Wageningen University – Department of Social Sciences

Management Studies Group

# Designing scenarios of sustainable production and distribution for the supply chains of beef and pork in Brazil

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MSc Management, Economics and Consumer Studies


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## Acknowledgements

With pride I would like to present my thesis, the result of a seven months research and empirical review, aiming at obtaining my two MSc degrees in Management Studies from the Wageningen University, and in Economics and Management in the Agribusiness from the Catholic University of the Sacred Heart. This journey brought me into the underwood of the Brazilian beef and pork chains, giving me the chance to network with field experts all over the globe. The actual and eventual implementation of my findings will be brought in by the SALSA project, a project funded by the European Commission, aimed at increasing the value added through sustainability of the Latin American beef and soy supply chains.

Hereby, I would like to thank my supervisors Dr. Jacques Trienekens, Dr. Jacqueline Bloemhof, and Dr. Stefano Boccaletti who supervised me, and gave me some creative space during the research. They have been inspirational due to their experience and devotion to the supply chain management topics. All of this helped me to develop and sharpen my research and managerial skills.

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This research helped me gain knowledge on the beef and pork Brazilian chains and on various major sustainability aspects in the management of food supply chains worldwide. I will hold on to this experience and I will make treasure of this knowledge, putting my newly acquired expertise at the service of my future employers and the scientific community.

Giulia Dondè

February, 2014

## Executive Summary

The objective of this thesis is *to provide farmers and other actors of beef and pork supply chains in Brazil with scenarios of sustainable production and distribution, by identifying the sustainable practices that are needed in those chains to make their operations in compliance with the required principles of sustainability*. The sustainability scenarios are described by the sustainable practices that they involve, which address sustainability issues in the 3P areas of sustainability.
Different opportunities of sustainable development regarding the beef and pork supply chains in Brazil are under investigation, but there is a gap in the literature about the development of a qualitative methodology which provides sustainability scenarios for these chains. Therefore, this paper designs a number of future sustainability scenarios that are feasible to be implemented to the Brazilian case of these two chains.

A literature review has been conducted to understand which sustainability indicators are most suitable for this study (thirteen, divided in economic, social and environmental). Then a round of interviews was pursued with eleven Latin American and European experts of these chains, to help the selection of the future draft scenarios. These draft scenarios obtained by the analyses of the interviews have been combined with the use of four criteria into six sustainability scenarios. These are: *intensification, local production and sustainable operations* and *integrated land use* for beef, and *integration of animal and crop production, sophistication* and *balanced sustainability* for pork.
The literature review on the definition of scenarios, on the global flows of beef and pork meat and on the beef and pork industry in Brazil, has been carried out. Eventually, the last step of the literature study involved the detailing of the practices in the selected six scenarios via literature review, in order to make those practices (thus the scenarios) implementable.

The empirical review encompasses a second round of interviews with fourteen Latin American and European experts of these chains. These interviews have a triple purpose: validate, assess and detail the scenarios. The purpose of the detailing step is to support the detailing via literature, by asking the experts interviewed for concrete actions that make the practices applicable. The combination of the findings from the literature and the empirical reviews resulted in the description of the six scenarios. Specific and general conclusions have been drawn. The outlook of the improvements towards more sustainable chains has to be chain-wide, and it should prioritise the farmland operations and the governmental actions that impose responsible bonds to the chain operations and ease their monitoring. Moreover, the information flows in the chain should be guaranteed as a powerful instrument to manage the operations and to create transparency for the consumer. This information should also specify when the practices in the chain are responsible, so that the marketplace of reference can reward the chain operations.
The many sustainable improvement options brought about by the six sustainability scenarios for the beef and pork supply chains in Brazil provide inputs for further research that has to investigate their representativeness for other food chains.

The final recommendations to the beef and pork chain players in Brazil is to consider the sustainable improvements that these scenarios would bring and to take the cue from them to retrench, invest or support supply chain decisions and policy making, more sustainably.

## List of Abbreviations

| Abbreviation | Stands for |
|---|---|
| 3P | People, Planet and Profit |
| 3PL | Third Party Logistics |
| DSS | Decision Support System |
| EU | European Union |
| GHG | Greenhouse Gas |
| GS | Governance Structure |
| HACCP | Hazard Analysis and Critical Control Points |
| IDEA | Indicateurs de Durabilitè des Exploitations Agricoles |
| K | Potassium |
| LA | Latin America |
| LM | Logistics Management |
| Mmt | Million metric tons |
| N | Nitrogen |
| OIE | World Organization for Animal Health |
| P | Phosphorus |
| PS | Production System |
| QM | Quality Management |
| RFID | Radio Frequency Identification |
| ROI | Return on Investments |
| RQ | Research Question |
| SALSA | Knowledge-based sustainable value-added food chains: innovative tools for monitoring ethical, environmental and Socio-economic impacts and implementing EU-Latin America shared strategies |
| SC | Supply Chain |
| SCM | Supply Chain Management |
| SME | Small and Medium Enterprises |
| WHO | World Health Organization |

# 1. Introduction: problem statement

The forecasts are clear about the idea that by 20 years from now the world population will increase by 3 billion people, mostly belonging to the middle class (www.Agrivision.com, 24-6-2013). In the context of this huge challenge posed by feeding the future, sustainability emerges as a top point of concern in the agendas of all the countries involved. "Sustainable development has been defined as meeting the needs of the present without compromising the ability of future generations to meet their needs" (Baldwin, 2009). In this thesis, the concept of sustainable development encompasses three essential aspects: economic (avoid imbalances and unfair behaviours), environmental (maintain biodiversity, atmospheric stability, etc.) and social (fair distribution and opportunities, etc.) (Harris, 2003).
In order to feed the growing population in a sustainable way, the glance at the enormous resources of the developing countries is needed. In this sense, an interesting case to deepen into is Latin America (LA). The farmers in Latin America are facing enormous obstacles in accessing the European markets (EU, 2002). The socioeconomic and environmental negative impacts of the commodity chains of beef and pork make it difficult in some cases to interface with EU marketplaces (Da Silva *et al.*, 2013). The rate of production that is meant to sustain the requirements of the marketplaces and the peculiar production systems in Latin America involve environmental, social and economic problems for the Brazilian society at large, due to the heavy usage of natural resources and the consequent air and water pollution, and ecological diseases (Hillstorm & Collier, 2004). This holds true also for the two commodities on which this thesis is focused: pork and beef from Brazil. This combination of supply chains is interesting to investigate. Despite the similar nature of the product, different sustainability issues and therefore different sustainability scenarios are expected.

Therefore, the objective of this research project is *to provide farmers and other actors of beef and pork supply chains in Brazil with scenarios of sustainable production and distribution, by identifying the sustainable practices that are needed in those chains to make their operations in compliance with the required principles of sustainability*.

The next subparagraphs detail some of the basic information to introduce the sustainability issues specific for the Brazilian beef and pork chains.

## 1.1 Background information

### 1.1.1 The beef and pork chains in Brazil: chain players and sustainability issues

**The beef supply chain**

Before the discussion upon some of the sustainability issues that affect the beef chains worldwide, a brief explanation of the SC and the system boundary considered in this thesis is provided (Figure 1).


Figure 1: The beef supply chain from Brazil to the EU markets (adapted from Meuwissen *et al.*, 2013).

The supply chain players of the Brazilian beef chains taken into account are the following: breeder, producer, transporter (from farm to abattoir), slaughterhouse, transporter (from slaughterhouse to ports), packer, and retailer (e.g. supermarkets, restaurants and post-processing companies). Moreover, the producer of farm inputs (e.g. feeds) will be taken into account (Meuwissen *et al.*, 2013).
The precise frame of the system boundary helps to understand the relevant stakeholders involved and to appreciate the complexity of the chain.
The next paragraph is centred on the sustainability issues that impact the beef supply chain.

***Sustainability issues in the beef supply chain***

According to Euclides Filho (2004) and Cederberg *et al.* (2009), Brazil has to face the increase in competition in the global beef market by being more efficient and sustainable. The major issues expressed in the literature for the Brazilian beef chains are the following: limited expansion of technical barriers, effective introduction of the beef product from Brazil into the world economy (e.g. Europe marketplaces), the internal beef consumption in Brazil, food health, the exploitation of renewable resources, the assurance of social welfare (human and animal), the quality and safety of the final product (free from residues), the land use expansion (especially in the forestland adjacent to the Amazon forest), and the GHG emissions from production and transportation. It is clear from now that the sustainability issues that Brazil faces range from environmental to social and economic concerns. Apart from these major sustainability issues, many more exist and are mentioned in the remaining of the thesis.

**The pork supply chain**

The overview of the chain players in the Brazilian pork supply chains and the major sustainable issues, are made available in this section. Figure 2 shows the pork supply chain, detecting the main players and activities involved from the breeder to the consumer.

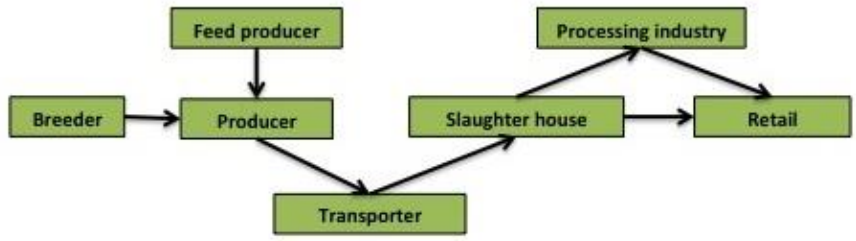



Figure 2: The pork supply chain from the breeder to the consumer (adapted from Pas *et al.*, 2011).

The supply chain players of the Brazilian pork chains taken into account are the following: breeder (optimization of the animal genetic characteristics), feed producer, producer, transporter (from farm to slaughterhouse), processing industry, and retailer.
Again, this picture is important to frame the actors and the complexity of the chain.

***Sustainability issues in the pork supply chain***

Honeyman (1996) and Australian Pork Limited (2008) recognize a number of major sustainability issues in the pork production chain in Brazil. These are: the farms issues (related to manure and by-product management, as well as animal welfare at the housing), the meat quality and safety (e.g. use of antibiotics and subsequent residues), the rural community (e.g. fair incomes), and the environmental burdens. The main environmental issues have to do with the use of resources and

services (water usage, energy usage, etc.), soil and catchment health (reuse of by-product nutrients, etc.), climate change (managing gas emissions, renewable energy, climate variance, etc.), and community interactions (facilities impacts, relationships with the community, etc.). The challenges and issues in the pork supply chain cited here are just some of the many sustainability obstacles that this SC has to overcome.

As for the beef sustainable issues, the aforementioned major sustainability problems can be grouped according to the economic, social and environmental concerns.

**In sum: the sustainability issues in the Brazilian beef and pork supply chains**

The table shown below summarizes the major sustainability issues for the Brazilian beef and pork supply chains. The rest of the thesis has the objective to provide sustainability scenarios as improvement options to overcome these (and other further mentioned) issues.

Table 1: Summary of the sustainability issues for beef and pork (mentioned in the literature).

| Brazilian | Economic issues | Social issues | Environmental issues |
|---|---|---|---|
| **Beef chains** | • Limited expansion of the technical barriers<br>• Effective introduction into world economy<br>• Internal market consumption | • Food health<br>• Assurance of social welfare (human and animal)<br>• Quality and safety of meat products | • Renewable resources<br>• Land use expansion<br>• GHG emissions from production and transportation |
| **Pork chains** | • Fair incomes for rural community | • Animal welfare at housing<br>• Meat quality and safety (e.g. antibiotics' residues)<br>• Community interactions | • Manure and by product management<br>• Use of resources and services (water, energy, etc.)<br>• Climate change (GHG emissions) |

These sustainability issues will be further investigated in the thesis. Their triple nature of economic, social and environmental calls for an integrated approach that addresses all the three areas of sustainability (see ch. 1.1.2 the definition of 'scenario').

The next chapters belong to the background information of this thesis. First, the definition of supply chain scenario is provided (chapter 1.1.2); second, the global flows of beef and pork meat are collected from the literature (chapter 1.1.3); finally, a brief industry analysis that seeks to delineate the essentialities of the beef and pork industries in Brazil is presented (chapter 1.1.4).

### 1.1.2 Supply chain scenario

This section is the outcome of the literature review about supply chain scenarios, in order to give an explicit definition of what this thesis intends as sustainability scenarios.

#### *From the theory of system approach to the definition of supply chain scenario*

This paragraph is aimed at providing the reader with a clear definition of " scenario" as intended to be in this research. Moreover, what the objective calls 'sustainable practices' is to be distinguished in generic and SCM sustainable practices. Four areas of SCM are chosen, namely: production system (PS), logistics management (LM), governance structure (GS), and quality management (QM) (since the thesis is about sustainability in SCs).

Regarding the definition of scenario, the system approach used in biological sciences in 1950s and 1960s has evolved within the social sciences into the concept of system boundary, which is a sub-level of a more complex system (Jackson, 1993; Checkland and Scholes, 1990; according to Van der Vorst, 2000). The system boundary of the system of this research is demarcated early in chapter 1.1, where steps of the supply chains of pork and beef are visualised. The further evolution of the system approach theories culminates into the concept of "scenario" (Van der Vorst, 2000).
According to Michael Porter (1985) a scenario is "an internally consistent view of what the future might turn out to be". Therefore, scenarios show the changes in the environment and within the system itself. For the purpose of this thesis, the concept of change involves the improvement of the sustainability of the beef and pork supply chains with the use of more sustainable generic and SCM practices.
The choice of demarcating the SCM practices into the four areas: PS, LM, GS and QM, was made by the author for the purpose of covering the main areas of intervention in a SC. This is an assumption that, nevertheless, is reasonable given the time constraints to fulfil the objective of the study. The conclusions will discuss which and to what extent these areas of SCM are conducive to sustainable improvements in the beef and pork chains in Brazil.
Thus, the following definition from Van der Vorst (2000), tailored to the purpose of our research project, seems to be best suited:

> "A SC scenario is an internally consistent view of a possible instance of the managerial and logistical SC concept, i.e. the production systems, governance structures, logistics management and quality management systems, seen as a combination of values of indicators in the 3P areas".

Indeed, the visualisation of scenarios is useful to make people understand certain situations and take actions accordingly.

### 1.1.3 Pork and beef: the global flows

Chapter 1.1.3 is the outcome of a literature review of the global flows of pork and beef meat, in order to give some figures that justify the importance of Brazil in these two sectors.
According to Euclides Filho (2004) and McGlone (2013), the growing trend for sustainable beef and pork meat is to be taken into account by both the supply chains. The consumers of beef products ask for good nutritional qualities, meat free of residues, or other contaminants that might affect human health. This requires a sustainable production and supply chains that keep an eye on food safety, food quality and animal welfare. The same holds true for pork, since the demand for sustainable products is present and is to be addressed by innovative sustainable production systems (McGlone, 2013).

| Meat | Meat consumed, 2012 (mmt) | Percentage of Meat (%) |
|---|---|---|
| Pork/Porcine | 110.8 | 37.4% |
| Poultry | 104.5 | 35.3% |
| Bovine | 66.8 | 22.6% |
| Ovine | 13.9 | 4.7% |
| **Total common meats** | 296.0 | 100.0% |

Table 2: Worldwide meat consumed in million metric tonnes, mmt (FAO, 2013).

The table above shows the main consumption figures related to pork and bovine meat in 2012 in million metric tonnes. These impressive volumes contributed to the increase of the global population, but have to be converted into more sustainable production systems, as asked from the beef and pork meat consumer.
The next sub-section is meant to describe the global flows of beef and pork meat.

### *Beef and pork global flows*

According to FAO (2013), the average of meat consumption in the developed countries is around 80 kg/year, while in certain developing countries it is still stuck at 10 kg/year. These countries will soon join the "livestock revolution" and will represent a rich opportunity as future targets of the beef and pork production chains (FAO, 2013).
According to FAO (2012), the pig production is significantly increasing, compared to beef, with an increase in the meat flows and market expansion especially in countries like Brazil and India.
According to USDA-FAS (2013), the worldwide meat export for beef, pork and poultry have grown over 40% throughout the past 10 years, with a forecasted record growth in 2014 due to the rising incomes and a stronger demand. While beef export is expected to skyrocket further, the pork meat's forecast is levelling off, though still increasing. The demand from Asian countries is rising, and fostering the increase of pork (moderately) and beef productions for export (USDA-FAS, 2013).

> […] both the production and consumption of the global major players for beef and pork have increased since 2009. Seemingly the import figures followed the same trend (USDA-FAS, 2013).

The database from USDA-FAS shows how both the production and consumption of the global major players (USA, Brazil, EU, China, India, Argentina, Australia, Mexico, Russia, Canada, New Zeland, Uruguay, Paraguay, Japan, and South Korea) for beef and pork have increased since 2009. Seemingly, also the figures concerning imports and export of beef and pork meat have undergone a step-wise but constant increase over the past years (USDA-FAS, 2013).
The next two sub-sections are meant to go deeper into the different figures for *beef* and *pork*.

### ***Beef global flows***

USA is the world's largest beef producer, while Argentina, Brazil, Paraguay and Uruguay have rising outputs (FAO, 2012).
The consumption figures worldwide are decreased in 2012 due to prices, in the developed marketplaces. Nevertheless, the shortages of domestic supply of beef are backing the global demand that in 2012 increased by 1%. The increase in import is forecasted in the United States, the Russian Federation, whilst in Japan, Republic of Korea and Indonesia the demand is decreasing (FAO, 2012). In the EU a depression of imports is having place. Latin American countries (i.e. Brazil) are expected to step up the exports, due to the increase in scale of farms and the larger herds.
According to USDA-FAS (2013), the forecast about the worldwide beef production in 2014 foretells a rise to 58.6 million tons, since major producers are seen as benefitting from cheaper feed supplies and an increased demand from importing countries (i.e. China). In Brazil the beef production is forecast to increase to a record 9.9 million tons by 2014, with a leap forward of 3% in production. The reason for this is that there will be an expanded herd made possible by governmental subsidies or lower interest rates to increase in the investments for pasture improvements, in combination with a better genetics (USDA-FAS, 2013). The other main driver of this increase in production would also be the increase in feedlots, as well as higher cattle prices and moderate prices of the feed (balancing

the feed intake given to the herd during the dry season, compared to the rainy one). In 2014 the exports are foretold beyond 1.9 million tons.

***Pork global flows***

According to FAO (2012), in 2012 the disease recovery in Asia and the higher slaughter due to downsizing operations brought the world pork production to 110.8 million tons. Some countries are pursuing a build of pig stocks and this is exerting a push down of prices in those markets (FAO, 2012). China is still the largest producer, sustaining the expansion figures. In USA, Canada and EU the consumption trend is not growing, while US excess pig supply is expected to foster trade by 3% to 7.4 million tons in 2012 (FAO, 2012). China's imports are keeping on surging, despite the recent disease outbreaks and the low domestic prices. The exports from developing countries are fluctuating year by year. For instance, the exports from Brazil are increasing due to the renew of Russian quality and sanitary restrictions on pork meat and thanks to a number of better equipped processing units and the employment of the diversification of sales to alternative markets (e.g. Ukraine) (FAO, 2012).
The production of pork, globally, is forecast to increase by 2014 following a step-wise positive trend. According to USDA-FAS (2013), in Brazil the production is forecast to increase moderately to a record 3.4 million tons, thanks to lower supplied feed costs and higher meat prices. The demand should expand as well. In particular, Russia is expected to remain Brazil's top market, although some sanitary-lead delimitations are foreseen (USDA-FAS, 2013). The recent access to the Japanese marketplaces will be maintained and, probably shifted to more mature markets, with well-established incumbents (USDA-FAS, 2013).

### 1.1.4 Industry analysis of Brazilian beef and pork meat

This chapter is a brief industry analysis that seeks to delineate the essentialities of the beef and pork industries in Brazil, underlying aspects of the chain coordination and operations that are needed to understand how these chains operate.

***The beef industry in Brazil***

According to Foch *et al.* (2013), the Brazilian beef cattle counts up to 200 million heads, mostly Zebu (Nellore). The beef sector is the second agricultural sector in the Country for importance, with an export of 20% of the production, making Brazil the world's largest beef exporter (WSPA, 2012). The large land availability, large feedstuff supply, the significant internal consumption of beef and the liberalization of trade barriers allow for scale up of farms and this huge production figures (Millen *et al.*, 2011). The production system is mainly extensive and based on grazing systems, with a slaughter age of the animal that reaches the 48 months (average is 36 months). Just 10% of the productions have an intensive finishing (from 90 to 120 days on feed) (Foch *et al.*, 2013).

Pasture management should be improved to avoid the negative impact of the grazing system. Overgrazing disrupts the nutrient cycle and pastureland. Concerning the GHG emission, although Brazil has the highest growth rate of enteric methane emission, the growth rate of methane emission per unit of product is negative (WSPA, 2012; Millen *et al*., 2011).

Mato Grosso presents production systems and farms that are mainly large-scaled, and the common system of production (also in other Brazilian states) is extensive. Thus, the animals have free access to the outside grassland to pasture and during winter (dry season), their diet is supplemented with other typologies of feed (WSPA, 2012). Although the extensive production system has the potential to be efficient, pasture management should be improved to avoid the negative impact of the grazing system. A good

pasture management also improves the productivity of animals, safeguarding animal health and welfare (WSPA, 2012). The problem of overgrazing is pervasive with vast areas where the nutrient cycle is disrupted and pastureland is, as a consequence, degraded (WSPA, 2012). Moreover, 50 million hectares of the Amazon forest have been turned into pasture (half of which already degrading) (WSPA, 2012). Concerning the GHG emission, although Brazil has the highest growth rate of enteric methane emission, the growth rate of methane emission per unit of product is negative (-1.82%/year) thanks to the growth rate of beef production that is significant (Millen *et al.*, 2011). The largest beef production in Brazil is located in Mato grosso do Sul (29.8%), followed by Minas Gerais and Parà. The largest feedlot production in Brazil is in the Midwest regions of Mato Grosso, Mato Grosso do Sul and Sao Paulo (Millen *et al.*, 2011). The following figure shows the map of Brazil with the concentration of cattle locations.

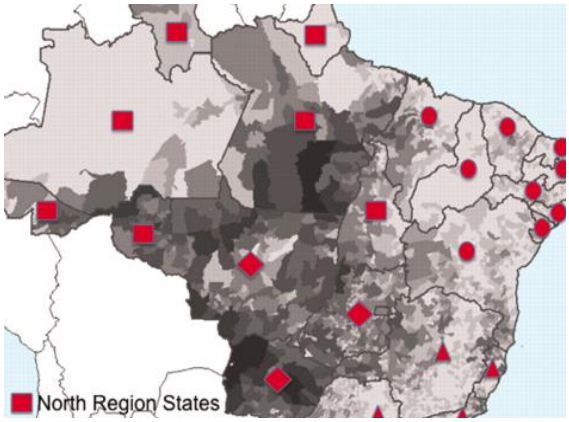


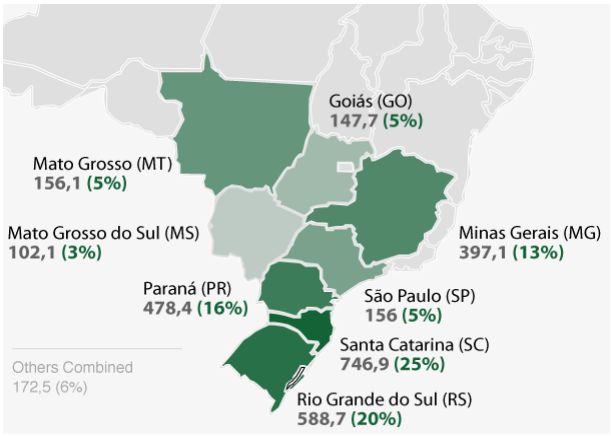

Figure 3: concentration of cattle in Brazil (the grey intensity indicates the concentration) (Millen *et al.*, 2011).

Concerning the supply chains, a traceability system has been implemented in the chain in 2002 due to international requirements. In order to tackle the antibiotics use in animal production, Brazilian packers have regulated their utilization (especially of ionophores, used as growth promoters) for those farms that are certified to produce for export to EU (Millen *et al.*, 2011). Nevertheless, 16 out of 27 Brazilian states are still considered affected by foot-mouth-disease and, also due to the lack of a good carcass grading system, many opportunities for exports are limited (Millen *et al.*, 2011).
According to Anderson and Hudson (2008), the Brazilian beef industry is typically not vertically integrated, but, instead, it is rather disperse. A recent merger between a Brazilian packer and an American processor have affected the horizontal structure of the beef processing industry, and represents a substantial vertical integration of the backward an upward operations in the chain. The packing sector in Brazil is also undergoing consolidation trend with non-pricing systems that increase vertical coordination with the upward stage through ownership of cattle, fixed price contracts, and other types of agreements (Anderson & Hudson, 2008). Rossi Soares *et al.* (2005) confirm that in the current beef industry in Brazil the coordination between the SC actors is weak, with little chances to find contracts between farmers and abattoirs and between abattoirs and retailers (Rossi Soares *et al.*, 2005). Nevertheless, interfacing with importing countries and especially EU requires strong chain coordination.

### *The pork industry in Brazil*

Brazil is the fourth largest pork producer globally with a produce of about 3,300 million tonnes (mmt), consumption of 2,700,000 tonnes, and export of 600,000 tonnes (Brazilianpork.com, 9-12-13). The production of pork in Brazil is scattered among all the 26 states and the Federal District (see Figure 4).

Figure 4: pork production by state (in thousand tonnes) (Brazilianpork.com, 9-12-13).




According to De Barcellos *et al.* (2011), in Brazil 88% of the technological pig farms is vertically integrated with agrifood industries and cooperatives, through the contract type of coordination or farm promotion programs. In the south of Brazil the vertical integration is the major reality for many farms and it is becoming the predominant coordination type also in the Central-west region. The bargaining power is in the hands of agrifood industries, which exert more control through the integration strategy with the other chain members (De Barcellos *et al.*, 2011). Given the bulk market that the pig production in Brazil represents, innovation has become an important source of differentiation for export and internal markets (De Barcellos *et al.*, 2011). Nevertheless, due to the high taxes and energy costs and the absence of a sufficient logistics infrastructure, the competitive marketplace is still won from whom has the lowest costs and the bountiful natural resources (De Barcellos *et al.*, 2011).

Although the pig meat is the most worldwide meat consumed (15 kg/person/year), the pork ranks third in Brazil after beef and poultry. Indeed, the internal market should be targeted as a fruitful opportunity (De Barcellos *et al.*, 2011). According to the statistics (IBGE, 2010), pork consumption has increased during the past years. Most of the pork meat consumed is processed into sausages. The resourcification that has to upgrade the sustainability of the pork chains in Brazil is based on innovation, focused on technological advancements and animal genetic development (mainly for quality assurance, feed conversion efficiency and animal lean pork production) (De Barcellos *et al*., 2011).

Both the lower production and logistics costs have allowed pig producers and meat processors to scale up. Nevertheless, this intensive pig production brings about a number of sustainability issues that follow the high concentration of the animals at the farm and the increasing dependence from external inputs (Franzese *et al.*, 2013).

## 1.2 Conceptual design

This follows the structure given by Figure 5. The research objective, research questions and research framework are the three elements developed in the next paragraphs.

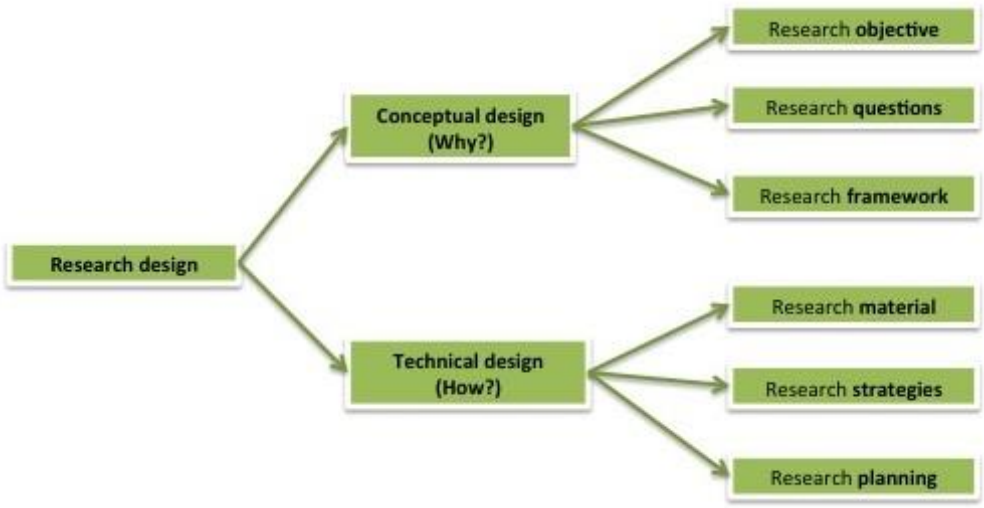



Figure 5: The research design composition.

### 1.2.1 Research objective

The *objective* in relation to this research project can be stated as follows:

> To provide farmers and other actors of beef and pork supply chains in Brazil with scenarios of sustainable production and distribution, by identifying the sustainable practices that are needed in those chains to make their operations in compliance with the required principles of sustainability.

The pork chain and the beef chain in Brazil are the two areas of interest in this thesis, and the two cases around which this project will revolve. The already mentioned 3 billion increase of the world population will pose serious challenges to the sustainable development of these two chains in Latin America. The farmers are one of the subjects of change and the recipient of the improvement options and guidelines that EU projects (e.g. SALSA project, funded by the European Commission) are developing to foster the sustainable development and value increase of the Latin American meat supply chains. In this context, many studies from FAO, Eurostat, and also Wageningen University are trying to frame a large number of indicators to assess the sustainability of a supply chain. These indicators are much more integrated across the three dimensions (3P areas) of sustainable development (economic, environmental, social), than in sustainability studies of the past. This integrated view of sustainability is taken up in this thesis in order to grasp a bit of the complexity of what sustainable development means for actors of supply chains. The expected outcome of this study is a number of sustainability scenarios of pork and beef in Brazil. The scenarios are a combination of sustainable generic (not SCM related, e.g. improved outdoor access for the pigs) and SCM practices (regarding four SCM areas: logistics management, production system, governance structure, quality management) that have to be employed by the farmers and other supply chain actors. The aforementioned four SCM areas are chosen in an attempt to cover the key strategic areas of decision making in a food supply chain. Thus, the following definition of scenario seems to be best suited:

"*A SC scenario is an internally consistent view of a possible instance of the managerial and logistical SC concept, i.e. the production systems, governance structures, logistics management and quality management systems, seen as a combination of values of indicators in the 3P areas*".
The generic and SCM sustainable practices that make up the sustainability scenarios for beef and pork in Brazil have been selected via literature review and interviews with experts of the two chains.

### 1.2.2 Research questions

The selected **central research question** in relation to this thesis is:
What are the best suited sustainability scenarios, as sets of generic and SCM sustainable practices, that farmers and actors of the two supply chains of pork and beef from Brazil have to employ in order to manage sustainable development?

The **specific research questions** are the following:

**RQ1.** What sustainability indicators (economic, environmental and social) would be best suited to assess the sustainability of the beef and pork supply chains?
**RQ2.** What is the current situation with respect to sustainability of the SCs of pork and beef from Brazil?
**RQ3.** What sustainability scenarios are feasible?
**RQ4.** What are the sustainability improvement options that, from a certain level of sustainability, bring to a future desired level of sustainability in these chains?

### 1.2.3 Research framework

The research framework shown in Figure 6 consists of six steps that employ: literature review, empirical review, the formulation of the results and conclusions. In the following subparagraphs, the detailed description of the research framework is provided:

- *Step 1* involves the literature review on the sustainability indicators and the selection of those that are suitable for this study. The concept of integrated view of sustainability in the 3P areas is used.
- *Step 2* is the empirical review in the form of interviews with experts of sustainability of supply chains and with experts of the SCs of pork and beef in Brazil. This first round of interviews has the aim of defining those future sustainable situations (called 'draft scenarios') for pork and beef, which are the starting point for the scenario development.
- *Step 3* involves the selection of the sustainability scenarios for beef and pork, using certain criteria to combine the draft scenarios from the first round of interviews. Step 3 comprises also the literature review on scenario development, on the global flows of beef and pork meat, and a brief industry analysis of these two sectors in Brazil (that become part of the background information). Finally, a literature review to detail the sustainable practices in the selected sustainability scenarios for beef and pork is conducted.
- *Step 4* entails a second round of interviews with the same type of experts of the first round. The aim is to detail the sustainable practices into concrete actions (as already carried out via literature), and to assess the selected sustainability scenarios. This empirical review ends with the analysis of the results from the interviews and the design of the sustainability scenarios for pork and beef in Brazil.

- *Step 5* frames the results. These are in the form of the final description of the sustainability scenarios for beef and pork in Brazil. Moreover, the assessment of the scenarios across the 3P sustainability indicators selected in step 1 is displayed.
- *Step 6* regards the conclusions of the study. The conclusions entail the reflections and discussions upon the process followed to evaluate the methodology used. Furthermore, those sustainable practices that the author speculates as applicable to other cases are described. Thus, the main idea of improvement options that they bring is explained. The purpose is to point at these practices and to promote further investigation on the representativeness of their effect toward an upgrade in the sustainability of other supply chains than beef and pork in Brazil.

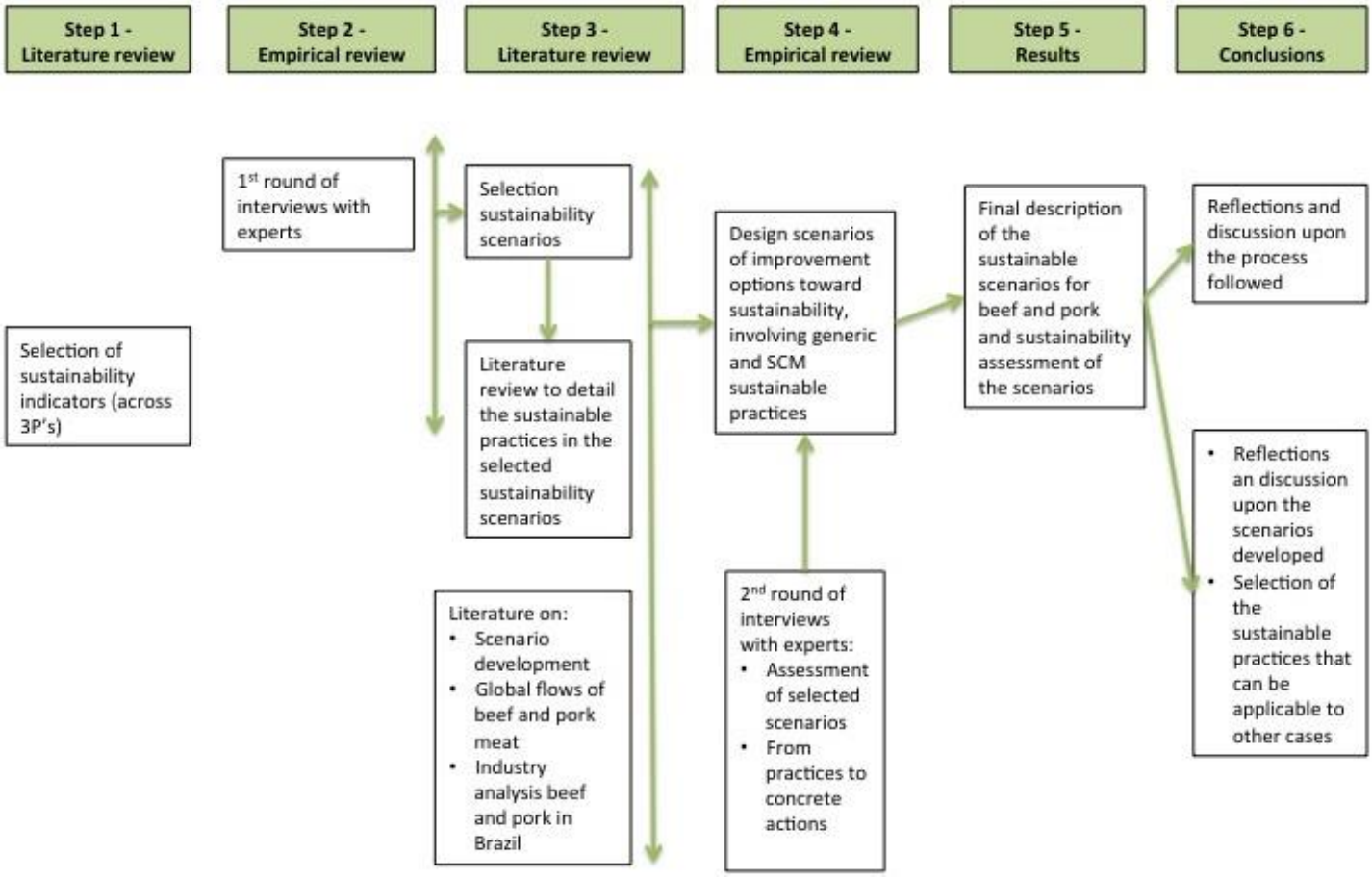



Figure 6: Research framework.

Given the non-linear steps of literature and empirical reviews that intertwine in this thesis, the next chapter promptly introduces the methodology. This is meant to ease the readability of this thesis, putting forth the methodology ingredients that have been used.
It is relevant to anticipate that the single answers to the four research questions are provided at the end of the thesis (chapter 7) and they will not be dispensed intermediately.

# 2. Methodology

This chapter zooms out to the methodology that has been used in the literature and empirical reviews.
The problem under investigation calls for a research strategy that employs: the case study. Then, the steps-wise process to the design of the sustainability scenarios is explained (chapter 2.1.1), the methods of data collection (chap. 2.1.2), the data analysis (chap. 2.1.3) and a sub-section on the discussion of the reliability and validity of this research are provided (chap. 2.1.4).

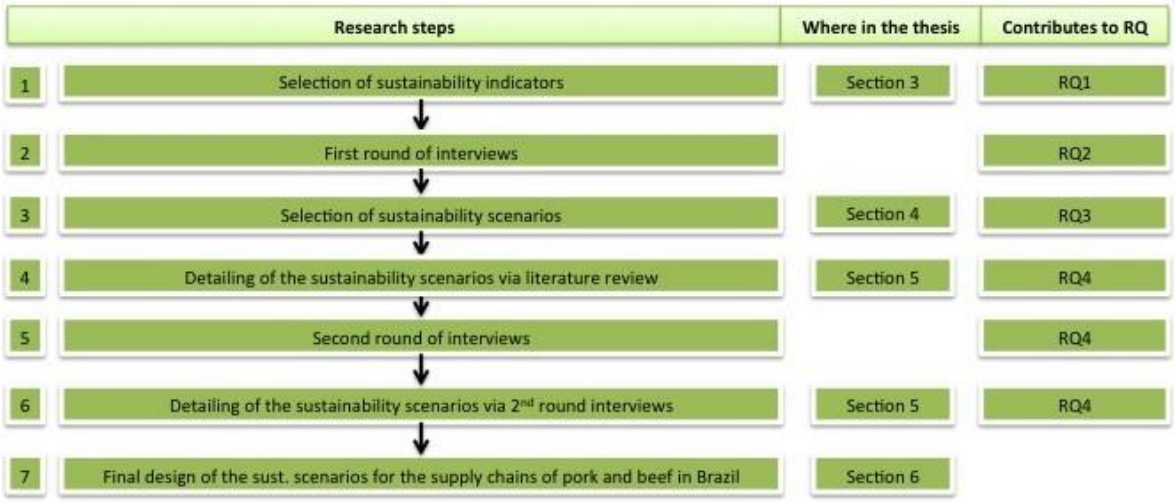
## 2.1 Case study design

The problem of this research is to support Brazilian farmers and other beef and pork SC members in their attempt to increase their sustainability while raising profitability. This is to be done providing them with sustainability scenarios that are feasible to implement. In order to design these scenarios, a step-wise approach has been followed.
The literature review is meant to answer **RQ1**, while the case study seeks to answer **RQ2**, **RQ3** and **RQ4**.
The case study is employed because the supply chains of beef and pork in Brazil have been investigated, with all the aspects potentially relevant to develop the sustainability scenarios starting from the current sustainable situation. Thus, the beef and pork supply chains in Brazil are treated as case studies. The different sustainability scenarios are the different options of sustainability that the two cases might follow.

### 2.1.1 Research steps and key concepts

The sustainability scenarios have been designed step by step through a bottom up process. This step-wise approach is displayed in Figure 7. Every step is then developed further in this sub-section with: (i) a description of the aim and the activities involved, (ii) the key concepts involved, and (iii) the research question it addresses (see RQs in chapter 1.2.2).

Figure 7: the steps of this thesis.




