Study on Livestock scenarios for Belgium in 2050

Full report

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This study was conducted independently by UCLouvain (team of Professor Philippe Baret) in 2017 and 2018.

The terms of reference were written by Greenpeace Belgium. The criteria for ecological agriculture and livestock developed by Greenpeace were taken into account in the selection of environmental impacts to be assessed as well as in the determination of the entry parameters of transition scenarios. The study was entirely financed by Greenpeace Belgium.

The study went through a peer-review process involving experts from scientific institutions and the sector.

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Summary

This study has been commissioned by Greenpeace Belgium in 2017 with the aim to open a public debate on the environmental consequences of current livestock practices and food consumption patterns in Belgium, and on existing alternative production systems, based on scientific data.

The study is based on a prospective approach: it starts with the description of the current livestock sector and highlights the diversity of production systems for the five main livestock productions. Several scenarios for the development of the livestock sector towards 2050 are then developed and their consequences in terms of production, consumption and environmental impacts are assessed.

The five main livestock productions in Belgium are bovine meat, pork, poultry meat, eggs, and milk. In the current situation (2015), national production largely overpasses national demand, with self-sufficiency ratios (ratio of production vs. net apparent consumption) of 158% for beef, 261% for pork, 158% for poultry meat, 109% for eggs, and 135% for milk (Table 2 and Figure 8). In terms of historical evolution, the sizes of the livestock populations have remained rather stable over the past ten years.

Although the general consumption of meat products has decreased over the last 10 years, the average consumption of meat products is still twice the recommended level. In terms of protein intake, although it is recommended to consume both sources of protein in a balanced way, about 65% of protein sources are from animal origin (Table 1 and Figure 7).

In terms of GHG emissions, considering the three sources of emissions which were assessed in the study (feed-related emissions, enteric fermentation and manure management emissions), the main Belgian livestock sectors emitted 13.920 kt CO_2e in 2015 (Table 81). The biggest contributors are the dairy and pork sectors (34% and 33% of total GHG emissions each), followed by the bovine meat sector (23%), and by both poultry sectors to a lesser extent (10% of emissions for the two sectors together). About 60% of the emissions can be attributed to livestock products actually consumed in Belgium whereas 40% of the emissions can be attributed to livestock products which are exported (see 8.4.1).

Animal production requires about 13.000 kt of feed per year (Figure 13). Grass and annual forages are the main feed for cattle, whereas feed from cereals are largely used for pigs and poultry. Protein-rich feeds (including soy) are used by all categories of livestock.

For each livestock sector, typologies of production systems were identified. It is estimated that pork production comes mainly from conventional systems, which can be Certus-certified or not (96% of slaughters) while less than 5% of slaughters come from differentiated and organic systems. Similarly, egg production mainly comes from in-cage and indoor systems (respectively 60% and 27%) while 9% comes from free-range systems and 3% from organic systems. Poultry meat largely comes from conventional systems (97% of slaughters), of which the vast majority are Belplume-certified. Less than 4% comes from differentiated and organic systems. Milk production comes from a rather large diversity of systems: 9% of the systems are based on grass, 26% are semi-intensive systems based on maize and 65% are intensive systems based on maize. Cattle breeding systems are also quite diverse: 16% of systems are extensive systems with French breeds, 23% are systems with Belgian blue breed based on grass, and 61% are systems with Belgian blue breed based on maize. In terms of GHG and N emissions, more intensive systems tend to have lower relative emission levels but contribute more to the total emissions given their larger shares. Extensive systems generally have better performances in terms of biodiversity, low use of phytopharmaceutical products (PPP) and animal welfare.

Three scenarios towards 2050 were designed (see Table 96 for hypotheses). Scenarios were assessed under different consumption patterns (see Chapter 13).

The Business-as-usual scenario (Chapter 10) extends the trends observed in the Belgian livestock sector during the past 10 years until 2050. While the dairy cow, laying hen and suckler cow populations are expected to decrease (respectively -5%, -7% and -20%), the pig population is likely to remain stable (+1%) and the broiler population would increase significantly (+20%). In terms of livestock-related GHG emissions, this scenario would result in a reduction of 13% in 2050 compared to 2015 (12.008 kt CO_2e in 2050 vs. 13.850 kt CO_2e in 2015). This is mainly the result of technological and productivity improvements. The production of meat in 2050 in this scenario would be 743 kt (similar to 2015).

In the Transition 1 scenario (Chapter 11), the sizes of the livestock populations were established on the basis of national resources available for animal feed (grassland and national production of cereals). Only organic and extensive systems are considered (30% of organic systems and 70% of extensive systems). The specialised dairy herd and the specialised bovine meat herd are replaced by a single mixed dairy herd, which is assumed to occupy all available grassland resources and ensures the production of both milk and bovine meat. As a result, the total number of cows in 2050 decreases by 24% compared to 2015 (688.286 cows in 2050 vs. 900.895 cows in 2015). The sizes of the pig and poultry populations are based on the national cereal resources. This means that only cereals produced in Belgium and available for animal feed are used. In such a scenario, the pig population would decrease by 63%, the broiler population by 70% and the laying hen population by 56%. This scenario results in a GHG emissions level of 7.231 kt CO_2e in 2050, i.e. a reduction of 48% of emissions compared to 2015 emission levels. The production of meat in 2050 in this scenario would be 300 kt (-59% vs. 2015), that is 65 g meat/cap/day.

The Transition 2 scenario (Chapter 12) was designed in order to follow as closely as possible Greenpeace's criteria for ecological livestock. As a consequence, only organic systems were considered in the scenario and the size of the herds were established on the basis of available national and regional resources which do not result in a food-feed competition. In this context, the same assumptions as in Transition 1 were made regarding the bovine herd, i.e. only a mixed dairy herd which occupies all the available grassland resources was considered. Regarding the pig and poultry populations, only regional sources of coproducts (national and/or EU-origin) were considered for animal feed. Based on these considerations, the sizes of the pig and poultry herds would be reduced drastically (-91% for the pig population, -93% for the broilers population, and -90% for the laying hen population). As a result of the important decrease in the animal populations, Transition 2 leads to a significant reduction of 59% of the livestock sector's GHG emissions in 2050 compared with 2015 emissions levels. The production of meat in 2050 in this scenario would be 125 kt (-83% vs. 2015), that is 27 g meat/cap/day.

While the current consumption is 87 g of meat/capita/day, the trend (a decrease in animal-based products consumption) would lead to 70 g meat/cap/day in 2050. The production according to BAU scenario would be significantly higher to the national demand, resulting in a strong export capacity (as per the current situation). In scenario T1, the production would approximately cover the demand but no export potential would remain. Finally, in scenario T2, meat production and consumption would be much lower and diets would require more proteins from vegetal products.

Chapter 1. Introduction

1.1. Objectives and overall approach of the study

This study has been commissioned by Greenpeace Belgium in 2017 with the aim to open a public debate on the environmental consequences of current livestock practices and food consumption patterns in Belgium, and on existing alternative production systems.

The study is based on a prospective approach: it starts with a description of characteristics and current production systems of the livestock sectors. Several scenarios for the development of the livestock sector towards 2050 are then described and their consequences in terms of production, consumption and environmental impacts are assessed. Opposite to a predictive approach aimed at describing the most likely scenario, the interest of such a work is to provide diverse possible horizons which can contribute to the elaboration of a shared strategic framework for actors and help them prioritising relevant actions. Over the past years, such approaches have been used in the areas of food and agriculture, for example in France (Couturier et al., 2016), Germany (Wirz et al., 2017) and at a global level (Tirado et al., 2018).

1.2. Scope and scale of the study

The study focuses on the five main livestock productions in Belgium (dairy, bovine meat, pork, poultry meat and eggs production). When relevant, analyses at the regional level (Flanders, Wallonia) are provided.

Agricultural and food systems can be studied at different scales: the field; the farm; the processing and marketing chain; the national and European policy level; the world. The scale determines the entry point for studying the system and the level of action considered. Starting from the field, the technical dimensions are amplified and the farmer is often the only actor considered. On the other hand, the choice of a large-scale approach, such as the European or global level, offers broader perspectives but may lead to neglecting the diversity of production methods. Inspired by the prospective study *Afterres 2050* in France, the scale chosen for the present study is that of the *production systems* in each livestock sector. A livestock *production system* is a set of practices and resources mobilised by a farmer to attain certain production levels in accordance with a specific logic and objectives (Antier et al., 2017). It comes with a set of technical choices that determine elements such as the animal breed, the breeding practices, the quantities of inputs used, the level of productivity and, to a certain extent, the marketing channel. Those choices are visible at the farm level, but they are also determined by an individual and collective trajectory and influenced by the general context of the agriculture and livestock sector (actors, economic environment, etc.). In this study, a typology of production systems is proposed for each livestock sector as a way to represent the diversity of practices. In order to account for diversity without overcomplicating, the number of production systems modelled in each typology ranges between four and eight.

Regarding environmental impacts, five categories are assessed: climate change, eutrophication potential, use of PPP, biodiversity and animal welfare. The methodology used for estimating environmental impacts is presented in Chapter 2.

Social and economic aspects which influence the trajectories of agricultural and food systems are not modelled in this study because these parameters are strongly linked to the current situation and susceptible to complex evolutions. However, focus groups were organized in July 2018 in order to foster discussions on these aspects with sector's actors.

1.3. Content

The study is presented in three main steps (Figure 1):

(1) **Food system description (Chapter 3):** the current food and agriculture system in Belgium is described, with a focus on both food consumption and production patterns.

(2) **Livestock production systems (Chapter 4 to Chapter 9):** each livestock sector is described, in a technical, social and economic perspective. Within each sector, a typology of production systems is proposed to characterise the diversity of practices and environmental aspects (Chapter 4 to Chapter 7). A synthesis of the consequences of the livestock sector in general is provided in Chapter 8 and the results are compared to other sources in Chapter 9.

(3) **Scenarios design and analysis (Chapter 10 to Chapter 14):** Several scenarios for the future of agriculture and food consumption in Belgium towards 2050 are proposed. The consequences of the scenarios are evaluated in terms of production, consumption changes and environmental impacts. Scenarios are compared and their relevance is discussed.

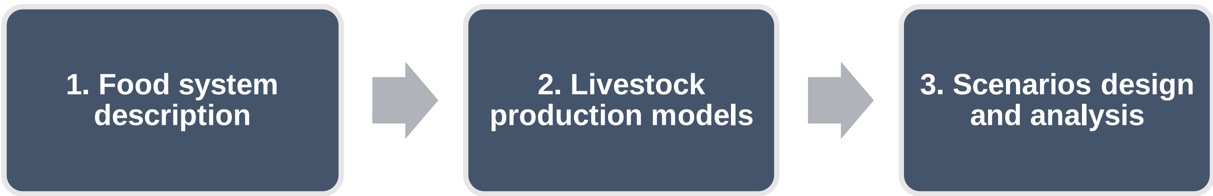

Figure 1. Steps of the study.

Chapter 2. Methodology

2.1. Sources and process

First, a review of the scientific and grey literature on the Belgian livestock sectors was carried out. This review was complemented by a series of individual semi-structured interviews with key actors (farmers, researchers, actors from the public sector…). This allowed to build up a first characterisation of each livestock sector (including a typology of the different production systems within each sector). This initial characterisation was then validated and fine-tuned through additional actor interviews, leading to the final version of the livestock sectors' assessment. This process is in line with the *informed participatory research* methodology[1] (Van Damme et al., 2016). In total, 24 interviews were carried out in the context of this study (see Appendix 1 – List of participating actors).

A first version of different scenarios was then designed: a “business as usual” scenario that continues trends from the past decade until 2030 and 2050 and two “transition” scenarios that favour specific production systems. The consequences of the scenarios in terms of environmental impacts as well as production and consumption levels were assessed.

Multi-stakeholder focus groups were then organised in July 2018 to present and discuss the obtained results, as well as to highlight potential barriers and opportunities for the development of more sustainable production systems (see Appendix 1 – List of participating actors). Practically, the meetings consisted of a presentation of the current results of the study, followed by discussions in which the actors discussed the presented results. Details about the methodology and results of these meetings are provided in PART III: Feedback and assessment processes of the study.

The hereby document presenting the final results of the study was then assembled based on this inclusive and iterative approach.

2.2. Methodological principles

Participative and inclusive research: The results of the study aim to be as realistic as possible and a large number of stakeholders were therefore involved throughout the entire research process. First, actor interviews allowed to validate and refine the characterisation of the different livestock sectors. Second, the multi-actor focus group provided the opportunity for stakeholders of the entire sector to provide collective feedback on the scenarios and general results of the study. The idea was to be as inclusive as possible by involving all kinds of stakeholders.

[1] The informed participatory research approach combines the classic elements of participatory research and a specific, comprehensive and multi-dimensional assessment of the diversity of farming systems. This method was first implemented in Wallonia, Belgium, to discuss the development of organic farming in the 2010s. Authors argued that the understanding of the diversity of farming systems and a participatory process are needed if the research is to be relevant and grounded in reality. We chose this method to favor the appropriation of the process and results by the sector's actors.

Open-ended research: The study and its results were built on data relative to a specific timeframe, in accordance with the available information. Nevertheless, the presented situation is obviously likely to be subject to changes if additional or more precise information become available, and could therefore be updated in the future.

Holistic and multi-scale approach: As the project aimed to obtain a holistic view of the livestock sector in Belgium, it was studied with different perspectives: the individual scale (both from the producers and the consumers' perspective), the territorial and regional scale, and the sectors (with the invitation of a diversity of stakeholders, from pre-production activities to the retail of products, to participate in the process).

2.3. Methodology for the elaboration of typologies and characterisation of production systems in each sector

Characterisation of the food system. Estimates of the Belgian production, import and export were obtained from national and international statistics. Estimates of the Belgian consumption were taken from the last national food consumption survey carried out in Belgium in 2014-2015. Losses that can occur at diverse steps between the production of meat and actual consumption were also estimated.

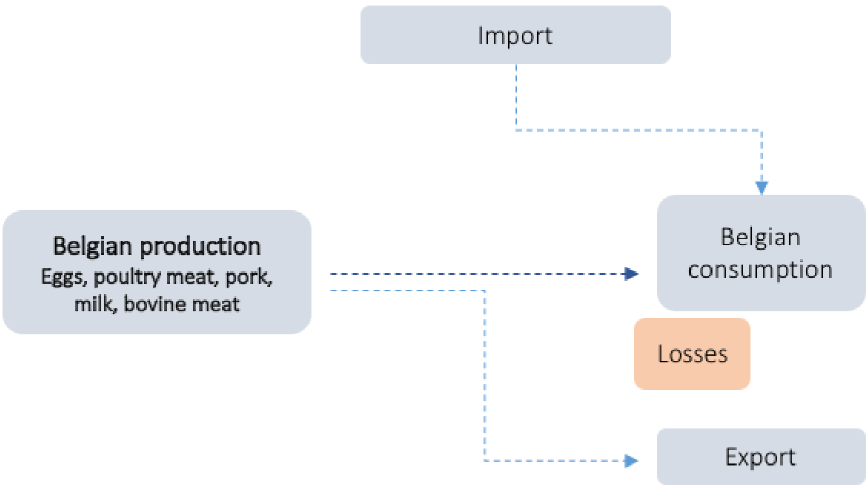

Figure 2. Aspects of the food system that were characterised.

Identification of a typology of production systems: For each livestock sector, a typology of production systems was identified in order to represent the diversity of production systems in each sector. The typology was based on a literature review and interviews with the sector's actors. Each of the identified systems was then characterised in terms of practices, production levels and environmental consequences.

Feeding practices in each livestock system: Among other characteristics which were analysed, identifying feeding practices (feed composition and consumption) is a crucial step of this study as these are closely related to environmental impacts, such as nitrogen (N) emissions, Greenhouse gas (GHG) emissions, etc.

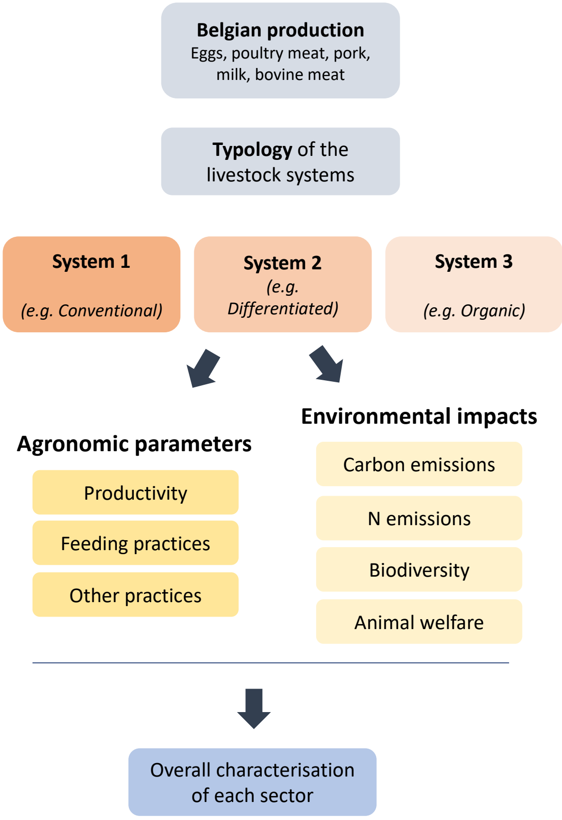

Figure 3. Scope of the study: characterization of livestock systems and their environmental impacts.
Note: The use of PPP related to livestock sector was assessed too but not at the level of production systems.

2.4. Methodology for the assessment of the environmental impacts of livestock systems

2.4.1. Scope for the evaluation of environmental impacts

The production systems differ in terms of practices and production levels but also in terms of environmental impacts. Life Cycle Assessments (LCA) applied to livestock products include twelve midpoint impact categories[2]: acidification; biodiversity; climate change (or global warming potential); ecotoxicity; eutrophication; human toxicity; ionizing radiation; land use or land occupation; ozone depletion; particulate matter; photochemical ozone formation or photo-oxidant formation; and resource depletion (including biotic and abiotic resources; e.g., fossil fuel, electricity, water, etc.) (McLelland et al., 2018)[3].

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[2] In LCA, a midpoint category describes a proximate impact along the environmental chain that can be measured before the end- point impact is realized (e.g., GHG emissions are a midpoint indicator for average global temperature changes) (Jolliet et al., 2003).

[3] McLelland et al. completed a systematic review of the livestock LCA literature to better understand the impact categories included and the progress made towards more comprehensive LCAs. The authors' search of publications between 2000 and 2016 identified 173 relevant peer-reviewed papers and then categorized midpoint environmental impacts into 12 categories based on Jolliet et al. (2004).

Although a complete LCA evaluation would be relevant, for feasibility reasons, this study focuses on a restricted scope of three environmental impact categories[4]. This allows to compare performance of livestock categories and systems and to highlight potential trade-offs considering those environmental aspects. The evaluation of the environmental impacts per livestock category and system could be further developed by providing estimations for other environmental aspects. Such additional estimates can be added to the modelling and consequences of the scenarios on other impacts could then be obtained.

Considered impact categories (and related indicators) are: Biodiversity (Damage score), Climate change (GHG emissions) and Eutrophication potential (N emissions) (Figure 4). The use of phytopharmaceutical products, that may cause human toxicity and ecotoxicity, was assessed too but not at the level of production systems. In addition, animal welfare aspects (which is generally not defined as an environmental impact category) are discussed.

Methodology and indicator definitions are detailed below.

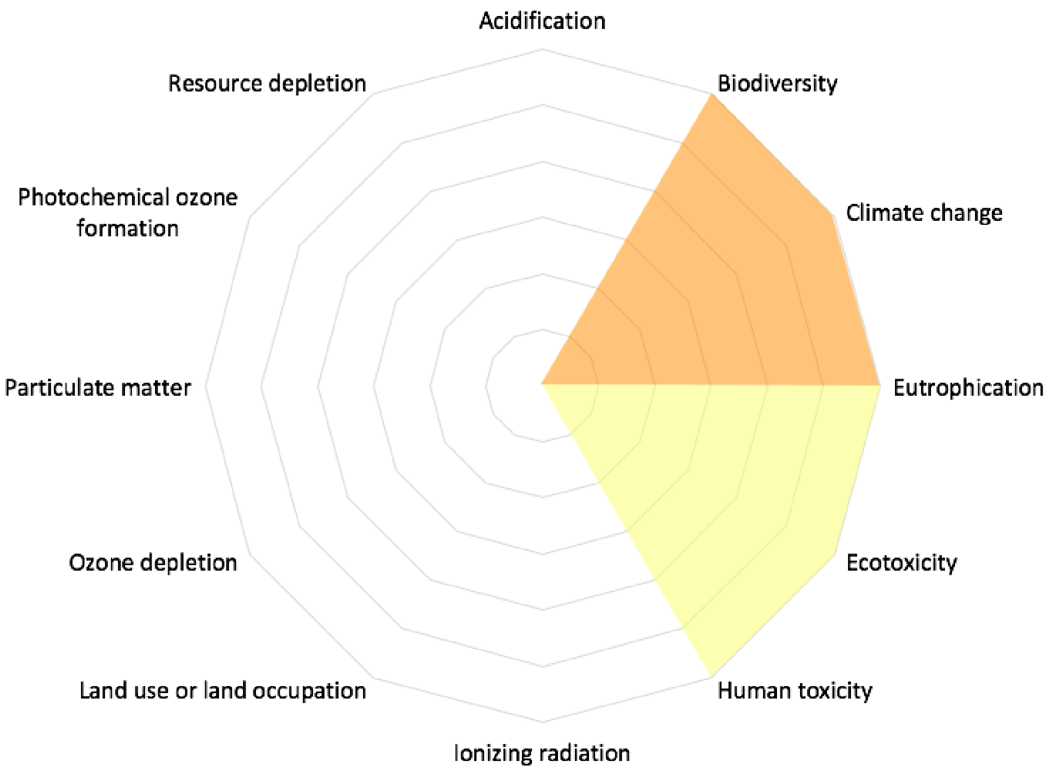

Figure 4. Environmental midpoint impact categories identified in LCA review (McLelland et al. 2018) and scope of this study (in orange and yellow).
Note: in orange: impact categories assessed in this study for each production systems; in yellow: impact categories assessed only at the level of the livestock sector overall.

4 This restricted scope is consistent with European Commission guidance for Product Environmental Footprint evaluation, which requires that at least three impact categories be included in LCAs (European Commission, 2016).

2.4.2. Assessment of feed composition and consumption

Given the importance of feeding practices in the assessment of N and GHG emissions, a typical feed (with the shares of each ingredient) is proposed for every production system within each sector, based on the existing literature and actor interviews. Specific feed conversion ratios (FCR) to each system then allow to quantify how much of each ingredient is consumed in each system. A comparison of these results with literature values, both from national and international sources, is provided.

2.4.3. Assessment of GHG emissions

GHG emissions are calculated for each livestock sector and each production system within each sector with a LCA approach. Several processes involved in livestock rearing result in GHG emissions. The scope of the assessment included:

- Feed production and consumption: Feed-related GHG emissions are estimated by multiplying the share of each ingredient in the animal diet by its emission factor (Table 165 in appendix)[5].
- Emissions from enteric fermentation of animals[6] were estimated through IPCC[7] empirical relations which are used in national GHG inventories (Table 166).
- Manure management related emissions are estimated through empirical relations from IPCC (Table 166).
- On-farm energy consumption also contributes to GHG emissions but was not considered in this study because of lack of available data. Measures such as anaerobic digestion of manure could however contribute to lower the sector's emissions.
- The sequestration of carbon by pastures and grasslands is not considered (see Box 1 below).

2.4.4. Assessment of N emissions

The emissions of N through livestock manure can contribute to the leaching of nitrates in groundwater and surface waters and therefore to eutrophication. N emissions are calculated based on feed composition and consumption. The N-value in the feed and the Nitrogen Use Efficiency (NUE)[8] of a particular species allow calculating how much N is emitted.

2.4.5. Assessment of PPP use

The use of livestock-related phytopharmaceutical products (PPP) was assessed at a sectoral level (and not for each production system because of insufficient data). Section 8.4.2 explains the used methodology in more detail.

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[5] The emission factor of each ingredient includes transportation emissions. The emission factor also include the land use change of a specific ingredient (in the case of soy). It must be underlined that the considered emission factors are averages; no distinction could be made between organic and conventional productions of these ingredients (because of lacking data).
[6] Enteric fermentation emissions are negligible for poultry but are relevant for pigs and bovines.
[7] IPCC: Intergovernmental Panel on Climate Change
[8] Indeed, the NUE indicates the amount of nitrogen retained in animal products as a percentage of total feed nitrogen intake. Hence, 1-NUE indicates the proportion of N emitted.

Box 1. Carbon sequestration by pastures.

The sequestration of carbon by pastures is an often-cited argument which could contribute to mitigate the adverse climate change impacts of livestock, and in particular of cattle systems. Indeed, grazing ruminants contribute to keeping carbon sequestered in pastures, which could be released under other land management practices. If well managed, grazing systems could even contribute to sequester more carbon in the soils out of the atmosphere. As a consequence, there have been numerous calls to include these sequestration effects when realising GHG assessments of livestock systems.

Interestingly, a study was carried out specifically in Belgium to assess the carbon sequestration potential of a pasture in Southern Belgium. It found that the sequestration potential was of about 5,9 t CO_2/ha/year on a pasture with a stocking rate of 2,2 livestock units/ha (Gourlez de la Motte et al., 2016).

Nevertheless, a recent study published in 2017 analysed the question with more scrutiny. It reviewed several studies on the subject and found that important variations exist in terms of sequestration potentials of grassland, varying from 0,18 t CO_2/ha/year to 9,17 t CO_2/ha/year, as shown on Figure 5. Several parameters can indeed affect the sequestration potential of a particular pasture (rainfall, management, etc.). As a matter of fact, the authors of the Belgian paper acknowledged themselves that the estimate found for the studied pasture was rather high and it would be inaccurate to extrapolate the figure to all Belgian grasslands (personal communication, 2018).

Given the important uncertainty which exists around this matter in the current state of affairs, it was chosen not to include this effect directly in the calculations. It is nevertheless important to keep this question in mind and remind it could still play a significant role when it comes to the development of livestock systems in the future. As such, assuming a theoretical sequestration potential of 2 t CO_2/ha/year (which seems to be the average resulting from the study by Garnett et al. (2017)), one estimation of the sequestration potential at Belgian level could amount 1.114 kt CO_2/year (total pasture area of 556.845 ha in Belgium in 2015).

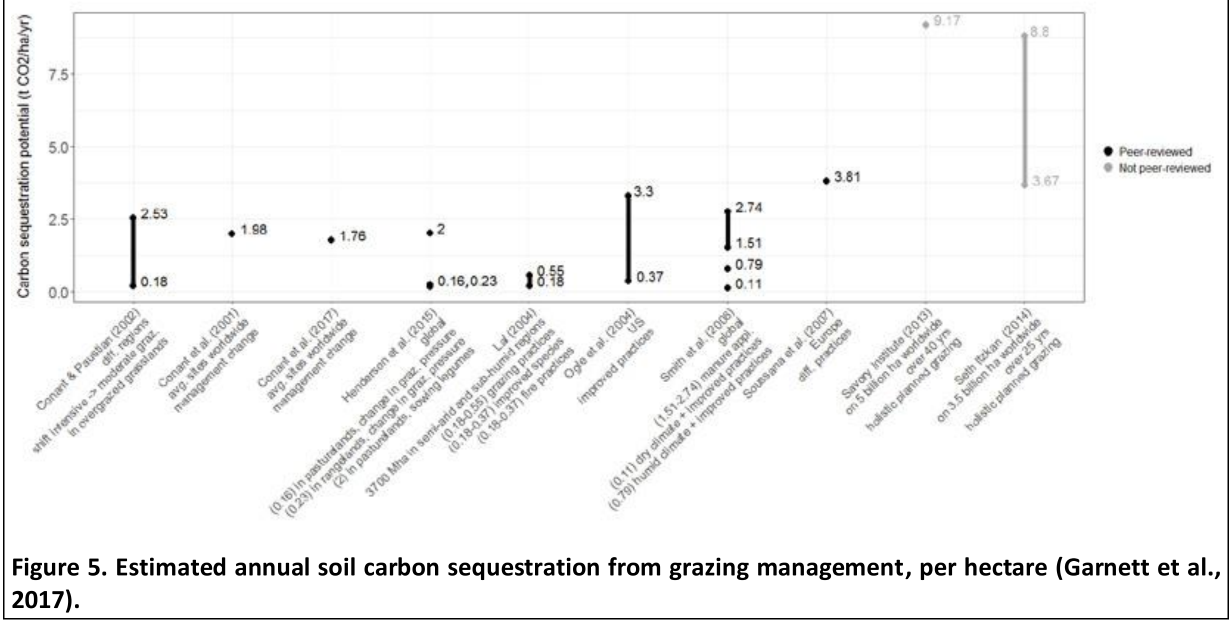

Figure 5. Estimated annual soil carbon sequestration from grazing management, per hectare (Garnett et al., 2017).

2.4.6. *Assessment of animal welfare considerations*

In order to assess how each system performs regarding animal welfare, a series of criteria established by the animal welfare charity Compassion In World Farming (CIWF), which specifically focuses on farm animals, were used. For each livestock species, CIWF has defined *bad*, *better* and *best* practices (CIWF, 2014). Per species, two or three welfare categories and corresponding CIWF criteria were identified (Table 157 to Table 161 in the Appendices).

This allowed to perform a qualitative assessment of animal welfare considerations by confronting each system of each livestock sector to these criteria. For each category and each production system, an animal welfare score is attributed (1 for *bad* practices, 2 for *intermediate* practices, and 3 for recommended *best* practices). When aggregated over the two or three categories, an overall animal welfare score was determined for each system (with three (two) categories: orange if *total score* $\leq$ 4 (2); yellow if 5 (3) $\leq$ *total score* $\leq$ 7 (4); green if *total score* $\geq$ 8 (5)).

Issues of animal welfare remain subject to much debate with contrasting views[9]. As a consequence, it must be kept in mind that other frameworks could have been used to assess animal welfare considerations and that the evaluation provided in this study is the result of one particular framework. It has the advantage of providing an international frame, although it presents the risk of being less adapted to local sectoral specificities (such as the importance of the Belgian Blue breed in Belgium).

2.4.7. *Assessment of biodiversity impacts*

In order to characterise the biodiversity impacts of each system, the methodology developed by De Schryver et al. (2010)[10] was used. The method is based on the impact of feed ingredients on biodiversity: a characterisation factor (CF) which expresses the ecosystem damages of certain land-uses and agricultural areas, is attributed to each feed ingredient. The CF depends on land uses (arable land and grassland) and intensiveness of agricultural practices (organic vs. intensive). The indicator also varies with the duration of the crop and the occupied area (see step 1 below). The impact of each feed ingredient is then aggregated to determine the overall Damage Score (DS) associated to a certain production system (step 2). The higher the Damage Score, the higher the impact on biodiversity.

Two steps are thus necessary to calculate the overall biodiversity impact of a livestock system (see Table 162 and Table 163 in the Appendix):

(1) For each feed ingredient category i: CF_i = Needed crop area (ha) x CF x Crop duration (months)
(2) Aggregation over a production system: DS = Σ CF_i

It must be noted that specific impacts of each culture are not taken into account in this indicator. In particular, land-use change is not taken into account as this indicator is not related to the location where the feed is produced. It gives an indication of the global impact on biodiversity associated with the feed consumption of the livestock sector, regardless of the location where the feed is produced[11].

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[9] For instance, the use of double-muscled breeds for bovine meat production is often associated with non-natural birth-giving and hence much debated, especially in the Belgian context given the importance of the Belgian Blue (BB) breed.
[10] This methodology is applied for example in Guerci et al. (2013).
[11] A more precise indicator would indeed depend on the location of feed production, which could be a significant aspect of biodiversity impact, especially for imported feed.

2.4.8. *Comparison of environmental indicators with sustainability thresholds*

The environmental consequences of the scenarios are assessed against sustainability thresholds in Section 14.2.

2.5. From livestock sectors' characteristics to general outputs

The assessment of production, feed consumption, environmental consequences resulting from the production systems in each livestock sector can then be aggregated at the national level.

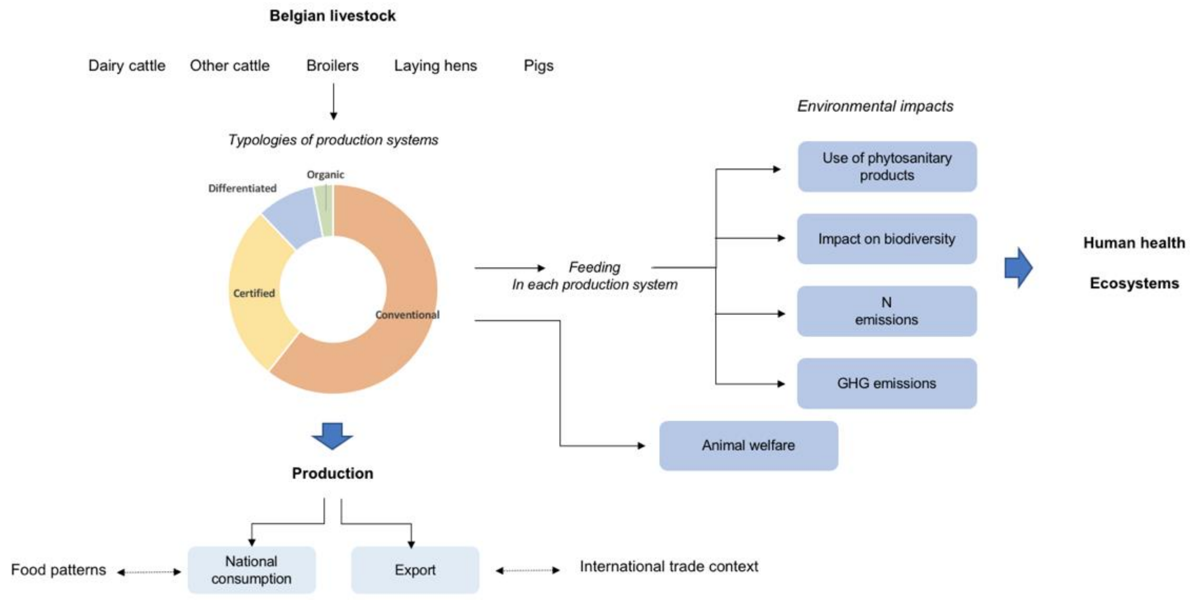

Figure 6. Approach for the assessment of environmental impacts of the livestock sector.

2.6. Limits of the study

A series of limits to the study have been identified during the process and by consulted experts. These limits can be inherent to the scope of the study, due to the lack of available data or related to methodological choices. An overview of these limits is provided below; some are discussed in the text too.

- **Focus on environmental issues and consideration of socio-economic aspects:** The main limitation of the study (which was also pointed out in every focus group) is probably the fact that the study puts a strong focus on the environmental outcomes of the livestock sector while socio-economic dimensions are not addressed in a detailed and comprehensive way. These matters were nevertheless discussed during the focus groups.
- **Environmental assessment:** Within the environmental assessment, five impact categories were analysed (GHG emissions, N emissions, Biodiversity impacts, livestock-related PPP use and animal welfare considerations), with methodological limitations for each category :
  - *GHG emissions*: many processes contribute to emissions but only a few (considered to be the more important) were included here (feed-related emissions, enteric fermentation and manure-management emissions). Regarding feed-related emissions, average values were used and no distinction was made between organic or conventional feed sources.
  - *N emissions*: only direct emissions from the livestock herd were assessed. N emissions that may result from the use of N fertiliser for livestock feed cultures was not included in the assessment.
  - *Biodiversity impact*: this measure was assessed according to a methodology which provides a not yet universal and well-acknowledged indicator. The DS indicator has a limited level of precision, as it does not allow to take into account all specificities of the cultures (e.g. location of the production and specific agricultural practices).
  - *Livestock-related PPP use*: it was estimated at the level of the entire sector and not specifically for each production system, due to lacking available data.
  - *Animal welfare considerations:* these were assessed according to one possible framework but it must be kept in mind that others exist.
- **Choice of reference year and data:** The year 2015 was chosen as a reference year throughout the entire study. Although more recent data is available in some cases, this choice ensures that all the necessary data applies to the same year and hence it allows for a certain coherence throughout the entire study. This also implies that specific events which occurred in more recent years are not considered here (as discussed for the food balances in section 3.2.1 and the impact of the 2012 ban on battery cages in the laying hen sector in section 10.1). Furthermore, although much important data was available, some estimations had to be made when specific data was missing. The relevance of these estimations was verified by consulting sectors' experts.

- **Regional approach:** The study focussed on both Belgian regions: Flanders and Wallonia. As much as possible, it aimed to put forward and characterise the differences between these regions. Nevertheless, in some cases, the available data was not sufficient to differentiate between the regions. In particular, regarding the shares of production systems, Flanders and Wallonia could be assessed distinctly for the laying hen and the dairy sectors, but for the pork and broiler sectors, the analysis was carried out at a national level. Within the bovine meat sector, the breeding step could be assessed separately for both regions but the fattening of young bulls was characterised in Flanders (and was then extrapolated to whole Belgium).

- **Consideration of displaced processes:** The study focuses on the Belgian livestock sector. Hence the consequences in terms of production, consumption and environmental impacts of the scenarios are limited to the Belgian livestock sector too. This means that displaced processes, such as increased livestock production in foreign countries related to lower production levels in Belgium or increased production of vegetal products because of lower meat consumption levels, are not included in the scope of the study. Additional assessment on those aspects could be further developed in the future in order to obtain a more comprehensive view of the consequences of the scenarios.

- **Consumption of animal products:** In the developed scenarios consumption patterns change compared to 2015. In particular, in the transition scenarios, consumption levels are aligned with production levels. This not only means lower consumption levels of animal products but also that other animal products will need to be consumed. Indeed, in the current situation, certain animal products which are not typically consumed in Belgium (such as heads, tails, ears, etc.) are exported. Nevertheless, as the transition scenarios assume that all the productions will be consumed, this implies that these products will need to be consumed too.

- **Consideration of grassland and arable land resources:** The developed scenarios assume that the grassland and arable land resources will remain constant to 2015 levels. Yet, this does not account for the potential expansion of urbanised areas (cities and villages) which might put a pressure on those resources. Furthermore, the transition scenarios assume that all pasture are occupied by a mixed dairy herd. Yet, other animals such as sheep which were not modelled in the scenarios will occupy a share of those pastures too. Furthermore, the choice to work with a mixed dairy herd implies to milk all the cows, which is not always practically feasible.

