn, sugar cane and cotton (Human Rights Watch, 2018). Between 2000 and 2010, over 10’000 deaths from pesticide poisoning were registered (Caldas, 2016). According to a study by Bortoli et al. (2009), 69% of the surveyed workers did not wear protective clothing. However, studies suggest that health implication do also occur when protective clothing is used (Benedetti et al., 2013) (Bortoli et al., 2009).

The results depend on various factors, in particular the type of pesticides used. However, three recent further studies specifically investigated Brazilian soy field workers and found chromosomal changes and deposits of aluminum and other metals in their cells (Bortoli, Azevedo, & Silva, 2009) (Khayat et al., 2013) (Benedetti et al., 2013). Four of the ten most commonly used pesticides in Brazil are not permitted in Europe (Human Rights Watch, 2018) e.g. paraquat, which is also classified as "highly toxic" by the American regulatory authority (Spring, 2018b). The Pesticide law (Act 7802) currently regulates the approval and application of pesticides. The Brazilian law is to be revised by 2019 in favor of faster approval (Spring, 2018). The amendment is highly controversial among NGOs and environmental associations, worrying a softening of the law.

Broiler Farming Stage – General Working Conditions (Contracts of broiler farmers)

Six reports were found about potentially unfavorable contract conditions for broiler farmers. The contracts between the broiler farmers and the integrating companies should specify the payment conditions for farmers. However, disagreements about contracts are common in integrated farming systems worldwide (Worldbank, 2014). Reports indicate that there is a dissatisfaction among Brazilian broiler farmers which is mainly caused by intransparencies in the contract. Farmers get paid depending on the feed conversion ratio of their chickens, which is varying. Therefore, farmers have no possibility to know in advance how much they will receive. The basic margins per kg live weight are very low and farmers with poorer performance and worse rankings might not being able to cover their production costs (IATP, 2017) (Repórter Brasil, 2016) (Miele, 2013). The integrator Sadia (which was merged to BRF in 2009) was sued by the Brazilian Ministry of Labor for not paying the integrators sufficient to meet their needs, calculated by the Embrapa (JusBrasil, 2010). Further critical points of the integrated system are a limitation of producers' freedom of choice and a high bargaining power of integrators. The NGO Repórter Brasil (2016) reported that many farmers fall into a debt trap because of pressures by the integrators to make large investments for management systems, e.g. cooling systems or dark-house systems. Farmers in debt have often no other choice but to continue producing. Due to the inconsistencies, a legal innovation was introduced in 2016 (Law No. 13’288), establishing new obligations and regulations for the integrators (Repórter Brasil, 2016) (FAO, 2018a). According to FAO (2018), the regulations are assumed to have a neutral effect on the relations between farmers and integrators.

Feed Production Stage – Human Rights Violations (Forced labor)

Six NGO reports were found on the phenomenon of "forced labor” in the feed production stage, especially related to soy cultivation. The International Labor Organization ILO (2009) reported that forced labor is a widespread phenomenon in Brazil's rural areas and agriculture. Since the problem was made public by the human rights organizations Human Rights Watch and the NGO Pastoral Commission CPT, Brazil has stepped up its efforts: since 2000, over 30,000 people were liberated from slave-like conditions (ILO, 2009). Mostly young, job-seeking men are recruited by so-called "Gatos" who promise them work. These men are then taken to distant places from where on they have no possibilities to get away on their own. In addition, they are deliberately driven into a debt trap by being charged excessive prices for food, drink and other necessities, which the workers have to pay with their future wages. Soy cultivation needs low labor-inputs and is therefore not the sector where most forced labor incidences were noted. Typically, forced labor occurs in sugarcane plantations and cattle ranches and mainly in the Northern regions of Brazil (Guimarães et al., 2013). However, the ILO (2009) and several NGOs, among them CPT (2018) and Repórter Brasil (2012), reported that forced labor does also occur in soy plantations. The NGO Dutch Soy Coalition (DSC, 2014) reported that forced workers were used in particular for deforestation and subsequent clearing of the fields. In Mato Grosso, the largest soybean cultivation state, the second highest number of workers were liberated from slave-like conditions, many of them originally from northern areas (ILO, 2009). Alone in 2017, 34 workers had been freed in Mato Grosso from soy plantations (of total 90 workers in Mato Grosso) (CPT, 2018). From 2004 to 2014, the government published and updated a list with producers who had been convicted of forced labor practices, the so-called “dirty list” (Pierce, 2015). On this list had also appeared 9 soy producers (Glass, 2012).

Feed Production Stage - Land conflicts

Several NGOs reported about land conflicts related to soy production in Brazil (DSC, 2014) (Kessler et al., 2012) (AIDenvironment, o. J.) (Reporter Brasil, 2010). The NGO CPT registered Brazilian land conflicts between farmers and indigenous or landless persons for the last 30 years. These conflicts between farmers and rural or indigenous communities arise mainly due to the expansion of agricultural land. Especially rights of vulnerable communities such as indigenous people were violated frequently (Franke et al., 2012). A weak land register enhances disputes about property rights additionally. CPT counted 28’805 conflicts in the last 30 years, whereby an increase has been observed in the last years. Alone in the year 2016, more than 1500 land conflicts and 61 assassinations were counted, which corresponds to a rise of 26% in conflicts compared to 2015 (CPT, 2017). Although most conflicts can be observed in the Northern part of Brazil, they do increasingly occur in the soy production states: about 8% of the area under conflict lies currently in Mato Grosso. In 2014, a new regulation, called the *Zero-Deforestation* Agreement, lead to a reduction of deforestation in the Amazon. As a result, the expansion of agricultural area shifted to the *Cerrado* biome in the Center-west region, where many indigenous and protected communities live in protected territories. The NGO Repórter Brasil (Glass, 2012) reported that in Mato Grosso do Sul, large soybean and sugarcane farms cultivate on areas of protected communities (indigenous people, quilombola). In Mato Grosso, 464 farms had settled illegally on 6.6 Million ha of public land (Bickel & Dros, 2003). Bickel and Dros (2003) reported that while half of the farms had received a legal status in the meanwhile, 3.2 Million ha were still occupied by illegally by large farms.

Slaughtering Stage – Health and Safety (Working environment)

Several NGO reports have pointed to working conditions in Brazilian slaughterhouses which promote injuries and accidents (Sindicarne, 2015) (Repórter Brasil, 2016) (IATP, 2017). The reports refer to the slaughtering, processing and packaging work in the cooled abattoirs and processing rooms with average temperatures under 12°C. The situation in Brazil is similar to the United States, where studies have also found institutional injustice in slaughterhouses (Marín et al., 2009). A review of several scientific studies (Buzanello & Moro, 2012) confirmed that workers in cooled Brazilian slaughterhouses are likely to be confronted with physiological and mental problems. In slaughterhouses, many factors come together that support the occurrence of injuries and illnesses, e.g. the presence of knives and other sharp tools, repetitive movements, a high work pace, long working hours and a cold environment (Repórter Brasil, 2016). The injury rate, as well as the rate of musculo-skeletal disorders, respiratory and skin problems and mental illnesses among workers is several times higher than the national average (Repórter Brasil, 2016) (Campbell, 1999). According to Buzanello and Moro (2012), 20% of the employees face musculoskeletal disorders. The probability of suffering from mental illness is 3.4 times higher than the national average, physical illnesses such as carpal tunnel syndrome 6.7 times higher and muscular problems 4.3 times higher (Repórter Brasil, 2016). Mental health problems affect especially workers who kill and disassemble animals (Hutz, Zanon, & Brum Neto, 2013). Slaughterhouse workers have often a low educational background: according to Sindicarne (2015), 34% of the Brazilian slaughterhouse workers have a primary school or lower level of education.

In addition to the injury-promoting working environment, many accusations have been made to the meat companies JBS and BRF, relating to the violation of workers' dignity, among them (Repórter Brasil, 2012):

- In 2011, justice finds Brasil Foods (BRF) from Dois Vizinhos guilty of illegal outsourcing and degrading working conditions for its Muslim employees;
- Labour Justice order breaks to be allowed to Brasil Foods (BRF) employees in Lucas do Rio Verde, MT;
- Labour prosecutors sue Brasil Foods (BRF) in Carambeí for searching employees at the end of workday;
- Workers fainting and feeling sick due to very high temperatures led labour prosecutors to file a request to interdict JBS's slaughter department in November 2010;
- With 1,850 employees, JBS's local unit had 496 workers on leave for physical and psychological problems in the first half of 2011, according to labour prosecutors. Justice ordered the company to grant pauses to employees working in "artificially cold" environments;
- Between 2005 and 2011, JBS's Barra do Garças, MT, unit saw an average of more than one accident a month, say labour prosecutors.

In 2013, the Regulatory Norm 36 (RN36) was introduced to improve working conditions in slaughterhouses (Exame, 2013). A major impact of the RN36 is the right for breaks (10-20 minutes per day) and preventive measures. Oliveira and Mendes (2014) found several examples of good practices in their study. However, they state that the RN36 still has severe drawbacks, among them a lacking distribution of tasks between the governmental authorities.

Chicken Catching Stage – Health and Safety (Working conditions)

"Chicken catchers" are considered to be especially vulnerable stakeholders of the value chain. Often, they deal with difficult personal backgrounds of low education or lacking resident's permit (Repórter Brasil, 2016). Their dependency on employment and missing financial resources complicate taking legal proceedings. The "catching teams" are usually accommodated together and are ordered to the chicken farms on call by the integrators. According to the NGO Repórter Brasil (2016), catchers work partly 17 hours a day, come home for sleep and after 2 hours of sleep leave again for the next action. The working and sleeping times are therefore irregular, and catchers are not informed in advance. The catching work includes the manual catching of chicken in a high pace of work, up to 50'000 chicken per day (Mendes, 2017). It is regarded as strenuous and as particularly associated with a high risk of injury, as various NGO reports and scientific studies have shown. The problem is apparently not limited to Brazil: exploitative conditions have also been reported in the American and Canadian chicken industry (NCFH, 2014) (Mercy for Animals, 2014). Several studies indicate that respiratory disorders occur frequently (Lenhart et al., 1990) (Morris, Lenhart, & Service, n/a). In addition, the working conditions (hardly training and a fast working rhythm) promote further health problems such as trauma, muscle or joint disorders, drug abuse or transmission of parasites (Quandt et al., n.e.c.) (Rossiter, 1997). The NGO Repórter Brasil (2016) also reported low wages and lack of employment contracts. There have also been some cases of BRF and JBS suppliers where workers were freed from slave-like conditions (Repórter Brasil, 2016). The Institute for Agricultural Trade Policy (IATP, 2017) describes such conditions as "endemic" in the Brazilian chicken industry. According to Reuters (Mendes, 2017), the meat processor BRF stated that they are participating in a program "Apanha Legal" to improve the working condition of chicken catchers since 2015.