#### *Step 1: the selection of the sustainability indicators*

A literature review about the 'sustainable development' has been pursued, in order to select a set of sustainability indicators that are suitable for this study. The literature has been searched for in the relevant databases (e.g. Scopus and the university portal). Two steps of selection have been followed: one to define a number of relevant studies and the successive one for selecting the final set of sustainability indicators. Fourteen relevant studies selected have been elected within the large amount of literature because the

sustainability indicators that they propose: (i) are suitable to assess the sustainability of a supply chain, and (ii) are organized according to the 3P areas (Profit, People, Planet, or economic, social and environmental).
The set of sustainability indicators has been selected out of these fourteen studies according to: (i) the consistency (number of times) wherewith the sustainability indicator has been mentioned, (ii) applicability to supply chains, and (iii) the fit in the 3P areas. Those studies specific for the beef and pork sector have been prioritized. Thus, thirteen sustainability indicators have been selected.

| Activity in step 1 | To obtain | Contributes to answering | Key concepts involved |
|---|---|---|---|
| Selection of the sustainability indicators | Set of suitable sustainability indicators | RQ1 | Sustainability indicator in the 3P areas of sustainability |

### *Step 2: first round of interviews*

The first round of interviews was aimed at: (i) identifying the sustainability indicators (among the selection made in the previous step) that have to be improved, (ii) the identification of future sustainable situations (that the author calls 'draft scenarios') that are future pictures that address the sustainability problems in the beef and pork chains, and (iii) identifying the practices involved in the draft scenarios, to picture the activities that are involved.
All this has been obtained through eleven interviews with experts of the Brazilian beef and pork chains. These experts are mostly from Brazilian Research Institutes and involved in the chain operations. A part of the interviewees comes from the network of the SALSA project, whether a minority belongs to the research centres of the Wageningen University.
The interviewees were asked, first, to identify a number of sustainability indicators out of the thirteen in the 3P areas. Then they were asked to describe a future sustainable situation (i.e. 'draft scenario') that might overcome each of them. Thirdly, they were asked to mention a number of practices for each draft scenario to make it applicable. These practices can be generic sustainable practices or sustainable SCM practices (the interviewee was asked to specify if generic or SCM). The SCM practices refer to those practices that can be recognized as belonging to the SCM areas of competence: production system (PS), logistics management (LM), governance structure (GS), and quality management (QM). The acronyms PS, LM, GS and QM are used in the proceeding of the thesis meaning the four SCM areas aforementioned.
The interviewees were provided, first, with a semi-structured pre-interview questionnaire to be filled out before the semi-structured interview took place by Skype, phone-call or face-to-face. The interviews were meant to clarify and deepen into the answers to the questionnaire. In appendix 1, the interview document of the first round of interviews is available, containing the pre-interview questionnaire and the interview questions. Chapter 2.1.2 specifies the data sources and the methods of data collection used in step 2.

| Activity in step 2 | To obtain | Contributes to answering | Key concepts involved |
|---|---|---|---|
| First round of interviews | Draft scenarios and the sustainable generic and SCM practices involved | RQ2 | Draft scenario, generic sustainable practice, SCM sustainable practice (i.e. in the production system (PS), logistics management (LM), governance structure (GS), quality management (QM) areas) |

### *Step 3: Selection of sustainability scenarios*

The transcripts of the first round of interviews have been analysed and the draft scenarios, with the involved sustainable generic and SCM practices, are the outcome of step 2. Step 3 entailed the selection of the 'sustainability scenarios'. The aim was to select the sustainability scenarios from the draft scenarios gathered from the interviews. In order to pursue it, four criteria (chosen by the author) were used with the purpose of making the sustainability scenarios fit the definition that they are given in this thesis (see chapter 1.1.2). The four criteria are the following:

*1) Selection of a draft scenario that addresses more than one sustainability indicator:*

This first criterion is fundamental, given the definition of scenario provided in this thesis. The idea is that the benefits of the implementation of the scenario should cover the 3P areas of sustainability, with less possible anomalous trade-offs among indicators.

*2) The number of times that the draft scenario has been mentioned by different respondents:*

A sustainability scenario that is mentioned by multiple experts in the field is assumed more feasible than others.

*3) The number of sustainability indicators addressed by the draft scenario:*

Thus, the draft scenarios that addressed the largest number of sustainability indicators have been selected. This number is relative to the number of respondents for beef (eight) and pork (six).

*4) The personal evaluation:*

The author reserved the task of overruling, if necessary, the aforementioned three criteria. In case of this occurrence, the author would promptly mention it in the text (chapters 4.1 and 4.2).

The resulting sustainability scenarios cover the 3P areas of sustainability, as to fit the definition of scenario given by this thesis. Note that the process of selection of the sustainability scenarios using the four criteria has been carried out by the author under the supervision of two experts of these sectors and chains. The selection of sustainability scenarios has been tested with a survey on the 22nd November 2013 in Argentina with twenty experts of the beef and pork supply chains in Latin America.

| Activity in step 3 | To obtain | Contributes to answering | Key concepts involved |
|---|---|---|---|
| Selection of the sustainability scenarios | A number of sustainability scenarios each of which covers the 3P areas of sustainability | RQ3 | Selection criteria, draft scenario, generic sustainable practice, SCM sustainable practice, sustainability scenario, survey |

### *Step 4: Detailing of the sustainability scenarios via literature review*

The sustainability scenarios selected in step 3 have been turned into a set of concrete actions through a step of 'detailing' via literature review. This detailing is meant to take the insights from case studies and other researches in Brazil on how to make the selected practices in the scenarios applicable. Practically, the main Internet-sourced databases have been searched to detail each practice of each sustainability scenario. The aim is to detail the scenarios into concrete actions that give specific advices for the implementation of the scenarios.

| Activity in step 4 | To obtain | Contributes to answering | Key concepts involved |
|---|---|---|---|
| Detailing of the sustainability scenarios via literature review | (From the literature) the concrete actions to implement the sustainability scenarios | RQ4 | Sustainability scenario, detailing, concrete actions |

### *Step 5: second round of interviews*

The second round of interviews was aimed at: (i) validating the sustainability scenarios selected in step 3 in terms of feasibility of implementation and sustainable improvement, (ii) assessing the sustainability of each scenario, and (iii) detailing the practices in the sustainability scenarios into concrete actions (to support the detailing by the literature review in step 4).

Therefore, fourteen interviews with experts of the Brazilian beef and pork chains have been executed. As for the first round of interviews, the experts were mostly from: Brazilian Research institutes, businesses in the chain, the SALSA project, and the Wageningen University.

The interviewees were asked, first, to assess the sustainability scenarios using a 5-points Likert scale for each of the thirteen sustainability indicators. Then, the validation and the detailing were performed. The validation has been executed by selecting the practices that were feasible and sustainable for each scenario.

Besides, the detailing has been pursued asking the respondents to give concrete actions for each practice in each scenario.

The interviewees were provided, first, with a semi-structured pre-interview questionnaire to be filled out before the semi-structured interview took place by Skype, phone-call or face-to-face. The interviews were meant to clarify and deepen into the answers to the questionnaire. In appendix 3, the interview document of the second round of interviews is available. Chapter 2.1.2 specifies the data sources and the methods of data collection used in step 5.

| Activity in step 5 | To obtain | Contributes to answering | Key concepts involved |
|---|---|---|---|
| Second round of interviews | Assessment of the sustainability of the scenarios, validate the selection of the scenarios, detail the scenarios | RQ4 | Sustainability scenario, detailing, sustainability assessment, concrete actions, sustainability indicator, validation |

#### *Step 6: detailing of the sustainability scenarios via 2nd round of interviews*

The second round of interviews had, among its purposes, the one of detailing the sustainable scenarios into concrete actions. This detailing was meant to support the one carried out via literature review. Therefore, the respondents were asked to give a concrete action for each of the practices in the scenarios.

| Activity in step 6 | To obtain | Contributes to answering | Key concepts involved |
|---|---|---|---|
| Detailing of the sustainability scenarios via interviews | (From the interviews) the concrete actions to implement the sustainable scenarios | RQ4 | Sustainability scenario, detailing, concrete actions |

#### *Step 7: final design of the sustainability scenarios for beef and pork*

These concrete actions that have been researched via literature review and via the second round of interviews have been combined in the final design of the scenarios. No step of selection has been pursued, since the information provided by both the detailing steps was needed to make the practices of the scenarios concretely applicable to the Brazilian beef and pork chains. The final product is the description of the sustainability scenarios up to the detail of the concrete actions that they involve. The practices in each sustainability scenario have been organized into 'categories of improvement options', in order to ease the formulation of the conclusions and reveal further insights on the core improvements that these scenarios would bring. Moreover, the radar plot with the scores (from the 5-point Likert scales used in the second round of interviews) for the assessment of the current situation of sustainability (three experts have been involved in it) of the general beef and pork chains is displayed, along with the assessment of each of the scenarios (ex post the assessment of its potential future implementation). This is meant to visualise what would be the leap forward in terms of sustainability (across the thirteen indicators) brought by the implementation of these scenarios, compared to the current situation.

| Activity in step 7 | To obtain | Contributes to answering | Key concepts involved |
|---|---|---|---|
| Final design of the sustainability scenarios | A description of the sustainability scenarios for beef and pork in Brazil | RQ4 | Sustainability scenario, generic sustainable practices, SCM sustainable practices, concrete actions, sustainability assessment (13 scores/scenario), categories of improvement options |

### 2.1.2 Data sources and methods of data collection

According to Verschuren and Doorewaard (2010), there are three different data sources that are used in empirical research: documents, media, and people. The first two have been used in the literature review in chapters 1.1, 3 and 5. These documents and media are mostly web-based, in the form of official reports, databanks and websites (e.g. FAOSTAT and USDA-FAS). On the other hand, "people" is the main data source of information during the empirical review, in order to answer RQ2, RQ3 and RQ4. The experts of

sustainability, pork sector, and beef sector in Brazil are mostly from Brazilian Research Institutes, network of SALSA project, and the Wageningen University.
The interviewees have been provided with, first, a semi-structured pre-interview questionnaire to be filled out before the semi-structured interview. The interviews were meant to clarify and deepen into the answers to the questionnaire. The procedure for the data gathering using the aforementioned methods of data collection is available in appendices 1 and 3, with the interview document: (1) pre interview questionnaire and (2) the interview questions (for both the rounds of interviews). The purpose of the case study protocol that is self-designed by the author of the thesis is to increase the reliability and validity of the research.
The following sub-sections are meant to describe the content and the aim of the two methods of data collection used: the pre-interview questionnaire and the interview. The validation survey is also presented.

***Pre-interview questionnaire: first round interviews***
The goal of the pre-interview questionnaire was both to introduce the project to the interviewee and to frame the essential information that had to be deepened into during the interview. The layouts of the pre-interview questionnaires for the first and second round interviews are in appendix 1A and 3A.
The main purpose of the *first pre-interview questionnaire* is reflected by its structure: (i) general information about the respondent, (ii) identification of a number of sustainability indicators to be improved in the Brazilian or global beef and pork supply chains, and (iii) identification of a number of draft scenarios and the sustainable practices involved (specifying if generic or SCM practices).

***Pre-interview questionnaire: second round interviews***
The structure of the *second pre-interview questionnaire* encompasses: (i) generic information about the respondent, (ii) assessment of the sustainability scenarios with the use of 5-points Likert scales (to score each scenario across thirteen sustainability indicators), (iii) selection of the scenarios to detail, according to the expertise and the experience of the respondent, (iv) selection of those practices that are feasible to implement and sustainable, and (v) the final detailing of the scenarios, asking the respondent to turn the practices in the scenario into concrete actions.
The first and second round questionnaires are semi-structured, which consist of closed-ended, multiple choice and also open-ended questions.

***Survey***
In order to preserve the internal validity of the research, the triangulation of methods has been employed. The pre-interview questionnaires and the interviews following them are just part of the diversification of the methods of data gathering. A survey is taken up after the selection of the sustainability scenarios (before the detail of those scenarios via literature review and the second round of interviews). The survey was meant to validate the selection of the sustainability scenarios (with the generic and SCM practices involved) for the Brazilian case, considering: feasibility of the implementation, and effective esteem of the improvement of the sustainability. In case of a general positive response to the developed sustainability scenarios, the author would have proceeded with the detailing of the scenarios.
The selection of sustainability scenarios has been tested with a survey on the 22$^{nd}$ November 2013 in Argentina with twenty experts of the beef and pork supply chains in Latin America.

***Interview***
The goal of the first and second round interviews was to clarify the responses to the pre-interview questionnaires and to detail them. The interview was performed with both the interviewer and the

interviewee using the filled in questionnaire. The interview questions in the first and second round are semi-structured since they follow the different parts of the two questionnaires (see appendices 1, 3). The aim of the first and the second round of interviews is explained in detail in chapter 2.1.1 *step 2* and *step 5.*
The first round of interviews encompasses 11 interviews, while the second round 14 interviews.
The following table gives the overview of the interview schedule. This schedule shows the name of the interviewee, the expertise, the date and duration of the interview, the type of interview (F: face to face; P: phone call; S: Skype), the focus on the responses (if on beef, pork or both), and the round of the interview (1st or 2nd).

| N | Name | Expertise | Date and duration | Type | Beef | Pork | Round |
|---|---|---|---|---|---|---|---|
| 1 | Dr. Karel de Greef | Animal sciences | 8/10/13 (60 min) | F | | X | 1st |
| 2 | Davi Bungenstab | Beef and pork chains in Brazil | 28/10/13 (60 min) | S | X | | 1st |
| 3 | Cesare Zanasi | Rural economics, governance SCs | 25/10/13 (50 min) | S | X | | 1st |
| 4 | Rafael Trueta Santiago | Economics, beef sector, animal production and health | 6/11/13 (45 min) | S | X | | 1st |
| 5 | Isabel Blanco Penedo | Animal welfare | 16/10/13 (45 min) | F | X | X | 1st |
| 6 | Pieter Sijbrandij | Coordinator livestock program | 11/10/13 (45 min) | S | X | | 1st |
| 7 | Rafael Olea Perez | Animal productions (pork) | 4/10/13 (3hrs) | F | X | X | 1st |
| 8 | Rarahnaz Pashaei Kamal | Sustainability supply chains, beef chains in Brazil | 10/10/13 (40 min) | F | X | | 1st |
| 9 | Franco Muller Martins | Pork supply chains in Brazil | 30/10/13 (70 min) | F | | X | 1st |
| 10 | John Hermansen | Agricultural systems for sustainability | 31/10/13 (60 min) | S | X | X | 1st |
| 11 | Hannah van Zanten | Pork production | 4/11/13 (60 min) | F | | X | 1st |
| | | | | | | | |
| 1 | Gabriele Canali | Supply chain management, pork chains | 22/11/13 (70 min) | S | X | X | 2nd |
| 2 | Theun Vellinga | Pork chains in Brazil and sustainable development | 3/12/13 (60 min) | F | X | X | 2nd |
| 3 | Franco Muller Martins | Pork supply chains in Brazil | 18/12/13 (50 min) | F | | X | 2nd |
| 4 | Niels Halberg | Agronomy | 25/11/13 (60 min) | P | | X | 2nd |
| 5 | Willem Rijpkema | Pork supply chains | 10/12/13 (70 min) | F | | X | 2nd |
| 6 | Farahnaz Pashaei Kamal | Beef sector, sustainable supply chains | 10/12/13 (40 min) | F | X | | 2nd |
| 7 | Robert Hoste | Brazilian pork chains and sustainable supply chains | 26/11/13 (70 min) | F | | X | 2nd |
| 8 | Rafael Olea Perez | Pork and beef sector in Brazil | 9/12/13 (60 min) | S | X | X | 2nd |
| 9 | Henk Udo | Animal science and sustainable development | 26/11/1 (70 min) | F | X | X | 2nd |
| 10 | Andre Mancebo Mazzetto | Brazilian beef chains, sustainable supply chains | 28/11/13 (70 min) | F | X | | 2nd |
| 11 | Ruaraidh Petre | Brazilian beef supply chains | 29/11/13 (60 min) | S | X | | 2nd |
| 12 | Carlos Tavares de Castro | Brazilian beef, dairy cattle | 11/12/13 (30 min) | S | X | | 2nd |
| 13 | Mehmet Soysal | Brazilian beef supply chains | 6/12/13 (50 min) | F | X | | 2nd |
| 14 | German Borbolla | Brazilian pork sector | 10/12/13 (60 min) | S | | X | 2nd |

Table 3: Schedule of the first round (orange) and second round (light blue) interviews.

### 2.1.3 Data analysis

The primary data gathered through the first and the second round of interviews have been analysed in order to design the sustainability scenarios for the supply chains of pork and beef in Brazil. The following sections describe how the data gathered from the first and the second round of interviews were analysed, according to the different items in the questionnaires. The use of the frameworks is pivotal in order to analyse in a systematic way the information provided during the interviews and to frame as much information as possible without missing relevant data (see appendices 1C, 1D, 3B, 3C). The following description of the data analysis of the first and the second round of interviews refer to the structure of the questionnaire to ease the readability.

***Analysis of first round interviews***

The framework used for the analysis follows the same order of the questions in the questionnaire. In chapter 2.1.2 the pre-interview questionnaire and the interview questions have been described. The sustainability indicators identified from the respondents (the ones that have to be improved) in part two have been collected and a final average was made across all the respondents to see what indicators have been picked by more than 50% of the interviewees. Those chosen by more than 50% of the interviewees

have been selected as sustainability indicators to be improved. Then, as chapter 2.1.1 describes, from the selection of the sustainability indicators for beef and pork in Brazil, the author obtained the draft scenarios with the generic and SCM sustainable practices involved. The analysis of the data gathered has been carried out simply organizing the draft scenarios in a table with the sustainability indicators they affect and the respective practices, indicating when the practices are in the four SCM areas (and specifying if PS, LM, GS or QM).
The successive step involved the selection of the sustainability scenarios out of the draft scenarios developed in the first round of interviews. This was pursued as described earlier in chapter 2.1.1 (step 3), using four criteria.

***Analysis of second round interviews***
The aim, the main activities and the research question addressed by the second round interviews are explained in chap. 2.1.1. The frameworks used for the analysis of this round of interviews are in appendix 3.
It is important to anticipate that during the fourteen interviews, the aim of the author was to have at least six people assessing the sustainability of each of the sustainability scenarios and at least three respondents pursuing the validation and detailing of each of the scenarios.
The 5-point Likert scales were used to *assess* the sustainability level of the scenarios across thirteen sustainability indicators. Therefore, each scenario, after the assessment, received thirteen scores. These thirteen scores on a 5-points scale were obtained after the computation of the average score for that indicator for each scenario, across all the respondents. For example, 14 respondents have assessed the 'income distribution' indicator of the scenario 'intensification' on a 5-points Likert scale. Therefore, the average of the 14 scores has been made to determine the score in 'income distribution' associated to that scenario. The same has been done for that (and each scenario) for the rest of the indicators.
Then the *validation* step engaged the respondents in selecting the practices that are feasible and sustainable for each of the scenarios, screening out (with a substantiated justification) the not feasible and/or not sustainable ones. The analysis entailed screening out those practices that have been excluded by at least 2 respondents. There was also the possibility that practices were added to the scenarios. In that case, they would have been automatically inserted in the panorama of sustainable practices.
The *detailing* of the scenarios involved giving concrete actions for each of the practices in the scenarios, to make the scenarios concretely applicable to the Brazilian case. Therefore, the concrete actions from the different respondents have been added to each other during the analysis of the interviews, without screening out any information. The detailing, of course, is not embedded in the results for those practices that have been left out from the sustainability scenarios during the validation.
The final description of the sustainability scenarios (in the results of this thesis) is the combination of the concrete actions found via literature review and interviews.

### 2.1.4 Reliability and validity
The quality of a research is linked to its reliability and validity (Boeije, 2010). Both will be discussed in this section.
*Reliability* refers to the consistency of the methods and measures. When the same phenomenon is repeatedly measured using the same instrument it should lead to the same outcomes, assuming that the phenomenon itself has not changed (Boeije, 2010). To be sure that this research is reliable, the data were gathered and analysed all in the same way, with the use of pre-interview questionnaires and frameworks for the analysis of the transcript of the interviews (appendices 1 and 3).

*Validity* is also an important concept what is linked to the quality of the research. Validity consists of internal and external validity. *Internal validity* means that the author can be confident that respondents describe and or explain what they had to set out to describe and explain. The results are to be considered internally valid when no alternative explanations or external variables intervene in explaining the same results (De Vaus, 2001). Therefore, if no alternative explanations for the findings are involved, the conclusions are correct within the research population. The choice of embracing a triangulation of methods (pre-interview questionnaire, survey and interviews) helps safeguarding the internal validity of this research.
*External validity* refers to whether the results of a study can be generalized beyond the specific research context (Boeije, 2010). This research is focused on the beef and pork Brazilian supply chains. However, the author cannot be confident that the same findings are suitable also for other sectors. Therefore the outcomes of this research project are only externally valid for the pork and beef sector especially in Latin America.

The problems related to the reliability of the findings have been tackled as much as possible with the use of triangulation of methods (pre-interview questionnaire, interviews and survey) and sources (people, documents and media).

# 3. The 3P sustainability indicators

Chapter 3 is pivotal to address the specific RQ1 by means of a literature review:
**RQ1**. *What sustainability indicators (economic, environmental and social) would be best suited to assess the sustainability of the beef and pork supply chains?*

Therefore, after a scan of the literature about sustainable development, a selection of suitable sustainability indicators has been made. Eventually, fourteen relevant studies were selected from the literature. This selection was made out of all the studies overviewed because the following fourteen studies are more suitable to assess, with a set of indicators, the sustainability of a supply chain, instead of, for example, the sustainable development of a country (as many studies propose). Moreover, the sustainability indicators proposed by the selected fourteen studies are organized according to the 3P areas (Profit, People, Planet, or economic, social and environmental). It is important to notice that out of these fourteen studies, therefore out of the fourteen taxonomies of sustainability indicators proposed, a further and final selection of sustainability indicators in the 3P areas has been carried out.
The next paragraph describes the different taxonomies of the fourteen studies on the indicators of sustainable development, while chapter 3.2 will deal with the final selection of sustainability indicators.

## 3.1 Overview of sustainability indicators

The following fourteen studies selected from the literature available about sustainable development and sustainability of supply chains enclose the indicators that have been selected as the most significant and suitable for this study (chapter 3.2). A sum up table is available below, which shows the author of the study, the sustainability tool developed by the study, the 3P areas involved, the sustainability indicators, and the corresponding sustainability measures.
The table is further described below, along with the substantiation of the final selection of the sustainability indicators that has been used in the proceeding of this study.

| Author | Sustainability Tool developed | Categories of sustainability (3P areas) | Sustainability indicator | Sustainability measures |
|---|---|---|---|---|
| Eurostat (2011) | Sustainable development indicators | Climate change and energy | GHG emissions | Projections of GHG emissions, global surface average temperature |
| | | | Energy dependence | Electricity generated from renewable resources, energy consumption by fuel, implicit tax rate on energy |
| | | Sustainable transport | Modal split of freight transport | Energy consumption by transport mode, investment in transport infrastructure by mode |
| | | Natural resources | Land use | Forest trees damaged by defoliation |
| Unilever (2010) | Sustainability indicators | | Reduction of land use | (Hectares used/average local yield suppliers)-(hectares used/average yield local country) |
| | | | Soil health improvement per hectare | Land used for cultivation or livestock under sustainable practices x proportion of crop bought |
| | | | Livelihoods per farmer | Income=number of farmers and farm workers in our SC who earn at least the MAX of (minimum wage; avg. GDP/capita per agricultural workforce; international poverty line)<br>Welfare=no. workers w/access to improved housing, improved drinking water, improved sanitation; advanced education or training above the requirements of the fob, to healthcare for themselves and their families. |
| | | | Amount of nitrogen lost in the environment (N lost) | N input inorganic and organic fertilisers (kg/yr) – N output (kg/yr) taken off from the harvested proportion of the crop |
| | | | Amount of GHG emitted from cropping | Sum of CO2 emitted + sum of N2O emitted * 296 + sum of CH4 emitted *23 |
| OECD (2001) | Sustainability indicators | Environmental | Air quality | GHG emissions index and CO2 emissions, NOx emissions |
| | | | Water resources | Intensity of water use=abstractions/renewable resources |
| | | | Energy resources | Consumption of energy resources |
| | | | Biodiversity | Size of protected areas as a share of total area |
| | | Economic | Income distribution | Gini coefficients |
| | | | Produced assets | Volume of net capital stock |
| | | | Technological change | Multifactor productivity growth rate |
| | | | Financial assets | Net foreign assets and current account balance |
| | | Human capital | Stock of human capital | Proportion of population with upper secondary/tertiary qualifications |
| | | | Investment in human capital | Education expenditure |
| | | | Depreciation of human capital | Rate and level of unemployment |
| Callens and Tyteca (1999) | Sustainability indicators at firm level | Economic | Short term economic | Turnover, value added, output, production, resources used as inputs (including recycled products and energy) |
| | | | Long-term economic | Profitability, competitiveness, market shares, product durability, research and development efforts |
| | | Social | Short-term social | Employment, salaries, labour intensiveness or productivity, injury risk noise, odour |
| | | | Long-term social | Welfare, education, availability of (non) renewable resources (including energy), size (SME vs big), personnel rotation rate |
| | | Ecological | Short-term ecological | Natural resources, wastes, pollution, transportation modes and distances |
| | | | Long-term ecological | Global impacts, biodiversity, global warming, acid deposition, landscape, ultimate waste disposal, product recycling ability |
| Epstein and Roy | Sustainability | Economic | Not specified | Percentage of supplying companies owned by minority groups |

| | | | | |
|---|---|---|---|---|
| (2001)<br><br>(GS) | indicators at firm level | Social | Not specified | % of women (senior position)<br>working hour/wages<br>cases of bribery |
| | | Environmental | Not specified | Emissions/air (tonnes), discharge to water |
| Hutchins and Sutherland (2008)<br><br>(GS) | Sustainability assessment tool for SCs | Social | Gender equality | Ratio of average female wage to male wage |
| | | | Labour equity | Ratio of the average hourly labour cost (including benefits and taxes) to the total compensation package |
| | | | Healthcare | Ratio of charitable contributions to market capitalization |
| Nikolaou and Tsalis (2013)<br><br>(GS) | Environmental performance indicators for SCs | Environmental | Recyclability | % of the mass or the volume of a product that can be recycled |
| | | | Reusability | % of the mass or the volume of a product that can be reused at components' level |
| | | | Energy consumption | amount of energy that is consumed during the manufacturing of a product |
| | | | Energy sources | sources of energy that are used e.g. electricity, fuels |
| | | | Fresh water use | Quantity of fresh water that is consumed during the manufacturing of a product |
| | | | Water reuse | % of the volume of water that is reused in the manufacturing processes |
| | | | Use of recycled material | % of the mass or the volume of raw materials that are products of recycling processes |
| | | | Standardization | standardized parts that are used in a product |
| | | | Disassemblability | easiness to disassemble a product at components level |
| | | | By-products | quantity of by-products that is produced during the manufacturing of a product |
| | | | By-products reuse | % of the mass or the volume of by-products that is re-used in he manufacturing processes |
| | | | Defects | % of the items or mass or volume of end products that is defect |
| | | | Production waste | appraisal of the waste that is produced in the manufacture |
| | | | Biodegradable products | % of the mass or volume of the end product that is biodegradable |
| | | | Size of the packaging | size |
| | | | Sorting | how early in the reverse logistics chain the reusable products are separated to the not-reusable ones |
| | | | Worthy used products | % of used products that is worthy after the sorting |
| | | | Fuel consumption recovery | fuel consumed during freight to recovery facilities, volume of fuel consumed/item during the distribution to retailers or consumers |
| Figge *et al.* (2002a) | Environmental sustainability indicators in SCs | Environmental | Emissions | Air, water, soil |
| | | | Waste | |
| | | | Material input/material intensity | |
| | | | Energy intensity | |
| | | | Noise and vibrations | |
| | | | Waste heat | |
| | | | Radiation | |
| | | | Direct interventions on nature and landscape | |
| Willard (2005) | Sustainability balanced scorecard for firms | Economic | Not specified | Profits, sales, ROI, jobs created, cash flow |
| | | Environmental | | Impacts on air, water, waste, biodiversity, energy use |
| | | Social | | Product responsibility, community impacts, labour practices, human rights |

| | | | | |
|---|---|---|---|---|
| Epstein and Wisner (2001) | Sustainability indicators | Economic growth and employment | Economic growth | Company turnover |
| | | | Social investment | Total annual investment |
| | | | Employment | Number of full-time equivalent employees |
| | | Social progress | Education and training | Employee days training in a year |
| | | Effective protection of the environment | Climate change | GHG indicator |
| | | | Air pollution | Acidic gas emissions, $NO_2$, $SO_2$ |
| | | | Transport | Total distance travelled for operational and business purposes |
| | | | Land use | Area of land restored |
| Figge *et al.* (2002b) | Sustainability balanced scorecard | Environmental | Emissions | Waste water that leaks from chemical substances |
| | | | Waste | Residues of dyes |
| | | | Material input and intensity | Water consumption, use of pesticides and heavy metals |
| | | | Energy intensity | Energy consumption of processes |
| | | | Noise and vibrations | Not specified |
| | | | Land use | Not specified |
| Bonneau *et al.* (2011) | Economic, environmental and animal welfare performance indicators | Economic | Not specified | Production costs , Selling price , Selling price – production costs |
| | | Environmental | Manure management | Soil index, % spread, % spread on farm, % exported, % treated |
| | | Animal welfare | Mortality | Mortality rates (%) as % of birth to weaning, post-weaning, fattening, weaning to slaughter, birth to slaughter, sows |
| Edwards *et al.* (2008) | Sustainability tool IDEA | Economic | Economic viability | Available income per worker, Economic specialization rate |
| | | | Independence | Financial autonomy, Reliance on subsidies |
| | | | Transferability | Operating capital |
| | | | Efficiency | Operating expenses=production value |
| | | Animal welfare | Welfare quality programme | Questionnaire or monitoring system |
| Meuwissen *et al.* (2013) | Sustainability assessment framework | Environmental | Global warming | Global warming potential |
| | | | Primary energy use | Total energy consumption in each phase |
| | | | Water deprivation | Multiply the volume of consumptive freshwater by the weighted water stress index |
| | | | Land use | Area used for production of 1kg meat in 1 year |
| | | Economic | Profitability | Total revenue-total operating costs-depreciation |
| | | | Volatility | Standard deviation of bar-to-bar price variations multiplied by square root of time |
| | | Social | Feed safety | Not specified |
| | | | Working conditions | Not specified |
| | | | Employability | Not specified |
| | | | Animal welfare | Farmers score “worst, neutral, best” situation |
| | | | Food quality | Questions |
| | | | Food safety | Questions |

Table 4: The fourteen studies. From left to right: the author, the sustainability tool, the 3P area, the sustainability indicators, and the sustainability measures.

- *Eurostat* publishes every two years a number of Sustainable Development Indicators. They are presented in ten themes: socio-economic development, sustainable consumption and production, social inclusion, demographic changes, public health, climate change and energy, sustainable transport, natural resources, global partnership and good governance (Eurostat, 2011). From an overview of the indicators involved in these themes, the ones that could be suited are: climate change and energy, sustainable transport, and natural resources. The climate change indicator is GHG emissions, the energy indicator is energy dependence, the sustainable transport indicator is modal split of freight transport, and natural resources uses land use as indicator. Most of these sustainability indicators are taken up also in other studies (see DiSano, 2002; ess.co.at Reports, 2013; ECIFM, 2013; sustainablemeasures.com, 2013; International Institute for Sustainable Development, 1999).
- *Unilever* (2010) published a report that summarizes, in slightly different categories, a number of sustainability indicators: reduction of land use, soil health improvement per hectare, livelihoods per farmer, amount of nitrogen lost in the environment through e.g. fertilizers, and amount of GHG emitted from cropping.
- *OECD* (2001) proposed another taxonomy of indicators with the triple component systems of the 3P's. The environmental indicators encompass: air quality, water resources, energy resources, and biodiversity. The economic indicators encompass: income distribution, produced assets, technological change, and financial assets. The human capital indicators are: stock of human capital, investment in human capital, and depreciation of human capital.
- *Callens and Tyteca* (1999) propose a classification of sustainability indicators at firm level that ranges from economic to social and ecological, but the distinction is between the short-term and the long-term efficacy. The short-term economic aspects include: turnover, value added, output, production, and resources used as inputs (including recycled products and energy). The short-term social aspects include: employment, salaries, labour intensiveness or productivity, injury risk, noise, and odour. The short-term ecological aspects are: natural resources, wastes, pollution, transportation modes and distances. The long-term economic aspects are: profitability, competitiveness, market shares, product durability, and research and development efforts. The long-term social aspects are welfare, education, availability of (non-) renewable resources (including energy), size (SME vs big), and personnel rotation rate. The long-term ecological aspects include: global impacts, biodiversity, global warming, acid deposition, landscape, ultimate waste disposal, and product recycling ability.
- According to *Epstein and Roy* (2001), useful sustainability indicators at firm level are: the % of supplying companies owned by minority groups, the % of women (senior position), the working hours/wages, emissions/air (tonnes), discharge to water, and cases of bribery.
- *Hutchins and Sutherland* (2008) talk about the sustainability assessment and its importance that justifies its integration into supply chain decisions. The indicators that they examine are mostly social: gender equality, labour equity, healthcare, safety, and philanthropy.
- *Nikolaou and Tsalis* (2013) design an extensive study about the environmental performance indicators to check the sustainability of supply chains. These environmental performance indicators are: recyclability, reusability, energy consumption, energy sources, fresh water use, water reuse, use of recycled material, standardization, disassemblability, by-products, by-products reuse, defects, production waste, biodegradable products, and size of the packaging. Nikolaou and Tsalis are also concerned with transportation and collection environmental performance indicators: fuel consumption, sorting, worthy used products, and fuel consumption recovery.
- According to *Figge et al.* (2002a), the environmental interventions that can be put into practice in a SC have to do with: emissions (to air, water, and soil), waste, material input/material intensity, energy intensity, noise and vibrations, waste heat, radiation, and direct interventions on nature and landscape.

- *Willard* (2005) designed a sustainability-balanced scorecard for a firm that accounts for the following indicators in the areas of the 3P's: economic (sales, profits, ROI, jobs created, cash flow), environmental (impacts on air, water, waste, biodiversity, energy use), and social (product responsibility, community impacts, labour practices, human rights).
- *Epstein and Wisner* (2001) categorize sustainability indicators as belonging to four categories: economic growth and employment, social progress, effective protection of the environment, and prudent use of natural resources. In every category there are a number of sustainability indicators. In the first there are: economic growth, social investment, and employment. In the second there is: education and training. In the third there are: climate change, air pollution, transport, and land use. In the fourth, the indicators pointed out are too tailored to the specific case, thus, not suited for the pork and beef chains.
- *Figge et al.* (2002b) take their cue from Kaplan and Norton's Balanced Scorecard to design a sustainability-balanced scorecard that integrates environmental and social issues in the performance measurement system. The environmental exposures are: emissions, waste, material input and intensity, energy intensity, noise and vibrations, land use, etc.
- *Bonneau et al.* (2011) describe the difference in performance among different European pork production systems, pointing at the economic, environmental and animal welfare performance. The economic performance encompasses: production costs, selling price, and selling price minus production costs. The environmental performance encompasses: manure management. The animal welfare performance encompasses: mortality rates (%).
- According to *Edwards et al.* (2008), a good economic sustainability tool is IDEA (Indicateurs de Durabilitè des Exploitations Agricoles), whose indicators are: economic viability, independence, transferability, and efficiency. Concerning the animal welfare indicators, Edwards *et al.* recognize 'welfare quality programme' as a good sustainability assessment tool to test if the business is animal friendly and, therefore, sustainable (with the use of an assessment tool for monitoring the animal welfare, e.g. questionnaire or monitoring system).
- Ultimately, *Meuwissen et al.* (2013) provide a sustainability assessment framework that encompasses: environmental, economic and social sustainability concerns. The environmental category of sustainability indicators comprises: global warming, primary energy use, acidification, eutrophication, water deprivation, land use, and eco-toxicity. The economic category comprises: profitability and volatility, while the social category involves: feed safety, working conditions, employability, animal welfare, food quality and food safety.

Chapter 3.2 deals with the final selection of the sustainability indicators that are suitable for this study, therefore addressing **RQ1** (see chapter 7).

## 3.2 Selection of sustainability indicators

In order to answer **RQ1**, a number of sustainability indicators in the economic, social and environmental areas have been selected out of the many indicators listed in chapter 3.1. This final selection out of the fourteen studies previously described follows an important criterion which is the consistency (number of times) wherewith the sustainability indicator has been mentioned. Moreover, the selection of sustainability indicators should be applicable to supply chains. Those studies from the beef and pork sector have been prioritized, using their specificity as an important criterion of selection. Finally, they should fit in the 3P areas: economic, social and environmental.

The table below substantiates the selection of the thirteen sustainability indicators out of the fourteen studies and the many more indicators presented in chapter 3.1. First of all the suitability for the SC

assessment has been verified. Then, the belonging to a certain well-defined 3P area has been checked. Eventually, the number of mentions represented the last cut off for the selection of the indicators. In this context, as apparent from the examination of Table 5, *economic growth*, *mortality* and *food quality* have just been mentioned once across the fourteen studies. Nevertheless, economic growth is considered by the author an extremely important indicator when it comes to the assessment of the sustainability of a SC, while food quality and mortality both come from studies in the field of the beef and pork SCs, therefore they are prioritized. The table below substantiates the selection of thirteen sustainability indicators.

| Sustainability indicator | Suitable for SCs | 3P area | No. mentions |
|---|---|---|---|
| Income distribution | Yes | Economic | 3 |
| Profitability | Yes | Economic | 3 |
| Employment | Yes | Economic | 4 |
| Economic growth | Yes | Economic | 1 |
| Gender equality | Yes | Social | 2 |
| Animal welfare | Yes | Social | 4 |
| Mortality | Yes | Social | 1 |
| Food quality | Yes | Social | 1 |
| Food safety | Yes | Social | 2 |
| GHG emission | Yes | Environmental | 5 |
| Energy dependence | Yes | Environmental | 9 |
| Land use | Yes | Environmental | 7 |
| Water resources | Yes | Environmental | 10 |

Table 5: From the fourteen studies to the thirteen sustainability indicators.

The following table shows the final selection of the sustainability indicators (in the related 3P areas) and the corresponding sustainability measures.

Table 6: The final selection of the sustainability indicators in the 3P areas, and the corresponding measures.

| Sustainability area (3P's) | Sustainability indicator | Sustainability measure |
|---|---|---|
| **Economic**<br><br>**(P = Profit)** | 1. Income distribution | 1a. Gini coefficients. |
| | 2. Profitability | 2a. Profits<br>2b. Sales<br>2c. ROI<br>2d. Cash flow |
| | 3. Employment | 3a. Company turnover<br>3b. Jobs created |
| | 4. Economic growth | 4a. Number of full-time equivalent employees |
| **Social**<br><br>**(P= People)** | 5. Gender equality | 5a. Ratio of average female wage to male wage |
| | 6. Animal welfare | 6a. Farmers score "worst, neutral, best" situation |
| | 7. Mortality | 7a. Mortality rates (%) as % of birth to weaning, post-weaning, fattening, weaning to slaughter, birth to slaughter, sows |
| | 8. Food quality | 8a. 7-points Likert scale |
| | 9. Food safety | 9a. 7-points Likert scale |
| **Environmental**<br><br>**(P = Planet)** | 10. GHG emission | 10a. Projections of GHG emissions<br>10b. Global surface average temperature<br>10c. GHG indicator<br>10d. % of suppliers with ISO 14001 certification or equivalent |

| | | |
|---|---|---|
| | 11. Energy dependence | 11a. Electricity generated from renewable resources<br>11b. Energy consumption by fuel<br>11c. Implicit tax rate on energy<br>11d. Total energy consumption in each phase |
| | 12. Land use | 12a. Forest trees damaged by defoliation,<br>12b. (Hectares used/average local yield suppliers)-(hectares used/average yield local country) |
| | 13. Water resources | 13a. Intensity of water use=abstractions/renewable resources<br>13b. Quantity of fresh water that is consumed during the manufacturing of a product |

The result is this set of thirteen sustainability indicators in Table 6, any of which is divided in a number of sustainability measures suitable for the beef and pork supply chains in Brazil. The sustainability indicators that belong to the Economic area are: income distribution, profitability, employment, and economic growth. The sustainability indicators that belong to the Social area are: gender equality, animal welfare, mortality, food quality and food safety. Finally, the sustainability indicators that belong to the Environmental area are: GHG emission, energy dependence, land use and water resources.

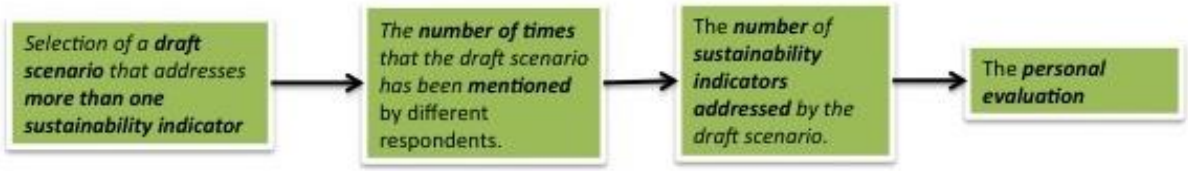
After the selection of sustainability indicators suitable for this study, the first round of interviews has been performed (see chapter 2.1.1). Thus, a number of draft sustainability scenarios have been identified with the help of the experts. These draft scenarios have been re-elaborated into sustainability scenarios in chapter 4 (addressing **RQ3**). Moreover, the first round interviews addressed **RQ2** (chap. 2.1.1 *step 2*).

# 4. The selection of the sustainability scenarios

Chapter 4 belongs to the empirical chapters, aimed at addressing the RQ2 and RQ3.
**RQ3.** *What sustainability scenarios are feasible?*

According to the data analysis described in the methodology chapter (chapter 2), the first round of interviews has been first analysed using two frameworks (appendix 1) developed by the author. One is for the analysis of the transcripts, while the other is for the comparison of the singular analyses.
Note that the future sustainable situations envisioned (called 'draft scenarios') and substantiated by the respondents have been here turned into sustainability scenarios after this selection.
Four selection criteria have been employed, in order to elect from the draft scenarios, a number of sustainability scenarios that fit the definition (chapter 1.1.2) and are feasible to be implemented in Brazil. The criteria that have been used for the selection are prioritized as follows (as explained in chapter 2.1.1):

Figure 8: the four criteria for the selection of the sustainability scenarios.




Chapters 4.1 and 4.2 concretely apply the aforementioned four criteria for the selection of the sustainability scenarios to the results of the first round interviews (i.e. on the draft scenarios). These sections are meant to clarify to the reader and substantiate the final choice of the sustainability scenarios for beef and pork that is summed up and discussed further in chapter 4.3.

## 4.1 Selection of sustainability scenarios for the Brazilian beef supply chains

From the first round interviews, about seventy draft scenarios have been identified. The four criteria explained in chapter 2.1.1 (step 3) and introduced earlier have been applied for the selection of the sustainability scenarios.
According to the beef respondents (eight in total) to the pre-interview questionnaire and interviews, the draft scenarios that address more than one sustainability indicator (criterion one) were twelve: *intensification, reduce transport (shorter routes), integrated land use, renew transportation infrastructure, avoid trade to less strict countries, agrosilvopastoral system, uniform supply through all the year, apply carcass certification schemes, better leather, fostering local product marketing, transparency in the food chain,* and *mix of organic and intensive production systems.*

Table 7: Application of criterion one for the selection of the sustainability scenarios for beef.

| **Draft scenarios** | **Sustainability indicators addressed** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Income distribution* | *Profitability* | *Employment* | *Economic growth* | *Gender equality* | *Animal welfare* | *Mortality* | *Food quality* | *Food safety* | *GHG emission* | *Energy dependence* | *Land use* | *Water resources* |
| Intensification | | | | | | | | | | | | | |
| Reduce transport (shorter routes) | | | | | | | | | | | | | |
| Integration of crop | | | | | | | | | | | | | |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| and animal production | | | | | | | | | | | | | |
| Renew transportation infrastructure | | | | | | | | | | | | | |
| Avoid trade to countries with less strict rules | | | | | | | | | | | | | |
| Agrosilvopastoral system | | | | | | | | | | | | | |
| Uniform supply through all the year | | | | | | | | | | | | | |
| Apply carcass certification schemes | | | | | | | | | | | | | |
| Better leather | | | | | | | | | | | | | |
| Fostering local product marketing | | | | | | | | | | | | | |
| Transparency in the food chain | | | | | | | | | | | | | |
| Mix organic and intensive production systems | | | | | | | | | | | | | |

It is apparent that, as they look like, these draft scenarios do not fit the definition in chapter 1.1.2, since they do not represent a future picture or future sustainability scenario of a supply chain. Likewise, they do not address the 3P areas indicators of sustainability, as by definition. Therefore, the other three criteria of selection are needed to make the selected scenarios fit with the definition provided in the thesis, without upsetting the results from the interviews.