PART I: Describing current livestock sectors in Belgium

The following chapters aim at describing the current livestock sector in Belgium in order to obtain an accurate vision of the current situation before looking at potential ways of development for the future in the second part of the report (PART II. Challenging the trends with a diversity of scenarios).

First, Chapter 3 sets the general context of the Belgian food system. It outlines food consumption habits and average diets; presents the global livestock sector, with livestock populations and production levels; and looks at the global impacts of this sector.

Second, Chapter 4 to Chapter 7 present each livestock sector in more detail. Each chapter begins by a general presentation of the sector, before proposing a typology of production systems and assessing the environmental impacts of each production system and of the entire sector.

Finally, Chapter 8 and Chapter 9 allow to aggregate the results found in the previous chapters and thus present a global picture of the Belgian livestock sector, as well as validating the obtained results.

Chapter 3. Livestock and food system in Belgium

3.1. Food consumption in Belgium: average consumption and diets

The objective of this study is to explore possible transition pathways of the livestock sector in Belgium both from a production and consumption perspective. Here, an outline of the food consumption patterns of Belgian citizens, with a focus on animal products, is presented.

3.1.1. Current consumption levels

Table 1 shows the average food consumption habits in Belgium (De Ridder et al., 2016). Regarding vegetal products, the consumption levels are lower than the nutritional recommendations. For animal products, the situation is contrasted. There is an overconsumption of meat as the average consumption level for the 15-64 years old category in 2014 was twice the recommended level (114 g meat/cap/day vs. 57 g meat/cap/day)[12]. Regarding other animal products, consumption levels are below the recommendations for eggs and milk but higher for cheese (see Table 1 and Table 169 in Appendix 4).

If these reported average daily per capita consumption are extrapolated to the entire Belgian population (11.209.044 inhabitants in 2015 (Statistics Belgium, 2015), about 450 kt of meat are consumed over one year, of which 43% is pork, 28% is poultry meat and 19% is bovine meat.

The average and recommended food habits can be translated in terms of protein intake based on the protein content of a typical food for each food category (based on (ANSES, 2016), see Table 169 in Appendix 4). According to the Conseil Supérieur de la Santé (2016), the recommended total protein intake level for adults (18-59 years old) ranges between 52 and 62 g protein/cap/day (depending on gender) and it is advised to observe a balance between vegetal-based and animal-based protein sources (Conseil Supérieur de la Santé, 2016). In practice however, the average Belgian protein intake amounts 76 g protein/cap/dap/day, showing a situation of protein overconsumption. Furthermore, animal-based products represent 65% of total protein intake, i.e. 49,6 g protein/cap/day of which 40% are meat products and 25% are other animal-based protein sources such as eggs and dairy products. Vegetal based-products represent the remaining 35% (26,4 g protein/cap/day), which shows a situation of imbalance between animal-based and vegetal-based protein sources (Figure 7). This is in line with a study carried out on all EU member states which estimated that the average intake of protein in Belgium in 2007 amounted 47 g protein/cap/day for animal protein and 30 g protein/cap/day for vegetal protein (Westhoek et al., 2011). In conclusion, there is both an overconsumption of (total and animal) protein and an imbalance between animal and vegetal protein sources.

Those average consumption levels hide a certain diversity of food habits in the country. In this regard, the results of a survey carried out in 2015 with 500 Flemish consumers showed that 5% of the respondents were vegetarian and another 5% were flexitarian. The remaining 90% considered

[12] The average meat consumption for the entire Belgian population (including all age categories) is 111 g/cap/day. Extrapolating the total meat consumption based on 114 g/cap/day thus results in an overestimation of the total consumption. Nevertheless, the difference represents less than 3% and using the value of 114 g/cap/day presents the advantage of allowing for a comparison with 2004 data (which is only available for the 15-64 category).

themselves as flexivores (65%) or real carnivores (25%) (VLAM, 2015) [13]. More recent surveys conducted in 2017 and 2018 for the vegetarian organisation Eva and the Apaq-W confirm these results.

3.1.2. Historical evolution

The two last food consumption surveys (2004 and 2014, see Table 1) show that the consumption of meat products and milk has decreased whereas the consumption of cheese and fish remained stable (De Ridder et al., 2016).

Table 1. Average food consumption habits in Belgium in 2004 and 2014 (for people between 15-64 years).

	Consumption per capita (g/day)			**Total consumption [a] (t/year)**	
	2004	**2014**	**Recommended**	**2004**	**2014**
Vegetal-based products					
Cereals (Bread)	121	107	210-240	495.047	437.769
Potatoes	73	46	-	298.665	188.200
+ substitutes (rice, pasta, quinoa…)	149	142	240-350	609.604	580.965
Vegetables	167	157	300	683.247	642.334
Fruits	113	108	250	462.317	441.861
TOTAL vegetal-based products	448	514	-[e]	2.548.880	2.102.929
Animal-based products					
Meat products	121	114	57 [c]	495.047	466.408
- Bovine meat	23 [b]	21 [b]	-	103.350	86.745
- Pork	50 [b]	47 [b]	-	202.487	202.025
- Poultry meat	33 [b]	31 [b]	-	122.602	128.698
- Others	15 [b]	15 [b]	-	66.609	48.941
Eggs	11	11	20	45.004	45.004
Milk and Ca-enriched soy products	154	139	450 ml	630.060	568.691
Cheese	30	32	20	122.739	130.922
Fish and fish products	24	25	100 [d]	98.191	102.283
TOTAL animal-based products	340	321	-[e]	1.391.041	1.313.308

Source:

De Ridder et al. (2016), which is the last food consumption survey carried out in Belgium in 2014-2015.

Notes:

[a] Total consumption was estimated by extrapolating the daily per capita consumption to the entire Belgian population, which was of 11.209.044 inhabitants in 2015 (Statistics Belgium, 2015).

[b] The shares of pork, poultry, bovine meat and others are estimated through the shares of those meats in the apparent consumption numbers (expressed in kg of carcass weight) published every year by Statistics Belgium (Statistics Belgium (2017).

[c] According to De Ridder et al. (2016), the consumption of meat should be limited to 57g meat/cap/day (i.e. eating meat four times a week). Although there is no subdivision of this total amount, one can estimate it based on apparent consumption numbers, as explained in the previous note. As a result, the total 57 g meat/cap/day can be subdivided in 50g from the pork, poultry and bovine meat group and 7 g come from other meat types.

[d] The 100g/day recommendation is for meat AND fish products together.

[e] The study from De Ridder et al. (2016) does not provide recommendations on the total level of animal-based products consumption.

[13] The word *flexitarian* is used for people who eat meat but do not always feel right about it and try to limit their consumption. *Carnivores* eat meat almost every day. The study does not provide a specific definition of *flexivore* but it can be considered as an intermediate category between flexitarian and carnivores.

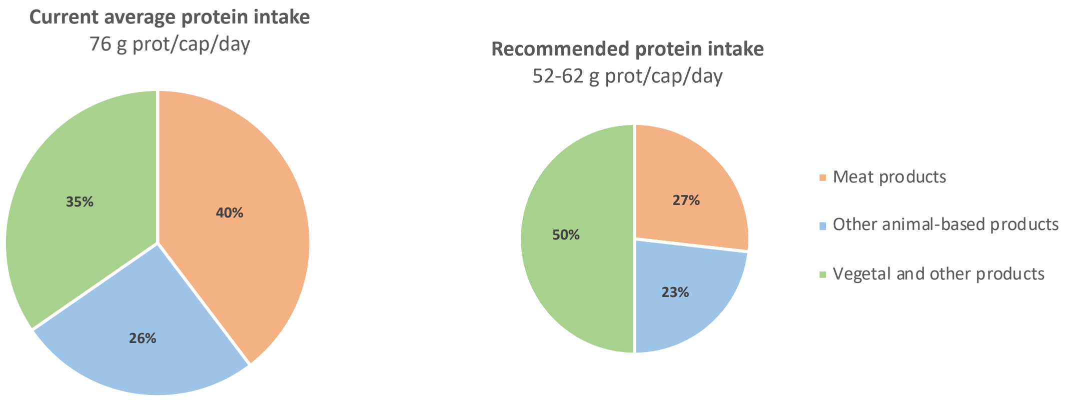

Figure 7. Comparison of protein sources in recommended and average diets in Belgium (in g protein/cap/day).
Sources: Current protein intake is based on De Ridder et al. (2016) and ANSES (2016) for the conversion in protein terms. Recommended protein intake based on Conseil Supérieur de la Santé (2016).

3.2. Food production, import and export of livestock in Belgium

3.2.1. National production and international flows

The five main livestock productions in Belgium are bovine meat, pork, poultry meat, eggs, and milk. The shares of other livestock productions are relatively small.

Animal-based products consumed in Belgium are partly produced in the country or imported; part of the national production is also exported. Table 2 shows production, import and export numbers for animal products in Belgium, as well as the net available values (Net = Production + Imports – Exports) and the self-sufficiency ratios (Production/Net). The net value can be associated with the apparent consumption and the self-sufficiency is thus a result of the Production/Consumption ratio. Belgium has self-sufficiency ratios higher than 100% for all animal products. Domestic supply is thus higher than domestic demand, in particular for pork, followed by bovine meat, poultry meat, dairy products and finally eggs for which self-sufficiency is closer to 100% (Figure 8).

The data shown here and the associated self-sufficiency ratios are for the year 2015, which was used as a reference year throughout the entire study. This ensures a certain coherence of results, although it is true that for certain measures more recent data is available (see section 2.6 for limits of the study). For instance, regarding the self-sufficiency ratios, it has been pointed out that 2015 and 2016 were years during which the dairy herd decreased significantly due to the milk crisis, leading to increased self-sufficiency ratios for those years (Actor interviews, 2018). Such elements must be kept in mind.

Table 2. Production, importation and exportation of meat products in 2015 in Belgium.

	Production	Imports	Exports	Net [b]	Ratio Prod/Net [c]
			Tonnes of product [a]		
Bovine meat [1]	261.639	86.828	182.384	166.083	158%
Pork [1]	1.140.326	174.955	877.649	437.632	261%
Poultry meat [1]	369.590	457.649	593.407	233.832	158%
Eggs [2]	165.269	97.817	111.971	151.116	109%
Milk [3]	1.275.496	302.212	634.546	943.162	135%

Sources:
[1] Statistics Belgium (2017), [2] Statistics Belgium (2014), [3] Statistics Belgium (2013).
Notes:
[a] For bovine, pork and poultry meat, values are expressed in tonnes of carcass weight. For eggs, data is from 2013 (last available data) and values are in tonnes of eggs and are estimated from number of eggs, assuming that one egg weights 60g. Finally, for milk, data is from 2012 (last available data) and values are in tonnes of fresh liquid dairy products.
[b] Net = Production + Imports – Exports and can be associated with apparent consumption.
[c] Corresponds to the self-sufficiency ratio, which gives an indication on how much the national production contributes to the national consumption.

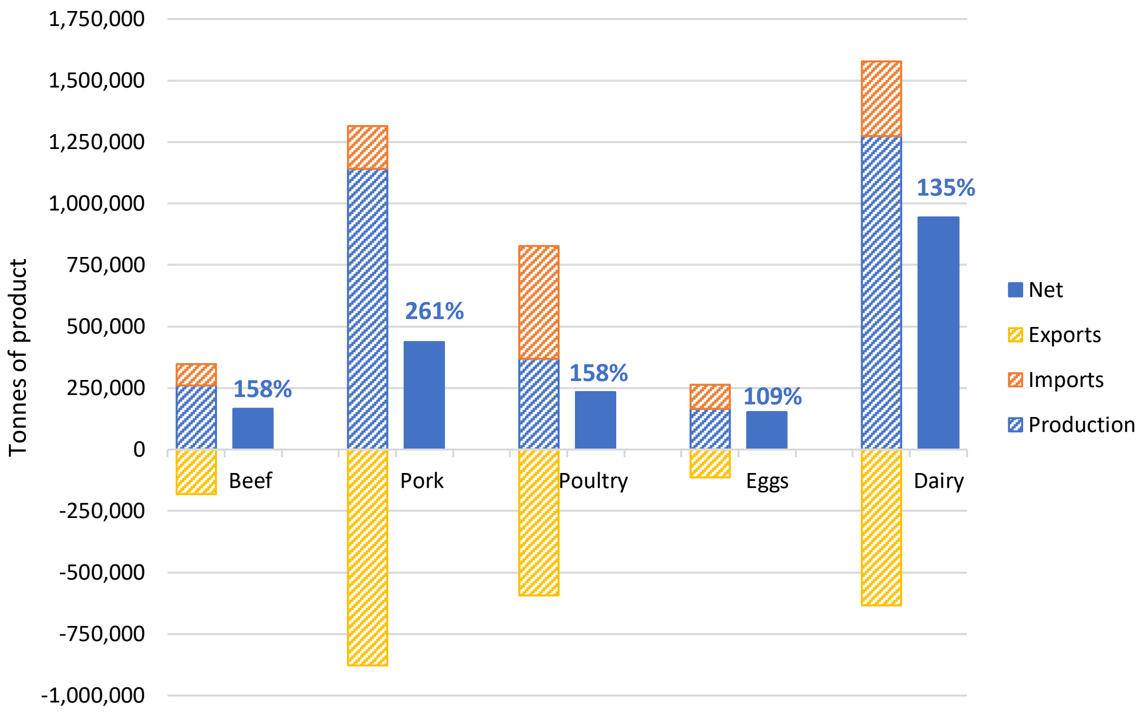

Figure 8. Food balance of different animal products in Belgium (2015) and associated self-sufficiency ratios (Production/Net).
Sources: (Statistics Belgium, 2017a, 2014a, 2013).

3.2.2. Real vs. apparent consumption

At this point, it is important to make a distinction between real and apparent consumption. Indeed, there is a significant difference between total consumption values presented in Table 1 and the net values presented in the food balances (Table 2 and Figure 8). The differences between these values, can be explained by the different approaches used to obtain the data.

On one hand, the data presented in Table 1 comes from the last survey on food consumption in Belgium. The surveys are carried out with a certain number of people and the resulting values indicate how much of a given product is effectively consumed and ingested. They show the real consumption.

On the other hand, the food balances are published every year by the national directorate-general for statistics (Statistics Belgium), based on production, export and import values. The net value gives the amount of a given product which is available for national consumption but all of it is not necessarily consumed. Indeed, the net balance does not account for possible losses along the food chain and the fact that some parts such as intestines, blood, etc. will not be consumed (but can still be used as coproducts for other purposes). Hence, whereas the first values are collected from the consumption side and thus represent real consumption values, the second are collected from a production side and thus present apparent consumption values.

3.2.3. Waste

The difference between apparent and real consumption can thus be assimilated to the occurrence of losses across the food chain. Nevertheless, as shown on Figure 9, several types of losses can be identified:

1. **Unavoidable losses** which occur during the slaughtering and carcass cutting steps of the transformation process, leading from a live animal weight to a net meat weight which is available for commercialisation.
2. **Avoidable losses** occurring along the logistics chain and which are defined as *food losses* by the FAO.
3. **Final preparation losses,** which are defined as *food waste* by the FAO and mainly include expired products.

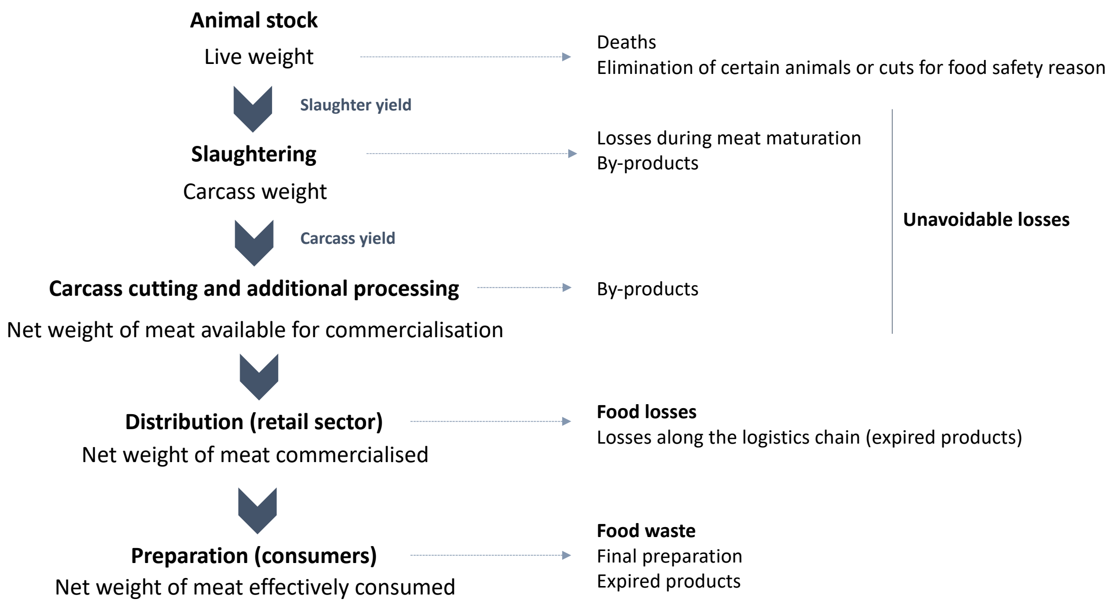

Figure 9. Steps from animal stock to meat, and associated losses.

Table 3 provides an assessment of the losses occurring in the food chain for different meat products in Belgium. The departing points for this table are the apparent consumption numbers mentioned in Table 2, i.e. the net available values (expressed in carcass weight) when exports and imports are taken into account.

Going down the transformation chain, Statistics Belgium applies transformation ratios (carcass yield: percentage of available meat per carcass) in order to estimate quantities available for consumption in net meat weight, and hence what can actually be consumed. The difference between quantities available for consumption (when the carcass, intestines, blood, etc. have been withdrawn) and the real consumption is assumed to represent the food losses. These losses represent 154.138 tonnes every year. This means that 25% of the net meat weight is lost along the food chain (a certain fraction occurs as *food losses* and another fraction occurs as *food waste,* as explained above). It must be noted that products such as the bones, intestines or blood can serve for other purposes and are hence not included in these food losses (they represent the unavoidable 'losses').

Going up the transformation chain, for the estimation of the corresponding live weight, slaughter yields from the literature were applied to the carcass weights (Association IGP BBB, 2017), (ERM and Universiteit Gent, 2011a), (Hoffmann et al., 2013)). The live weight column thus expresses the apparent consumption values in terms of live weight instead of carcass weight. Table 4 provides an overview per livestock production of how much final meat is obtained from one kg of live weight and how much live weight is necessary to obtain one kg of meat.

Table 3. Losses occurring in the food chain for different meat products in Belgium in 2015.

	Live weight t/year	**Slaughter yield** %	**Carcass weight[1]** t/year	**Carcass yield [1]** %	**Net meat weight [1]** t/year	**Consum-ption[1, 2]** t/year	**Estimated losses** t/year
Bovine meat	255.512	65% [3]	166.083	70% [a]	115.775	87.017	28.757
Pork	553.965	79% [4]	437.632	59%	256.859	193.058	63.802
Poultry	324.767	72% [5]	233.832	72%	168.766	126.846	41.920
Others	-	*varies*	104.172	*varies*	79.147	59.487	19.659
Total meat	-	-	941.719	-	620.547	466.408 [b]	154.138

Sources:

[1] (Statistics Belgium, 2017a), [2] (De Ridder et al., 2016a), [3] (Association IGP BBB, 2017), [4] (ERM and Universiteit Gent, 2011a), [5] (Hoffmann et al., 2013)

Notes:

[a] 70% is the carcass yield applied by Statstics Belgium to pass from a carcass to a net, available meat weight. It is applied without making a distinction between dairy cows and specialised meat animals, which however are likely to present different carcass yields.

[b] The total meat consumption number (466.408 t) comes from the national survey on food consumption. The shares of bovine meat, pork, poultry and others were estimated based on the shares of these categories in apparent consumption numbers provided by Statistics Belgium.

According to the FAO (FAO, 2011), average losses along the food chain for meat products in Europe are the following: 5% during the processing and packaging step, 4% during the distribution step and 11% during the consumption step (FAO, 2011). According to these numbers, losses would amount to 19% of the meat weight available after slaughtering and carcass cutting, that is 116.861 tonnes per year. This figure shows a difference of 37.277 tonnes per year (24%) with the previous estimate.

It must be mentioned that the presented value of 25% of losses only constitutes an estimate made in the context of this study due to a lack of specific data on this measure. It must be used with caution as it links real consumption and apparent consumption values, which result from different measuring methods as already mentioned. In practice, several actors have mentioned that 25% seems a rather high estimate given the importance of breeds with high carcass yield in Belgium (Belgian blue for bovine and Pietrain for pigs) (Actor interviews, 2018).

Table 4. Conversion of live weight in meat weight for different livestock productions.

	kg live weight/kg meat	kg meat/kg live weight
Bovine meat [1, 2]	2,2	0,4
Pork [1, 3]	2,2	0,5
Poultry [1, 4]	1,9	0,5

Sources:
[1] (Statistics Belgium, 2017), [2] (De Ridder et al., 2016), [2] (Association IGP BBB, 2017), [3] (ERM and Universiteit Gent, 2011a)

3.2.4. International trade

In terms of international trade of animal products from and to Belgium, the vast majority of flows happen in Europe (Figure 10, Table 5). On the imports side, European countries represents more than 95% of all incoming flows of animal products in Belgium. On the exports side, destinations are more diverse but European countries still remain the main destinations, particularly for pork and bovine meat. Other important trading regions include Africa for poultry meat and eggs and Asia for eggs.

It must be noted that export and import flows do not apply to the same products. Indeed, exported products tend not to be consumed commonly in Belgium (e.g. edible offal, heads, ears, tails, etc.) (Actor interviews, 2018). On the other hand, an example of significant import flow is that of live chickens imported to be slaughtered in Belgium.

More specifically, when looking at the three biggest import and export flows for each product, Table 5 confirms that trade mainly occurs with neighbouring European countries. In particular, the Netherlands is the main partner for all flows except for pork exports. Besides the Netherlands, France and Germany are important destinations too, as well as Poland which is the second biggest destination for pork after Germany. The only non-European country in the list is Iraq which is an important destination for Belgian eggs.

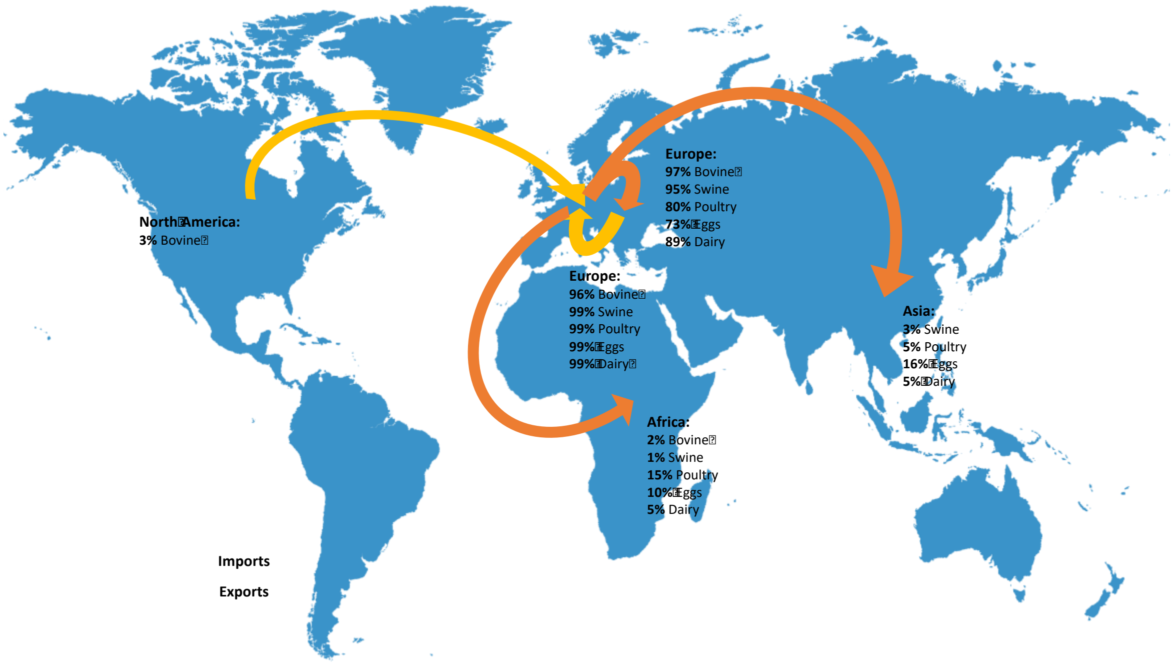

Figure 10. International flows of meat products from and to Belgium in 2015.
Source: (ITC, 2017)
Note: The percentage shows how much of the total flow (in tonnes of product) goes to a particular region of the world. Flows to South America and Oceania exist but represent less than 1%. Asia comprises the Middle-East.

Table 5. Main international flows of animal products (in tonnes of product) from and to Belgium in 2015.

Product/Country	Imports (t)	Product/Country	Exports (t)
Bovine meat			
Netherlands	47.261	Netherlands	60.861
France	17.535	France	39.060
Germany	5.746	Germany	25.408
Pork			
Netherlands	33.597	Germany	272.818
France	31.271	Poland	200.345
Germany	11.751	Netherlands	90.841
Poultry meat			
Netherlands	245.135	Netherlands	172.121
France	123.343	France	135.856
Germany	28651	Germany	58.282
Eggs			
Netherlands	38.640	Netherlands	31.256
France	8445	Germany	21.913
Poland	5452	Iraq	7697
Dairy			
Germany	650.879	Germany	438.732
Netherlands	569.943	France	365.930
France	269.054	Netherlands	339.993

Source: (ITC, 2017)

3.2.5. Geographical distribution of livestock production in Belgium

The livestock population is mainly located in Flanders, especially with regard to pork production, poultry and eggs (respectively 94%, 84% and 86% of the Belgian livestock population). The bovine population is more equally distributed over the two regions (Table 6 and Figure 11).

Table 6. Livestock population in 2015 in Belgium and repartition in Wallonia and Flanders.

	Livestock population in Belgium		Livestock population in Wallonia		Livestock population in Flanders	
Other bovine	1.995.872	100%	978.560	49%	1.016.701	51%
Pigs	6.364.164	100%	382.973	6%	5.981.191	94%
Poultry	23.838.182	100%	3.907.768	16%	19.930.414	84%
Laying hens	8.109.466	100%	1.176.40	15%	6.933.062	86%
Dairy cows	507.390	100%	202.825	40%	304.304	60%
Sheep	117.321	100%	48.375	41%	68.865	59%
Goats	38.591	100%	10.665	28%	27.900	72%
Equidae	38.155	100%	13.341	35%	24.734	65%

Sources: Statistics Belgium (2016, 2014b)
Note: The category 'other bovine' represents the difference between the total bovine herd and dairy cows.

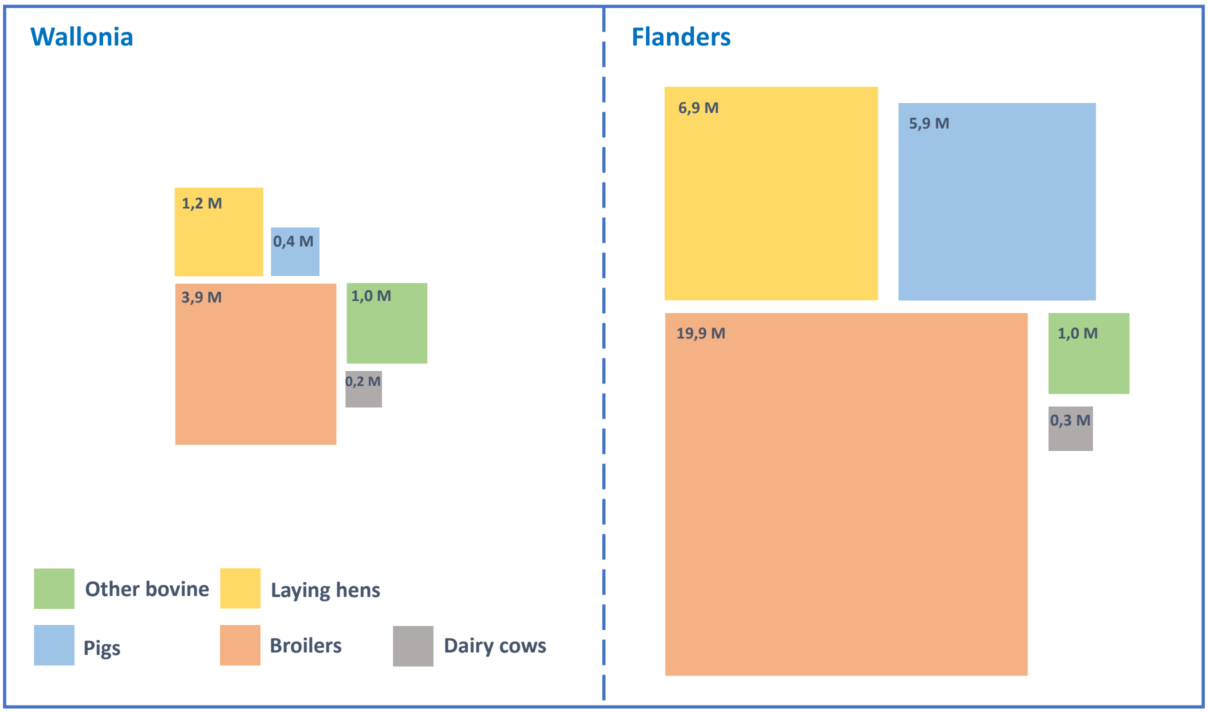

Figure 11. Geographical distribution of livestock numbers in Belgium (Flanders and Wallonia) in 2015.
Source: Statistics Belgium (2016, 2014b)
Note: Boxes and values refer to animal numbers.

3.2.6. Historical evolution

Over the last ten years (from 2005 to 2015), the pig population was maintained whereas the laying hens, dairy cows and other bovine populations tended to decrease (respectively -5%, -3% and -8%) and the poultry population increased (13%) (Table 7 and Figure 12).

Table 7. Evolution of the livestock population in Belgium between 2005 and 2015.

	Livestock population in 2005	Livestock population in 2015	Average growth rate per year	Growth rate over 10 years
Other bovine	2.175.368	1.995.872	-0,85%	-8%
Pigs	6.318.213	6.364.164	0,08%	+1%
Poultry	21.073.353	23.838.182	1,41%	+13%
Laying hens	8.540.257	8.109.466	-0,27%	-5%
Dairy cows	523.281	507.390	-0,29%	-3%

Sources: Statistics Belgium (2016, 2010)
Note: The category ‘other bovine’ represents the difference between the total bovine herd and dairy cows.

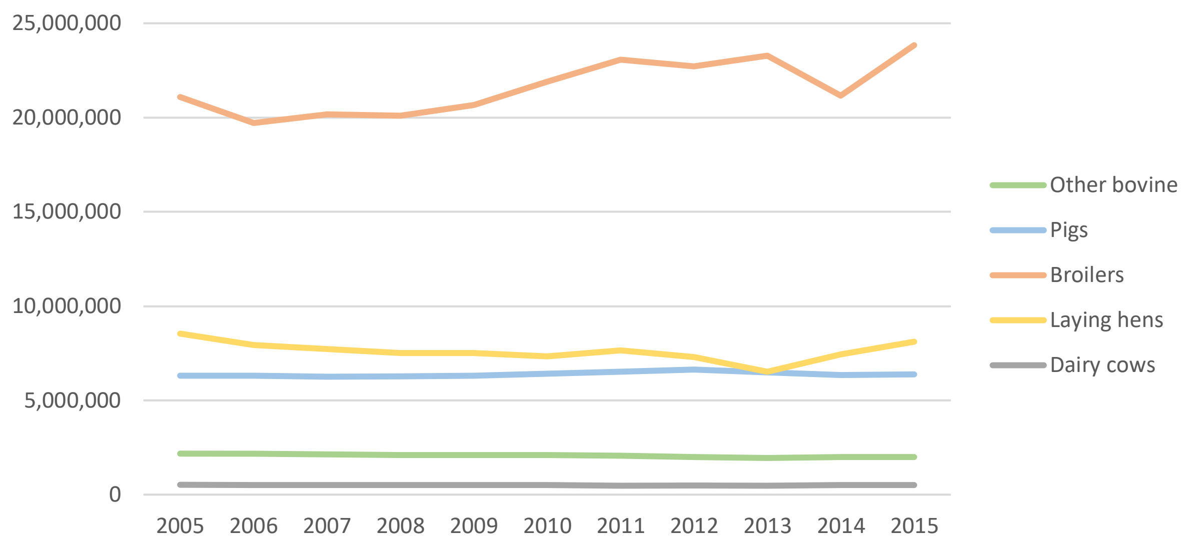

Figure 12. Evolution of the livestock population in Belgium from 2005 to 2015.
Source: Statistics Belgium (2016, 2014b)
Note: The category 'other bovine' represents the difference between the total bovine herd and dairy cows.

3.3. Utilisation of feed for livestock in Belgium

Figure 13 shows the annual feed consumption of different livestock sectors in Belgium. Cattle (dairy and non-dairy) are responsible for about half of total feed consumption, mainly roughage feed (grass or other forages). Monogastric animals on the other hand (pigs and poultry) are responsible for the majority of non-roughage feed consumption, such as cereals, protein-rich feed, brans, etc.

The Belgian Feed Association (BFA) works since 2006 to improve the sustainability and social responsibility of feed ingredients (more details in Appendix 5 – Socially responsible soy (BFA standard)) (BFA, 2016).

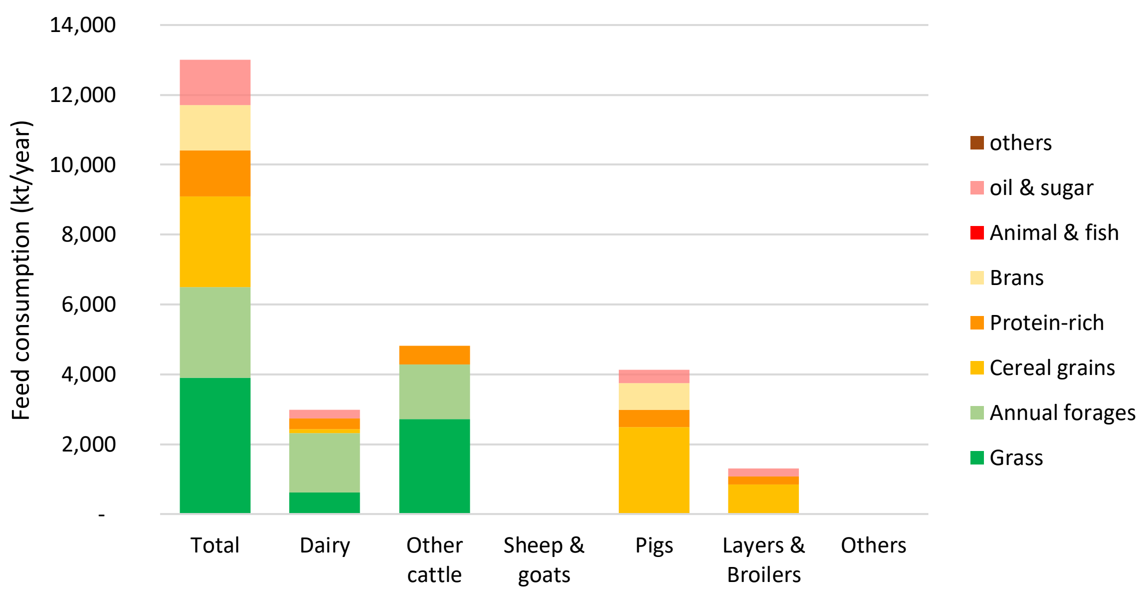

Figure 13. Annual feed consumption in Belgium in each livestock sector.
Source: (Hou et al., 2016)
Notes: The feed consumption of sheep & goats category appears to be inexistent on this figure. In reality it is not but it represents less than 1% of total feed consumption (61 kt per year). It must also be noted that this feed can have multiple origins (it can either be nationally produced or imported from other countries).

3.4. Contribution of agriculture and livestock to environmental impacts in Belgium

3.4.1. GHG emissions due to livestock in Belgium

According to Belgium's national GHG inventory (VMM et al., 2017), emissions from the *agriculture sector* amounted 13.358 kt CO_2e in 2015, i.e. 12% of total Belgian emissions (Table 8). Focussing only on the *livestock sector*, the inventory shows that its direct emissions amounted 7.538 kt CO_2e in 2015 (mainly under the form of CH_4 and N_2O emissions; see Table 8), i.e. 7% of the total annual GHG emissions in Belgium. Cattle (dairy and other cattle) contribute to 69% of GHG emissions from livestock in Belgium, while pigs contribute to 14% of emissions and poultry (laying hens and broilers) less than 1% (Figure 14).

Box 2 below provides insight into the different scopes of GHG assessments of both this study and the national inventory (for more details, see Appendix 6 – Belgian GHG inventory). Additionally, a further assessment of the livestock sector's GHG emissions (resulting from the present study's calculations) is provided in Chapter 8.

Table 8. Distribution of GHG emissions in Belgium (2015).