4.4.3 Animal welfare in the value chain

Commercial hybrid broilers reach their slaughter weight of 2.5 kg in about 42 days (Elson, de Jong, Kjaer, & Tauson, 2012). This high growth performance, achieved by cross-breeding and feed adaptation, also leads to various health problems during rearing, which have been scientifically documented several times. These include heart and leg problems, behavioural disorders, contact dermatitis, ascites and sudden death syndrome (Elson et al., 2012) (Robins & Phillips, 2011). The European Committee for Animal Welfare (SCAHAW, 2000) concluded that genetic selection according to one-sided criteria causes the health problems mentioned above. The problems can also be aggravated by a high stocking density. SCAHAW (2000) found that the above a stocking density of 30 kg/m^2, welfare problems seem to emerge. In Brazil there is no maximum stocking density, but according to da Silva (2014), 32 kg/m^2 are kept on average. In the European Union the maximum allowed is 42 kg/m^2, in Switzerland 30 kg/m^2 (Proviande, 2016). A Brazilian study by Arruda et al. (2016) recommended a stocking density of 41.5 kg/m^2, as otherwise the probability of dermatoses increases.

Catching and transport are both stages assumed to be further critical points regarding animal losses. According to a review by Schütze (2017), experts agree that transportation is one of the most stressful events in a chicken's life. The chickens are usually not fed and don’t receive water during their journey and are normally exposed to outside temperatures without any protection (HSUS, n.d.). Many studies to optimize transport conditions have already been carried out (Schwartzkopf-Genswein et al., 2012) (Broom, 2008). The death rate strongly depends on the transport duration, more than on the density (Schuetze, 2017). However, since chickens only feel comfortable between 22°C and 24°C, and otherwise quickly suffer from heat stress, it is difficult to make the transport animal-friendly.

The parents and grandparents of the broilers, the breeders, are also confronted with animal welfare issues. Their feed rations are severely restricted in order to limit a too rapid weight gain and thus to guarantee their fertility. This, however, increases the stress and aggression potential of the animals. Despite these measures, many hens are severely injured during mating (Jong & Guémené, 2011). Although breeding companies are aware of these problems, it seems to be difficult to combine welfare and efficiency targets (Jong & Guémené, 2011).

It should be noted, however, that the above studies do not refer to Brazil in particular but are endemic in the whole industry. Federici et al. (2016) carried out a study in Brazil and found that there was optimisation potential in some points (emotional well-being, injuries and heat stress), but good results were achieved in others (e.g. human-animal relationship). Tuyttens et al. (2015) compared 11 Brazilian and 10 Belgian chicken flocks and concluded that Brazilian keepers performed better in three out of four points ("good feeding", "good housing", "good health"). According to the authors, the investigated Brazilian chickens were less "frustrated" and "happier".

4.5 Ecological Impacts

4.5.1 Overview

The resulting environmental impacts, caused by the production of 1 kg chicken meat (cw), at retailer (CH), are presented in Table 10 for several impact categories, according to the LCIA method ILCD Midpoint+ 2011.

In the following sections, main *contributing life cycle phases* by means of an LCA (ILCD Midpoint+ 2011) and *areas of concern* (“hotspots”) by means of an LCA (Ecological Scarcity 2013) and SHSA are presented in 4.5.2 and 4.5.3, respectively.

Table 10: Result of LCIA (ILCD Midpoint+ 2011) for the production of 1 kg Brazilian chicken meat (cw), at retail (CH).

Impact category	Unit	Amount
Climate change	kg CO_2 eq	2.53E+00
Ozone depletion	kg CFC-11 eq	2.38E-07
Human toxicity, cancer effects	CTUh	3.97E-08
Particulate matter	kg PM2.5 eq	4.77E-03
Ionizing radiation HH	kBq U235 eq	9.29E-02
Ionizing radiation E (interim)	CTUe	7.17E-07
Photochemical ozone formation	kg NMVOC eq	1.75E-02
Acidification	molc H+ eq	1.01E-01
Terrestrial eutrophication	molc N eq	4.19E-01
Freshwater eutrophication	kg P eq	6.27E-04
Marine eutrophication	kg N eq	3.52E-02
Freshwater ecotoxicity	CTUe	2.43E+01
Land use	kg C deficit	7.45E+01
Water resource depletion	m^3 water eq	3.47E-01
Mineral, fossil & ren resource depletion	kg Sb eq	5.02E-04

4.5.2 Contributions of Value Chain Stages

The comparison between value chain stages, according to the LCIA method ILCD Midpoint+ V1.1, is shown in Figure 21.

Results suggest the stage of **feed production** accounts for the largest share of environmental impacts in almost all environmental impact categories with contributions between 43% (climate change) and 99% (water resource depletion). Exceptions are the categories "terrestrial eutrophication", "marine eutrophication" and "acidification", in which the stage of **chicken rearing** is the largest contributor to the impacts with 68%, 44% and 63%, respectively.

The highest contributions of **transport** processes can be found in the categories "ozone depletion", “ionizing raditiation E/HH”, “acidification” and “climate change” with 42%, 33%, 29% and 18%, respectively. The contribution of **slaughter** and **breeding** to environmental impacts is comparatively small in all categories.

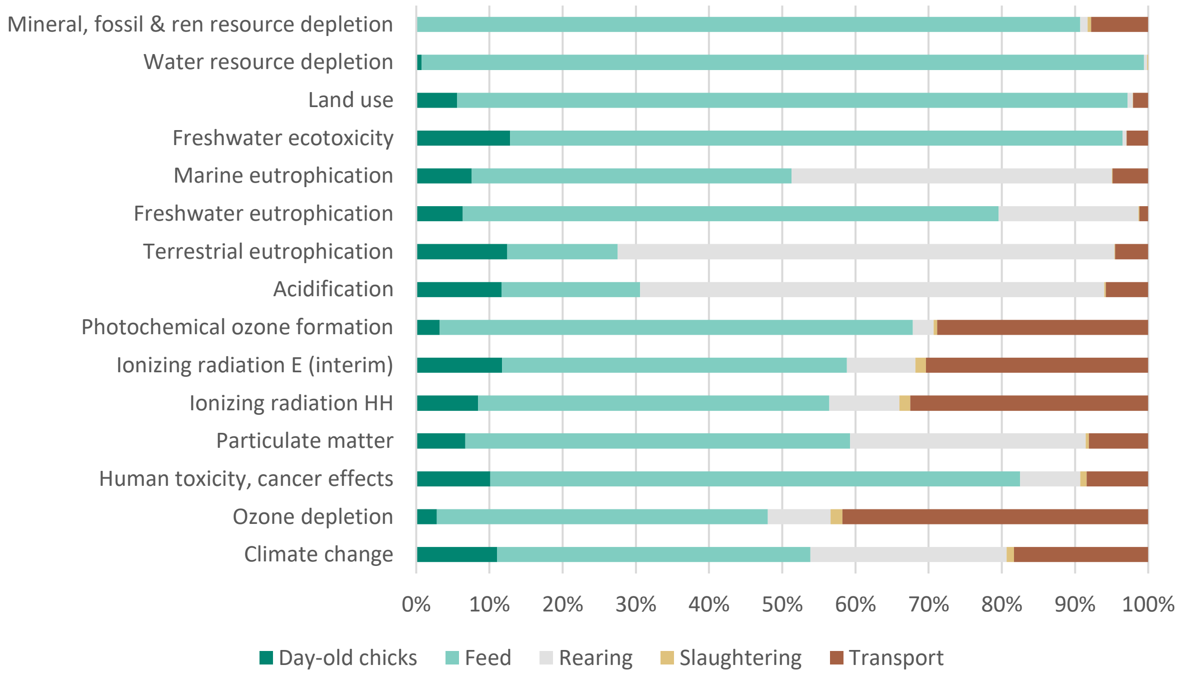

Figure 21: Life cycle impact analysis (ILCD Midpoint+ 2011 V1.10). Contribution of the life cycle stages feed supply, rearing, slaughtering and transport to impact in several midpoint categories (100% = total impact).

4.5.3 Ecological Hotspots

Table 11 shows a summary of the ecological Sustainable Hotspot Analysis results (LCIA method Ecological Scarcity 2013 and SHSA).

Table 11: Summary of SHSA based on LCA (Ecological Scarcity 2013), indicating main areas of concern ("hotspots"). BF: Broiler farming; FP: Feed production

Rating	VC Stage	Subcategory/ Environmental issues	Topic
9	BF	Main air pollutants	Ammonia emissions
6	FP	Main air pollutants	Particulates
6	FP	Climate change	CO_2 through land transformation
6	FP	Water pollution	Nitrate and phosphate leaching
6	FP	Land use	Land use for feed crop cultivation

It was found that hotspots arise in the impact categories "air pollutants", climate change", "water pollutants" and "land use", whereby most occur int the feed production stage (4 of 5 hotspots). However, the most critical hotspot is caused by the rearing stage (broiler farming) in the category "air pollutants". Table 12 shows the hotspot result of the environmental impacts. Hotspots (rating "6" or "9") have only been found in the feed production and broiler farming stage. The main topics are explained in the following part.

Table 12: Result of Sustainable Hotspot Analysis (ecological impacts) according to Wallbaum & Kummer (2006). Blue fields indicate hotspots at certain value chain stages and categories. BR: breeding; FP: Feed production; BF: broiler farming; SL: slaughtering; CT: Catching and transport

	BR	FP	BF	SL	CT
Water resources	1	3	1	1	1
Energy resources	1	3	1	1	2
Mineral resources	1	3	1	1	2
Land use	2	6	1	1	1
Global warming	1	6	4	2	2
Ozone layer depletion	1	3	1	1	2
Main air pollutants and PM	2	6	9	2	3
Carcinogenic substances into air	1	3	1	1	1
Heavy metals into air	1	3	2	1	2
Water pollutants	2	6	4	1	1
POP into water	1	3	1	1	3
Heavy metals into water	1	3	1	1	1
Pesticides into soil	4	3	1	1	1
Heavy metals into soil	2	3	1	1	1
Radioactive substances into air	1	3	1	1	2
Radioactive substances into water	1	3	2	1	2
Non-radioactive waste to deposit	1	3	2	2	2
Radioactive waste to deposit	1	3	2	1	2

Contribution to air pollution

The ecological hotspot with the highest rating ("9") was found in the stage of **chicken rearing** in the category "main air pollutants". According to the LCIA result (Ecological Scarcity 2013), air pollution in the broiler farming stage is mainly caused by ammonia emissions (96%). Ammonia (NH_3) is a gaseous nitrogen compound, which emits from broiler excreta due to the degradation of urea. Resulting problems of ammonia emissions are local eutrophication through nitrogen surplus and acidification of soils. Both problems lead in the long term to damaging of sensitive plants, ecosystems and a decline in biodiversity. Nutrient inputs may furthermore result in nitrate pollution in groundwater (Wagner, 2013). Ammonia may also contribute to the formation of fine dust, which can lead to irritations of the respiratory tract (Agrarbericht, 2016).