The second criterion screened out, along with the third one, a number of draft scenarios. It has to do with the number of times that the draft scenarios (the aforementioned twelve for beef) have been mentioned and the number of sustainability indicators that each of them addresses. The logic behind these two criteria is that the more respondents mention the draft scenarios (and the more sustainability indicators are targeted by each draft scenario), the better the draft scenario is in increasing the sustainability of the chain. The following table displays the twelve draft scenarios out of the selection with the first criterion to make clear the successive use of selection criteria two and three.

Table 8: Re-adaptation of table 7 for the application of criteria two and three.

| Draft scenarios | No. of citations | Indicators addressed | Sustainability indicator addressed |
|---|---|---|---|
| Intensification | 6 | 6 | Income distribution, GHG emission, land use, profitability, food safety, energy dependence |
| Reduce transport (shorter routes) | 2 | 4 | Food quality, animal welfare, GHG emission, energy dependence |
| Integrated land use | 2 | 4 | GHG emission, profitability, economic growth, land use |
| Renew transportation infrastructure | 1 | 2 | GHG emission, economic growth |
| Avoid trade to less strict countries | 1 | 3 | Food quality, profitability, food safety |
| Agrosilvopastoral system | 2 | 3 | Land use, employment, animal welfare |
| Uniform supply through all the year | 1 | 2 | Profitability, income distribution |
| Apply carcass certification | 2 | 4 | Profitability, income distribution, food quality, food safety |

| | | | |
|---|---|---|---|
| schemes | | | |
| Better leather | 1 | 2 | Profitability, animal welfare |
| Fostering local product marketing | 1 | 3 | Animal welfare, GHG emission, income distribution |
| Transparency in the food chain | 1 | 2 | Food quality, food safety |
| Mix organic and intensive production systems | 1 | 2 | GHG emission, profitability |

Taking the first draft scenario as an example, the 'intensification' of beef production systems has been reputed needed for the beef supply chains in Brazil by six respondents. Moreover, the potential future implementation of more intensive production practices would address sustainability indicators regarding economic (income distribution, profitability), environmental (GHG emission, energy dependence, land use) and social (food safety) concerns. This is surely a good candidate draft scenario to be elected. Overall, looking at the criteria two and three, the choice of three draft scenarios to be left out was made. These are: uniform supply through all the year, better leather, and transparency in the food chain. The reason for this choice is, apart from the application of the criteria that does not have to be merely mechanical, that they come back in some of the practices of the nine draft scenarios that are left.

Finally, the fourth criterion has been used to come to the sustainability scenarios for beef (respecting the definition given of 'scenario', namely 'covering the 3P areas of sustainability'). The 'personal evaluation' criterion has been used by means of a combination of the nine scenarios that remain: intensification, reduce transport (shorter routes), integrated land use, renew transportation infrastructure, avoid trade to less strict countries, agrosilvopastoral system, apply carcass certification schemes, fostering local product marketing, and mix organic and intensive production systems.

A combination was made within these nine draft scenarios in order to come up with a number of sustainability scenarios. The rationale underneath the combination of the draft scenarios resides in the similarity between the practices in the draft scenarios, which facilitates their implementation.

The result is three sustainability scenarios: *intensification of the production system (combination of intensification of beef production systems and apply carcass certification scheme), local production and sustainable operations (combination of reduce transport (shorter routes) and renew infrastructure),* and *integrated land use (combination of integration of crop and animal production, agrosilvopastoral systems, fostering local product marketing, mix organic and intensive production systems,* and *avoid trade with countries with less strict rules).* Table 9 clearly shows that *intensification, local production and sustainable operations and integrated land use* cover the 3P areas of sustainability.

Table 9: Final selection of beef sustainability scenarios from the interviews.

| **Sustainability scenarios** | **Sustainability indicators addressed** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Economic** | | | | **Social** | | | | | **Environmental** | | | |
| | *Income distribution* | *Profitability* | *Employment* | *Economic growth* | *Gender equality* | *Animal welfare* | *Mortality* | *Food quality* | *Food safety* | *GHG emission* | *Energy dependence* | *Land use* | *Water resources* |
| **Intensification**<br>• Intensification of the beef production systems<br>• Apply carcass certification schemes | | | | | | | | | | | | | |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Local production and sustainable operations**<br>• Reduce transport (shorter routes)<br>• Renew infrastructure | | | | | | | | | | | | | |
| **Integrated land use**<br>• Integration of crop and animal production<br>• Agrosilvopastoral system<br>• Fostering local product marketing<br>• Mix organic and intensive production systems<br>• Avoid trade with countries with less strict rules | | | | | | | | | | | | | |

In order to preserve the internal validity of this study, the fourth criterion has been used under the supervision of two experts of these sectors and chains, and twenty experts have validated the selection. Chapter 4.3 provides the comments to the important findings from this selection, by deepening into the practices that are involved in these three beef sustainability scenarios.

## 4.2 Selection of sustainability scenarios for the Brazilian pork supply chains

From the first round interviews, about fifty draft scenarios were identified. The four criteria have been applied to the pork draft scenarios to obtain the sustainability scenarios.

According to the pork respondents (six in total) to the pre-interview questionnaire and interviews, the draft scenarios that address multiple sustainability indicators (criterion one) are twelve: *integration of animal and crop production, reduce transport and enhance sustainability of transport, local meat processing and local raw material purchasing, diversified chains, scaling up, energy neutrality, animal welfare in global agenda and minimization of risk from microbe resistance in humans, use of feed sources not in competition with human consumption, more sustainability standards to be applied in the supply chain, reuse of manure to make organic fertiliser and sell it branded, enhance Brazilian internal market,* and *use feed suitable for human consumption and use feed-print models to monitor impacts.*

Table 10: Application of criterion one for the selection of the sustainability scenarios for pork.

| **Draft scenarios** | **Sustainability indicators addressed** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Economic** | | | | **Social** | | | | | **Environmental** | | | |
| | *Income distribution* | *Profitability* | *Employment* | *Economic growth* | *Gender equality* | *Animal welfare* | *Mortality* | *Food quality* | *Food safety* | *GHG emission* | *Energy dependence* | *Land use* | *Water resources* |
| Integration of animal and crop production | | | | | | | | | | | | | |
| Reduce transport | | | | | | | | | | | | | |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Local meat processing and local raw material purchasing | | | | | | | | | | | | | |
| Diversified chains | | | | | | | | | | | | | |
| Scaling up farms | | | | | | | | | | | | | |
| Energy neutrality (e.g. biogas) | | | | | | | | | | | | | |
| Animal welfare in global agenda and minimize risk microbe resistance in humans | | | | | | | | | | | | | |
| Use of feed sources that do not compete with human consumption | | | | | | | | | | | | | |
| More sustainability standards to be applied in SC | | | | | | | | | | | | | |
| Reuse of manure to make organic fertiliser to be sold branded | | | | | | | | | | | | | |
| Enhance Brazilian internal market (vs prejudices) | | | | | | | | | | | | | |
| Use feed suitable for human consumption, but use feed print models to monitor impacts | | | | | | | | | | | | | |

As for beef, the sustainability scenarios for pork have to be selected in a way that they can provide improvements in all the 3P areas of sustainability, as by definition (chapter 1.1.2). Therefore, the other three criteria of selection are needed to make the selected scenarios fitted with the definition provided in the thesis, and without upsetting the results from the interviews.

The following table displays the twelve draft scenarios out of the selection with the first criterion. These were subjected to criteria two and three.

Table 11: Re-adaptation of table 10 for the application of criteria two and three.

| Draft scenarios | No. of citations | Indicators addressed | Sustainability indicators addressed |
|---|---|---|---|
| Integration of animal and crop production | 1 | 4 | Economic growth, GHG emission, energy dependence, water resources |
| Reduce transport | 1 | 3 | GHG emission, energy dependence, food quality |
| Local meat processing and local raw material purchasing | 1 | 2 | Economic growth, energy dependence |
| Diversified chains | 2 | 4 | Income distribution, animal welfare, food quality, profitability |
| Scaling up farms | 2 | 2 | Economic growth, profitability |
| Energy neutrality (e.g. biogas) | 2 | 3 | GHG emission, energy dependence, profitability |
| Animal welfare in global agenda and minimize risk microbe resistance in humans | 1 | 2 | Animal welfare, food safety |
| Use of feed sources that do not compete with human consumption | 2 | 7 | Land use, profitability, energy dependence, water resources, animal welfare, GHG emission, economic growth (no negative effects on others) |
| More sustainability standards to be applied in SC | 1 | 2 | Profitability, animal welfare |

| | | | |
|---|---|---|---|
| Reuse of manure to make organic fertiliser to be sold branded | 1 | 5 | Profitability, GHG emission, energy dependence, income distribution, employment |
| Enhance Brazilian internal market (vs prejudices) | 1 | 2 | Profitability, animal welfare |
| Use feed suitable for human consumption, but use feed print models to monitor impacts | 1 | 6 | Profitability, energy dependence, land use, water, GHG emission, economic growth |

The second and third selection criteria screened out three draft scenarios: reduce transport and enhance sustainability of transport, scaling up, and animal welfare in global agenda and minimization of microbe resistance in humans.

The respondents, for example, have mentioned 'Integration of animal and crop production', once. However, the implementation of the integrated systems would address economic (economic growth), and environmental (GHG emission, energy dependence, water resources) sustainability concerns. Therefore, this was a good candidate draft scenario to be, eventually, elected.

Ultimately, the fourth criterion ('personal evaluation') has been used to come to the sustainability scenarios for pork, which tackle sustainability indicators in the 3P areas. Again, the personal evaluation substantiated in a combination of the nine scenarios: integration of animal and crop production, local meat processing and local raw material purchasing, diversified chains, energy neutrality, use of feed sources not in competition with human consumption, reuse of manure to make organic fertiliser to be sold branded, enhance Brazilian internal market, use feed suitable for human consumption whose impacts are monitored with feed-print models. The rationale underneath the combination of these draft scenarios resides in the similarity between the practices in the draft scenarios, which facilitates their implementation.

The three sustainability scenarios are: *integration of animal and crop production (a combination of integration of animal and crop production, use of feed sources that do not compete with human consumption, reuse the manure to make organic fertiliser,* and *use feed suitable for human consumption monitored with feed-print models), sophistication (a combination of diversified chains, local meat processing and local raw material purchasing,* and *enhance Brazilian internal market),* and *balanced sustainability (a combination of animal welfare in global agenda and minimize microbe resistance in humans from use of antibiotics and heavy metals during animal production,* and *more sustainability standards to be applied in the supply chain).*

Table 12 displays how *integration of animal and crop production, sophistication and balanced sustainability* cover the 3P areas of sustainability.

Table 12: Final selection of pork sustainability scenarios from the interviews.

| **Sustainability scenarios** | **Sustainability indicators addressed** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Income distribution* | *Profitability* | *Employment* | *Economic growth* | *Gender equality* | *Animal welfare* | *Mortality* | *Food quality* | *Food safety* | *GHG emission* | *Energy dependence* | *Land use* | *Water resources* |
| **Integration of animal and crop production**<br>• Integration of animal and crop production<br>• Use of feed sources that do not compete with human | | | | | | | | | | | | | |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| consumption<br>• Reuse of manure to make organic fertiliser<br>• Use feed suitable for human consumption monitored with feed-print models | | | | | | | | | | | | | |
| **Sophistication**<br>• Diversified chains<br>• Local meat processing and local raw material purchasing<br>• Enhance Brazilian internal market | | | | | | | | | | | | | |
| **Balanced sustainability**<br>• Animal welfare in global agenda and minimize microbe resistance in humans from use of antibiotics and heavy metals during animal production<br>• More sustainability standards to be applied in the supply chain | | | | | | | | | | | | | |

In order to preserve the internal validity of this study, the fourth criterion has been used under the supervision of two experts of these sectors and chains. Also in this case, twenty experts have validated the selection. Chapter 4.3 further explains the three sustainability scenarios for the Brazilian pork chains.

## 4.3 Summary of the selection of beef and pork sustainability scenarios

In order to have the overview of all the scenarios demarcated, a summary table (table 13) is provided. The upper part of the table is describing the sustainability scenarios for beef, while the lower part of the table the scenarios for pork. The components of the table are: the scenarios of sustainability for the beef (three) and pork (three) chains, the sustainability indicators addressed by the scenario, and the generic and SCM sustainable practices involved in the scenario. Moreover, the practices that are recognized as SCM practices bring the coding of the area of supply chain management they belong to: production system (PS), logistics management (LM), governance structure (GS), or quality management (QM).
The single practices are not commented here, nevertheless they are displayed in table 13 and further investigated in-depth in chapter 5.

The three **beef sustainability scenarios** that have been selected using the selection criteria described in chapter 5.1 are the following:
***Intensification*** is the first scenario. Six out of eight interviewees have mentioned it, during the first round interviews. The number of sustainable indicators addressed is seven: income distribution, GHG emission, land use, energy dependence, profitability, food safety, and food quality.

The two draft scenarios that have been brought together in this sustainability scenario are: intensification of the beef production systems and apply carcass certification schemes. These bring about, to make this scenario applicable, a number of practices. The sustainable SCM practices for this scenario belong mostly to the production system practices, but also in a minority of them, to governance structure and quality management system.

***Local production and sustainable operations*** addresses six sustainability indicators: food quality, animal welfare, GHG emission, energy dependence, economic growth, and employment.

The draft scenarios that have been combined to design this sustainability scenario are: reduce transport (shorter routes) and renew the infrastructure. This sustainability scenario involves certain practices that, according to the analysis and the responses of the experts, belong to the logistics management SCM area.

The ***integrated land use*** is the third sustainability scenario for beef Brazilian supply chains. This scenario, according to the respondents, addresses nine sustainability indicators in Brazil: GHG emission, profitability, economic growth, land use, employment, animal welfare, income distribution, food quality and food safety.

The draft scenarios that are combined in this scenario are: integration of crop and animal production, the use of Agrosilvopastoral system, fostering local product marketing, mix organic and intensive production systems, and avoid trade with countries with less strict rules. The SCM practices among the various practices that are to be employed in this scenario are mainly belonging to the production system area of SCM, and some others belong to QM, GS, and LM.

The three **pork sustainability scenarios** that are elected using the four criteria are now described according to the categories in Table 13, that have been mentioned at the beginning of this section.

The ***Integration of animal and crop production*** is one of the three scenarios. The application of this sustainability scenario to the Brazilian case, in accordance to the respondents, would address nine sustainability indicators: economic growth, GHG emission, energy dependence, water resources, animal welfare, profitability, income distribution, employment, and land use.

The draft scenarios that have been brought about from the experts, which have been combined in this scenario are: integration of animal and crop production, use of feed sources that do not compete with human consumption, reuse of manure to make organic fertiliser, and use feed suitable for human consumption monitored with feed-print models. All the SCM practices that are mentioned by the experts belong to the production system area of SCM.

***Sophistication*** is another sustainability scenario for pork supply chains in Brazil. According to the experts, it would address six sustainability indicators: income distribution, animal welfare, food quality, profitability, economic growth, and energy dependence. The draft scenarios that have been combined in this scenario are: the establishment of diversified chains, local meat processing and local raw material purchasing, and enhance Brazilian internal market. Among the practices, the quota of SCM practices is low, since just a few practices pointed by the experts are SCM practices. Those few ones are mainly production system practices.

***Balanced sustainability*** is the last sustainability scenario for pork. The implementation of this scenario in the real life situation of the Brazilian pork supply chains, according to the experts, would address five sustainability indicators: GHG emission, energy dependence, profitability, animal welfare and food safety.

This sustainability scenario is designed starting from two draft scenarios: animal welfare in global agenda and minimization of microbe resistance in humans from use of antibiotics and heavy metals during animal production, and more sustainability standards to be applied in the supply chain. As for the former scenario, not many SCM practices are present, and they are mainly belonging to production systems and quality management areas of SCM.

Many practices in the six sustainability scenarios just listed are recursively the same. This aspect is interesting to be investigated further in the next chapters and to be the object of the discussion at the end of the thesis upon the applicability of these practices to food chains other than beef and pork in Brazil. The existence of these common practices across the scenarios of two different chains is the product of the four criteria of selection to obtain the sustainability scenarios. However, it is reasonable to expect a pattern of sustainability improvements that are less chain-specific.

The potential validity mistakes that could be brought about by the selection steps of the scenarios are levelled off by a survey that has been performed in Argentina among 20 beef and pork sustainability experts (see methodology, chapter 2.1.2). These experts had the task to evaluate the sustainability scenarios on their feasibility (on the feasibility of the practices involved). Moreover, they have been asked to give a score to evaluate the potential increase in sustainability that the application of these scenarios to the Brazilian case would provide (see the form in appendix 2).

The selected scenarios have been discussed and approved by the experts' team, who approved the quality of the methodology steps with regards to the scenarios' selection.

The following table wraps up all the information described in chapters 4.1, 4.2 and 4.3. More literature study, based on these results, as well as a second round of interviews were needed for the detailing of the selected sustainability scenarios. This is the aim of chapters 5 and 6.

| | Sustainability scenarios | Sustainability indicators addressed | Sustainable generic/SCM practices |
|---|---|---|---|
| **Beef supply chains** | **Intensification**<br>• Intensification of the beef production systems<br>• Apply carcass certification schemes | • Income distribution<br>• GHG emission<br>• Land use<br>• Energy dependence<br>• Profitability<br>• Food safety<br>• Food quality | Give importance to welfare considerations (i.e. more shadow for beef).<br>Fortification of the grass (**PS).**<br>Nutrient recycling (**PS).**<br>Local feedstuff supply (**GS, PS).**<br>Use grain (bought from another area) instead of grazing grass, and extra feed in dry seasons (**PS).**<br>Improve the feeding technologies (better feed, slaughter the animal when younger, less emissions) (**PS).**<br>Improve grass and land management (farm management techniques) (**PS).**<br>Optimization of animal slaughter age and valorise the products when it comes from young beef **(PS)**<br>Governance system could stimulate to use DSS's to help farmers to make operations more efficient (**GS).**<br>HACCP system (**QM).**<br>Genetic improvement of animals and feed (**PS).**<br>Make the farms more efficient.<br>Efficiency action plan at the farm.<br>Mix of organic and intensive beef production system (**PS).**<br>Use concentrated feed (**PS).**<br>Pay according to classes of quality.<br>Use tags to check sanitary status of herd, transportation following the limits (no. heads) set by the law (**QM, LM).**<br>Monitoring systems especially where preventive antibiotics are not allowed (**QM, LM).**<br>Documentation system with farmers registering operations (document practices) (**QM, LM).** |
| | **Local production and sustainable operations**<br>• Reduce transport (shorter routes)<br>• Renew infrastructure | • Food quality<br>• Animal welfare<br>• GHG emission,<br>• Energy dependence<br>• Economic growth<br>• Employment | Local slaughtering.<br>Local meat processing.<br>Local feedstuff supply.<br>Improve sustainable transport (river, low impacting vehicles) and support sustainable beef production systems (**LM).**<br>Expand the transportation network, but with the use of sustainable modes (**LM).**<br>Improve legislation on live animals transport and slaughtering welfare, support investments in modern vehicles (**LM).**<br>Improve education on relation between animal welfare and meat quality.<br>Pay price according to meat quality. |
| | **Integrated land use**<br>• Integration of crop and animal production<br>• Agrosilvopastoral system<br>• fostering local product marketing<br>• Mix and intensive production systems<br>• Avoid trade with countries with | • GHG emission<br>• Profitability<br>• Economic growth<br>• Land use<br>• Employment<br>• Animal welfare<br>• Income distribution<br>• Food quality | Nutrient recycling (**PS).**<br>Improve research on mixed beef production systems (alternative to extensive).<br>Increase the research on organic and other sustainable beef production technical development (e.g. agrosilvopastoral systems).<br>Use of more balanced production systems (soy, corn and Brachiaria) to avoid the cattle weight drop because of the dry period (**PS).**<br>Improve grazing techniques (more intelligent grazing techniques) (**PS).**<br>Increase differentiation in quality by introducing more labour intensive and quality enhancing production processes |

| | | | |
|---|---|---|---|
| | less strict rules | • Food safety | (e.g. certified beef).<br>Perform toxicological integrative studies on agro-systems.<br>Ensure optimal conditions for animal transport, shortening distance on animal transportation (**LM).**<br>Invest in local roads and agroindustry (e.g. mills, pasteurisers) (**LM, PS).**<br>Give support, subsidies to farmers to increase their profitability, so that they can invest.<br>Government should bear for the construction of infrastructure (lot of dirt roads), and build insemination centres.<br>Subsidise local production to be more self-sufficient and place on the market the locally produces goods.<br>Tailoring feed regimes of extensive farm system to a more intensive regime (**PS).**<br>Use concentrated feed (**PS).**<br>Monitoring systems especially where preventive antibiotics are not allowed.<br>Fair trade initiatives and information campaigns in China and India to sensitise about sustainability in beef chains (increase public opinion about sustainability).<br>Push on political parties to establish more sustainability-oriented regulations and enhance the entry barriers for supplies (**GS).**<br>Establish a worldwide quality and sustainability standard (focus on food security and food safety).<br>Regulation level has to be higher, to comply with international levels of quality (**GS, QM).** |
| **Pork supply chains** | **Integration of animal and crop production**<br>• Integration of animal and crop production<br>• Use of feed sources that do not compete with human consumption<br>• Reuse of manure to make organic fertiliser<br>• Use feed suitable for human consumption monitored with feed-print models | • Economic growth<br>• GHG emission<br>• Energy dependence<br>• Water resources<br>• Animal welfare<br>• Profitability<br>• Income distribution<br>• Employment<br>• Land use | Nutrient recycling between agricultural sectors<br>Invest in meat quality and traceability (**PS).**<br>Make sure that the animal feed is not in competition with food intended for human use (use by-products).<br>Use fertilisers made from manure (**PS).**<br>Invest in biofuel production from the process of manure into energy and the by-product can still become a fertiliser (**PS).**<br>Use DSS and models to optimize the nutritional value of the feed ingredient on cost price and animal performance (using % of by-products in the formula) (**PS).**<br>Mix manure with straw to have a fertiliser and sell it branded (**PS).**<br>Use a feed-print model (optimize each ingredient on $CO_2$ equivalents of the feed production, maintaining the expected animal performance high) (**PS).** |
| | **Sophistication**<br>• Diversified chains<br>• Local meat processing and local raw material purchasing<br>• Enhance Brazilian internal market | • Income distribution<br>• Animal welfare<br>• Food quality<br>• Profitability<br>• Economic growth<br>• Energy dependence | Switch from commodity system to a more diversified pork sector (e.g. the KDR chains).<br>Operational excellence and scale increase.<br>Create new niches.<br>Better outdoor access (housing).<br>Genetic improvement (**PS).**<br>Different nutrition (more responsible), recognizable with claims on a label.<br>The independent producers should offer room for new systems of coordination and create niche markets.<br>Local slaughtering.<br>Local meat processing.<br>Local raw material purchases. |

| | | | |
|---|---|---|---|
| | | | Local feedstuff supply (% of money that is produced locally and retained internally should be higher).<br>Nutrient recycling between agricultural sectors.<br>Invest on meat quality and traceability (**PS).**<br>Improve manure management (make energy out of manure) and methane use (**PS).**<br>Ensure short commercial channels.<br>Make pressure on these supply chains to establish sustainable claims and standards. (**GS).**<br>Campaigns to sensitise people (versus prejudices about pork meat as fatty and unhealthy). |
| | **Balanced sustainability**<br>• Animal welfare in global agenda and minimize microbe resistance in humans from use of antibiotics and heavy metals during animal production<br>• More sustainability standards to be applied in the supply chain | • GHG emission<br>• Energy dependence<br>• Profitability<br>• Animal welfare<br>• Food safety | Biogas investment to make energy for the feed mills (cost-benefit analysis on self-sufficiency in energy use) (**PS).**<br>Mix manure with straw to have a fertiliser and sell it branded (**PS).**<br>Adapt the system into more animal-friendly, especially at the housing.<br>Invest in monitoring system in SC to manage residues and about the antibiotic resistant bacteria **(QM).**<br>Establish new sustainability standards to be applied in Brazil (**GS, QM).**<br>Campaigns to sensitise people (versus prejudices about pork meat as fatty and unhealthy).<br>Minimize risk of development of microbe resistance of human in the chains (exposure to antibiotic resistant bacteria). |

Table 13: Final selection of the six sustainability scenarios for the pork and beef. The table displays: the sustainability scenario, the sustainability indicators addressed and the sustainable generic and SCM practices involved.

# 5. Detailing via literature and empirical review of the sustainability scenarios

This chapter contributes to address RQ4:

**RQ4.** *What are the sustainability improvement options that, from a certain level of sustainability, bring to a future desired level of sustainability in these chains?*

This detailing via literature review is meant to take the insights from case studies and other researches in Brazil on how to make the selected practices in the scenarios applicable. Therefore, the practices for each of the six scenarios were searched for in the literature. These concrete actions that the literature provides have been used in the final design of the scenarios, when combined with the ones from the second round of interviews (see chapter 2.1.1). The tables that summarise the detailing of the practices via literature have been enriched with the insights from the second round of interviews. This is done for all the sustainability scenarios further described in chapter 5, in order to detail those practices for which no concrete action was found in the literature (bold and italics text in the tables 14 to 19). Therefore, the complete list of detailed practices from the literature review is presented, along with a part of the detailed practices through the interviews. The complete list of concrete actions obtained through the second round of interviews can be found in appendix 4.

Chapter 5.3 synthesizes with a *Sustainability scenario framework* all the findings that have been collected so far, structuring them to ease the formulation of the results (chapter 6).

## 5.1 Beef supply chain sustainability scenarios

According to chapter 4, the results of the first round interviews are three sustainability scenarios for beef and three sustainability scenarios for pork. This section deals with the detail, or the put into practice of the three sustainability scenarios identified for the Brazilian beef supply chains, namely: *intensification*, *local production and sustainable operations* and *integrated land use*.

### 5.1.1 Intensification

#### *The concrete actions: farmland management and tradability improvements*

There are reasons to believe that the traditional livestock system deteriorates the landscape over time. This comes from the evidence that avoiding the intensification of production systems there is no increase in income and reduction of deforestation (Carpentier *et al.*, 2001). In this thesis, the definition of intensification is: “adoption of cattle production systems that have higher output per hectare” (Carpentier *et al.*, 2001). This is achievable with a number of herd management and pasture management practices that do not have to do with enlarging the herds (e.g. an increased amount of inputs purchased from outside the farm and an improved genetics of the animals and feed).

According to Carpentier *et al.* (2001), the legume-based pasture is an alternative more intensive feed for animals. Improving the fencing, improving breed of cattle, purchasing inputs, improving animal husbandry techniques, providing mineral salt and elephant grass (green chop) in the dry season, increasing the number (and doses) and type of vaccinations are all needed practices. Moreover, the rancher has to manage herd more intensively to express its potential. To do so, the increase in capital and labour are required to adopt the technologies needed for the upgrade. Furthermore, in such an evolved system, registering information of pasture costs and operational costs becomes fundamental.

According to Muchagata and Brown (2003), pasture management is the key to make the intensification successful and sustainable in the Brazilian supply chains.

Peterson and Gerrish (1995) talk about the importance of nutrient recycling for the soil. The shade and watery locations in the pasture are the places where the animal off-takes N and P while camping, since

these are the places where they defecate and urinate (Peterson & Gerrish, 1995). Thus, the design of a grazing system more intensive that uses paddocks with a certain stocking rate, rotation frequency, water access may give uniform payback of nutrients from the cattle excrements. The use of grass-legume mix feeding is helping the fast digestion (use of legumes swards) and improves litter quality. Grass-legume pastures should include *Desmodium ovalifolium*, *Arachis pintoi*, *Pueraria phaseoloides*, and *Calopogonium mucunoides*, combined with different *Brachiaria* types (Vendramini *et al.*, 2007). According to Vendramini *et al.*, moving shades and watery points helps nutrient distribution to the soil and its efficiency in more limited plots of land like in more intensive systems. Fortifying the soil mesofauna may increase the efficiency of nutrient recycling. The manure beetles (from Scarabaeidae family) and earthworms (Lumbricidae family) would help the mineralization and decrease ammonia volatilization.

### *A successful case study in Mato Grosso*

The case study about a successful large-scale beef producer in Mato Grosso reveals that the producer's investments in pasture management, staff knowledge and animal welfare helped increasing productivity without erasing more natural resources like land (WSPA, 2012). This producer employs mostly the manpower available from a local village, thus retaining the local workforce. The use of the Animal welfare plan, in the case study, has been a successful choice in terms of safety of the workforce and of the animals. The introduction of a pen and corral saves time when vaccinations and transport have to be performed (WSPA, 2012). The ranch under case study also implements rotational approach for crops and uses grass species to help a high performance grazing system. Moreover, the individual identification system employed at the farm allows for the total traceability from birth to the abattoir (WSPA, 2012). The increase in the quota of arable land used to produce feed crops for cattle allows for a more efficient diet for the animals. The extra feed throughout the dry season helps to avoid starvation in the herd, along with shade and freshwater available during the pasture. The compliance to a number of certification standards that ensure animal welfare at the farm is needed. The compliance with GLOBAL GAP is another transit channel to more sophisticated marketplaces and retailers. The training to the workers especially about the behaviour of cattle is another important component. The efficiency of grouping the herd is both given by the training to ranchers and by the use of fences (WSPA, 2012).

A case study in Mato Grosso reveals that producer's investments in pasture management, staff knowledge and animal welfare helped increasing productivity without erasing more natural resources like land (WSPA, 2012)

### *Additions from the second round interviews*

According to the interviewees in the second round of interviews, the stimuli from the government in order to have farmers using DSS's would make the operations more efficient (e.g. existing tools to monitor paddock's operations). Therefore, record keeping should be in place and its use should be rewarded. The HACCP system should be in place through all the chain and it should be nationally promoted. The use of HACCP system should be a criterion of selection of feed suppliers. An important practice to foster intensification of beef supply chains is the improvement of the genetics. The respondents underlined the importance of suiting the genetics of the animal to the system, depending on the market of reference. Artificial insemination should become the harmonized system to standardise and improve the animal genetics. Ultimately, paying the meat according to classes of quality requires 'quality' to be precisely defined by a governmental action. There is the need of a marketing research to understand the market of reference and the establishment of a system (ex post the definition of classes of quality and related production protocols) to monitor the operations.

The following table re-elaborates the detailing of the practices. The concrete actions for those practices that have not been detailed through literature are provided from the second round of interviews. They are presented with bold and italics text in the table (the same is done for the next five sustainability scenarios). Along with providing extra information, the second round of interviews has also contributed to validate the sustainability scenarios selected and eventually screen out practices that are not feasible and sustainable (this has been specified in tables 14 to 19).

| **Sustainability scenario** | **Generic/SCM practices** | **Detailing from** literature and ***interviews*** |
|---|---|---|
| **Intensification**<br>• Intensification of the beef production systems<br>• Apply carcass certification schemes | 1. Give importance to welfare considerations (i.e. more shadow for beef). | Implementation of an animal welfare plan at the ranch (e.g. use of white flags to move the herd moving). |
| | 2. For intensification, there is the need of more nutrients in the grass: change the grass, but then biodiversity changes, or use inputs to make grass more nutritious (**PS).** | The use of grass-legume mix feeding. |
| | 3. Nutrient recycling (**PS).** | Uses paddocks. Fortify the soil mesofauna. Use manure beetles and earthworms. |
| | 4. Local feedstuff supply (**GS, PS).** | ***The second round interview respondents have eliminated this practice.*** |
| | 5. Use grain instead of grazing grass (better weigh conversion) for intensification, along with giving extra feed, grain (bought from another area) (**PS).** | Pasture management, diet supplementation in the dry season. Use rotational approach for crops and use grass species to help a high performance grazing system. ***The second round interview respondents have eliminated this practice.*** |
| | 6. Improve the feeding technologies (better feed, slaughter the animal when younger, less emissions) (**PS).** | Increase the quota of arable land used to produce feed crops for cattle. Give extra feed throughout the dry season, shade and freshwater available during the pasture. |
| | 7. Improve grass and land management (farm management techniques) to improve productions (**PS).** | The legume-based pasture is an alternative more intensive feed for animals.<br>Improve the fencing, improve breed of cattle, purchase inputs, improve animal husbandry techniques, provide mineral salt and elephant grass (green chop) in dry season, increase the number (and doses) and type of vaccinations. |
| | 8. Improve land management and valorise the products when it comes from young beef (underline the importance of slaughtering young animals) | Improve the fencing, improve breed of cattle, purchase inputs, improve animal husbandry techniques, provide mineral salt and elephant grass (green chop) in dry season, increase the number (and doses) and type of vaccinations.<br>The rancher has to manage herd more intensively to express its potential. The increase in capital and labour. |
| | 9. Governance system could stimulate to use DSS's to help farmers to make operations more efficient (intensification) (**GS, PS).** | ***Record keeping to improve information flow in the chain (transparency). Use existing tools on grassland management to follow the paddock operations. Evaluation at the end and employ corrective plans. Reward farmers that use DSS (processors, slaughters, retailers).*** |
| | 10. HACCP system (**QM).** | ***Farmers and other SC actors should have HACCP systems in place (subsidies for small farmers to stimulate). It requires traceability. Require that the supplier of feed has HACCP system implemented. Implement HACCP nationally and impose it to every member of the beef chain. Establish a national campaign to promote its use.*** |
| | 11. Better genetics (**PS).** | ***Selection, cross-breeding, artificial insemination. Suit the genetics of the animal to the system, depending on the market of reference.*** |

| | | |
|---|---|---|
| | 12. Make the farms more efficient (efficiency just at economic level, e.g. DEA sustainability indicators). | Employ local manpower. Introduce a pen and corral. Increase in the quota of arable land used to produce feed crops for cattle. Train the workers especially about the behaviour of cattle. Legume-based pasture. |
| | 13. Action plan according to the productive efficiency of extensive farm systems (including organic farming). | The increase in capital and labour. |
| | 14. Mix of organic and intensive beef production systems (**PS).** | ***The second round interview respondents have eliminated this practice.*** |
| | 15. Use concentrated feed not to have the animal prone to disease because it runs out of energy (also better conversion of carcass) (**PS).** | ***The second round interview respondents have eliminated this practice.*** |
| | 16. Pay according to class of quality. | ***Governmental action to define precisely the quality classes, and to establish a system (protocols to be followed) to monitor it. Make market research to understand the market of reference.*** |
| | **17.** Use tags to check sanitary status of herd, transportation following the limits (no. heads) set by the law (**QM, LM).** | Individual identification system employed at the farm allows for the total traceability from birth to the abattoir. |
| | 18. Monitoring systems especially where preventive antibiotics are not allowed (**QM, LM).** | Individual identification system employed at the farm allows for the total traceability from birth to the abattoir. |
| | 19. Documentation system with farmers registering operations (document practices) (**QM, LM).** | Register information of pasture costs and operational costs. |
| | 20. Apply carcass certification schemes. | Comply with carcass certification standards and with GLOBAL GAP. |

Table 14: Detailing of the practices of sustainability scenario *Intensification* of beef supply chains in Brazil.

### 5.1.2 Local production and sustainable operations

The GHG emissions in Brazil are high on global average, because of the extensive beef production systems and because of the deforestation of the Amazon. Fenley *et al.* (2007) describe that in the states of Mato Grosso and Parà there is an extensive transportation network that is quite effective for the logistics of the low-added value but high weigh volume Brazilian commodities like agricultural products and beef cattle. Therefore, the next step should be the promotion of alternative sustainable modes like river-ways and the expansion of the railway and airline networks (Fenley *et al.*, 2007). Air cargo carriers are considered a sustainable mode, especially in the Amazonas state of Brazil. Air transport provides "fast, high-cost connections between selected cities" (Fenley *et al.*, 2007). Nevertheless, the nature of the commodity product beef cattle facilitates road transportation.

Going into the detail of the transportation traits, there are mainly two segments in a general beef supply chain: from the ranch to the slaughterhouse, and from the slaughterhouse to the port (in case of exports) (Cederberg *et al.*, 2009). In both of them, the most common freight mode is the truck. Holding transporters and producers accountable for losses helps the sustainability of transport (Grandin & Gallo, 2007). Grandin and Gallo state that the payment system should be changed, since transporters are now paid according to the number or the total weight of the truckload. Therefore, there is no incentive in the form of payments that rewards a more sustainable transport that avoids bruises and stress for the animal (Grandin & Gallo, 2007). Therefore, the space for the animal in the trucks has to be increased to have less bruises thanks to a better level of handling and transport. Another important aspect is to make a selection of those animals that are fit enough and healthy enough to survive transportation, avoiding the load of weak and debilitated ones. Therefore, following the OIE animal welfare guidelines (that specify the animals unsuited for travel) is needed (OIE, 2005).

The outlook of Grandin and Gallo underlines the importance of a good driver training (to acquire a suitable driving behaviour), and the frequent maintenance and check-up of the vehicles.

According to Grandin and Gallo (2007), some other basic principles of sustainable transport involve: rest-stop requirements (extending the strict EU requirement, no more than 14 hours of travel, with longer trips that require at least 1 hour rest and water supply), stressors during handling and transportation (good ramp design to load and unload, which is the main cause of stress). In Latin America there are no obligations such as rest-stop requirements. The stocking density should be kept lower than 400 kg/m$^2$ and some distance should be created in the truck to separate the animals (e.g. through fences) and avoid injuries and bruises.

The loading is itself the main cause of this stress (Grandin & Gallo, 2007)

Co-modality, as the optimized combination of different transport modes in the supply chain motion of goods is a sustainable solution for the future. Indeed, the transport modes should be renovated; therefore investments in technical innovations should be in place. The use of alternative fuelling facilities for trucks is equally important. The EU suggests to rely on the Sustainable transport toolbox, which is a program that works as a guideline for sustainable transport (passenger and freight) (EU, 2013).

#### *A case study in Sao Paulo*

In the state of Sao Paulo, a large beef producing state in Brazil, the infrastructure is developed, therefore presenting a shorter distance between ranch and abattoir (Cederberg *et al.*, 2009). The calculated average distance is 200 km, whilst the average distances in the rest of Brazil are higher. In Brazil the road network counts 1.6 million km (1.3 million km municipal roads, 210 000 km state roads and 73 000 km of federal roads) (Cederberg *et al.*, 2009), and about 70% of those roads are in sufficient-poor conditions. Conversely, about 50% of the roads in Sao Paulo are labelled as in "perfect" conditions and less than 10% are in "poor"

or “very poor” conditions. Once at the slaughter, the animals are meant to rest 24 hours before being slaughtered, according to the Brazilian law (Cederberg *et al.*, 2009).
From the abattoir to the port, the meat is transported into trucks with a refrigeration system installed, and, according to Cederberg *et al.*, 45% of these trucks in Sao Paulo belong to the slaughterhouses (easing the monitoring of the freezing systems). Typically, these trucks allow the transport of 20 to 30 tonnes of meat each load to the Brazilian ports (the main ports are Santos, Rio Grande, Antonina, Ibituba, Paranagua, Rio de Janeiro Sao Francisco do Sul, Vitoria, Sepetiba and Salvador) (Cederberg *et al.*, 2009). The average distance between the slaughters in Sao Paulo and the ports is about 400 km, way less than the esteem of the average distances from the slaughterhouses in other regions of Brazil.

### *Additions from the second round interviews*

Two sustainable practices are detailed though the insights from the interviews, since the case studies from the literature reviewed lacked of concrete actions for those practices. According to the respondents to the second round of interviews, the local meat processing would be beneficial for the sustainability of the beef chains in Brazil. Therefore, it has been suggested to propose the merge of the processing and slaughtering activities in the same location (vertical integration), prior the assessment of the economic viability of this investment. The supply of local feedstuff is another important practice that the respondents would make applicable by mixing crop and livestock productions.

| **Sustainability scenario** | **Generic/SCM practices** | **Detailing from** literature and ***interviews*** |
|---|---|---|
| **Local production and sustainable operations**<br>• Reduce transport (shorter routes)<br>• Renew infrastructure | 1. Local slaughtering. | The development in infrastructure (e.g. in Sao Paulo). |
| | 2. Local meat processing. | ***Meat processing performed at the same location of the slaughterhouse (vertical integration) or keep processing in EU.*** |
| | 3. Local feedstuff supply. | ***Mixed crop- livestock productions.*** |
| | 4. Improve sustainable transport (river, low impacting vehicles) and support sustainable beef production systems (**LM).** | Use of alternative sustainable modes, e.g. river-ways and air cargos. Monitor refrigerated system (slaughter) on trucks. Promotion of co-modality. The transport modes should be renovated. |
| | 5. Expand the transportation network, but with the use of sustainable modes (**LM).** | Extension of the infrastructure to facilitate trade (step-wise renovation plan). |
| | 6. Improve legislation on live animals transport and slaughtering welfare, support investments in modern vehicles (trucks and boats) for animals transport (In order to invest, the returns for the farmer have to be higher) (**LM).** | Avoid overstocked trucks and separate the cattle in the truck. Rest-stop requirements, use stressors during handling and transportation. Stocking density should be lower than 400 kg of live weight/$m^2$.<br>Hold transporters and producers accountable for losses during transportation. Follow OIE animal welfare guidelines during transportation. Rely on the Sustainable transport toolbox (from EU). |
| | 7. Improve education on relation between animal welfare and meat quality. | Training (e.g. aided by government) for drivers (e.g. on handling and driving behaviour). Frequent check-up of the vehicles. |
| | 8. Pay price according to meat quality. | Change payment system, no more according to the number or the total weight of the truckload. Establish incentives (i.e. payments that reward a more sustainable transport). |

Table 15: Detailing of the practices of sustainability scenario *Local production and sustainable operations* of beef supply chains in Brazil.