	Emissions (kt CO_2e)	Share of total emissions	Of which CO_2 (%)	CH_4 (%)	N_2O (%)
Total emissions in Belgium	115.537				
% of emissions due to agriculture & livestock	13.358	12%	3%	74%	72%
Of which % of emissions due to livestock	7.538	7%	0%	72%	28%
% of livestock emissions in Wallonia		42%			
% of livestock emissions in Flanders		58%			

Source: Belgium's national GHG inventory (2015)

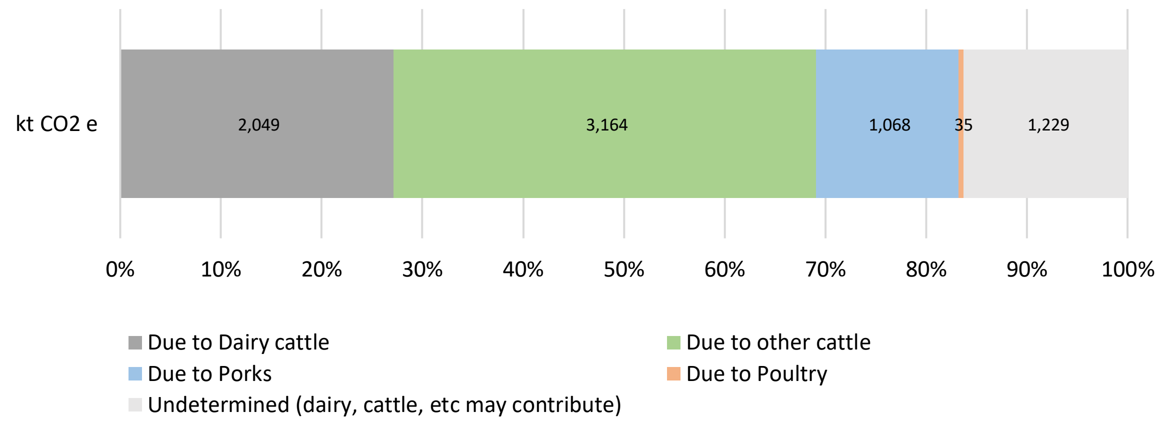

Figure 14: Contribution of livestock categories to livestock GHG emissions in Belgium.
Source: Belgium's national GHG inventory (2015)

Box 2. Scope of GHG assessments in the national GHG inventory and in this study

1. National GHG inventory

(a) Agriculture

In Belgium's national GHG inventory, five categories contribute to GHG emissions related to agriculture (cultures and livestock) : enteric fermentation, manure management, emissions from agricultural soils, liming, and urea application. Fuel combustion in agriculture and fertliser production are two additional categories which are not considered under agricultural emissions in the national inventory but were nevertheless included in the total value presented here for agriculture (13.358 kt CO_2e in 2015; see Table 8) because they are related to the sector.

(b) Livestock

The value presented here for the livestock sector (7.538 kt CO_2e in 2015; see Table 8) includes the following categories: enteric fermentation, manure management (including urine and dung deposited by grazing animals) as well as emissions from animal manure applied to soils for fertilisation. It is important to note that feed-related emissions which were estimated in the present study are not included in the national inventory.

2. This study

Emission sources assessed in this study include feed-related emissions, enteric fermentation emissions and manure management emissions. The scopes of this study and the national GHG inventory are thus not entirely similar.

The common scope between this study and the national inventory are enteric fermentation and manure maangement emissions. Looking only at these two categories for the pork, poultry and bovine sectors, the inventory reports an emissions level of 6.817 kt CO_2e in 2015. A comparison between figures from this study and from the national inventory is provided in Chapter 9.3.

Departing from the initial description of the Belgian food system and livestock sector in the previous chapter, the following chapters describe in more detail each of the five livestock sectors which are of interest in this study. These chapters aim at characterising existing production systems within each livestock sector and their associated impacts. The results obtained for each sector separately in the following chapters are aggregated in Chapter 8 and then compared to other sources in Chapter 9.

Chapter 4. Pork production in Belgium

4.1. The Belgian pork sector

4.1.1. Animal, farm and production numbers

In 2015, there were 6.364.164 pigs in Belgium. The vast majority of them are located in Flanders which hosts 94% of the total pig population versus 6% in Wallonia (Figure 15). Moreover, Flemish pig production is importantly concentrated in the coastal province of West Flanders which hosts 53% of the total pig population in Belgium. Pig farming also occurs in the neighbouring province of East Flanders and the north of the Antwerp province, but to a lesser extent (16% of total animals each) (Statistics Belgium, 2016a). These pigs were raised in 4.727 farms in Belgium, of which 4.145 were located in Flanders. The average number of pigs per farm is 1.443 in Flanders compared to 658 pigs per farm in Wallonia (Statistics Belgium, 2016). In terms of production, 11.886.693 pigs were slaughtered in Belgium in 2015, resulting in the production of 1,1 million tonnes of slaughtered pig meat (carcass weight)[14]. An important characteristic of the sector is that 73% of the net production is exported (815.037 tonnes of carcass weight). Key numbers are summarised in Table 9.

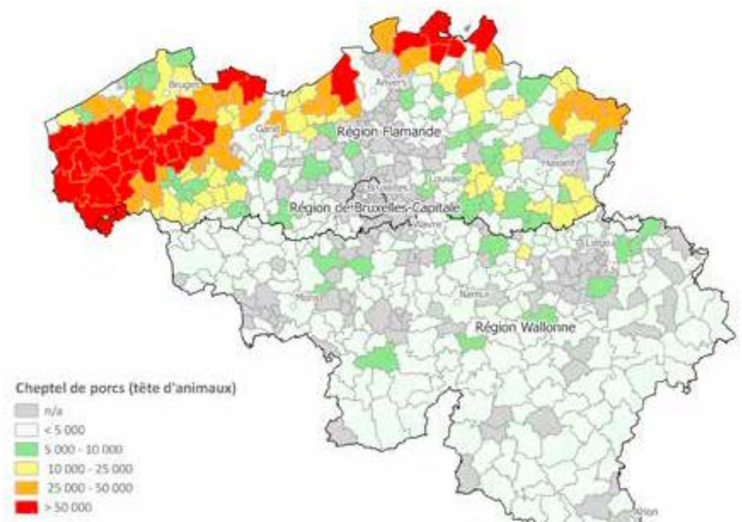

Figure 15. Intensity of pig farming in Belgium in 2014 (in number of animals per municipality) (SOGEPA, 2014).

[14] This figure represents the net production and thus includes the imports of live animals slaughtered in Belgium and excludes the exports of live animals raised in Belgium but slaughtered in other countries. It can be noted however that these two flows are quite close (imports of live animals represented 46.680 tonnes of carcass weight and exports of live animals corresponded to 62.612 tonnes of carcass weight in 2015). Hence, it can be assumed that the net number of slaughters corresponds to the number of pigs raised in Belgium during one year as the difference represents 1%.

Table 9. Summary of key numbers of the Belgian pork sector in 2015.

	Belgium	Flanders		Wallonia	
Animals [1]	6.364.164	5.981.191	94%	382.973	6%
Farms [1]	4.727	4.145	88%	582	12%
Animals/farm [1]	1346	1443	-	658	-
Production					
Slaughters [1]	11.886.693	11.139.245	94%	747.448	6%
t carcass weight [2]	1.124.394	1.056.930	94%	67.464	6%
Imports (t carcass weight) [2]					
Live animals	46.680	-	-	-	-
Meat products	128.275	-	-	-	-
Exports (t carcass weight) [2]					
Live animals	62.612	-	-	-	-
Meat products	815.073	-	-	-	-

Sources: [1] (Statistics Belgium, 2016), [2] (Statistics Belgium, 2017)

Note: It must be mentioned that the export figures mentioned here (and in Figure 8) do not include the export of by-products such as heads, tails, legs to countries such as China.

4.1.2. Historical evolution

Over the last years, there has been a clear trend towards lesser but bigger farms. In Flanders in 1997, there were more than 10.000 farms, holding an average of about 700 pigs per farm. Yet, in 2015 the number of farms had decreased to about 4.000, holding an average of 1.440 animals per farm (Figure 16) (Departement Landbouw en Visserij, 2016).

In terms of animal numbers, there has been a decrease in the number of pigs in the early 2000s but it has remained rather stable since then. This is mainly due to the implementation of environmental policies related to the management of manure and in particular the introduction of manure quotas. Since 2008, farmers are allowed to grow again if they can prove they treat the manure adequately (FOD Economie, 2015; Platteau et al., 2009). The decrease in animal numbers happened mainly for sows but this was compensated by the fact that the number of piglets per sow increased as well as the lifetime of the sows.

It is acknowledged that, during the last years, the sector has experienced a severe crisis, due to several factors. First, pig farms, which face high structural feeding costs (see paragraph 4.1.5), have suffered from the fact that since 2006, feed prices have increased and become more volatile, without this being compensated with higher revenue prices. Second, pig farmers are exposed to volatile international prices, not only for feed and other inputs but also for their final products. Finally, the sector also suffered from external shocks such as the Russian embargos in 2014 and 2015. It was first due to cases of swine fever in Poland and Lithuania and it was then followed by a general trade embargo on European agricultural products (Van Buggenhout and Vuylsteke, 2016).

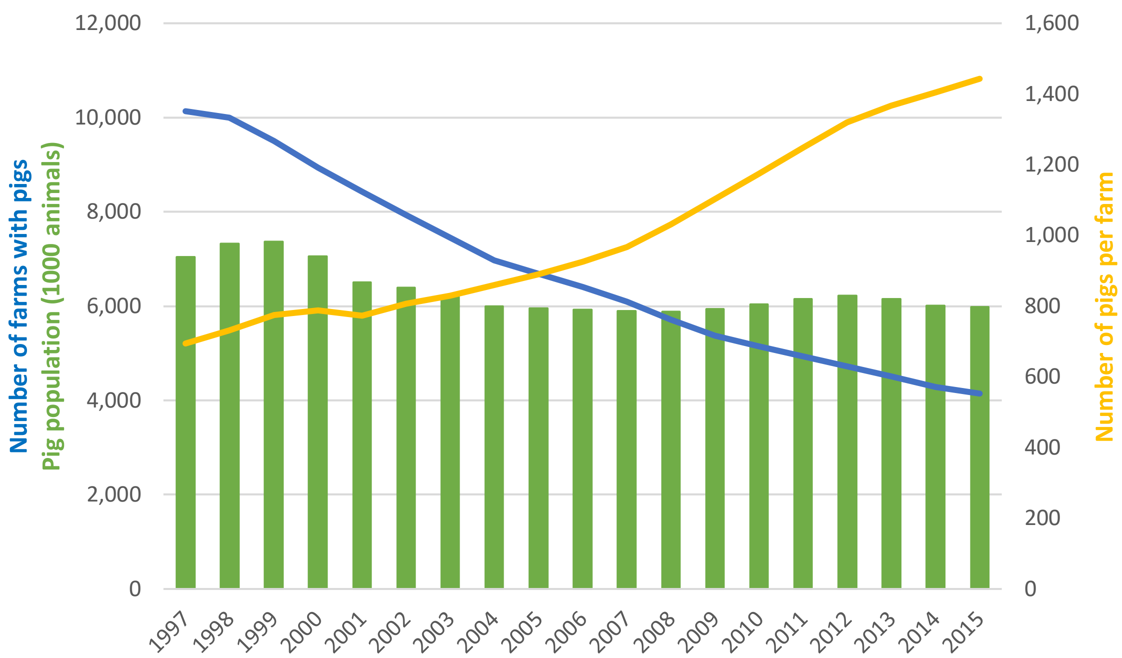

Figure 16. Evolution of the number of farms with pigs and the number of pigs per farm in Flanders (2004-2015).
Source: (Departement Landbouw en Visserij, 2016)

4.1.3. Farming systems

Among pig farms, it is important to distinguish mixed farms from specialised ones, i.e. farms for which pig farming represents two thirds or more of the total revenue. In 2012, these specialised farms represented 57% of total farms with pigs but concentrated 81% of the total pig population, whereas mixed farms (43% of pig farms) only hosted 19% of the total pig population (Table *10*) (FOD Economie, 2015). In 2015, there were 2.206 specialised pig farms in Flanders (53% of pig farms in Flanders) (Departement Landbouw en Visserij, 2016).

These specialised farms can be separated into four main categories:

- Pig **breeders** focus exclusively on the reproduction of pigs and hence on producing piglets. They exclusively hold sows and will sell all their piglets.
- Pig **fatteners** focus on fattening the piglets they buy from pig breeders.
- **Closed systems** combine both breeding and fattening and can thus operate in a closed loop.
- Intermediate **Semi-closed systems** operate similarly to closed systems but occasionally sell or buy some piglets.

The situation regarding pig farms and their operation models is summarised in Table 10 for the year 2012 in Belgium. A survey carried out in 2016 with Flemish 989 pig farmers showed that among the respondents, there were 41% of specialised fatteners, 27% of closed farms, 25% of semi-closed closed and 7% of specialised breeders (Deuninck et al., 2017).

It is interesting to note that, according to experts from the pig sector, pig farmers will in the majority of cases strive to operate under a closed system. On the one hand, there are only a few farms which specifically choose to focus exclusively on breeding activities. Often, breeders are young farmers who are starting with their pig farming activities and cannot complete the fattening activity yet. Unlike countries such as Denmark, Belgium does not have a particular specialisation in the production of piglets. On the other hand, fatteners are sometimes older farmers who used to operate under a closed system but wishing to reduce their activities without entirely stopping them. Leaving behind the breeding step and focusing on the fattening is one way of achieving this (Actor interviews, 2018).

Another important factor which is likely to have led some farmers to abandoning the breeding step is the implementation of the new housing regulation for sows. This law from 2001 came into force in 2013 and forbids to house sows which are 4 weeks pregnant or more in individual cages or compartments. Instead, they should be housed in groups. For a farmer, passing from the old individual housing system to the new housing system implied investing in new structures. In the light of these costs, some farmers chose to stop holding sows. This also explains the decrease in numbers of sows which was mentioned earlier (Actor interviews, 2017; Deuninck et al., 2017; Platteau et al., 2012).

Table 10. Numbers and shares of pigs and farms according to the activity in Belgium in 2012.

	Number of pigs		**Number of farms**		**Pigs/farm**
	Amount	%	Amount	%	Amount
Specialised farms	5.401.561	81%	3.049	57%	1.772
- *Breeders*	*391.089*	*6%*	*195*	*4%*	*2.006*
- *Fatteners*	*2.536.788*	*38%*	*1.619*	*30%*	*1.567*
- *Closed systems*	*2.473.684*	*37%*	*1.235*	*23%*	*2.003*
Mixed farms	1.232.052	19%	2.340	43%	527
TOTAL	6.633.613	100%	5.389	100%	1.231

Source: (FOD Economie, 2015)

4.1.4. Sectoral organisation

Besides the actual farmers, several other actors are involved in the pig sector, the general organisation of which is presented in Figure 17 and Figure 19, which focuses more specifically on post-production steps.

(a) Upstream actors

A crucial upstream actor in the pig sector is the compound feed industry which provides feed to all pig farmers. Belgium is one of the few Western-European countries where this industry has such an important influence on farmers and is so much integrated in the sector (Platteau et al., 2016). This integration (illustrated by the grey box on Figure 17) goes much further than just the provision of feed. Indeed, feed companies provide much information and technical advice to farmers. Furthermore, many of them use veterinary and administration services which are offered by their feeding company. In some cases, the feed producer even owns the farm and the pigs. The farmer is then hired by the feed producer to raise the pigs (FOD Economie, 2015; Platteau et al., 2016). This strong interaction with the feeding industry (be it through proper integration or through the use of specific services) affects more than 95% of farmers (Actor interviews, 2018). Important actors are companies such as Vanden Avenne, Danis or AVEVE.

Only in some cases do pig farmers operate independently. In those cases, farms are usually big enough to do so. They can then switch from one feed producer to another and usually hire independent people to do their administration (Actor interviews, 2018).

The importance of the feed industry is also reflected by the fact that, in the aforementioned survey carried out in 2016, 29% of non-contract producers (see below) were in debt with feed producers and 59% believe pig farmers are too dependent of the feed industry (Deuninck et al., 2017).

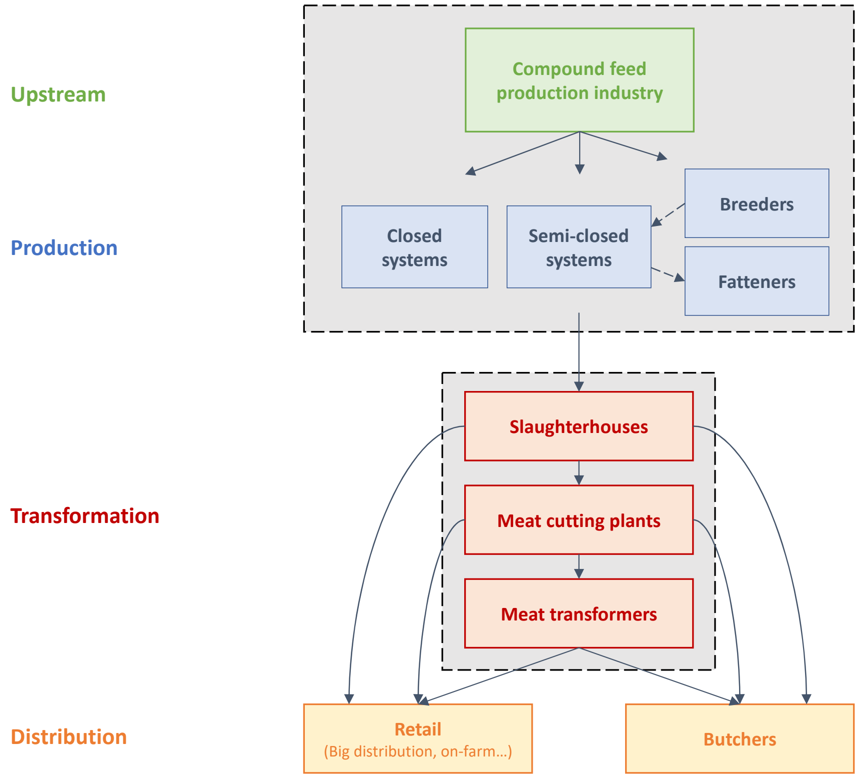

Figure 17. General organisation of the pig farming sector (adapted from FOD Economie (2015)).

(b) Pork producers

As mentioned above, pork producers can either specialise in breeding or fattening, or operate in a closed or semi-closed system.

The use of contracts was mentioned in the previous paragraph and plays an important role for pig farmers, especially for fatteners as about 50% of them work under contracts. Closed systems on the other hand almost never work under contracts and it is rather uncommon for pig breeders too. (FOD Economie, 2015; Gabriëls and Van Gijseghem, 2003). These contracts can take several forms (they are sometimes still purely verbal) and they can happen with different partners, such as the feed industry (majority of the cases), other pig farmers (between breeders and fatteners) and merchants. It is interesting to note that the perception of those contracts is contrasted. Indeed, they are quite badly seen from the outside (50% of interviewed farmers consider contracts as negative for the Flemish pig sector) but rather well perceived by farmers who work with contracts (72% of contract-producers are happy with this system) (Deuninck et al., 2017). There can also be a preconception among non-contract farmers who consider that contract farmers are "bad" farmers. In practice, these contracts can offer a certain stability for the farmers.

(c) Institutions

In Flanders, apart from traditional farmers unions such as the Boerenbond (BB) and the Algemeen Boerensyndicaat (ABS), the VPOV (Vlaamse Producentenorganisatie Varkenshouders), the first Flemish producers' organisation of the sector formed in 2016. For the moment it mainly aims at making market and commercial information available to farmers in order to increase the transparency of the sector. Another producers' organisation related to the Belgian Pork Group (see paragraph below) was almost created but the project was stopped to give more chances to VPOV. An example of commercialisation cooperative is Propigs (formerly COVAVEE) which groups 700 producers and depends directly from the Belgian Pork Group (Platteau et al., 2016).

In Wallonia, the traditional farmer unions are the Fédération wallonne de l'Agriculture (FWA) and FUGEA. Furthermore, two initiatives can be mentioned. First, the farmers' cooperative Porc Qualité Ardennes (PQA) was created in 1989 by 14 pig farmers and counts more than 150 pig farmers today. It controls the entirety of the production chain (from pig farming to transformation and distribution) and aims at providing a just and stable revenue to its members. Second, more recently the first group of organic pig producers was created in 2017, through the intermediary of the UNAB (Union Nationale des Agrobiologistes Belges). It aims at grouping organic producers in order to strengthen their position on the market and ensure a better revenue.

(d) Downstream actors

Pig farmers usually deliver their pigs either directly to a slaughterhouse or to a wholesaler. It would seem pig farmers are loyal to their downstream partner as 75% of the 2016 survey respondents work with only one partner (Deuninck et al., 2017).

The downstream comprises several actors and steps. First, when pigs are ready to be slaughtered, they are sent to the slaughterhouses or exported to neighbouring countries. The carcasses are then cut into pieces in cutting plants. These plants can then deliver the meat either to meat transformers, butchers or directly to retail and distribution actors. Part of it is exported as well and further processed in other countries.

These steps do not necessarily occur separately as some companies can perform all of them: they slaughter the pigs, cut the carcasses and transform the meat. There can thus be a certain degree of integration in the processing and transformation sector (FOD Economie, 2015).

Moreover, during the last years, there has been a strong concentration of the slaughtering industry. Indeed, about 35% of total Belgian slaughters are realised by four Flemish slaughterhouses which reach production levels of more than 1 million pigs a year each (SOGEPA, 2014). Furthermore, this phenomenon has been accentuated by the recent merger in 2015 of the groups Covalis and Westvlees into the Belgian Pork Group. This group holds several slaughterhouses, cutting plants and transformation plants and is the biggest actor in the Belgian pig downstream sector with the annual transformation of 420.000 tonnes of pig meat (Platteau et al., 2016).

As a consequence of the strong regional concentration of the pig sector in Flanders, the number of slaughterhouses located in Wallonia as well as their importance in terms of production is very limited compared to Flanders (Figure 18). Only one Walloon slaughterhouse (Lovenfosse) slaughters more than 500.000 pigs a year. It is part of the Belgian Pork Group (SOGEPA, 2014).

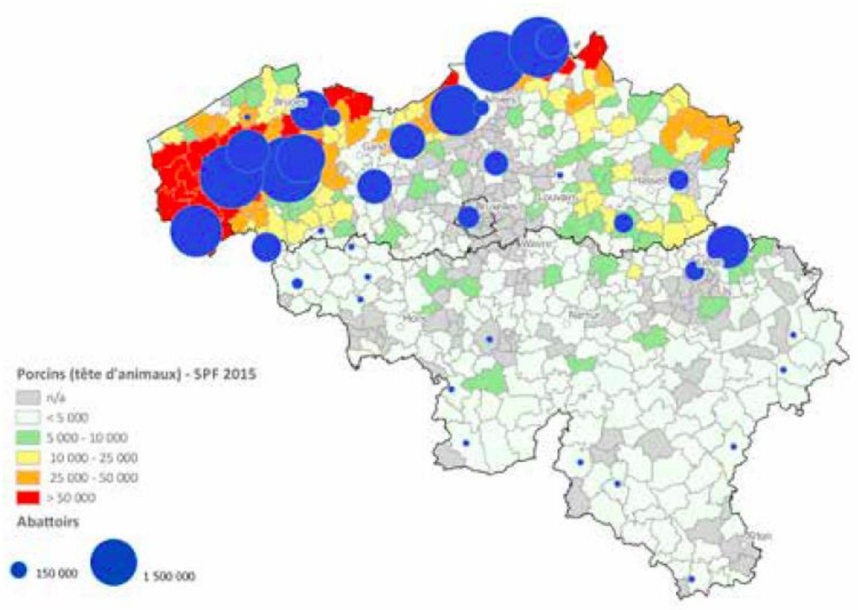

Figure 18. Geographical distribution of Belgian slaughterhouses and their relative importance (in number of slaughtered animals per year).
Source: (SOGEPA, 2014).

(e) Commercialisation actors

The distribution of fresh and/or transformed meat mainly happens through traditional distribution paths i.e. mainly supermarkets. Belgian citizens buy 70% of their fresh meat in traditional retail stores. Butchers distribute less than 25%, and this number has been decreasing over the last years. On-farm sales exist but at much smaller scales (FOD Economie, 2015; Van Buggenhout and Vuylsteke, 2016).

As shown on Figure 19, several transformation and distribution models exist after the production step. The conventional pathway (in blue on the figure) is certainly the predominant one. Here, farmers sell their pigs to slaughterhouses, which then sell them to cutting plants and then to transforming industries. As mentioned earlier, there can be a certain degree of integration between those steps. Furthermore, butchers and retail operators can also directly buy carcasses from slaughterhouses and further process them before finally selling the transformed meat products. Another model (in yellow on the figure) does not follow the conventional pathway but transforms the products on-farm. In this case, distribution usually occurs through on-farm shops, farmers markets or farmers shops. Classical retail through big distribution is also a possibility. Finally, a third pathway involves cooperatives (in green on the figure) such as the already-mentioned Porc Qualité Ardenne, which collects the pigs, slaughters and processes them and commercialises the final products.

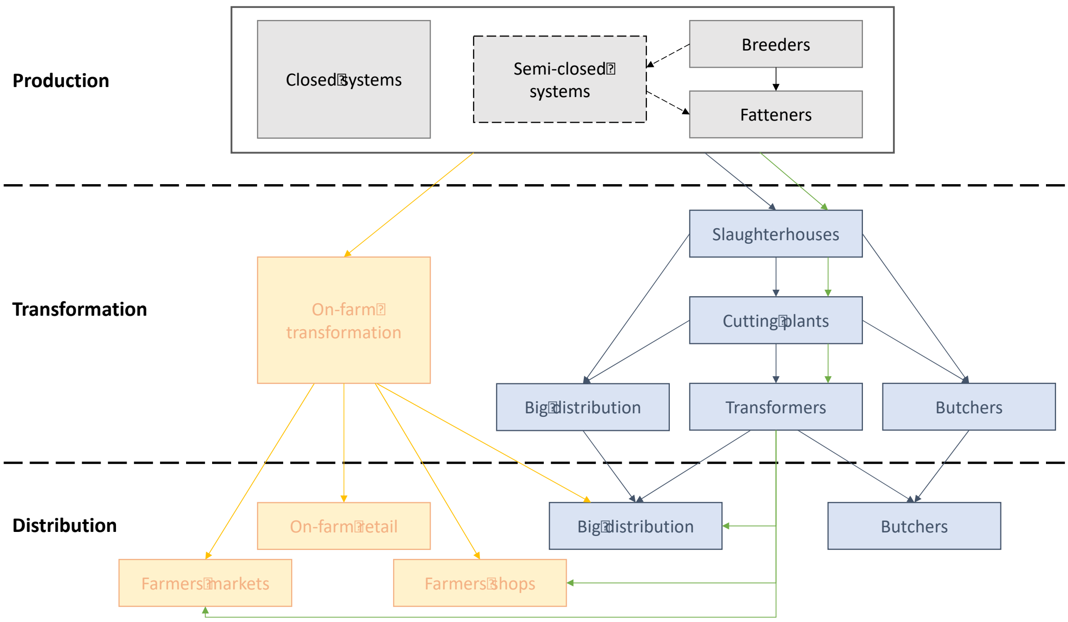

Figure 19. Different organisation models of the post-production in the pig sector (Blue: conventional model, Yellow: on-farm model, Green: cooperative model).

4.1.5. Socio-economic dimensions

(a) Economic performance

In 2014, the total production value of the Flemish pig sector amounted 1,49 billion euros. Over the last ten years this value has somewhat increased (with nevertheless some fluctuations from one year to another) as in 2004 the total production value of the sector represented 1,29 billion euros in Flanders (+15%) (Departement Landbouw en Visserij, 2016). The importance of the Flemish pork sector cannot be neglected as in 2011, it represented 43% of the total value from the Flemish livestock sector, and 27% of the total value from the Flemish agricultural sector (Platteau et al., 2012).

For specialised pig farms in Flanders in 2013, the average revenue per farm attributed to pig farming accounted to 393.665€ per farm, with an additional 9.844€ of premiums and 106.957€ of other revenue sources (Departement Landbouw en Visserij, 2016)

(b) Costs structure

As mentioned in previous paragraphs, pig farmers face high feeding costs. As a matter of fact, they represented 56% of total costs for an average specialised pig farm in 2013 (306.817€ per farm). Other important costs were related to land and infrastructure capital (12%; 66.696€ per farm), labour costs (12%; 64.929€ per farm) and others such as veterinary costs, energy, etc. (Departement Landbouw en Visserij, 2016).

(c) Employment, age and succession

In terms of employment, the pig sector represented 11% of total agricultural labour force in the agricultural sector in Flanders in 2011 (Platteau et al., 2012). In terms of age, pig farmers were on average 50,3 years old in 2013, which makes them younger than in other agricultural sectors as the average age over the entire sector was 52,1 years in 2013.

In terms of succession, it was estimated that only 15% of producers over 50 years old had a successor for their farm. This percentage is slightly higher for bigger farms as it rises to 18% for farms which have a standard output higher than 250.000€ (Departement Landbouw en Visserij, 2016).

4.2. Characterisation of production systems in the pork sector

Here we propose a typology of production systems which represents the diversity of production practices in the sector and which can serve as a framework for the further assessment of the sector.

4.2.1. Typology of production systems

In consistency with analysis available in Belgium[15], four main production systems can be distinguished in the pig farming sector (Van Buggenhout and Vuylsteke, 2016):

- **Conventional:** According to that study, a conventional pig in Belgium is from the Pietrain breed, has a probability of 2 out of 3 of being exported (generally to Germany or Poland) and if not, it reaches the consumer predominantly through supermarkets on the national market.
- **Certified:** follows the *Certus* criteria. This quality label was originated at a sectoral level. Its criteria focus on traceability and transparency, on animal welfare questions and on the use of medication. It applies to the entire chain: farmers, transporters and slaughterhouses. Also, it is an equivalent of the German QS label and hence gives access to the German market. In practice, this system is very close to the conventional one described above (Actor interviews 2018).
- **Differentiated:** Apart from the Organic and the Certus certifications, there are numerous differentiation initiatives (Table 170 in Appendix). Differentiation initiatives can originate at all levels from the chain (from upstream feed producers, to pig farmers and downstream transformers and retailers). The most important aspects on which these initiatives focus are the feed, the breed, animal welfare considerations and quality of the meat. A few initiatives also put an emphasis on the local aspect and short distribution chains.
- **Organic:** follows the organic (EU biolabel) criteria.

Additionally, a further distinction can be made within the differentiated systems. Indeed, some initiatives (such as Porc Fermier, Porc Plein Air, etc.) might involve more extensive practices, and thus come closer to organic systems, whereas others will be more similar to conventional systems. This is why an additional distinction is made between 'Differentiated' and 'Differentiated+' systems.

The main characteristics of each system are summarised in Table 11 below.

[15] In 2016, the Flemish department for agriculture and fisheries carried out a study on the differentiation of the pig farming sector. It aimed to assess potential ways of diversification of production systems.

Table 11. Characteristics of pork production systems.

	Conventional	Certified (Certus)	Differentiated	Differentiated +	Organic
Outdoor area (m^2/pig)	-	-	*varies*	*varies*	1,2
Fattening period (days)	120	120	135	135	135
Production cycles per year	2,6	2,6	2,5	2,5	2,5
Final live weight (kg) [1]	110	110	120	120	120
Feed consumption (kg feed/kg live weight)[2]	2,7	2,7	2,7	3,3	3,3

Sources:

The information was collected from the literature and through actor interviews. In particular the feed conversion ratios were found in (Nguyen et al., 2010).

Note:

[1] The differences in final weight have been subject to debate among actors. Some argue that there are no differences between conventional and organic systems, while others argue organic and extensive systems tend to achieve higher final weights. This option was selected for the present typology. Nevertheless, even so, the difference between systems is rather small.

[2] The feed consumption factor or ''feed conversion ratio'' of an animal can be estimated by examining feed consumed against weight gained. Feed conversion ratios were obtained from literature and then adjusted according to local sector's experts' knowledge. According to current data, pigs have a conversion ratio of 2.6–3.3 kg feed to 1 kg pork weight gain (Nguyen et al., 2010; Weidema et al., 2008; Actor interviews, 2018).

4.2.2. Shares of production systems

According to the same study (Van Buggenhout and Vuylsteke, 2016), 73% of slaughters come from the conventional system, 23% are Certus-certified, 4% come from the differentiated system (including both 'Differentiated' and 'Differentiated+' systems) and only 0,1% come from the organic system (Table 12 and Figure 20). The conventional system is significantly predominant and the shares of differentiated and organic systems on the contrary are extremely low. It is interesting to note that although the sector is largely concentrated in Flanders, the organic pig sector is bigger in Wallonia. Indeed, in 2015 there were 6.822 organic pigs in Wallonia and only 3.452 in Flanders.

Table 12. Differentiation of the Belgian pig sector in terms of farm numbers and slaughter numbers in 2013 or 2014 (depending on data availability).

Category	Pig farms		Slaughters	
	No.	%	No.	%
Conventional	2698	52%	8.747.896	73%
Certified (Certus)	2189	42%	2.704.104	23%
Organic	36	<1%	10.000	<1%
Differentiated	Min. 257	5%	Min. 438.000	4%
Belgian Total	5180	100%	11.900.000	100%

Source:

(Van Buggenhout and Vuylsteke, 2016)

Note:

In this case, a conventional pig is considered to be from the Piétrain breed, is likely to be exported and if not will reach the consumer through supermarkets on the national market; Certus is a quality label which puts the emphasis on traceability and transparency; the organic system follows the European organic criteria and finally, the differentiated system aims at producing high-quality meat, based on specific feeds, breeds, animal welfare considerations, etc. (Van Buggenhout and Vuylsteke, 2016). Differentiated and differentiated + are assumed to represent each 2% of slaughters.

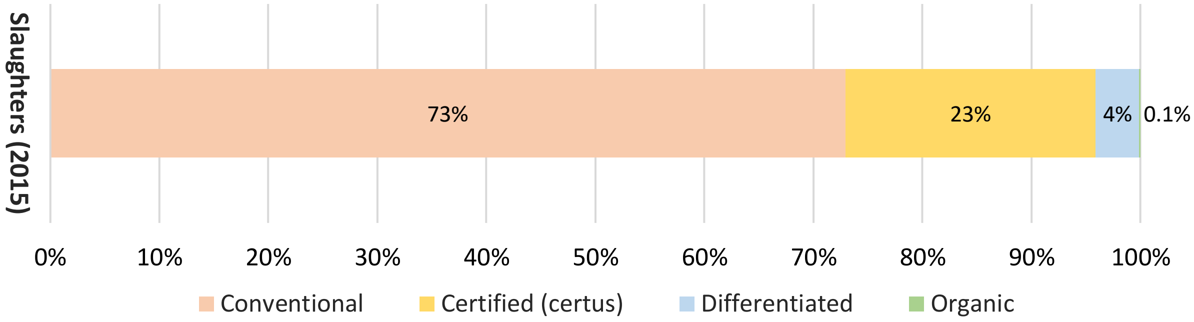

Figure 20. Shares of production systems in the pork sector (in percentage of total slaughters in 2015).
Source: Based on (Van Buggenhout and Vuylsteke, 2016).

4.2.3. Environmental externalities of pork production systems

The objective here is to evaluate environmental externalities of each pork production system. Figures will allow to compare externalities in three different midpoint impact categories. The results are compared to other sources in Chapter 9.

(a) Feed intake and composition

A necessary step involved in the calculation of the environmental impacts resides in the determination of feeding practices. Table 13 and Table 14 show the composition of a typical feed in each production system.[16] This information, combined with feed conversion ratios (FCR; shown in Table 11 under feed consumption) allow to determine the feed intake in each system. For Certus and differentiated systems, no specific data on FCR was found; the feed in those systems is assumed to be similar to conventional and organic systems respectively.

Aggregating these numbers over the entire sector, we find that 4.100 kt of feed are used for the production of pigs over a year (this number includes the consumption of feed by both productive and reproductive animals). This figure is compared to other sources in Chapter 9.

Table 13. Feed composition (mass % of each feed category) of pigs in different production systems.

Production system	Composition (mass %)							
	Cereals			Olea/Protea-ginous	Protein rich ingredients			Others
	Wheat/ triticale	*Maize*	*Barley*		*Soybean meal*	*Sunflower meal*	*rapeseed meal*	*(Vitamins, minerals…)*
Conventional [1]	30%	15%	20%	12%	13%	-	-	10%
Certified (certus)	30%	15%	20%	12%	13%	-	-	10%
Differentiated	30%	15%	20%	18%	12%	-	-	5%
Differentiated +	45%	6%	20%	12%	4%	5%	2%	6%
Organic [2]	22%	30%	15%	15%	14%	-	-	4%

Sources: Feed compositions were based on actor interviews (with feed producing companies) as well as sources from the literature (such as ERM & Ugent (2011), FAO (2013) and Blonk Milieu Advies (2007)).

[16] The feed compositions used in the context of this study only constitute examples of typical animal feeds, estimated and validated through literature review and actor interviews. Nevertheless, it should be noted that important variations in composition can happen both between and within specific systems.

Table 14. Total feed intake of a pig over its lifecycle in different production systems.

Production system	Feed intake (kg/life cycle)								
	Cereals			Olea/Protea-ginous	Protein rich ingredients			Others (Vit/ min)	TOTAL
	Wheat/ triticale	*Maize*	*Barley*		*Soybean meal*	*Sunflowe r meal*	*rapeseed meal*		
Conventional [1]	89	45	59	193	36	39	0	0	297
Certified (Certus) *	89	45	59	193	36	39	0	0	297
Differentiated *	97	49	65	211	58	39	0	0	324
Differentiate +	178	24	79	281	48	16	20	8	396
Organic [2]	87	119	59	265	59	55	0	0	396

Sources: Feed compositions were based on actor interviews (with feed producing companies) as well as sources from the literature (such as ERM & Ugent (2011), FAO (2013) and Blonk Milieu Advies (2007)).

(b) GHG emissions

Several processes were included when assessing the greenhouse gas (GHG) emissions of the pig sector: feed-related emissions, enteric fermentation emissions, emissions from manure management. Transportation emissions are included in the feed-related emissions (they are included in the emission factors for feed ingredients mentioned in ERM and Universiteit Gent (2011) and used in this study). Results are expressed in kg of CO_2e per kg of live weight, per kg of meat, per animal (over its lifetime) and over the entire sector. To pass from kg CO_2e/kg live weight to kg CO_2e/kg meat, slaughter and carcass yields are applied (of 79% and 80% respectively according to ERM and Universiteit Gent (2011)).

- *Feed related emissions*

These are assessed by applying emissions factors (global warming potentials (GWP), which include Land-Use Change or LUC for soy) to feed ingredients (Table 165 in Appendix). Results are shown in Table 15.

Due to higher FCRs, organic systems have higher relative impacts, per kg of live weight. When expressed over the entire life cycle of an animal, differentiated and organic systems result in higher emissions because the final weight is higher than in the two other systems. The results shown here are slightly higher to the ones obtained by the University of Ghent who performed a life cycle assessment of pig meat production. They found that the feed related GHG emissions were of 2,1kg CO_2e/kg live weight (ERM and Universiteit Gent, 2011).

Including the emissions of reproductive animals, the total emissions amount 3.634 kt CO_2e/year.

Table 15. Feed related GHG emissions of the pork sector.