Furthermore, considerable amounts of air pollutants are emitted in the **feed production stage** (rating “6”). Air pollution is this value chain stage is to about 60% caused by emission of particulates (<10um). These are emitted from diesel-powered agricultural machinery for cultivation steps, such as for ploughing, sowing, fertilization, pesticide application and harvesting for the main feed component maize and soya. Further emissions leading to air pollutions are nitrous oxide (13%) and ammonia (12%). Nitrous oxide is an additional emission of fuel-powered agricultural machinery, whereas ammonia is emitted from N-fertilizers, such as urea. The contribution of soy cultivation to air pollution is relatively large: although soy components account together for 39% of the feed mass, the contribution to air pollution in the cultivation stage is 65%.

Contribution to climate change

The emission of greenhouse gases (GHG) through **feed production** was found to be a hotspot with rating “6”. In this value chain stage, CO_2 is the mainly emitted GHG (88%), whereas the major part (68%) are released through land transformation and a minor part (20%) is fossil, emitted through the use of agricultural machinery and the production of N-fertilizers. Further emitted GHG of the feed production stage are N_2O (10%) and methane (1%). Soybean and -oil as feed components account together for 78% of the GHG emissions in the feed production stage, although the mass accounts for only 39% of feed composition.

Contribution to water pollution

Water pollution is caused by feed production and rearing. However, water pollution through **feed production** stage was found to be a hotspot (rating “6”). The major cause of water pollution in feed production is leaching of fertilizer compounds to the groundwater. Nitrate and phosphorus contribute to the water pollution of the feed production stage with 81% and 21%, respectively. Cultivation of soy and maize components accounts for 50% and 31% of the water pollution, respectively.

Contribution to land use

Land use in **feed production** stage was found to be a hotspot with rating “6”. Land use is directly connected to the use of agricultural area for crop cultivation. Again, soy cultivation contributes to a relatively high share (71%) to land use.

4.6 Interviews

4.6.1 Chicken value chain

The information of the stakeholders about the value chain corresponded to a large extent with the information from desk research. For this reason, only additional information is provided here about the several value chain stages.

According to the academic experts, there are hardly any alternative for producers than to sell via the integrated markets channels. Independent farmers exist, mainly producing “organic” and "Caipira" chicken. However, some experts doubt large growing potential in Brazil due to the high product prices. One of the academic experts explained that the production of Brazilian organic chicken is limited because of small production amounts of Brazilian maize and soy.

Feed Production Stage

According to the industry representatives, the large integrators (e.g. BRF) prepare and mix their feed mixtures in own facilities. According to the industry representative 6, the amino acids were mainly imported. According to him, the market-leading company is Evonik, headquartered in Germany. They supply the integrators with individual amino acids. A small amount of about 10% is delivered in prefabricated mixtures to so-called *premix* companies in Brazil. These companies mix feed for chickens and pigs and sell it to smaller, independent farmers.

Day-old Chick Production Stage

Industry representatives 3 and 4 identified as main supplier of broiler genetics the company Cobb-Vantress (breed "Cobb").

Rearing Stage

According to an academic expert, non-integrated broiler farmers supply mainly domestic, alternative market channels, e.g. with “Caipira” or “organic” chicken. “Caipira” describes chickens, which are fed without concentrate feed and are usually held free-range. Caipira chickens are usually alternative breeds, held in backyard production systems for subsistence purposes or sold in rural, local markets (academic expert).

One of the industry representatives pointed to fundamental differences between private integrating companies (e.g. BRF or JBS) and integrating cooperatives. According to him, the latter structure can mainly be found in the Southern part of Brazil, as an association of medium or small-scale family farmers in order to achieve a higher bargaining weight and for economies of scale. The third largest exporting chicken company, following BRF and JBS, is an integrating cooperative: Aurora Alimentos (ABPA, 2017).

Slaughtering Stage

According to industry representatives working in a slaughterhouse facility, sanitary controls in the slaughterhouses are conducted dually: on the one hand by sanitary inspectors, employed by the integrators. The samples are then double-checked by sanitary inspectors, employed by the Federal Sanitary Inspection (SIF). Federal inspections have access to all room, the inspections are conducted regularly in a two-week rhythm and, additionally, unannounced.

Challenges of the Poultry Industry

The interviewees were asked about main challenges in the poultry industry to know, in which fields (ecological, social, economic) they have biggest concerns and see urgent fields of actions. The academic experts pointed mainly to economic obstacles, an industry representative showed concern about the abuse of antibiotics as growth promoters, in the light of bacterial resistance development. As main challenges were stated:

i) Development of feed without antibiotic additives as growth promoters (industry representative, health concern);
ii) dependence of imports on amino acids (academic expert, economic concern);
iii) changing import requirements (academic expert, economic concern).

4.6.2 Benefits

The creation of 3.5 million jobs seems was mentioned several times. According to the academic experts, these jobs were necessary for the Brazilian population. They also stated that affordably and healthy chicken meat was important for the food security of poorer population parts.

One of the academic experts explained that farmers would have better market access through the integrated system. In addition, the farmers would receive the opportunity to diversify their farm strategies. Especially in the Southern part of Brazil, family farms would use that strategy. Therefore, integrated farming was an important tool to strengthen rural areas.

4.6.3 Socio-economic Hotspots

In general, there seemed to be a consensus among most interviewees that the jobs created by the poultry industry outweigh possible social problems. However, there was some awareness among the interviewees that certain value chain stages are related to social problems.

Situation of integrated broiler farmers

One of the academic experts showed big concern about industrial and integrated systems in general. According to him, farmers' vulnerability would increase with this kind of production system. He stated that vertically integrated farmers would bear increased risks and simultaneously decrease their possibilities for action since generally, decisions on the farm-level must be confirmed by the integrators. Two other interviewees (academic and industry representative) confirmed that farmers were confronted with high financial risks and that they would lose a certain amount of freedom, in relation to their management practices. According to one of the academic experts, market fluctuations - for example caused by the EU embargo – would lead to a decrease in meat prices and therefore to sinking revenues, sometimes not enough to cover production costs. Although the integrating companies intend to implement an assurance for natural disasters to reduce the farmers' risks, an implementation of fixed minimum wages covering the production costs is not anticipated. Nevertheless, most were not clear in their final judgement. They mentioned that the farmers would not change to the integrating system, if they would not benefit at all. The interviewees did not agree in their opinion about the usefulness of cooperatives. One of the industry representatives was of the opinion that cooperatives provide more benefits for farmers, such as participation opportunities and a share of the revenue at the end of the year. Others (academic expert and industry representative) stated that private and cooperative integrators function identically and no tangible difference was detectable for farmers.

Soy field workers

The working conditions of workers on soy fields were addressed by the subsistence farmer. He had never worked as an integrated farmer, but, he explained that he was previously employed in large soy fields and suffered many health problems during this time. He told about long working shifts from 3 p.m. to 10 a.m. and related health problems, Furthermore, he explained that he had become very ill and dizzy several times through the application of pesticides.

Slaughterhouse workers

According to an academic expert, working conditions in slaughterhouses were generally considered as dangerous and poorly paid. However, he added that even these jobs were better than to have no employment, since there is no social security net in Brazil. When asked about the working conditions in slaughterhouses, two industry representatives, working in slaughterhouses replied that the conditions had considerably improved during the last years and that they would have no health problems anymore due to special health programs, e.g. physiotherapy and special food for pregnant women. They stated that companies would try to keep their workers to increase the turnover rate of employees. An academic expert commented on this statement that it was more of a one-off case because many problems had arisen in the past in that specific facility.

Chicken Catchers

When asked about the working conditions of chicken catchers, only one of the interviewees (industry representative) could make a statement, as the others had no contact with these workers and therefore had no picture of the circumstances. He explained that working with the teams was very difficult, as people often had a very difficult background, but added nothing to the working conditions per se.

4.6.4 Ecological Hotspots

When asked about possible ecological problems in the value chain, most academic experts and nutritionists stated that the poultry industry was a clean industry compared to other meat industries, such as swine or beef. The low feed conversion ratio (FCR) of chicken and a comparatively low water consumption in the slaughtering stage were mentioned. However, one of the interviewees with an academic background mentioned that many resources (e.g. water) were exported and showed concern about the sustainability in the long-term.

5 Discussion

5.1 Discussion of Results

5.1.1 Benefits, Hotspots and Potential Solutions

The findings of this study showed that the export-oriented poultry production in Brazil is valuable for the Brazilian society, especially because it creates 3.5 million jobs directly or indirectly. According to Pingali (2007), the increase of income promotes also growth in other, non-agricultural, sectors and is therefore a driver of a positive reinforcing loop (Figure 22).

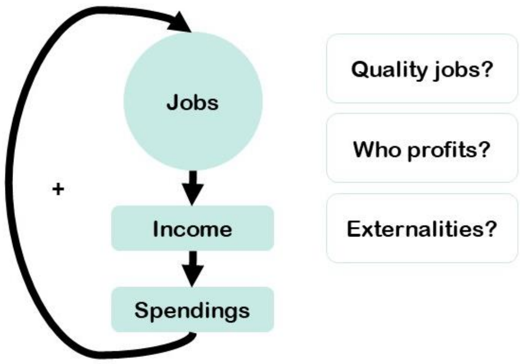

Figure 22: Benefit feedback loop, according to Pingali (2007). Right: accompanying questions for discussion.

However, besides the pure number of employment opportunities, there are further dimensions of importance, such as quality of the jobs and the question about beneficiaries and victims of the value chains.

Who are the main beneficiaries of the created jobs?

The distribution of the jobs in the poultry industry indicates that most jobs are located in urban or semi-urban areas. However, rural poverty rate is much higher than urban poverty in Brazil (World Bank, 2018). Therefore, the creation of employment opportunities in rural areas would be desirable. A possible strategy would therefore be to promote an increase of collaboration between integrating companies and smallholder poultry farmers. In theory, contract farming is considered as a structure, which provides plenty of opportunities to include small-scale farmers into supply chains (Eaton & Shepherd, 2002). Furthermore, according to an interviewee, poultry farming is basically suitable for small-scale farmers, since it requires low land and infrastructure inputs and may provide the opportunity to diversify. However, results suggest that large integrators prefer to work with poultry farms, which are above average in size. According to Ton et al. (2017), it is a widespread phenomenon, that small-scale farmers are not integrated into vertically integrated supply chains. They state that one possible explanation might be that transaction cost decrease for larger farms. Furthermore, smaller farms are often not able to bear risks associated with contract farming. For Brazilian poultry farmers, it was found that the rentability of small-scale farmers is comparatively low in comparison to large poultry farms (Valdes et al., 2015).

Due to these reasons it might be reasonable to increase economic incentives for integrators to work include smaller poultry farmers, e.g. with the creation of a family-farm label and the development of a new supply channel.

How is the quality of the created jobs?

Although occupational health and safety problems have been considerably reduced in the last years in Brazil (Mendeloff, 2014), results indicate that work-related accidents and health problems are a common phenomenon in nearly all value chain stages. Accident rates in Brazilian abattoirs are considerably higher than in US facilities of the same integrating company (JBS, 2018). Generally, there are two possible explanations for these findings:

- A low legal standard;
- A weak enforcement strategy.