### 5.1.3 Integrated land use

The coordinated framework of activities in an integrated system allows having "waste products of one component serve as resource for the other" (IFAD, 2010). For example, manure is beneficial for crop production, while crop production by-products are used as feed for animals, to tap insufficient feed supplies (IFAD, 2010). This mixed farming concept is the most widely used in the livestock sector. The manure from animal production improves nutrient recycling (since it contains N, P, K) and is often used for the production of biogas (e.g. used instead of wood) and energy (saving service costs at the farm, e.g. water pumps' energy) (IFAD, 2010). On the other hand, the nutritional value and digestibility of the crop residues is low compared to the canonical feed. Nevertheless, chemical and physical processes may be applied on the bare crop residues to make those by-products more digestible. Therefore, investments are needed. The growth of fodder legumes in the mixed farm system allows their use in addition to the crop residues to increase the nutritional value (especially during the dry season) (IFAD, 2010).

Another option of mixed farming may involve the use of rice production coupled with beef cattle livestock. According to Silveira (1999), the rice production lasts 7 months between September/October and April/May, while until September the beef cattle could graze for three or four years before the system is reconverted to rice production. Moreover, the rice by-products and residues can be used as additional feed for the beef cattle (with or without treatment with ammonia) (Silveira, 1999).

Manure should be managed timely and efficiently to avoid losses due to leaching and volatilisation (Tilman *et al.*, 2002). Cropping systems that use crop rotations or intercropping production systems (more crops grown at the same time) are beneficial for pest control and to increase the efficiency of the use of nutrients and water. Agroforestry is an interesting example of integration of production systems, with trees that are included in the system of crop production (Tilman *et al.*, 2002). The animal excretions could be processed and composted to make crop fertiliser (to be then used with minimal leaching at the right doses). Therefore, the plant growth is fostered and nourished by the wastes from the pasturing animals. A very important means to implement successfully this integrated system is to establish partnerships between grain producers and the beef ranchers (Pacheco *et al.*, 2012). For these new production systems there is the need to monitor BSE and scrapie, and to foster targeted research on the potential markers to identify them on live animals (and speed up diagnosis). Performing strategic research on plant genomics and chemistry, environmental studies on nutrient flows, studies on rumen microbiology, would be beneficial to both the supply chain and the government that can be supported in the policy making by these findings (Raymond, 2005). Another concrete action entails to rely on grassland-related technical support and expertise through more interaction with research centres.

#### *Case study: the grass intensive-organic cattle farming*

An example of integration is the grass-intensive organic cattle farming. In this context, a number of studies have been conducted on the successful performance of a mixed farming system where organic cattle farming and intensive crop farming are in place. A recent study from the International Centre for Research in Organic Food Systems (ICROFS) examines the opportunities of infield and outfield crop rotations to benefit pasture management and therefore the cattle productivity. In the case of organic cattle farming, the animals need space to graze and this hypothetic future production system could fit the case of Brazil and its large-scale farms with much large plots of land for extensive pasture. The problem of an organic production system with that amount of space is that the eating and watery locations might be far away to reach for the cattle. A number of strategies to better pasture are in place, as aforementioned (ICROFS, 2010). The infield rotation would consist in a turnaround from the typical grass types to a grass-clover pasture for grazing. The outfield rotation encompasses, instead, the rotation of grass with "maize, lupine, feed grain, and grass for silage" (ICROFS, 2010). The grass-clover eventually would be mixed with high

quality herbs such as chicory, plantain, caraway, lotus, etc. (important especially for organic farmers) (ICROFS, 2010). Increasing the number of earthworms is helping to contain the leaching of nitrates during the cold season. Moreover, the use of mixed farming allows for a closed system in which nutrient recycling is possible (farm becomes a self renewing unit).

### *Case study: agrosilvopastoral system in Cerrado*

A concrete example that comes from a pilot case study conducted in Cerrado region of Brazil displays the dynamics in the agrosilvopastoral system implementation: during the first year, eucalyptus plants were sowed in rows and soybean was planted in the space between the rows of trees (Pacheco *et al.*, 2012). During the second year, the plot of land was sown with a maize/Brachiaria grass intercrop and after seventy days from the harvest of maize, the livestock was introduced into the plot to graze. The eucalyptus trees after this span of time (18 months) are 6 metres tall and provide a good animal husbandry. Between the fourth and the sixth year from the establishment of the system, the eucalyptus trees are cut (Pacheco *et al.*, 2012). The disposition of plants and the percentage of forest and percentage of crop/livestock can be diverse. Different soybean and Brachiaria cultivars may be used (e.g. BRS-GO 8360 and Marandu respectively).

### *Additions from the second round interviews*

According to the respondents, the conditions of the transportation of the animals should be improved. Locating DC's and processing facilities closer to farms is to be considered. Moreover, the modernization of the slaughterhouses would help to handle the animals more efficiently and responsibly. The OIE guidelines should be followed as a basic requisite of sustainable transport and handling of the beef cattle. Government and SC players should support investments in local roads and agroindustry. The support of the government should be also tailored to the farmer (credit support or low interest rates) to increase their profitability and therefore fostering investments in better technologies and techniques. In this concern also local private industries and SC players should create a safety network to increase local production. Moreover, the government should set a system of credits and disincentives for those farmers that do not reinvest this cash to benefit the local production. The costs of the infrastructure investments (roads, AI, etc.) should be bore by the government.

The intensification of the feed regimes (considering the use of concentrates) should be in place, prior the verification of its economic viability and, in case, buying feed from outside or using more legume grass is suggested. The fair trade initiatives and information campaigns in China and India to sensitise about the sustainability and quality of the beef chains are important. These campaigns should be boosted by traders and by the government. More sustainability-oriented regulations should be launched as a result of the negotiation between the Brazilian and the foreign governments. The establishment of a worldwide quality and sustainability standard needs, for example, the election of an existing standard as widely accepted. Overall, the regulation level has to be higher. Therefore, the government should restrict the requirements in order to have the chain complying with international-level regulations upon the quality of the products traded (e.g. OIE and Codex Alimentarius should be the basic requirements).

| Sustainability scenario | Generic/SCM practices | **Detailing from** literature and ***interviews*** |
|---|---|---|
| **Integrated land use**<br>• Integration of crop and animal production<br>• Agrosilvopastoral system<br>• Fostering local product marketing<br>• Mix organic and intensive production systems<br>• Avoid trade with countries with less strict rules | 1. Nutrient recycling (**PS).** | Timely and efficient use of management of manure to avoid losses due to leaching and volatilisation. Use crop rotations or intercropping production systems. |
| | 2. Improve research on mixed beef production systems (alternative to extensive). | More research on nutrient budget burdens from the large-scale use of lupins as feed, feed utilization and emissions from animals. Research rice production coupled with beef cattle livestock. Research on markers of BSE and scrapie. |
| | 3. Increase the research on organic and other sustainable beef production technical development (e.g. agrosilvopastoral systems). | Perform strategic research on plant genomics and chemistry, environmental studies on nutrient flows, studies on rumen microbiology. |
| | 4. Use of more balanced production systems (soy, corn and Brachiaria) to avoid the cattle weight drop because of the dry period (**PS).** | Grass-intensive organic cattle farming.<br>Infield (from use of typical grass types to use of grass-clover pasture for grazing, enriched with quality herbs) and outfield (rotation of grass with maize, rice, lupine, feed grain and grass for silage) crop rotations. |
| | 5. Improve grazing techniques (more intelligent grazing techniques) (**PS).** | Grow fodder legumes to be used with crop by-products to increase the nutritional value. Rely on grassland-related technical support from research centres. |
| | 6. Increase differentiation in quality by introducing more labour intensive and quality enhancing production processes (e.g. certified beef) (e.g. Sustainable Agriculture Network and agrosilvopastoral systems). | Use agrosilvopastoral systems (eucalyptus, sorghum and maize, or maize/Brachiaria grass intercrop, and cattle). Before all of this, establish partnerships between grain producers and the beef ranchers. |
| | 7. Perform toxicological integrative studies on agrosystems (mixed forest, crop and animal production). | Monitor diseases like BSE and scrapie and identify potential markers of these diseases on live animals. |
| | 8. Ensure optimal conditions for animal transport, shortening distance on animal transportation (**LM).** | ***Locating DCs closer to farms, to ensure better infrastructure investments. Shorten distance by more local processing facilities, and modernization of slaughterhouses to handle the animals more efficiently and responsibly. Follow OIE guidelines.*** |
| | 9. Invest in local roads and agroindustry (e.g. mills, pasteurisers) (**LM, PS).** | ***Process more locally soybean. The investment burden could be combined among government and SC actors.*** |
| | 10. Give support, subsidies to farmers to increase their profitability, so that they can invest. | ***Government subsidies to farmers. Low interest rates, credit support to farmers.*** |
| | 11. Government should bear for the construction of infrastructure (lot of dirt roads), and build insemination centres, so that farmers do not have to buy the doses of inputs abroad. | ***Government (and processors) should invest in the roads, research centres, and an efficient insemination centre system.*** |
| | 12. Subsidise local production to be more self- sufficient and place on the market the locally produces goods. | ***Local private industries and SC members should create a support/safety network to increase the local production. More credits for farmers or disincentives when not improving.*** |
| | 13. Tailoring feed regimes of extensive farm system to a more intensive regime (**PS).** | ***Verify viability of intensifying feed regimes. Buy more feed from outside and legume grass.*** |

| | | |
|---|---|---|
| | 14. Use concentrated feed not to have the animal prone to disease because it runs out of energy (also better conversion of carcass) (**PS).** | ***Buy more feed from outside. Verify economic viability, first.*** |
| | 15. Monitoring systems especially where preventive antibiotics are not allowed. | Monitor diseases like BSE and scrapie and identify potential markers of these diseases on live animals. |
| | 16. Fair trade initiatives and information campaigns in China and India to sensitise about sustainability in beef chains (increase public opinion about sustainability). | ***Traders should advice the potential customers about the sustainability/quality, besides the government. Governmental action in China to sensitize. Monitor fair trade initiatives.*** |
| | 17. Push on political parties to establish more sustainability-oriented regulations and enhance the entry barriers for supplies (**GS).** | ***The Brazilian government should negotiate with the other government the sustainability related issues (more roundtables). Establish more sustainability-oriented regulations.*** |
| | 18. Establish a worldwide quality and sustainability standard (focus on food security and food safety). | ***Elect one sustainability tool/standard that is worldwide accepted. Establish an organization that deals with monitoring the national/regional standards.*** |
| | 19. Regulation level has to be higher, to comply with international levels of quality of products to be traded (**GS, QM).** | ***Government should restrict requirements, but also the farmer should be adaptive according to their market outlet. All traded beef should be in compliance with OIE and Codex Alimentarius (enough).*** |

Table 16: Detailing of the practices of sustainability scenario *Integrated land use* of beef supply chains in Brazil.

## 5.2 Pork supply chain sustainability scenarios

The three sustainability scenarios for the Brazilian pork supply chains are: *integration of animal and crop production, sophistication and balanced sustainability*. These have been detailed by a literature review in the next three sub-sections.

### 5.2.1 Integration of animal and crop production

The major number of big pig producers in Brazil use production systems that integrate animal and crop productions. However, there is a risk associated with environmental burden when the manure is produced in surplus with respect to the crop use. Moreover, it is very common to reuse the manure as fertiliser with little or not treatment and this can also become environmentally risky (Stein & de Lange, 2007). Typically the soybean production is very important. One of the reasons of the quick expansion of this market and production chains is that it represents a cheap and high-protein ingredient for the feeding formulas used by livestock. Most of the pig production is concentrated in the south of Brazil and it is mainly intensive with a reduction of chain costs associated to production and logistics (Stein & de Lange, 2007). Regarding the manure management, a convenient system would be the integration of pigs and vegetable greenhouses, coupled with the use of biogas (Qi *et al.*, 2005). The digested manure and urine can be used for the illumination and the air temperature of the greenhouse or for the energy requirements of the facilities. In addition, the $CO_2$ from the digestion, the pig respiration and the organic matter decomposition foster the photosynthesis of vegetables. Once digested and made soluble, the by-product of manure fermentation is soluble and good enough to be used as fertiliser for the vegetables (Qi *et al.*, 2005).

According to Stein and de Lange, soybean production and export in Brazil is the second worldwide after the United States. About 80% of the worldwide production of soybean is devoted to animal production, which is definitely in competition with human consumption (Stein & de Lange, 2007). Many studies advocate that the production of soybean in Brazil, due to the high direct and indirect use of fossil fuels (machineries, fertilizers, agrochemical, etc.) is jeopardizing the sustainability of the production system.

Co- and by-products from food and biofuel industry (e.g. distilled dried grains) are high-performance feed ingredients (Stein & de Lange, 2007).

This is one of the reasons why the production of feed for pig production is shifting to the use of co-products and a lot of research has being done on the modelling of feeding formulas in order to maintain the nutritional value and the animal expected performance. Moreover, due to an increase of the demand for grains for the biofuel industry and due to an increasing population, the cost of feed energy will increase globally, reducing the profitability of producing it as animal feed (Stein & de Lange, 2007). Thaler and Holden (2007) state that the potential protein-rich by-products to be used for the pig production are from the following primary sources: grain, animal, vegetables, sugar and starch production. Their research proves that all these products are of nutritive value, palatable and available.

Lab analyses on the nutritional value of the ingredients should always be performed in order to prove that feeds are properly formulated and all the nutrient needs of the animals are fulfilled (Stein & de Lange, 2007).

Alternatively, if having feeding formulas that include ingredients suitable for human consumption is preferred, feed-print models should be in place to monitor the environmental impact of feed production (i.e. FeedPrint from the Wageningen University).

The interviews' respondents add to the literature the importance of the investments in meat quality and traceability. These require the use of a system of identification of the animals though electronic tags or other kinds of individual ID's.

| Sustainability scenario | Generic/SCM practices | Detailing from literature and *interviews* |
|---|---|---|
| **Integration of animal and crop production**<br>• Integration of animal and crop production<br>• Use of feed sources that do not compete with human consumption<br>• Reuse of manure to make organic fertiliser<br>• Use feed suitable for human consumption monitored with feed-print models | 1. Nutrient recycling (manure comes back to the crop producer) between agricultural sectors (**PS)**. | Monitor environmental burden of surplus manure not used with respect to crop use. |
| | 2. Invest in meat quality and traceability**.** | ***Investment in quality and traceability (they should be better than competitors). Traceability performed by using tags (identification of animals).*** |
| | 3. Make sure that the animal feed is not in competition with more valuable food intended for human use (use by-products that cannot be used for human consumption). | Research on the modelling of feeding formulas (high- proteins and palatable). By products (rich in proteins) from grain, from animal from sugar and starch production. |
| | 4. Use fertilisers made from manure (**PS).** | Reuse manure as fertiliser after manure treatment. |
| | 5. Invest in biofuel production from the process of manure into energy and the by-product can still become a fertiliser (**PS).** | Integration of pigs and vegetable greenhouses, coupled with the use of biogas to process the excreta from the animal production (closed system). |
| | 6. Use DSS and models to optimize the nutritional value of the feed ingredient on cost price and expected performance of the animal (using percentages of by-products in the formula) (**PS).** | Use Feed-print models to monitor the environmental impact of feed production. |
| | 7. Mix manure with straw to have a fertiliser and sell it branded (**PS).** | ***The second round interview respondents have eliminated this practice.*** |
| | 8. Use a feed-print model (optimize each ingredient on $CO_2$ equivalents of the feed production, maintaining the expected animal performance high) (**PS).** | Use feed-print models. |

Table 17: Detailing of the practices of sustainability scenario *Integration of animal and crop production* of pork supply chains in Brazil.

### 5.2.2 Sophistication

Providing a product with a range of detailed specifications has become the new frontier for many pork chains, since the traditional system of production is not enough to fulfil the expectation of this new segment of demand (Pan & Kinsey, 2002). The ability of the information systems to trace back from meat to animal needs a high level of coordination, and it is one of the milestones of the sophistication of supply chains. Moreover, an increased coordination in the supply chain is beneficial to reduce transaction costs (grading, quality of inputs, middlemen costs, etc.), and to share risks among chain partners (Pan & Kinsey, 2002). Given that the pork sector in Brazil is seen as a commodity system, a number of initiatives should arise, taking the cue from the outside. According to De Greef and Casabianca (2008), quality assurance schemes (e.g. HACCP, EUREP GAP, Red Tractor, Label Rouge), and sustainable innovations are the core of the philosophy of the sophistication of pork supply chains. These quality assurance schemes should specify a number of requirements (technical) on producing, processing, and transporting (De Greef & Casabianca, 2008). Certification schemes similar to IKB (Integrated Quality Control) should be introduced to guarantee the quality and safety of the pork meat products.

New production systems, quality assurance schemes, local productions, claims on label, innovation for quality, market research, and new pork products are the milestones of the chain sophistication

Furthermore, according to De Greef and Casabianca, the standardization of production processes is fundamental to monitor the chain, especially when trading abroad (to comply with the requirements of the export contracts).

The diversification of pork production chain entails also the use of new (or alternative) production systems that bring in animal welfare, environmental, food safety, food quality concerns (De Greef & Casabianca, 2008). The use of labels to claim the quality (animal welfare, safety, origin, etc.) that is followed through the production step of the chain is another important item that creates awareness into the consumers' mind on the responsible practices taken up in the chain. Initiatives in terms of alternative systems of production or innovative husbandry are examples of that. Nevertheless, there should be a market initiative that justifies the production costs (De Greef & Casabianca, 2008).

Initiatives like the Dutch KDR Foundation (Sustainable Beef Chain), which controls the participating companies through an annual audit, are good examples. It is a partnership between farmers, butchers, wholesalers, supermarkets or other market outlets. A label is used to make recognizable the sustainable practices involved in these chains and to assure that all the practices follow animal welfare regulations, with castration as one of the prohibited practices (De Greef & Casabianca, 2008). There is the need of the development of new innovative methods to monitor this quality (e.g. use of RFID technology to monitor the cold chain) (Q-Pork Chains, 2012).

The literature states that the Brazilian consumption of pork meat is low and out of this small amount, 70% is processed pork (i.e. salami) (Miele, 2011). There are strong regional differences that justify a diversified consumer buying behaviour. The tropical region in the Northwest is less wealthy and has different habits than the wealthy southern states. Given that the survey performed by de Barcellos *et al.* proves that the pork meat in Brazil is consumed any day of the week or occasionally, the increase in variety of products and the increase in the convenience would be beneficial to enhance internal consumption. Diffusing the presence of pork products in snack bars would increase consumption and create a routine of eating pork out. Eventually, also educating the consumers on how to properly cook pork dishes would be an advantage, as well as training courses for professional chefs, to make pork meals tastier (increasing the trend of Brazilian food consumption out of home) (de Barcellos *et al.* (2011).

### *Additions from the second round interviews*

The respondents to the second round of interviews advocate the importance of creating new market niches, prior a market research to verify the viability of the investment. Quality-oriented production can be the keystone and the claim should be backed by the compliance with certification schemes. The quality improvements can be both in the production and in the marketing chains. The animal genetic improvement should be anticipated by the investigation of the market opportunities, and, if present, the strategic marketing on the best swine species for Brazil has to be performed (same for feed genetic improvement). The claim on these chains using particular animal breeds should be clear. Another aspect of the sophistication of the pork supply chains has to do with the diversification of nutrition, for example, using feed from organic production or responsible soy (use claims on the label of the final product).

Aspects of local slaughtering and local meat processing are important also in this scenario. Therefore, the optimization of the allocation planning of the slaughterhouses and of the processing plants should be carried out. Moreover, a coordinated approach with inter-branch organizations should be promoted. The purchasing of local raw material is to be considered and the experts suggest that the verification of the economic compatibility should be set upfront. Another way to local supplying these materials is to integrate or to impose taxes on their import. The local feedstuff supply depends on the contracts, and, in this respect, if the chains' coordination is weak, vertical coordination should be pursued to decrease the transaction costs.

Nutrient recycle between agricultural sectors is to be fostered by adapting the existing technologies and therefore reducing the emissions (e.g. manure processed into fertiliser or processed for disposal). The improvement of manure management is important also for the production of energy out of manure. For this purpose, the experts support the idea of biogas investments. The investments in meat quality and traceability are important and depend on both the identification systems that should be in place and the education of the chain operators (e.g. establish training courses).

Ultimately, the shortening of the commercial channels would be beneficial for the sustainability of these Brazilian chains, prior the identification at local scale of the potential of the initiative.

| Sustainability scenario | Generic/SCM practices | Detailing from literature and *interviews* |
|---|---|---|
| **Sophistication**<br>• Diversified chains<br>• Local meat processing and local raw material purchasing<br>• Enhance Brazilian internal market | 1. Switch from commodity system to a more diversified pork sector (e.g. the KDR chain in the Netherlands and Green Farms Star Initiative with animal protection labels). | Use of new (or alternative) production systems that bring in animal welfare, environmental, food safety, food quality concerns. Information systems for traceability. Comply with quality assurance schemes (e.g. HACCP, EUREP GAP, Red Tractor, Label Rouge). Use certification schemes similar to IKB. Organic production system. Promotion of local production.<br>Use innovation for quality and ways to monitor this quality (e.g. RFID to monitor the cold chain). |
| | 2. Operational excellence and scale increase. | Increase coordination in the SC to reduce transaction costs, and to share risk among chain partners. Use a quality assurance scheme and monitor it in order to standardize the production processes in the chain. |
| | 3. Create new niches. | ***Market research. More quality production to fulfil market niches' needs, and certification to back the claim.***<br>***Either/both new properties of product given by the diversified production or/and diversification of market outlet.*** |
| | 4. Better outdoor access (housing). | Innovative husbandry. |
| | 5. Genetic improvement (**PS).** | ***First, map the market opportunities with a marketing research. Second, perform strategic marketing on the genetics of the best swine species for Brazil. Clearly establish a claim on the diversified chain.*** |
| | 6. Different nutrition (more responsible), recognizable with claims on a label. | ***Feed from organic productions (dependent on the marketplace, so need for market research before). Use of responsible soy (that does not come from the Amazon area) and ingredients coming from outside the farm. Use claims recognizable on a label.*** |
| | 7. The independent producers should offer room for new systems of coordination and create niche markets with more added value products. | Information systems for traceability. |
| | 8. Local slaughtering. | ***Optimize allocation planning of slaughterhouses (from which farm to which abattoir) and the capacity utilization up of the local slaughterhouses. Civil society should promote it.*** |
| | 9. Local meat processing. | ***Promote a coordinated approach with inter-branch organizations. Civil society should promote it. Optimize allocation planning of processing plants.*** |
| | 10. Local raw material purchases. | ***Verify the economic compatibility of local raw material purchases. Integration. Taxes on import of material.*** |
| | 11. Local feedstuff supply (% of money that is produced locally and retained internally should be higher). | ***To be obtained with good negotiating skills (contracts). If the chain coordination is weak, vertically integrated. Perform an agronomic analysis to divide the main cost drivers of production in a pie chart to see what is locally and what is not locally sourced (to see where to improve).*** |
| | 12. Nutrient recycling (manure comes back to the crop producer) between agricultural sectors | ***Adapt the technologies to reduce emissions. More process of manure into fertiliser. Cradle-to-cradle.*** |
| | 13. Invest on meat quality and traceability (**PS).** | ***Implement traceability and perform it in the whole SC. Training courses for chain operators on traceability (quality enabler). Individual identification system must be in place. Establish*** |

| | | |
|---|---|---|
| | | ***governmental or chain initiatives (e.g. IKB).*** |
| | 14. Improve manure management (make energy out of manure) and methane use (**PS).** | ***Verify the energy balance of these technologies. Trade biogas to the local villages. Make a claim out of energy produced from manure when the energy use at the farm drops significantly and there is emissions reduction.*** |
| | 15. Ensure short commercial channels. | ***Develop short marketing channels after the identification at local scale of the potentials. Once identified, promote those channels.*** |
| | 16. Make pressure on these supply chains to establish sustainable claims and standards. (**GS).** | Comply to a certification schemes similar to IKB. Use labels to claim the quality (animal welfare, safety, origin, etc.) of the process to create awareness about how responsible the chain is. |
| | 17. Campaigns to sensitise people (versus prejudices about pork meat as fatty and unhealthy). | Marketing research before any market initiative, which justifies the production costs. Increase the variety of products and increase in the convenience to enhance internal consumption (e.eg. snacks and convenient food). Educate the consumers to properly cook pork dishes, training courses for professional chefs. |

Table 18: Detailing of the practices of sustainability scenario *Sophistication* of pork supply chains in Brazil.

### 5.2.3 Balanced sustainability

The biodigesters, according to Domingues *et al.* (2013), are a cheap alternative to reuse manure and treat it after pig farming. The manure enters the digester and biogas is captured thanks to the anaerobic digestion so that GHG emissions at the farm are reduced and the farm gas and energy consumption can be more self-sufficient. The producer could also sell carbon credits (from less GHG emissions in atmosphere, Certified Emissions Reductions - CERs). This implantation should follow the National Agro Energy Plan, whose objective is " to promote sustainable development and competitiveness of agribusiness for the benefit of Brazilian society". It is equally important to monitor the generated $CO_2$ emission factors from the production of energy through biogas digestion (Domingues *et al.*, 2013). The Central-west Brazilian large farms (four or five thousand animals on average), compared to the Southern productions, which are integrated with cropland, have more conceivable potential use of manure applications to make fertiliser and energy out of it (Embrapa, 2012). The storage of liquid manure is a common application at the Brazilian farms. Beyond the freight distance, the cost-benefit analysis of this manure management practice has to be considered (Embrapa, 2012). Therefore, the scaling up of productions is constrained by the availability of nearby arable land that might use the manure from pig production. In the Central-west region there is a wide availability of land, hereby the use of biodigesters is a viable investment for local producers (Embrapa, 2012). For those farms with land limitation, thus, with problems with the disposal of manure, technologies like SISTRATES that removes the N and P nutrients from the manure for the disposal are needed. Composting is another alternative for manure management in Brazil through evaporation of water, reducing handling and transportation costs (Embrapa, 2012). Basically, if the cropland fertilisation need is higher or equal to the manure production by pigs, the investment in a biodigester for manure treatment is not mandatory (Embrapa, 2012). Otherwise, the use of a digester is compulsory because a limiting amount of land might create significant environmental burdens when it comes to manure disposal (in Southern Brazil). The manure can be mixed with rice straw to make different C/N ratios fertilisers (Bengtsson, 2009).

- Cost-benefit analysis on the use of biodigesters for energy, gas and fertiliser production or for disposal.
- Monitor antibiotic resistant bacteria
- Harmonization of Standards

Another prioritized issue in the balanced sustainability scenario is the investment in a monitoring system to ensure that the residues of antibiotic resistant bacteria (e.g. cephalosporins) from pig production are not present. According to Bengtsson (2009), a dedicated Organization (e.g. Swedish Veterinary Antimicrobial Resistance Monitoring) that at national and regional level monitors the analyses to avoid these residues would be beneficial. Seeking for expert's collaborations with the European Food and Safety Authority (EFSA) would be the chance to take a cue from Europe and their sustainable chain operations. The harmonization of the food safety practices in the Brazilian pork supply chains would ease the possibility to trade to EU marketplaces (Bengtsson, 2009). Regardless the dilemma about which microbial agent to look at when monitoring the chain, there is common agreement that collaboration between animal medicine and human medicine to tackle together the problem of resistance would be beneficial (Wallmann, 2006). In order to tackle this sustainable issue (resistance bacteria), the WHO guidelines have to be followed (they are based on a "rational use of antibiotics") (Khachatourians, 1998). This is possible through a monitoring system that starts at the producer, and pilots alternative applications: discontinued use of antibiotics, or their substitution with lactic acid bacteria and the associated antibacterial peptides (probiotic effect) (Khachatourians, 1998).

Once fulfilled a number of sustainable requirements, the just reward from the market is to be achieved with a trademark label such as Sustainable Pork®. The adoption of sustainability standards is the required

way to back the claims on the labels. It is important to educate the consumers that these advanced technologies are needed (e.g. immunological castration). Furthermore, there are many other sustainable practices, such as the involvement of water management at the farm as an indicator of pig health, through the installation of hydrometers (Vicari, 2012).

According to USDA–FSIS (2013), the big producers globally should harmonize together the standards available to meet consumer demands and ease competitive trade. Moreover, it is important for animal wellness during transport that the production chain of pork meat follows the OIE guidelines, along with specific documentation requirements to ease tradability (e.g. Export Certificate for Animal Casings) (OIE, 2011).

| Sustainability scenario | Generic/SCM practices | **Detailing from** literature and ***interviews*** |
|---|---|---|
| **Balanced sustainability**<br>• Animal welfare in global agenda and minimize microbe resistance in humans from use of antibiotics and heavy metals during animal production<br>• More sustainability standards to be applied in the supply chain | 1. Biogas investment to make energy for the feed mills (investment costs levelled by the savings of self-sufficiency in energy use) (**PS).** | Store liquid manure and use of biodigesters (viable opportunity for producers in the Central-west region) that follow the National Agro Energy Plan. For farms with land limitation use technologies like SISTRATES (energy produced for disposal is sold out). Carbon credits (CERs). Monitor the $CO_2$ emission factors generated from the production of energy from biogas. |
| | 2. Mix manure with straw to have a fertiliser and sell it branded (**PS).** | Mix manure with rice straw to make different C/N ratios fertilisers. |
| | 3. Adapt the system into more animal-friendly (more animal welfare), especially at the housing. | Ban physical castration of the pigs, and favour immunological castration. Involvement of water management actions at the farm as an indicator for pig health (installation of hydrometers). |
| | 4. Invest in monitoring system in later part of SC to ensure about residues management and about the antibiotic resistant bacteria **(QM).** | Ensure that the residues of antibiotic resistant bacteria (e.g. cephalosporins) from pig production are not present. Establish a dedicated Organization that at national and regional level monitors the analyses to avoid these residues. Follow the WHO guidelines. |
| | 5. Establish new sustainability standards to be applied in Brazil to better animal welfare and better the tradability to EU markets (**GS, QM).** | Use trademark labels such as Sustainable Pork®. Adopt sustainability standards. Harmonization of standards based on consumer demand. Follow OIE guidelines. |
| | 6. Campaigns to sensitise people (versus prejudices about pork meat as fatty and unhealthy). | Educate the consumers that advanced technologies are needed to provide safe pork meat to everyone. |
| | 7. Minimize risk of development of microbe resistance of human in the chains (exposure to antibiotic resistant bacteria) given by overuse of antibiotics and heavy metals (these increase the chances that human have microbial resistance to antibiotics) during animal production. | Seek for expert's collaborations with EFSA. Analyses through the supply chain must be put in place and monitored (harmonize food safety practices in the SC). Establish collaborations between animal medicine and human medicine to tackle the problem of resistance together. |

Table 19: Detailing of the practices of sustainability scenario *Balanced sustainability* of pork supply chains in Brazil.

## 5.3 Sustainability Scenario Framework

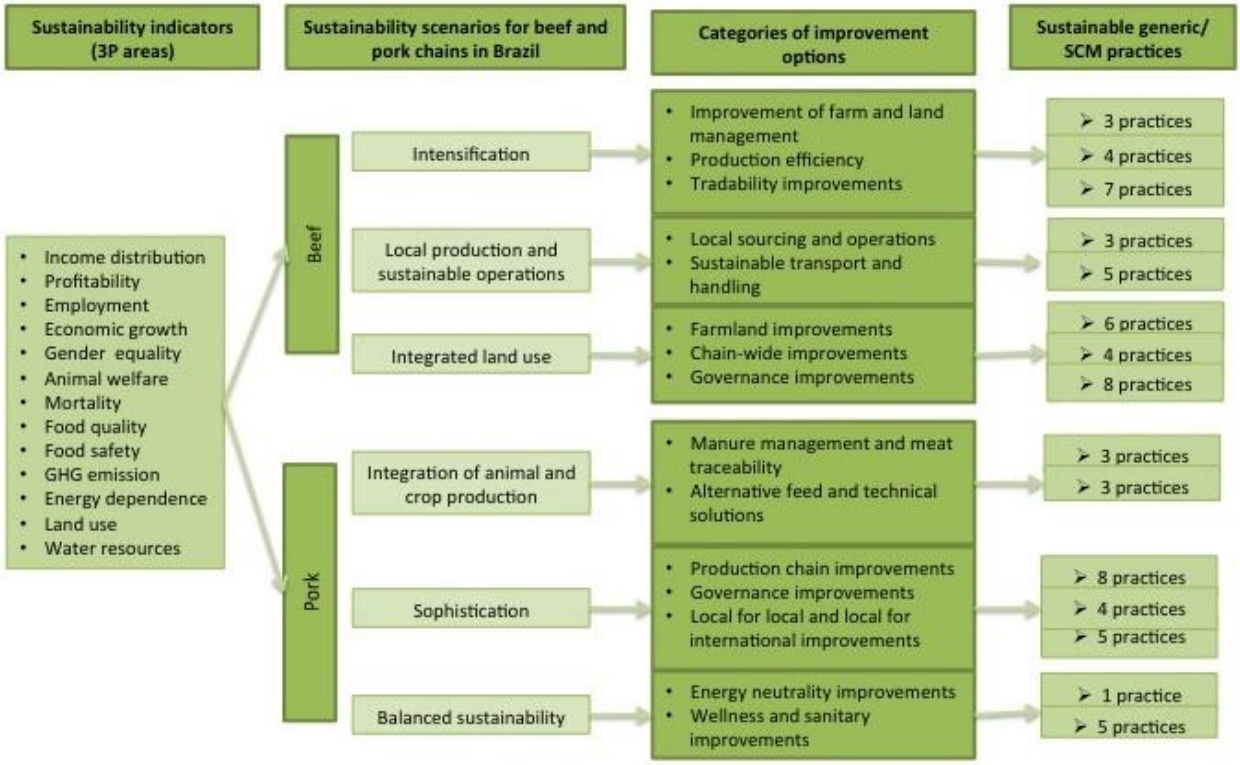



Figure 9: *Sustainability scenario framework* shows: the sustainability indicators, the scenarios, the categories of improvement options and the practices.

The *Sustainability scenario framework* in Figure 9 has been used to answer the general research question of this research once enriched with the insights from the literature and the empirical review (the second round interviews) (see chapters 5.1 and 5.2). It derives from the seven steps described in chapter 2.1.1 of the methodology: the selection of the thirteen sustainability indicators, the first round of interviews (to retrieve the draft scenarios), the selection of the six sustainability scenarios, the detailing of the sustainability scenarios via literature review, the second round of interviews (to validate, assess and detail the scenarios), the detailing of the sustainability scenarios via the second round of interviews (that supports the detailing via literature review), and the final design of the sustainability scenarios for beef and pork (which is the combination of the detailing via literature and interviews of the six scenarios). Appendix 4 displays the complete detailing of the practices of the six sustainability scenarios, especially the ones from the second round of interviews that were not presented in chapter 5. All of them are used for the final description of the scenarios, which represent the result of this thesis (chapter 6) and the basis to draw conclusions and recommendations for the chain players (chapters 7 and 8).
The Sustainability scenario framework displays the logic that has been followed in order to fulfil the objective of this research, and it makes clear how the results have been structured in the next chapter. It early displays what chapter 6 calls the "categories of improvement options", that are convenient labels that have been given from the author to groups of practices in each scenario. These categories of improvement options ease the discussions upon the sustainable message brought by each scenario and enclose the core idea of where in the chain the intervention should be prioritized.

The conclusions with the specific answers to the four research questions and the recommendations are, respectively, in chapters 7 and 8.

# 6. Results and analysis

This chapter presents the analysis of the results of the literature and the empirical review. It provides the answer to RQ4, which is:

**RQ4.** *What are the sustainability improvement options that, from a certain level of sustainability, bring to a future desired level of sustainability in these chains?*

The analysis of the results presented in the following sections refers to the data gathered and presented in appendix 4. As described in the methodology (chap. 2.1.1), the detailing of the practices in the scenarios from (i) the literature review and (ii) the second round of interviews, have been combined to precisely describe the sustainability scenarios. Moreover, the author, while elaborating these results, chose to zoom out from the level of detail of the practices and concrete actions, and to find a way to describe more generally the scenarios. Here come to place the 'categories of improvement options' that are simply a way to categorise the practices in the scenarios. Therefore, the next sections describe the sustainability scenarios, which contain the categories of improvement options and the sustainable practices involved (detailed to the concrete actions). The results for beef and pork substantiate in a description of the three sustainability scenarios for beef and the three for pork in the Brazilian supply chains. Moreover, for each of the scenarios, the sustainability assessment (radar plot with the assessment of the thirteen sustainability indicators) is provided, and it is compared to the assessment of the general beef and pork chains up to today.

## 6.1 The three sustainability scenarios for beef

In this chapter the three sustainability scenarios for the Brazilian beef supply chains are described and the radar plot is the visual aid used to represent the sustainability assessment of the scenarios. The three beef scenarios are: *intensification, local production and sustainable operations* and *integrated land use*. Each of the sustainability scenarios is the composition of a number of sustainable practices derived from the comparison of the literature and interviews. These practices have been grouped in categories of improvement options, in order to make explicit the key areas of intervention in the chain.

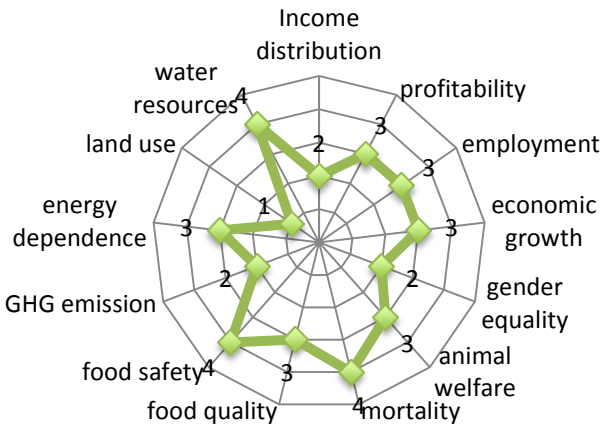
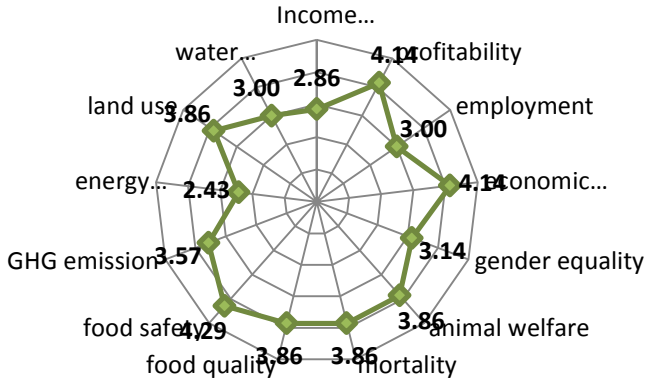
In the introductory section of each of the scenarios, a summarized illustration is provided, with the sum up description of the sustainable practices in the scenarios and the radar plots for the assessment of the scenarios.

### 6.1.1 Intensification

The foremost important insight to present is the presence of two alternatives of intensification of the production system: the extensive production system with the daily supplement of concentrates or fodder, and the confinement of animals into paddocks or feedlots. This first choice to pursue intensification influences the successive practices that are needed to make either of these two intensified production systems work.

The following three sections describe the three main categories of improvement options to make the beef production chain more intensive: *improvement of farm and land management*, *production efficiency*, and *tradability improvements*.

| **Summarized illustration of: *Intensification*** | |
|---|---|
| **Categories of improvement options** | **Sustainable practices involved** |
| Improvement of farm and land management | Fortification of the grass<br>Nutrient recycling<br>Use of decision support systems (DSS) |
| Production efficiency | Optimization of animal slaughter age<br>Improvement of feeding techniques |

| | |
|---|---|
| | Genetic improvement<br>Efficiency action plan at the farm |
| Tradability improvements | Animal welfare considerations<br>HACCP system requirement<br>Pay price according to meat quality<br>Electronic identification<br>Requirement of a monitoring system for food safety<br>Documentation requirement at the farm<br>Compliance to carcass certification schemes |
| **Current level of sustainability of these chains** | **Sustainability level from implementation of the scenario** |
|  |  |
| Radar plot from the re-elaboration of the 5-points Likert scales across the 13 sustainability indicators (1=very bad, 3=neutral, to 5=very good) | Radar plot from the re-elaboration of the 5-points Likert scales across the 13 sustainability indicators (1=very bad, 3=neutral, to 5=very good) |

**In sum:**

The **intensification scenario** for the beef Brazilian supply chains involves a number of implementable sustainable practices that range ***from farm and land management*** improvements, ***production efficiency*** improvements, and ***tradability*** improvements. The *farm and land management improvements* put down roots in practices like: fortification of the grass, nutrient recycling, and the use of decision support systems at the farm. The research of the region-specific soil types and grass species is fundamental, as well as pasture rotation. The confinement of animals eases both this practice and manure management (for nutrient recycling). Record keeping is important to map nutrient imbalances and create transparency in the chain. The *production efficiency* sustainable practices foster the need (expressed by the interviewees) to optimizing the slaughter age with the support of DSS's, to improve the feeding techniques (crop and grass rotation), to improve the animal genetic (artificial insemination), and to develop an efficiency-action plan at the farm (record keeping and use of DSS). Among the *tradability improvements*, taking into account animal welfare considerations (OIE guidelines), the requirement of an HACCP system (traceability must be in place), the establishment of payment criteria (according to classes of quality defined by the government), the electronic identification, a monitoring system for food safety (traceability), a documentation system (record keeping), and the compliance to carcass certification schemes (traceability and standards), are the elected practices.

According to the radar plot on the right, the implementation of this scenario would bring an increase in income distribution, animal welfare, food quality (+0,86), profitability (+1,14), food safety (+0,29), GHG emission (+1,57), and land use (+2,86). The highest scores to the sustainability indicators are attributed to food safety (4,29 out of 5), economic growth (4,14), land use, and food quality (3,86). On the other hand, income distribution (2,86) and energy dependence (2,43) would still be below the neutral average (3,00).