Production system	**Relative impact**		**Total impact**
	kg CO_2e/kg live weight	kg CO_2e/animal	kt CO_2e/year
Conventional	2,41	265	2.647
Certified (Certus)	2,41	265	830
Differentiated	2,31	278	75
Differentiated +	2,40	289	76
Organic	2,95	354	5
TOTAL			**3.634**

- *Enteric fermentation emissions*

Emissions from enteric fermentation can be assessed by using emissions factors provided by the IPCC and used in the Belgian national GHG inventory, corresponding to 1,5 kg CH_4/pig/year (see Table 166 in Appendix). The results (Table 16) show that differentiated and organic systems result in higher relative emissions (both per kg of live weight and over the entire life cycle) as a result of their longer life cycle.

Table 16. GHG emissions from enteric fermentation of the pork sector.

Production system	**Relative impact**		**Total impact**
	kg CO_2e/kg live weight	kg CO_2e/animal	kt CO_2e/year
Conventional	0,18	19,5	182
Certified (Certus)	0,18	19,5	57
Differentiated	0,19	22,6	6
Differentiated +	0,19	22,6	6
Organic	0,19	22,6	<1
TOTAL			**250**

- *Manure management emissions*

The manure produced by animals can lead to emissions of both methane (CH_4) and Nitrous oxide (N_2O). Both these emissions are determined through emission factors. Regarding methane emissions from manure management, a coefficient of 4,47 kg CH_4/animal/year used in the Belgian national GHG inventory and calculated according to IPPC guidelines was used (see Table 166 in Appendix). Regarding nitrous oxide emissions, it was assumed that 0,1% of emitted N resulted in direct N_2O emissions (ERM and Universiteit Gent, 2011b). Furthermore, indirect N_2O emissions occur through the intermediate formation of NH_3 and NO_x, which was assumed to represent 25% of N emissions. Of these, 1% will be emitted as N_2O (ERM and Universiteit Gent, 2011b). The aggregated results (for both gases) are shown in the table below (Table 17).

Table 17. GHG emissions from manure management in the pork sector.

Production system	**Relative GHG emissions from manure**		**TOTAL emissions from manure**
	kg CO_2e/kg live weight	**kg CO_2e/animal**	**kt CO_2e/year**
Conventional	0,58	63,5	595
Certified (Certus)	0,58	63,5	187
Differentiated	0,61	73,4	19
Differentiated +	0,62	74,3	19
Organic	0,62	74,7	1
TOTAL			**820**

- *Total GHG emissions*

Table 18 presents the final aggregated and average results. Total emissions of the pork sector are estimated at 4.705 kt CO_2e per year. Feed is the largest contributor to the sector's GHG emissions (77%), followed by manure-related emissions (17%), enteric fermentation (5%) (Figure 21). Per kg of product (live weight or meat) or over the entire lifecycle, differentiated and organic systems result in higher per animal emissions due to their longer lifecycle and higher final weight. On the global picture nonetheless, these systems contribute very little to total emission from the sector.

Compared to other sources, it appears there is a great variability of results among studies regarding the GHG emissions involved in pork production (see Table 171 in Appendix 8). The results are comparable to (ERM and Universiteit Gent, 2011b), especially if their sensitivity analysis is considered, which provides a range of 3,1-4,2 kg CO_2e/kg live weight, 4,0-5,3 kg CO_2e/kg carcass or 4,8-6,4 kg CO_2e/kg meat. A comparison with other sources is presented in Chapter 9.

Table 18. Total GHG emissions in the Belgian pork sector in 2015.

Production system	Relative GHG emissions			TOTAL emissions	
	kg CO_2e/kg live weight	kg CO_2e/kg meat [1]	kg CO_2e/animal	kt CO_2e/year	%
Conventional	3,16	5,00	348	3.424	73%
Certified (Certus)	3,16	5,00	348	1.074	23%
Differentiated	3,11	4,92	374	100	2%
Differentiated +	3,21	5,08	385	101	2%
Organic	3,76	5,95	451	6	<1%
TOTAL[2]				**4.705**	**100%**
- Feed-related em.				*3.634*	*77%*
- Enteric em.				*250*	*5%*
- Manure em.				*820*	*17%*

Notes:
[1] To pass from kg CO_2e/kg live weight to kg CO_2e/kg meat, slaughter and carcass yields are applied (79% and 80% respectively according to ERM and Universiteit Gent (2011)). It should be noted that there is a difference between these numbers and the ones used by (Statistics Belgium, 2017) (59% for the carcass yield).
[2] Included emissions are: feed-related emissions, enteric fermentation, emissions from manure management, on-farm energy usage.

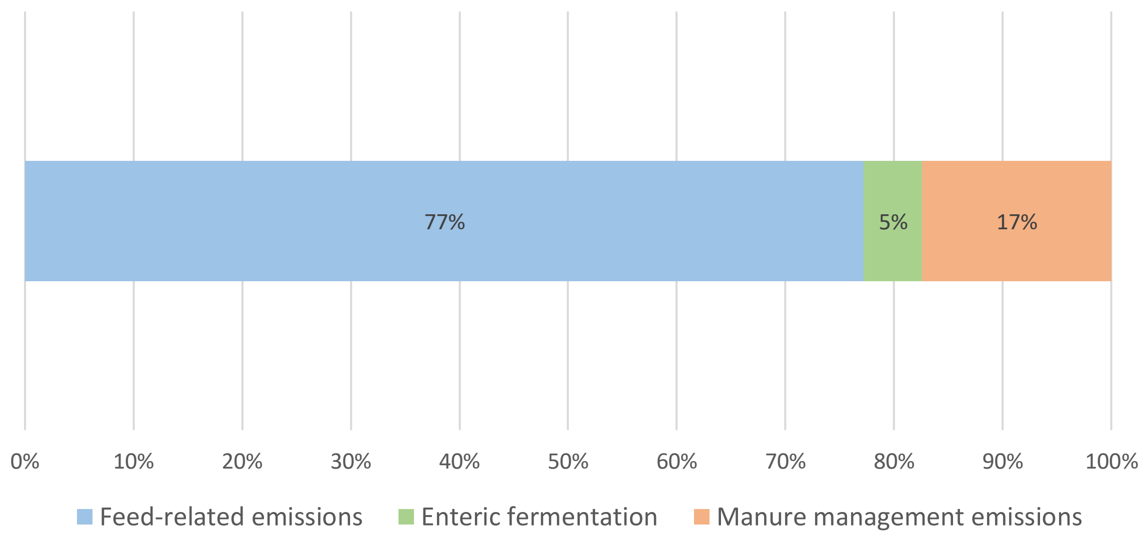

Figure 21. Estimate of the contribution of GHG sources to total emissions in the pork sector.

(c) N emissions

Based on feed consumption and nitrogen (N) content of the feed (see Table 168 in the Appendix), one can calculate how much nitrogen is retained by the animal and hence how much is excreted (emitted). Indeed, the Nitrogen Use Efficiency (NUE) indicates the amount of nitrogen retained in animal products as percentage of total nitrogen intake.

The results for the pork sector are shown in Table 19 and Table 20 (including reproductive animals). Differentiated and organic systems result in higher relative emissions (because of higher FCRs and longer life cycles) but contribute very little on the global national picture. Results are compared to other sources in Chapter 9.

Table 19. N emissions of pigs.

Production system	N intake	N retained	N emissions		
	kg N/kg live weight	kg N/kg live weight	kg N/kg live weight	kg N/animal [1]	kg N/ animal/year
Conventional	0,07	0,02	0,046	5,10	9,8
Certified (Certus)	0,07	0,02	0,046	5,10	9,8
Differentiated	0,07	0,02	0,048	5,75	9,5
Differentiated +	0,08	0,03	0,055	6,65	11,0
Organic	0,09	0,03	0,058	6,97	11,6
Average				5,15	9,9

Note: [1] These values express the N emissions of an animal over its lifecycle.

Table 20. Total N emissions in the Belgian pork sector in 2015.

Production system	Total N emissions	Share
	kt N/year	%
Conventional	51	72%
Certified (Certus)	16	23%
Differentiated	2	2%
Differentiated +	2	3%
Organic	<1	<1%
Total	70	100%

4.2.4. Animal welfare consideration in the pork sector

Confronting each production system to the CIWF animal welfare criteria (Table 157 in Annex), it is possible to carry out a qualitative animal welfare assessment of pork systems, which is visible on Table 21 (orange ● corresponding to inadequate practices on animal welfare terms, yellow ● to intermediate practices and green ● to adequate practices).

Three welfare categories are considered in the case of the pork sector: housing conditions, mutilation and birth-giving conditions. According to this framework, organic systems are the most in line with the CIWF criteria (Table 21).

Table 21. Animal welfare assessment of the pork sector.

	Conventional	Certified (Certus)	Differentiated	Differentiated +	Organic
Housing	2	2	2	3	3
Mutilation	1	1	1	1	2
Birth-giving	2	2	2	2	3
Overall score	●	●	●	●	●

Note: The criteria and ranking methodology are detailed in Chapter 1. The number (1-3) indicates the consistency of the production system with the considered category (housing, mutilation or birth-giving); 1 indicates low consistency, 3 indicates high consistency.

4.2.5. Biodiversity impacts of the pork sector

In order to assess the biodiversity impacts of each production system, the methodology developed by De Schryver et al. (2010). It consists in attributing a characterisation factor (CF), which expresses the ecosystem damages of certain land-uses and agricultural areas, to each feed ingredient (Table 162). The impact of each feed ingredient is then aggregated to determine the overall Damage Score (DS) associated to a certain production system. This gives an indication of the global biodiversity impact associated with the feed consumed by the Belgian pork sector (regardless of where it is produced).

The results and show that the least impactful system is the organic one (lowest DS of 0,0036), followed by the conventional and Certus systems (Table 22). The Differentiated+ system has the highest impact due to its high Feed Conversion Ratio (the organic system has a high FCR too but this is compensated by the lower impact of organic feed, as shown in Table 162).

Table 22. Biodiversity impacts (damage scores) of different pork production systems.

Production system	**Intake (ha/kg live weight)**							**Damage Score (DS)**
	Wheat/ triticale	Maize	Barley	Olea/ Protea-ginous	Soybean meal	Sunflower meal	Rapeseed meal	**/kg live weight**
Conventional	1,2E-04	3,5E-05	5,4E-04	7,9E-05	1,2E-04	0,0E+00	0,0E+00	**0,0073**
Certified (Certus)	1,2E-04	3,5E-05	5,4E-04	7,9E-05	1,2E-04	0,0E+00	0,0E+00	**0,0073**
Differentiated	1,2E-04	3,5E-05	5,4E-04	1,2E-04	1,1E-04	0,0E+00	0,0E+00	**0,0076**
Differentiated +	2,2E-04	1,7E-05	6,6E-04	9,6E-05	4,6E-05	4,0E-05	1,6E-05	**0,0089**
Organic	1,1E-04	8,5E-05	5,0E-04	1,2E-04	1,6E-04	0,0E+00	0,0E+00	**0,0036**

4.2.6. Summary of environmental impacts of the pork sector

For one kg of meat produced, organic and differentiated systems show higher GHG and N emissions (Figure 22 and Figure 23). This is mainly due to higher FCR of the animals and their longer life cycle of animals. In terms of animal welfare, organic systems have the best practices.

Table 23. Summary of environmental impacts of different pork production systems.

	Conventional & certified	**Differentiated**	**Differentiated +**	**Organic**
GHG emissions *(kg CO_2e/kg live weight)*	3,16	3,11	3,21	3,76
N emissions *(Kg N/kg live weight)*	0,046	0,048	0,055	0,058
Animal welfare	●	●	●	●
Biodiversity *(DS/kg live weight)*	0,0073	0,0076	0,0089	0,0036
Use of chemical phytopharmaceuticals	Yes	Yes	Yes	No use
Share (% of slaughters)	96%	2%	2%	<1%
Total GHG emissions *(kt CO_2e/year)*	4.498	100	101	6

Note: Conventional and certified systems are considered together because no specific data was found to differentiate their practices, which were assumed to be similar (which was confirmed by experts from the sector).

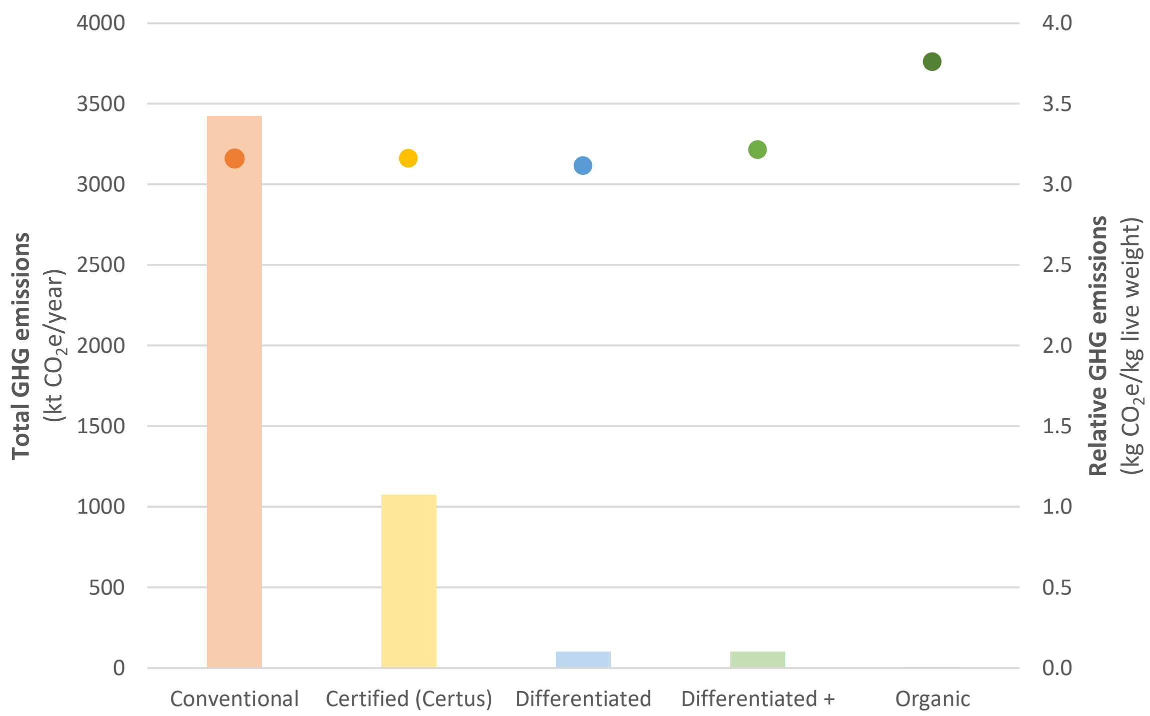

Figure 22. Contribution of pork production systems to total and relative GHG emissions (dots represent relative emissions, bars represent total emissions).

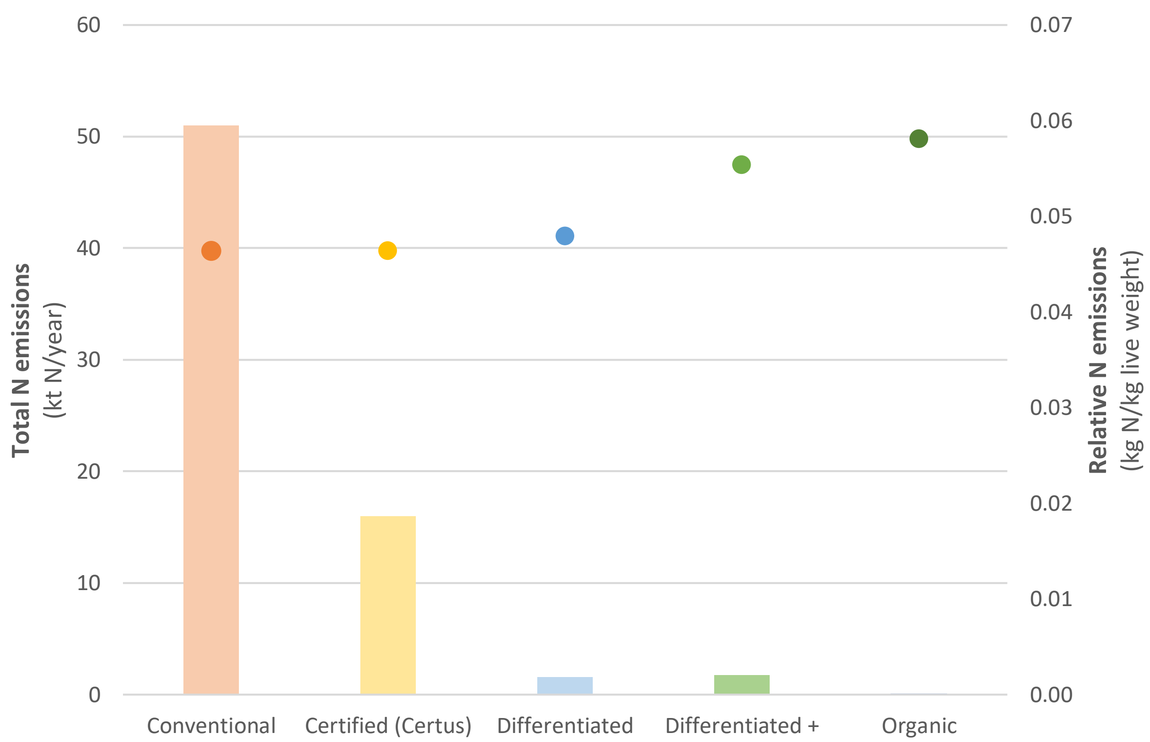

Figure 23. Contribution of pork production systems to total and relative N emissions (dots represent relative emissions, bars represent total emissions).

4.3. Conclusion of Chapter 4

- Pork production in Belgium mainly occurs in conventional systems (which can be Certus-certified or not).
- Differentiated and organic systems respectively represent only 4% and 0,1% of the annual slaughters.
- National production, which is largely located in Flanders, amounts to 1.140 kt of carcass weight per year, while 175 kt are imported and 878 kt are exported. Production level is therefore more than twice the net utilisation in the country (see Table 2).
- Organic and differentiated systems have slightly higher GHG and N emissions per kg of meat produced, but overall contribute very little given their shares (Figure 22 and Figure 23).
- In terms of biodiversity and animal welfare aspects, the organic system performs better than the other systems.

Chapter 5. Poultry production in Belgium

5.1. The Belgian poultry sector

In 2015, the total number of poultry in Belgium was of 37.368.002. There is a notable regional concentration of the sector: 85% of the animals (31.766.298 individuals) are hosted in Flanders and only 15% in Wallonia (5.601.704 individuals) (Statistics Belgium, 2016a).

These figures characterise the entirety of the Belgian poultry sector and hence include both broilers which are raised for meat production and laying hens, raised for the production of eggs. As a consequence, and as shown on Figure 24, the poultry sector is in fact made up of three distinct sectors.

In the breeding sector, "lightweight" mothers produce eggs and chicks which are destined for the laying hen sector. On the other hand, "heavyweight" mothers produce eggs and chicks which are destined for the broiler sector and hence for the production of poultry meat. In the laying hen sector, the chicks are first "fattened" before going to an actual laying farm. In the broiler sector, the chicks go straight to broiler farms where they are fattened until they are slaughtered (Platteau et al., 2009).

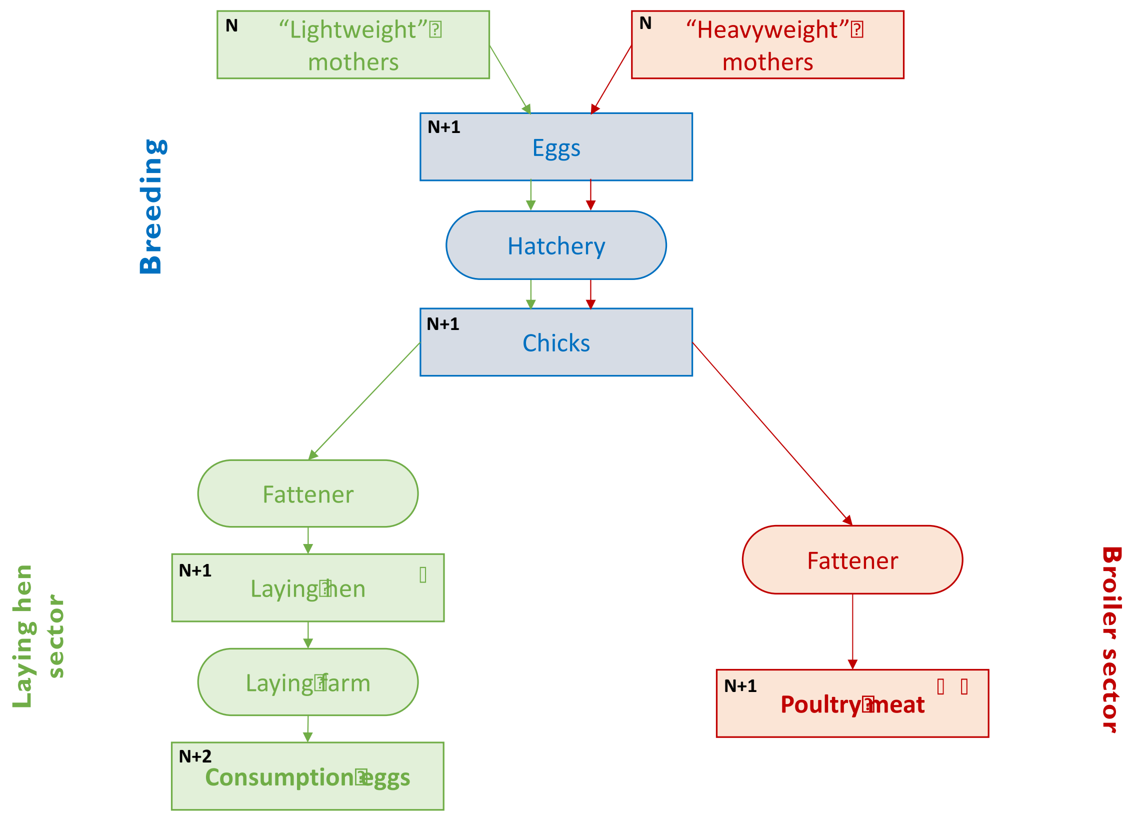

Figure 24. Organisation of the Belgian poultry sector and sub-sectors.

The following sections of this chapter will aim at describing each sub-sector individually, as far as the availability of data allows for this distinction between sub-sectors.

5.1.1. The breeding sector

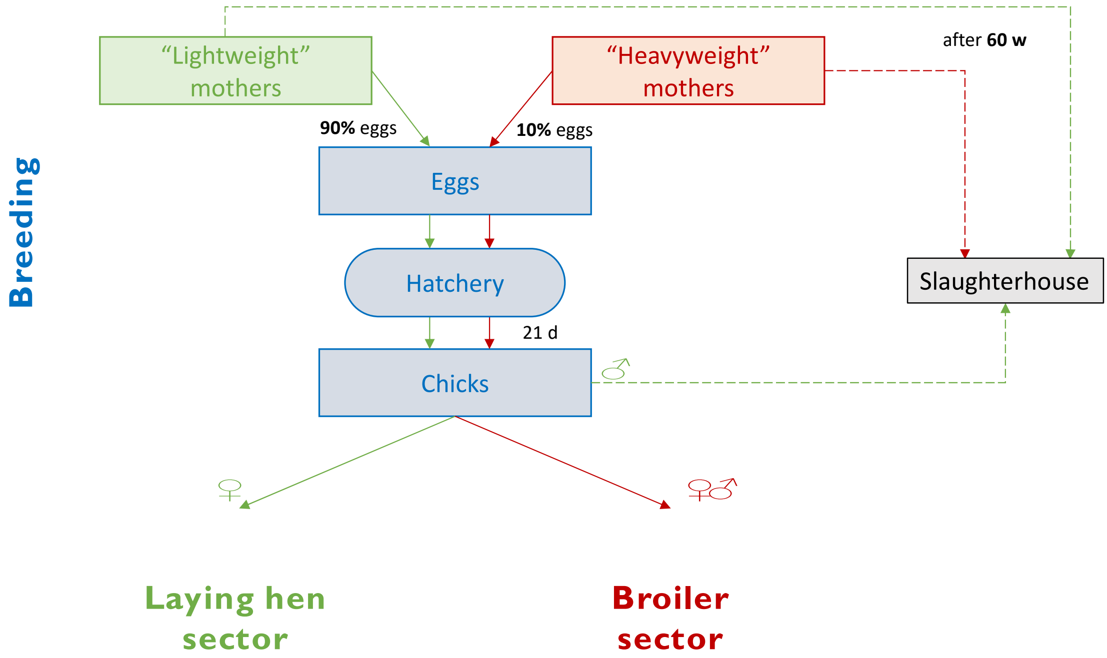

Figure 25. General organisation of the breeding sub-sector.

The breeding sector provides chicks for both the broiler and laying hen sector. According to the final purpose of the chicks two types of mothers exist. On one hand, so called "lightweight" mothers lay eggs destined for the laying hen sector. On the other hand, so-called "heavyweight" mothers lay eggs destined for the broiler sector. Generally, one particular breeding company will choose to specialise in one production and will not raise both types of mothers. The replacement of mother animals is ensured through chicks coming from grand-parent animals.

Mother chickens are ready to mate and lay eggs after a growing period of about twenty weeks. This first step occurs in the breeding companies. The eggs are then transferred to a hatchery, where they will hatch "artificially" after 21 days. The new-born chicks are then transferred either to a laying hen farm or to a broiler farm. On average, the laying cycle of mother chickens lasts until they are about 60 weeks old. After that they are sent to slaughterhouses (Figure 25).

In 2017, there were 124 recognised breeding companies and 26 recognised hatcheries in Flanders. In Wallonia in the same year, there were 13 recognised breeding companies but no hatcheries.

(a) Numbers and historical evolution

In 2011 there were 80.113 "lightweight" mothers and 2.367.000 "heavyweight" mothers. As can be seen on Figure 26 and Figure 27, the numbers of "lightweight" mothers have fluctuated much more over the last years than that of "heavyweight" mothers (Viaene, 2012a).

In terms of egg production, 337 million eggs were produced in 2011, of which 91% were destined for the broiler sector and 9% for the laying hen sector (Viaene, 2012a).

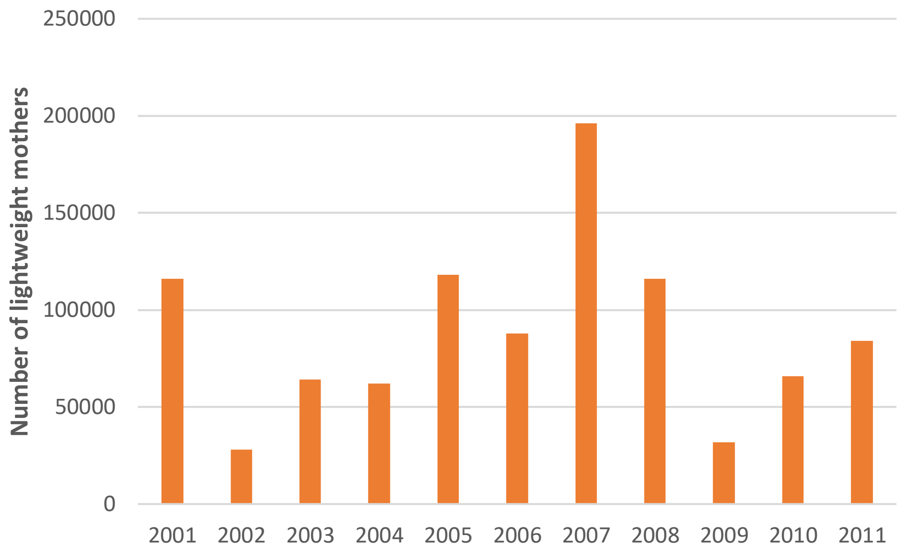

Figure 26. Numbers of "lightweight" mothers between 2001 and 2011 in Belgium (Viaene, 2012b).

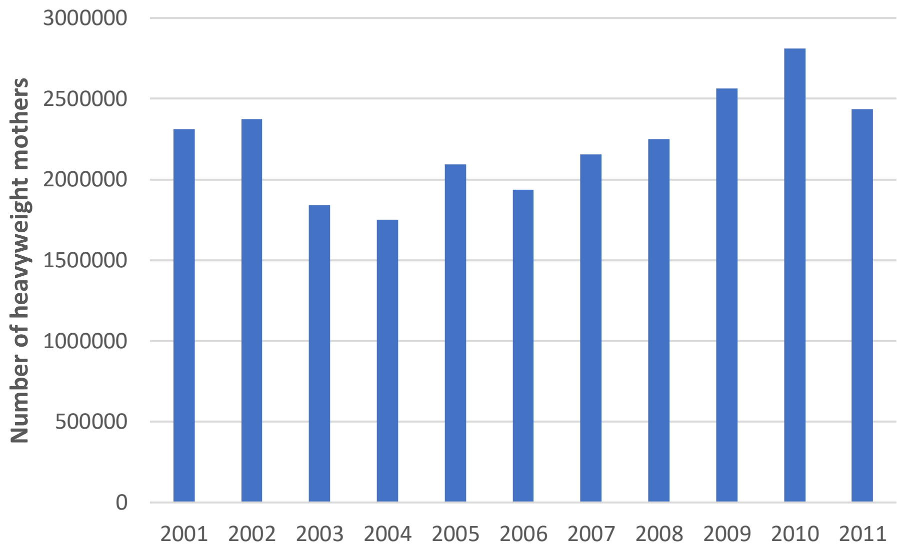

Figure 27. Numbers of "heavyweight" mothers between 2001 and 2011 in Belgium (Viaene, 2012b).

(b) Technical results of the breeding sector

In 2010, mothers started breeding on average after 139 days and the laying cycle lasted for 297 days (which corresponds to the numbers mentioned before of a growing period of 20 weeks and the end of the laying activities after about 60 weeks). Mothers laid on average 161 eggs (Viaene, 2012b).

Overall feed consumption numbers were of 175 g/day/animal or 295 g/egg (Viaene, 2012b).

5.1.2. The laying hen/egg sector

As mentioned earlier, the laying hen sector aims at producing eggs for human consumption. As only female chickens lay eggs, male chicks coming from the breeding sector (i.e. from lightweight mothers) are useless for the laying hen sector. Indeed, because the breeds which are used in the laying hen sector were not selected for their fast-growing or interesting feed conversion traits, these male chicks are generally not fattened for the production of poultry meat. Instead, they are usually used for pet food or killed and discarded (personal communication). Nevertheless, some rare cases exist in which the fattening of these chicks occurs. For example, Lidl has recently decided to sell poultry meat from male "laying chicks" (Van Ammelrooy, 2017).

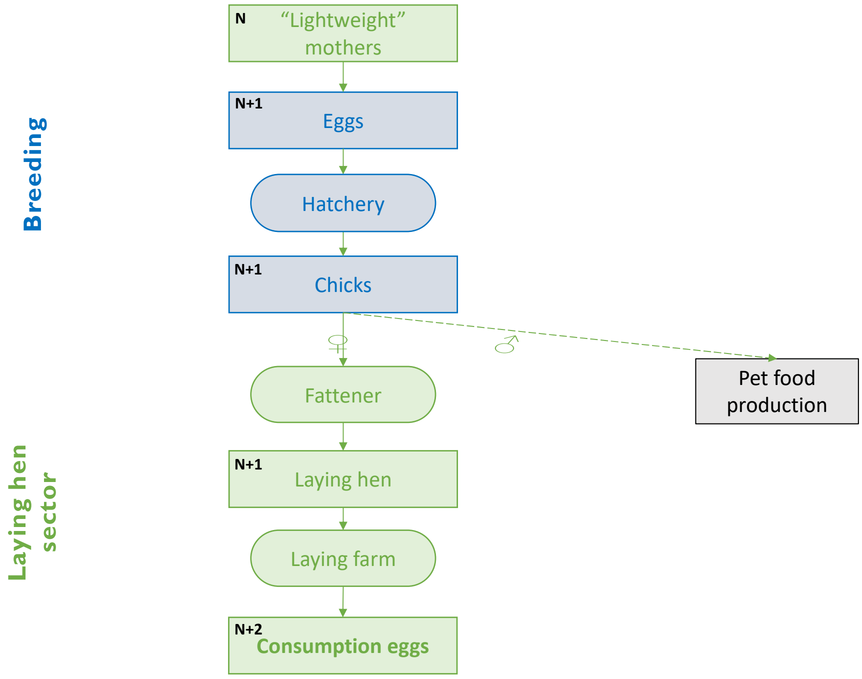

Figure 28. General organisation of the laying hen sector in Belgium.

(a) Animal and farm numbers

In 2015, there were 8.109.466 laying hens, i.e. female chicken laying eggs for human consumption. 86% of these numbers were located in Flanders (6.933.062 ind) and 14% (1.176.404 ind) in Wallonia (Statistics Belgium, 2016a).

The province of Antwerp is the one with the most laying hens (30% of Belgian total), followed by the province of Western Flanders (28% of Belgian total), as well as Eastern Flanders and Limburg to a lesser extent (16% and 9% of Belgian total respectively) (Statistics Belgium, 2016a).

In terms of farm numbers, Flanders had 448 farms with at least 20 laying hens in 2013. However, in the same year, 95% of the total laying hen population was held by 51% of these farms (230 farms) which had more than 10.000 chickens (Table 172 in the appendix). On average, there are 23.952 laying hens per farm (Departement Landbouw en Visserij, 2016a).

(b) Historical evolution

There has been a decrease in the laying hen population over the last decade, as it appears on Figure 29 for Flemish farms with 100 or more laying hens between 2001 and 2013. In terms of farms, there is a clear trend towards an increase in their size accompanied by a decrease in their numbers (passing from about 20.000 animals per farm in 2001to more than 31.000 animals per farm in 2013). The drop in 2003 is due to an avian flu epidemic and the associated reduction of poultry numbers and farms (Platteau et al., 2016).

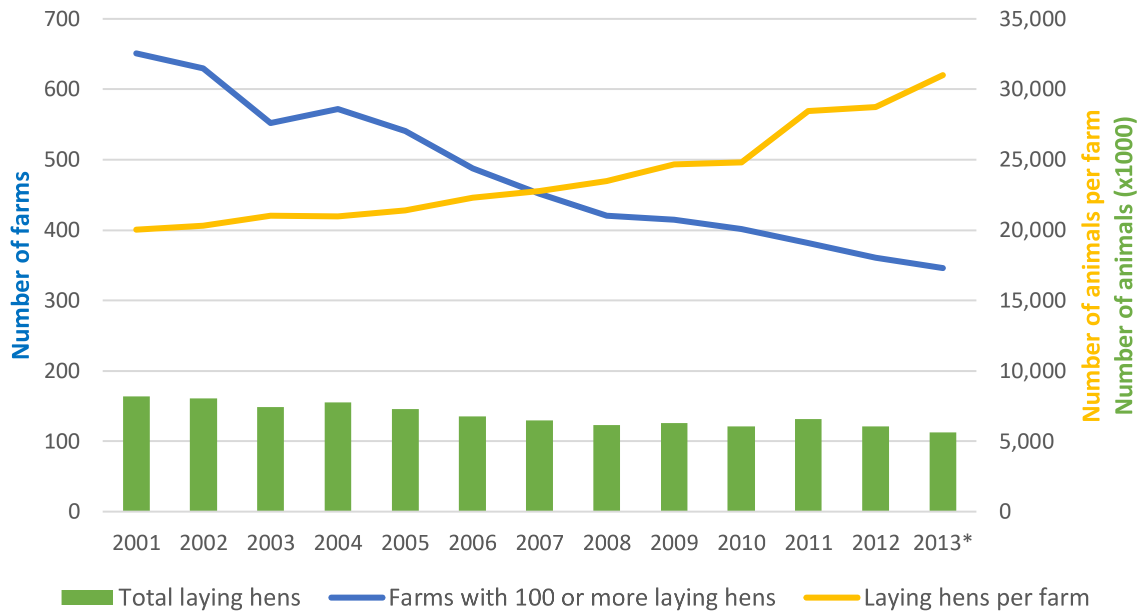

Figure 29. Evolution of the laying hen population, laying hen farms and animals per farm in Flanders for farms with 100 or more laying hens (2001-2013).
Source: (Departement Landbouw en Visserij, 2016a)

(c) Technical results of the laying hen sector

On average, in 2010 a hen started laying after 123 days and did so during 440 days. On average a laying hen laid 297 eggs in 2010, i.e. about 354 eggs over its entire laying cycle. That year, the average weight of an egg was 63 g (Viaene, 2012b).

In terms of feed consumption, a laying hen consumed on average 117 g feed/day in 2010, or 139 g feed/egg (Viaene, 2012b).

5.1.3. The broiler/poultry meat sector

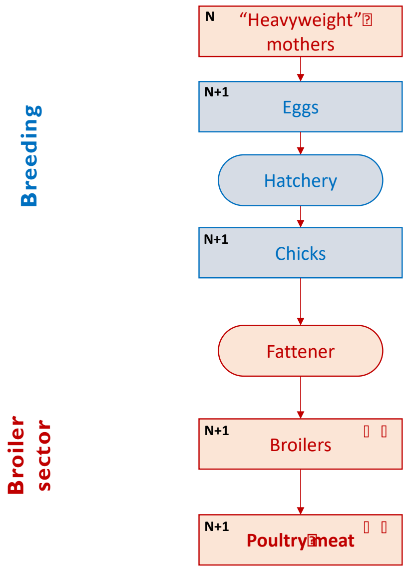

Figure 30. General organisation of the broiler sector in Belgium.

(a) Animal, farm and production numbers

According to the 2015 Belgian agricultural survey, there were 23.838.182 broilers in Belgium, i.e. chicken raised for human consumption of poultry meat. 84% of these numbers were located in Flanders (19.930.414 ind) and 16% (3.907.768 ind) in Wallonia (Statistics Belgium, 2016). As it is the case for the laying hen sector, there is thus a strong sectoral concentration in Flanders (Statistics Belgium, 2016a).

The province with the biggest broiler population is Western Flanders (27% of Belgian total), followed by Antwerp (22% of Belgian total), as well as Eastern Flanders and Limburg to a lesser extent (17% and 14% of Belgian total respectively) (Statistics Belgium, 2016a).

In terms of farm numbers, Flanders had 520 farms with at least 20 broilers in 2013. However, in the same year, 83% of the total broiler population in Flanders was held by 51% of these farms (265 farms) which had more than 30.000 chickens (Table 173 in the appendix). On average, there were 39.490 broilers per farm (Departement Landbouw en Visserij, 2016a).

In Flanders, there are thus more broiler farms than laying hen farms, and the broiler farms also tend to be bigger in terms of chickens per farm.