In case of slaughterhouse workers, the recently introduced regulation RN36, caused by pressures of a public campaign of the NGO Repórter Brasil, hat improved standards (Repórter Brasil, 2012). However, a recent study by Takeda et al. (2018) found that injury rates in Brazilian slaughterhouses are still similarly high than before. Reports state that controls are by-passed by the integrating companies, e.g. by decreasing the work speed in presence of enforcement personal (Repórter Brasil, 2016). These findings indicate that an increase of monitoring activities, with higher pace of (unannounced) controls and high penalties is necessary to increase effectiveness of such regulations.

In case of pesticide accidents and health implications, current regulations are considered as weak (Ribeiro et al., 2012). However, recent developments indicate a change in legislation towards a faster approval for pesticides in 2019 (Spring, 2018a). A decrease of pesticide regulations might increase trade volumes of agricultural products considerably, but lead to a reduction of pesticide health implications, at the same time (Wilson, 2002). However, a further approach could be to increase training and education for employees and employers: Ribeiro et al. (2012) found in their study a striking lack of awareness of health hazards related to pesticides. They propose to disseminate knowledge about storage, application and treatment of pesticides and the introduction of easy-understandable labels.

Broilers farmers are not defined as “employees”, since they are under contract. However, according to most interviewees, they are in a kind of employment relationship. Nevertheless, the findings of this study showed that they are poorly paid and bear a lot of risks at the same time. Although the current bonus-system is reasonable to promote good management qualities, the reduction of risks, in case of under-performing, should be reconsidered. In order to prevent farmers from indebtedness, the introduction of assurances or of a minimum threshold for revenues could be feasible instruments. Furthermore, more clarity about financial risks seems necessary, e.g. through courses and trainings.

What are the main social and ecological negative externalities?

Rural and indigenous communities were found to be frequently involved in violent conflicts with farmers, which arise through an expanding crop area and a lack of clear land titles. The expansion of crop area is promoted by large-scale rentable production of agricultural products, among them poultry feed. Although many reserves exist in Brazil, the currently ongoing expansion in the *Cerrado* biome threatens many indigenous communities living in this area (Glass, 2012). Therefore, it seems, again, to be a weak law enforcement promoting land disputes, indicating that stricter monitoring, e.g. with satellite tools, and higher penalties are necessary to ensure compliance (Soares-Filho et al., 2014).

Land seems to be a crucial factor in Brazilian agriculture, also regarding ecological impacts: land transformation was found to be a major driver for the release GHG emissions due to the feed production stage. The findings of this study suggest that a large share of the emitted GHG related to the chicken value chain is released through land transformation for crop cultivation. These findings are in accordance with other studies, stating that Brazilian agriculture does not only contribute considerably to biodiversity loss, but also of climate change (Soares-Filho et al., 2014).

In general, the results of this study showed that most ecological "areas of concern" are related to the feed production stage. Higher values were found for GHG emissions (3.6 kg CO_2-eq. in live weight) and acidification than in the studies by da Silva (2012), Leip et al. (2010), Spies (2003) or Alig et al. (2012)(Table 2), which can be partly explained by the consideration of post-farm gate processes. Furthermore, this study used an average value for land transformation, contained in the ecoinvent dataset. Since land transformation was found to be of crucial importance, regarding GHG emissions, different assumptions regarding the share of deforestated land for crop cultivation would lead to significant differences. More detailed studies would be needed to determine exact amounts of land transformation and related GHG emissions. However, studies by Alig et al. (2014) and da Silva (2014) confirm that the share of deforested area for crop cultivation has a significant effect on GHG emissions.

Although deforestation rates decreased due to the Zero-Deforestation agreement, the recently adapted *Forest Code* regulation in Brazil decreased the amount of protected areas considerably (Soares-Filho et al., 2014). However, with the payment of ecosystem services, it provides a new instrument to keep native areas forested (Costa, 2016). These economic incentives, together with a strict law enforcement through investments in satellite-based monitoring tools could lead to a higher compliance in future.

In general, there is an accordance between this and further studies that feed production stage is the main contributor to most environmental impact categories, even when post-farm processes are considered (Nemecek et al., 2016).

Furthermore, ammonia emissions were found to be of major concern in the poultry value chain. This is in accordance with the evaluation of the National Research Council, classifying ammonia as the major emission of concern related to animal agriculture (NRC, 2003). Ammonia emissions are related to adverse effects on a local, national and global scale (NRC et al., 2003). Among these effects are negative implications for human and animal health, and furthermore, acidification of water and soil through atmospheric deposition (Becker & Graves, 2004). According to Battye et al. (1994), animal agriculture and poultry production account for 90% and 25% of total ammonia emissions, respectively. Considering a total amount of poultry production in Brazil of 12.9 million tonnes in 2016, and average emission factor of 0.269 kg ammonia per bird and year, a total ammonia release of 1’763 tonnes can be estimated (Battye et al., 1994). However, the magnitude of emissions depends on various factors. Therfore, several strategies exist for a reduction.

One approach is to reduce ammonia emissions through litter amendments and litter treatment. Litter amendments may change pH conditions in litter and lead to a decrease in emissions. The most common amendments are alum and zeolite, newer studies propose the use of gypsum, biochar, sand, refused tea and bacterial or enzymatic additives to decrease litter emissions (Naseem & King, 2018) (Atapattu, Lakmal, & Perera, 2017). According to an interviewee, litter in Brazilian broiler production is usually stored for two years in the chicken barns and then used as fertilizer or soil amendment. An industry representative added that no actions were taken to prevent ammonia emissions. However, long storage time were shown to increase ammonia concentrations in broiler sheds and emissions significantly (Nicholson, Chambers, & Walker, 2004). Furthermore, *anaerobic* litter treatment leads to significantly lower ammonia losses than *aerobic* decomposition (Naseem & King, 2018). Therefore, a faster removal of litter and subsequent anaerobic treatment could lead to significant reductions and furthermore be used for biogas production (Marinho Mathias, 2014). A further approach is the use of acidifying agents on poultry litter (Pokharel, 2013).

Ammonia emissions result from the degradation of urea and uric acid in broiler excreta (Naseem & King, 2018). Since broilers have no physical ability to store surplus amino acids, a reduction of protein-content in feed could help to prevent the formation of ammonia gas. Studies propose the use of fibrous diets with low crude-protein content, complemented with crystalline amino acids to meet the requirements of the birds (Naseem & King, 2018) (Bregendahl & Roberts, 2006). A further possibility is the use of feed amendments: Xin et al. (2006) reported that a low-protein diet, fortified with gypsum and zeolite, reduces ammonia emission from laying hens by 40%. Furthermore, bamboo charcoal or probiotics (*Lactobacillus casei*) as feed additives have been shown to reduce the formation of ammonia (Maliselo & Nkonde, 2015) (Chang & Chen, 2003).

A change of diet seems to be a promising approach to decrease environmental impacts, since feed production contributes to the largest share of the environmental impacts. However, nutrition must be adapted to the physical needs of the utilized broiler strains. In Brazilian poultry feed, soy was found to be an important component. However, soy production was found in this study to have relatively high impact contributions to several environmental problems. An approach would therefore be to reduce the environmental impacts related to feed by the use of feed components with smaller environmental impacts (Alig et al., 2014). A lower crude-protein content, together with crystalline amino acids could contribute to smaller environmental impacts related to feed production. As mentioned above, a lower protein-content and higher roughage-content would, furthermore, reduce air emissions from broiler excreta. However, a strong interaction between nutritionists, breeders and the scientific community is necessary to develop environmentally friendlier feed compositions suitable for the requirements of fast-growing broiler strains.

In general, the cultivation of crops is generally related to high environmental impacts, which was confirmed by this study. However, studies showed that alternative cultivation systems, such as organic farming, have lower environmental impacts than *conventional* farming systems (Nemecek, Dubois, Huguenin-Elie, & Gaillard, 2011). Since organic food was found to be a growing but underdeveloped sector in Brazil, the development of organic agricultural feed products for organic poultry production might therefore be a feasible strategy for landowners, leading to new business opportunities and decreasing environmental impacts, at the same time. Unfortunately, organic chicken production needs higher feed amounts and is therefore not more ecologically sustainable than conventional chicken (da Silva et al., 2014).

Nevertheless, in the long-term, the alteration of cropping systems would be desirable to enable a sustainable intensification by a decrease of fertilizer use, e.g. with the use of modern soil management techniques (e.g. *smart farming*) or the development of breeds with better nutrient use efficiency (Tilman, Balzer, Hill, & Befort, 2011).

5.1.2 Further instruments for the Development of Sustainable Value Chains

Besides the above-mentioned *farm/firm*-level and *command and control*-strategies, the following *economic* instruments could be used to increase profitability of social and ecological standards in the value chain.

Voluntary standards I – agreements between integrators and retailers: Agreements between private exporting companies and importing retailers have already been successfully implemented, e.g. within the Soy Moratorium (H. K. Gibbs et al., 2015). European retailers might use their bargain power to introduce higher voluntary standards in Brazilian facilities.

Voluntary standards II – labels: Labels are considered as a tool to provide consumers with more information and give incentives to producers to increase their standards (Horne & Achterbosch, 2008). With this instrument, new market channels could be developed, e.g. integrating family farms into the supply chain.

Inclusion of sustainability aspects into free trade agreements: Trade agreements provide the opportunity to include social aspects of global value chains (Polaski, 2003). Considering animal welfare as an example, Horne & Achterbosch (2008) found that developing countries are likely to increase their animal welfare standards to EU-standards to get market access. According to Chavaz, (2018), the EU-Mercosur free-trade agreement is likely to contain a section about sustainability of value chains, targeting several topics, such as forced labor.

5.2 Limitations of the Study

This study used several approaches for the evaluation of ecological and socio-economic impacts. However, some limitations should be considered.

The LCA is mainly based on background data. Although energy inputs were adapted to Brazilian conditions, the actual input amounts may differ, e.g. through smaller heat necessities in Brazilian broiler houses. Furthermore, there are big differences between Brazilian production regions or even on farm-level. Therefore, a more accurate data collection and an analysis of different scenarios, including different production regions of the feed components, would be of interest to evaluate a specific context and to give recommendations about the most sustainable agricultural practice and market channel.

For the application of the HSHA method (Wallbaum & Kummer, 2006), the use of a single-score LCIA method was necessary. For this purpose, the LCIA method Ecological Scarcity 2013 (Frischknecht & Büsser Knöpfl, 2013) was applied. However, this method uses a distance-to-target principle to create a single-score out of different environmental problems, based on Swiss environmental laws. Therefore, results of the Ecological Scarcity-method in other contexts should only be considered with reservations (Frischknecht & Büsser Knöpfl, 2013). However, in this study, the method was mainly used to gain a qualitative overview of the most severe areas of concern.

A further constraint is that Portuguese literature is to a large extent missing in the literature list. As a consequence, internationally known problems were included in the study, in particular.

Lastly, the amount of literature about a topic does is not necessarily reflect the amount of people affected by or the “severeness” of a problem. Certain interest groups (e.g. farmers) have a larger group of interests than others (e.g. chicken catcher), which increases the probability that their problems are being discussed in public.