**Improvement of farm and land management**

Three main sustainable practices belong to this category, namely: *fortification of the grass*, *nutrient recycling*, and *use of DDS* (decision support systems). The *fortification of the grass* can be conveyed both by changing the grass species or fortifying the grass already adapted to the soil. Therefore, region-specific research on the types of soil in order to investigate the best adaptable and high-protein grass type is

needed (e.g. combination of grass and legumes has been cited a number of times by both the respondents and the literature). The alternative to changing the grass species would be to add N and P to the grassland. Another important practice encompasses the optimization of soil, grass, pasture species and pasture rotation. The latter one should be more intensive (intensive grass rotation system). Here comes to place the agrosilvopastoral system, a production system that integrates in a coherent framework of operations forest, crop and animal production. The improvement of animal husbandry with the confinement of the animal is important for managing the cattle more intensively and to manage efficiently the manure. *Nutrient cycling*, in this case, would benefit from the construction of fences or other types of confinements. In the case of intensifying the extensive system without confinements, the design of the watery points to strategically distribute the excreta would help the scientific management of slurry. Finally, the *use of support tools* such as DSS's systems, for example to avoid nutrient imbalances at the farm, or to follow the operations at the different paddocks, is important. The needed requirement is to implement record keeping at the farm and the registration of operations, which would be beneficial to all the other chain members and should be rewarded through the price received by the farmer.

**Production efficiency**

Four sustainable practices belong to this category: *optimize animal's slaughter ag*e, *improvement of feeding techniques, genetic improvement*, and *efficiency action plan at the farm*. Regarding the *animal slaughter age*, the common agreement among the interviewees is that there is the need to optimize the slaughter age to when the animal is full-grown. Therefore, more region-specific research is needed, and research on which feedlots (and amounts) the cattle should have in the different growth stages. Overall, talking about optimization of slaughter age, extensive grown animals should be slaughtered younger (considered by respondents as more sustainable) than the confined animals. The last step is to create awareness among the consumers that the decrease of the slaughter age of the animal can be beneficial for the environment. This is to be done through sensitization campaigns. The literature fosters the importance of improving the fencing, of improving the region-specific genetic research, of giving supplement feed (especially in the dry seasons). Moreover, the rancher has to manage the herd more intensively to express its potential and there must be an increase in capital and labour to better manage the operations at the farm. Regarding the *feeding technologies*, the important actions involve the improvement of the rotation of grass, the use of nitrogen fertiliser and lime. Clustering the animals in age-homogeneous groups at the farm would ease the feeding operations. The literature stresses the important concern of the dry season in which extra feed, shade and freshwater should be available. Additionally, the ranchers have to be trained about the behaviour of the cattle, in order to manage it efficiently.

The *genetic improvement* sustainable practice is fundamental to the production efficiency at the farm and it involves better selection, cross-breeding, and, especially, artificial insemination (highly advocated by several interviewees). In this case, the market outlet of reference of the different regional productions should be known in advance (market research is needed). Eventually, an *action plan for the efficiency at the farm* is of pivotal importance. It needs an improvement in record keeping, facilitated by the use of DSS from external service providers, and the design of a production-efficiency plan made by the farmer in association with external expertise. This plan should encompass, respectively: recording operations, monitoring and prioritizing actions. The farmers should be rewarded through the price from the use of these responsible practices.

**Tradability improvements**

Among the tradability improvements, there are *animal welfare considerations, HACCP system requirement, payment criteria, electronic identification, monitoring system requirement, documentation requirements,*

*and compliance to carcass certification schemes*. All these practices have been recognized as important, when intensifying the current beef production systems, in order to improve the tradability of the beef meat. The *animal welfare considerations* are the implementation of an action plan for animal welfare in the chain, the use of agrosilvopastoral system since it is beneficial for both profitability and animal welfare (it provides shadow for the animals), and the adaptation of the EU regulations to the Brazilian case. For example, following the OIE guidelines would make transport and handling operations in the beef chains more sustainable. The *requirement of a HACCP system* is of fundamental importance for the tradability of the beef meat and it requires a traceability system already in place. HACCP system for food safety should be implemented at every step of the chain (and required from the feed suppliers!), monitored and promoted. Concerning the *payment criteria*, paying according to the classes of quality is of foremost importance as catalyser to a number of responsible changes in the chain operations. Upstream, a governmental action to precisely define classes of quality and to establish protocols to monitor it is needed. These classes of quality should be set according to the main markets of reference of the production chain (market research is needed). The traceability system is paramount also to check the sanitary status of the herd and to monitor transportation. The *electronic identification* is the easiest requirement to track and trace the material flows in the chain, and it is vital to perform it from the first stages (tagging the animals and record keeping).

The *requirement of a monitoring system* is important, especially where preventive antibiotics' use is not allowed. The government should step in to monitor food safety and to establish a chain-wide monitoring system. Traceability is the starting point to have and maintain a good monitoring system for food safety.

A *documentation system* is required at the farm, as long as in the rest of the supply chain. It should be promoted from the government and rewarded to provide the economic stimuli. The record keeping could be taken up by a manager at the farm and facilitated by the use of user-friendly systems.

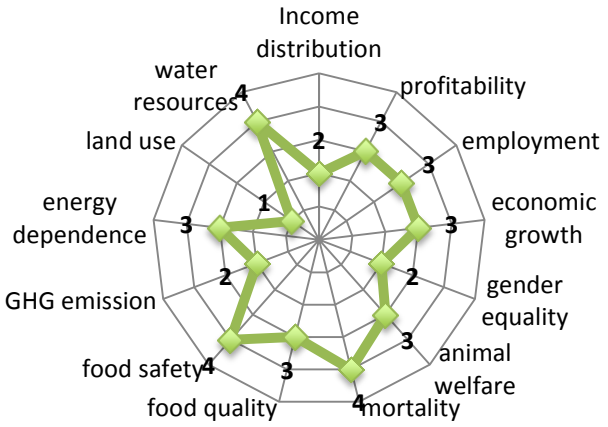
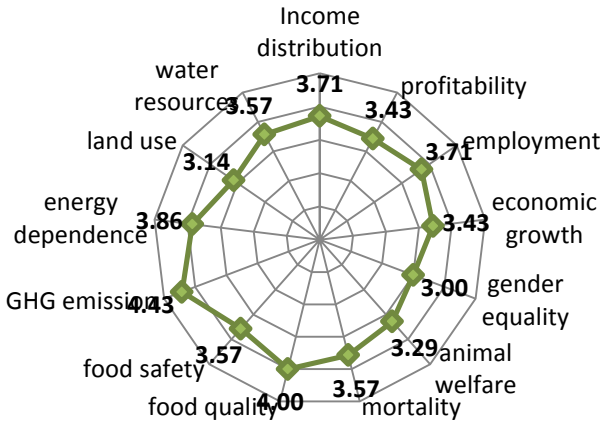
Finally, the *compliance to the carcass certification schemes* is another important concern to improve tradability while intensifying the production chain. In this concern, complying with carcass certification standards (farmers and slaughters) and GLOBAL GAP, as suggested by the literature and the interviewees, is of pivotal importance.

### 6.1.2 Local production and sustainable operations

This sustainability scenario is the result of the assembly of two mainstream improvement options: *local sourcing and operations*, and *sustainable transport and handling.*

The following two sections are meant to deepen into the practices involved in these two categories of improvement options towards sustainability.

| **Summarized illustration of: *Local production and sustainable operations*** | |
|---|---|
| **Categories of improvement options** | **Sustainable practices involved** |
| Local sourcing and operations | Local slaughtering<br>Local meat processing<br>Local feedstuff supply |
| Sustainable transport and handling | Improve the sustainable transport<br>Expand transportation network<br>Improve the legislation on live animal transport<br>Improve the education on relation between animal welfare and meat quality<br>Pay price according to meat quality. |

| Current level of sustainability of these chains | Sustainability level from implementation of the scenario |
|---|---|
|  |  |
| Radar plot from the re-elaboration of the 5-points Likert scales across the 13 sustainability indicators (1=very bad, 3=neutral, to 5=very good) | Radar plot from the re-elaboration of the 5-points Likert scales across the 13 sustainability indicators (1=very bad, 3=neutral, to 5=very good) |

**In sum:**

The **local production and sustainable operations** scenario for the beef Brazilian supply chains involves a number of implementable sustainable practices that range from improvements in ***local sourcing and operations*** to ***sustainable transport and handling***. *Local sourcing and operations* involve: local meat slaughtering (improve the infrastructure), local meat processing (vertical integration with slaughterhouses), and local feedstuff supply (mixed crop farming). The *sustainable transport and handling* encompasses: sustainable transport (investments in train and river modes), the expansion of the transportation network (investments in infrastructure), the improvement in the animal welfare legislation (OIE guidelines), the improvement of the education on the relation between animal welfare and meat quality (training to drivers), and payment according to meat quality (establish incentives).

According to the radar plot on the right, the implementation of this scenario would bring an improvement in income distribution (+1,71), profitability (+1,43), employment (+0,71), animal welfare (+0,29), food quality (+1,00), GHG emission (+2,43), and land use (+2,14). The highest scores are attributed to GHG emission (4,43) and energy dependence (3,86). Overall, the scenario brings improvements in all the sustainability indicators (the lowest are gender equality and land use, however still above 3,00).

**Local sourcing and operations**

This category encompasses mainly three sustainable practices: *local meat slaughtering*, *local meat processing*, and *local feedstuff supply*. The *local meat slaughtering* requires an improved infrastructure, with the need of strategic slaughterhouses built up per production region. This would reduce the distance travelled by the animals. Nevertheless, it would need an investigation on the economic viability. Moreover, the slaughterhouses should be all certified. The *local meat processing* would require the processing operations to be moved into the slaughter facilities, therefore fostering vertical integration. If it is not economically viable, keep processing abroad. Regarding the *local feedstuff supply*, the only improvements suggested by the interviewees were toward fostering mixed crop animal farming.

**Sustainable transport and handling**

This category of sustainability improvement options encompasses five practices, namely: *improve the sustainable transport*, *expand transportation network*, *improve the legislation on live animal transport, improve the education on relation between animal welfare and meat quality,* and *pay price according to meat quality*. According to the interviewees, there is the need to use *transportation modes* that are more *sustainable* than road transport. Therefore, more investments in train and river modes are to be fostered, after a precise cost-benefit analysis on the economic viability and the research on location-specific convenient sustainable modes. The use of inter- and co-modality is a sustainable transport strategy highly

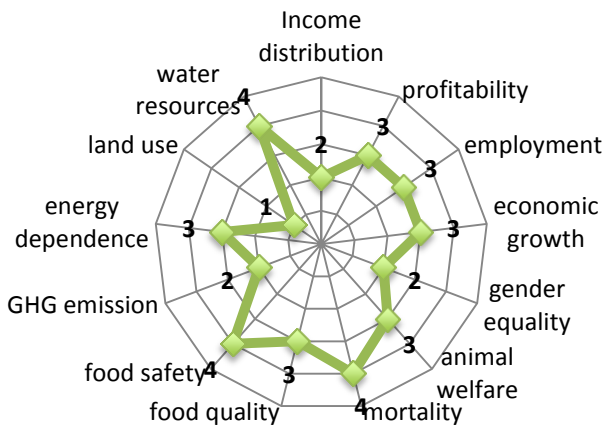
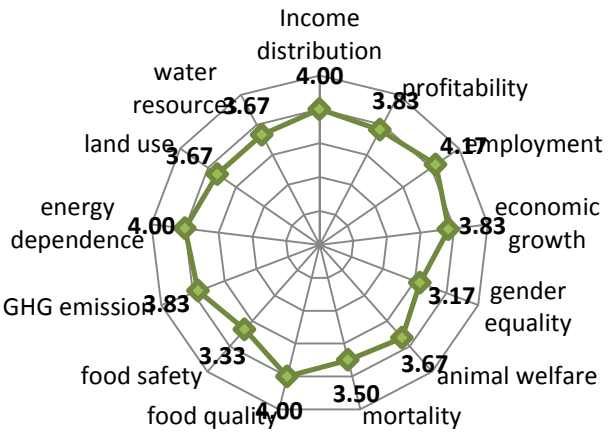
used nowadays and suitable in the Brazilian case, prior the construction of physical hubs or satellite distribution centres. The use of refrigerated cargos for the transport stage from slaughter to port is fundamental, as well as the construction of strategic finishing farms close to slaughters. Overall, the renovation of the road transportation fleet is the first intervention and the simplest to be made.

The *transportation network* has to be *expanded*. Therefore, the investments in train infrastructures (aforementioned) are needed, along with sharing the privately owned railway connections. The *improvement on animal welfare legislation* during transport and at the slaughter is fundamental in this sustainability scenario. The 3PL carriers (owners of 65% of the trucks) should invest in modern vehicles, supported by governmental tax credit incentives, and the drivers should be held accountable for losses during transportation. The rest-stops should be re-designed and tailored to the Brazilian case. Everything considered, the transportation should rely on the OIE guidelines and the Sustainable transport toolbox (from EU). In order to *improve the education* on the relation between *animal welfare and meat quality*, special trainings (government-sponsored) to drivers have to be performed. These should be focused on the responsible handling of animals, therefore giving importance to the handling of animals, the driving behaviour and the check up of vehicles. Eventually, *paying price according to meat quality* is possible when the payment system changes from the reward according the total weight of the truckload to a reward system more quality- and sustainability-related (establishing incentives). Moreover, there should be some research on the economic viability of increasing the quota of fresh meat exported instead of frozen, given that the price reward for the fresh cuts is triple.

### 6.1.3 Integrated land use

The sustainability scenario integrated land use encompasses several sustainable practices that range from farm specific, to chain-wide. Therefore, their categorization in three groups of improvement options is the suitable way to describe this scenario. These categories are: *farmland improvements*, *chain-wide improvements*, and *governance improvements*.

| **Summarized illustration of: *Integrated land use*** | |
|---|---|
| **Categories of improvement options** | **Sustainable practices involved** |
| Farmland improvements | Nutrient recycling<br>Improve research on mixed beef production systems<br>Increase research on organic and other sustainable production technical developments<br>Use of more balanced production systems<br>Improve grazing techniques<br>Tailor feed regimes to more intensive and use of concentrated feed |
| Chain-wide improvements | Increase differentiation in quality by introducing more labour intensive and quality enhancing production processes<br>Perform toxicological integrative studies on agrosilvopastoral systems<br>Ensure optimal conditions of animal transport<br>Invest in local roads and agroindustry |
| Governance improvements | Give support to farmers to increase profitability<br>Government bears infrastructure investments<br>Subsidise local production<br>Monitoring system<br>Fair trade initiatives and sensitisation campaigns in China and India<br>More sustainability-oriented regulations |

| | Establish a worldwide quality and sustainability standard<br>Increase in the regulation level |
|---|---|
| **Current level of sustainability of these chains** | **Sustainability level from implementation of the scenario** |
|  |  |
| Radar plot from the re-elaboration of the 5-points Likert scales across the 13 sustainability indicators (1=very bad, 3=neutral, to 5=very good) | Radar plot from the re-elaboration of the 5-points Likert scales across the 13 sustainability indicators (1=very bad, 3=neutral, to 5=very good) |

**In sum:**

The **integrated land use** scenario for the beef Brazilian supply chains involves a number of implementable sustainable practices that range from ***farmland improvements***, ***chain-wide improvements***, to ***governance improvements***. Among the f*armland improvements,* the most important sustainable practices are: nutrient recycling (confinement, crop rotation), improvement of research on mixed beef production systems (alternative feed sources), improvement of research on sustainable production technical developments (alternative feed sources), the use of balanced production systems (feed supplementation, intensive rotational grazing), the improvement of the grazing techniques (intensive rotational grazing, expertise support, fences), and the intensification of the feed regimes (concentrates and legumes). Among the *chain-wide improvements*, the sustainable practices are: increased differentiation in quality by introducing more labour intensive and quality enhancing production processes (certification schemes), the performance of toxicological integrative studies on agrosilvopastoral systems (new health regulations), ensuring optimal condition for animal transport (OIE guidelines), and invest in local roads and agroindustry (joint aids for investments in infrastructures). The *governance improvements* encompass: support to farmers to increase their profitability (government subsidies, lower interest rates, and credit support), government bearing infrastructure investments (roads and insemination centres), subsidies to local production (from SC players and local private industries' subsidies, and incentive system from government), monitoring system especially for organic production (extend monitoring system for export chains to the other chains), fair trade initiatives and sensitisation campaigns in China and India, more sustainability-oriented regulations (roundtable among Brazilian and other governments), the establishment of a worldwide quality and sustainability standard (elect an existing one as worldwide accepted), and a higher regulation level (OIE and Codex Alimentarius).

According to the radar plot on the right, the implementation of this scenario would bring an improvement in income distribution (+2,00), profitability (+1,43), employment (+1,17), animal welfare (+0,67), food quality (+1,00), GHG emission (+1,83), and land use (+2,67). The highest scores are attributed to employment (4,17), energy dependence, food quality, and income distribution (4,00). The experts have attributed the lowest scores to gender equality (3,17) and food safety (3,33), even though they are above 3,00.

**Farmland improvements**

Eight sustainable practices belong to this category: *nutrient recycling, improve research on mixed beef production systems, increase research on organic and other sustainable production technical developments, use of more balanced production systems, improve grazing techniques, tailor feed regimes to more intensive* and *use of concentrated feed*. *Nutrient recycling* could be improved by establishing the agrosilvopastoral systems. Alternatively, the strategic design of the watery points or the confinement of the animals, are good options in order to ease the timely and efficient management of manure. The use of crop rotations or intercropping production systems, are good ways to better nutrient cycling. There must be an *improvement*

*of research on mixed beef production systems* and on *sustainable production technical developments*. These are to be conduced by universities, especially focusing on the alternative feed sources than the ones used, and on the nutrient budget burdens derived from the use of lupins and rice as alternative feed sources. The use of *more balanced production systems* to avoid the cattle weight drop during the dry seasons is fundamental. The supplementation to the animal during the dry period is important and the economic viability of the use of Brachiaria, soy or corn has to be evaluated upfront. The use of intensive rotational grazing management, infield ad outfield crop rotations and zoned irrigation systems are important as well. The *improvement of the grazing techniques* should be supported by the expertise of agronomists and zootechnicians from the local research centres. The use of intensive rotational grazing is beneficial as grazing technical improvement, helped by the use of fences in the pasture area. The integrated land use scenario brings about the improvement related to the *switch to a more intensive feed regime*, with the use of *concentrated feed* as extreme. This is possible when there is an upfront evaluation of the economic viability of intensifying feed regimes. If needed, buy more feed from outside and utilize legume grass as feed source.

**Chain-wide improvements**

This category encompasses four sustainable practices: *increase differentiation in quality by introducing more labour intensive and quality enhancing production processes, perform toxicological integrative studies on agrosilvopastoral systems, ensure optimal conditions of animal transport,* and *invest in local roads and agroindustry*. The *increase of differentiation of production processes* is facilitated by the use of rotational grazing and the certification of the chains to claim the use of quality enhancing practices. Agrosilvopastoral systems are another way to differentiate the production system, especially diversifying the sources of profit (eucalyptus wood, sorghum and maize or maize and Brachiaria, and cattle). The consumer must be informed of this quality upgrade of the chain through awareness campaigns. When using the agrosilvopastoral system, *toxicological integrative studies* are needed, since it is a newly born production type. Therefore, an upfront health regulation has to be established by the policy makers, in order to guarantee that the spread of BSE and scrapie does not occur. *Ensuring optimal conditions of animal transport* is needed. It is possible by shortening the distance between the ranch and the slaughterhouse. The construction of local processing facilities, the modernization of the existing abattoir (for efficient handling) and the compliance to OIE guidelines are all the needed concrete actions. Eventually, the *investment in local roads and agroindustry* completes the panorama of investments to expand and improve the chain infrastructure. The burden of such an investment should be bore from both the government and the SC members.

**Governance improvements**

This category of improvement options towards the sustainability of the Brazilian beef supply chains involves eight practices: *give support to farmers to increase profitability, government bears infrastructure investments, subsidise local production, monitoring system, fair trade initiatives and sensitisation campaigns in China and India, more sustainability-oriented regulations, establish a worldwide quality and sustainability standard,* and *increase in the regulation level*. The *support to farmers* to increase their profitability and therefore their capability to invest into their business to make it more efficient and sustainable is pivotal for this scenario and it is a recursive practice from many interviews. The government direct subsidies to farmers, as well as lower interest rates, and credit support are the vocational instruments. The *government should bear the infrastructure investment*, therefore investing in roads, research centres and into an efficient insemination centre system. According to more than one interviewee, the burden of these investments should be more equally split between government and the

processors. The *subsidies to local production* to foster for local market outlets are possible if the SC players and local private industries create a support network to aid local production. Moreover, the government should introduce an incentive system for farmers in order to improve productivity (the clash is between credits and disincentives). The *monitoring system* for the control of food safety requires a governmental law that pushes producers to establish that. Furthermore, the monitoring system already in place for export chains should be extended to the rest of the beef chains. According to the literature, the research should intervene in order to find solutions to map the markers of BSE and scrapie on live animals. Another governance improvement option entails the *fair trade initiatives* and information *campaigns* to sensitise the consumers *in China and India* about sustainability in the beef chains. The Chinese government should step in and promote sensitisation campaigns, as much as monitor fair trade initiatives. More *sustainability-oriented regulations* are needed in order to enhance the entry barriers for supplies, and this should be negotiated by the Brazilian and other governments (roundtables). A *worldwide quality and sustainability standard* should be set and agreed upon by every country. The concrete action might be to elect one sustainability tool or standard and make it worldwide accepted. Further, an organization that monitors that standard at national and regional level is needed. Overall, the *regulation level has to be higher* in order to increase the visibility of the chain as quality and sustainability driven. In this case, the Brazilian government should restrict the requirements and demand, for all the traded beef, the compliance with OIE and Codex Alimentarius.

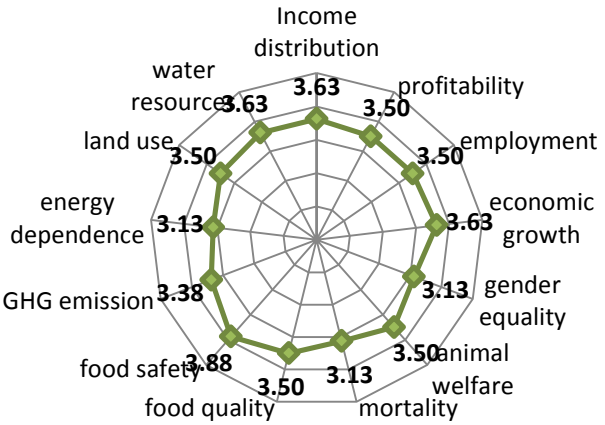
## 6.2 The three sustainability scenarios for pork

In this chapter the three sustainability scenarios for the Brazilian pork supply chains are described and the radar plot is the visual aid used to represent the sustainability assessment of the scenarios. The three pork scenarios are: *integration of animal and crop production, sophistication* and *balanced sustainability*. Each of these sustainability scenarios is the composition of a number of sustainable practices derived from the comparison of the literature and interviews. These practices have been grouped in categories of improvement options, in order to make explicit the key areas of intervention in the chain.
In the introductory section of each of the scenarios, a summarized illustration is provided, with the sum up description of the sustainable practices in the scenarios and the radar plots for their assessment.

### 6.2.1 Integration of animal and crop production

This sustainability scenario for the Brazilian pork supply chains encompasses two main categories of improvement options towards sustainability: *manure management and meat traceability,* and *alternative feed and technical solutions*.
The following two sections are meant to deepen into the practices involved in these two categories of improvement options.

| **Summarized illustration of: *Integration of animal and crop production*** | |
|---|---|
| **Categories of improvement options** | **Sustainable practices involved** |
| Manure management and meat traceability | Nutrient recycle<br>Invest in a biodigester to process manure into energy and fertiliser<br>Invest in meat quality and traceability |
| Alternative feed and technical solutions | Use animal feed not in competition with human consumption<br>Use DSS's to optimize the nutritional value of feed ingredients<br>Use of feed-print models |

| Current level of sustainability of these chains | Sustainability level from implementation of the scenario |
|---|---|
|  |  |
| Radar plot from the re-elaboration of the 5-points Likert scales across the 13 sustainability indicators (1=very bad, 3=neutral, to 5=very good) | Radar plot from the re-elaboration of the 5-points Likert scales across the 13 sustainability indicators (1=very bad, 3=neutral, to 5=very good) |

**In sum:**

The **integration of animal and crop production** scenario for the pork Brazilian supply chains involves a number of implementable sustainable practices, grouped in: ***manure management and meat traceability***, and ***alternative feed and technical solutions***. Among the *manure management and meat traceability* improvements, some practices are paramount: nutrient recycle (integration, mineral balance tools), investment in biodigesters to process manure into energy and fertilisers (closed loop system), and investment in meat quality and traceability (electronic tags). The *alternative feed and technical solutions* include: use of animal feed not in competition with human consumption (by-products from grain, animal, sugar, and starch production, and use of optimization models), use of DSS's to optimize the nutritional value of feed ingredients (large access to by-products, feed planning tools), and the use of feed-print models (optimize $CO_2$ equivalents during feed production).

According to the radar plot on the right, the implementation of this scenario would bring an improvement in income distribution (+1,63), profitability (+1,50), animal welfare (+0,50), food safety (+0,88), GHG emission (+1,38), energy dependence (+0,13), and land use (+1,50). The highest score has been attributed to food safety (3,88), while the lowest sustainability scores have been attributed to gender equality, mortality and energy dependence (3,13). All the values are between 3,13 and 3,88, therefore above the neutral average of 3,00.

**Manure management and meat traceability**

*Nutrient recycle* is a recursively mentioned practice, which is to be implemented when the integrated farming system is in place. The use of mineral balance tools is important to assess the nutrient profile of manure, what is the need that the crop has of those nutrients, and to know how much to use of the manure. According to the literature, the environmental burden or surplus manure not used with respect to its application to the crops has to be investigated. A viable option could be to *invest in a biodigester to process manure into energy* and the by-product of digestion is still good as *fertiliser*, since it is more soluble. The literature suggests that the mixed farming that couples pigs and vegetable greenhouses with this closed loop system of biodigestion is extremely efficient and sustainable. Finally, the trading requirements internationally demand good *systems of meat quality and traceability*. Therefore, targeted investments in quality and traceability in the chain are needed. Traceability could be performed with the use of electronic tags.

**Alternative feed and technical solutions**

The sustainable practices belonging to this category of improvement options are three: *use animal feed not in competition with human consumption*, *use DSS's to optimize the nutritional value of feed ingredients,* and *use of feed-print models*. Two interviewees stressed the importance of *animal feed as not in competition* with more valuable food intended for *human use*. Hereby, the use of by-products (from grain, animal,

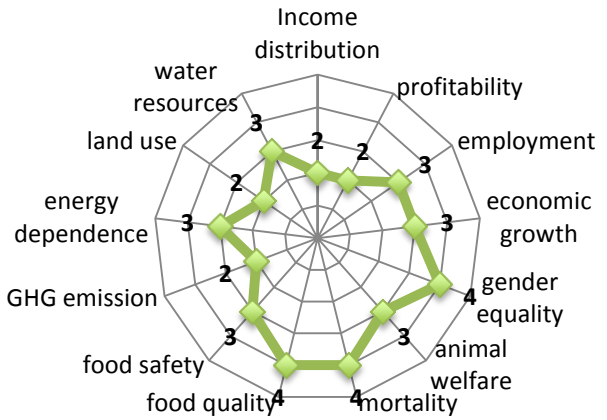
sugar, and starch production) after sterilization and mixture with the right ingredient (using optimization models) is recommended. Nutrient tests have to be carried out to benchmark this alternative feed with the conventional feed. The literature adds that the research on the modelling of the feeding formulas (high-protein content and palatable) is fundamental. The *use of DSS's and models to optimize the nutritional value of the feed ingredients* (i.e. precision feeding) on cost price and expected animal performance is an example. First, the farmer should have the guarantee of the access to large amounts of these by-products. Then, the use of feeding programs to optimize the formula (feed planning tools) and the continuous monitoring of the formula are needed (fortification of feed according to the age of the animal). The last sustainable practice of this sustainability scenario involves the *use of feed-print models*. These are meant to optimize each ingredient on $CO_2$ equivalents of the feed production, maintaining the expected animal performance high. It is pivotal to verify that the single optimization at company level is not suboptimal at global level.

### 6.2.2 Sophistication

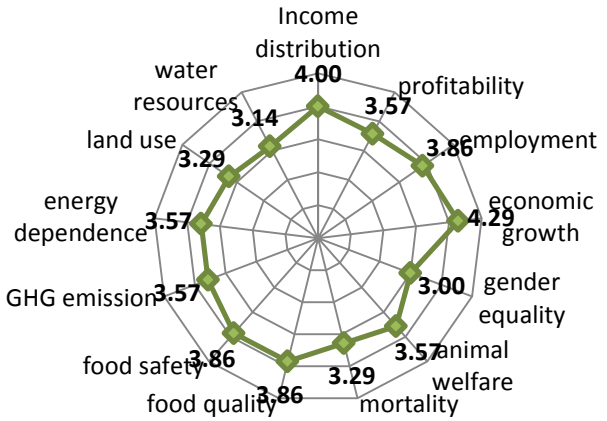
This sustainability scenario brings about a significant number of sustainable practices, grouped in three categories of improvement options: *production chain improvements, governance improvements,* and *local for local and local for international improvements*.

The following three sections will detail these three categories of sustainable practices to describe the concrete actions to make this sustainability scenario implementable to the Brazilian case.

| **Summarized illustration of: *Sophistication*** | |
|---|---|
| **Categories of improvement options** | **Sustainable practices involved** |
| Production chain improvements | Switch from a commodity system to a more diversified pork sector<br>Operational excellence and scale increase<br>Creation of new niches<br>Better outdoor access<br>Genetic improvement<br>Different nutrition<br>Nutrient recycling<br>Improve manure management |
| Governance improvements | Initiatives to increase the coordination in the chain<br>Invest in meat quality and traceability<br>Establish claims and standards<br>Campaigns to sensitise people and enhance pork consumption |
| Local for local and local for international improvements | Local slaughtering<br>Local meat processing<br>Local raw material purchases<br>Local feed stuff supply<br>Ensure short commercial channels |
| **Current level of sustainability of these chains** | **Sustainability level from implementation of the scenario** |




Radar plot from the re-elaboration of the 5-points Likert scales across the 13 sustainability indicators (1=very bad, 3=neutral, to 5=very good)




Radar plot from the re-elaboration of the 5-points Likert scales across the 13 sustainability indicators (1=very bad, 3=neutral, to 5=very good)

**In sum:**

The **sophistication** scenario for the pork Brazilian supply chains involves a number of implementable sustainable practices, grouped in: ***production chain improvements, governance improvements, and local for local and local for international improvements***. Among the *production chain improvements*, the need is to: switch from a commodity system to a more diversified pork sector (market research, quality classes definition, quality assurance schemes), invest in operational excellence and scale increase (more coordination in the chain, quality assurance schemes), creation of new niches (market research, certification to back claims), better outdoor access (open access, innovative husbandry), invest in genetic improvement (strategic marketing on the animal genetics), differentiate nutrition (organic feed, responsible soy), improve nutrient recycling (adapt technologies for cradle-to-cradle), and improve manure management (biodigester, evaluate energy balance of biodigester). Among the *governance improvements*, the sustainable practices are: initiatives to increase the coordination in the chain (inter-branch organizations, good ICT system), invest in meat quality and traceability (good ICT system), establish claims and standards (identification system, certification schemes), and campaigns to sensitise people and enhance pork consumption (diversification of pork products, more convenient food, pilot campaigns locally to be up-scaled, website information points). The *local for local and local for international* improvements encompass these practices: local slaughtering (allocation planning of the slaughterhouses), local meat processing (more chain coordination, allocation planning of processing plants), local raw material purchases (integration, taxes on imported materials), local feedstuff supply (contracts, vertical integration, agronomic analysis on cost drivers), and ensuring short commercial channels (investigate local scale potentials).

According to the radar plot on the right, the implementation of this scenario would bring an improvement in income distribution (+2,00), profitability, GHG emission (+1,57), animal welfare, energy dependence (+0,57), food safety (+0,86), and land use (+1,29). The highest scores have been attributed to economic growth (4,29), and income distribution (4,00). The other sustainability indicators have been scored above the neutral average, excluding gender equality (3,00).

**Production chain improvements**

This categorization of the following sustainable practices is mainly focused on those changes that have to be undertaken in the first step of the supply chain, namely the production chain, in order to make the pork sector more sophisticated. The *switch from a commodity system to a more diversified pork sector* requires market research at internal and international level. The drivers of diversification should be quality and animal welfare, and the retailer should be the architect of these quality classes definition, rewarding those suppliers able to provided it. Therefore, the use of alternative or new production systems that are more sustainability oriented, the implementation in the chain of traceability, and the compliance with quality assurance schemes (e.g. EUREP GAP and IKB) are needed. *Operational excellence and scale increase* are feasible, prior investigation of the possible environmental diseconomies. In order to foster operational excellence (in the whole chain), more coordination in the chain to reduce transaction costs and risk is

needed. The standardization of the chain processes brought by the use of a quality assurance scheme and its monitoring are important. The *creation of new niches* is the essence of diversification, starting from the production chain. A market research has to be conducted beforehand, and once the opportunity is discovered, the chain has to use a certification to back the claim. In general, the diversification is given by the new properties of the product given by the diversified production or by the diversification of the market outlet. An exemplar practice involves the *better outdoor access* for pigs at the farm. Thus, the construction of outdoor access with shaded areas, or the use of innovative husbandry are both good examples. *Genetic improvement* is another production innovation for diversification and it should be based on a strategic marketing on the genetics of the best swine species for Brazil. The *different nutrition* is a highly inflated example of important property of a niche. The feed may come from organic production, or from the responsible soy initiatives. *Nutrient recycling* is to be optimized with the use of adapted technologies for the digestion of manure into usable end- and by-products (import cradle-to-cradle from Europe). In order to *improve manure management*, the investment in a biodigester and the evaluation of the energy balance of this technology is needed. The energy produced by the biogas is to be sold to the local villages. When the energy use at the farm drops significantly, enforce the claim about the responsible manure management of that chain.

**Governance improvements**

This category of sustainable practices includes: *initiatives to increase the coordination in the chain, investments in meat quality and traceability, establishment of claims and standards,* and *campaigns to sensitise people and enhance pork consumption.* The independent producers (that 10% of meat whose production is not contracted) should offer room for *new systems of coordination* and create niche markets with more added value products. A better coordination is possible prior the establishment of inter-branch organizations, and the establishment of a good information system for traceability. The *investment on meat quality and traceability* is connected to the previous practice. It requires, indeed, that traceability is performed all the way from farm to fork, and that the chain operators are trained to handle it, since traceability is a quality enabler. An identification system must be settled, as well as governmental or chain *initiatives to bear the quality claim* of the diversified chains (e.g. as with IKB). These chains, as aforementioned, need to *comply with sustainability standards*, to back their claims. The market opportunities for the niche have to be investigated and, if considered viable, somebody in the chain has to start it up. Ultimately, *campaigns to sensitise people towards the consumption of pork meat* (enhancing the Brazilian market outlet), are recommended (especially increasing the variety of pork product and proposing it as convenient food). Thus, an option is the development of pilot campaigns on local markets that, if successful, are to be implemented on a larger scale. Moreover, the use of websites and information campaigns is the means to extend these initiatives to the public.

**Local for local and local for international**

A number of sustainable practices belong to this category, namely: *local slaughtering, local meat processing, local raw material purchases, local feed stuff supply,* and *ensure short commercial channels*.

The *local slaughtering* is possible when an allocation planning of the slaughterhouses is performed, to see which farms source which abattoir. Moreover, the optimization of the capacity utilization of the slaughterhouse is needed. *Local meat processing* is possible prior the promotion of a coordinated chain approach through inter-branch organizations, and prior allocation planning of processing plants (as for the slaughterhouses). Concerning the *local raw material* purchases, the economic compatibility has to be verified. Integration of crop and animal production would certainly help, as well as the application of taxes on the imported raw materials. The *local feedstuff supply* is to be obtained with good negotiating skills (by

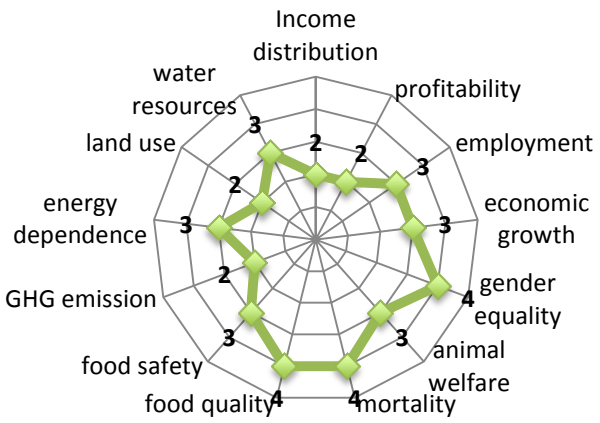
means of contracts), or through vertical integration (to enhance chain coordination). Performing an agronomic analysis on the main cost drivers of production is helpful to see the feed that is locally and the feed that is not locally sourced. Finally, *ensuring short commercial channels* is an opportunity when the local scale potentials are first proven and then promoted.

### 6.2.3 Balanced sustainability

This sustainability scenario brings about two main categories of improvement options: *energy neutrality improvements,* and *wellness and sanitary improvements* in the Brazilian pork supply chains. The following two sections are meant to detail the sustainable practices that have to do with these two categories of improvement options.

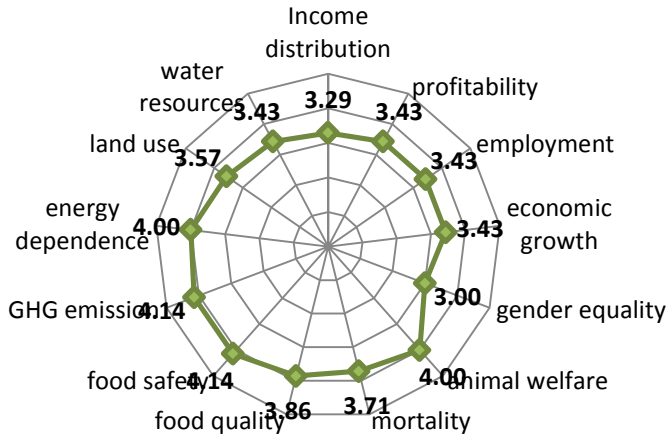
| **Summarized illustration of: *Balanced sustainability*** | |
|---|---|
| **Categories of improvement options** | **Sustainable practices involved** |
| Energy neutrality improvements | Biogas investment to make energy for the feed mills |
| Wellness and sanitary improvements | Make SC operations more animal-friendly<br>Investment in a monitoring system for residues management<br>Minimize the risk of development of microbe resistance<br>Establishment of new sustainability standards<br>Campaigns to sensitise people and enhance pork consumption |

**Current level of sustainability of these chains**




Radar plot from the re-elaboration of the 5-points Likert scales across the 13 sustainability indicators (1=very bad, 3=neutral, to 5=very good)

**Sustainability level from implementation of the scenario**




Radar plot from the re-elaboration of the 5-points Likert scales across the 13 sustainability indicators (1=very bad, 3=neutral, to 5=very good)

**In sum:**

The **balanced sustainability** scenario for the pork Brazilian supply chains involves the following groups of sustainable practices: ***energy neutrality improvements****, and* ***wellness and sanitary improvements***. Among the *energy neutrality* improvements: biogas investment to make energy for feed mills (economic stimuli by government to invest in biodigester or tax increase from energy use, SISTRATE technology for farms with limited land). The *wellness and sanitary improvements* encompasses the following sustainable practices: make supply chain operations more animal friendly (stick to EU welfare standards, hydrometers), investment in a monitoring system for residues management (EU standard, create Brazilian ractopamine standard, good ICT, record keeping, individual identification, follow WHO guidelines, establish monitoring organization), minimization of the risk of development of microbe resistance in humans (integration crop and animal production, information exchange in SC, EU standards, EFSA's support, collaboration human and animal medicine), the establishment of new sustainability standards (compliance with GLOBAL GAP, codes of conduct like OIE guidelines, certification schemes, harmonization of standards), and campaigns to sensitise people and enhance pork consumption (website information, information campaigns from human doctors and nutritionist).

According to the radar plot on the right, the implementation of this scenario would bring an improvement in income distribution (+1,29), profitability (+1,43), animal welfare, energy dependence (+1,00), food safety (+1,14), GHG emission (+2,14), and land use (+1,57). The highest scores have been attributed to food safety and GHG emission (4,14), animal welfare and energy dependence (4,00). All the other sustainability indicators are above the neutral average, apart from gender equality (3,00).

**Energy neutrality improvements**

The main sustainable practice that belongs to this category of improvement options toward sustainability of the pork supply chain is: *biogas investment to make energy for the feed mills*. Therefore, governmental subsidies are needed to stimulate the investments in biodigesters. Otherwise, the increase in taxes according to the energy use is another feasible incentive. According to the literature, the biogas digesters are a viable opportunity for the large producers in the Midwest regions of Brazil. For those farms with land limitations, the adoption of technologies like SISTRATES is beneficial to collect the energy produced from the disposal of the manure. The biodigesters' implantation should follow the National Agro Energy Plan. The carbon credits are another incentive to use the digesters, even though for the sole disposal (following CERs certification).

**Wellness and sanitary improvements**

Making the production and the later *SC operations more animal-friendly* is the first of the sustainable practices described in this category of improvement options. In order to achieve this, sticking to the recognizable system of EU welfare standards is needed (e.g. that demand more free space for pigs with open access outside and the freedom from cages). Another hot point is the substitution of physical castration with immunological castration. A further example is the installation of hydrometers at the farm to use water management as an indicator of pig health. The *investment in a monitoring system* in the SC to fortify *residue management* (e.g. antibiotic resistant bacteria) is feasible if the Brazilian chain follows the EU standards. Brazil should introduce a ractopamine free production standard (private standard, not legal) to claim the freedom from that widely spread disease. Having a good ICT backbone is fundamental to ease the analyses, for monitoring and pursuing corrective actions. The individual identification system and record keeping with the farmers registering the operations are other backbone requirements to monitor residues through the chain. Following the WHO guidelines and establishing an organization that monitors the analyses of the residues at national and regional level would help. In order to *minimize the risk of development of microbe resistance* for humans due to exposure to antibiotic resistant bacteria, the integration of crop and animal production and an improved exchange of information through the chain are important. Through the compliance with EU standards, the collaboration with the experts (e.g. from EFSA), the collaboration between human and animal medicine, this residue risk would be minimized. The *establishment of new sustainability standards* to be applied in Brazil is dependent on the effective functioning of the traceability system. In order to increase the animal welfare and therefore better the tradability of pork meat inside and outside Brazil, the compliance with GLOBAL GAP, other codes of conduct (OIE guidelines) and certification schemes (for downstream chain players) are needed. According to the literature, the harmonization of the standards would be beneficial for the efficiency of the chain operations. The harmonization of the existing set of standards should be based on the study of the demand. Ultimately, the *campaigns to sensitise* Brazilian people and boost internal *pork consumption* are needed to use the home market as a buffer against market disruptions (e.g. Russian ban to pork imports). The website information and information campaigns performed by human doctors and nutritionists are the best options.