In terms of production, 303 million chickens were slaughtered in Belgium in 2015. It should be noted that this figure includes the imports of live animals from neighbouring countries such as France or the Netherlands which are slaughtered in Belgium, and also slaughters of laying hens at the end of their cycle. Hence, the number of nationally produced broiler chickens is much lower (Bergen, 2015). Based on the 2015 survey numbers of 23.838.182 broilers (which represent the animal numbers at one specific time of year but not over the full year) and assuming that on average seven production cycles can be performed over one year, one can estimate that 167 million broiler chickens were raised and slaughtered in Belgium in 2015, i.e. 3,2 million animals per week.

(b) Historical evolution

Figure 31 shows the evolution of the broiler sector in Flanders over the last decade. As for the laying hen sector, the trend towards lesser and bigger farms is also visible for this sector. Comparatively to the laying hen sector, the 2003 drop was much more significant in the broiler sector. Although the sector partly recuperated after the year 2003, broiler numbers continued to decrease after the epidemic, reaching the lowest number of 16,5 million animals in 2008. Nevertheless, since 2008, broiler numbers are increasing and in 2013 they were close to pre-epidemic numbers (Platteau et al., 2016).

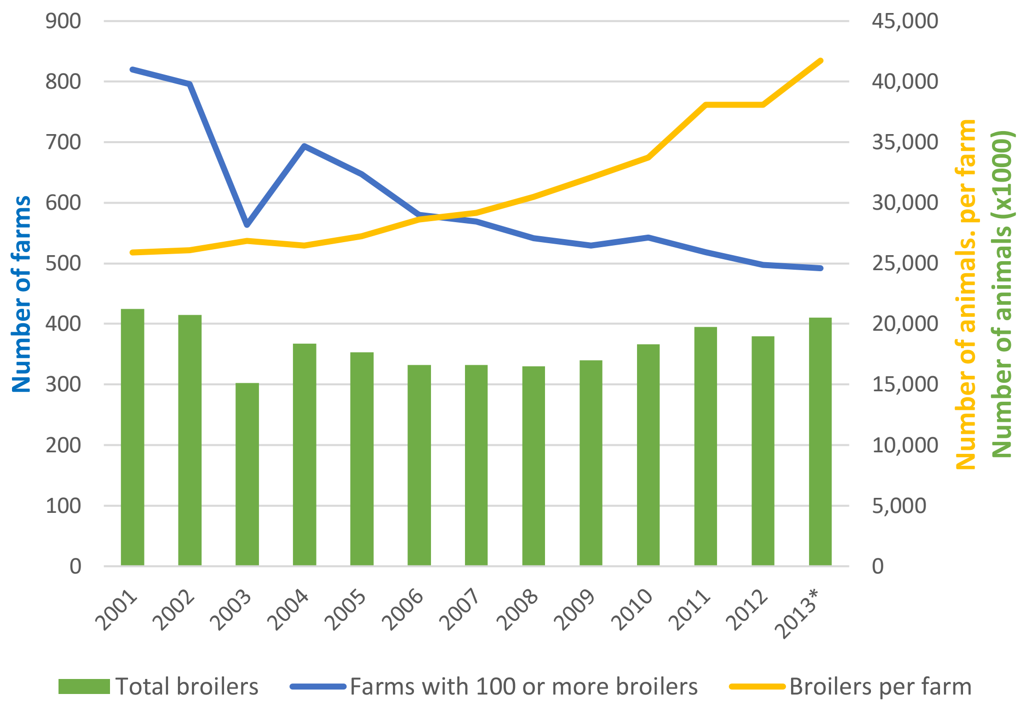

Figure 31. Evolution of the broiler population, broiler farms and animals per farm in Flanders (2001-2013).
Source: (Departement Landbouw en Visserij, 2016a)

(c) Technical results of the broiler sector

In 2008, broiler chickens achieved a final weight of 2,4 kg after 40 days on average. The average growth rate was of 62 g/day (Viaene, 2012b). In terms of feed consumption, the feed consumption rate was of 102 g feed/animal/day or 4,1 kg/animal over its entire lifetime or 1,8 kg feed/kg animal (Viaene, 2012b).

5.1.4. Socio-economic dimensions

(a) Economic performance

Over the last ten years, the total economic values of both the egg and the poultry meat sector have increased consistently, passing from 114 million euros in 2004 to 204 million euros in 2015 (+79%) for the Flemish egg sector and from 232 million euros in 2004 to 362 million euros in 2015 (+56%) for the Flemish poultry meat sector (Departement Landbouw en Visserij, 2016a). In 2009, the poultry meat sector represented 6% of the total output of agricultural products in Flanders (Platteau et al., 2012).

(b) Employment, age and succession

In terms of employment, the poultry sector represented 2% of total agricultural labour force in the agricultural sector in Flanders in 2013 (Departement Landbouw en Visserij, 2016a).

In terms of age, Flemish poultry farmers were on average 50,4 years old in 2013, which is very similar to the pig sector (50,3 years old) but about two years younger than the overall average in the agricultural sector of 52,1 years (Departement Landbouw en Visserij, 2016a).

In terms of succession, it was estimated that only 15% of producers over 50 years old had a successor for their farm. This percentage is higher for bigger farms: it rises to 24% for farms which have a standard output higher than 250.000€ (Departement Landbouw en Visserij, 2016a).

5.1.5. Sectoral organisation

Given the links and interactions between the three sub-sectors, the actors presented here are representative of the entirety of the poultry sector, thus including the breeding, laying hen and broiler sectors. Nevertheless, some actors are specific to one sector, in which case this will be obviously be specified.

(a) Upstream actors

As it is the case in the pork sector, a predominant upstream actor is the **feed producing industry** which plays a central role in the poultry sector as it links all of its sub-sectors.

There is a certain form of integration in the sector as in more than 90% of the cases, it is the feed industry which organises the production and links the production with the transformation steps, i.e. the farmers and the slaughterhouses in the case of the broiler sector. The feed company signs contracts with both the slaughterhouse and the farmer. It is thus the feeding company which plans the production. The slaughterhouses pick up the broilers, pay the feeding company which in turn pays the farmer. Hence, although the sector is not entirely integrated, it can be argued the decisional power of the sector resides in the hands of the feed producing industry (Chenut et al., 2013).

Major actors from this industry are located in Flanders and include Spoormans, Huys Voeders and Vanden Avenne (Chenut et al., 2013). The Belgian Feed Association (BFA, formerly BEMEFA or APFACA) is made up of 160 manufacturers which cover 98% of the national feed production. Among these, about 20 produce feed for the poultry sector.

(b) Producers

As it has been explained above, producers of the poultry sector belong to one of the three sub-sectors: breeding, egg production, poultry meat production.

(c) Farmer unions and other institutions

Several organisations specific to the poultry sector operate in Belgium:

- De **Landsbond**, or **Pluimvee** is a farmers' association which focuses on the poultry and rabbit sectors;
- **VEPEK** (Verbond voor Pluimvee, Eieren en Konijnen) in Flanders and **FACW** (Filière Avicole et Cunicole Wallonne) in Wallonia are two interprofesional associations which focus on the poultry (both poultry meat and egg production) and rabbit sectors.
- **NBFB** (Nationale Beroepsvereniging van Fokkers en Broeiers) represents the breeding companies and hatcheries.
- **NVP** (Nationaal verbond Pluimveeslachthuizen en uitsnijderijen) and **VIP** (Vereniging van Industriële Pluimveeslachterijen van België) are two associations which represent the slaughterhouses of the poultry meat sector. VIP focuses on the bigger, industrial slaughterhouses whereas NVP represents the smaller ones;
- **NVE** (Nationaal Verbond van Eihandelaars) represents the egg trading companies;
- **Belplume** is a Belgian certification that originated from VEPEK. It focuses on guaranteeing the quality of products and hence puts a lot of emphasis on traceability and food safety. It also aims to be equivalent to other national standards such as IKB in the Netherlands.

(d) Downstream actors

For the **egg sector**, commercialisation actors include packing and breaking companies, depending on whether the eggs are destined for the fresh market (in which case they are "packed") or to be used in preparations for egg-containing products (in which case they are "broken").

In terms of distribution, fresh eggs are predominantly commercialised through supermarkets as this channel represented about 90% in terms of volume in 2011. Within the supermarket category, traditional supermarkets such as Delhaize and Carrefour account for about 50%, hard discount supermarkets such as Lidl and Aldi account for about 30% and neighbourhood supermarkets for about 10%. Other channels such as farmers markets, on-farm commercialisation and special distribution channels (such as domestic delivery) are minor in comparison (Viaene, 2012b).

Regarding the **poultry meat sector**, important downstream actors include the slaughterhouses, which are mainly located in Flanders. Every slaughterhouse has to be registered (just as every actor in the food chain) and recognised by the Federal Agency for the Safety of the Food Chain (FASFC; FAVV in Dutch or AFSCA in French). There appears to be an ongoing concentration of the slaughtering sector as the number of slaughterhouses went from 72 in 2005 to 41 in 2011 and in 2010, 90% of the broilers were slaughtered in only nine slaughterhouses (Chenut et al., 2013; Viaene, 2012b). In 2017, the NVP had 36 registered member slaughterhouses (NVP, 2017).

Regarding commercialisation of the poultry meat, distribution generally happens through traditional distribution channels. In 2011, supermarkets represented 74% of commercialisation in terms of volume, with traditional supermarkets accounting for 41%, hard discounts for 18% and neighbourhood supermarkets for 15%. Other channels include butchers and farmers markets which represented 17% and 5% of volumes respectively in 2010. Over the last years, hard discounts have gradually taken up shares of other distribution channels, in particular traditional supermarkets and butchers (Viaene, 2012b).

5.2. Characterisation of production systems in the laying hen sector

5.2.1. Typology of production systems

An important aspect which will determine the adoption of a production system in the egg sector relates to the housing system. European eggs are classified according to the housing conditions in which the laying hens were raised. Each egg has a code, the first number of which indicates the housing type. As such, the classification identifies four different production systems, ranging from 0 to 3: Organic eggs (0); free-range eggs (1); indoor eggs (2); cage eggs (3).

Each system involves different housing conditions for the chickens (Figure 32). As shown on the figure, all systems involve indoor areas but only the organic and free-range systems involve outdoor areas. The indoor area varies according to the housing system, organic systems are the least densely populated as they have a maximum density of 6 laying hens/m² (1667 cm²/laying hen). Free-range and indoor systems have intermediate densities with maximum 9 laying hens/m² (1110 cm²/laying hen). Finally, cage eggs systems have the highest density with 13 laying hens/m² (750 cm²/laying hen).

Up to 2012, so-called battery cages allowed farmers operating under this system to keep their laying hens in cages in high densities of up to 18 animals/m² (550 cm²/laying hen). Since 2012, these battery cages are no longer allowed in the EU but cage systems still exist. Indeed, the new regulation allows the use of so-called 'enriched' or 'furnished' cages, in which the animals have more space (750 cm²/animal vs. 550 cm²/animal), access to straw to scavenge, a nesting space and sitting pole.

The practices associated with these four housing/production systems are presented in Table 24. It is interesting to note that in neighbouring countries such as France, a fifth category can be added as they also have additional labels which make up significant shares of egg production (e.g. Red Label or 'Label rouge'). In Belgium, the emergence of a fifth production system was mentioned several times during the collective focus groups. This additional housing system can be considered as an intermediate system between the indoor and free-range systems as it includes a 'winter garden' in which animals can benefit from fresh air while still being protected and covered by a ceiling. According to the consulted experts, this system represents a good compromise between animal welfare, food safety and animal health. It is estimated that this system, which is often used in combination with a classical free-range system, is becoming more common and is likely to gain in importance in the coming years (Actor interviews, 2018). Nevertheless, due to a lack of data regarding this specific system, it was not formally included as a production system in the typology.

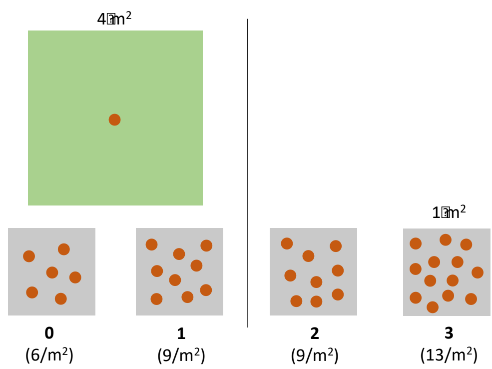

Figure 32. Associated housing areas of each egg category (green=outdoor, grey=indoor; 0=organic, 1=free-range, 2=indoor, 3=cage).

Table 24. Characteristics of egg production systems.

Production and inputs	***Average***	**Cage**	**Indoor**	**Free-range**	**Organic**
Max farm size (animals)		-	-	-	3000 [1]
Indoor area (cm^2/animal)		750 [1]	1110 [1]	1110 [1]	1667 [1]
Outdoor area (m^2/animal)		-	-	4 [1]	4 [1]
Production period (days)	*440 [2]*	392 [3]	381 [3]	363 [3]	362 [3]
Productivity (eggs/laying hen/year)	*297 [2]*	327 [3]	321 [3]	321 [3]	310 [3]
Egg weight	*63 [2]*	63 [3]	63 [3]	63 [3]	63 [3]
Feed consumption					
- (g feed/egg)	*139 [2]*	-	-	-	-
- (g feed/day)	*117 [2]*	-	-	-	-
- (kg feed/kg egg)	*2,21 [2]*	2,01 [3]	2,2 [3]	2,33 [3]	2,41 [3]
Feed origin		Vegetal	Vegetal	Vegetal	Vegetal, min 95% organic and 20% EU
Maximum load (kg N/ha)		-	-	-	170

Sources:
[1] (VILT, 2015). For the organic system, this corresponds to the Article 12 from the Commission regulation (EC) No 889/2008 of 5 September 2008.
[2] Averages for Belgium in 2010 (Viaene, 2012b).
[3] Values from the Netherlands (Wageningen UR, 2013).

5.2.2. Shares of production systems and historical evolution

In Flanders in 2014, 63% of laying hens were kept in cage systems, 28% of laying hens were raised in indoor systems, 7% in free-range systems and 2% in organic systems (VILT, 2015). In Wallonia, the animal rights association Gaia estimates that 45% of laying hens are raised in cage farming systems, 23% in indoor systems and free-range systems each, and 9% in organic systems (Figure 33) (Gaia, 2015). Relatively, organic and free-range systems are thus more common in Wallonia than in Flanders, even though the laying hen population is much smaller in Wallonia.

When expressed in terms of farm numbers, 44% of laying hen farms practiced cage farming in Flanders in 2014, 31% followed the indoor system, 16% followed the free-range system and 9% of farms were organic (VILT, 2015). When expressed in terms of farm numbers rather than animal numbers, the shares of the organic and free-range systems are more important. This seems coherent given the fact that organic farms are limited in terms of animal numbers whereas conventional producers are not.

Over the last years, the share of each egg category has changed rather significantly (Figure 34). Indeed, cage eggs which represented 46% of the egg consumption in terms of volume in 2006 have become much less abundant and only made up 7% in 2011. This is due to the fact that retailers do not sell fresh cage eggs anymore. Cage eggs are thus almost entirely destined for the preparation of egg-containing products or sold through alternative distribution paths such as on-farm sales personal communication). On the other hand, free-range eggs, indoor eggs and organic eggs to a lesser extent have all increased their shares over the same period. Organic eggs represented about 5% of sales in volumes in 2011 (vs. 4% in 2006), free-range eggs 31% (vs. 18% in 2006) and indoor eggs 57% (vs. 33% in 2006). In terms of expenditures, the share of organic eggs is more important given their higher price (almost twice that of other categories) (Viaene, 2012b).

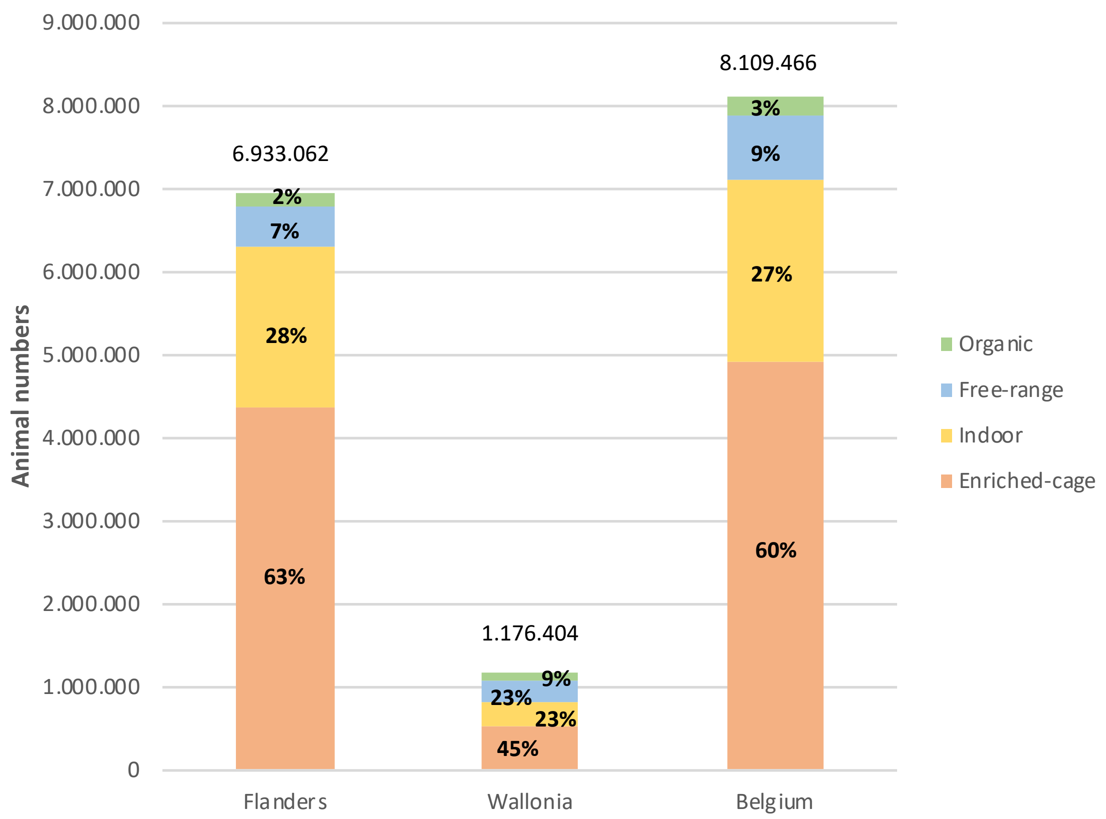

Figure 33. Shares of egg production systems (in animal numbers) in Flanders, Wallonia and Belgium.

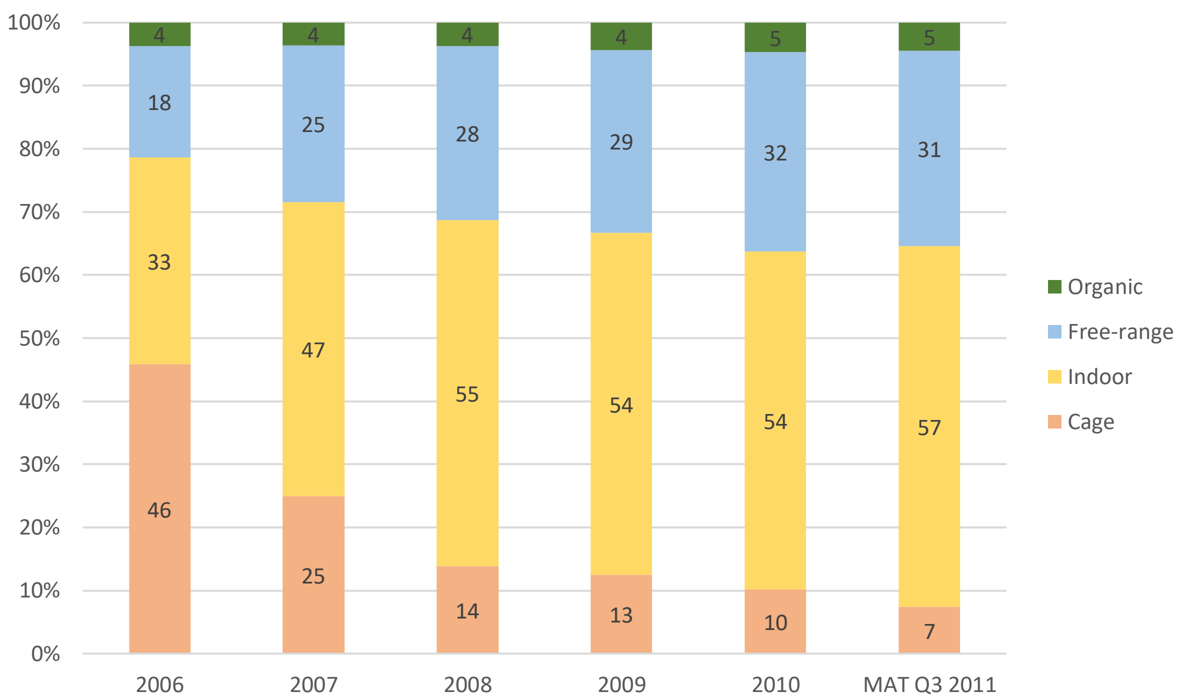

Figure 34. Evolution of egg consumption between 2006 and 2011 in Belgium according to the four egg categories, expressed in terms of volumes (Viaene, 2012b).

5.2.3. Environmental externalities of the laying hen sector

(a) Feed intake and composition

A necessary step involved in the calculation of the environmental impacts resides in the determination of feeding practices. Table 25 shows the composition of a typical feed in each production system. This information, combined with feed conversion ratios (Table 26) allow to determine the feed intake in each system.

Table 25. Feed composition (mass % of each feed category) of laying hens in different production systems.

Production system	Composition (mass %)						
	Cereals			**Protein-rich feed**			**Others**
	Wheat/triticale	*Maize*	***Total***	*Soybean meal*	*Sunflower meal*	***Total***	*(Vitamins, minerals…)*
Enriched cage	24%	44%	**68%**	20%	-	**20%**	**12%**
Indoor *	24%	44%	**68%**	20%	-	**20%**	**12%**
Free-range *	26%	40%	**64%**	15%	8%	**23%**	**11%**
Organic	26%	40%	**64%**	15%	8%	**23%**	**11%**

Sources: Feed compositions were based on actor interviews (with feed producing companies) as well as sources from the literature (Dekker et al., 2011) .
Note: * No specific feed compositions were found for indoor and free-range systems. Hence, indoor systems are assumed to have the same the composition as cage systems and free-range systems are assumed to have the same composition as organic systems.

Table 26. Feed conversion ratios (FCR) and feed intake of each production system.

Production system	Consumption		
	kg feed/kg egg [1]	kg feed/hen/year	kt feed/year (BEL)
Enriched cage	2,01	41,1	200
Indoor	2,2	44,2	98
Free-range	2,33	46,8	35
Organic	2,41	46,7	13
TOTAL			346

Sources: [1] Wageningen UR (2013).

(b) GHG emissions

Several processes were included when assessing the GHG emissions of the poultry sector: feed-related emissions, enteric fermentation emissions and emissions from manure management. Transportation emissions are included in the feed-related emissions and emissions from on-farm energy usage were not considered for now.

- *Feed-related emissions*

These are assessed in a similar way as the N emissions (see below), i.e. by applying emissions factors (global warming potentials (GWP), which include LUC for soy) to feed ingredients (Table 165). Results are shown in Table 27.

Table 27. Feed-related GHG emissions of the laying sector.

Production system	Relative impact	Total impact		
		Flanders	Wallonia	Belgium
	kg CO_2e/kg egg	kt CO_2e/year		
Enriched cage	2,22	198	23	221
Indoor	2,43	95	13	108
Free-range	2,37	23	12	35
Organic	2,45	7	7	13
TOTAL		323	55	378

Overall, the four systems show rather similar results in terms of feed-related emissions, with the indoor system resulting in the highest relative GHG emissions (2,43 kg CO_2e/kg egg). These results are higher than the results obtained by the FAO in a Life Cycle Assessment of pig and poultry production, which indicate that in Western European countries, feed related-emissions are of about 1,75 kg CO_2e/kg egg (FAO, 2013).

- *Enteric fermentation*

It is assumed these emissions can be neglected as chickens are not ruminants (FAO, 2013).

- *Emissions from manure management*

The manure produced by animals can lead to emissions of both methane (CH_4) and Nitrous oxide (N_2O). Both these emissions are determined through emission factors. Regarding methane emissions from manure management, a coefficient of 0,023 kg CH_4/animal/year provided by the IPCC and used in the Belgian national GHG inventory was used. Regarding nitrous oxide emissions, it was assumed that 0,01% of emitted N resulted in N_2O emissions (ERM and Universiteit Gent, 2011a).

The aggregated results (for both gases) are shown in the table below (Table 28). Again, all four systems show very similar results, with the organic system resulting in slightly higher emissions of 0,079 kg CO_2e/kg egg.

Table 28. GHG emissions from manure management in the laying hen sector.

Production system	Relative GHG emissions from manure		TOTAL emissions Flanders	TOTAL emissions Wallonia	TOTAL emissions Belgium
	kg CO_2e/animal/year	kg CO_2e/kg egg	t CO_2e/year		
Enriched cage	1,40	0,068	6.112	708	6.820
Indoor	1,46	0,073	2.835	395	3.230
Free-range	1,54	0,077	749	399	1.148
Organic	1,54	0,079	214	218	431
TOTAL			9.910	1.720	11.630

- *Total GHG emissions from the laying hen sector*

Table 29 shows the final results of GHG emissions in the laying hen sector. The results obtained here are quite lower than the ones obtain by the FAO which show emissions levels of about 4 kg CO_2e/kg egg. Nevertheless, compared to Dekker et al. (2011), results are very similar as the figures they found range between 2,235 kg CO_2e/kg egg for cage systems and 2,75 kg CO_2e/kg egg for free-range systems.

When looking at the aggregate picture, it appears that the biggest share of emissions occurs in cage systems in Flanders (52% of total national emissions), followed by indoor systems in Flanders (25% of total national emissions). This is largely due to the shares of each system (Table 29).

Table 29. Total GHG emission from the laying hen sector.

Production system	Relative GHG emissions	TOTAL emissions Flanders	TOTAL emissions Wallonia	TOTAL emissions Belgium
	kg CO_2e/kg egg		kt CO_2e/year	
Enriched cage	2,29	204	24	228
Indoor	2,50	98	14	111
Free-range	2,45	24	13	37
Organic	2,53	7	7	14
TOTAL		332	57	389
Average	*2,37*			

Note: The total values do not include emissions form young hens and reproductive animals, which amount 198 kt CO_2e. The total emissions of the Belgian laying hen sector thus amounted 587 kt CO_2e in 2015.

(c) N emissions

Based on feed consumption and nitrogen (N) content of the feed (see Table 168 in the appendix), one can calculate how much nitrogen is retained by the animal and hence how much is excreted. Indeed, the Nitrogen Use Efficiency (NUE) indicates the amount of nitrogen retained in animal products as percentage of total nitrogen intake.

Per kg egg, the results show that free-range and organic systems result in higher N emissions, which is explained by their higher Feed Conversion Ratios (FCRs) and the fact that they consume more feed per kg of egg (Table 30).

These figures of N emissions are somewhat higher than the results obtained by Hou et al. (2016) who assessed the feed use and nitrogen excretion of livestock in the EU-27. Indeed, they found that in Belgium N emission levels are of 0,65 kg N/laying hen/year instead of 0,78-0,92 kg N/laying hen/year found here (depending on the production system).

Table 30. N emissions in the laying hen sector.

Production system	N intake	N retained	N emissions (relative)		N emissions (total)		
					Flanders	Wallonia	Belgium
	kg N/hen/ year	kg N/hen/ year	kg N/hen/ year	kg N/kg egg		t N/year	
Enriched cage	1,05	0,27	0,78	0,038	3.405	394	3.799
Indoor	1,13	0,29	0,84	0,042	1.627	227	1.853
Free-range	1,24	0,32	0,92	0,046	445	237	682
Organic	1,24	0,32	0,92	0,047	127	129	256
TOTAL					5.603	988	6.591
Average			*0,81*	*0,04*			

Note: Including N emissions from young hens and reproductive animals, the total emissions rise to 9,9 kt in 2015.

5.2.4. Animal welfare consideration in the laying hen sector

Confronting each production system to the CIWF animal welfare criteria (Table 159 in the appendix), it is possible to carry out a qualitative animal welfare assessment of laying hens systems. Two welfare categories are considered: housing conditions and mutilation. Organic and Free-range systems appear to be the most in line with CIWF criteria (Table 31).

Table 31. Welfare assessment for the laying hen sector.

	Cage	Indoor	Free-range	Organic
Housing	1	2	3	3
Mutilation	1	1	1	1
Overall score	●	●	●	●

Note: The criteria and ranking methodology are detailed in Chapter 1. The number (1-3) indicates the consistency of the production system with the considered category (housing, mutilation or birth-giving); 1 indicates low consistency, 3 indicates high consistency.

5.2.5. Biodiversity impacts of the laying hen sector

In order to assess the biodiversity impacts of each production system, the methodology developed by De Schryver et al. (2010) was used. It gives an indication of the biodiversity impact related with the production of feed consumed by the Belgian laying hen sector (regardless of where it is produced). The impact of each feed ingredient is then aggregated to determine the overall Damage Score (DS) associated to a certain production system. The results are visible on Table 32 and show that the least impactful system is the organic one (lowest DS of 0,0013), followed by enriched cage, indoor and free-range systems.

Table 32. Biodiversity impacts (damage scores) of different laying hen systems.

Production system	Intake (ha/kg egg)				Damage Score (DS)
	Wheat/ triticale	Maize	Soybean meal	Sunflower meal	/kg egg
In-cage	7,0E-05	7,6E-05	1,4E-04	0,0E+00	**0,0024**
Indoor	7,7E-05	8,3E-05	1,5E-04	0,0E+00	**0,0026**
Free-range	8,8E-05	8,0E-05	1,2E-04	4,5E-05	**0,0028**
Organic	9,1E-05	8,2E-05	1,3E-04	4,6E-05	**0,0013**

5.2.6. Conclusion and summary of environmental impacts of the laying hen sector

- Egg production in Belgium mainly occurs in conventional systems (laying hens can be kept in enriched cages or just indoors).
- Free-range and organic systems represent only 9% and 3% of the total laying hen population respectively. They are more frequent in Wallonia than in Flanders (Figure 33).
- National production, which is largely located in Flanders, amounts to 165 kt of eggs per year, while 98 kt are imported and 112 kt are exported. As a result, the production level is slightly higher than the net utilisation in the country (Table 2).
- Organic and differentiated systems have slightly higher GHG and N emissions per kg of egg produced but they contribute very little overall given their shares (Table 33, Figure 35 and Figure 36).
- In terms of animal welfare, free-range and organic systems perform best. The latter performs the best in terms of biodiversity too.

Table 33. Summary table of environmental impacts related to the laying hen sector.

	Cage	Indoor	Free-range	Organic
GHG emissions *(kg CO_2e/kg egg)*	2,29	2,50	2,45	2,53
N emissions *(Kg N/kg egg)*	0,038	0,042	0,046	0,047
Animal welfare	•	•	•	•
Biodiversity *(DS/kg egg)*	0,0023	0,0025	0,0027	0,0013
Use of chemical phytopharmaceuticals	Yes	Yes	Yes	No use
Shares *(% of laying hens)*	60%	27%	9%	3%
Total GHG emissions *(kt CO_2e/year)*	228	111	37	14

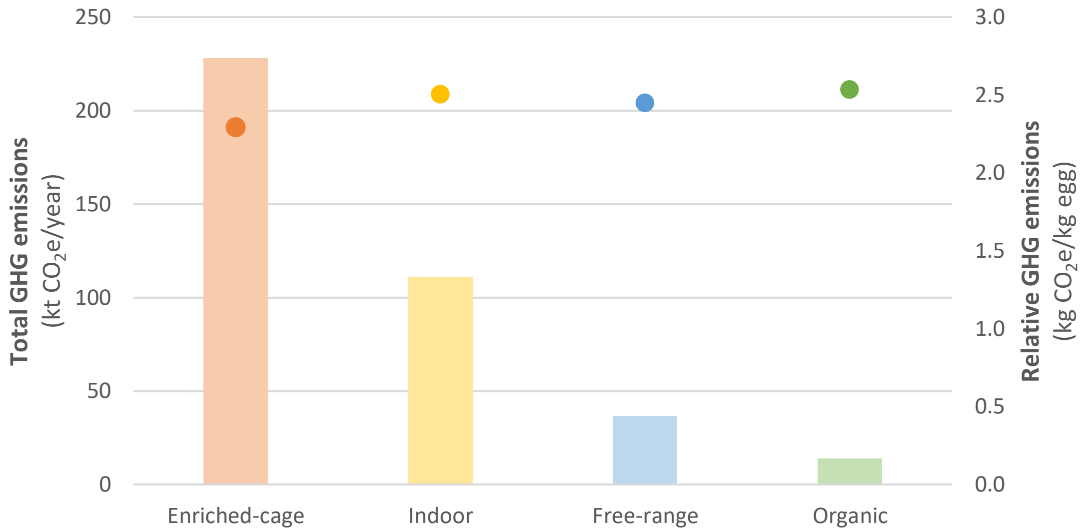

Figure 35. Contribution of egg production systems to relative (dots) and total (bars) GHG emissions.

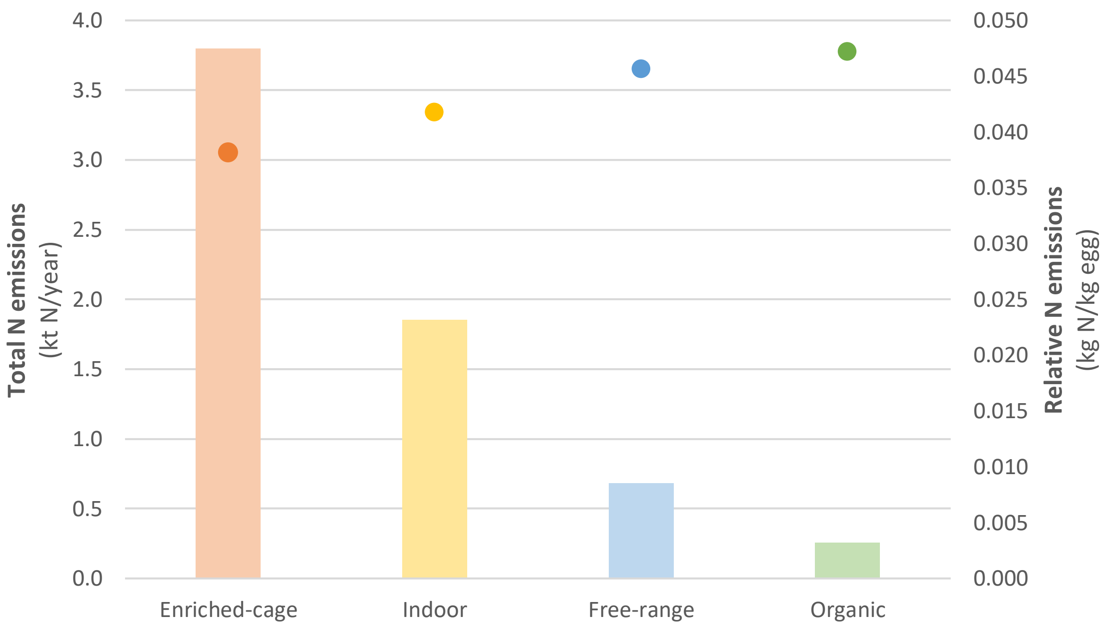

Figure 36. Contribution of egg production systems to relative (dots) and total (bars) N emissions.

5.3. Characterisation of production systems in the broiler sector

5.3.1. Typology of production systems

It must be noted that in this study, the production of poultry meat is assessed only through the production of broilers. Nevertheless, in reality, old laying hens which have reached the end of their laying cycle (after about 18 months) are sent to slaughterhouses and hence also contribute to the production of poultry meat.

In the broiler sector, four main production systems can be identified.

- **Organic:** The organic certification and production system has the highest number of criteria. It involves a series of practices and conditions such as an access to an outdoor area for the broilers, a maximum number of animals per building and per farm, an organic diet for the animals, etc.
- **Differentiated:** A study carried out in 2015 by the Department of Agriculture and Fisheries of the Flemish government has identified eight differentiation initiatives in Flanders and Wallonia, apart from the organic certification (see Table 174 in the appendix). These initiatives put the emphasis on several aspects such as the use of specific breeds, specific animal diets or specific housing systems, or a combination of those elements (Bergen, 2015).
- **Certified (Belplume):** Today, the Belplume certification which was mentioned earlier (see section 5.1.5) represents the standard for poultry meat production in Belgium as it covers more than 90% of total national production (and more than 95% in Flanders). In addition to this standard, some retail companies have extra requirements such as 100% vegetal diets. This sometimes considered as “Belplume Plus”, although formally there is no such standard.
- **Conventional:** Although the Belplume certification covers nearly the entirety of the Belgian poultry meat production, some farms do not operate under the Belplume specifications yet. However, according to actor interviews, practices in conventional not-certified systems are rather similar to practices in Belplume-certified systems.

Among other differences, it seems important to mention the differences in breeds between systems. Indeed, whereas Belplume and conventional systems will work with fast growing breeds, differentiated and organic systems will tend to work with intermediate to slow growing breeds. This is of particular importance as it affects the overall duration of a production cycle. In conventional systems, the chickens attain their final weight much faster compared to differentiated or organic systems (about 40 days vs. 80 days). This has an impact on overall annual production levels but also on input use.

As a result of the previous point, a further distinction is made within differentiated systems and a fifth ‘Differentiated +’ system is identified. This system which comes closer to organic systems compared to ‘Differentiated’ systems, will tend to work with slow-growing breeds, provides outdoor access to the chickens, etc.

Table 34 below provides a summary of the characteristics of the five identified production systems. Furthermore, Table 174 in the appendix provides an overview of the existing differentiation initiatives in Belgium. As can be seen, the majority of these initiatives are located in Wallonia rather than Flanders.

Table 34. Characteristics of poultry meat production systems.

Production system	Unit	Conventional	Certified (Belplume)	Differentiated	Differentiated +	Organic
Indoor density	kg/m²	Up to 42	Up to 42	Varies [3]	Varies [3]	21
Outdoor area	m²/animal	0	0	0-2	0-2	4
Production period	Days	38 [2]	38 [2]	56 [2]	70 [2]	70 [2]
Production cycles	Cycles/year	7	7	5,5	4,5	4,5
Final Weight	kg	2,2 [2]	2,2 [2]	2,3 [2]	2,4 [2]	2,4 [2]
Feed consumption *(Avg: 1,8)* [1]	kg feed/kg live weight	1,7 [2]	1,7 [2]	2,4 [2]	2,6	2,6 [2]

Sources:
[1] Average for Belgium in 2010 (Viaene, 2012b).
[2] Estimates based on actor interviews and (ITAVI, 2014) for the feed consumption.
[3] See Table 174 in the appendix for differentiated and differentiated + systems.