6 Conclusion

The results from this thesis suggest that Brazilian chicken value chain is related to the creation of 3.5 million jobs in Brazil, which can mainly be found in rural areas. Socio-economic impact assessment showed that exporting integrating companies work mainly with larger poultry farms. Therefore, the inclusion of small-scale farms would be desirable to promote rural development in Brazil. Furthermore, precarious working conditions in several value chain stages. Especially occupational health and safety issues arise in several value chain stages. Furthermore, contract farmers work for low revenues and incidences of forced labor occurred. These results indicate a necessity of introducing one or many instruments to increase social sustainability along the value chain, which could be: stricter legal standards related to occupational health and safety, higher pace of unannounced controls and penalties, training of employers and employees. Environmental problems are mainly related to feed production and results indicate that changes in feed composition to lower crude-protein content could have a broad spectrum of benefiting environmental effects. In sum, further studies would be necessary to see how the found problems could be minimized or eradicated through several instruments and a collaboration of governments, NGOs, private companies and farms, e.g. through the inclusion of sustainability aspects into free-trade agreements or the introduction of voluntary agreements.

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Appendix

A1 Life Cycle Inventory

Table 13: Calculation parameters for LCI

Parameter (abbreviation)	Value (unit)	Source
Exploitation ratio (e) = carcass weight / live weight	0.7	Hoffman et al. (2013)
Average weight at slaughter age (slaugtw)	2.44 (kg)	Da Silva (2010)
Feed conversion ratio (FCR)	1.87	Hoffman et al. (2013)
Mortality (mortality)	4.3%	Da Silva (2010)

Table 14: LCI for production of 1 kg chicken meat (cw), transported to Switzerland. Considered processes: breeding (includes hatching), feed inputs, rearing, slaughtering, transport.

Output	SimaPro Name	amount	unit	Comments/	Source
Chicken meat	6 Chicken meat, at retail, cw {CH}| bachelor thesis	1	kg		
Inputs		amount	unit		
Day-old chicks	*One-day-chickens, at hatchery/NL Economic**	0.61	p	Broilers / kg meat (cw) = Average live weight per kg meat (cw) / live weight per bird * (1-mortality)	Own calculation based on parameters
Feed	2 chicken feed {BR}| Transfood BA	2.79	kg	1/e*FCR/(1-mortality)	Own calculation based on parameters
Adult chicken	3 Chicken for slaughtering, live weight, raising without feed inputs, at farm {BR}| Transfood BA	1.43	kg	1/e	Own calculation
Slaughtering	4 Slaughtering, chicken meat, only infrastructure and energy | Transfood BA	1	kg		
Transport	5 Chicken meat, transport BR -> CH | Transfood BA	1	kg		

** Heat input adapted to {BR}*

Table 15: LCI for 1 kg poultry feed, according to Alig et al. (2012)

Output	SimaPro Name	amount	unit	Comments
Chicken feed	2 chicken feed {BR}| TRANSFOOD BA	1	kg	1 kg chicken feed, composition according to Alig et al. (2012)
Inputs		**amount**	**unit**	
Soybean meal	Soybean meal {BR}| soybean meal and crude oil production | Alloc Rec, U	0.34	kg	34% approximation for soy extraction grist
Maize	Maize grain, feed {GLO}| market for | Alloc Rec, U	0.57	kg	57% of feed composition
Soybean oil	Soybean oil, crude {BR}| soybean meal and crude oil production | Alloc Rec, U	0.05	kg	5% of feed composition
Lime	Lime {GLO}| market for | Alloc Rec, U	0.12	kg	1.2% of feed composition
Sodium chloride	Sodium chloride, powder {GLO}| market for | Alloc Rec, U	0.005	kg	0.5% cattle lick, approximation for

Table 16: LCI for production of 1 kg chicken (live weight), at farm gate. Source: data set "Chicken for slaughtering, live weight {GLO}| chicken production | Alloc Rec, U", ecoinvent v3."

Output	SimaPro Name	amount	unit	Comments
Chicken, live weight	3 Chicken for slaughtering, live weight, raising without feed inputs, at farm {BR}| Transfood BA	1	kg	1 kg live weight. Only infrastructure, heat and electricity. Main source: data set "Chicken for slaughtering, live weight {GLO}| chicken production | Alloc Rec, U", ecoinvent v3.
Inputs		**amount**	**unit**	
	Water, unspecified natural origin, GLO	0.0052	m3	Original data set"
	Shed {GLO}| market for | Alloc Rec, U	5.27E-8	m2	Original data set

	Poultry manure, fresh {GLO}| poultry manure, fresh, Recycled Content cut-off | Alloc Rec, U	-1.93	kg	Original data set
	Heat, district or industrial, other than natural gas {BR}| heat and power co-generation, oil | Alloc Rec, U	0.31	MJ	adapted to BR heat
	Electricity, low voltage {BR}| market for | Alloc Rec, U	0.53	kWh	Adapted to BR electricity
Emissions (air)				
	Ammonia	0.01	kg	Original data set
	Methane, biogenic	0.00057	kg	Original data set
	Water/m3	0.00078	m3	Original data set
	Dinitrogen monoxide	0.0011	kg	Original data set
Emissions (water)				
	Nitrate	0.041	kg	Original data set
	Phosphate	0.00023	kg	Original data set
	Water, BR	0.0044	m3	Original data set

Table 17: LCI for production of 1.179 kg chicken meat, after slaughtering (cw). Based on dataset "chicken, meat, carcass (cold) at slaughterhouse/kg/GLO U" of the Agrifood Database EI3.3

Output	SimaPro Name	amount	unit	Comments
Slaughtered meat	4 Slaughtering, chicken meat, only infrastructure and energy | Transfood	1.179	kg	1.179 kg chicken meat (cw) "chicken, meat, carcass (cold) at slaughterhouse/kg/GLO U"
Inputs		**amount**	**unit**	
	Iron sulfate {RER}| production | Alloc Rec, U	0.0022	kg	Original data set
	Iron (III) chloride, without water, in 40% solution state {GLO}| market for | Alloc Rec, U	0.00089	kg	Original data set
	Sodium hydroxide, without water, in 50% solution state {GLO}| market for | Alloc Rec, U	0.00042	kg	Original data set
	Electricity, low voltage {BR}| market for | Alloc Rec, U	0.04	kWh	Original data set
	Electricity, low voltage {BR}| market for | Alloc Rec, U	0.00081	kWh	Original data set
	Tap water {GLO}| market group for | Alloc Rec, U	3.33	Kg	Original data set
	Heat, district or industrial, other than natural gas {BR}| heat and power co-generation, oil | Alloc Rec, U	0.392	MJ	Original data set
	Transport, freight, lorry, unspecified {GLO}| market for | Alloc Rec, U	0	tkm	Set to zero (included in data set "transport"
	Transport, freight, lorry, unspecified {GLO}| market for | Alloc Rec, U	0	tkm	Set to zero (included in data set "transport"
	Slaughterhouse	1/50/15865828	P	Original data set
Waste				
	Raw sewage sludge {CH}| treatment of, municipal incineration | Alloc Rec, U	3.326709454/1000	kg	Original data set

Table 18: LCI for transport of 1kg chicken meat, considering transports between farm, slaughterhouse, port Brazil, port Netherlands, Switzerland (distribution platform, distribution center and retail)

Output	SimaPro Name	amount	Unit	Comments
Transported chicken	5 Chicken meat, transport BR -> CH | Transfood BA	1	kg	Source: Alig et al. (2012)
Inputs		**amount**	**Unit**	
	Transport, freight, lorry, unspecified {GLO}| market for | Alloc Rec, U	250/1000	tkm	Farm -> slaughterhouse/processing
	Transport, freight, lorry with reefer, cooling {GLO}| market for | Alloc Rec, U	800/1000	tkm	Slaughterhouse/processing BR -> port BR
	Transport, freight, sea, transoceanic ship with reefer, cooling {GLO}| market for | Alloc Rec, U	10000/1000	tkm	Port BR -> port Rotterdam EU
	Transport, freight, lorry with reefer, cooling {GLO}| market for | Alloc Rec, U	750/1000	tkm	Port Rotterdam -> distribution platform CH
	Transport, freight, lorry with reefer, cooling {GLO}| market for | Alloc Rec, U	100/1000	tkm	Distribution platform -> distribution center
	Transport, freight, lorry with reefer, cooling {GLO}| market for | Alloc Rec, U	25/1000	tkm	Distribution center -> retailer

A2 Literature Socio-economic impacts

WC: Working conditions; HS: Health and safety; HR: Human Rights; LC: Land conflicts; FS: Food supply

Stage Feed production

Autor	Type / NGO	WC	HS	HR	LC	FS
Kessler et al, 2012	AidEnvironment	1	1	1		1
Bickel and Dros, 2003	WWF	1	1	1	1	
Guimarães, 2013	ILO			1		
Gomes et al. (2009)	Repórter Brasil	1	1	1	1	
DSC (2014)	Dutch Soy Commission			1	1	1
Bortoli et al . (2009)	Paper		1			
Khayat et al. (2013)	Paper		1			
Sanborn (2007)	Paper		1			
Bassil (2007)	Paper		1			
Benedetti (2013)	Paper		1			
Human Rights Watch (2018)	Human Rights Watch		1			
CPT, 2018	CPT			1	1	
SUMME		3	9	6	4	2

Stage Breeding

No reports about negative social impacts available

Stage Rearing

Autor	Type / NGO	WC	HS	HR	LC	FS
Reporter Brasil (2016)	Repõrter Brasil	1				1
IATP (2017)	IATP	1				
FAO, web	FAO	1				
(Alencar, Nääs, & Gontijo, 2004)	Paper		1			
Wainaina, 2012	Paper		0			
Tuyttens, 2015	Paper					
Miele, 2013	Paper					
Robins and Philips, 2011	Paper					
Elson, 2012	Paper					
Worldbank, 2014	Paper	1				
Action Aid, 2015 (NGO)	Paper	1				
Ton, 2017 (Review)	Paper	0				1
JusBrasil	Paper	1				
Frederici, 2016	Paper					
SUMME		6	1	0	0	2

Stage Catching and Transport

Autor	Type / NGO	WC	HS	HR	LC	FS
Reporter Brasil (2016)	Repõrter Brasil	1	1	1		
IATP (2017)	IATP	1	1	1		
Morris et al. (1991)	Paper		1			
Quandt et al. (o. J.)	Paper		1			
Lenhart et al.(1990)	Paper		1			
Rossiter (1997)	Paper		1			
SUMME		2	6	2	0	0

Stage Slaughtering

Autor	Type / NGO	WC	HS	HR	LC	FS
Reporter Brasil (2016)	Repõrter Brasil	1	1	1		
IATP (2017)	IATP	1	1	1		
HSUS (o. J.)	Paper	1				
Buzanello & Moro (2012)	Paper		1			
Campbell (1999)	Paper					
Tirloni et al. (2012)	Paper		1			
Hutz et al. (2013)	Paper		1			
Sagransky & Feldmann (2012)	Paper		1			
SUMME		3	6	2		

A3 Interview protocols

Interview Professor Euclides and farmer (non-integrated), 4. Juli 2018

Location: Caipira farm

Euclides explains that since he is working with a Quilomboli community (autor: located about 15 minutes by car from the UFGD campus). He says that Quilomboli are descendants of African slaves which have escaped into this region and have built their own community. Meanwhile, they had mixed with white people. About 365 people were living in the community with people working inside or outside of the community. Vegetables and fruits from their production were sold and processed in a restaurant on the campus which is quite small, therefore a reservation is necessary. They also sold on the street market in Dourados every week. Some were also working at the university (e.g. in the mentioned restaurant). Euclides has been working for over twenty years in this community and mentions that is a slow and steady process.