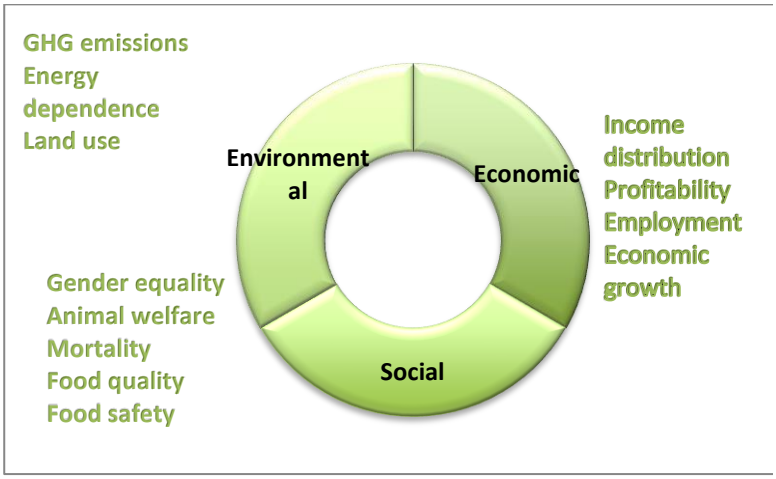
## 7. Conclusions

This chapter concludes on the results and analysis of the collected data, providing the answer to the central research question:

> What are the best suited sustainability scenarios, as sets of generic and SCM sustainable practices, that farmers and actors of the two supply chains of pork and beef from Brazil have to employ in order to manage sustainable development?

The central question is answered by means of answering the single specific research questions. Therefore, the answers to the specific questions will be shortly presented:

**RQ1**. *What sustainability indicators (economic, environmental and social) would be best suited to assess the sustainability of the beef and pork supply chains?*




These sustainability indicators have been selected from the plentiful literature about sustainable development, and propose a taxonomy that follows the 3P areas categorization (Economic, Social and Environmental). The figure on the left displays the different indicators for each of the three areas. These sustainability indicators are for both beef and pork indistinctively.

**RQ2.** *What is the current situation with respect to sustainability of the SCs of pork and beef from Brazil?*
The following table is meant to sum up the description of the sustainability indicators that have to be improved in the beef and pork supply chains in Brazil. The cut off to determine the presence of a sustainability issue has been settled according to the percentage of respondents for beef and pork that evaluated above 50% that the sustainability indicator represents an issue. Those sustainability indicators mentioned exactly by 50% of the respondents are left out as not considered a major issue.

| Sustainability issues for beef | Sustainability issues for pork | Comments |
|---|---|---|
| Income distribution | Income distribution | For **both the supply chains** of beef and pork in Brazil, a number of sustainability issues are present: income distribution, profitability, animal welfare, food quality, food safety, GHG emission, and land use.<br>On the other hand, the **beef-specific sustainability issue** is employment, whether for **pork** it is energy dependence.<br>While for beef most of the animal welfare concerns are about the insufficient feed during the dry seasons, for pork the concern is the insufficient outdoor access at the housing.<br>Also GHG emission is deceivingly the same, as for beef the main sustainable issue concerns the enteric emissions, while for pork it is about the emissions during transport (overall a very small percentage of the emissions looking at the whole chain operations), the emissions from the production of feed, and mostly the emissions through the slurry into the soil and groundwater (leaching). |
| Profitability | Profitability | |
| Employment | Animal welfare | |
| Animal welfare | Food quality | |
| Food quality | Food safety | |
| Food safety | GHG emission | |
| GHG emission | Energy dependence | |
| Land use | Land use | |

***RQ3.*** *What sustainability scenarios are feasible?*

The sustainability scenarios for the supply chains of beef and pork in Brazil that are feasible are six. The three for beef are: *intensification, local production and sustainable operations* and *integrated land use*. The three for pork are: *integration of animal and crop production, sophistication* and *balanced sustainability*.

**RQ4.** *What are the sustainability improvement options that, from a certain level of sustainability, bring to a future desired level of sustainability in these chains?*

Within the three sustainability scenarios for beef and the three scenarios for pork, a number of sustainable practices are identified. Concerning scenarios for beef and pork in Brazil, the sustainable practices have been grouped into categories of improvement options, in an attempt to structure the many of them. The following table neatly displays the different sustainable practices for each scenario, underlying the categories of improvement options to which they correspond.

Table 20: the six sustainability scenarios for beef and pork with the practices clustered in categories of improvement options.

| | Sustainability scenario | Categories of improvement options | Sustainable practices involved |
|---|---|---|---|
| Beef | Intensification | Improvement of farm and land management | Fortification of the grass<br>Nutrient recycling<br>Use of decision support systems (DSS) |
| | | Production efficiency | Optimization of the animal slaughter age<br>Improvement of feeding techniques<br>Genetic improvement<br>Efficiency action plan at the farm |
| | | Tradability improvements | Animal welfare considerations<br>HACCP system requirement<br>Pay price according to meat quality<br>Electronic identification<br>Requirement of a monitoring system for food safety<br>Documentation requirement at the farm<br>Compliance to carcass certification schemes |
| | Local production and sustainable operations | Local sourcing and operations | Local slaughtering<br>Local meat processing<br>Local feedstuff supply |
| | | Sustainable transport and handling | Improve the sustainable transport<br>Expand transportation network<br>Improve the legislation on live animal transport<br>Improve the education on relation between animal welfare and meat quality<br>Pay price according to meat quality |
| | Integrated land use | Farmland improvements | Nutrient recycling<br>Improve research on mixed beef production systems<br>Increase research on organic and other sustainable production technical developments<br>Use of more balanced production systems<br>Improve grazing techniques<br>Tailor feed regimes to more intensive and use of concentrated feed |
| | | Chain-wide improvements | Increase differentiation in quality by introducing more labour intensive and quality enhancing production processes<br>Perform toxicological integrative studies on agrosilvopastoral systems<br>Ensure optimal conditions of animal transport<br>Invest in local roads and agroindustry |
| | | Governance improvements | Give support to farmers to increase profitability |

| | | | |
|---|---|---|---|
| | | | Government bears infrastructure investments<br>Subsidise local production<br>Monitoring system<br>Fair trade initiatives and sensitisation campaigns in China and India<br>More sustainability-oriented regulations<br>Establish a worldwide quality and sustainability standard<br>Increase in the regulation level |
| Pork | Integration of animal and crop production | Manure management and meat traceability | Nutrient recycle<br>Invest in a biodigester to process manure into energy and fertiliser<br>Invest in meat quality and traceability |
| | | Alternative feed and technical solutions | Use animal feed not in competition with human consumption<br>Use DSS's to optimize the nutritional value of feed ingredients (i.e. precision feeding)<br>Use of feed-print models |
| | Sophistication | Production chain improvements | Switch from a commodity system to a more diversified pork sector<br>Operational excellence and scale increase<br>Creation of new niches<br>Better outdoor access<br>Genetic improvement<br>Different nutrition<br>Nutrient recycling<br>Improve manure management |
| | | Governance improvements | Initiatives to increase the coordination in the chain<br>Invest in meat quality and traceability<br>Establish claims and standards<br>Campaigns to sensitise people and enhance pork consumption |
| | | Local for local and local for international improvements | Local slaughtering<br>Local meat processing<br>Local raw material purchases<br>Local feed stuff supply<br>Ensure short commercial channels |
| | Balanced sustainability | Energy neutrality improvements | Biogas investment to make energy for the feed mills |
| | | Wellness and sanitary improvements | Make SC operations more animal-friendly<br>Investment in a monitoring system for residues management<br>Minimize the risk of development of microbe resistance<br>Establishment of new sustainability standards<br>Campaigns to sensitise people and enhance pork consumption |

After having answered the sub-questions, the answer to the central question is provided.

*What are the best suited sustainability scenarios, as sets of generic and SCM sustainable practices, that farmers and actors of the two supply chains of pork and beef from Brazil have to employ in order to manage sustainable development?*

Table 20 in RQ4 is explicative to understand what are the sustainable generic and SCM practices that have to be employed to manage the sustainable development of those chains. The table at the end of this paragraph pictures the overview of the type of SCM practices for each scenario that are here discussed, using the acronyms PS, LM, GS and QM (i.e. the four SCM areas chosen in this thesis).

The **beef scenarios** encompass: intensification, local production and sustainable operations and integrated land use. *Intensification* is mainly described by practices that have to do with production system area of SCM. The improvement options that are covered range from farmland improvements (mainly about the fortification of the grass and the nutrient recycling), production efficiency (genetic improvement of feed and animals and implementation of efficiency action plans at the farm), and to tradability improvements (change in payment criteria, HACCP, individual ID, and record keeping at the farm). *Local production and sustainable operations* contains a significative quota of SCM practices afferent to the logistics management

area of SCM. The main practices involved have to do with local sourcing and operations and sustainable transport and handling. These are mainly the local sourcing of feed and the local slaughter and process. Moreover, the sustainable transport, the expansion of the infrastructure and the animal welfare considerations are important. The *integrated land use* scenario for beef entails a good amount of production system practices. The practices in this scenario are categorised as farmland improvements (mainly nutrient recycling, research on alternative production systems, improvement of grazing techniques and use of more intensive feed), chain-wide improvements (increase differentiation in quality, improve the conditions of animal transport, and investment in infrastructure), and governance improvements (mainly supports to farmers, more sustainability-oriented regulations and establishment of a worldwide sustainability standard).

The **pork scenarios** encompass: integration of animal and crop production, sophistication and balanced sustainability. *Integration of animal and crop production* involves principally practices in the production system area of SCM. The practices are categorised in manure management and meat traceability (mainly nutrient recycling and investment in a biodigester), and alternative feed and technical solutions (use of feed that is not in competition with human consumption and use of DSS's to optimize the feed ingredients). The *sophistication* scenario involves mainly generic practices that range from production chain improvements (better housing, more diversified pork sector, genetic improvement, nutrient recycling), governance improvements (more coordination in the chain, electronic ID of animals, more standards, and enhancement of internal consumption), and local for local and local for international improvements (mainly local slaughter, process and supply of feed, and short commercial channels). The *balanced sustainability* scenario involves mainly practices in the production system SCM area. The energy neutrality improvements consist in the investment in biogas technology. Furthermore, the improvements in the wellness and sanitation in the chain are mostly: make SC operations more animal-friendly, monitoring of microbe resistance bacteria, and establish new sustainability standards. The following table displays the nature of the practices in each of the six sustainability scenarios, according to the categorization in generic and SCM practices (chapter 2.1.1). The percentages shown make explicit the quota of sustainable generic and SCM practices that the scenarios encompass, as mentioned by the interviewees (e.g. intensification counts 40% of the practices in the PS area). These **SCM areas** are of importance for the author to frame the main areas of interest in which some interventions have to be applied to improve the sustainability of the beef and pork chains in Brazil. It is fundamental to recommend targeted actions to these areas and to prioritize the interventions, due to the objective scarcity of resources and the high expenditures involved to comply with some of the practices recommended. Therefore, for instance in the implementation of the scenario 'Intensification', the prioritized actions should be in the production system area of SCM: improvement of nutrient recycling, fortification of the grass, the local sourcing of feedstuff, the improved animal and feed genetics, the improvement of the feeding technologies, and the use of concentrated feed.

| **Beef sustainability scenarios: quota of generic and SCM practices** | | | | | |
|---|---|---|---|---|---|
| *Intensification* | • PS 40%<br>• GS+PS 10%<br>• QM 5%<br>• QM+LM 15%<br>• Generic 30% | *Local production and sustainable operations* | • LM 37,5%<br>• Generic 62,5% | *Integrated land use* | • PS 27%<br>• PS+LM 5%<br>• LM 5%<br>• GS 5%<br>• GS+QM 5%<br>• Generic 53% |
| **Pork sustainability scenarios: quota of generic and SCM practices** | | | | | |
| *Integration of animal and crop production* | • PS 75%<br>• Generic 25% | *Sophistication* | • PS 18%<br>• GS 6%<br>• Generic 76% | *Balanced sustainability* | • PS 29%<br>• QM 14%<br>• GS+QM 14%<br>• Generic 43% |

Table 21: quota of generic and SCM practices (PS, LM, GS, QM and mix of them) in the six scenarios. Some practices belong simultaneously to different SCM areas (e.g. GS+QM).

**From a chain-specific to the general outlook of sustainable supply chains**

Chapter 6 thoroughly lists and describes the scenarios of sustainable production and distribution for the supply chains of beef and pork in Brazil, which are the outcome of this thesis. In chapter 5 the detailing of the practices into concrete actions to make the scenarios implementable in the panorama of the specific Brazilian case is provided. As expected, the scenarios to improve the future state of sustainability of the two chains are profoundly diverse, since they respond to sustainable issues that are different in the two chains. Therefore, a number of chain-specific practices emerge (e.g. fortification of the grass for beef and investment in biodigesters for pork, and many others that are easily recognizable as chain-specific from table 20).

Besides the numerous chain-specific practices, a consistent number of sustainable generic and SCM practices are common between the beef ad pork chain, as well as recommendable for other food chains. These are: improvement of nutrient recycling, use of decision support systems, genetic improvement of animals and feed, animal welfare considerations, HACCP system applied in the chain, electronic identification of the animals, implementation of a monitoring system for food safety in the chain, improvement of sustainable transport, more coordination in the chain and governmental initiatives that level the benefits of the chain partners (especially bettering off the farm level), record keeping at the farm, the increase of the sustainability-oriented regulation, the use of feed-print models, local slaughtering and local feed stuff supply, and the establishment of a worldwide accepted sustainability standard for food chains. These sustainable practices are scattered within the chosen categories of improvement options at different levels of the chain, namely: improvement of farm and land management, production efficiency, tradability improvements, local sourcing and operations, sustainable transport and handling, farmland improvements, chain-wide improvements, governance improvements, manure management and meat traceability, alternative feed and technical solutions, production chain improvements, local for local and local for international improvements, energy neutrality improvements, and wellness and sanitary improvements.

Therefore the results show how generic some sustainable practices can be with regard to different food chains than beef and pork. The power of these results lays in the concrete message that these findings from the literature and interviews convey: the outlook of the improvements towards more sustainable chains has to be chain-wide, and it should prioritise the farmland operations and the governmental actions that impose responsible bonds to the chain operations and ease their monitoring. Moreover, the information flows in the chain should be guaranteed as a powerful instrument to manage the operations and to create transparency for the consumer. This information should also specify when the practices in the chain are responsible, so that the marketplace of reference can reward the chain operations.

The many sustainable improvement options brought about by the six sustainability scenarios for the beef and pork supply chains in Brazil provide inputs for further research that has to investigate their representativeness for other food chains.

Furthermore, the idea of the implementation of the scenarios into the real life case of these chains deserves a further step of investigation only centred on the concrete feasibility of the project. This thesis fills a gap in the literature about sustainability scenarios that beef and pork Brazilian chain players have to pursue to improve their performance while being sustainable. Therefore, it seeks to contribute to the working packages of the SALSA project, by giving concrete actions in the form of structured sustainability scenarios for the improvement of the sustainability of these chains.

# 8. Recommendations and discussion

The objective of this part of the study is to give recommendations to the farmers and supply chain actors of the beef and pork supply chains in Brazil. These recommendations will be disseminated through the network of the SALSA project. Moreover, chapter 8 seeks to evaluate the research, by discussing the methodology used, the results that were found and the limitations of the study.

## 8.1 Recommendations

The recommendations are dispensed to the chain partners and the further researches.

**For the beef chain partners in Brazil**

The findings of this thesis should be disseminated among the supply chain players in the beef chains in Brazil, in order, for them, to identify which of the three options of sustainability upgrade that are represented by the sustainability scenarios, is more viable to be pursued. The sustainability scenarios developed in this thesis should support the chain players in the selection of a number of improvement options to be implemented to increase the sustainability of the chain practices. In total, the three sustainability scenarios for beef are: *intensification, local production and sustainable operations* and *integrated land use*. These are the different options that look at different aspects of the operations in the chain that should be modified to comply more with the principles of sustainability that are required by the international regulations and the markets.

**For the pork chain partners in Brazil**

The same holds true for the pork chain partners. The three scenarios developed for the pork chains in Brazil are: *integration of animal and crop production, sophistication* and *balanced sustainability*. The three of them have been considered feasible options for upgrading the sustainability of the chain, by means of the implementation of the practices proposed in the scenarios (chapter 6).

**For further research**

The importance of the findings is paramount not only for the practical support that they can provide to the beef and pork chain players in Brazil. In fact, the methodology used and that has been carried out to generate the scenarios might be extended to other food chains than the beef and pork, in the Brazilian area. Besides, further research should identify whether this methodology might be applicable to the beef and pork supply chains in geographical locations other than Brazil. The steps of the methodology are described in chapter 1.1.3 and in chapter 2.

## 8.2 Discussion

Quite a number of limitations of this study have to be addressed and improved in further researches.

The selection of the thirteen sustainability indicators might not cover all the sustainability issues that these food supply chains face in Brazil, as elsewhere. Many more studies upon the sustainability indicators present in the literature could be taken into account to have the complete picture before their selection. Nevertheless, the selection of the literature used has been well substantiated in chapter 3.

The twenty-five interviewees might not be enough to gather the necessary information up to saturation. The second round of interviews for the detailing of the practices in the scenarios and the assessment of the six scenarios required specific expertise that could be diverse in the different interviews, according to the scenario. Having more interviewees for the different areas of competence of the six scenarios could have been more beneficial. The four criteria used to screen out the draft scenarios and come to the three

scenarios of sustainability for beef and the three for pork are applied not mechanically. The endeavour for finding a real logical and content-wise selection of the draft scenarios is applied. However, the criteria used could have been applied in a different order or substituted by more practical ones, prior the proof that the internal validity of the study would have been better. The step of the validating survey with experts of the beef and pork chain in Brazil is fundamental to screen out suspects of a poor selection of the sustainability scenarios, thus, protecting the internal validity of the thesis. Unfortunately, just few surveys were filled in. Nevertheless, even though the survey has not been retrieved from the experts, the expert team discussed, approved and therefore validated the choice of the sustainability scenarios on the 22nd of November in Argentina, during a SALSA roundtable. The second round interviews, and the way the questionnaire was designed, has somehow the same function, so that those scenarios that the experts might recognize as not feasible or sustainable could be screened out. The general acceptance of the scenarios (as feasible and potentially more sustainable than the current situation) by the respondents is a positive sign for the validity of the selection of the sustainability scenarios. The author under the supervision of two experts has given the names to the sustainability scenarios and the categories of improvement options. Those names recall the meaning of the sustainable practices that are included in the scenarios. Even though this has been a matter of validation through the second round of interviews, some of those names might have been different if chosen by another author.

Moreover, the combination of the literature and the empirical findings on the detailing of the scenarios is used as the means to pursue the final description of the scenarios. The combination of the insights from literature and empirical reviews needs a further validation step that is outside the scope of this thesis and unfeasible given the time constraints.

The radar plot of the current situation of the general beef and pork chains in Brazil is the result of the assessment of only three experts, but since they are experts of these Brazilian chains, they are considered enough. The given information is double checked in the literature.

The way the scenarios are designed calls for an integral implementation of all the practices involved. The assessment is referred to the scenario as a whole with the contribution of all the practices involved. Therefore, there is no assessment and validation that the implementation of different practices picked from different scenarios might be beneficial, as well.

In order not to upset the information from the interviews and to be as transparent as possible, all the relevant information has been provided in the thesis and in the appendices part.

The interviews are used in order to check the clarity of the responses to the questionnaires and to avoid misunderstandings upon the requests in the pre-interview questionnaire. As explained in chapter 2, the choice of embracing a triangulation of methods (pre-interview questionnaire, survey and interviews) and sources (people, documents and media) help safeguarding the reliability and internal validity of this research.

All the aforementioned limitations of this study call for further research, which, nonetheless, would base on a solid underground that is provided by the findings presented here.

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Wageningen University – Department of Social Sciences

Management Studies Group

**Designing scenarios of sustainable production and distribution for the supply chains of beef and pork in Brazil**

**-APPENDICES-**

Wageningen, February 2014

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## Summary

# Appendix 1 – Interview document of the first round of interviews

## Appendix 1A - Pre-interview questionnaire (first round of interviews)

**Questionnaire**
**Sustainability in the beef and pork Brazilian supply chains**

This questionnaire that I have asked you to fill in gives me upfront information about the supply chain practices that may help the supply chains of beef and pork in Brazil to be more sustainable. Therefore, the objective is to provide farmers and other actors of the se supply chains with scenarios of sustainable development that are feasible to implement and that use sustainable supply chain management practices. At this stage, the questionnaire is meant to select, with your help, among a number of sustainable future scenarios that might be feasible for a beef and pork supply chain to be attained. I appreciate your effort and help. You are requested to point at the **SUSTAINABILITY ISSUES that Brazilian or the global beef and pork chains are facing,** the **SUSTAINABLE FUTURE SITUATIONS** to overcome the selected issues, and the **SUPPLY CHAIN MANAGEMENT practices** to make the future situation happen, thus, addressing those sustainability issues**.**
For this purpose, I have created this file with **3 PARTS** or topics to discuss.

**PART 1** is the Generic part. General information about you will be asked. Questions from 1 to 5 belong to Part 1.

**PART 2** deals with the identification of a number of Sustainability Issues that the Brazilian or global beef and pork supply chains are facing. Questions 6 and 7 belong to Part 2.

**PART 3** deals with the identification of a number of sustainability future situations and a set of sustainable supply chain management practices to reach them in the pork and beef supply chains. Questions 8 to 15 belong to Part 3.

Filling this questionnaire will take approximately 50-60 minutes.

Thank you for your collaboration!

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**PART 1 – GENERIC INFORMATION**

1. Name of the respondent _____

2. Name of your institution _____

3. Your company/organization is a (Single answer):

   a. Research institution
   b. University
   c. Ministry (e.g. of Agriculture). If yes, specify: _____
   d. Association
   e. Class entity (e,g, Brazilian Agribusiness Association)
   f. Foreign Government
   g. Statistics centre
   h. Business involved in the beef or pork supply chain. If Yes, specify what (e.g. farmer, processor, abattoir, trader, etc.): _____
   i. Other: _____

4. Your function/position _____

5. In which field are you an expertise? (Multiple answers)

   a. Supply chain management
   b. Pork sector
   c. Beef sector
   d. Sustainable development
   e. Agriculture
   f. Sustainable supply chains
   g. Animal science
   h. Brazilian supply chains
   i. Other: _____

**PART 2 – SUSTAINBILITY ISSUES IN PORK AND BEEF SUPPLY CHAINS**

6. Regarding the **beef supply chains**, in what chains are you able to identify any sustainable issue? (Multiple answers)

   a. Brazilian beef supply chains
   b. Global beef supply chains
   b. European beef supply chains
   d. Other: _____

7. Regarding the **pork supply chains**, in what chains are you able to identify any sustainable issue? (Multiple answers)

   a. Brazilian pork supply chains
   b. Global pork supply chains
   b. European pork supply chains
   d. Other: _____

**PART 3 – THE SUSTAINABILITY ISSUES AND THE SUSTAINABLE SUPPLY CHAIN MANAGEMENT PRACTICES IN PORK AND BEEF SUPPLY CHAINS**

8. You are now requested to fill in the table below about **beef supply chains**. The logical order entails moving from the left-side of the table to the right. First, you are asked to select for each (or some of the) sustainability indicators (column one) a number of future sustainable situations to overcome the issue (column two). Second, the feasible future sustainability issue envisioned is to be reached with a number of sustainable supply chain management (SCM) practices. Thus, choose the SCM area that helps making the future sustainable situation possible, addressing the sustainability issue (column three). Your choice is among the following SCM areas: **LM**: Logistics management; **GS**: Governance structure; **QM**: Quality management system; **PS**: Production system. Third, specify what SCM practices are of use to reach the future sustainable situation (in column two), addressing the sustainability issue (in column one). For example: a future situation to address GHG emission might be “carbon neutral” production, to be reached with the help of logistics management (LM), in the form of a new low-emission fleet of trucks.

| Sustainability indicators (sustainab. Issues) | Future sustainable situation | What supply chain management area can address the sustainability issue | | | | What practices in the chosen SCM area |
|---|---|---|---|---|---|---|
| 1. Income distribution | | LM | PS | GS | QM | |
| 2. Profitability | | LM | PS | GS | QM | |
| 3. Employment | | LM | PS | GS | QM | |
| 4. Economic growth | | LM | PS | GS | QM | |
| 5. Gender equality | | LM | PS | GS | QM | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| 6. Animal welfare | | LM | PS | GS | QM | |
| 7. Mortality | | LM | PS | GS | QM | |
| 8. Food quality | | LM | PS | GS | QM | |
| 9. Food safety | | LM | PS | GS | QM | |
| 10. GHG emission | | LM | PS | GS | QM | |
| 11. Energy dependence | | LM | PS | GS | QM | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| 12. Land use change | | LM | PS | GS | QM | |
| 13. Water resources | | LM | PS | GS | QM | |

9. You are now requested to fill in the table below about **pork supply chains**. The logical order entails moving from the left-side of the table to the right. First, you are asked to select for each (or some of the) sustainability indicator (first column) a number of future sustainable situations to overcome the issue (second column). Second, the feasible future sustainability issue envisioned is to be reached somehow with a number of sustainable supply chain management (SCM) practices. Thus, choose the SCM area that helps making the future sustainable situation possible, addressing the sustainability issue (column three). Your choice is among the following SCM areas: **LM**: Logistics management; **GS**: Governance structure; **QM**: Quality management system; **PS**: Production system. Third, specify what SCM practices are of use to reach the future sustainable situation (column two), addressing the sustainability issue (column one). For example: a future situation to address GHG emission might be "carbon neutral" production, to be reached with the help of logistics management (LM), in the form of a new low-mission fleet of trucks.

| **Sustainability indicator (sustainab. Issues)** | **Future sustainable situation** | **What supply chain management area can address the sustainability issue** | | | | **What practices in the chosen SCM area** |
|---|---|---|---|---|---|---|
| 1. Income distribution | | LM | PS | GS | QM | |
| 2. Profitability | | LM | PS | GS | QM | |
| 3. Employment | | LM | PS | GS | QM | |
| 4. Economic growth | | LM | PS | GS | QM | |
| 5. Gender equality | | LM | PS | GS | QM | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| 6. Animal welfare | | LM | PS | GS | QM | |
| 7. Mortality | | LM | PS | GS | QM | |
| 8. Food quality | | LM | PS | GS | QM | |
| 9. Food safety | | LM | PS | GS | QM | |
| 10. GHG emission | | LM | PS | GS | QM | |
| 11. Energy dependence | | LM | PS | GS | QM | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| 12. Land use | | LM | PS | GS | QM | |
| 13. Water resources | | LM | PS | GS | QM | |

10. Are there any peculiar sustainability issues for the (global and/or Brazilian and/or European) **beef** supply chains that differentiate these chains from other food SCs?

    a. Yes
    b. No

11. If Yes, please tick one of the next options: (Single answer)

    a. Peculiar sustainability issues in global beef supply chains (generic to all the beef supply chains)
    b. Peculiar sustainability issues in the Brazilian beef supply chains (excluding global, European and others)
    c. Peculiar sustainability issues in the European beef supply chains (excluding global, Brazilian and others)
    d. Peculiar sustainability issues in beef supply chains in: _____ (e.g. China)

12. If Yes (at point 10), would you please name some of those beef-specific sustainability issues?

    _____
    _____
    _____
    _____
    _____
    _____

13. Are there any peculiar sustainability issues for the (global and/or Brazilian and/or European) **pork** supply chains that differentiate these chains from other food SCs?

    a. Yes
    b. No

14. If Yes, please tick one of the next options: (Single answers)

    a. Peculiar sustainability issues in pork supply chains (generic to all the beef supply chains)
    b. Peculiar sustainability issues in the Brazilian pork supply chains (excluding global, European and others)
    c. Peculiar sustainability issues in the European pork supply chains (excluding global, Brazilian and others)
    d. Peculiar sustainability issues in pork supply chains in: _____ (e.g. China)

15. If Yes (at point 13), would you please name some of those pork-specific sustainability issues?

    _____
    _____
    _____
    _____
    _____
    _____

End of the questionnaire. Thank you for your collaboration!

## Appendix 1B - Interview questions (first round of interviews)

What of these indicators are to be improved to increase the economic, social and environmental sustainability of the chain?

What are the most important sustainability issues related to income distribution (same question for the other sustainability indicators)?

What could be a future sustainable situation that overcomes that sustainability issue, affecting that sustainability indicator "income distribution"? e.g. different SC organization or new contracts in the chains?

What SCM area can address the sustainability issue that you have pointed out? Does the future sustainable situation need an action in logistics management, in production systems, in governance structure or SC organization, or quality management systems (e.g. certifications and standards)?

Please explain your choice and give precise indications of which practices you are thinking about when you say that a certain SCM area is involved in making the future sustainable situation possible. E.g. if you say that logistics management is a way to reduce GHG emissions, please, specify that the specific action of "buying a new fleet of low-emission truck" is the sustainable practice you have in mind.

*Up until now, this is what will be asked for each of the 13 sustainability indicators in the list for both pork and beef.*

What are those issues in the SC that you chose (global, or Brazilian or European) that make beef unique compared to other food supply chains?

What are those issues in the SC that you chose (global, or Brazilian or European) that make pork unique compared to other food supply chains?

## Appendix 1C – Framework for the analysis of the first round interviews

**Part 1: generic information**
1. Name respondent
2. Name of the institution
3. Type of company/organization
4. Function/position
5. Expertise

**Part 2: sustainability issues in pork and beef supply chains**
6. Expert in beef Brazilian/global/European
7. Expert in pork Brazilian global/European

**Part 3: The sustainability indicators and the sustainable supply chain management practices in pork and beef supply chains**

**8. Beef:**
8.1 Income distribution:

| Future sustainable situation | Explanation | What practices in the chosen SCM area | Explanation |
|---|---|---|---|
| | | | |

8.2 Profitability:

| Future sustainable situation | Explanation | What practices in the chosen SCM area | Explanation |
|---|---|---|---|
| | | | |

8.3 Employment/employability:

| Future sustainable situation | Explanation | What practices in the chosen SCM area | Explanation |
|---|---|---|---|
| | | | |

8.4 Economic growth:

| Future sustainable situation | Explanation | What practices in the chosen SCM area | Explanation |
|---|---|---|---|
| | | | |

8.5 Gender equality:

| Future sustainable situation | Explanation | What practices in the chosen SCM area | Explanation |
|---|---|---|---|
| | | | |

8.6 Animal welfare:

| Future sustainable situation | Explanation | What practices in the chosen SCM area | Explanation |
|---|---|---|---|
| | | | |

8.7 Mortality:

| Future sustainable situation | Explanation | What practices in the chosen SCM area | Explanation |
|---|---|---|---|
| | | | |

8.8 Food quality:

| Future sustainable situation | Explanation | What practices in the chosen SCM area | Explanation |
|---|---|---|---|
| | | | |

8.9 Food safety:

| Future sustainable situation | Explanation | What practices in the chosen SCM area | Explanation |
|---|---|---|---|
| | | | |

8.10 GHG emission:

| Future sustainable situation | Explanation | What practices in the chosen SCM area | Explanation |
|---|---|---|---|
| | | | |

8.11 Energy dependence:

| Future sustainable situation | Explanation | What practices in the chosen SCM area | Explanation |
|---|---|---|---|
| | | | |

8.12 Land use change:

| Future sustainable situation | Explanation | What practices in the chosen SCM area | Explanation |
|---|---|---|---|
| | | | |

8.13 Water resources:

| Future sustainable situation | Explanation | What practices in the chosen SCM area | Explanation |
|---|---|---|---|
| | | | |

**9. Pork:**

9.1 Income distribution:

| Future sustainable situation | Explanation | What practices in the chosen SCM area | Explanation |
|---|---|---|---|
| | | | |

9.2 Profitability:

| Future sustainable situation | Explanation | What practices in the chosen SCM area | Explanation |
|---|---|---|---|
| | | | |

9.3 Employment/employability:

| Future sustainable situation | Explanation | What practices in the chosen SCM area | Explanation |
|---|---|---|---|
| | | | |

9.4 Economic growth:

| Future sustainable situation | Explanation | What practices in | Explanation |
|---|---|---|---|

| | | **the chosen SCM area** | |
|---|---|---|---|
| | | | |

9.5 Gender equality:

| **Future sustainable situation** | **Explanation** | **What practices in the chosen SCM area** | **Explanation** |
|---|---|---|---|
| | | | |

9.6 Animal welfare:

| **Future sustainable situation** | **Explanation** | **What practices in the chosen SCM area** | **Explanation** |
|---|---|---|---|
| | | | |

9.7 Mortality:

| **Future sustainable situation** | **Explanation** | **What practices in the chosen SCM area** | **Explanation** |
|---|---|---|---|
| | | | |

9.8 Food quality:

| **Future sustainable situation** | **Explanation** | **What practices in the chosen SCM area** | **Explanation** |
|---|---|---|---|
| | | | |

9.9 Food safety:

| **Future sustainable situation** | **Explanation** | **What practices in the chosen SCM area** | **Explanation** |
|---|---|---|---|
| | | | |

9.10 GHG emission:

| **Future sustainable situation** | **Explanation** | **What practices in the chosen SCM area** | **Explanation** |
|---|---|---|---|
| | | | |

9.11 Energy dependence:

| **Future sustainable situation** | **Explanation** | **What practices in the chosen SCM area** | **Explanation** |
|---|---|---|---|
| | | | |

9.12 Land use change:

| **Future sustainable situation** | **Explanation** | **What practices in the chosen SCM area** | **Explanation** |
|---|---|---|---|
| | | | |

9.13 Water resources:

| **Future sustainable situation** | **Explanation** | **What practices in the chosen SCM area** | **Explanation** |
|---|---|---|---|
| | | | |

## Appendix 1D – Framework for the comparison of the first interviews' analyses

| Name | Expertise in | | Organization | Sustainable issue (where) | | | Sustainable indicator | Draft sustainable scenario | Sust. SCM practices | SCM area |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | B | P | | G | B | EU | Income distribution | | | |
| | | | | | | | Profitability | | | |
| | | | | | | | Employment | | | |
| | | | | | | | Economic growth | | | |
| | | | | | | | Gender equality | | | |
| | | | | | | | Animal welfare | | | |
| | | | | | | | Mortality | | | |
| | | | | | | | Food quality | | | |
| | | | | | | | Food safety | | | |
| | | | | | | | GHG emission | | | |
| | | | | | | | Energy dependence | | | |
| | | | | | | | Land use | | | |
| | | | | | | | Water resources | | | |
| 2 (up until 11) | B | P | | G | B | EU | Income distribution | | | |
| | | | | | | | Profitability | | | |
| | | | | | | | Employment | | | |
| | | | | | | | Economic growth | | | |
| | | | | | | | Gender equality | | | |
| | | | | | | | Animal welfare | | | |
| | | | | | | | Mortality | | | |
| | | | | | | | Food quality | | | |
| | | | | | | | Food safety | | | |
| | | | | | | | GHG emission | | | |
| | | | | | | | Energy dependence | | | |
| | | | | | | | Land use | | | |
| | | | | | | | Water resources | | | |

## Appendix 2 – Survey on the selected six sustainability scenarios

**Survey**
**Sustainability in the beef and pork Brazilian supply chains**

This survey that I have asked you to fill in is meant to give insights about the supply chain practices that may help the supply chains of beef and pork in Brazil to be more sustainable. Therefore, the objective is to provide farmers and other actors of these supply chains with scenarios of sustainable development that are feasible to implement and that use sustainable supply chain management practices. This survey is aimed at assessing the practices in six sustainability scenarios, giving them a score. I appreciate your effort and help. You are requested to **ASSESS** the level of **SUSTAINABILITY** of the **six scenarios for Brazilian or the global beef and pork chains** that are presented**,** and to **ADD/INDICATE** other **PRACTICES** than the ones mentioned in the six scenarios that might be feasible.

Filling this survey will take approximately 30-40 minutes.
Thank you for your collaboration!

**THE SUSTAINABILITY ASSESSMENT OF THE SCENARIOS FOR BEEF AND PORK**

Please, tick the most important practices for each (or some of the) scenario and for each practice fill in the sustainability assessment table following the instructions.

- **Instructions:**

Select for each sustainable scenario the practices that you think are important writing 'No' (Not important) or a 'Yes' (Important), in the appropriate column (the pink coloured column).
Assess the selected practices for each scenario using the following legend (in the green coloured cells):

--- = Very damaging
-- = Quite damaging
- = Bit damaging,
0 = No impact,
+ = Bit improvement,
++ = Quite improving,
+++ = Very improving

Please, also indicate below every table those practices that are not included but would be beneficial for the sustainability of the beef and pork chains in Brazil, related to that sustainability scenario.