5.3.2. Shares of production systems

According to the study carried out by Bergen (2015), Belplume certified systems represent about 90-95% of total production, there are 5-10 remaining conventional farmers, i.e. non-certified, and the differentiated productions, including the organic products, account for about 2% of total production. Hence, based on these results and on actor interviews, an estimation of the shares of each production system is presented on Figure 37.

According to the authors of the study, there is a rather limited scope for differentiated and organic systems to further develop and expand in Flanders. However, the potential for those systems in Wallonia is more important. This is mainly explained by the fact that more land is available in Wallonia and that its price is thus lower when compared to Flanders, which is an important factor given that these systems require more land compared to conventional systems. Furthermore, the authors note that Carrefour supermarkets import their organic poultry products from France. Hence, there could be an opportunity to further develop the organic sector if Carrefour supermarkets were to work with national producers instead of French.

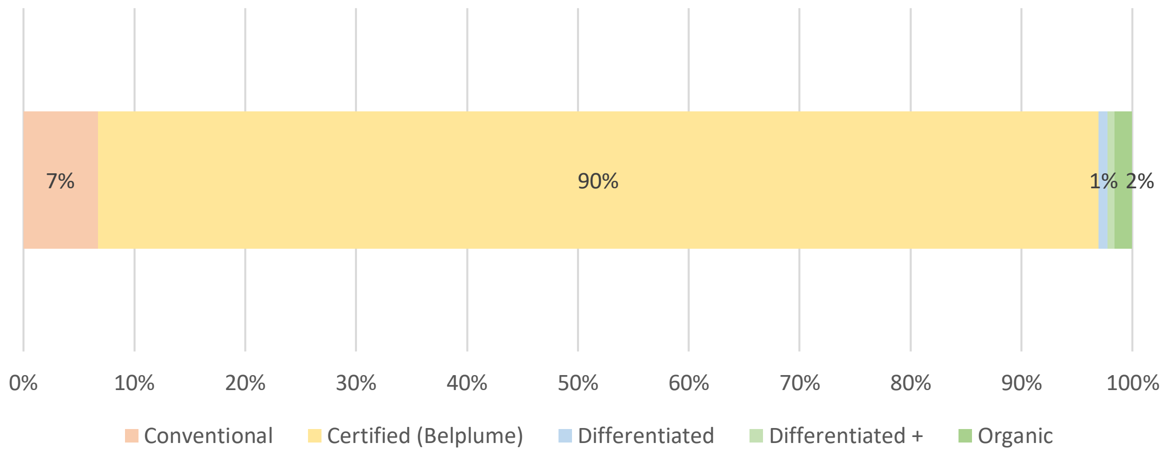

Figure 37. Shares of broiler production systems in Belgium (percentage of Belgian broiler slaughters in 2015).
Source: Estimated from (Bergen, 2015) and actor interviews
Note: 'Differentiated' and 'Differentiated+' systems are considered together here. Separately, they represent about 0,75% of total broiler slaughters.

5.3.3. Environmental externalities of the broiler sector

(a) Feed intake and consumption

Feeding practices in the broiler sector (composition and conversion ratios) are shown on Table 35 and Table 36.

Here, a clear distinction appears between the two first systems (conventional and certified) and two others (differentiated and organic) in terms of feed conversion. As a result of longer production cycles (around 80 days for differentiated and organic systems instead of 40 days for conventional and Belplume systems) as well as the use of different breeds, chickens in differentiated and organic systems need much more feed to grow.

Table 35. Feed composition of different broiler production systems.

Production system	**Feed composition (mass %) [1]**						
	Cereals		**Oleaginous/ proteaginous**	**Protein-rich feed**			**Others**
	Wheat/ triticale	*Maize*		*Soybean meal*	*Sunflower meal*	*Rapeseed meal*	*(Vitamins, minerals…)*
Conventional [1]	50%	15%	7%	20%	-	-	8%
Certified (Belplume) [1]	50%	15%	7%	20%	-	-	8%
Differentiated	35%	35%	5%	20%	-	-	5%
Differentiated +	35%	35%	5%	20%	-	-	5%
Organic	35%	30%	4%	26%	-	-	5%

Sources: [1] Feed compositions are based on actor interviews (with feed producing companies) as well as sources from the literature (Blonk et al., 2007).

Table 36. Feed conversion ratios and feed intake of broiler production systems.

Production system		**Consumption [1]**	
	kg/kg live weight	kg feed/animal	kt feed/year (BE)
Conventional	1,7	3,74	41
Certified (Belplume)	1,7	3,74	555
Differentiated	2,4	5,52	7
Differentiated +	2,6	6,24	7
Organic	2,6	6,24	16
TOTAL			627

Source: [1] Personal communication through actor interviews (2018).

(b) GHG emissions

The same methodology which was used for the laying hen sector was applied to the broiler sector.

- *Feed-related GHG emissions*

From Table 37, it appears quite clearly that differentiated, differentiated+ and organic systems result in higher relative emissions (2,72, 2,95 and 3,36 kg CO_2e/kg live weight respectively) compared to conventional and Belplume systems. This is again a result of the differences in FCR between systems.

Table 37. Feed-related GHG emissions in the broiler sector.

Production system	Relative impact		Total impact
	kg CO_2e/kg live weight	kg CO_2e/animal	kt CO_2e/year
Conventional	2,02	4,44	49
Certified (Belplume)	2,02	4,44	659
Differentiated	2,72	6,26	8
Differentiated +	2,95	7,07	8
Organic	3,36	8,05	21
TOTAL			745
Average	*2,1*	*4,53*	

Note: include LUC for soy.

- *Manure management*

Here again, the organic and differentiated systems result in higher relative emissions although organic systems come closer to conventional systems in this regard.

Table 38. GHG emissions from manure management in the broiler sector.

Production system	Relative GHG emissions from manure		TOTAL emissions from manure
	kg CO_2e/kg live weight	kg CO_2e/animal	t CO_2e/year
Conventional	0,06	0,13	1.411
Certified (Belplume)	0,06	0,13	19.028
Differentiated	0,08	0,19	243
Differentiated +	0,09	0,22	236
Organic	0,06	0,15	459
TOTAL			21.377
Average	*0,06*	*0,13*	

- *Total GHG emissions from the broiler sector from the broiler sector*

The aggregate picture (Table 39) indicates that the system resulting in the highest relative emissions is the organic one (3,4 kg CO_2e/kg live weight), followed by the differentiated + and differentiated systems (3,0 and 2,8 kg CO_2e/kg live weight respectively) and finally the conventional and Belplume systems (2,1 kg CO_2e/kg live weight). Overall it is the Belplume system which has the biggest share of total emissions (89%), which is consistent with the fact that it is the most common system.

Table 39. Total GHG emissions from the broiler sector.

Production system	Relative GHG emissions		TOTAL emissions
	kg CO_2e/kg live weight	kg CO_2e/animal	kt CO_2e/year
Conventional	2,1	4,6	50,3
Certified (Belplume)	2,1	4,6	678,3
Differentiated	2,8	6,4	8,4
Differentiated +	3,0	7,3	7,8
Organic	3,4	8,2	21,2
TOTAL			766,1
Average	*2,1*	*4,7*	

(c) N emissions

N contents shown in Table 168 were also used to calculate N emissions in the broiler sector. In this case, the NUE is of 40% (Hou et al., 2016). Table 40 shows the results for the broiler sector. As a result of their lower FCR, differentiated and organic systems result in higher relative (per kg live weight) N emissions compared to the other two systems.

It should be noted that the numbers shown here under kg N/animal correspond to the emissions arising during the lifecycle of the animal, i.e. 40 days for conventional or Belplume systems and about 80 days for differentiated and organic systems. When expressed over a full year, these emissions rise to about 0,6 kg N/animal/year.

Table 40. N emissions in the broiler sector.

Production system	**N intake**	**N retained**	**N emissions (relative)**			**N excretion (total)**
	kg N/kg live weight	kg N/kg live weight	kg N/kg live weight	kg N/ animal	kg N/ animal/year	t N/year
Conventional	0,05	0,02	0,029	0,06	0,62	708
Certified (Belplume)	0,05	0,02	0,029	0,06	0,62	9.551
Differentiated	0,07	0,03	0,040	0,09	0,59	120
Differentiated +	0,07	0,03	0,043	0,10	0,54	111
Organic	0,08	0,03	0,047	0,11	0,59	292
TOTAL						10.782
Average			*0,030*	*0,066*	*0,62*	

5.3.4. Animal welfare considerations in the broiler sector

Confronting each production system to the CIWF animal welfare criteria (Table 158 in the appendix), it is possible to carry out a qualitative animal welfare assessment of broiler systems (orange corresponding to inadequate practices on animal welfare terms, yellow to intermediate practices and green to adequate practices).

Broiler systems are assessed in terms of housing conditions, mutilation and breed. It appears that the organic system is the most in line with the CIWF criteria, followed by the differentiated + and differentiated systems (Table 41).

Table 41. Welfare assessment for the broiler sector.

	Conventional	**Certified (Belplume)**	**Differentiated**	**Differentiatied +**	**Organic**
Housing	1	1	2	2	3
Mutilation	1	1	1	1	2
Breed	1	1	2	3	3
Overall score	●	●	●	●	●

Note: The criteria and ranking methodology are detailed in Chapter 1. The number (1-3) indicates the consistency of the production system with the considered category (housing, mutilation or birth-giving); 1 indicates low consistency, 3 indicates high consistency.

5.3.5. *Biodiversity impacts of the broiler sector*

Using the methodology proposed by De Schryver et al. (2010) and the values from Table 162, we find the biodiversity impacts related with the feed consumption of each broiler production system (Table 42). Again, it is the organic system which scores best and has the lowest overall damage score (0,0018). Differentiated and Differentiated + systems have the highest Damage score given their higher FCRs.

Table 42. Biodiversity impacts (damage scores) of the broiler sector.

Production system	**Intake (ha/kg live weight)**				**Damage Score (DS)**
	Wheat/ triticale	Maize	Olea/Protea-ginous (Beans)	Soybean meal	/kg live weight
Conventional	1,2E-04	2,2E-05	2,9E-05	1,2E-04	0,0025
Certified (Belplume)	1,2E-04	2,2E-05	2,9E-05	1,2E-04	0,0025
Differentiated	1,2E-04	7,2E-05	2,9E-05	1,7E-04	0,0033
Differentiated +	1,3E-04	7,8E-05	3,2E-05	1,8E-04	0,0036
Organic	1,3E-04	6,7E-05	2,5E-05	2,4E-04	0,0018

5.3.6. *Conclusion and summary of environmental impacts of the broiler sector*

- The production of poultry meat from broilers in Belgium mainly occurs in conventional systems (which are Belplume-certified in the vast majority of cases).
- Differentiated and organic systems based on slower growing breeds only represent 4% (2% each) of the total broiler slaughters (Figure 37).
- National production, which is largely located in Flanders, amounts to 370 kt of broiler meat, while 458 kt are imported and 593 kt are exported. As a result, the production level is about 60% higher than the net utilisation in the country (Table 2).
- Organic and differentiated systems have slightly higher GHG and N emissions per kg of meat but they contribute very little overall given their shares (Table 43, Figure 38 and Figure 39).
- In terms of animal welfare and biodiversity, the organic system performs the best.

Table 43. Summary table of environmental impacts related to the broiler sector.

	Conventional	**Certified (Belplume)**	**Differentiated**	**Differentiated +**	**Organic**
GHG emissions *(kg CO_2e/kg live weight)*	2,1	2,1	2,8	3,0	3,4
N emissions *(Kg N/kg live weight)*	0,06	0,06	0,09	0,10	0,11
Animal welfare	●	●	●	●	●
Biodiversity *(DS/kg live weight)*	0,0025	0,0025	0,0033	0,0036	0,0018
Use of chemical phytopharmaceuticals	Yes	Yes	Yes	Yes	No use
Shares *(% of slaughters)*	7%	90%	1%	1%	2%
Total GHG emissions *(kt CO_2e/year)*	50	678	8	8	21

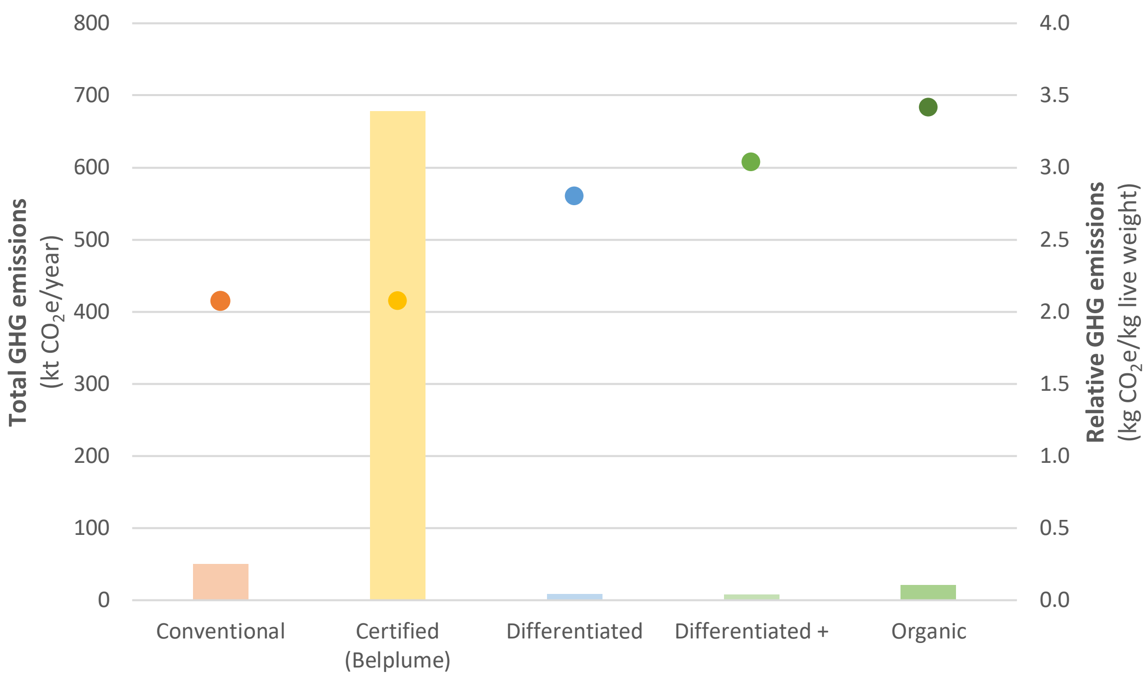

Figure 38. Contribution of broiler production systems to total (bars) and relative (dots) GHG emissions.

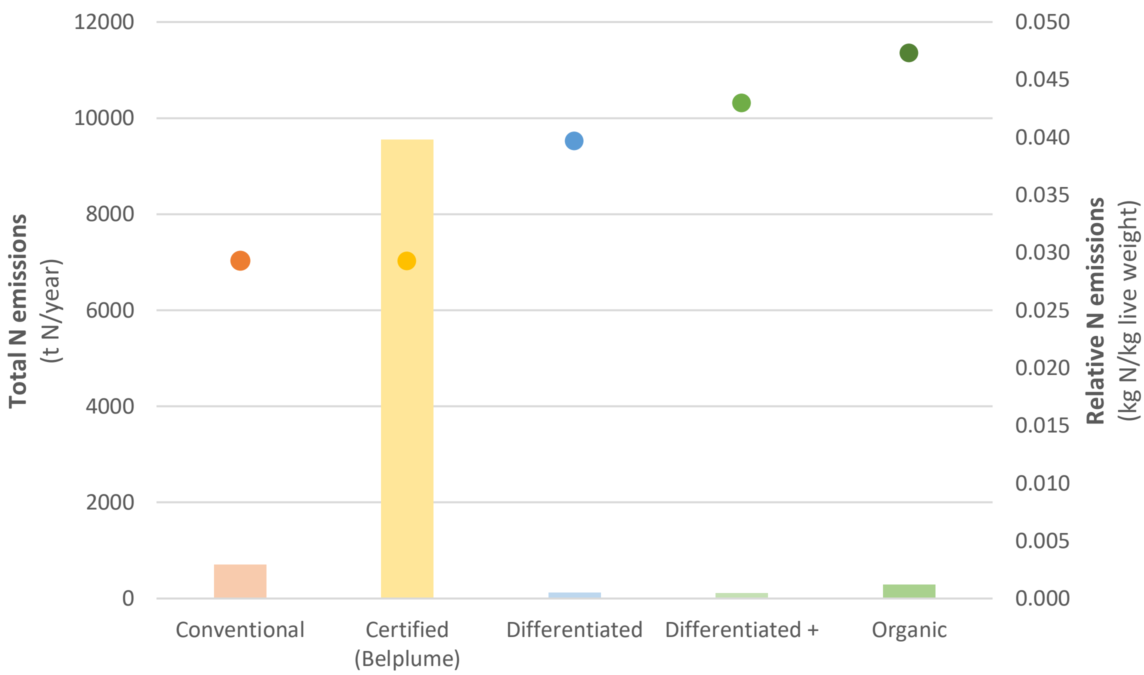

Figure 39. Contribution of broiler production systems to total (bars) and relative (dots) N emissions.

5.4. Total impacts of the poultry sector

In this section, the results from the previous sections are aggregated and presented over the entire poultry sector (including young hens and reproductive animals) for three categories: feed consumption, N emissions and GHG emissions (Table 44 to Table 47). A comparison of these results with other sources is carried out in Chapter 9.

Table 44. Total annual feed consumption of the Belgian poultry sector.

Category	Feed consumption
	kt feed/year
Broilers	627
Laying hens	346
Young hens	91
Reproductive animals	83
Poultry (total)	1.146

Table 45. Total and relative N emissions in the Belgian poultry sector.

Category	Total N emissions	Relative emissions	
	kt N/year	kg N/kg product*	kg N/animal/year
Broilers	10,8	0,03	0,62
Laying hens	6,6	0,04	0,81
Young hens	1,7	-	0,51
Reproductive animals	1,6	-	0,85
Poultry (total)	20,7	-	-

Note: * per kg product means per kg egg for laying hens and per kg live weight for broilers.

Table 46. Relative GHG emissions in the poultry sector.

Category	GHG emissions	Slaughter yield	GHG emissions
	kg CO_2e/kg product [1]	%	kg CO_2e/kg carcass
Broiler sector	2,11	72%	2,9
Laying hen sector	2,37	-	-

Note: [1] per kg product means per kg egg for laying hens and per kg live weight for broilers.

Table 47. Total GHG emissions in the poultry sector.

Step	Broilers	Laying hens	Young hens	Reproductive animals	TOTAL Poultry
	kt CO_2e/year	kt CO_2e/year	kt CO_2e/year	kt CO_2e/year	kt CO_2e/year
TOTAL	766	389	104	94	1.353
- Feed related emissions	745	378	100	91	1.314
- Manure mgmt: CH4	10	5	2	1	18
- Manure mgmt: N2O	11	7	2	2	21
- Manure mgmt: TOTAL	21	12	4	3	39

Chapter 6. Dairy production in Belgium

6.1. The dairy sector

6.1.1. Animal and farm numbers, regional distribution and production

In 2015, there were 507.390 dairy cows in production in Belgium. Compared to other livestock sectors, the regional concentration is not so strong for the dairy sector as 304.304 (60%) of these dairy cows were located in Flanders and 202.825 (40%) in Wallonia (see Figure 40) (Statistics Belgium, 2016a).

In **Flanders**, the dairy sector is rather well spread over the region. Nevertheless, more important hubs appear in the Northern parts of the provinces of Antwerp and Limburg, as well as in the North of Eastern and Western Flanders (Figure 40). In **Wallonia**, the dairy sector is very important in the North-East of the region, i.e. the 'Région herbagère liégeoise' (or 'grassland regions from Liège') and the 'haute Ardennes' (or 'high Ardennes'). Other agricultural areas such as the 'Condroz' and the 'Région limoneuse' also represent important areas for the sector (Figure 40) (SPW, 2017).

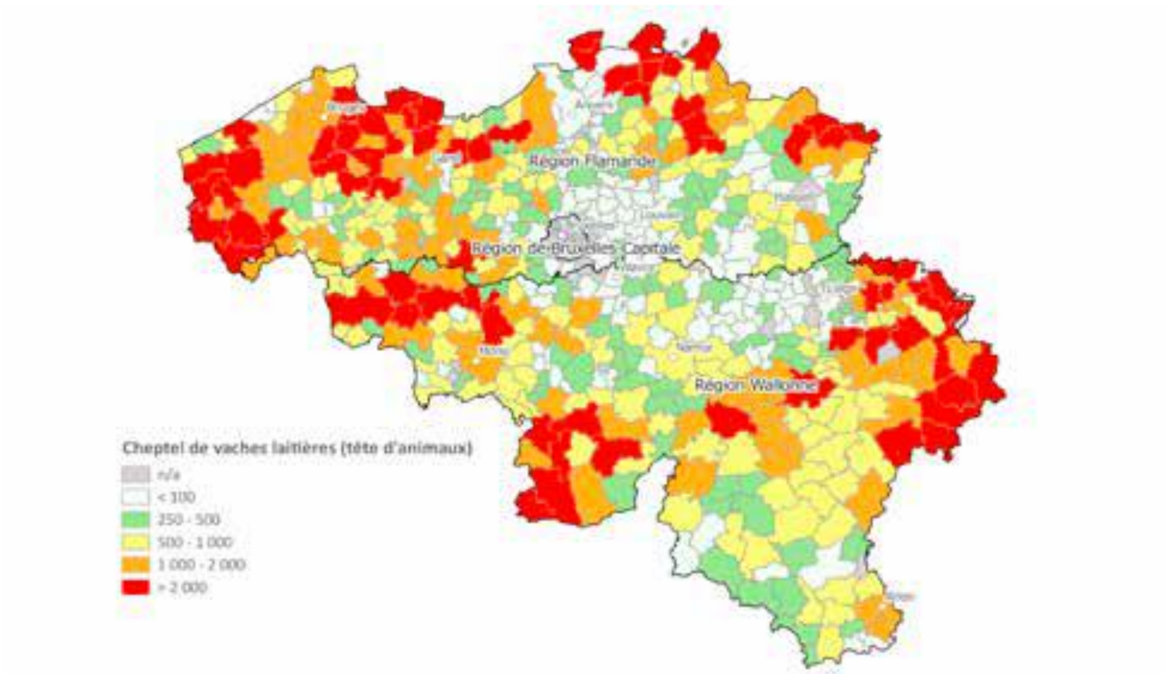

Figure 40. Regional distribution of the dairy sector in Belgium in 2014 (cows per municipality) (SOGEPA, 2014).

In terms of farm numbers, there were 12.076 farms with dairy cows in Belgium in 2015, of which 6.658 were located in Flanders (55%) and 5.413 in Wallonia (45%) (Statistics Belgium, 2016a). This results in average animal loads of 42 animals per farm in Belgium. When comparing the two regions however, it appears that the average animal load is higher in Flanders than in Wallonia (46 vs. 38 animals/farm). It is interesting to note that a non-negligible number of farms hold only a few animals. Indeed, in Flanders, 1.944 of farms (29%) have less than 14 dairy cows, and an additional 813 farms have between 15 and 29 dairy cows (12%). Hence, the remaining 59% of farms, which have more than 30 dairy cows, hold 92% of all dairy cows in Flanders (Departement Landbouw en Visserij, 2016b). Similarly, 3.966 farms in Wallonia hold more than 5 dairy cows, meaning that a non-negligible amount of 1.447 farms have between 1 and 4 dairy cows (SPW, 2017). For these farms, it can thus be assumed milk production is not their main activity.

In 2015, about 3.482 million litres of milk were produced and delivered in Belgium. Of this total amount, 2.150 million litres were produced in Flanders (62%) and 1.332 million litres were produced in Wallonia (38%) (Departement Landbouw en Visserij, 2016b; SPW, 2017). Table 48 provides an overview of the aforementioned key numbers of the sector.

Table 48. Summary of key numbers of the Belgian dairy sector in 2015.

	Belgium	Flanders	Wallonia
Animal numbers	507.390	304.304	202.825
Farm numbers	12.076	6.658	5.413
Animals/farm	42	46	38
Production (million L)	3.482	2.150	1.332

6.1.2. Historical evolution

The dairy sector has experienced some radical changes over the past years in Belgium. In general, the trend is towards a more concentrated sector, with fewer but bigger farms, both in Flanders and Wallonia (shown for Flanders on Figure 41). The number of dairy cows has declined too over the last years, particularly in Flanders (Figure 42).

After having remained rather stable for about twenty years, milk production levels have increased at a steady pace over the last years. This is shown on Figure 42 for Belgium and Wallonia and on Figure 43 for Flanders. On this last figure, it appears quite clearly that these phenomena have resulted in increased milk production per farm. According to VILT (2014), the number of farms with dairy cows in Flanders has more than halved during the period 1996/97 – 2012/13 (from 11.556 farms in 1996/97 to 5.449 farms in 2012/2013) but the productivity of farms has more than doubled over the same period (from 161.900 litres/farm in 1996/97 to 376.500 litres/farm in 2012/13). Furthermore, the authors believe this trend will continue as they believe that in 2020, there will be about 3.300 dairy farms which will have average production levels of 700.000 litres per farm.

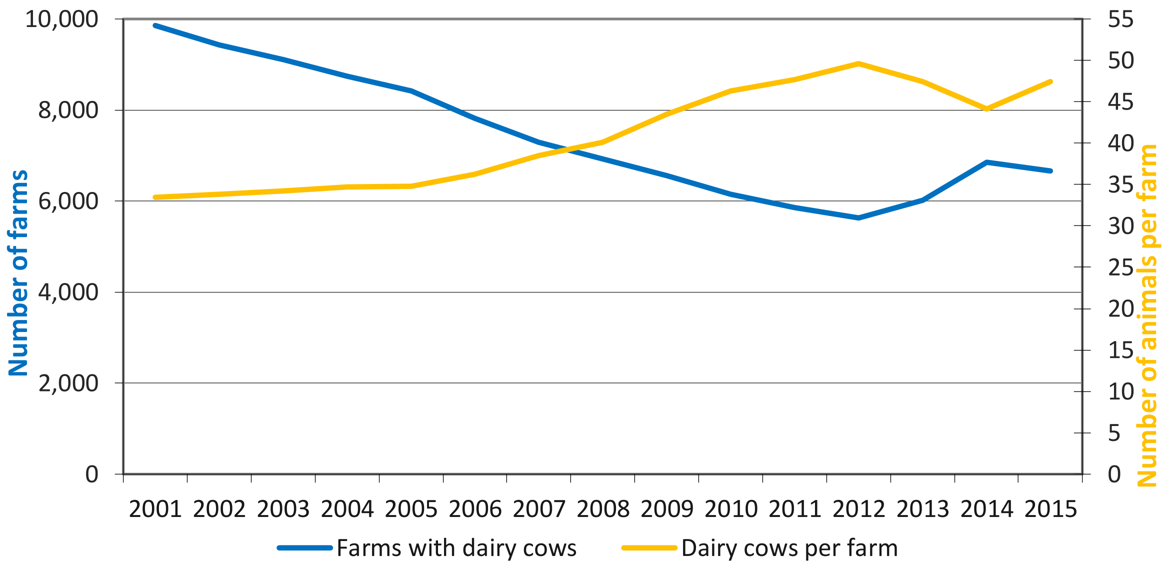

Figure 41. Evolution of the number of farms with dairy cows and the number of dairy cows per farm in Flanders between 2001 and 2015.

Source: (Departement Landbouw en Visserij, 2016b)

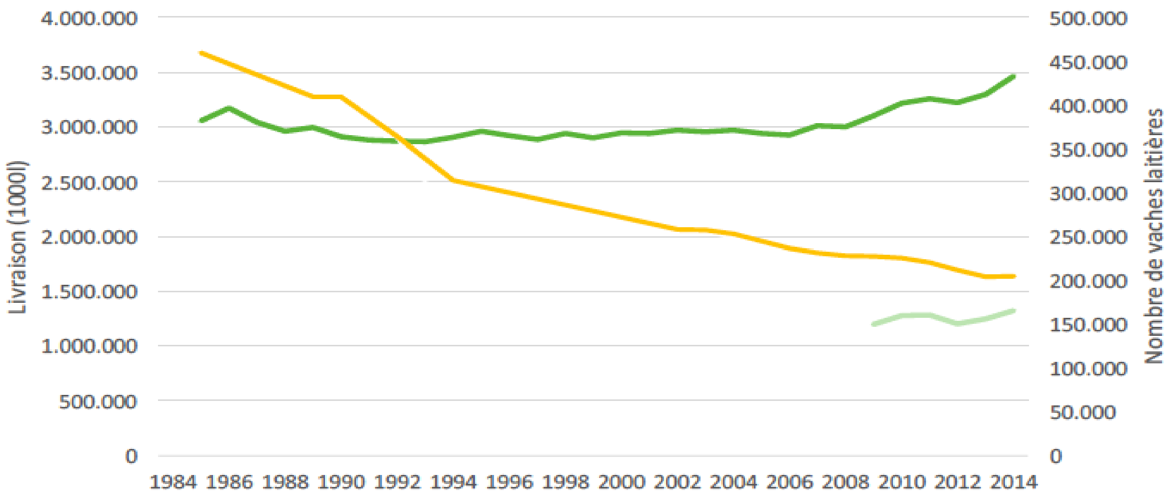

Figure 42. Evolution of dairy cows (in yellow) and milk delivery in Belgium (in dark green) and Wallonia (in light green) between 1984 and 2014.

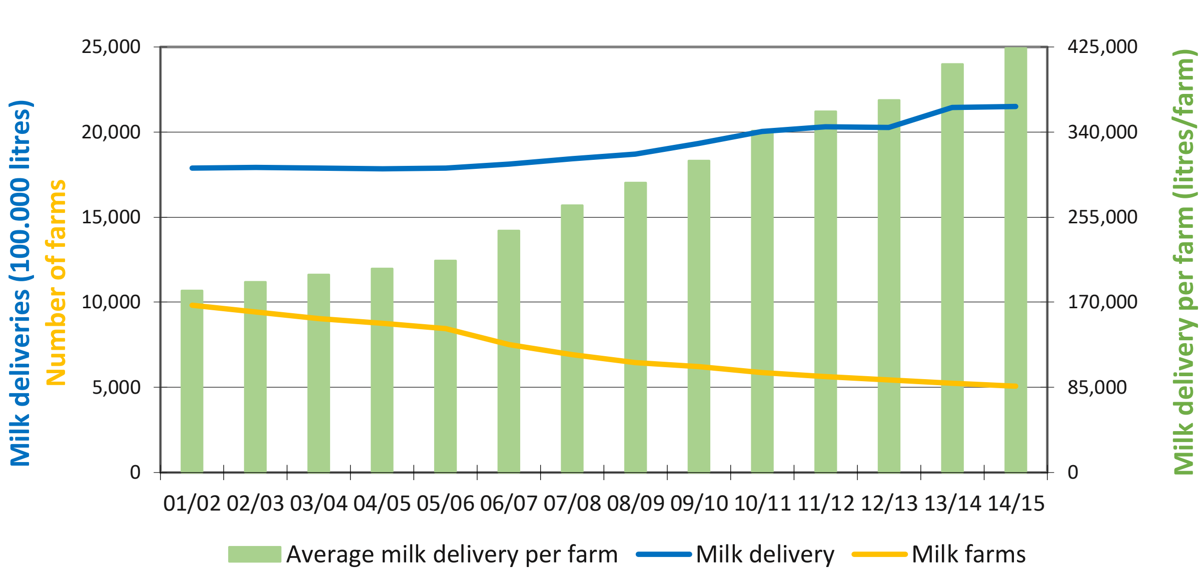

Figure 43. Evolution of farm numbers, milk production and average milk production per farm in Flanders between 2001 and 2015.
Source: (Departement Landbouw en Visserij, 2016b)

6.1.3. Dairy quotas

The historical evolution of the dairy sector is closely linked to the implementation of dairy quotas by the EU in 1984 and more recently to the abolishment of the policy in 2015. This policy, which was part of the Common Agricultural Policy, attributed production quotas for member states in order to control and regulate milk production levels in the EU. As can be seen on Figure 42, Belgian production levels remained rather stable after the implementation of the policy in 1984 (at about 3.10^9 L of milk). Although absolute production remained rather stable, the sector experienced important structural changes. Indeed, as explained above, although the number of farms has decreased and these have become more productive on average. Since 2009, production levels appear to have increased, which can be explained by the fact that the quotas were increased gradually before being abolished entirely in 2015. The increase in production has mainly occurred in Flanders, as shown on the figures above.

6.2. Characterisation of production systems in the dairy sector

6.2.1. Typology of production systems

The typology used for this study is based on a typology which was implemented in the context of a similar study at the scale of the Walloon region. The results of that study will thus be used for Wallonia. The typology was constructed on three differentiation levels (Figure 45) (Petel et al., 2018):

1. The presence or absence of maize silage in the agricultural area dedicated to milk production;
2. The share of pasture or pasture + maize silage in the agricultural area dedicated to milk production (higher or lower than 95%);
3. The milk yield, expressed in litres of milk per dairy cow per year (higher or lower than the regional milk production average, i.e. 6.483 litres per dairy cow per year in Wallonia).

The agricultural area dedicated to milk production (AAMP) can be explained as follows. At a farm-level, it is composed of the forage area (the sum of areas for pasture, maize silage and other forage crops) as well the area for cereals destined for animal feed. Potential cash crops which are part of the agricultural area of the farm are thus left behind (Figure 44).

Based on this differentiation key, 8 distinct production systems were identified. Nevertheless, the application of this key to a dataset of 82 dairy farms revealed that the categories G&C E and G&C I only included 5 farms in total. Hence, these two categories were merged into one: G&C. Each system is described more precisely in the appendix. Table 49 shows the average values of the structural characteristics of each system. The exact composition of concentrates is estimated through (ERM and Universiteit Gent, 2011b) which propose a composition for concentrates used for dairy cows as well as the associated global warming potentials (GWP) of each ingredient (Table 175).

Limits of the typology: The presented typology was elaborated based on a sample of 82 specialised dairy farms (farms that include dairy production and other farming activities were not included in the database). Yet, it is assumed that the typology is relevant for all dairy systems, given than the characterisation specifically focuses on indicators of dairy activities and is not made at the farm level.

Role of organic systems in the proposed typology: Under this typology, organic systems do not constitute a specific production system. Rather, according to interviewed actors, organic systems can be found under several of the proposed production systems as there is great variability both in terms of practices and production levels in the organic dairy sector. Nevertheless, if they had to be classified in one category, it is estimated that the majority would be found in the Grass Extensive system, with production levels generally under 6000 L/cow/year (Petel et al., 2018).

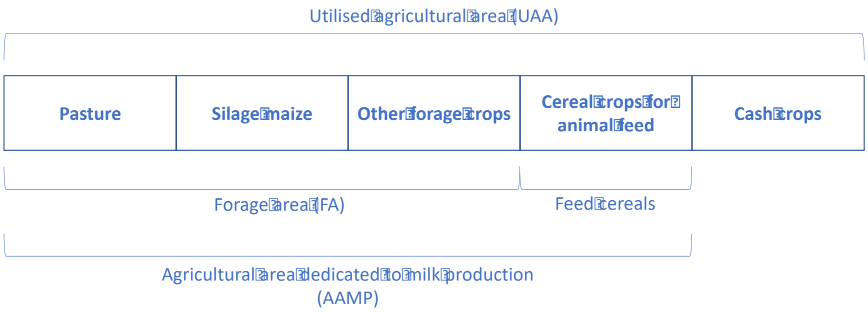

Figure 44. Representation of the different potential areas composing the UAA of a farm with dairy cattle.
Source: (Petel et al., 2017)

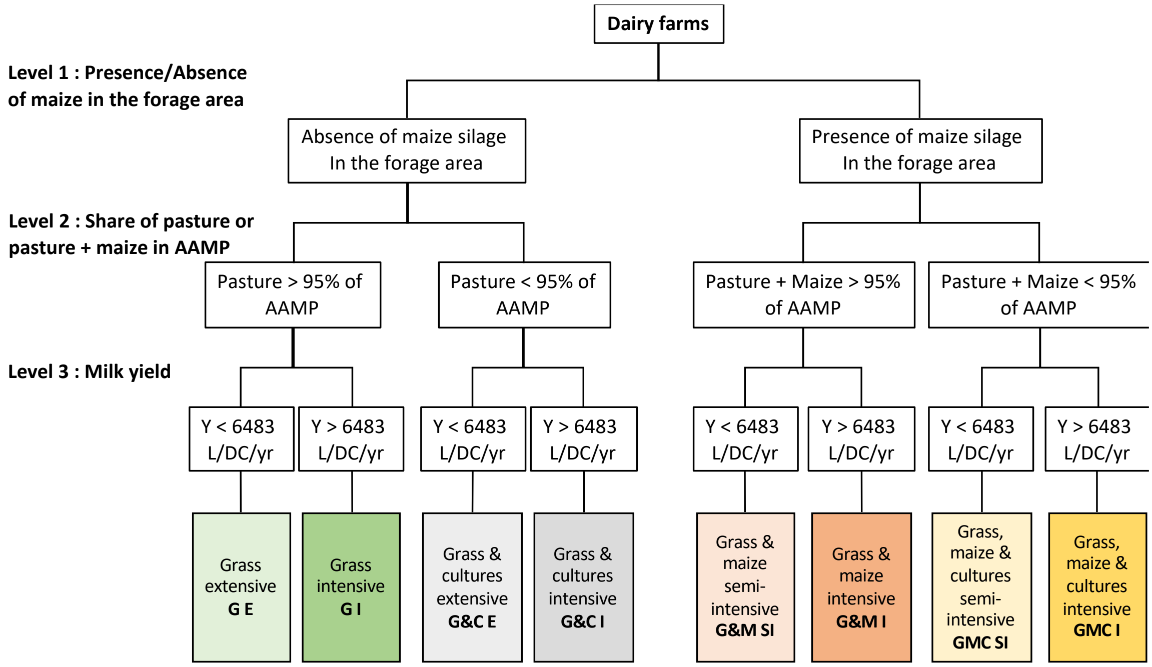

Figure 45. Differentiation key for the elaboration of a typology of dairy production in Wallonia.
Source: (Petel et al., 2018)

Table 49. Structural characteristics of dairy production systems in Wallonia.