On the way, he shows corn fields on the right side, which belong to other Quilombolis which are producing in a conventional way. On the left side, a diversified field with corn, many different fruit trees, is visible, belonging to a farmer with an organic production system, working with Euclides. They were free to choose their production system, he mentions. I ask, why he works with an organic production system. “Welfare” is the answer.

He shows a water tank they have built because they have had big problems with water scarcity.

We are arriving at the farm, where Professor Euclides started to work in 2006 and meet the farmer who came to the community about 15 years ago by marrying a Quilomboli woman. The farm has about 2.5 ha land, with about 0.3 ha used for horticulture. We visit the gardens with vegetables and fruits. Euclides shows the irrigations pipelines which he helped to install. I ask, where they sell their harvest. They had five different channels, Euclides answers. Besides the restaurant on the campus and the mentioned street market, they also sell in shops in Dourados. They work together with the Organic Agriculture Organization of Dourados. Euclides emphasized that the crops are very diversified. For the protection of the crops they use flowers and a mixture of cow manure, milk, ashes, lime and leaves. The latter is also used as a fertilizer. Chicken dung from a conventional integrated broiler farm is used as fertilizer, additionally. Mycorrhiza is added as a soil improver. The system is called “agroecological”.

We arrive at the broiler houses. They are raised in a semi-Caipira system. Euclides explains that Caipiras are raised without any concentrate feed, here they would mix concentrate corn feed with leaves from the garden, therefore semi-caipira. So, they wouldn’t need a rotational system, the chicken could stay in the shed. Professor Euclides emphasized that they had been lucky with their supplier, finding him at the right time. He supplied them with one-day-old chicks from Paraná. I ask, if the genetics comes from Aviagen and Cobb-Vantress. He answers, that he didn’t know the answer. The breed was called “naked neck”. The first delivery was in 2006, where they received 100 chicks from their supplier and made some reproduction. Nowadays, they wouldn’t reproduce the chicken anymore. Euclides emphasizes, that it was crucial to buy the feed in big amounts at the right time to save money.

I ask, how many families are living in the community. The farmer answers, that they were about 30 families. His family was the only one producing in an organic way and therefore would be surrounded by pesticides. I ask, what the other families think about the organic farming system. He answers, that they would try to convince him to change and use pesticides. Euclides said, that organic farming needs another perspective because the harvests will be bigger in the long term, whereas conventional producing is a short-term perspective with quick results. I ask the farmer, if he had never been frustrated because of the diseases and maybe thought of changing to the conventional system. He hesitates, the answers, “Yes”, he is struggling a lot with diseases. Sometimes, he had thought of changing, but as he was producing the food for his family, he didn’t want to poison it with pesticides.

I ask, if they produce everything they need. The farmer answers, that they bought only rice, salt and coffee. He estimates, that they produced about 80% of their food. They sold only what is left. Euclides explains, that they start their projects little, with the goal to increase their food self-sufficiency. Later, when the results improve and there is something left, they would look for channels and sell it.

I ask, what they think of the integrated system. Euclides reacts sharply: “100% against - Never”. The farmer hesitates. Euclides explains, that the farmer had experiences in the conventional system for many years.

I ask the farmer about his experiences there. He explains that he worked in a broiler house with 15’000 chicken for two years and in a cropping system with 3000 ha and a lot of pesticides for 10 years. He said, he was suffering a lot during this time. I ask, what the main problems were. He answers, that they night-shift every day and they were only allowed to sleep from 9 am to 3 pm. I asked him about health problems in this time. He said, that he had a lot of health problems, especially because of some specific pesticides which caused him dizziness and illness.

The farmer answers more questions. The farm had existed since they could think, also with chicken which had been raised in a caipira system before 2006. They had also fishes and previously a dairy cow. I ask the farmer for his plans for near- or far future. He hesitates, then answers that he just wishes continuity and that everything works out well. They were going to see what would happen.

Driving back to the university campus, I ask Professor Euclides to explain his opinion about the integrated system. He responds that farmers under an integrated system lose their freedom, their ability to choose their sellers, to make decisions. They were a kind of employees and bearing all the risks, at the same time. In the end, their vulnerability would increase.

Interview sanitary inspectors from BRF, 5. Juli 2018
Translators: Carla, Gabriel
Location: Mato Grosso do Sul, BRF

He has been working in the exporting poultry industry for 25 years and since 5 years he works with BRF. They were in a team of 4 veterinaries. They were federal inspectors for sanitary conditions (SIF) in this specific BRF plant. They were employed by the government and their task would be to control the tests which are continuously made by the sanitary controllers which are employed by BRF. They would double check the samples and control the facilities on a 15-daily basis but had access to all facilities at every time.

We start to talk about the weak meat scandal (carne fraca). They explain that some positive samples had been found. As a consequence, the company blocked their own plants for export. Now, investigations were still going on and all of the plants are still blocked for exports into the European Union since there are assumptions of fraud. I ask about their opinion on the motives of the blockade. They suggest political motives to protect the European market, since no positive samples had ever been found by other labs or the sanitary control in the European Union (Rotterdam).

I ask about the reasons for the competitiveness of Brazilian poultry meat. They assume that the climate in Brazil is favorable, leading to high crop yields and cheaper feed. Additionally, workforce was still cheaper in Brazil than in other countries.

I ask about the main challenges regarding animal welfare issues. They explain that they had no contact with the production sites, but regarding the genetics and the feed, which was highly adapted to specific needs, the animals would reach their potential and their welfare was good. I ask about leg problems. They say that this was always a problem because of their weight gain. Julianna and Dr. Munchon think that the main problems regarding animal welfare arise from human & machine failure during the catching, transportation and unloading leading to broken wings or legs. There were attempts to automatize the steps.

They explain that an important change had happened some years ago when the responsibility of quality control was passed by the government to the industry. If samples were found to be positive, the company would be fined. The product would then be discarded or processed to meal for feedstuff.

I ask who the suppliers of the genetic material are. They state that BRF and other Brazilian companies would get their fertilized eggs from Cobb-Vantress (ROSS). BRF had some breeding facilities in Brazil, the grandparent eggs were imported from the United States by Cobb-Vantress.

We talk about the end product of the facility and the exporting markets. They say, the facility was supplied by about 280-300 broiler farms and slaughtered about 150’000 chicken per day.

They state that in this facility, the chicken was slaughtered and processed to a ready-for-export product (e.g. cuts) which was sent to the distribution centers and shipped. As destination countries they named Kuwait, Iran, Vietnam, Japan, China, UAE, Kosovo, South Africa and Kongo. They also produced halal products for Muslim countries. For this they had to employ Muslim workers for the slaughtering. Saudi-Arabia had recently changed its legislation, demanding that imported poultry should not be desensibilized before slaughtering by an electric water bath. The reason is that they do not believe that the chicken is still alive after desensibilization (death must happen through bleeding).
According to the inspectors, the European Union was regarded as a market with very high requirements. Companies with the permission to export to the EU were considered to have high quality standards. The import blockade would lead to a bad reputation of Brazilian meat and to price pressure, favoring other markets (Thailand, Mexico).
Main changes in the industry had happened when they passed the responsibility to the industry. Since they had additionally increased their thresholds for salmonella and never received a negative feedback of the EU control, they did not understand the blockade. They also mention that big losses had occurred due to weak meat.
We ask about the wellbeing of the employed slaughterhouse workers. They emphasize that there were a lot of efforts from the company to keep their workers. From an economical point of view, it would not make sense to change workers frequently since that would cause more time for the education. Therefore, programs for slaughterhouse workers, such as Pilates, physiotherapy or special food for pregnant women have been implemented. They state, that these efforts would happen in the whole industry.

Interview Animal welfare consultant, anonymous, 5. Juli 2018
Translators: Carla
Location: UFGD, Dourados (phone)

Richard (altered name) is an Animal scientist. He works for a private small company which offers consultancies for companies in the animal industry and their employees e.g. slaughterhouse companies, farmers and drivers. The company works also for the government or NGO's as a consultant in animal welfare issues. The company, consisting of 4 people, has a cooperation with a university doing the necessary research which is demanded by their clients.

In the poultry industry, their work focusses mainly on the training of the catchers and the slaughterhouse workers, since these seem to be the most delicate points in poultry welfare. They try to improve the catching schemes and provide training in slaughterhouses.

Whereas in Brazil, the main problems are hot weather conditions and long transport distances, in other countries occur different problems for animal welfare, such as cold weather conditions. Brazil is working with a catching scheme (back catch) which is more animal friendly than in most other countries (leg catch). The back catch method needs more training and can't be automatized. Since workforce is still cheap in Brazil, it is feasible to use this method.

I ask about problems which arise due to the breeding targets. He replies that there are challenges for breeders since the breeds have to be feed restricted but that their company focuses on the work with the slaughterhouses and the catching teams to improve the catching techniques.

He states that the work with the catching teams is difficult. The teams consist of 10-12 catchers which come from very poor background, usually.

We talk about the *dark house* systems which are the state-of-the-art in Brazil. He explains that the *Best-practice* scheme specifies 30 kg/m2 but, with a dark house system, this stocking density is not enough to cover the costs. An additional problem might be the lack of UV-light. Many studies are indicating that the absence of UV-light leads to stress for the chicken.

Interview Nutritionist, 6. Juli 2018

Location: UFGD, Dourados (phone)

Ney Andre is working for Evonik Industries AG, a German company present in Brazil, which produces highly specialized chemicals for various applications. In the segment “Nutrition and Care”, they also produce amino acids as feed additives for the poultry and swine feeding industry.

Ney explains that Brazil was the largest producer of poultry meat worldwide with about 18-20’000’000 broilers per day, resulting in 6.4 Billion dollars per year. In comparison to other countries Brazil had technology and experts. As a consequence, broiler producers would yield great results. Additionally, the feed is grown locally, reducing transport and transaction costs and space was available. Furthermore, Brazil was able to adapt to the preferences of various countries, e.g. with special cuts, broiler sizes or halal meat.

According to Ney, Evonik was producing amino acids which was very important to guarantee a sustainable way of feeding since less feed had to be used to raise chicken. The most important amino acids were Methionine and Lysin, whereby Evonik had a market share of about 40% of Methionine. Furthermore, they had a huge portfolio containing all different kinds of amino acids. Evonik produced amino acids which could be ordered pure from poultry companies which had the facilities and the know-how to mix the feed by themselves (e.g. BRF and JBS) or they sent it to processing companies (e.g. Cargill) which produce feed mixes for smaller companies. In Brazil, about 90% of the ordered amount was mixed by the poultry companies themselves.