## Beef sustainability scenarios

| **Scenario 1: Intensification**<br>• Intensification of the beef production systems<br>• Apply carcass certification schemes | | Sustainability Indicators: | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Economic** | | | | **Social** | | | | | **Environmental** | | | |
| **Farm and chain practices** | Selection of practices (Yes/No) | Income distribution | Profitability | Employment | Economic growth | Gender equality | Animal welfare | Mortality | Food quality | Food safety | Global warming | Energy consumption | Water consumption | Land use |
| Give importance to welfare considerations (i.e. more shadow for beef). | | | | | | | | | | | | | | |
| Environmental impact reduction, and healthy food. | | | | | | | | | | | | | | |
| For intensification, there is the need of more nutrients in the grass: change the grass, but then biodiversity changes, or use inputs to make grass more nutritious**.** | | | | | | | | | | | | | | |
| Nutrient recycling**.** | | | | | | | | | | | | | | |
| Local feedstuff supply**.** | | | | | | | | | | | | | | |
| Use grain instead of grazing grass (better weigh conversion) for intensification, along with giving extra feed, grain (bought from another area)**.** | | | | | | | | | | | | | | |
| Improve the feeding technologies (better feed, slaughter the animal when younger, less emissions)**.** | | | | | | | | | | | | | | |
| Improve grass and land management (farm management techniques) to improve productions**.** | | | | | | | | | | | | | | |
| Improve land management and valorise the products when it comes from young beef (underline the importance of slaughtering young animals, more intensive management of the system, governance system could stimulate to use DSS's to help farmers to make operations more efficient (intensification)**.** | | | | | | | | | | | | | | |
| HACCP system**.** | | | | | | | | | | | | | | |
| Better genetics (less fat)**.** | | | | | | | | | | | | | | |
| Make the farms more efficient (efficiency just at economic level, e.g. DEA sustainability indicators). | | | | | | | | | | | | | | |
| Action plan according to the productive efficiency of extensive farm systems (including organic farming). | | | | | | | | | | | | | | |
| Mix of organic and intensive beef production system**.** | | | | | | | | | | | | | | |
| Use concentrated feed not to have the animal prone to disease because it runs out of energy (also better conversion of carcass)**.** | | | | | | | | | | | | | | |
| Pay according to class of quality. | | | | | | | | | | | | | | |
| Use tags to check sanitary status of herd, transportation following the limits (no. heads) set by the law**.** | | | | | | | | | | | | | | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Monitoring systems especially for organic meat (where preventive antibiotics are not allowed)**.** | | | | | | | | | | | | | | |
| Documentation system with farmers registering operations (document practices)**.** | | | | | | | | | | | | | | |

**Are there other practices that should be added to this sustainability scenario?**

| **Scenario 2: local production and sustainable operations**<br>• Reduce transport (shorter routes)<br>• Renew infrastructure) | | Sustainability Indicators: | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Economic** | | | | **Social** | | | | | **Environmental** | | | |
| **Farm and chain practices** | Most important practices | Income distribution | Profitability | Employment | Economic growth | Gender equality | Animal welfare | Mortality | Food quality | Food safety | Global warming | Energy consumption | Water consumption | Land use |
| Local slaughtering. | | | | | | | | | | | | | | |
| Local meat processing. | | | | | | | | | | | | | | |
| Local feedstuff supply. | | | | | | | | | | | | | | |
| Improve sustainable transport (river, low impacting vehicles and support sustainable beef production systems**.** | | | | | | | | | | | | | | |
| Expand the transportation network, but with the use of sustainable modes**.** | | | | | | | | | | | | | | |
| Improve legislation on live animals transport and slaughtering welfare, support investments in modern vehicles (trucks and boats) for animals transport (In order to invest, the returns for the farmer have to be higher)**.** | | | | | | | | | | | | | | |
| Improve education on relation between animal welfare and meat quality. | | | | | | | | | | | | | | |
| Pay price according to meat quality. | | | | | | | | | | | | | | |

**Are there other practices that should be added to this sustainability scenario?**

| **Scenario 3: Integrated land use**<br>• Integration of crop and animal production<br>• Agrosilvopastoral system<br>• Fostering local product marketing<br>• Mix organic and intensive production systems | Sustainability Indicators: | | |
|---|---|---|---|
| | **Economic** | **Social** | **Environmental** |

| • Avoid trade with countries with less strict rules | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Farm and chain practices** | Most important practices | Income distribution | Profitability | Employment | Economic growth | Gender equality | Animal welfare | Mortality | Food quality | Food safety | Global warming | Energy consumption | Water consumption | Land use |
| Nutrient recycling**.** | | | | | | | | | | | | | | |
| Improve research on mixed beef production systems (alternative to extensive). | | | | | | | | | | | | | | |
| Increase the research on organic and other sustainable beef production technical development (e.g. agrosilvopastoral systems). | | | | | | | | | | | | | | |
| Use of more balanced production systems (soy, corn and brachiaria) to avoid the cattle weight drop because of the dry period**.** | | | | | | | | | | | | | | |
| Improve grazing techniques (more intelligent grazing techniques)**.** | | | | | | | | | | | | | | |
| Increase differentiation in quality by introducing more labour intensive and quality enhancing production processes (e.g. certified beef) (e.g. Sustainable Agriculture Network and Agrosilvopastoral systems). | | | | | | | | | | | | | | |
| Perform toxicological integrative studies on agrosystems (mixed forest, crop and animal production). | | | | | | | | | | | | | | |
| Ensure optimal conditions for animal transport, shortening distance on animal transportation**.** | | | | | | | | | | | | | | |
| Invest in local roads and agroindustry (e.g. mills, pasteurisers)**.** | | | | | | | | | | | | | | |
| Give support, subsidies to farmers to increase their profitability, so that they can invest. | | | | | | | | | | | | | | |
| Government should bear for the construction of infrastructure (lot of dirt roads), and build insemination centres, so that farmers do not have to buy the doses of inputs abroad. | | | | | | | | | | | | | | |
| Subsidise local production to be more self- sufficient and place on the market the locally produces goods. | | | | | | | | | | | | | | |
| Tailoring feed regimes of extensive farm system to a more intensive regime**.** | | | | | | | | | | | | | | |
| Use concentrated feed not to have the animal prone to disease because it runs out of energy (also better conversion of carcass)**.** | | | | | | | | | | | | | | |
| Monitoring systems especially for organic meat (where preventive antibiotics are not allowed). | | | | | | | | | | | | | | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fair trade initiatives like information campaigns in China and India to sensitise about sustainability in beef chains (increase public opinion about sustainability). | | | | | | | | | | | | | | |
| Push on political parties to establish more sustainability-oriented regulations and enhance the entry barriers for supplies. | | | | | | | | | | | | | | |
| Establish a worldwide quality and sustainability standard (focus on food security and food safety). | | | | | | | | | | | | | | |
| Regulation level has to be higher, to comply with international levels of quality of products to be traded. | | | | | | | | | | | | | | |

**Are there other practices that should be added to this sustainability scenario?**

## Pork sustainability scenarios

| **Scenario 1: Integration of animal and crop production**<br>• Integration of animal and crop production<br>• Use of feed sources that do not compete with human consumption<br>• Reuse of manure to make organic fertiliser<br>• Use feed suitable for human consumption monitored with feed-print models | | Sustainability Indicators: | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Economic** | | | | **Social** | | | | | **Environmental** | | | |
| **Farm and chain practices** | Most important practices | Income distribution | Profitability | Employment | Economic growth | Gender equality | Animal welfare | Mortality | Food quality | Food safety | Global warming | Energy consumption | Water consumption | Land use |
| Nutrient recycling (manure comes back to the crop producer) between agricultural sectors, invest in meat quality and traceability. | | | | | | | | | | | | | | |
| Make sure that the animal feed is not in competition with more valuable food intended for human use (use by-products that cannot be used for human consumption). | | | | | | | | | | | | | | |
| Use fertilisers made from manure. | | | | | | | | | | | | | | |
| Invest in biofuel production from the process of manure into energy and the by-product can still become a fertiliser. | | | | | | | | | | | | | | |
| Use DSS and models to optimize the nutritional value of the feed ingredient on cost price and expected performance of the animal (using percentages of by-products in the formula). | | | | | | | | | | | | | | |
| Mix manure with straw to have a fertiliser and sell it branded. | | | | | | | | | | | | | | |
| Use a feed-print model (optimize each ingredient on $CO_2$ | | | | | | | | | | | | | | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| equivalents of the feed production, maintaining the expected animal performance high)**.** | | | | | | | | | | | | | | |

**Are there other practices that should be added to this sustainability scenario?**

| **Scenario 2: Sophistication**<br>• Diversified chains<br>• Local meat processing and local raw material purchasing<br>• Enhance Brazilian internal market | | Sustainability Indicators: | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Economic** | | | | **Social** | | | | | **Environmental** | | | |
| **Farm and chain practices** | Most important practices | Income distribution | Profitability | Employment | Economic growth | Gender equality | Animal welfare | Mortality | Food quality | Food safety | Global warming | Energy consumption | Water consumption | Land use |
| Switch from commodity system to a more diversified pork sector (e.g. the KDV chain in the Netherlands and Green Farms Star Initiative with animal protection labels). | | | | | | | | | | | | | | |
| Operational excellence and scale increase. | | | | | | | | | | | | | | |
| Create new niches. | | | | | | | | | | | | | | |
| Better outdoor access (housing). | | | | | | | | | | | | | | |
| Genetic improvement**.** | | | | | | | | | | | | | | |
| Different nutrition (more responsible), recognizable with claims on a label. | | | | | | | | | | | | | | |
| The independent producers should offer room for new systems of coordination and create niche markets with more added value products. | | | | | | | | | | | | | | |
| Local slaughtering. | | | | | | | | | | | | | | |
| Local meat processing. | | | | | | | | | | | | | | |
| Local raw material purchases. | | | | | | | | | | | | | | |
| Local feedstuff supply (% of money that is produced locally and retained internally should be higher). | | | | | | | | | | | | | | |
| Nutrient recycling (manure comes back to the crop producer) between agricultural sectors | | | | | | | | | | | | | | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Invest on meat quality and traceability**.** | | | | | | | | | | | | | | |
| Improve manure management (make energy out of manure) and methane use**.** | | | | | | | | | | | | | | |
| Ensure short commercial channels. | | | | | | | | | | | | | | |
| Make pressure on these supply chains to establish sustainable claims and standards**.** | | | | | | | | | | | | | | |
| Campaigns to sensitise people (versus prejudices about pork meat as fatty and unhealthy). | | | | | | | | | | | | | | |

**Are there other practices that should be added to this sustainability scenario?**

| **Scenario 3: Balanced sustainability**<br>• Animal welfare in global agenda and minimize microbe resistance in humans from use of antibiotics and heavy metals during animal production<br>• More sustainability standards to be applied in the supply chain | | Sustainability Indicators: | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Economic** | | | | **Social** | | | | | **Environmental** | | | |
| **Farm and chain practices** | Most important practices | Income distribution | Profitability | Employment | Economic growth | Gender equality | Animal welfare | Mortality | Food quality | Food safety | Global warming | Energy consumption | Water consumption | Land use |
| Biogas investment to make energy for the feed mills (investment costs levelled by the savings of self-sufficiency in energy use)**.** | | | | | | | | | | | | | | |
| Mix manure with straw to have a fertiliser and sell it branded**.** | | | | | | | | | | | | | | |
| Adapt the system into more animal-friendly (more animal welfare), especially at the housing. | | | | | | | | | | | | | | |
| Invest in monitoring system in later part of SC to ensure about residues management and about the antibiotic resistant bacteria**.** | | | | | | | | | | | | | | |
| Establish new sustainability standards to be applied n Brazil to better animal welfare and better the tradability to EU markets**.** | | | | | | | | | | | | | | |
| Campaigns to sensitise people (versus prejudices about pork meat as fatty and unhealthy). | | | | | | | | | | | | | | |
| Minimize risk for development of microbe resistance of human in the chains (exposure to antibiotic resistant bacteria) given by overuse of antibiotics and heavy metals (these increase the chances that human have microbial resistance to antibiotics) during animal production. | | | | | | | | | | | | | | |

**Are there other practices that should be added to this sustainability scenarios?**

# Appendix 3 – Interview document of the second round of interviews

## Appendix 3A - Pre-interview questionnaire (second round of interviews)

**Questionnaire**
**Sustainability in the beef and pork Brazilian supply chains**

This questionnaire that I have asked you to fill in gives me upfront information about the supply chain practices that may help the supply chains of beef and pork in Brazil to be more sustainable. Therefore, the objective is to provide farmers and other actors of these supply chains with scenarios of sustainable development that are feasible to implement and that use sustainable supply chain management practices. At this stage, the questionnaire is meant to detail and make applicable (with a description of the concrete practices), with your help, a number of sustainable future scenarios that might be feasible for a beef and pork supply chain to be attained. I appreciate your effort and help. You are requested to **ASSESS** the level of **SUSTAINABILITY** of the **six scenarios for Brazilian or the global beef and pork chains** that are presented**,** and to select a number of **SUSTAINABLE SCENARIOS** out of the six presented that you will be asked to **DETAIL**.
For this purpose, I have created this file with **4 PARTS** or topics to discuss.

**PART 1** is the Generic part. General information about you will be asked. Questions from 1 to 5 belong to Part 1.
**PART 2** deals with the assessment (scoring) of six sustainability scenarios of pork and beef Brazilian supply chains. Questions 6 and 7 belong to Part 2.
**PART 3** deals with the selection, performed by the respondents, of the scenarios that he/she wants to detail. Question 8 belongs to Part 3.
**PART 4** deals with the detailing of the selected sustainability scenarios for pork and beef, to make those scenarios applicable to the Brazilian case. Question 9 belongs to Part 4.

Filling this questionnaire will take approximately 45-60 minutes.

Thank you for your collaboration!

---

**PART 1 – GENERIC INFORMATION**

16. Name of the respondent _____

17. Name of your institution _____

18. Your company/organization is a (Single answer):

    a. Research institution
    b. University
    c. Ministry (e.g. of Agriculture). If yes, specify: _____
    d. Association
    e. Class entity (e,g, Brazilian Agribusiness Association)
    f. Foreign Government
    g. Statistics centre
    h. Business involved in the beef or pork supply chain. If Yes, specify what (e.g. farmer, processor, abattoir, trader, etc.): _____
    i. Other: _____

19. Your function/position _____

20. In which field are you an expertise? (Multiple answers)

    a. Supply chain management
    b. Pork sector
    c. Beef sector
    d. Sustainable development
    e. Agriculture
    f. Sustainable supply chains
    g. Animal science
    h. Brazilian supply chains
    i. Other: _____

**PART 2 – SCORING THE SUSTAINABILITY OF A SET OF SCENARIOS FOR BEEF AND PORK**

21. Please, give a **score** to the **three sustainable scenarios for beef** using the 5 points Likert scale provided in the table below for each of the sustainability indicators shown (fill in just the orange coloured columns).

    - **Instructions:**

    Reading the table below from left to right, you will find the name of the sustainable scenario (first column), and its description through a number of practices to be involved to make it feasible (second column). The third column shows 13 sustainability indicators that might be affected by this scenario. You are asked to kindly give a score from 1 (very bad) to 5 (very good) to the sustainability indicator according to potential situation ex-post the implementation of that scenario.

| Sustainable scenario | SCM practices employed in the scenario | Sustainability indicator (example of *sustainability measure* involved) | Sustainability assessment (1= very bad, 5 = very good) | | | | |
|---|---|---|---|---|---|---|---|
| **Intensification**<br>• Intensification of the beef production systems<br>• Apply carcass certification schemes | 1. Give importance to welfare considerations (i.e. more shadow for beef).<br>2. For intensification, there is the need of more nutrients in the grass: change the grass, but then biodiversity changes, or use inputs to make grass more nutritious.<br>3. Nutrient recycling.<br>4. Local feedstuff supply.<br>5. Use grain instead of grazing grass (better weigh conversion) for intensification, along with giving extra feed, grain (bought from another area).<br>6. Improve the feeding technologies (better feed, slaughter the animal when younger, less emissions).<br>7. Improve grass and land management (farm management techniques) to improve productions.<br>8. Improve land management and valorise the products when it comes from young beef (underline the importance of slaughtering young animals, more intensive management of the system.<br>9. Governance system could stimulate to use DSS's to help farmers to make operations more efficient (intensification).<br>10. HACCP system.<br>11. Better genetics (less fat).<br>12. Make the farms more efficient (efficiency just at economic level, e.g. DEA sustainability indicators).<br>13. Action plan according to the productive efficiency of extensive farm systems (including organic farming).<br>14. Mix of organic and intensive beef production system.<br>15. Use concentrated feed not to have the animal prone to disease because it runs out of energy (also better conversion of carcass).<br>16. Pay according to class of quality.<br>**17.** Use tags to check sanitary status of herd, transportation following the limits (no. heads) set by the law. | **Income distribution** | 1 | 2 | 3 | 4 | 5 |
| | | **Profitability**<br>*Profits* | 1 | 2 | 3 | 4 | 5 |
| | | **Employment**<br>*Jobs created* | 1 | 2 | 3 | 4 | 5 |
| | | **Economic growth**<br>*Turnover sales (%)* | 1 | 2 | 3 | 4 | 5 |
| | | **Gender equality**<br>*Ratio of average female wage to male wage* | 1 | 2 | 3 | 4 | 5 |
| | | **Animal welfare**<br>*Rely on 5 point Likert scale level* | 1 | 2 | 3 | 4 | 5 |
| | | **Mortality**<br>*Mortality rates (%)* | 1 | 2 | 3 | 4 | 5 |
| | | **Food quality**<br>*Rely on 5 point Likert scale level* | 1 | 2 | 3 | 4 | 5 |
| | | **Food safety**<br>*Rely on 5 point Likert scale level* | 1 | 2 | 3 | 4 | 5 |
| | | **GHG emission**<br>*GHG indicator* | 1 | 2 | 3 | 4 | 5 |
| | | **Energy dependence**<br>*Total energy consumption in each phase* | 1 | 2 | 3 | 4 | 5 |
| | | **Land use** | 1 | 2 | 3 | 4 | 5 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 18. Monitoring systems especially for organic meat (where preventive antibiotics are not allowed)**.**<br>19. Documentation system with farmers registering operations (document practices)**.**<br>20. Apply carcass certification schemes. | *Land use change* | | | | | |
| | | **Water resources**<br>*Quantity of water consumed (manufacturing)* | 1 | 2 | 3 | 4 | 5 |
| **Local production and sustainable operations**<br>• Reduce transport (shorter routes)<br>• Renew infrastructure) | 1. Local slaughtering.<br>2. Local meat processing.<br>3. Local feedstuff supply.<br>4. Improve sustainable transport (river, low impacting vehicles and support sustainable beef production systems**.**<br>5. Expand the transportation network, but with the use of sustainable modes**.**<br>6. Improve legislation on live animals transport and slaughtering welfare, support investments in modern vehicles (trucks and boats) for animals transport (In order to invest, the returns for the farmer have to be higher)**.**<br>7. Improve education on relation between animal welfare and meat quality.<br>8. Pay price according to meat quality. | **Income distribution** | 1 | 2 | 3 | 4 | 5 |
| | | **Profitability**<br>*Profits* | 1 | 2 | 3 | 4 | 5 |
| | | **Employment**<br>*Jobs created* | 1 | 2 | 3 | 4 | 5 |
| | | **Economic growth**<br>*Turnover sales (%)* | 1 | 2 | 3 | 4 | 5 |
| | | **Gender equality**<br>*Ratio of average female wage to male wage* | 1 | 2 | 3 | 4 | 5 |
| | | **Animal welfare**<br>*Rely on 5 point Likert scale level* | 1 | 2 | 3 | 4 | 5 |
| | | **Mortality**<br>*Mortality rates (%)* | 1 | 2 | 3 | 4 | 5 |
| | | **Food quality**<br>*Rely on 5 point Likert scale level* | 1 | 2 | 3 | 4 | 5 |
| | | **Food safety**<br>*Rely on 5 point Likert scale level* | 1 | 2 | 3 | 4 | 5 |
| | | **GHG emission**<br>*GHG indicator* | 1 | 2 | 3 | 4 | 5 |
| | | **Energy dependence**<br>*Total energy consumption in each phase* | 1 | 2 | 3 | 4 | 5 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | **Land use**<br>*Land use change* | 1 | 2 | 3 | 4 | 5 |
| | | **Water resources**<br>*Quantity of water consumed (manufacturing)* | 1 | 2 | 3 | 4 | 5 |
| **Integrated land use**<br>• Integration of crop and animal production<br>• Agrosilvopastoral system<br>• Fostering local product marketing<br>• Mix organic and intensive production systems<br>• Avoid trade with countries with less strict rules | 1. Nutrient recycling**.**<br>2. Improve research on mixed beef production systems (alternative to extensive).<br>3. Increase the research on organic and other sustainable beef production technical development (e.g. agrosilvopastoral systems).<br>4. Use of more balanced production systems (soy, corn and brachiaria) to avoid the cattle weight drop because of the dry period**.**<br>5. Improve grazing techniques (more intelligent grazing techniques)**.**<br>6. Increase differentiation in quality by introducing more labour intensive and quality enhancing production processes (e.g. certified beef) (e.g. Sustainable Agriculture Network and Agrosilvopastoral systems).<br>7. Perform toxicological integrative studies on agrosystems (mixed forest, crop and animal production).<br>8. Ensure optimal conditions for animal transport, shortening distance on animal transportation**.**<br>9. Invest in local roads and agroindustry (e.g. mills, pasteurisers)**.**<br>10. Give support, subsidies to farmers to increase their profitability, so that they can invest.<br>11. Government should bear for the construction of infrastructure (lot of dirt roads), and build insemination centres, so that farmers do not have to buy the doses of inputs abroad.<br>12. Subsidise local production to be more self- sufficient and place on the market the locally produced goods.<br>13. Tailoring feed regimes of extensive farm system to a more intensive regime**.**<br>14. Use concentrated feed not to have the animal prone to disease | **Income distribution** | 1 | 2 | 3 | 4 | 5 |
| | | **Profitability**<br>*Profits* | 1 | 2 | 3 | 4 | 5 |
| | | **Employment**<br>*Jobs created* | 1 | 2 | 3 | 4 | 5 |
| | | **Economic growth**<br>*Turnover sales (%)* | 1 | 2 | 3 | 4 | 5 |
| | | **Gender equality**<br>*Ratio of average female wage to male wage* | 1 | 2 | 3 | 4 | 5 |
| | | **Animal welfare**<br>*Rely on 5 point Likert scale level* | 1 | 2 | 3 | 4 | 5 |
| | | **Mortality**<br>*Mortality rates (%)* | 1 | 2 | 3 | 4 | 5 |
| | | **Food quality**<br>*Rely on 5 point Likert scale level* | 1 | 2 | 3 | 4 | 5 |
| | | **Food safety**<br>*Rely on 5 point Likert scale level* | 1 | 2 | 3 | 4 | 5 |
| | | **GHG emission**<br>*GHG indicator* | 1 | 2 | 3 | 4 | 5 |
| | | **Energy dependence**<br>*Total energy consumption in each* | 1 | 2 | 3 | 4 | 5 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | because it runs out of energy (also better conversion of carcass).<br>15. Monitoring systems especially for organic meat (where preventive antibiotics are not allowed).<br>16. Fair trade initiatives like information campaigns in China and India to sensitise about sustainability in beef chains (increase public opinion about sustainability).<br>17. Push on political parties to establish more sustainability-oriented regulations and enhance the entry barriers for supplies.<br>18. Establish a worldwide quality and sustainability standard (focus on food security and food safety).<br>19. Regulation level has to be higher, to comply with international levels of quality of products to be traded. | *phase* | | | | | |
| | | **Land use**<br>*Land use change* | 1 | 2 | 3 | 4 | 5 |
| | | **Water resources**<br>*Quantity of water consumed (manufacturing)* | 1 | 2 | 3 | 4 | 5 |

22. Please, give a **score** to the **three sustainable scenarios for pork** using the 5 points Likert scale provided in the table below for each of the sustainability indicators shown (fill in just the orange coloured columns).
    - **Instructions:**

    Reading the table below from left to right, you will find the name of the sustainable scenario (first column), and its description through a number of practices to be involved to make it feasible (second column). The third column shows 13 sustainability indicators that might be affected by this scenario. You are asked to kindly give a score from 1 (very bad) to 5 (very good) to the sustainability indicator according to potential situation ex-post the implementation of that scenario.

| Sustainable scenario | SCM practices employed in the scenario | Sustainability indicator (example of *sustainability measure* involved) | Sustainability assessment (1= very bad, 3 = unchanged, 5 = very good) | | | | |
|---|---|---|---|---|---|---|---|
| **Integration of animal and crop production**<br>• Integration of animal and crop production<br>• Use of feed sources that do not compete with human consumption<br>• Reuse of manure to make organic fertiliser<br>• Use feed suitable for | 1. Nutrient recycling (manure comes back to the crop producer) between agricultural sectors.<br>2. Invest in meat quality and traceability.<br>3. Make sure that the animal feed is not in competition with more valuable food intended for human use (use by-products that cannot be used for human consumption).<br>4. Use fertilisers made from manure.<br>5. Invest in biofuel production from the process of manure into energy and the by-product can still become a fertiliser.<br>6. Use DSS and models to optimize the nutritional value of the | **Income distribution** | 1 | 2 | 3 | 4 | 5 |
| | | **Profitability**<br>*Profits* | 1 | 2 | 3 | 4 | 5 |
| | | **Employment**<br>*Jobs created* | 1 | 2 | 3 | 4 | 5 |
| | | **Economic growth**<br>*Turnover sales (%)* | 1 | 2 | 3 | 4 | 5 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| human consumption monitored with feed-print models | feed ingredient on cost price and expected performance of the animal (using percentages of by-products in the formula)**.**<br>7. Mix manure with straw to have a fertiliser and sell it branded**.**<br>8. Use a feed-print model (optimize each ingredient on $CO_2$ equivalents of the feed production, maintaining the expected animal performance high)**.** | **Gender equality**<br>*Ratio of average female wage to male wage* | 1 | 2 | 3 | 4 | 5 |
| | | **Animal welfare**<br>*Rely on 5 point Likert scale level* | 1 | 2 | 3 | 4 | 5 |
| | | **Mortality**<br>*Mortality rates (%)* | 1 | 2 | 3 | 4 | 5 |
| | | **Food quality**<br>*Rely on 5 point Likert scale level* | 1 | 2 | 3 | 4 | 5 |
| | | **Food safety**<br>*Rely on 5 point Likert scale level* | 1 | 2 | 3 | 4 | 5 |
| | | **GHG emission**<br>*GHG indicator* | 1 | 2 | 3 | 4 | 5 |
| | | **Energy dependence**<br>*Total energy consumption in each phase* | 1 | 2 | 3 | 4 | 5 |
| | | **Land use**<br>*Land use change* | 1 | 2 | 3 | 4 | 5 |
| | | **Water resources**<br>*Quantity of water consumed (manufacturing)* | 1 | 2 | 3 | 4 | 5 |
| **Sophistication**<br>• Diversified chains<br>• Local meat processing and local raw material purchasing<br>• Enhance Brazilian internal market | 1. Switch from commodity system to a more diversified pork sector (e.g. the KDV chain in the Netherlands and Green Farms Star Initiative with animal protection labels).<br>2. Operational excellence and scale increase.<br>3. Create new niches.<br>4. Better outdoor access (housing).<br>5. Genetic improvement**.**<br>6. Different nutrition (more responsible), recognizable with claims on a label.<br>7. The independent producers should offer room for new systems | **Income distribution** | 1 | 2 | 3 | 4 | 5 |
| | | **Profitability**<br>*Profits* | 1 | 2 | 3 | 4 | 5 |
| | | **Employment**<br>*Jobs created* | 1 | 2 | 3 | 4 | 5 |
| | | **Economic growth**<br>*Turnover sales (%)* | 1 | 2 | 3 | 4 | 5 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | of coordination and create niche markets with more added value products.<br>8. Local slaughtering.<br>9. Local meat processing.<br>10. Local raw material purchases.<br>11. Local feedstuff supply (% of money that is produced locally and retained internally should be higher).<br>12. Nutrient recycling (manure comes back to the crop producer) between agricultural sectors<br>13. Invest on meat quality and traceability**.**<br>14. Improve manure management (make energy out of manure) and methane use**.**<br>15. Ensure short commercial channels.<br>16. Make pressure on these supply chains to establish sustainable claims and standards**.**<br>17. Campaigns to sensitise people (versus prejudices about pork meat as fatty and unhealthy). | | | | | | |
| | | **Gender equality**<br>*Ratio of average female wage to male wage* | 1 | 2 | 3 | 4 | 5 |
| | | **Animal welfare**<br>*Rely on 5 point Likert scale level* | 1 | 2 | 3 | 4 | 5 |
| | | **Mortality**<br>*Mortality rates (%)* | 1 | 2 | 3 | 4 | 5 |
| | | **Food quality**<br>*Rely on 5 point Likert scale level* | 1 | 2 | 3 | 4 | 5 |
| | | **Food safety**<br>*Rely on 5 point Likert scale level* | 1 | 2 | 3 | 4 | 5 |
| | | **GHG emission**<br>*GHG indicator* | 1 | 2 | 3 | 4 | 5 |
| | | **Energy dependence**<br>*Total energy consumption in each phase* | 1 | 2 | 3 | 4 | 5 |
| | | **Land use**<br>*Land use change* | 1 | 2 | 3 | 4 | 5 |
| | | **Water resources**<br>*Quantity of water consumed (manufacturing)* | 1 | 2 | 3 | 4 | 5 |
| **Balanced sustainability**<br>• Animal welfare in global agenda and minimize microbe resistance in humans from use of antibiotics and heavy metals during animal production<br>• More sustainability | 1. Biogas investment to make energy for the feed mills (investment costs levelled by the savings of self-sufficiency in energy use)**.**<br>2. Mix manure with straw to have a fertiliser and sell it branded**.**<br>3. Adapt the system into more animal-friendly (more animal welfare), especially at the housing.<br>4. Invest in monitoring system in later part of SC to ensure about residues management and about the antibiotic resistant bacteria**.** | **Income distribution** | 1 | 2 | 3 | 4 | 5 |
| | | **Profitability**<br>*Profits* | 1 | 2 | 3 | 4 | 5 |
| | | **Employment**<br>*Jobs created* | 1 | 2 | 3 | 4 | 5 |
| | | **Economic growth** | 1 | 2 | 3 | 4 | 5 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| standards to be applied in the supply chain | 5. Establish new sustainability standards to be applied n Brazil to better animal welfare and better the tradability to EU markets.<br>6. Campaigns to sensitise people (versus prejudices about pork meat as fatty and unhealthy).<br>7. Minimize risk of development of microbe resistance of human in the chains (exposure to antibiotic resistant bacteria) given by overuse of antibiotics and heavy metals (these increase the chances that human have microbial resistance to antibiotics) during animal production. | *Turnover sales (%)* | | | | | |
| | | **Gender equality**<br>*Ratio of average female wage to male wage* | 1 | 2 | 3 | 4 | 5 |
| | | **Animal welfare**<br>*Rely on 5 point Likert scale level* | 1 | 2 | 3 | 4 | 5 |
| | | **Mortality**<br>*Mortality rates (%)* | 1 | 2 | 3 | 4 | 5 |
| | | **Food quality**<br>*Rely on 5 point Likert scale level* | 1 | 2 | 3 | 4 | 5 |
| | | **Food safety**<br>*Rely on 5 point Likert scale level* | 1 | 2 | 3 | 4 | 5 |
| | | **GHG emission**<br>*GHG indicator* | 1 | 2 | 3 | 4 | 5 |
| | | **Energy dependence**<br>*Total energy consumption in each phase* | 1 | 2 | 3 | 4 | 5 |
| | | **Land use**<br>*Land use change* | 1 | 2 | 3 | 4 | 5 |
| | | **Water resources**<br>*Quantity of water consumed (manufacturing)* | 1 | 2 | 3 | 4 | 5 |

**PART 3 – SELECTION OF THE SCENARIOS TO DETAIL**

23. Please, choose among the following sustainability scenarios the ones that you prefer (or all of them) or have more knowledge about, to help us with the description or "detailing" of those scenarios, and make it applicable to the Brazilian case.

**Beef** sustainable scenarios:

| Sustainable scenario | Choice of the scenarios to detail | |
|---|---|---|
| **Intensification** | Yes | No |
| **Local production and sustainable operations** | Yes | No |
| **Integrated land use** | Yes | No |

**Pork** sustainable scenarios:

| Sustainable scenario | Choice of the scenarios to detail | |
|---|---|---|
| **Integration of animal and crop production** | Yes | No |
| **Sophistication** | Yes | No |
| **Balanced sustainability** | Yes | No |

**PART 4 – DETAILING OF THE SCENARIOS**

24. In the next table, please, fill out the required spaces (coloured ones) for the selected scenarios (for the **future** of the pork and beef chains in Brazil), following the titles and the instructions.
    - **Note**:

Just **fill in** the spaces in the next two tables that are belonging to the **sustainable scenarios** that **you chose** in **question 8**.

- **Instruction**:

For each of the scenarios that you chose in question 8 for pork and beef, read the name of the scenario (first column) that highlights the main future sustainable situations in it. Then, read through the practices involved in the scenario (second column). Indicate if the practice is important (Yes) or not (No) in the third column (coloured space). In the fourth column you will be asked to add more practices that should be employed in that sustainable scenario (coloured space). For each (or some of) the practices of the sustainable scenarios, indicate a number of practical/concrete applications of the practices (that is equivalent to providing a 'detailing' of the practices).

*For example:*
*The beef intensification of the production system (scenario) might require a scaling up of the farm (practice), and what I ask to you is to make these practices concrete, for instance mentioning the number of heads that the herd should have*.

## Beef:

| Sustainable Scenario | Practices involved | Important? | Practical/concrete application of the practices (detailing) |
|---|---|---|---|
| **Intensification**<br>• Intensification of the beef production systems<br>• Apply carcass certification schemes | 1. Give importance to welfare considerations (i.e. more shadow for beef). | Yes<br>No | |
| | 2. For intensification, there is the need of more nutrients in the grass: change the grass, but then biodiversity changes, or use inputs to make grass more nutritious**.** | Yes<br>No | |
| | 3. Nutrient recycling**.** | Yes<br>No | |
| | 4. Local feedstuff supply**.** | Yes<br>No | |
| | 5. Use grain instead of grazing grass (better weigh conversion) for intensification, along with giving extra feed, grain (bought from another area)**.** | Yes<br>No | |
| | 6. Improve the feeding technologies (better feed, slaughter the animal when younger, less emissions)**.** | Yes<br>No | |
| | 7. Improve grass and land management (farm management techniques) to improve productions**.** | Yes<br>No | |
| | 8. Improve land management and valorise the products when it comes from young beef (underline the importance of slaughtering young animals, more intensive management of the system. | Yes<br>No | |

| | | | |
|---|---|---|---|
| | 9. Governance system could stimulate to use DSS's to help farmers to make operations more efficient (intensification)**.** | Yes<br>No | |
| | 10. HACCP system**.** | Yes<br>No | |
| | 11. Better genetics (less fat)**.** | Yes<br>No | |
| | 12. Make the farms more efficient (efficiency just at economic level, e.g. DEA sustainability indicators). | Yes<br>No | |
| | 13. Action plan according to the productive efficiency of extensive farm systems (including organic farming). | Yes<br>No | |
| | 14. Mix of organic and intensive beef production system**.** | Yes<br>No | |
| | 15. Use concentrated feed not to have the animal prone to disease because it runs out of energy (also better conversion of carcass)**.** | Yes<br>No | |
| | 16. Pay according to class of quality. | Yes<br>No | |
| | **17.** Use tags to check sanitary status of herd, transportation following the limits (no. heads) set by the law**.** | Yes<br>No | |
| | 18. Monitoring systems especially for organic meat (where preventive antibiotics are not allowed)**.** | Yes<br>No | |

| | | | |
|---|---|---|---|
| | | | |
| | 19. Documentation system with farmers registering operations (document practices)**.** | Yes<br>No | |
| | 20. Apply carcass certification schemes | Yes<br>No | |
| | **Are there other practices to be added to the aforementioned ones for this scenario?** | | |
| | | | |
| **Local production and sustainable operations**<br>• Reduce transport (shorter routes)<br>• Renew infrastructure) | 1. Local slaughtering. | Yes<br>No | |
| | 2. Local meat processing. | Yes<br>No | |
| | 3. Local feedstuff supply. | Yes<br>No | |
| | 4. Improve sustainable transport (river, low impacting vehicles and support sustainable beef production systems**.** | Yes<br>No | |
| | 5. Expand the transportation network, but with the use of sustainable modes**.** | Yes<br>No | |

| | | | |
|---|---|---|---|
| | | | |
| | 6. Improve legislation on live animals transport and slaughtering welfare, support investments in modern vehicles (trucks and boats) for animals transport (In order to invest, the returns for the farmer have to be higher)**.** | Yes<br>No | |
| | 7. Improve education on relation between animal welfare and meat quality. | Yes<br>No | |
| | 8. Pay price according to meat quality. | Yes<br>No | |
| | **Are there other practices to be added to the aforementioned ones for this scenario?** | | |
| | | | |
| **Integrated land use**<br>• Integration of crop and animal production<br>• Agrosilvopastoral system<br>• Fostering local product marketing<br>• Mix organic and intensive production systems<br>• Avoid trade with countries with | 1. Nutrient recycling**.** | Yes<br>No | |
| | 2. Improve research on mixed beef production systems (alternative to extensive). | Yes<br>No | |
| | 3. Increase the research on organic and other sustainable beef production technical development (e.g. Agrosilvopastoral systems). | Yes<br>No | |

| | | | |
|---|---|---|---|
| less strict rules | | | |
| | 4. Use of more balanced production systems (soy, corn and brachiaria) to avoid the cattle weight drop because of the dry period**.** | Yes<br>No | |
| | 5. Improve grazing techniques (more intelligent grazing techniques)**.** | Yes<br>No | |
| | 6. Increase differentiation in quality by introducing more labour intensive and quality enhancing production processes (e.g. certified beef) (e.g. Sustainable Agriculture Network and Agrosilvopastoral systems). | Yes<br>No | |
| | 7. Perform toxicological integrative studies on Agrosystems (mixed forest, crop and animal production). | Yes<br>No | |
| | 8. Ensure optimal conditions for animal transport, shortening distance on animal transportation**.** | Yes<br>No | |
| | 9. Invest in local roads and agroindustry (e.g. mills, pasteurisers)**.** | Yes<br>No | |
| | 10. Give support, subsidies to farmers to increase their profitability, so that they can invest. | Yes<br>No | |
| | 11. Government should bear for the construction of infrastructure (lot of dirt roads), and build insemination centres, so that farmers do not have to buy the doses of inputs abroad. | Yes<br>No | |
| | 12. Subsidise local production to be more self-sufficient and place on the market the locally produces goods. | Yes<br>No | |

| | | | |
|---|---|---|---|
| | 13. Tailoring feed regimes of extensive farm system to a more intensive regime**.** | Yes<br>No | |
| | 14. Use concentrated feed not to have the animal prone to disease because it runs out of energy (also better conversion of carcass)**.** | Yes<br>No | |
| | 15. Monitoring systems especially for organic meat (where preventive antibiotics are not allowed). | Yes<br>No | |
| | 16. Fair trade initiatives like information campaigns in China and India to sensitise about sustainability in beef chains (increase public opinion about sustainability). | Yes<br>No | |
| | 17. Push on political parties to establish more sustainability-oriented regulations and enhance the entry barriers for supplies**.** | Yes<br>No | |
| | 18. Establish a worldwide quality and sustainability standard (focus on food security and food safety). | Yes<br>No | |
| | 19. Regulation level has to be higher, to comply with international levels of quality of products to be traded**.** | Yes<br>No | |
| | **Are there other practices to be added to the aforementioned ones for this scenario?** | | |

| | | |
|---|---|---|
| | | |

## Pork:

| Sustainable Scenario | Practices involved | Important | Practical/concrete application of the practices (detailing) |
|---|---|---|---|
| **Integration of animal and crop production**<br>• Integration of animal and crop production<br>• Use of feed sources that do not compete with human consumption<br>• Reuse of manure to make organic fertiliser<br>• Use feed suitable for human consumption monitored with feed-print models | 1. Nutrient recycling (manure comes back to the crop producer) between agricultural sectors. | Yes<br>No | |
| | 2. Invest in meat quality and traceability**.** | Yes<br>No | |
| | 3. Make sure that the animal feed is not in competition with more valuable food intended for human use (use by-products that cannot be used for human consumption). | Yes<br>No | |
| | 4. Use fertilisers made from manure**.** | Yes<br>No | |
| | 5. Invest in biofuel production from the process of manure into energy and the by-product can still become a fertiliser**.** | Yes<br>No | |
| | 6. Use DSS and models to optimize the nutritional value of the feed ingredient on cost price and expected performance of the animal (using percentages of by-products in the formula)**.** | Yes<br>No | |
| | 7. Mix manure with straw to have a fertiliser and sell it branded**.** | Yes<br>No | |

| | | | |
|---|---|---|---|
| | | | |
| | **8.** Use a feed-print model (optimize each ingredient on $CO_2$ equivalents of the feed production, maintaining the expected animal performance high)**.** | Yes<br>No | |
| | **Are there other practices to be added to the aforementioned ones for this scenario?** | | |
| | | | |
| **Sophistication**<br>• Diversified chains<br>• Local meat processing and local raw material purchasing<br>• Enhance Brazilian internal market | 1. Switch from commodity system to a more diversified pork sector (e.g. the KDV chain in the Netherlands and Green Farms Star Initiative with animal protection labels). | Yes<br>No | |
| | 2. Operational excellence and scale increase. | Yes<br>No | |
| | 3. Create new niches. | Yes<br>No | |
| | 4. Better outdoor access (housing). | Yes<br>No | |
| | 5. Genetic improvement**.** | Yes<br>No | |

| | | | |
|---|---|---|---|
| | | | |
| | 6. Different nutrition (more responsible), recognizable with claims on a label. | Yes<br>No | |
| | 7. The independent producers should offer room for new systems of coordination and create niche markets with more added value products. | Yes<br>No | |
| | 8. Local slaughtering. | Yes<br>No | |
| | 9. Local meat processing. | Yes<br>No | |
| | 10. Local raw material purchases. | Yes<br>No | |
| | 11. Local feedstuff supply (% of money that is produced locally and retained internally should be higher). | Yes<br>No | |
| | 12. Nutrient recycling (manure comes back to the crop producer) between agricultural sectors | Yes<br>No | |
| | 13. Invest on meat quality and traceability**.** | Yes<br>No | |
| | 14. Improve manure management (make energy out of manure) and methane use**.** | Yes<br>No | |
| | 15. Ensure short commercial channels. | Yes<br>No | |

| | | | |
|---|---|---|---|
| | | | |
| | 16. Make pressure on these supply chains to establish sustainable claims and standards**.** | Yes<br>No | |
| | 17. Campaigns to sensitise people (versus prejudices about pork meat as fatty and unhealthy). | Yes<br>No | |
| | **Are there other practices to be added to the aforementioned ones for this scenario?** | | |
| | | | |
| **Balanced sustainability**<br>• Animal welfare in global agenda and minimize microbe resistance in humans from use of antibiotics and heavy metals during animal production<br>• More sustainability standards to be applied in the supply chain | 1. Biogas investment to make energy for the feed mills (investment costs levelled by the savings of self-sufficiency in energy use)**.** | Yes<br>No | |
| | 2. Mix manure with straw to have a fertiliser and sell it branded**.** | Yes<br>No | |
| | 3. Adapt the system into more animal-friendly (more animal welfare), especially at the housing. | Yes<br>No | |
| | 4. Invest in monitoring system in later part of SC to ensure about residues management and about the antibiotic resistant bacteria**.** | Yes<br>No | |
| | 5. Establish new sustainability standards to be applied n Brazil to better animal welfare and | Yes<br>No | |

| | | | |
|---|---|---|---|
| | better the tradability to EU markets**.** | | |
| | 6. Campaigns to sensitise people (versus prejudices about pork meat as fatty and unhealthy). | Yes<br>No | |
| | 7. Minimize risk of development of microbe resistance of human in the chains (exposure to antibiotic resistant bacteria) given by overuse of antibiotics and heavy metals (these increase the chances that human have microbial resistance to antibiotics) during animal production. | Yes<br>No | |
| | **Are there other practices to be added to the aforementioned ones for this scenario?** | | |
| | | | |

End of the questionnaire.

Thank you for your collaboration!

## Appendix 3B – Framework for the analysis of the second round interviews

**Part 1: generic information**

1. Name respondent
2. Name of the institution
3. Type of company/organization
4. Function/position
5. Expertise

**PART 2 – scoring the sustainability of a set of scenarios for beef and pork**

6. **Beef:**

1. **Intensification**

| Sustainability indicator | Sustainability score | Comments |
|---|---|---|
| 1. Income distribution | | |
| 2. Profitability | | |
| 3. Employment | | |
| 4. Economic growth | | |
| 5. Gender equality | | |
| 6. Animal welfare | | |
| 7. Mortality | | |
| 8. Food quality | | |
| 9. Food safety | | |
| 10. GHG emission | | |
| 11. Energy dependence | | |
| 12. Land use | | |
| 13. Water resources | | |

2. **Local production and sustainable operations**

| Sustainability indicator | Sustainability score | Comments |
|---|---|---|
| 1. Income distribution | | |
| 2. Profitability | | |
| 3. Employment | | |
| 4. Economic growth | | |
| 5. Gender equality | | |
| 6. Animal welfare | | |
| 7. Mortality | | |
| 8. Food quality | | |
| 9. Food safety | | |
| 10. GHG emission | | |
| 11. Energy dependence | | |
| 12. Land use | | |
| 13. Water resources | | |

3. **Integrated land use**

| Sustainability indicator | Sustainability score | Comments |
|---|---|---|
| 1. Income distribution | | |
| 2. Profitability | | |

| | | |
|---|---|---|
| 3. Employment | | |
| 4. Economic growth | | |
| 5. Gender equality | | |
| 6. Animal welfare | | |
| 7. Mortality | | |
| 8. Food quality | | |
| 9. Food safety | | |
| 10. GHG emission | | |
| 11. Energy dependence | | |
| 12. Land use | | |
| 13. Water resources | | |

7. **Pork:**

1. **Integration of animal and crop production**

| Sustainability indicator | Sustainability score | Comments |
|---|---|---|
| 1. Income distribution | | |
| 2. Profitability | | |
| 3. Employment | | |
| 4. Economic growth | | |
| 5. Gender equality | | |
| 6. Animal welfare | | |
| 7. Mortality | | |
| 8. Food quality | | |
| 9. Food safety | | |
| 10. GHG emission | | |
| 11. Energy dependence | | |
| 12. Land use | | |
| 13. Water resources | | |

2. **Sophistication**

| Sustainability indicator | Sustainability score | Comments |
|---|---|---|
| 1. Income distribution | | |
| 2. Profitability | | |
| 3. Employment | | |
| 4. Economic growth | | |
| 5. Gender equality | | |
| 6. Animal welfare | | |
| 7. Mortality | | |
| 8. Food quality | | |
| 9. Food safety | | |
| 10. GHG emission | | |
| 11. Energy dependence | | |
| 12. Land use | | |
| 13. Water resources | | |

3. **Balanced susainability**

| Sustainability indicator | Sustainability | Comments |
|---|---|---|

| | score | |
|---|---|---|
| 1. Income distribution | | |
| 2. Profitability | | |
| 3. Employment | | |
| 4. Economic growth | | |
| 5. Gender equality | | |
| 6. Animal welfare | | |
| 7. Mortality | | |
| 8. Food quality | | |
| 9. Food safety | | |
| 10. GHG emission | | |
| 11. Energy dependence | | |
| 12. Land use | | |
| 13. Water resources | | |

**Part 3: selection of the scenarios to detail**

8.