	GE	GI	G&C	G&M SI	G&M I	GMC SI	GMC I
Number of farms in dataset	22	15	5	12	16	3	9
Milk yield (L/DC/yr)	5.197	7.486	6.256	4.939	7.677	4.413	8.150
% of pasture + maize in AAMP	100%	100%	84%	99%	99%	89%	91%
% of permanent pasture	99%	100%	70%	79%	76%	62%	44%
% of temporary pasture	1%	0%	14%	2%	4%	8%	11%
% of maize silage	0%	0%	0%	18%	19%	19%	37%
Use of concentrates (kg/DC/yr)	179	220	191	154	209	133	211

Source: (Petel et al., 2018).

6.2.2. Shares of production systems

For Wallonia, the share of each system was estimated in the context of the previously-mentioned study in terms of cattle numbers. This estimation was made over the whole of Wallonia but also subdivides the region in two different zones: a "grassland" region (comprising the agricultural areas of Ardenne, Fagne, Famenne, Haute Ardenne, Région herbagère and Région jurassique) and a "cropland" region (comprising the agricultural areas of: Campine, Condroz, Région limoneuse and Région sablo-limoneuse). Grass systems are estimated to be more important in the grassland region (the biggest share goes to the intensive grass and maize system, followed by intensive grass systems), whereas in the cropland region, the biggest system is the intensive grass, maize and crop, followed by the semi-intensive grass, maize and crops system. In this region, systems based solely on pasture (G E and G I) are not represented at all. Over the entire Walloon region, the biggest share goes to the intensive grass and maize system (32%), followed by the intensive grass, maize and crops system (24%) and the intensive grass system (15%) (Petel et al., 2018).

For Flanders, the same typology was used and the shares were estimated through actor interviews. According to the experts, it is valid to assume that exclusively grass-based systems are non-existent in Flanders. All systems in this region thus include maize and they also tend to be more intensive than in Wallonia. Hence, only four systems were considered in Flanders (it is nevertheless obviously possible that a few more extensive cases based on grass are found in this region). Table 50 and Figure 46 show the shares of each system in Flanders, Wallonia and Belgium.

Table 50. Shares of dairy production systems in Flanders, Wallonia and Belgium.

Production system	Share in Flanders 1	Share in Wallonia 2	Population Wallonia	Population Flanders	Share Belgium 1 & 2
	%	%	DC	DC	%
Grass Extensive (G E)	0%	6%	12.170	0	2%
Grass Intensive (G I)	0%	15%	30.424	0	6%
Grass and Crops (G&C)	0%	3%	6.085	0	1%
Grass and Maize Semi-Intensive (GM SI)	15%	11%	22.311	45.646	13%
Grass and Maize Intensive (GM I)	35%	32%	64.904	106.506	34%
Grass, Maize and Crops Semi-Intensive (GMC SI)	15%	9%	18.254	45.646	13%
Grass, Maize and Crops Intensive (GMC I)	35%	24%	48.678	106.506	31%
Total			202.826	304.304	

Sources: [1] (Actor interviews,2018) ; [2] (Petel et al., 2018).
Note: DC stands for Dairy cow.

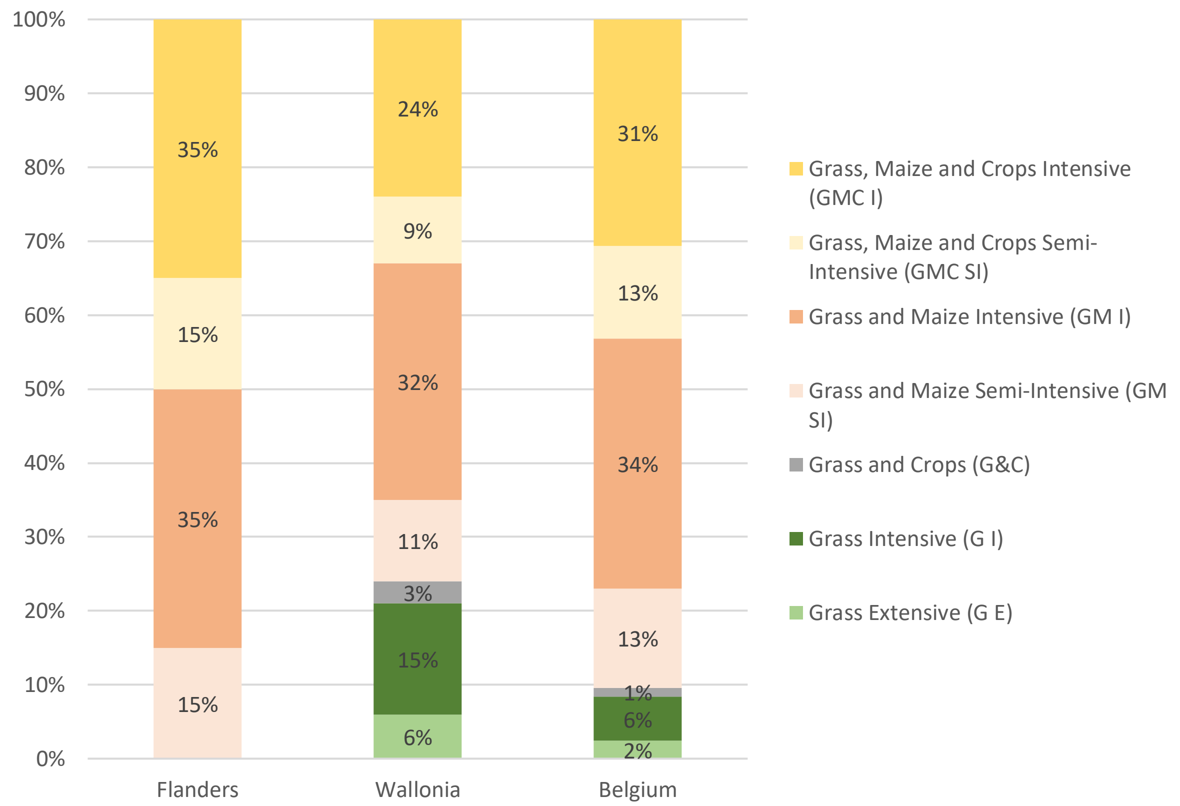

Figure 46. Shares of dairy production systems in terms of dairy cattle in Belgium in 2015.

6.2.3. Feed consumption

- Forage consumption

Table 51 presents the annual forage areas needed in each milk production system. These are expressed per dairy cow and her progeny. These areas are expressed in terms of forage consumption in Table 52 by applying the corresponding yield of each forage category (see Table 164 in the Appendix).

Table 51. Annual forage areas needed for different milk production systems.

Production system	Permanent pasture	Temporary pasture	Forage maize	Other forages
		ha/DC&P/year		
Grass Extensive (G E)	0,98	0,03	-	-
Grass Intensive (G I)	0,87	-	-	-
Grass and Crops (G&C)	0,77	0,14	-	0,14
Grass and Maize Semi-Intensive (GM SI)	0,64	0,01	0,13	0,01
Grass and Maize Intensive (GM I)	0,55	0,03	0,15	0,00
Grass, Maize and Crops Semi-Intensive (GMC SI)	0,57	0,07	0,18	0,07
Grass, Maize and Crops Intensive (GMC I)	0,33	0,08	0,23	0,04

Source: (Petel et al., 2018)

Note: DC&P means Dairy cow and progeny

Table 52. Consumption of forage of different milk production systems.

Production system	Permanent pasture	Temporary pasture	Forage maize	Other forages	TOTAL
		kg/DC&P/year			
Grass Extensive (G E)	6.860	300	-	-	**7.160**
Grass Intensive (G I)	6.090	-	-	-	**6.090**
Grass and Crops (G&C)	5.390	1.400	-	703	**7.493**
Grass and Maize Semi-Intensive (GM SI)	4.480	100	5.945	50	**10.575**
Grass and Maize Intensive (GM I)	3.850	300	6.859	-	**11.009**
Grass, Maize and Crops Semi-Intensive (GMC SI)	3.990	700	8.231	351	**13.272**
Grass, Maize and Crops Intensive (GMC I)	2.310	800	10.517	201	**13.828**

Source: (Petel et al., 2018)

- Concentrates consumption

Table 53 presents the concentrates consumption of the different dairy systems. Figures are presented for the entire herd (dairy cows and their progeny) and for dairy cows only. The difference between both values represents the concentrates consumption of the progeny only. Table 54 presents the concentrates consumption levels of the total dairy sector in Flanders, Wallonia and Belgium (see Table 175 for the specific composition of concentrates). Here too a distinction is made between the entire herd (dairy cows and their progeny) and dairy cows only.

Table 53. Concentrates consumption of different milk production systems in Belgium.

Production system	Concentrates intake		
	kg/DC&P/year [1]	kg/DC/year [1]	kg/P/year [1]
Grass Extensive (G E)	1.119	960	159
Grass Intensive (G I)	1.887	1.665	222
Grass and Crops (G&C)	1.476	1.298	178
Grass and Maize Semi-Intensive (GM SI)	950	794	156
Grass and Maize Intensive (GM I)	1.666	1.559	107
Grass, Maize and Crops SI[2] (GMC SI)	847	671	176
Grass, Maize and Crops Intensive (GMC I)	2.063	1.653	410

Sources: [1] (Petel et al., 2018).

Note: 'DC' stands for dairy cow; 'DC&P' stands for dairy cow and progeny and 'P' stands for progeny. [2]'SI' stands for semi-intensive.

Table 54. Average concentrates consumption of the dairy sector in Flanders, Wallonia and Belgium.

	TOTAL WAL		TOTAL FL		TOTAL BE	
	kt/year (DC&P)	kt/year (DC)	kt/year (DC&P)	kt/year (DC)	kt/year (DC&P)	kt/year (DC)
Grass Extensive (G E)	14	12	0	0	14	12
Grass Intensive (G I)	57	51	0	0	57	51
Grass and Crops (G&C)	9	8	0	0	9	8
Grass and Maize Semi-Intensive (GM SI)	21	18	43	36	65	54
Grass and Maize Intensive (GM I)	108	101	177	166	286	267
Grass, Maize and Crops Semi-Intensive (GMC SI)	15	12	39	31	54	43
Grass, Maize and Crops Intensive (GMC I)	100	80	220	176	320	257
TOTAL	325	282	479	409	804	691

6.2.4. Environmental externalities of the dairy sector

(a) GHG emissions

Per litre of milk, more extensive systems (extensive and semi-intensive) tend to have higher GHG emissions. Indeed, the GMC SI system results in emissions of 1,88 kg CO_2e/L milk, followed by the G E system with 1,74 kg CO_2e/L milk and the GM SI with 1,69 kg CO_2e/L milk. The GMC I system is the most efficient with 1,18 kg CO_2e/L milk. It is however interesting to note that over a full year, the intensive systems are the ones with the highest emissions (Table 55). They nevertheless compensate this with higher productivities.

In terms of total emissions however, the extensive systems contribute much less as they represent very small shares of the herd (see Table 50 and Figure 46). The two intensive systems based on grass and maize (GM I and GMC I) contribute the most to total emissions (about 33% each). These considerations highlight the choice of the unit when expressing results.

In terms of emission sources, 51% of the estimated emissions are due to enteric fermentation, followed by the feed-related emissions (22%).

Table 55. Summary of GHG emissions in the Belgian dairy sector.

Production system	Relative GHG emissions		TOTAL emissions WAL	TOTAL emissions FL	TOTAL emissions BE
	kg CO_2e/L	kg CO_2e/ DC&P/year	kt CO_2e /year		
Grass Extensive (G E)	1,73	8.990	109	0	109
Grass Intensive (G I)	1,31	9.776	297	0	297
Grass and Crops (G&C)	1,48	9.286	57	0	57
Grass and Maize Semi-Intensive (GM SI)	1,68	8.296	185	379	564
Grass and Maize Intensive (GM I)	1,20	9.188	596	979	1.575
Grass, Maize and Crops SI (GMC SI)	1,87	8.231	150	376	526
Grass, Maize and Crops Intensive (GMC I)	1,17	9.557	465	1.018	1.483
TOTAL	**-**	**-**	**1.860**	**2.751**	**4.611**
- *Concentrates related*	-	-	408	601	1.009
- *Forage related*	-	-	305	430	735
- *Enteric fermentation*	-	-	943	1.415	2.358
- *Manure management*	-	-	204	305	508
AVERAGE	**1,34**	**-**	**-**	**-**	**-**
- *Concentrates related*	*0,29*	-	-	-	-
- *Forage related*	*0,21*	-	-	-	-
- *Enteric fermentation*	*0,67*	-	-	-	-
- *Manure management*	*0,14*	-	-	-	-

Sources: ERM & UGent (2011) for feed impact (including LUC for soy) and N2O emissions from manure; National GHG inventory for emission factors related to enteric fermentation and CH4 emissions from manure.

(b) N emissions

Table 56 shows the N emissions of the dairy sector, in Wallonia, Flanders and Belgium. Results are here expressed for the entire herd (dairy cows and their progeny). As for GHG emissions, more extensive systems tend to have higher relative emissions but contribute very little to the total emissions. Again, over a full year, more intensive systems tend to result in higher emissions, which they compensate with higher productivities.

Table 56. N emissions of different milk production systems in Wallonia and Belgium.

Production system	N intake	N retained	N emissions (relative)		N emissions (total WAL)	N emissions (total FL)	N emissions (total BE)
	kg N/DC&P /year	kg N/DC&P /year	kg N/DC&P /year	kg N/L	kt N/year		
Grass Extensive (G E)	221	51	170	0,033	2,1	0	2,1
Grass Intensive (G I)	223	51	172	0,023	5,2	0	5,2
Grass and Crops (G&C)	244	56	188	0,030	1,1	0	1,1
Grass and Maize Semi-Intensive (GM SI)	229	53	176	0,036	3,9	8,0	11,9
Grass and Maize Intensive (GM I)	256	59	197	0,026	12,8	20,9	33,7
Grass, Maize and Crops Semi-Intensive (GMC SI)	265	61	204	0,046	3,7	9,3	13,0
Grass, Maize and Crops Intensive (GMC I)	297	68	229	0,028	11,1	24,4	35,5
TOTAL/AVG (DC&P)			197		40	63	103

6.2.5. Animal welfare considerations of the dairy sector

Confronting each production system to the CIWF animal welfare criteria (Table 161 in the appendix), it is possible to carry out a qualitative animal welfare assessment of dairy systems (orange corresponding to inadequate practices on animal welfare terms, yellow to intermediate practices and green to adequate practices).

Dairy systems are mainly assessed in terms of housing conditions and feeding practices (access to pasture). All systems perform quite well against the CIWF criteria, with the Grass Extensive system reaching the highest score (Table 57).

Table 57. Animal welfare assessment for the dairy sector.

Production system	Housing/Feed	Other considerations	Overall score
Grass Extensive (G E)	3	3	●
Grass Intensive (G I)	3	2	●
Grass and Crops (G&C)	3	2	●
Grass and Maize Semi-Int (GM SI)	2	3	●
Grass and Maize Intensive (GM I)	2	2	●
Grass, Maize, Crops Semi-In (GMC SI)	2	3	●
Grass, Maize, Crops Intensive (GMC I)	2	2	●

Note: The criteria and ranking methodology are detailed in Chapter 1. The number (1-3) indicates the consistency of the production system with the considered category (housing, mutilation or birth-giving); 1 indicates low consistency, 3 indicates high consistency.

6.2.6. Biodiversity impacts of the dairy sector

Using the methodology proposed by De Schryver et al. (2010) and the values from Table 162, we find the biodiversity impacts associated with the feed consumption (regardless of where the feed is produced) of each dairy production system (Table 58). Here more extensive systems tend to have lower impacts when expressed per dairy cow and progeny. When expressed per litre of milk, the situation with more intensive systems is less contrasted as the latter are more productive. The least impactful system is the Grass Extensive one, which is often associated to organic systems.

Table 58. Biodiversity impacts of the dairy sector.

Production system	Damage Score (DS)		
	DS/DC&P/year	DS/L milk	TOTAL
Grass Extensive (G E)	2,266	0,00044	27.580
Grass Intensive (G I)	10,812	0,00144	328.945
Grass and Cultures (G&C)	7,744	0,00124	47.120
Grass and Maize Semi-Intensive (GM SI)	5,499	0,00111	373.660
Grass and Maize Intensive (GM I)	8,790	0,00114	1.506.626
Grass, Maize and Cultures Semi-Intensive (GMC SI)	5,757	0,00130	367.869
Grass, Maize and Cultures Intensive (GMC I)	8,879	0,00109	1.377.948

Note: Here the hypothesis was made that the G E system corresponds to organic systems, as organic systems often operate under this system (although not exclusively). This explains the lower DS of this system.

6.3. Conclusion of Chapter 6

- Milk production in Belgium comes from a rather large diversity of systems: 9% of the systems are based on grass, 26% are semi-intensive systems based on maize 65% are intensive systems based on maize (Figure 46).
- Systems based on grass only occur in Wallonia and were estimated inexistent in Flanders, where intensive systems are more common.
- The national production, which is rather well balanced between Flanders and Wallonia, amounts to 1275 kt of fresh liquid products, while 302 kt are imported and 635 kt are exported. As a result, the production level is about 35% higher than the net utilisation in the country (Table 2).
- More extensive systems tend to have higher GHG and N emissions per L of milk but they contribute less overall compared to more intensive systems (Table 55, Figure 47 and Figure 48).
- In terms of animal welfare and biodiversity, more extensive systems tend to perform better (the Grass Extensive system has the best scores for both measures).

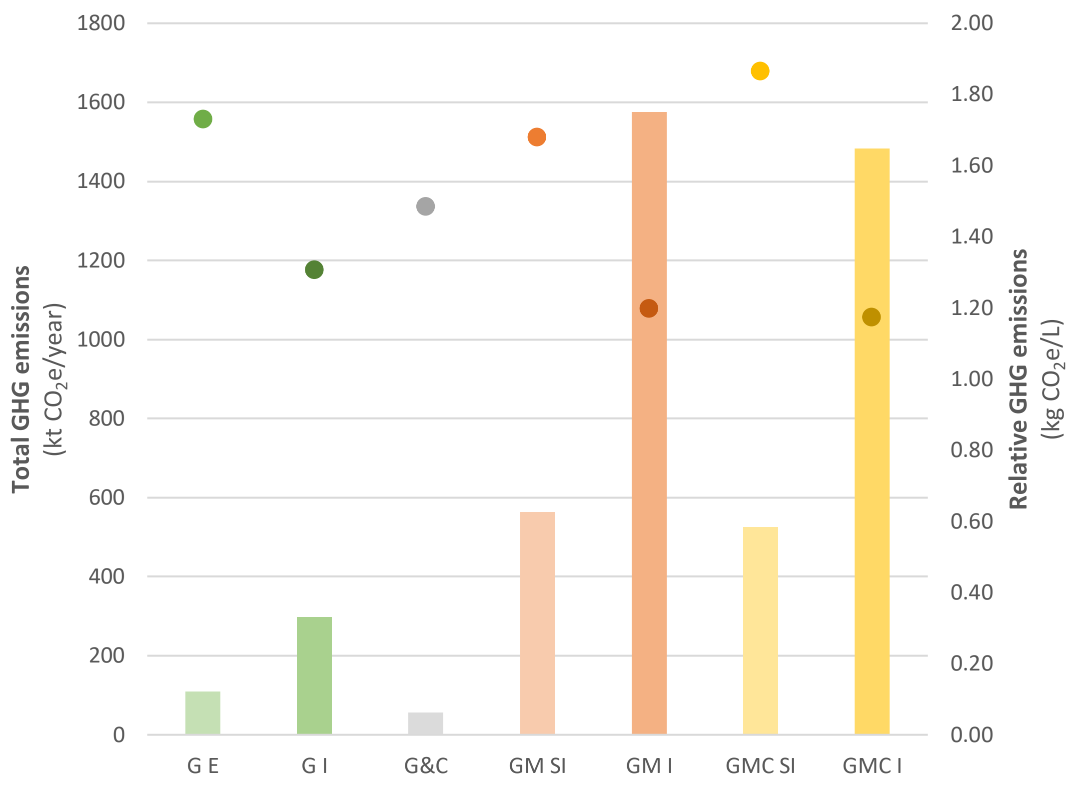

Figure 47. Contribution of milk production systems to total and relative GHG emissions.

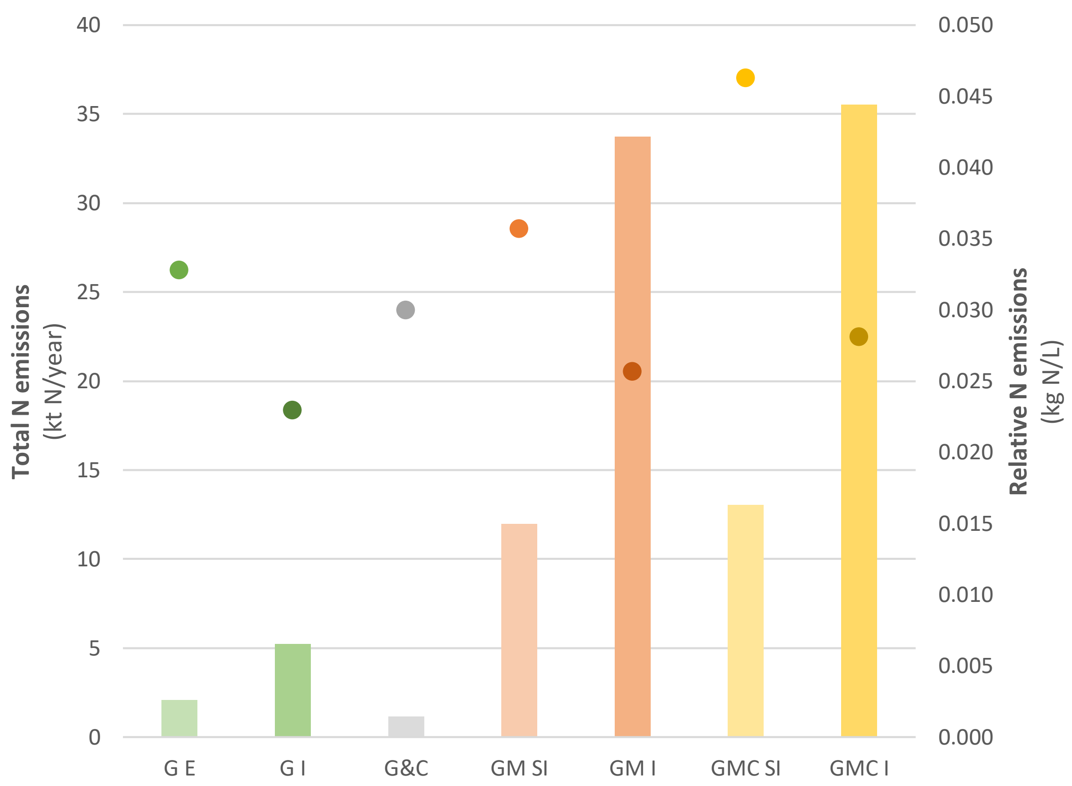

Figure 48. Contribution of milk production systems to total and relative N emissions.

Chapter 7. Bovine meat production in Belgium

7.1. The bovine meat sector

7.1.1. Farming systems and herd movements

The production of bovine meat can be achieved through three main farming systems:

(1) Specialised breeders hold suckler cows and focus on the production of young bulls. They keep female calves to breed them as heifers and suckler cows to renew their herd but they sell their male calves after 8-10 months.

(2) Specialised fatteners focus exclusively on fattening young bulls, which they buy from specialised breeders. They can also fatten dairy cows and suckler cows which have reached the end of their cycle (called cull cows). Certain fatteners also focus on the production of veal meat, which comes mainly from the male calves from the dairy sector.

(3) Closed systems perform both the breeding and fattening steps.

The organisation of the bovine meat sector is thus complex and involves several herd movements. On the one hand, male calves can undergo several paths. In most cases, they are reared as bulls for beef production until they are slaughtered after about 20 months (the slaughtering time can vary across farms and production systems). As explained above, this can happen on the same farm or they can be sold to specialised fatteners. Some male calves can also be sold for veal production (similarly to male calves from the dairy sector), although this is less common. Finally, male calves can also be reared as breeding bulls. Female calves on the other hand are in most cases used to replace older suckler cows and renew the herd. Nevertheless, some can also go into veal production or beef production. Finally, at the end of their cycle, suckler cows are also sold to be slaughtered for meat production as cull cows.

7.1.2. Animal, farm and production numbers

In 2015 there were 393.595 suckler cows in production in Belgium, of which 240.233 (61% of Belgian total) were located in Wallonia and 153.268 (39% of Belgian total) were located in Flanders (Statistics Belgium, 2016b). These numbers show that, in terms of suckler cows, there is thus a certain sectoral concentration in the Walloon region (as shown on the left-hand map of Figure 49).

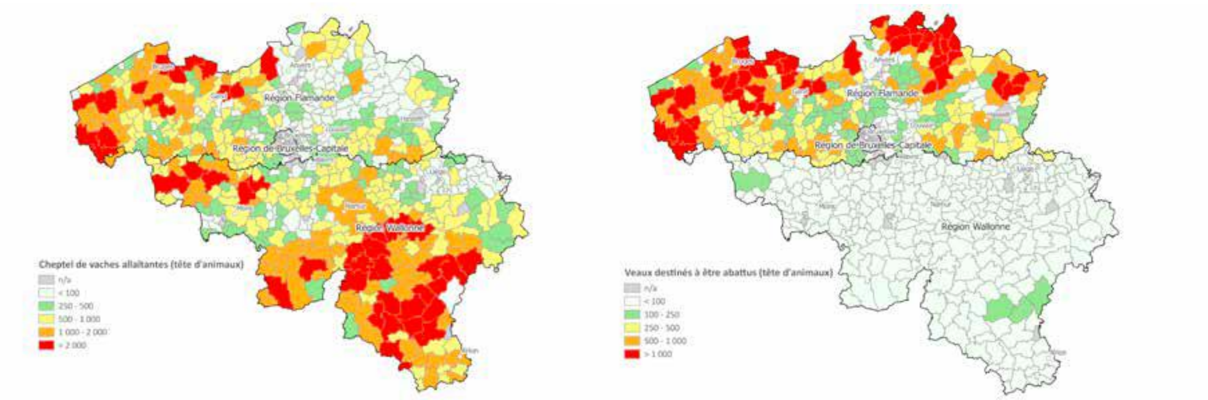

Figure 49. Geographical distribution of suckler cows (left) and veal calves (right) in Belgium in 2014 (in number of suckler cows and veal calves per municipality) (SOGEPA, 2014).

Nevertheless, given the several herd movements explained above, this regional concentration of suckler cows in Wallonia does not necessarily imply that the entire sector is more concentrated in this region. As a matter of fact, the right-hand map of Figure 49 shows that the production of veal meat for example is almost exclusively concentrated in Flanders (three integrators in Flanders concentrate the vast majority of veal calves slaughters in Belgium (Actor interviews, 2018)). In fact, each region of the country progressively tended to specialise in one activity : Wallonia, tends to focus on breeding whereas the fattening tends to happen in Flanders (SOGEPA, 2014).

In terms of farm numbers, there were 15.368 farms with suckler cows in Belgium in 2015, of which 8.224 (54%) were located in Flanders and 7.116 (46%) were located in Wallonia. On average, there were 25,6 suckler cows per farm with suckler cows in Belgium in 2015. This number was higher in Wallonia (33,8) than in Flanders (18,6) (Statistics Belgium, 2016b). These numbers include specialised breeders as well as closed systems but also farms which hold both suckler and dairy cows (mixed farms). The number of farms which hold only suckler cows (breeders + closed farms) can be estimated by subtracting the number of farms with dairy cows from the total number of farms with cows and hence also determine how many farms hold both types of cows. As such, 7.342 farms held only suckler cows in Belgium in 2015 and 8.026 farms were mixed and held both dairy and suckler cows (Hubrecht, 2018). The number of veal calf farms was in 2012 (last available data) of 1.653, of which 1.308 (79%) were located in Flanders. Finally, the number of specialised fatteners in 2015 was estimated to be 811 in 2012 (last available data), of which 729 (90%) were located in Flanders (Hubrecht, 2018).

In terms of production, 872.548 bovine animals were slaughtered in Belgium in 2015, resulting in the production of 267.877.455 kg of bovine meat (in carcass weight). Of these animals, 78% were slaughtered in Flanders and 22% in Wallonia. 41% of slaughtered animals were veal calves (although they contributed to 21% of meat production); 38% of slaughtered animals were cows (which contributed to 47% of meat production) and 19% of slaughters were young bulls (which contributed to 30% of meat production) (Statistics Belgium, 2016b). Table 59 below provides a summary of all key numbers.

7.1.3. Scope and approach of the study

The following sections aim at characterising the existing practices for both the breeding and fattening activities. Breeding activities were evaluated based on a typology established for the Walloon region (Petel et al., 2018), and assessed in Flanders through actor interviews and collective focus groups. For the fattening activities, given the differentiation of the sector between Wallonia and Flanders explained above, the scope for the characterisation will primarily be Flanders. The results for Flanders are then be extrapolated to Wallonia and whole Belgium based on the shares of young bull slaughters which occur in both regions of the country. In this regard, based on actor interviews, it was estimated that about two thirds (67%) of young bull slaughters occur in Flanders (Actor interviews, 2018).

Table 59. Summary of key numbers in the Belgian bovine meat sector in 2015.

	Belgium	Flanders	Wallonia
Animal numbers			
Suckler cows [1]	393.595	153.268	240.233
Veal calves [1]	163.837	157.300	6.537
Farm numbers			
Farms w/ suckler cows (All) [1]	15.368	8.244	7.116
Farms w/ suckler cows (only) [2]	7.342	4.282	3.056
Farms w/ veal calves [1]	1.653	1.308	345
Specialised fatteners [2]	811	729	82
Farm size			
Suckler cows/farm w/ suckler cows [1]	25,6	18,6	33,8
Production			
Slaughters (animal numbers) [1]	872.548	680.780	191.768
Slaughters (kg carcass weight) [1]	267.877.455	209.003.532	58.873.923

Sources: [1] (Statistics Belgium, 2016b); [2] (Hubrecht, 2018) *based on* (Statistics Belgium, 2016b)

7.2. Characterisation of breeding systems in the bovine meat sector (Wallonia)

7.2.1. Typology of production systems

The typology of breeding systems which follows is a typology proposed in the context of a similar study, performed at the scale of the Walloon region and which can thus be applied in the context of this study (Petel et al., 2018).

The typology is based on a statistical dataset and built on three differentiation criteria:

- The **breed**. Here it is possible to distinguish farmers who work with the Belgian Blue (BB) breed and farmers who work with a French breed (Blonde d'Aquitaine, Charolaise or Limousine).
- The **stocking rate (SR),** expressed in Livestock units (LU) per hectare of area dedicated to the production of feed for the cattle. It gives a measure of the intensity level of the activity. Three levels are distinguished: Intensive if SR > 3; Semi-intensive if 2 < SR < 3; Extensive if SR < 2.
- The presence or absence of **maize silage**.

Applying this differentiation criteria to the dataset (of 59 specialised bovine meat farms), some systems were left behind because not present in the dataset. Six production systems were identified:

- Extensive BB with maize (BB E M);
- Extensive BB without maize (with grass) (BB E G);
- Semi-intensive BB with maize (BB SI M);
- Semi-intensive BB without maize (with grass) (BB SI G);
- Extensive Fr with maize (FR E M);
- Extensive Fr without maize (with grass) (FR E G).

The table below provides an overview of the main characteristics of each system, i.e. productivity levels and concentrates use. The productivity is expressed in terms of kg of live weight produced annually, per suckler cow and her progeny (SC&P) over the entire farm (it gives an indication of the net gain in live weight on the farm). The same applies to the use of concentrates, which is expressed in kg of concentrate per suckler cow and her progeny per year.

Table 60. Productivity and use of concentrates of each breeding system (in kg per suckler cow per year).

	Productivity kg weight gain /SC&P/yr	**Total Concentrates** kg/SC/year	**Cereals** kg/SC/year	**Protein-rich** kg/SC/year	**Coproducts** kg/SC/year
BB		**850**	**403**	**32**	**415**
Extensive		774	409	26	339
Grass	357	693	342	25	326
Maize	430	861	481	27	353
Intensive		636	191	32	413
Grass	431	1.151	393	54	704
Maize	438	1.095	421	48	626
FR		**400**	**179**	**70**	**151**
Extensive		400	179	70	151
Grass	373	392	149	90	154
Maize	363	421	268	11	142

Source: (Petel et al., 2018).

7.2.2. Shares of production systems

When assessed over the entire Walloon Region, systems based on French breeds are estimated to represent 20% of total suckler cows (10% each). The most common system is the intensive Belgian blue with maize (24%), followed by the extensive Belgian blue with grass (20%). Extensive Belgian blue systems based on maize and intensive Belgian blue systems based on grass represent 19% and 18% respectively (Petel et al., 2018). In Flanders, according to the actors from the sector, there are no systems without maize (Actor interviews, 2018). The three remaining systems are distributed as follows: a vast majority of intensive BB systems, and a minority of extensive systems (either with BB or French breeds, mainly Blonde d'Aquitaine in Flanders) (Figure 50).

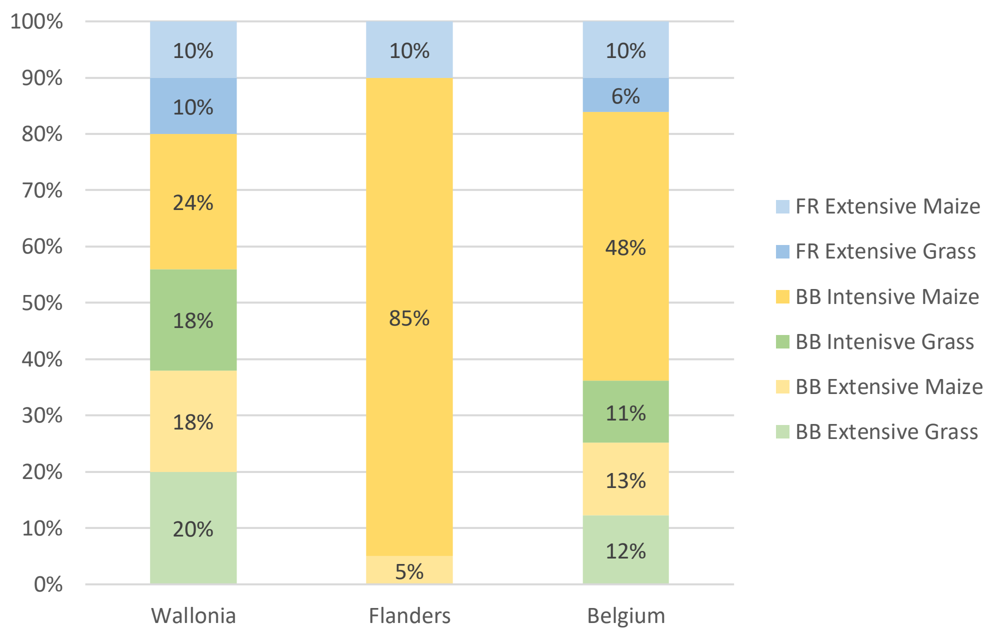

Figure 50. Shares of breeding systems in Wallonia, Flanders and Belgium (in numbers of suckler cows).
Source: (Petel et al., 2018) for Wallonia.; (Actor interviews, 2018) for Flanders.

7.2.3. Environmental impacts

(a) Feed

Table 61 and Table 62 show the forage and concentrates consumption of different breeding models in Wallonia, Flanders and Belgium. For forage consumption, the data was expressed in ha initially. The surface numbers were transformed in quantities through crop yields (see Table 164 in the Appendix). Regarding the consumption of concentrates, the initial data is subdivided three categories of ingredients: cereals, proteaginous ingredients and coproducts. The further composition of the coproducts category was estimated through (ERM and Universiteit Gent, 2011) (see table in Appendix 10 for the exact composition).

- *Forage*

Table 61. Forage consumption of the bovine meat breeding sector in Wallonia, Flanders and Belgium.

Production system	Permanent pasture	Temporary pasture	Forage maize	Other forages	TOTAL	TOTAL WAL	TOTAL FL	TOTAL BE
	kg/SC&P/year					kt/year	kt/year	Kt/year
BB Ext Grass	8.190	1.600	0	50	**9.840**	473	0	473
BB Ext Maize	6.230	400	4.116	50	**10.796**	467	83	550
BB Int Grass	4.340	800	0	50	**5.190**	224	0	224
BB Int Maize	3.570	700	4.573	151	**8.993**	519	1.172	1.690
FR Ext Grass	10.150	500	0	401	**11.051**	265	0	265
FR Ext Maize	5.810	300	3.658	151	**9.919**	238	152	390
TOTAL						2.186	1.406	3.593

Source: (Petel et al., 2018). See Table 164 for the yields of several forage crops.

- *Concentrates*

Table 62. Concentrates consumption of the bovine meat breeding sector in Wallonia, Flanders and Belgium.

Production system	Cereals	Proteaginous	Coproducts	TOTAL	TOTAL WAL	TOTAL FL	TOTAL BE
	kg/SC&P/year				kt/year		
BB Extensive Grass	342	25	326	**693**	33	0	33
BB Extensive Maize	481	27	353	**861**	37	7	44
BB Intensive Grass	393	54	704	**1.151**	50	0	50
BB Intensive Maize	421	48	626	**1.095**	63	143	206
FR Extensive Grass	149	90	154	**392**	9	0	9
FR Extensive Maize	268	11	142	**421**	10	6	17
TOTAL					203	156	359

Source: (Petel et al., 2018).

(b) GHG emissions

Table 63 provides an overview of the GHG emissions for different breeding systems in Wallonia as well as the regional and Belgian totals.

Table 63. GHG emissions of the bovine meat breeding sector in Wallonia, Flanders and Belgium.

Production system	Relative GHG emissions		TOTAL WAL	TOTAL FL	TOTAL BE
	kg CO_2e/kg live weight	kg CO_2e/ SC&P/year	kt CO_2e/year	kt CO_2e/year	kt CO_2e/year
BB Extensive Grass	20,4	7.292	350	0	350
BB Extensive Maize	16,7	7.200	311	55	366
BB Intensive Grass	15,0	6.456	279	0	279
BB Intensive Maize	15,6	6.851	395	893	1288
FR Extensive Grass	20,3	7.564	182	0	182
FR Extensive Maize	18,6	6.748	162	103	266
TOTAL			1.680	1.051	2.731
- *Forage related*			285	159	444
- *Concentrates related*[a]			130	98	228
- *Enteric fermentation*			994	634	1.628
- *Manure management*			271	160	431
Average		*6.992*			

Note: [a] Includes LUC for soy.