The main challenges for the poultry industry would be, according to Ney, to increase the sustainability of the products. I ask, what he meant with “sustainability”. He points out that there would be no doubt that the industry had to skip the antibiotics in the feed. However, the health of the animals still had to be maintained and the yields should not be decreased.

In general, the main goal was and always would be to improve the food conversion ratio (FCR) and to increase the broiler weight.

I ask about his opinion on Caipira chicken (free range only fed with green leaves, without concentrate feed). He says that the main challenge with free range chicken would be to maintain the sanitary conditions.

I ask who was the main responsible to lower the FCR, the breeding companies or the feeding industries. He replies that there was a strong interaction between those.

Interview Nutritionist II, 9. Juli 2018

Location: UFGD, Dourados (phone)

Roberto (Name altered) works for a so-called premix company. They buy main ingredients such as corn and soy and add other ingredients, such as amino acids to produce swine and poultry feed. He is an animal scientist with a specialization in swine science.

He explains that the Brazilian poultry industry is highly industrialized and about 90% of the chain is vertically integrated. There exist two different organization structures: Private companies and cooperatives, where small farmers gather to increase their bargain power and share a profit at the end of the year. The private companies BRF and JBS produce about 50% of the total Brazilian production. Cooperatives give more power to the single farmer and might therefore be a possibility to support local farmers. Nevertheless, it must be considered that there are better and worse cooperatives, in terms of corruption.

A major challenge is, according to A. that the EU market keeps on introducing more and more rules for imported poultry (e.g. no growth promoters, antibiotics, DHD or DHA). He states that, as the EU pays well, the producers try to fulfill the requirements of the EU. Not all farmers are able to produce according to these requirements and therefore for export, but a lot of cooperatives can do it.

We speak about the advantages and disadvantages of the vertically integrated system. He states that the system is good and bad at the same time. On the one hand, it keeps the prices low and the poultry cheap for the poor people. On the other hand, farmers have no other choice than to participate in the system, since there is no market for independent farmers (which is a big difference to the swine industry). For the farmers, the vertically integrated system means a constant income, but it seems that most farmers are not satisfied with the system since they are not being paid as they should (not covering costs and investments).

Interview Professor, 10. Juli 2018

Translators: João

Location: UFGD, Dourados (phone)

Professor works as a professor in zootechnic at the Federal University of Sta. Maria in the research group "Nutrition for pork and poultry". He has a post-doc in aviculture nutrition and switched later from egg to broiler production.

I ask about the main challenges in the poultry industry. The professor explains that soy and corn prices are highly dependent on the international demand. Higher demands on the international market lead to higher prices for the farmers. Additionally, Brazil is dependent on the import of amino acids.

The main challenges on the farmer level are, according to the professor, that nearly all farmers have to work in the integrated system and they do not have the possibility to choose their suppliers and customers. They are kind of employees but with risks. If the feed prices rise, the company would give lower incomes to the farmers. Also, if the poultry prices decrease, the farmers get paid less by the integrating companies.

Slaughterhouses provide poultry, feed, transport. The producer provides the facilities, energy and heating.

He explains that embargos have strong consequences for the farmers since the poultry has to be sold within Brazil. As a consequence, prices go down and farmers get paid badly, sometimes not even covering their production costs. At the moment, selling prices are low and farmers get paid badly.

I ask if there are intentions to decrease the risks taken by the farmers? He said he wasn't aware that companies want to guarantee a minimum price, but they are currently implementing an insurance for natural disasters. Pay amounts are usually depending on the FCR (feed conversion ratio).

I ask about the perception of the farmers? According to Prof. X, the farmers are always complaining, no matter what. Currently, there is no space for independent farmers, since they have no bargain power as individuals. It is different for organic poultry production.

Differences between cooperatives and private companies? Cooperatives are mimicking the integrated system model from the private companies because the system works. The only difference is that a certain share is paid out to the farmers at the end of the year. Although the farmers have a certain influence due to meetings and votes within the cooperatives, the difference is very small, according to Prof.X.

I ask if he sees any other issues in the value chain. He responds that the chain is generally doing something good for the country since it generates about 3.5 Million jobs directly and indirectly with about 130'000 family farms being involved. Therefore, the value chain also acts as a driver for rural development. Additionally, most family farms are not only producing poultry but use the poultry business as a diversification strategy to increase their income. Especially dairy farms use this concept. In general, family farms are mostly located in the South of Brazil, whereas in the Center-West region, mainly big companies such as BRF and JBS are buying land to produce poultry in big amounts.

I ask about the sustainability of the value chain. He replies that from an economic perspective, the value chain is sustainable, since it is providing jobs, income, rural development and cheap meat for the population. Considering the environmental effects, the poultry chain is more sustainable than others, e.g. the swine industry (using less water, better FCR). Additionally, the beddings can be used as fertilizers (after two years they are sold by the farmers or used on their own land). The slaughterhouse residues are used as animal nutrition.

We start to talk about the dark house system. He says that for the farmers the dark house system was like a salvation since bigger profits were achievable. On the other hand, very high investments are necessary. The system was adapted from the United States, creating an artificial atmosphere with the best conditions for poultry (humidity, temperature). In the daytime, lights are turned off, creating an artificial night time, when the temperature outside is hot. At night, when temperature is decreasing, the lights are turned on to create an artificial daytime in the barn. With this system, temperature can be monitored and altered more easily than with a conventional system.

He explains that there are best practice guidelines, but no legal upper limit for the stocking densities. The usual density in a dark house system is 14-22 chicken per m2, whereas in the conventional system it is 10-12 chicken per m2. According to scientific literature, he states, problems with animal welfare start at 18 chickens per m2.

I ask about potential socio-economic problems in the value chain. He replies that it is known that slaughterhouse workers have problems with joints and get low wages, but on the other hand, jobs are provided and that it is better to have a bad job than no job at all.

Since I conducted an interview with two BRF inspectors who told me about the good working environments (physiotherapy etc..) in the facility, I ask if this was the general case. He explains that especially in the facility I visited, there were a lot of complaints from workers. The pressure led to improvements in the facility but that the measures are not implemented everywhere.

I ask about the working conditions of chicken catchers. He explains that some years ago, the companies were responsible for the catchers. But, since the work is related with low wages and health issues (dust, night shifts), they got a lot of complaints. As a consequence, the catching was outsourced, continuing being poorly paid but with nobody to address the complaints.

Besuch und Interview Darkhorse Chicken Farm, 12. Juli 2018

Translator: Marcelo, Guilherme

Location: Mato Grosso do Sul, broiler farm

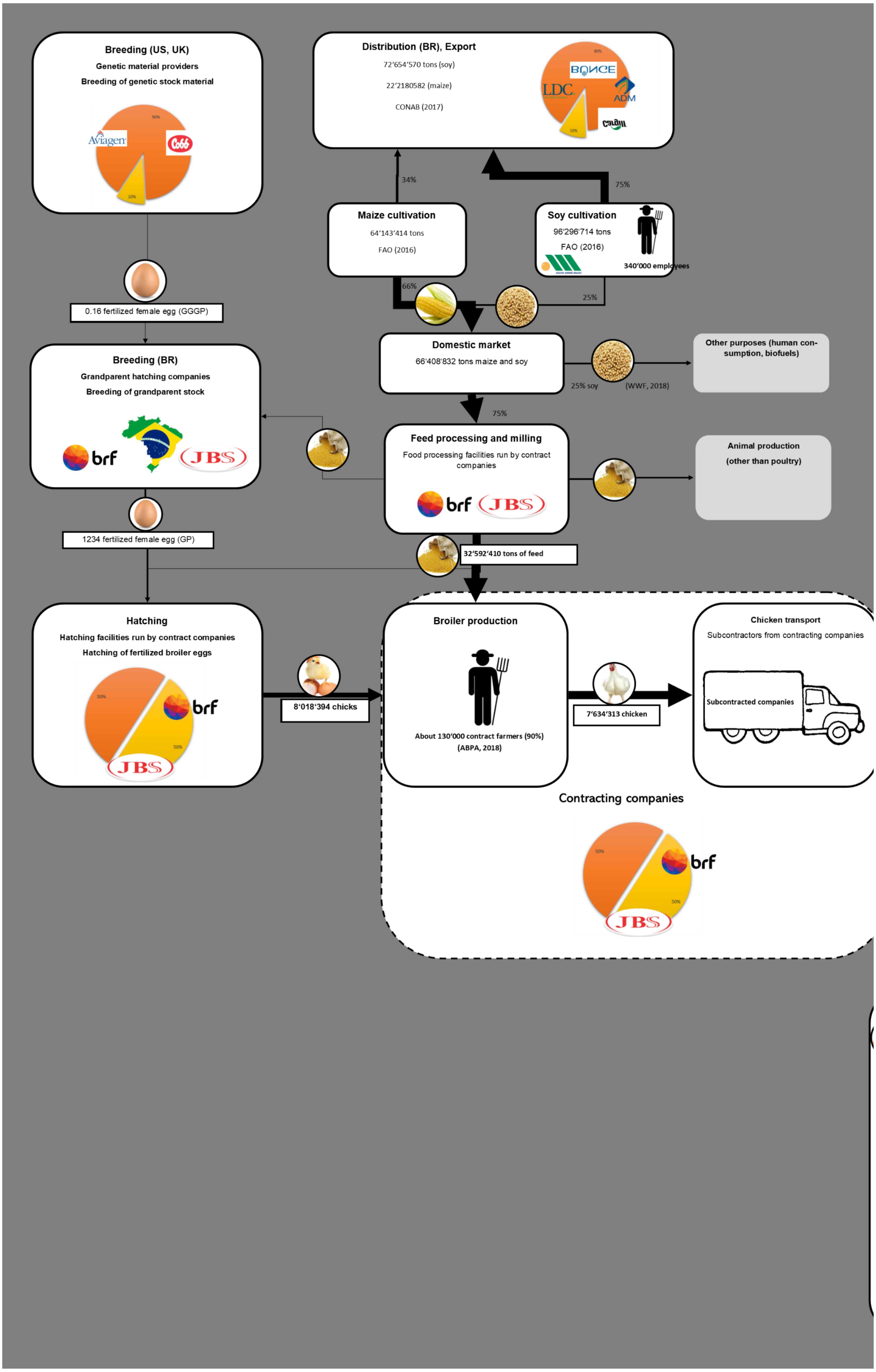
We visited a dark house chicken farm from Mr. X near Ivinhema, a city in Mato Grosso do Sul. Mr. X, the broiler farmer, his wife and a young employee received us at the gate. He explains that he switched about two years ago from cattle to chicken farming. He is an integrated poultry farmer with two producing facilities (barns) working for the private company Frango Bello (Bello Alimentos) which also produces for export. The company is owned by the group Pluma which owns four slaughtering facilities in Brazil. They also own breeding facilities for the parent generation. Bello Alimentos is active in Mato Grosso do Sul and in Paraná. Their slaughtering facility slaughters about 140’000 chicken per day.