Beef: 1, 2, 3

Pork: 1, 2, 3

**Part 4: detailing of the scenarios**

8. **Beef**:

1. **Intensification**

| Practices | Specify excluded | Detailing | Explanation |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
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| 4 | | | |
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| 15 | | | |
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| 18 | | | |
| 19 | | | |
| 20 | | | |
| **More practices** | | **Explanation** | |
| | | | |

2. **Local production and sustainable operations**

| Practices | Specify excluded | Detailing | Explanation |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |
| 6 | | | |
| 7 | | | |
| 8 | | | |
| **More practices** | | **Explanation** | |
| | | | |

3. **Integrated land use**

| Practices | Specify excluded | Detailing | Explanation |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |
| 6 | | | |
| 7 | | | |
| 8 | | | |
| 9 | | | |
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| 12 | | | |
| 13 | | | |
| 14 | | | |
| 15 | | | |
| 16 | | | |
| 17 | | | |
| 18 | | | |
| 19 | | | |
| **More practices** | | **Explanation** | |
| | | | |

**Pork:**

1. **Integration of animal and crop production**

| Practices | Specify excluded | Detailing | Explanation |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |

| | | | |
|---|---|---|---|
| 4 | | | |
| 5 | | | |
| 6 | | | |
| 7 | | | |
| **More practices** | | **Explanation** | |
| | | | |

2. **Sophistication**

| **Practices** | **Specify excluded** | **Detailing** | **Explanation** |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |
| 6 | | | |
| 7 | | | |
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| 11 | | | |
| 12 | | | |
| 13 | | | |
| 14 | | | |
| 15 | | | |
| 16 | | | |
| 17 | | | |
| **More practices** | | **Explanation** | |
| | | | |

3. **Balanced sustainability**

| **Practices** | **Specify excluded** | **Detailing** | **Explanation** |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |
| 6 | | | |
| 7 | | | |
| **More practices** | | **Explanation** | |
| | | | |

## Appendix 3C – Framework for the comparison of the second round of interviews

### 1) Assessment scenarios

**Beef**

| | | Respondents | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Scenario | Sustainable indicator | Canali | Halberg | Petre | Udo | Hoste | Mancebo | Vellinga | Soysal | Pashaei | Rijpkema | Borbolla | Tavares | Average sustainable indicator |
| Intensification | Income distribution | | | | | | | | | | | | | |
| | Profitability | | | | | | | | | | | | | |
| | Employment | | | | | | | | | | | | | |
| | Economic growth | | | | | | | | | | | | | |
| | Gender equality | | | | | | | | | | | | | |
| | Animal welfare | | | | | | | | | | | | | |
| | Mortality | | | | | | | | | | | | | |
| | Food quality | | | | | | | | | | | | | |
| | Food safety | | | | | | | | | | | | | |
| | GHG emission | | | | | | | | | | | | | |
| | Energy dependence | | | | | | | | | | | | | |
| | Land use | | | | | | | | | | | | | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | |
| | Water resources | | | | | | | | | | | | | |

| | | Respondents | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Scenario | Sustainable indicator | Canali | Halberg | Petre | Udo | Hoste | Mancebo | Vellinga | Soysal | Pashaei | Rijpkema | Borbolla | Tavares | Average sustainable indicator |
| Local production and sustainable operations | Income distribution | | | | | | | | | | | | | |
| | Profitability | | | | | | | | | | | | | |
| | Employment | | | | | | | | | | | | | |
| | Economic growth | | | | | | | | | | | | | |
| | Gender equality | | | | | | | | | | | | | |
| | Animal welfare | | | | | | | | | | | | | |
| | Mortality | | | | | | | | | | | | | |
| | Food quality | | | | | | | | | | | | | |
| | Food safety | | | | | | | | | | | | | |
| | GHG emission | | | | | | | | | | | | | |
| | Energy dependence | | | | | | | | | | | | | |
| | Land use | | | | | | | | | | | | | |
| | Water | | | | | | | | | | | | | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | resources | | | | | | | | | | | | | |

| | | Respondents | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Scenario | Sustainable indicator | Canali | Halberg | Petre | Udo | Hoste | Mancebo | Vellinga | Soysal | Pashaei | Rijpkema | Borbolla | Tavares | Average sustainable indicator |
| Integrated land use | Income distribution | | | | | | | | | | | | | |
| | Profitability | | | | | | | | | | | | | |
| | Employment | | | | | | | | | | | | | |
| | Economic growth | | | | | | | | | | | | | |
| | Gender equality | | | | | | | | | | | | | |
| | Animal welfare | | | | | | | | | | | | | |
| | Mortality | | | | | | | | | | | | | |
| | Food quality | | | | | | | | | | | | | |
| | Food safety | | | | | | | | | | | | | |
| | GHG emission | | | | | | | | | | | | | |
| | Energy dependence | | | | | | | | | | | | | |
| | Land use | | | | | | | | | | | | | |
| | Water resources | | | | | | | | | | | | | |

**Pork**

| | | Respondents | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Scenario | Sustainable indicator | Canali | Halberg | Petre | Udo | Hoste | Mancebo | Vellinga | Soysal | Pashaei | Rijpkema | Borbolla | Tavares | Average sustainable indicator |
| Integration of animal and crop production | Income distribution | | | | | | | | | | | | | |
| | Profitability | | | | | | | | | | | | | |
| | Employment | | | | | | | | | | | | | |
| | Economic growth | | | | | | | | | | | | | |
| | Gender equality | | | | | | | | | | | | | |
| | Animal welfare | | | | | | | | | | | | | |
| | Mortality | | | | | | | | | | | | | |
| | Food quality | | | | | | | | | | | | | |
| | Food safety | | | | | | | | | | | | | |
| | GHG emission | | | | | | | | | | | | | |
| | Energy dependence | | | | | | | | | | | | | |
| | Land use | | | | | | | | | | | | | |
| | Water resources | | | | | | | | | | | | | |

| | | Respondents | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Scenario | Sustainable indicator | Canali | Halberg | Petre | Udo | Hoste | Mancebo | Vellinga | Soysal | Pashaei | Rijpkema | Borbolla | Tavares | Average sustainable indicator |
| Sophistication | Income distribution | | | | | | | | | | | | | |
| | Profitability | | | | | | | | | | | | | |
| | Employment | | | | | | | | | | | | | |
| | Economic growth | | | | | | | | | | | | | |
| | Gender equality | | | | | | | | | | | | | |
| | Animal welfare | | | | | | | | | | | | | |
| | Mortality | | | | | | | | | | | | | |
| | Food quality | | | | | | | | | | | | | |
| | Food safety | | | | | | | | | | | | | |
| | GHG emission | | | | | | | | | | | | | |
| | Energy dependence | | | | | | | | | | | | | |
| | Land use | | | | | | | | | | | | | |
| | Water resources | | | | | | | | | | | | | |

| | Respondents |
|---|---|

| Scenario | Sustainable indicator | Canali | Halberg | Petre | Udo | Hoste | Mancebo | Vellinga | Soysal | Pashaei | Rijpkema | Borbolla | Tavares | Average sustainable indicator |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Balanced sustainability | Income distribution | | | | | | | | | | | | | |
| | Profitability | | | | | | | | | | | | | |
| | Employment | | | | | | | | | | | | | |
| | Economic growth | | | | | | | | | | | | | |
| | Gender equality | | | | | | | | | | | | | |
| | Animal welfare | | | | | | | | | | | | | |
| | Mortality | | | | | | | | | | | | | |
| | Food quality | | | | | | | | | | | | | |
| | Food safety | | | | | | | | | | | | | |
| | GHG emission | | | | | | | | | | | | | |
| | Energy dependence | | | | | | | | | | | | | |
| | Land use | | | | | | | | | | | | | |
| | Water resources | | | | | | | | | | | | | |

**2) Detailing the scenarios: practices exclusion**

**Beef**

| | | Respondents | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Scenario | Sustainable practice | Canali | Halberg | Petre | Udo | Hoste | Mancebo | Vellinga | Soysal | Olea | Pashaei | Rijpkema | Borbolla | Tavares | Included/ Weak /Excluded |
| Intensification | 1 | | | | | | | | | | | | | | |
| | 2 | | | | | | | | | | | | | | |
| | 3 | | | | | | | | | | | | | | |
| | 4 | | | | | | | | | | | | | | |
| | 5 | | | | | | | | | | | | | | |
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| | 12 | | | | | | | | | | | | | | |
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| | 18 | | | | | | | | | | | | | | |
| | 19 | | | | | | | | | | | | | | |
| | 20 | | | | | | | | | | | | | | |
| | More practices | | | | | | | | | | | | | | |

| | Respondents |
|---|---|

| Scenario | Sustainable practice | Canali | Halberg | Petre | Udo | Hoste | Mancebo | Vellinga | Soysal | Olea | Pashaei | Rijpkema | Borbolla | Tavares | Included/ Weak /Excluded |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Local production and sustainable operations | 1 | | | | | | | | | | | | | | |
| | 2 | | | | | | | | | | | | | | |
| | 3 | | | | | | | | | | | | | | |
| | 4 | | | | | | | | | | | | | | |
| | 5 | | | | | | | | | | | | | | |
| | 6 | | | | | | | | | | | | | | |
| | 7 | | | | | | | | | | | | | | |
| | 8 | | | | | | | | | | | | | | |
| | More practices | | | | | | | | | | | | | | |

| | | Respondents | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Scenario | Sustainable practice | Canali | Halberg | Petre | Udo | Hoste | Mancebo | Vellinga | Soysal | Olea | Pashaei | Rijpkema | Borbolla | Tavares | Included/ Weak /Excluded |
| Integrated land use | 1 | | | | | | | | | | | | | | |
| | 2 | | | | | | | | | | | | | | |
| | 3 | | | | | | | | | | | | | | |
| | 4 | | | | | | | | | | | | | | |
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| | 16 | | | | | | | | | | | | | | |
| | 17 | | | | | | | | | | | | | | |
| | 18 | | | | | | | | | | | | | | |
| | 19 | | | | | | | | | | | | | | |
| | More practices | | | | | | | | | | | | | | |

**Pork**

| | | Respondents | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Scenario | Sustainable practice | Canali | Halberg | Petre | Udo | Hoste | Mancebo | Vellinga | Soysal | Olea | Pashaei | Rijpkema | Borbolla | Tavares | Included/ Weak /Excluded |
| Integrated animal and crop production | 1 | | | | | | | | | | | | | | |
| | 2 | | | | | | | | | | | | | | |
| | 3 | | | | | | | | | | | | | | |
| | 4 | | | | | | | | | | | | | | |
| | 5 | | | | | | | | | | | | | | |
| | 6 | | | | | | | | | | | | | | |
| | 7 | | | | | | | | | | | | | | |
| | 8 | | | | | | | | | | | | | | |
| | More practices | | | | | | | | | | | | | | |

| | | Respondents | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Scenario | Sustainable practice | Canali | Halberg | Petre | Udo | Hoste | Mancebo | Vellinga | Soysal | Olea | Pashaei | Rijpkema | Borbolla | Tavares | Included/ Weak /Excluded |
| [illegible] | 1 | | | | | | | | | | | | | | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | | | | | | | | | | | | | | |
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| | 5 | | | | | | | | | | | | | | |
| | 6 | | | | | | | | | | | | | | |
| | 7 | | | | | | | | | | | | | | |
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| | 9 | | | | | | | | | | | | | | |
| | 10 | | | | | | | | | | | | | | |
| | 11 | | | | | | | | | | | | | | |
| | 12 | | | | | | | | | | | | | | |
| | 13 | | | | | | | | | | | | | | |
| | 14 | | | | | | | | | | | | | | |
| | 15 | | | | | | | | | | | | | | |
| | 16 | | | | | | | | | | | | | | |
| | 17 | | | | | | | | | | | | | | |
| | More practices | | | | | | | | | | | | | | |

| | | Respondents | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Scenario | Sustainable practice | Canali | Halberg | Petre | Udo | Hoste | Mancebo | Vellinga | Soysal | Olea | Pashaei | Rijpkema | Borbolla | Tavares | Included/ Weak /Excluded |
| Balanced sustainability | 1 | | | | | | | | | | | | | | |
| | 2 | | | | | | | | | | | | | | |
| | 3 | | | | | | | | | | | | | | |
| | 4 | | | | | | | | | | | | | | |
| | 5 | | | | | | | | | | | | | | |
| | 6 | | | | | | | | | | | | | | |
| | 7 | | | | | | | | | | | | | | |
| | More practices | | | | | | | | | | | | | | |

**3) Detailed scenarios**

| | Respondent | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Scenario | Mancebo | Canali | Udo | Halberg | Hoste | Petre | Vellinga | Soysal | Olea | Pashaei | Rijpkema | Borbolla |
| **Beef** | | | | | | | | | | | | |
| Intensification | | | | | | | | | | | | |
| Local prod. | | | | | | | | | | | | |
| Integration | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| Integration | | | | | | | | | | | | |
| Sophistication | | | | | | | | | | | | |
| Balanc. sust. | | | | | | | | | | | | |

- **Colours legend:**

**Mancebo: green**
**Canali: red**
**Udo: purple**
**Halberg: light blue**
**Hoste: yellow**
**Petre: grey**
**Vellinga: brown**
**Soysal: dark blue**
**Olea: black**
**Pashaei: pink**
Rijpkema: red barred yellow
Borbolla: black barred yellow

**Beef**

| Scenario | Sustainable practice | Detailing (colour per respondent) |
|---|---|---|
| Intensification | 1 | |
| | 2 | |
| | 3 | |
| | 4 | |
| | 5 | |
| | 6 | |
| | 7 | |
| | 8 | |
| | 9 | |
| | 10 | |
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| | 16 | |
| | 17 | |
| | 18 | |
| | 19 | |
| | 20 | |

| Scenario | Sustainable practice | Detailing (colour per respondent) |
|---|---|---|
| Local production and sustainable operations | 1 | |
| | 2 | |
| | 3 | |
| | 4 | |
| | 5 | |
| | 6 | |
| | 7 | |
| | 8 | |
| | 9 | |

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| | 13 | |
| | 14 | |
| | 15 | |
| | 16 | |
| | 17 | |
| | 18 | |
| | 19 | |
| | 20 | |

| Scenario | Sustainable practice | Detailing (colour per respondent) |
|---|---|---|
| Integrated land use | 1 | |
| | 2 | |
| | 3 | |
| | 4 | |
| | 5 | |
| | 6 | |
| | 7 | |
| | 8 | |
| | 9 | |
| | 10 | |
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**Pork**

| Scenario | Sustainable practice | Detailing (colour per respondent) |
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| Integration of animal and crop production | 1 | |
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| Scenario | Sustainable practice | Detailing (colour per respondent) |
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| Sophistication | 1 | |
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| Scenario | Sustainable practice | Detailing (colour per respondent) |
|---|---|---|
| Balanced sustainability | 1 | |
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# Appendix 4 – Complete detailing of the practices in the scenarios via literature and 2nd round of interviews

**Beef**

| Scenario | Sustainable practice | Detailing from interviews | Detailing from literature |
|---|---|---|---|
| Intensification | 1. Give importance to welfare considerations (i.e. more shadow for beef). | Implement action plans for the animal welfare. Silvopastoral system. Be aware of the ratio heads/$m^2$. Adapt EU regulations to Brazilian case (follow the OIE guidelines). | Implementation of an animal welfare plan at the ranch (e.g. use of white flags to move the herd moving). |
| | 2. For intensification, there is the need of more nutrients in the grass: change the grass, but then biodiversity changes, or use inputs to make grass more nutritious**.** | Research on the types of soil (region-specific) to investigate the optimal grass to use (high protein content), to improve the pasture species and pasture management, e.g. combination of grass and legumes. Fortify grass with P and N. Change the quality of the grass (highly nutrient) or give extra feed to animals. | The use of grass-legume mix feeding. |
| | 3. Nutrient recycling**.** | Research to strategically distribute watery points in order to spread manure and research upon adequate techniques to avoid loss of gas and carbon. Collect manure and scientific management of slurry (e.g. use it as fertiliser). Confined grazing system, use legumes and management of legumes' water. Use models to avoid nutrients imbalance at the farm.. Investigate if it is better (depends on the region) to continue with extensive grazing and give extra feed as supplement (manure is spread naturally) or confine the animal (if confine the animal in feedlot and collect manure to make fertiliser). | Uses paddocks. Fortify the soil mesofauna. Use manure beetles and earthworms. |
| | 4. Improve the feeding technologies (better feed, slaughter the animal when younger, less emissions)**.** | Perform cost-benefit analysis of which of the two alternatives extensive with supplementation or confinement. Improve: rotation of grass, the use of nitrogen fertilizer and lime. Preference for groups of age-homogeneous animals to make feeding more efficient. Slaughter the animal when it is full-grown. Extensive grown animals slaughtered younger that confined ones. | Increase the quota of arable land used to produce feed crops for cattle. Give extra feed throughout the dry season, shade and freshwater available during the pasture. |
| | 5. Improve grass and land management (farm management techniques) to improve productions**.** | Research on soil and grass optimization. Use optimized pasture species, use pasture rotation more intensively (rotation system), use smaller fields for grazing, have the animal moving quicker. Give more feed per hectare of land. Use rotational grazing with separated paddocks. Establish agrosilvopastoral system. | The legume-based pasture is an alternative more intensive feed for animals.<br>Improve the fencing, improve breed of cattle, purchase inputs, improve animal husbandry techniques, provide mineral salt and elephant grass (green chop) in dry season, increase the number (and doses) and type of vaccinations. |
| | 6. Improve land management and valorise the products when it comes from young beef (underline the importance of slaughtering | Investigate which alternative would be more efficient per region. Make research about which feedlots that cattle should have and how much have to be used (the consumption amounts). Valorisation in 2 ways: propaganda to create awareness that young beef is better (sensitization campaigns), subsidising farmers to improve their capacity to invest and have higher margins. | Improve the fencing, improve breed of cattle, purchase inputs, improve animal husbandry techniques, provide mineral salt and elephant grass (green chop) in dry season, increase the number (and doses) and type of vaccinations. |

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| | young animals, more intensive management of the system. | | The rancher has to manage herd more intensively to express its potential. The increase in capital and labour. |
| | 7. Governance system could stimulate to use DSS's to help farmers to make operations more efficient (intensification)**.** | Record keeping to improve information flow in the chain (transparency). Use existing tools on grassland management to follow the paddock operations. Evaluation at the end and employ corrective plans. Reward farmers that use DSS (processors, slaughters, retailers). | |
| | 8. HACCP system**.** | Farmers and other SC actors should have HACCP systems in place (subsidies for small farmers to stimulate). It requires traceability. Require that the supplier of feed has HACCP system implemented. Implement HACCP nationally and impose it to every member of the beef chain. Establish a national campaign to promote its use. | |
| | 9. Better genetics**.** | Selection, cross-breeding, artificial insemination. Suit the genetics of the animal to the system, depending on the market of reference. | |
| | 10. Make the farms more efficient. | Record keeping (use DSS from external service providers). Improve the relationship between farmers and other SC actors. Reward (price) the farmer to stimulate better record keeping. | Employ local manpower. Introduce a pen and corral. Increase in the quota of arable land used to produce feed crops for cattle. Train the workers especially about the behaviour of cattle. Legume-based pasture. |
| | 11. Action plan according to the productive efficiency of extensive farm system. | Production-efficiency plan made by the farmer in association with external expertise (e.g. universities), which starts with recording operations, monitoring, and prioritizing actions. | The increase in capital and labour. |
| | 12. Pay according to class of quality. | Governmental action to define precisely the quality classes, and to establish a system (protocols to be followed) to monitor it. Make market research to understand the market of reference. | |
| | **13.** Use tags to check sanitary status of herd, transportation following the limits (no. heads) set by the law**.** | Implanted electronic chips and record keeping in a catalogue . Develop good transport practices (refer to EU regulations) and Reduce the distance to be covered. Needs a tracking and tracing system. | Individual identification system employed at the farm allows for the total traceability from birth to the abattoir. |
| | 14. Monitoring systems especially for organic meat (where preventive antibiotics are not allowed)**.** | Government monitors food safety. Establish monitoring systems chain-wide to check the operations for both export and local chains. Organic producers should be certified. | Individual identification system employed at the farm allows for the total traceability from birth to the abattoir. |
| | 15. Documentation system with farmers registering | Governmental activity, which demands from farmers to register their activity (with economic stimuli). Record keeping (manager at farm) with automated and user-friendly system. | Register information of pasture costs and operational costs. |

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| | operations (document practices)**.** | | |
| | 16. Apply carcass certification schemes | Apply certification schemes (farmers and slaughters). | Comply with carcass certification standards and with GLOBAL GAP. |

| Scenario | Sustainable practice | Detailing from interviews | Detailing from literature |
|---|---|---|---|
| Local production and sustainable operations | 1. Local slaughtering. | Slaughterhouses must be certified. Build strategic slaughterhouses per production region (first, verify if economically viable). | The development in infrastructure (e.g. in Sao Paulo). |
| | 2. Local meat processing. | Meat processing performed at the same location of the slaughterhouse (vertical integration) or keep processing in EU. | |
| | 3. Local feedstuff supply. | Mixed crop- livestock productions. | |
| | 4. Improve sustainable transport (river), low impacting vehicles and support sustainable beef production systems**.** | Research on location-specific sustainable modes. Make cost-benefit analyses before investing in train and river modes. Use co-modality and inter-modality (hub or satellite DC between modes). Finish the animals in specialized farms close to slaughterhouses. | Use of alternative sustainable modes, e.g. river-ways and air cargos. Monitor refrigerated system (slaughter) on trucks. Promotion of co-modality. The transport modes should be renovated. |
| | 5. Expand the transportation network, but with the use of sustainable modes**.** | Invest in train infrastructure (research feasibility per region). Share the privately owned connections. | Extension of the infrastructure to facilitate trade (step-wise renovation plan). |
| | 6. Improve legislation on live animals transport and slaughtering welfare, support investments in modern vehicles (trucks and boats) for animals transport**.** | Invest in modern trucks by 3PL (governmental tax credit incentives). Develop research to design how to perform rest-stops. | Avoid overstocked trucks and separate the cattle in the truck. Rest-stop requirements, use stressors during handling and transportation. Stocking density should be lower than 400 kg of live weight/$m^2$.<br>Hold transporters and producers accountable for losses during transportation. Follow OIE animal welfare guidelines during transportation. Rely on the Sustainable transport toolbox (from EU). |
| | 7. Improve education on relation between animal welfare and meat quality. | Training of drivers to make them aware of a responsible handling of animals. | Training (e.g. aided by government) for drivers (e.g. on handling and driving behaviour). Frequent check-up of the vehicles. |
| | 8. Pay price according to meat quality. | Make cost benefit analysis on how viable would be increasing the quota of fresh meat exported instead of frozen (price reward is triple). Governmental action. | Change payment system, no more according to the number or the total weight of the truckload. Establish incentives (i.e. payments that reward a more sustainable transport). |

| Scenario | Sustainable practice | Detailing from interviews | Detailing from literature |
|---|---|---|---|

| | | | |
|---|---|---|---|
| Integrated land use | 1. Nutrient recycling**.** | Agrosilvopastoral system. Strategic design of water points. Confined grazing system. Good management of legumes' water. | Timely and efficient use of management of manure to avoid losses due to leaching and volatilisation. Use crop rotations or intercropping production systems. |
| | 2. Improve research on mixed beef production systems (alternative to extensive). | Universities should make more research on mixed beef production systems. Technical improvements. Research on alternative feed sources. Improve the dissemination of the knowledge. | More research on nutrient budget burdens from the large-scale use of lupins as feed, feed utilization and emissions from animals. Research rice production coupled with beef cattle livestock. Research on markers of BSE and scrapie. |
| | 3. Increase the research on organic and other sustainable beef production technical development (e.g. Agrosilvopastoral systems). | Universities should make more research on mixed beef production system. More research on carbon sequestration. Increase research on organic systems and share experience with other countries with similar ecosystems. | Perform strategic research on plant genomics and chemistry, environmental studies on nutrient flows, studies on rumen microbiology. |
| | 4. Use of more balanced production systems (soy, corn and Brachiaria) to avoid the cattle weight drop because of the dry period**.** | Irrigation is a good practice to avoid weight drop during dry season (zoning it). Evaluate the viability of the use of Brachiaria or soy or corn as supplements for beef feed in the dry season. Use intensive rotational grazing management. | Grass-intensive organic cattle farming. Infield (from use of typical grass types to use of grass-clover pasture for grazing, enriched with quality herbs) and outfield (rotation of grass with maize, rice, lupine, feed grain and grass for silage) crop rotations. |
| | 5. Improve grazing techniques (more intelligent grazing techniques)**.** | Expertise support to farmers (agronomists and zootechnicians). Use intensive rotational grazing (fences). | Grow fodder legumes to be used with crop by-products to increase the nutritional value. Rely on grassland-related technical support from research centres. |
| | 6. Increase differentiation in quality by introducing more labour intensive and quality enhancing production processes (e.g. certified beef). | Use rotational grazing. Enhance the number of certified chains in Brazil (using quality enhancing practices). Awareness campaigns to sensitise consumers on sustainability issues. | Use agrosilvopastoral systems (eucalyptus, sorghum and maize, or maize/brachiaria grass intercrop, and cattle). Before all of this, establish partnerships between grain producers and the beef ranchers. |
| | 7. Perform toxicological integrative studies on Agrosystems (mixed forest, crop and animal production). | An health regulation is to be established by policy makers to monitor the toxicity of agrosilvopastural systems. | Monitor diseases like BSE and scrapie and identify potential markers of these diseases on live animals. |
| | 8. Ensure optimal conditions for animal transport, shortening distance on animal transportation**.** | Locating DCs closer to farms, to ensure better infrastructure investments. Shorten distance by more local processing facilities, and modernization of slaughterhouses to handle the animals more efficiently and responsibly. Follow OIE guidelines. | |
| | 9. Invest in local roads and agroindustry (e.g. mills, pasteurisers)**.** | Process more locally soybean. The investment burden could be combined among government and SC actors. | |
| | 10. Give support, subsidies to farmers to increase their profitability, so that they | Government subsidies to farmers. Low interest rates, credit support to farmers. | |

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| | can invest. | | |
| | 11. Government should bear for the construction of infrastructure (lot of dirt roads), and build insemination centres, so that farmers do not have to buy the doses of inputs abroad. | Government (and processors) should invest in the roads, research centres, and an efficient insemination centre system. | |
| | 12. Subsidise local production to be more self-sufficient and place on the market the locally produces goods. | Local private industries and SC members should create a support/safety network to increase the local production. More credits for farmers or disincentives when not improving. | |
| | 13. Tailoring feed regimes of extensive farm system to a more intensive regime**.** | Verify viability of intensifying feed regimes. Buy more feed from outside and legume grass. | |
| | 14. Use concentrated feed not to have the animal prone to disease because it runs out of energy (also better conversion of carcass)**.** | Buy more feed from outside. Verify economic viability, first. | |
| | 15. Monitoring systems especially for organic meat (where preventive antibiotics are not allowed). | Governmental law that forces organic systems to monitor operations. Extend the monitoring systems used for export chains to the internal needs. | Monitor diseases like BSE and scrapie and identify potential markers of these diseases on live animals. |
| | 16. Fair trade initiatives like information campaigns in China and India to sensitise about sustainability in beef chains (increase public opinion about sustainability). | Traders should advice the potential customers about the sustainability/quality, besides the government. Governmental action in China to sensitize. Monitor fair trade initiatives. | |
| | 17. Push on political parties to establish more sustainability-oriented regulations and enhance the entry barriers for supplies**.** | The Brazilian government should negotiate with the other government the sustainability related issues (more roundtables). Establish more sustainability-oriented regulations. | |
| | 18. Establish a worldwide quality and sustainability standard (focus on food security and food safety). | Elect one sustainability tool/standard that is worldwide accepted. Establish an organization that deals with monitoring the national/regional standards. | |
| | 19. Regulation level has to be higher, to comply with international levels of quality of products to be traded**.** | Government should restrict requirements, but also the farmer should be adaptive according to their market outlet. All traded beef should be in compliance with OIE and Codex Alimentarius (enough). | |

**Pork**

| Scenario | Sustainable practice | Detailing from interviews | Detailing from literature |
|---|---|---|---|
| of anima l and crop | 1. Nutrient recycling (manure comes back to the crop producer) between agricultural sectors. | Use mineral balance tools to assess the nutrient profile of manure and what is the need that the crop has of nutrients, in order to know how much manure must be used. Use the manure for biogas production and apply the processed manure to soil. | Monitor environmental burden of surplus manure not used with respect to crop use. |

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| | 2. Invest in meat quality and traceability**.** | Investment in quality and traceability (they should be better than competitors). Traceability performed by using tags (identification of animals). | |
| | 3. Make sure that the animal feed is not in competition with more valuable food intended for human use (use by-products that cannot be used for human consumption). | Use of by-products after sterilization and mixture with the right ingredients (using optimization models). Make nutrient tests to benchmark it with the feeds used. | Research on the modelling of feeding formulas (high- proteins and palatable). By products (rich in proteins) from grain, from animal from sugar and starch production. |
| | 4. Use fertilisers made from manure**.** | Use manure to make biogas and the rest of manure that comes out is more soluble and easier to process into a fertiliser. | Reuse manure as fertiliser after manure treatment. |
| | 5. Invest in biofuel production from the process of manure into energy and the by-product can still become a fertiliser**.** | P, K, and N cannot be sufficient from biogas because from it you just get Carbon. | Integration of pigs and vegetable greenhouses, coupled with the use of biogas to process the excreta from the animal production (closed system). |
| | 6. Use DSS and models to optimize the nutritional value of the feed ingredient on cost price and expected performance of the animal (using percentages of by-products in the formula)**.** | Ensure access to large amount of these by-products, first of all. Use a feeding program to optimize the formula (feed planning tools). Make regular lab analyses to check up the feeding formula and fortify it according to the age. | Use Feed-print models to monitor the environmental impact of feed production. |
| | **7.** Use a feed-print model (optimize each ingredient on $CO_2$ equivalents of the feed production, maintaining the expected animal performance high)**.** | Chain approach is needed to create awareness among producers. Use feed-print models and optimize feed formulas according to sustainability concerns. Verify that the optimizations at company level is not suboptimal at global level. | Use feed-print models. |

| Scenario | Sustainable practice | Detailing from interviews | Detailing from literature |
|---|---|---|---|
| Sophistication | 1. Switch from commodity system to a more diversified pork sector (e.g. the KDR chain). | Market research (internal and international markets). More quality-driven production, with animal welfare as one of main criteria behind production. The retailer should set quality classes. | Use of new (or alternative) production systems that bring in animal welfare, environmental, food safety, food quality concerns. Information systems for traceability. Comply to quality assurance schemes (e.g. HACCP, EUREP GAP, Red Tractor, Label Rouge). Use certification schemes like IKB. Organic production system. Promotion of local production. Use innovation for quality and ways to monitor this quality (e.g. RFID to monitor the cold chain). |
| | 2. Operational excellence and scale increase. | Investigate possible environmental diseconomies. Operational excellence is needed for the whole chain's operations. | Increase coordination in the SC to reduce transaction costs, and to share risk among chain partners. Use a |

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| | | | quality assurance scheme and monitor it in order to standardize the production processes in the chain. |
| | 3. Create new niches. | Market research. More quality production to fulfil market niches' needs, and certification to back the claim.<br>Either/both new properties of product given by the diversified production or/and diversification of market outlet. | |
| | 4. Better outdoor access (housing). | Implementation of the access to outside areas with some shade (doors behind paddocks). Clearly establish a claim on the diversified chain. | Innovative husbandry. |
| | 5. Genetic improvement**.** | First, map the market opportunities with a marketing research. Second, perform strategic marketing on the genetics of the best swine species for Brazil. Clearly establish a claim on the diversified chain. | |
| | 6. Different nutrition (more responsible), recognizable with claims on a label. | Feed from organic productions (dependent on the marketplace, so need for market research before). Use of responsible soy (that does not come from the Amazon area) and ingredients coming from outside the farm. Use claims recognizable on a label. | |
| | 7. The independent producers should offer room for new systems of coordination and create niche markets with more added value products. | Promote the establishment of inter-branch organizations to help coordination. | Information systems for traceability. |
| | 8. Local slaughtering. | Optimize allocation planning of slaughterhouses (from which farm to which abattoir) and the capacity utilization up of the local slaughterhouses. Civil society should promote it. | |
| | 9. Local meat processing. | Promote a coordinated approach with inter-branch organizations. Civil society should promote it. Optimize allocation planning of processing plants. | |
| | 10. Local raw material purchases. | Verify the economic compatibility of local raw material purchases. Integration. Taxes on import of material. | |
| | 11. Local feedstuff supply (% of money that is produced locally and retained internally should be higher). | To be obtained with good negotiating skills (contracts). If the chain coordination is weak, vertically integrated. Perform an agronomic analysis to divide the main cost drivers of production in a pie chart to see what is locally and what is not locally sourced (to see where to improve). | |
| | 12. Nutrient recycling (manure comes back to the crop producer) between agricultural sectors | Adapt the technologies to reduce emissions. More process of manure into fertiliser. Cradle-to-cradle. | |
| | 13. Invest on meat quality and traceability**.** | Implement traceability and perform it in the whole SC. Training courses for chain operators on traceability (quality enabler). Individual identification system must be in place. Establish governmental or chain initiatives (e.g. IKB). | |
| | 14. Improve manure management | Verify the energy balance of these technologies. Trade biogas to the local villages. | |

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| | (make energy out of manure) and methane use**.** | Make a claim out of energy produced from manure when the energy use at the farm drops significantly and there is emissions reduction. | |
| | 15. Ensure short commercial channels. | Develop short marketing channels after the identification at local scale of the potentials. Once identified, promote those channels. | |
| | 16. Make pressure on these supply chains to establish sustainable claims and standards**.** | Investigate the market opportunities, to see if it is profitable. Fund studies to prove it, as a starting point. Need for standard's compliance. Initiatives from somebody in the chain. | Comply to a certification schemes like IKB. Use labels to claim the quality (animal welfare, safety, origin, etc.) of the process to create awareness about how responsible the chain is. |
| | 17. Campaigns to sensitise people (versus prejudices about pork meat as fatty and unhealthy). | Pilot campaigns on local markets. If successful, implement larger scale campaigns to sensitise people towards the consumption of pork meat. Website information (with e.g. recipes), information campaigns. | Marketing research before any market initiative, which justifies the production costs. Increase the variety of products and increase in the convenience to enhance internal consumption (e.eg. snacks and convenient food). Educate the consumers to properly cook pork dishes, training courses for professional chefs. |

| Scenario | Sustainable practice | Detailing from interviews | Detailing from literature |
|---|---|---|---|
| Balanced sustainability | 1. Biogas investment to make energy for the feed mills**.** | Subsidies from government to stimulate investments in biodigesters. Otherwise, increase taxes from energy use. | Store liquid manure and use of biodigestors (viable opportunity for producers in the Central-west region) that follow the National Agro Energy Plan. For farms with land limitation use technologies like SISTRATES (energy produced for disposal is sold out). Carbon credits (CERs). Monitor the $CO_2$ emission factors generated from the production of energy from biogas. |
| | 2. Adapt the system into more animal-friendly (more animal welfare), especially at the housing. | Stick to the recognizable system of EU welfare standards. More free space to pigs (open access to outside). Get rid of the cages. | Ban physical castration of the pigs, and favour immunological castration. Involvement of water management actions at the farm as an indicator for pig health (installation of hydrometers). |
| | 3. Invest in monitoring system in later part of SC to ensure about residues management and about the antibiotic resistant bacteria**.** | Stick to the recognized system (EU standards). In order to export to China (which bans ractopamine) and Russia the Brazilian production chains have to adapt to the EU system. Establish a Brazilian ractopamine free production integration (a private standard, not legal). Sampling for antibiotic residues, establish a good ICT backbone, have farmers register operations to track back the use of antibiotics (use ID system). Establish a control mechanism performed by slaughterhouses or processors. | Ensure that the residues of antibiotic resistant bacteria (e.g. cephalosporins) from pig production are not present. Establish a dedicated Organization that at national and regional level monitors the analyses to avoid these residues. Follow the WHO guidelines. |
| | 4. Establish new sustainability standards to be applied n Brazil to better animal welfare and better | Establish a good traceability system before trading frozen meat.<br>Take the cue from EU standards (e.g. GLOBAL GAP taken as example). Implement protocols of production to have Brazil allowed to ease export opportunities | Use trademark labels such as Sustainable Pork®. Adopt sustainability standards. Harmonization of standards based on consumer demand. Follow OIE guidelines. |

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| | the tradability to EU markets**.** | (protocols about the slaughtering and handling of meat), promoted by producers and government. | |
| | 5. Campaigns to sensitise people (versus prejudices about pork meat as fatty and unhealthy). | Use home market as a buffer (e.g. risk if Russia bans imports), still keeping the export-oriented approach. Sensitize Brazilian consumers with campaigns. Website information (with e.g. recipes), information campaigns (human doctors and nutritionists). | Educate the consumers that advanced technologies are needed to provide safe pork meat to everyone. |
| | 6. Minimize risk of development of microbe resistance of human in the chains (exposure to antibiotic resistant bacteria) given by overuse of antibiotics and heavy metals (these increase the chances that human have microbial resistance to antibiotics) during animal production. | There is the need for the integration (crop and animal production) or information exchange through the supply chain. Stick to the recognized system (EU standards). Use campaigns to reduce the use of antibiotics. | Seek for expert's collaborations with EFSA. Analyses through the supply chain must be put in place and monitored (harmonize food safety practices in the SC). Establish collaborations between animal medicine and human medicine to tackle the problem of resistance together. |

# Appendix 5 – Questionnaire current sustainability of beef and pork chains in Brazil

**Questionnaire**
**Sustainability in the beef and pork Brazilian supply chains**

This questionnaire that I have asked you to fill in gives me upfront information about the supply chain practices that may help the supply chains of beef and pork in Brazil to be more sustainable. Therefore, the objective is to provide farmers and other actors of these supply chains with scenarios of sustainable development that are feasible and that use sustainable supply chain management practices. At this stage, the questionnaire is meant to **assess** the **current sustainability** of the **beef** and **pork** supply chains in **Brazil**. For this purpose, I have created this file with **2 PARTS** or topics to discuss.

**PART 1** is the Generic part. General information about you will be asked. Questions from 1 to 5 belong to Part 1.

**PART 2** deals with the identification of the sustainability indicators to be improved in the beef and pork supply chain in Brazil. Questions 6 and 7 belong to Part 2.

Filling this questionnaire will take approximately 20-30 minutes.

Thank you for your collaboration!

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**PART 1 – GENERIC INFORMATION**

25. Name of the respondent _____

26. Name of your institution _____

27. Your company/organization is a (Single answer):

    a. Research institution
    b. University
    c. Ministry (e.g. of Agriculture). If yes, specify: _____
    d. Association
    e. Class entity (e,g, Brazilian Agribusiness Association)
    f. Foreign Government
    g. Statistics centre
    h. Business involved in the beef or pork supply chain. If Yes, specify what (e.g. farmer, processor, abattoir, trader, etc.): _____
    i. Other: _____

28. Your function/position _____

29. In which field are you an expertise? (Multiple answers)

    a. Supply chain management
    b. Pork sector
    c. Beef sector
    d. Sustainable development
    e. Agriculture
    f. Sustainable supply chains
    g. Animal science

h. Brazilian supply chains
i. Other: _____

**PART 2 – IDENTIFICATION OF THE SUSTAINABILITY ISSUES IN THE BEEF AND PORK BRAZILIAN CHAINS**

**BEEF**

30. Please, give a score using a 5-points Likert scale provided in the table to each of the thirteen sustainability issues shown. This step is needed to assess the **sustainability** indicators in the current Brazilian supply chain of **beef**. Provide **one or more examples** of why you consider that a sustainable issue in those chains (i.e. if you score it 1=very bad or 2=bad).

| Sustainability indicator | Sustainability assessment (1= very bad, 5 = very good) | | | | | Example(s) |
|---|---|---|---|---|---|---|
| **Income distribution** | 1 | 2 | 3 | 4 | 5 | |
| **Profitability** | 1 | 2 | 3 | 4 | 5 | |
| **Employment** | 1 | 2 | 3 | 4 | 5 | |
| **Economic growth** | 1 | 2 | 3 | 4 | 5 | |
| **Gender equality** | 1 | 2 | 3 | 4 | 5 | |
| **Animal welfare** | 1 | 2 | 3 | 4 | 5 | |
| **Mortality** | 1 | 2 | 3 | 4 | 5 | |
| **Food quality** | 1 | 2 | 3 | 4 | 5 | |
| **Food safety** | 1 | 2 | 3 | 4 | 5 | |
| **GHG emission** | 1 | 2 | 3 | 4 | 5 | |
| **Energy dependence** | 1 | 2 | 3 | 4 | 5 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Land use** | 1 | 2 | 3 | 4 | 5 | |
| **Water resources** | 1 | 2 | 3 | 4 | 5 | |
| Other indicator(s) that you do not see listed here: _____ _____ _____ _____ | 1 | 2 | 3 | 4 | 5 | |

**PORK**

31. Please, give a score using a 5-points Likert scale provided in the table to each of the thirteen sustainability indicators shown. This step is needed to assess the **sustainability** indicators in the current Brazilian supply chain of **pork**. Provide **one or more examples** of why you consider that a sustainable issue in those chains (i.e. if you score it 1=very bad or 2=bad).

| Sustainability indicator | Sustainability assessment (1= very bad, 5 = very good) | | | | | Example(s) |
|---|---|---|---|---|---|---|
| **Income distribution** | 1 | 2 | 3 | 4 | 5 | |
| **Profitability** | 1 | 2 | 3 | 4 | 5 | |
| **Employment** | 1 | 2 | 3 | 4 | 5 | |
| **Economic growth** | 1 | 2 | 3 | 4 | 5 | |
| **Gender equality** | 1 | 2 | 3 | 4 | 5 | |
| **Animal welfare** | 1 | 2 | 3 | 4 | 5 | |
| **Mortality** | 1 | 2 | 3 | 4 | 5 | |
| **Food quality** | 1 | 2 | 3 | 4 | 5 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| **Food safety** | 1 | 2 | 3 | 4 | 5 | |
| **GHG emission** | 1 | 2 | 3 | 4 | 5 | |
| **Energy dependence** | 1 | 2 | 3 | 4 | 5 | |
| **Land use** | 1 | 2 | 3 | 4 | 5 | |
| **Water resources** | 1 | 2 | 3 | 4 | 5 | |
| Other indicator(s) that you do not see listed here: | 1 | 2 | 3 | 4 | 5 | |

End of the questionnaire.

Thank you for your collaboration!