When we arrive at the barn we meet a sanitary/nutrition specialist (SN) and a technical supporter (T) from Frango Bello. Both arrived before for a routine control to check the barns and to provide assistance to the farmer. We are asked about our contacts with other chicken during the last 7 days in order to avoid contaminations with Avian Influenza. Since we didn’t have any encounters with chicken we are allowed to visit the barns inside. Inside the dark house system, we find about 30’000 chicks, about 5 days old. The chicks seem healthy, no obvious injuries or any disorders can be observed, and the air does not smell of ammonia or excreta. The chicks have a blue powder on their feathers which is a leftover from the vaccines which were sprayed on. According to SN, the chicks stay 50 days in the barn before they are slaughtered. After a certain time, they explain, a separator in the middle of the barn is removed in order to increase the space. The temperature is regulated with an air flow (negative pressure): With fans, air is blown outside of the barn leading to an air stream through the barn with fresh air. The fresh air coming from outside passes through a cooling filter with water which cools the air in the barn down. Everything is measured and regulated automatically. The released air will not be filtered or treated. They explain that the chicken in the second barn have the same age as they build together a sanitary unit. The chicks are delivered by the company Frango Bello and

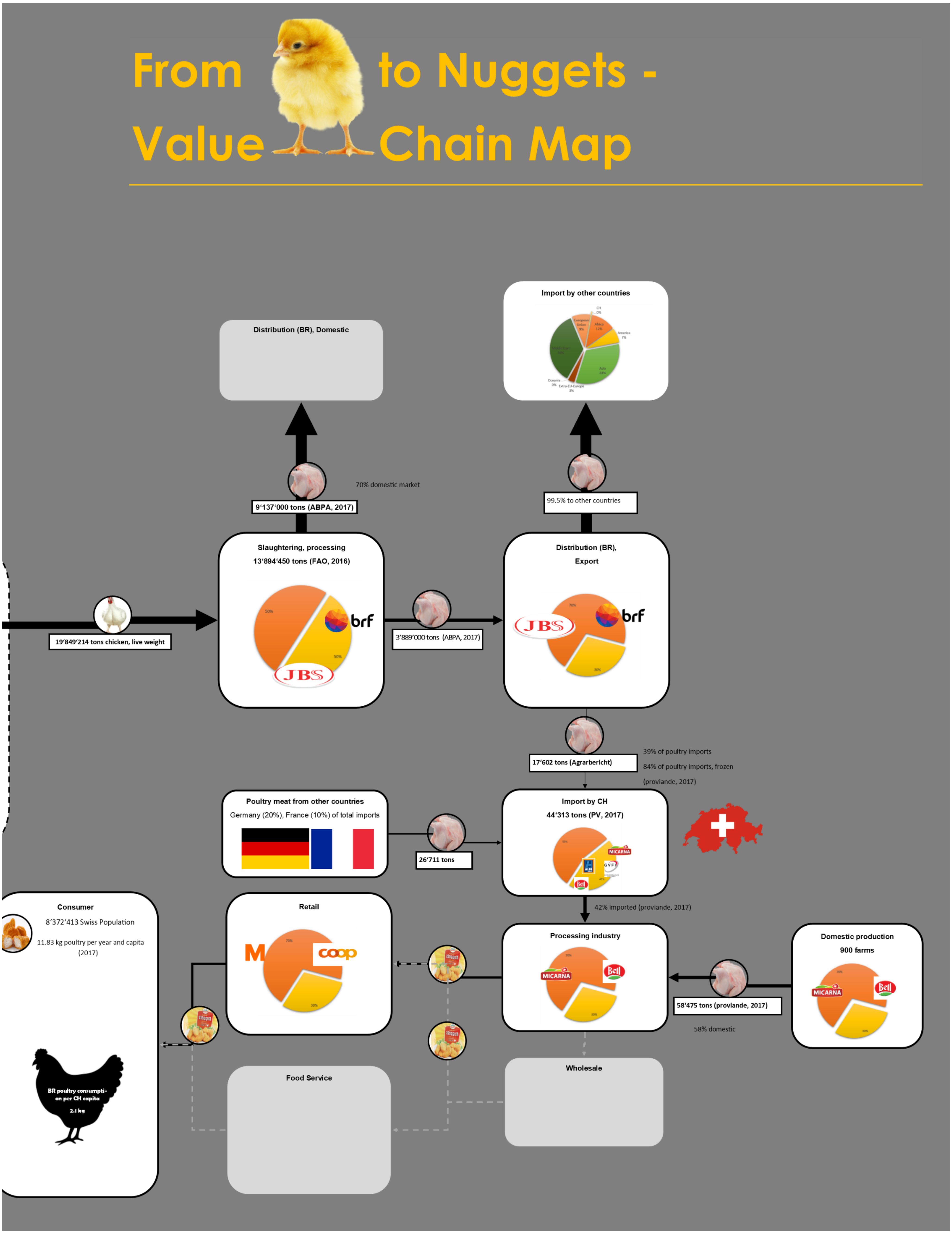
The young employee seems to have an age between 16 and 20. He is employed by Mr. X directly, not from Bello (the integrating company).

sanitary inspector explains that there are no big differences between cooperatives and private companies. According to him, the farmers have the same rights and responsibilities.

A4a Value Chain Map (Summary), page 1



A4b Value Chain Map (Summary), page 2



From Chicks to Nuggets

Assessing ecological and socio-economic impacts of the Brazilian-Swiss chicken value chain

Patricia Krayer, Bachelor Thesis, Environmental Engineering 13, Submission Date: 25.10.2018

Zürcher Hochschule für Angewandte Wissenschaften

zh aw Life Sciences und Facility Management

Introduction

In the course of globalization, the global trade volume of agricultural goods has increased considerably during the last decades.

Brazil is a net-exporting country, and one of the main global suppliers of several agricultural goods, such as coffee, orange juice, beef or chicken meat. Switzerland is a net-importer of agricultural goods, and imported about 17 000 tonnes of Brazilian chicken meat, in 2017 (BLW, 2017).

However, the production of agricultural goods is related to environmental burdens, such as soil degradation or water pollution. In global food value chains, these problems are shifted to exporting countries, such as Brazil.

The aim of this study was to impacts of the Brazilian-Swiss chicken value chain and to find related

- Socio-economic benefits,
- Socio-economic hotspots,
- Ecological hotspots.

Methods

Tje assessment was conducted in five steps for each Brazilian value chain stage:

I. Assessment of value chain structure
Method: Literature research

II. Assessment of ecological impacts
Method: Life cycle assessment
ILCD Midpoint 2011 (European Commission, 2010), Ecological Scarcity 2013 (Frischknecht, 2013)

III. Assessment of socio-economic impacts
Method: Literature research

IV. Quantiative evaluation of impacts
Method: Sustainable Hotspot Analysis (Wallbaum & Kummer, 2006)

V. Inclusion of stakeholder's perception of sustainability aspects
Methold: Interviews with Brazilian stakeholders

Results

Value chain structure

- 90% of the Brazilian poultry production is vertically integrated.
- The two largest integrators BRF and JBS control 50% of the Brazilian production and 70% of the poultry exports (Repórter Brasil, 2017)
- Chicken farmers receive feed, day-old chicks, medicine, technical assistance and improved access to financial credits from the integrators.
- Poultry feed consists to over 90% of maize and soy components, grown in Brazil.

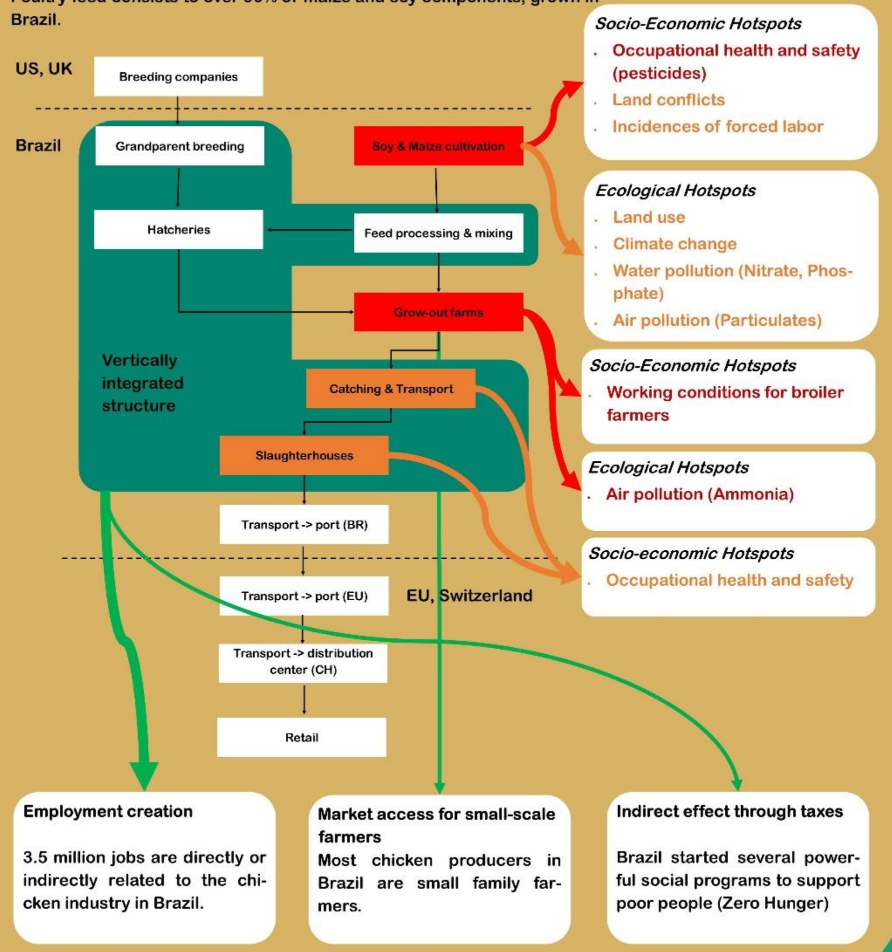


Illustration 1: Structure of the chicken value chain with main processes and related hotspots and benefits. Red: Strongest „areas of concern"; orange: „areas of concern". Green: benefits

Discussion

A sustainable Food Value Chain should increase the benefits and decrease negative impacts.

- The chicken value chain has potential to provide market access for small family farms in Brazil. However, the current main exporter works with over-average broiler farmers.
- In many cases, law standards already exist to protect environment, workers and communities. An accurate monitoring and higher penalties are necessary to ensure the sustainability of value chain activities, and decrease illegal deforestation, forced labor, land conflicts and health and safety-issues.
- Most ecological hotspots are related to the feed production. Therefore, a change of diet (lower crude protein-content) would help to decrease ammonia emissions and impacts through soy cultivation.
- The introduction of voluntary agreements between Swiss/ European retailers and the main producers in Brazil or the introduction of labels (e.g. family farm) could give incentives to include sustainability aspects into the value chain.

Conclusion

- The chicken value chain is of great importance for Brazil due to 3.5 million jobs which are related to the value chain.
- Many of the found environmental and social problems are caused by a weak law enforcement.
- Economic incentives, e.g. through the introduction of labels, could lead to the development of new and sustainable market channels.

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