(c) N emissions

Table 64 shows the N emissions of different breeding systems in Wallonia, Flanders and Belgium.

Table 64. N emissions of the bovine meat breeding sector in Wallonia, Flanders and Belgium.

Production system	N intake	N retained	N excretion (relative)		TOTAL WAL	TOTAL FL	TOTAL BE
	kg N/kg live weight/year	kg N/kg live weight/year	kg N/ SC&P/year	kg N/ kg live weight	kt N/year	kt N/year	kt N/year
BB Extensive Grass	265	24	241	0,7	12	0	12
BB Extensive Maize	243	22	221	0,5	10	2	11
BB Intensive Grass	164	15	149	0,3	6	0	6
BB Intensive Maize	202	18	183	0,4	11	24	34
FR Extensive Grass	288	26	262	0,7	6	0	6
FR Extensive Maize	215	19	195	0,5	5	3	8
TOTAL					49	29	78
Average			*205*				

7.2.4. Animal welfare considerations of the bovine meat breeding sector

Confronting each production system to the CIWF animal welfare criteria (Table 160 in the appendix), it is possible to carry out a qualitative animal welfare assessment of bovine meat breeding systems (orange corresponding to inadequate practices on animal welfare terms, yellow to intermediate practices and green to adequate practices). All BB systems perform poorly in terms of birth-giving given that the Belgian Blue is a double-muscle breed implying the use of caesareans (Table 65).

Table 65. Animal welfare assessment for the bovine meat breeding sector.

	Housing	Feed	Birth-giving	Overall score
BB Extensive Grass	3	3	1	●
BB Extensive Maize	3	3	1	●
BB Intensive Grass	3	2	1	●
BB Intensive Maize	3	2	1	●
FR Extensive Grass	3	3	3	●
FR Extensive Maize	3	3	3	●

Note: The criteria and ranking methodology are detailed in Chapter 1. The number (1-3) indicates the consistency of the production system with the considered category (housing, mutilation or birth-giving); 1 indicates low consistency, 3 indicates high consistency.

7.2.5. Biodiversity impacts of the breeding sector

Using the methodology proposed by De Schryver et al. (2010) and the values from Table 162, we find the biodiversity impacts of each broiler production system (Table 67). Here more extensive systems, tend to have lower impacts when expressed per dairy cow and progeny. When expressed per litre of milk, the situation with more intensive systems is less contrasted as the latter are more productive. The least impactful system is the Grass Extensive one, which is often associated to organic systems.

Table 66. Biodiversity impacts of the bovine meat breeding sector.

Production system	Damage Score (DS)	
	DC&P/year	TOTAL
BB Extensive Grass	7,3	351.868
BB Extensive Maize	6,3	319.475
BB Intensive Grass	8,4	363.897
BB Intensive Maize	7,8	1.467.417
FR Extensive Grass	1,1	26.135
FR Extensive Maize	5,0	198.336

7.3. Characterisation of fattening systems in the bovine meat sector (Flanders)

7.3.1. Typology of production systems

Based on the existing literature and actor interviews, a typology with three main fattening systems is proposed, based on two differentiation criteria: the breed and the fattening system.

As for the **breed**, in Flanders, the vast majority of cows are of the Belgian Blue breed. Another breed which can be found, but to a much lesser extent is the Blonde d'Aquitaine. As an illustration, in 2011 (last available data), there were 202.887 Belgian blue cows in Flanders, which were followed in terms of animal population by the Blonde d'Aquitaine breed with only 6.634 cows (Statistics Belgium, 2012).

In terms of **fattening system**, two main systems are identified. The fattening step comprises two phases. First, the *growing phase*, which can have a varying duration, aims at increasing the muscular mass of the animal. Following this, the final *finishing phase*, which is shorter and lasts about three months, aims at the deposition of fat in the meat. Because of the different objectives of each phase but also of the evolution of the physiological state of the animal, the feed consumption and composition will be different during the growing and the finishing stage.

On the one hand, it is possible to distinguish an *intensive* fattening system, which will incorporate more concentrates in the feed during the growing phase already. On the other hand, a more extensive (*semi-extensive*) system will rely more on forage feed during the growing phase and wait until the finishing phase before incorporating more concentrates. In this extensive system, the growing phase will last longer and the final weight will also be higher. In the intensive system, animals are thus fattened more quickly. In both cases, the finishing phase lasts about 3-4 months. In the extensive system, animals will grow at higher rate during this phase, during which the share of concentrates in the feed increases, whereas animals from the intensive system will have achieved more important growth rates during the growing phase.

Table 67 provides an overview of the specifications of the existing fattening systems in Flanders, based on references such as Fiems et al. (2002), Hubrecht et al., (2013), Rabeux and Elias (2015) and Petel et al. (2018).

Table 67. Characteristics of fattening systems in Flanders.

Production system	Share in Flanders [1]	Starting weight	Starting age	Final age	Duration	Final weight	Total gain	Daily gain	FCR
	%	kg	months	months	days	kg	kg	kg/ day	kg feed/kg gain
BB Intensive	70%	300	10	18	240	665	365	1,4	6,2
BB semi-intensive	20%	300	10	22	360	725	425	1,2	7,8
FR Semi-intensive	10%	300	10	22	360	750	450	1,2	8,4

Sources: [1] Estimated based on actor interviews (2018).

7.3.2. Shares of production systems

As shown on Table 67, according to experts from the sector, the Belgian Blue intensive system is the most common one. For this breed, semi-intensive systems are much less common but for French breeds, fattening appears to follow the semi-intensive approach.

7.3.3. Environmental impacts

(a) Feed

Table 68 and Table 69 show the feed compositions and feed consumption of the different fattening systems. In Table 68, a distinction is made between the initial growing phase and the final fattening phase for the two Belgian Blue systems. When looking at the entire sector, the total consumption of concentrates accounts to 199 kt/year in Flanders and 331 kt/year in Belgium (based on the assumption that 67% of bulls are fattened in Flanders).

Table 68. Feed compositions of fattening systems in Flanders per growing phase (per kg weight gain).

Production system & growing phase	Composition (%)							
	Forage (maize)	Forage (grass)	Cereals	Cereals coproducts	Beet root pulp	Protea-ginous	Protein rich *	Others
Growing - BB Intensive [1]	18%	-	9%	23%	20%	0%	26%	3%
Growing - BB Semi-extensive [1]	52%	-	7%	3%	9%	0%	26%	2%
Finishing (both BB)[1]	0%	-	16%	25%	29%	4%	23%	3%
FR semi-intensive [2]	60%	7%	18%	-	-	-	13%	2%

Sources: [1] (Rabeux and Elias, 2015); [2](Bastien et al., 2011).

Notes: * 50% of the protein-rich feed is considered to be soybean meal in BB systems (i.e. 13% of total). In French breed systems, 100% of the protein-rich feed is considered to be soybean meal (13% of total). The share of soybean meal is thus the same in BB and FR systems.

Table 69. Total feed consumption of fattening systems in Flanders (per kg weight gain).

Production system	Consumption (kg feed/kg gain)								
	Forage (maize)	Forage (grass)	Cereals	Cereals	Beet root pulp	Protea-ginous	Protein rich	Others	**TOTAL**
BB Intensive	0,6	0	0,8	1,5	1,5	0,1	1,5	0,2	**6,2**
BB semi-intensive	2,7	0	0,8	0,8	1,2	0,1	2,0	0,2	**7,8**
FR Semi-intensive	5,0	0,6	1,5	0,0	0,0	0,0	1,1	0,2	**8,4**

(b) GHG emissions

Table 70. GHG emissions of fattening systems in Flanders and Belgium.

Production system	**Relative GHG emissions**		**TOTAL FL**	**TOTAL BE**
	kg CO_2e/kg gain	**kg CO_2e/animal**	**kt CO_2e/year**	**kt CO_2e/year**
BB Intensive	7,6	2.792	217	-
BB Semi-intensive	9,2	3.909	87	-
FR Semi-intensive	8,6	3.851	43	-
TOTAL			**347**	**521**
- *Feed-related* [a]			*212*	*319*
- *Enteric fermentation*			*102*	*154*
- *Manure management*			*32*	*48*

Note: Includes LUC for soy.

(c) N emissions

Table 71. N emissions of fattening systems in Flanders and Belgium.

Production system	N intake	N retained	N emissions		TOTAL FL	TOTAL BE
	kg N/kg gain	kg N/kg gain	kg N/kg gain	kg N/animal	kt N/year	kt N/year
BB Intensive	0,19	0,02	0,17	62	4,8	-
BB Semi-intensive	0,22	0,02	0,20	86	1,9	-
FR Semi-intensive	0,18	0,02	0,17	75	0,8	-
TOTAL					7,6	11,3

7.3.4. Animal welfare considerations of the bovine meat fattening sector

Confronting each production system to the CIWF animal welfare criteria (Table 160 in the appendix), it is possible to carry out a qualitative animal welfare assessment of bovine meat breeding systems (orange corresponding to inadequate practices on animal welfare terms, yellow to intermediate practices and green to adequate practices). Both BB systems perform poorly in terms of birth-giving given that the Belgian Blue is a double-muscle breed implying the use of caesareans. In terms of feeding, the intensive strategy performs worse than the semi-intensive one given that the latter includes forage in the initial feeding phase (Table 72).

Table 72. Animal welfare assessment for the bovine meat fattening sector.

	Housing	Feed	Birth-giving	Overall score
BB Intensive	2	1	1	●
BB Semi-intensive	2	2	1	●
FR Semi-intensive	2	2	3	●

Note: The criteria and ranking methodology are detailed in Chapter 1. The number (1-3) indicates the consistency of the production system with the considered category (housing, mutilation or birth-giving); 1 indicates low consistency, 3 indicates high consistency.

7.3.5. Biodiversity impacts of the bovine meat fattening sector

Using the methodology proposed by De Schryver et al. (2010) and the values from Table 162, we find the biodiversity impacts of each bull fattening system (Table 73). The BB semi-intensive system is associated with the highest impact due to its higher FCR. The FR semi-intensive system which is associated with organic systems presents an intermediate situation.

Table 73. Biodiversity impacts of the bovine meat breeding sector.

Production system	Damage Score (DS)		
	DS/animal/year	TOTAL FL	TOTAL BE
BB Intensive	2,71	210.944	-
BB semi-intensive	3,45	76.703	-
FR Semi-intensive	2,76	30.698	-
TOTAL	-	318.345	477.518

7.4. Conclusions of chapter 7

- The bovine meat sector is characterized by a regional specialisation. As a result, the breeding sector was analysed departing from typology established for Wallonia whereas the fattening step was analysed in Flanders.
- Suckler cow breeding systems in Wallonia are quite diverse: 20% of systems are extensive systems with French breeds, 38% are systems with Belgian blue breed based on grass, and 43% are systems with Belgian blue breed based on maize (Figure 50).
- The fattening of young bulls happens most often intensively with BB animals (70% of total bull slaughters). Less intensive strategies are less frequent and can be applied with both BB and French breeds (30% of total bull slaughters)
- The national production amounts to 261 kt of bovine meat, while 86 kt are imported and 182 kt are exported. As a result, the production level is about 60% higher than the net utilisation in the country (Table 2).
- More extensive systems tend to have higher GHG and N emissions per kg of meat but they contribute less overall given their smaller hares (Table 63, Table 70 and Figure 51 and Figure 54).
- In terms of animal welfare and biodiversity, more extensive systems (in particular the ones based on French breeds) tend to perform better.

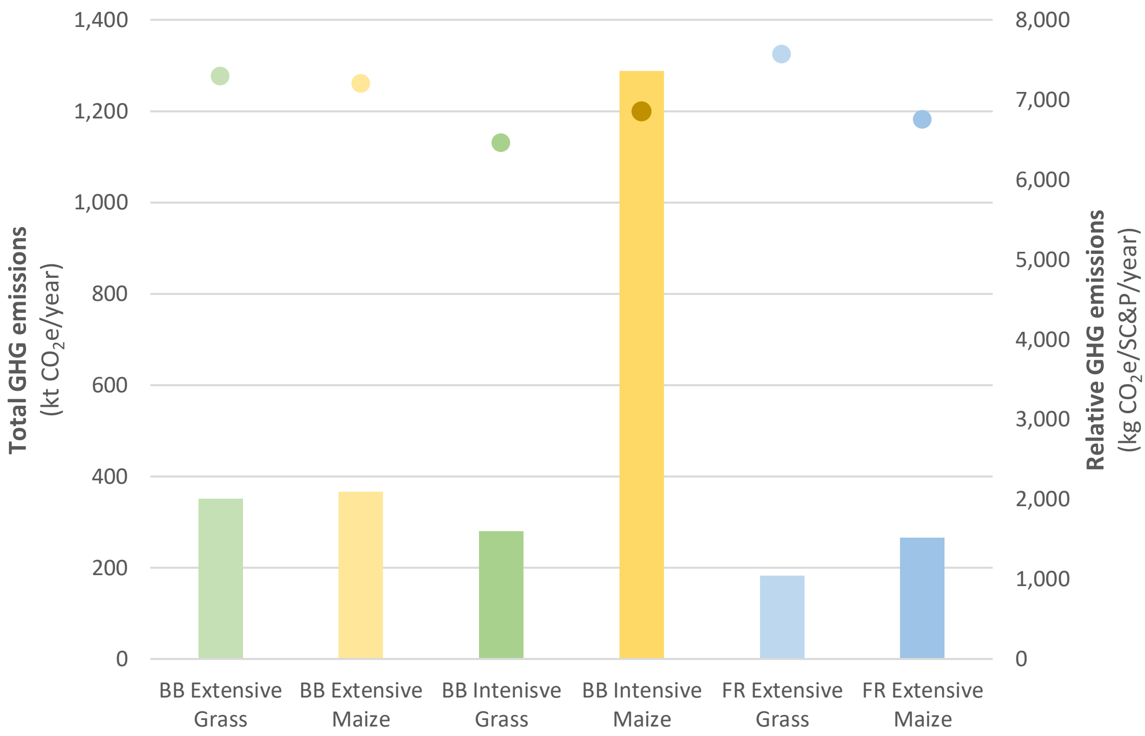

Figure 51. Contribution of bovine breeding systems to total and relative GHG emissions.

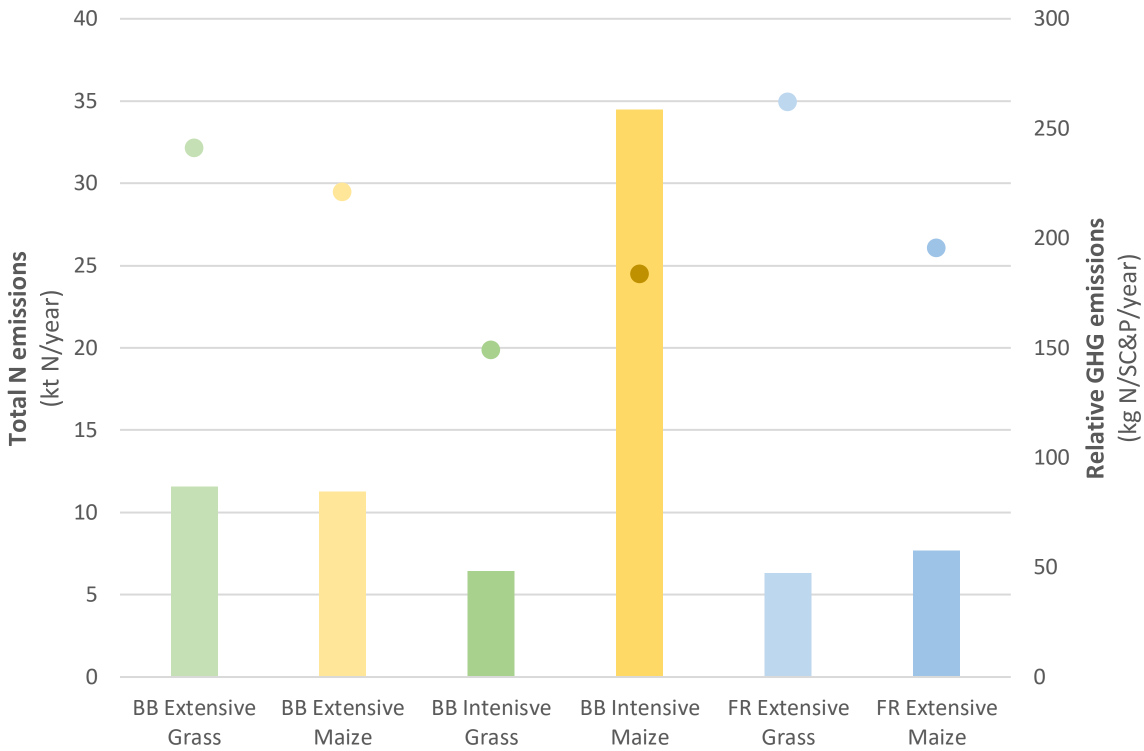

Figure 52. Contribution of bovine breeding systems to total and relative GHG emissions.

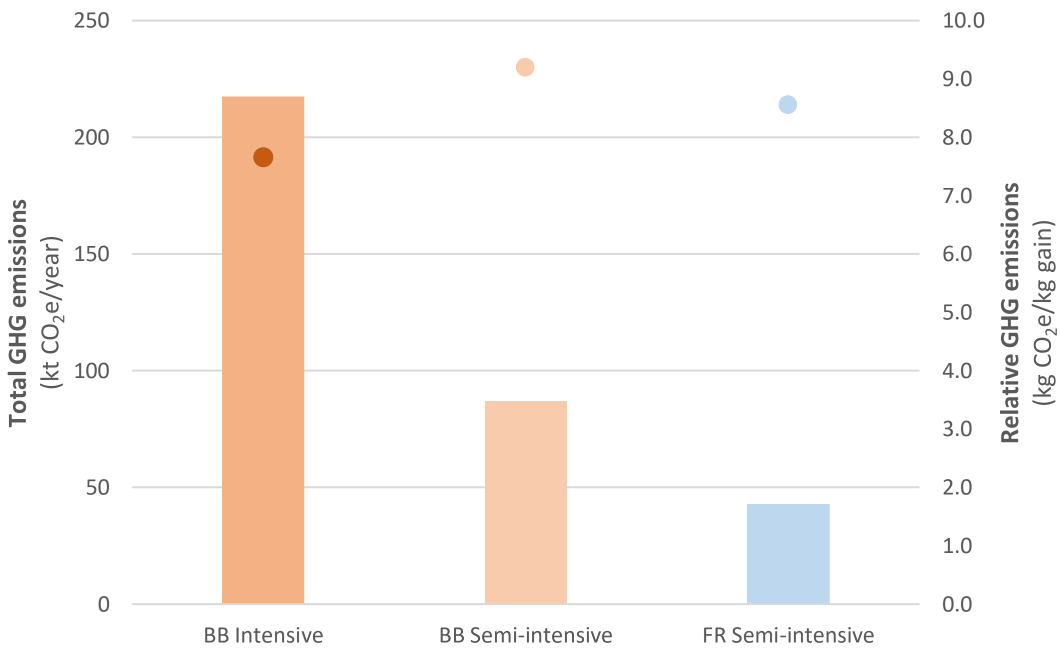

Figure 53. Contribution of bovine fattening systems to total and relative GHG emissions.

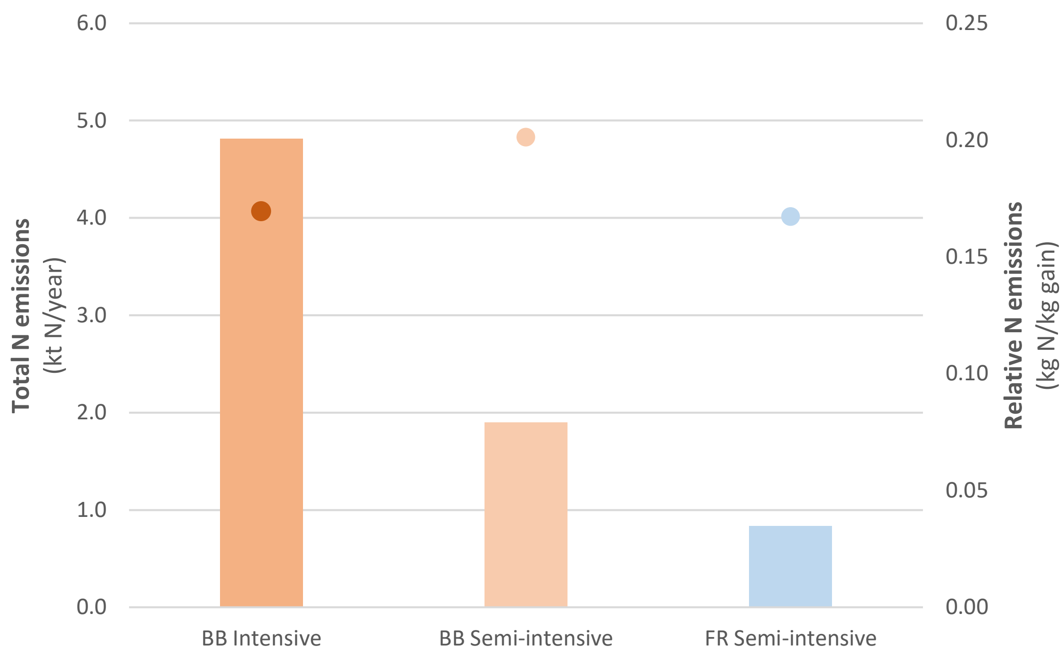

Figure 54. Contribution of bovine fattening systems to total and relative N emissions.

Chapter 8. Synthesis of the current situation: production and impacts

This chapter synthesises the results from the previous chapters in terms of production, consumption and environmental impacts. The analysis is first carried out at the level of the entire livestock sector, comparing and aggregating the contributions of each sector (sections 8.1 to 8.4). Section 8.5 provides a more detailed, sector-specific analysis and allows for the comparison of production systems.

8.1. Production and consumption of meat and animal products in 2015

Summing the results found previously for each sector, the production of pork, poultry and bovine meat available for consumption amounted 181 g meat/cap/day in 2015 (Table 74)[17]. The production was partly consumed nationally and exported. Based on the self-sufficiency ratios (see Table 2 in Chapter 3) the actual consumption of pork, poultry and bovine meat can be estimated to 87g meat/cap/day (amount available when slaughter, carcass and waste factors are taken into account ; see Table 74).

The total production of proteins from all five animal products amounted 74 g prot/cap/day (Table 74). Based on the self-sufficiency ratios, the average intake of animal-based protein sources in Belgium was of 43 g protein/cap/day.

Table 74. Production and consumption of meat and animal products in 2015 estimated in this study.

Production	Unit	Production	Consumption [a]
Pork	kt carcass	1.037	175
Poultry	kt carcass	261	90
Eggs	kt egg	164	113
Milk	mo L milk	3.527	1.965
Bovine meat	kt carcass	268	89
Total meat (pork, poultry and bovine meat)	g meat/cap/day	181	**87**
Total for all five animal products [b]	g prot/cap/day	74	**43**

Note:

[a] Consumption levels are here estimated based on production level and self-sufficiency ratios (the share of the production which is actually consumed in Belgium), a carcass yield for the meat products (pork, poultry and bovine meat) and a waste factor (see Table 2 and Table 3 in Chapter 3).

[b] See Table 169 in the Appendix for the average protein content of each animal product.

8.2. Feed: Consumption of cereals by the livestock sector

This section has the following objectives:

- To estimate the total consumption of cereals by the Belgian livestock sector;
- To estimate the share of the Belgian cereals production which is used for animal feed[18];
- To estimate the share of Belgian livestock sector's cereal consumption which is covered by the national cereals production.

[17] This is the amount available when slaughter and carcass yields and a waste factor are taken into account (see Table 3).

[18] No specific data could be found for other ingredient types such as protein sources, etc.

8.2.1. *Total consumption by the Belgian livestock sector*

Based on the feeding practices which were described in previous chapters (Chapter 4 to Chapter 7), Table 75 presents the total cereal consumption levels of the different livestock sectors in 2015. In total, 3.713 kt of cereals are consumed every year by the studied sectors. In the current situation, the pork sector is by far the biggest consumer of cereals (more than 70% of total cereals consumed).

Table 75. Estimated cereals consumption of different livestock sectors in Belgium in 2015.

Livestock sector	**Cereals intake (kt/year)**				
	Wheat/triticale	Maize	Barley	TOTAL CEREALS	% of total
Pork (productive animals)	1.082	526	712	**2.321**	63%
Pork (reproductive animals)	163	80	108	**350**	9%
Broilers	309	99	0	**408**	11%
Laying hens	84	150	0	**234**	6%
Other poultry	42	76	0	**118**	3%
Dairy	75	0	0	**75**	2%
Suckler cows	151	0	0	**151**	4%
Young bulls	55	0	0	**55**	1%
Total intake	1.961	932	820	**3.713**	100%

Source: Results of this study. This table does not include cereal co-products, which can be used either as protein sources or as cereal equivalents.

8.2.2. *Total cereals area and production and share used for animal feed*

The total cereals production at the Belgian level occupied 341.638 ha and amounted 3.283 kt in 2015 (Table 76 and Table 196), but the entirety of the cereals production is not destined for feed purposes.

In Wallonia, it was estimated that the share of cereal production destined for feed is 46% (Antier et al., 2017). For all Belgium, this percentage is estimated to rise to 62% of the total cereal production [19]. The share is thus higher in Flanders than in Wallonia, which can be explained by the fact that the majority of the grain maize production is concentrated in Flanders, of which 90% of the production is used as animal feed. For other cereals, the share amounts 55%. As a result, the estimated Belgian cereal production used for animal feed amounted to 2.048 kt in 2015.

Compared to the total consumption mentioned above (3.713 kt), this means that the national production of cereals covers 55% of the total cereal intake by the livestock sector (Table 77). Under such conditions, 45% of the cereal needs for animal feed must thus be imported.

[19] This is based on information from actor interviews according to which 90% of the Belgian production of grain maize and 55% of the production of the remaining cereals are destined for animal feed. The total share of Belgian cereals destined for animal feed is thus estimated at 62%. The remaining 38% of the cereals production can be destined for export, human consumption, energy purposes, etc. These remaining 38% are enough to cover the cereal needs of the Belgian population for food. Indeed, in 2015, these needs were met with 35% of the total production. In 2050, taking into account the predicted population growth and considering constant production levels and per capita cereal consumption, 40% of the total cereal production would be sufficient to cover the population’s cereal needs for food (Antier et al., 2017).

Table 76. Cereals area and production in Belgium in 2015 and share destined for animal feed.

Cereal type	Area [2]	Average yield [1]	Production [2]	Estimated use for feed [3]
	ha	t/ha	t	%
Winter wheat	198.626	9,1	1.909.701	55%
Spring wheat	3.143	6,2	19.243	55%
Spelt	20.011	7,3	147.318	55%
Rye	563	5,0	2.562	55%
Winter barley	44.213	8,6	410.290	55%
Spring barley	3.898	5,6	22.148	55%
Malting barley	266	6,4	1.704	0%
Oat (+ mixes of summer cereals)	3.935	5,7	22.210	55%
Triticale	5.551	6,9	40.627	55%
Grain maize	58.397	11,7	692.956	90%
Other cereals	3.035	4,5	13.780	55%
TOTAL cereals production (kt)	341.638	-	3.283	-
Estimated cereals used for feed (kt/year)	-	-	2.048	62%

Source: [1] Average Belgian yields over the period 2011-2015 (Statistics Belgium, 2016b); [2] (Statistics Belgium, 2016a) ; [3] (Actor interviews, 2018).

Table 77. Self-sufficiency of cereals for the Belgian livestock sector in 2015.

Parameter	Unit	Amount
Belgian cereals production	Kt/year	3.283
Belgian cereals production used for livestock feed	% of total production	62%
	Kt/year	2.048
Total consumption of cereals by the livestock sector (animal feed)	Kt/year	3.713
Self-sufficiency of cereals for livestock feed in Belgium	%	55%

8.3. Feed: Total consumption

8.3.1. Results from this study

Whereas the previous section focused specifically on the consumption of cereals, this section now considers the entire consumption of concentrates (i.e. non-forage feed) by the Belgian livestock sector (pork, poultry and bovine sectors). Appendix 12 specifically focuses on soybean meal.

Based on the feeding practices described in earlier chapters, it appears that the total consumption of concentrates by the pork, poultry and bovine sectors amounted 6.740 kt of feed in 2015 (Table 78), of which 3.901 of cereals and other energy-rich ingredients[20] (3.717 kt of cereals as presented in Section 8.2 and 189 kt of energy-rich ingredients) ; 2.233 kt of protein sources (1.688 kt of protein-rich ingredients and 564 kt of oleaginous and proteaginous ingredients) and 606 kt of other ingredients (yeast, minerals, etc.). Overall, 61% of the feed is consumed by the pork sector (4.100 kt), 17% by the poultry sectors (1.146 kt) and 22% by the bovine sectors (1.495 kt).

[20] Other energy-rich ingredients include beetroot pulp and 50% of cereals co-products (the other 50% are used as protein sources) (Actor interviews, 2018).

Table 78. Feed (concentrates) consumption of the different livestock sectors in 2015 according to this study (in kt/year).

Sector	Cereals				Other energy-rich[1]	Olea/protea -ginous	Protein-rich feed				Others (yeast, vit, minerals)	TOTAL
	Wheat/ triticale	Maize	Barley	TOTAL			Soybean meal	Rapeseed meal	Others[2]	TOTAL		
Pork (prod. animals)	1.082	526	712	**2.321**	**0**	**432**	454	2	5	**460**	**348**	**3.561**
Pork (reprod. animals)	163	80	108	**350**	**0**	**65**	69	0	1	**70**	**53**	**538**
Broilers	309	99	0	**408**	**0**	**43**	126	0	0	**126**	**49**	**627**
Laying hens	84	150	0	**234**	**0**	**0**	67	0	4	**71**	**41**	**346**
Other poultry	42	76	0	**118**	**0**	**0**	35	0	0	**35**	**21**	**173**
Dairy	75	0	0	**75**	**0**	**0**	179	126	342	**648**	**82**	**804**
Bovine meat (breeding)	151	0	0	**151**[4]	**69**	**17**	11	28	84	**122**	**0**	**359**
Bovine meat (fattening)	55	0	0	**55**[4]	**120**	**7**	54	0	83	**137**	**12**	**331**
TOTAL	1.961	932	820	**3.713**	**189**	**564**	**995**	**156**	517	**1.668**	**606**	**6.740**
- Cereals and energy-rich	-	-	-	**-**	**-**	**-**	-	-	-	**-**	**-**	*3.901*
- Protein sources[3]	-	-	-	**-**	**-**	**-**	-	-	-	**-**	**-**	*2.233*
- Others	-	-	-	**-**	**-**	**-**	-	-	-	**-**	**-**	*606*

Notes:

[1] Includes beetroot pulp and 50% of cereal co-products. The other 50% are considered as protein-rich feed (under the others category).

[2] Includes other protein-rich ingredients such as sunflower meal, 50% of cereal co-products.

[3] Includes protein-rich feed ingredients as well as oleaginous and proteaginous ingredients.

[4] For bovine meat systems, only a total cereal consumption value could be obtained, with no subdivision per cereal type. For further calculations, it was assumed that the cereals consumed by bovine meat systems correspond to wheat/triticale.

8.3.1. Data from the Belgian Feed Association (BFA)

The Belgian Feed Association (BFA) holds annual statistics on the production levels of animal feed in Belgium. This production level can be subdivided in feed types (feed ingredients) and uses (i.e. the sector of destination: pork, poultry, bovine and others). Additionally, although no specific data on import/export statistics is available, the BFA provides the two following assumptions: (a) imports and exports balance each other out, the production of animal feed can thus be considered as an estimation of the consumption of animal feed; (b) 50% of protein sources are from Belgian/EU origin (BFA, 2016).

In total, 7.180 kt of feed were consumed (produced) in Belgium in 2015 (Table 79). Of this amount, 94% (6.749 kt) were destined to the pork, poultry and bovine sectors. Grouping the different feed categories, it appears that cereals and other energy-rich ingredients represent 53% of total feed use (3.577 kt for pork, poultry and bovine), protein sources about 41% (2.767 kt) and other feed types about 6% (405 kt). As mentioned above, it is considered that 50% of protein sources, i.e. 1.384 kt, are of Belgian/EU-origin (BFA, 2016).

Focusing only on coproducts, the Belgian pork, poultry and bovine sectors used 3.442 kt of them in 2015 (Table 80). These coproducts can be grouped in cereal equivalents and protein sources, which represented 862 kt and 2.944 kt respectively. Here too, the BFA estimates that about 50% are from Belgian and EU origin, i.e. 439 kt of cereal equivalents and 1.282 kt of protein sources (BFA, 2017).

Primary information regarding BFA data is available in Appendix 12 (Figure 91 to Figure 93).

Table 79. Use of ingredients and ingredient categories by the Belgian feed industry in 2015, for all sectors as well as for the Pork, Poultry and Bovine (PPB) sectors specifically (BFA, 2016).

Ingredient	Share of total	All sectors	PPB [1]
	%	kt/year	kt/year
Ingredient			
Cereals	40%	2.872	2.700
Coproducts from oleaginous	24%	1.723	1.620
Coproducts from cereals	14%	1.005	945
Coproducts from sugar industry	6%	431	405
Minerals	4%	287	270
Oleaginous seeds	3%	215	202
Oils and fats	2%	144	135
Other ingredients [2]	7%	503	472
Feed categories			
Cereals and other energy-rich [3]	53%	3.805	3.577
Protein sources [4]	41%	2.944	2.767
Others [5]	6%	431	405
TOTAL	**100%**	**7.180**	**6.749**

Notes:

[1] According to the BFA, the share of total feed destined for the pork, poultry and bovine sectors is 94%. As no specific figures exist for each ingredient, this share was considered the same (94%) for all feed ingredients.

[2] Includes: bakery coproducts, coproducts from the biofuels industry, brewery coproducts, fruits and vegetables, animal-derived coproducts, dried fodder plants, yeast, high-fibre content products, carrots, roots and pulses, dried grains and vegetables.

[3] Includes: 'Cereals', 'Coproducts from sugar industry' and 50% of 'Coproducts from cereals'.

[4] Includes: 'Coproducts from oleaginous', 50% of 'Coproducts from cereals', 'Oleaginous seeds' and 'Other ingredients'.

[5] Includes: 'Minerals' and 'Oils and fats'.

Table 80. Use of coproducts by the Belgian feed industry in 2015, for all sectors; the pork, poultry and bovine sectors (PPB) specifically and volume from national + EU origin used by the PPB sectors (BFA, 2016).

Coproduct type	Use for all sectors	Use for PPB [1]	Estimated use for PPB from BE/EU origin [2]
	kt/year	kt/year	kt/year
Coproducts from oleaginous seeds (P)	1.723	1.620	810
Coproducts from cereals (C&P) [3]	1.005	945	472
Coproducts from sugar industry (C)	431	405	202
Other ingredients (P) [4]	503	472	236
TOTAL	**3.662**	**3.442**	**1.721**
- Of which cereal equivalents	*933*	*877*	*439*
- Of which protein sources	*2.728*	*2.565*	*1.282*

Notes:
[1] The share destined for the pork, poultry and bovine sectors is considered 94% for all feed ingredients.
[2] The share of Belgian/EU origin is estimated at 50% for all feed ingredients.
[3] (P) indicates that the coproduct category is considered as a protein source; (C) indicates that the coproduct category is considered as a cereal equivalent. For cereal coproducts, 50% are considered as cereal equivalents and 50% as protein sources according to the BFA (BFA, personal communication).
[4] 'Other ingredients' include: bakery coproducts, coproducts from the biofuels industry, brewery coproducts, fruits and vegetables, animal-derived coproducts dried fodder plants, yeast, high-fibre content products, carrots, roots and pulses, dried grains and vegetables. They are considered as protein sources.

8.4. Environmental consequences of the Belgian livestock sector in 2015

8.4.1. Total GHG emissions and 'exported' vs 'consumed' emissions

In total, the Belgian livestock sector emitted 13.920 kt CO_2e in 2015 (Table 81)[21]. The biggest contributors are the pork and dairy sectors (34% and 33% of total GHG emissions respectively), followed by the bovine meat sector (23%), and by both poultry sectors to a lesser extent (10% of emissions for the two sectors combined) (Table 81 and Figure 55).

In terms of GHG sources, feed is the biggest contributor as it represents 55% of total emissions assessed in this study, followed by enteric fermentation (32%) and manure emissions (13%).

Figure 56 makes a further distinction as it distinguishes "consumed" and "exported" emissions. It represents the shares of emissions which can be attributed to the production of livestock products used for national consumption and the shares of emissions attributed to exported production, with the hypothesis that emissions are proportional to volumes of production.

[21] Including feed-related emissions, enteric fermentation and manure management emissions.

Table 81. Synthesis of GHG emissions by livestock sector and by source in Belgium in 2015.

Sector	Feed [a]	Enteric fermentation	Manure	TOTAL	Shares
	kt CO_2e/year				%
Pork	3.634	250	820	**4.705**	*34%*
Broilers	745	0	21	**766**	*6%*
Laying hens	569	0	18	**587**	*4%*
Dairy	1.745	2.358	508	**4.611**	*33%*
Bovine meat	991	1.782	479	**3.252**	*23%*
TOTAL	**7.683**	**4.390**	**1.847**	**13.920**	*100%*
Shares (%)	*55%*	*32%*	*13%*	*100%*	

Note: Includes LUC for soy.

This distinction between "consumed" and "exported" emissions only constitutes an estimate. Indeed, the distinction is based on the self-sufficiency ratios presented in Chapter 1, which show how much of the gross production is actually consumed in Belgium. Yet, these ratios also consider imports, which were not included in the assessment of GHG emissions. Hence, it must be kept in mind that the ratios used here to assess the emissions related to exports of livestock products do not exclusively reflect the share of the gross national production which was exported but provides an estimate of it.

In total, 60% of the emissions (8.300 kt CO_2e/year) can be attributed to livestock products which are actually consumed in Belgium whereas 40% of the emissions (5.620 kt CO_2e/year) can be attributed to livestock products which are exported (Figure 90 in the Appendix). Largest contributors to "exported emissions" are the pork, dairy and bovine meat sectors (respectively 21%, 9% and 9% of the total livestock emissions) (Figure 56).

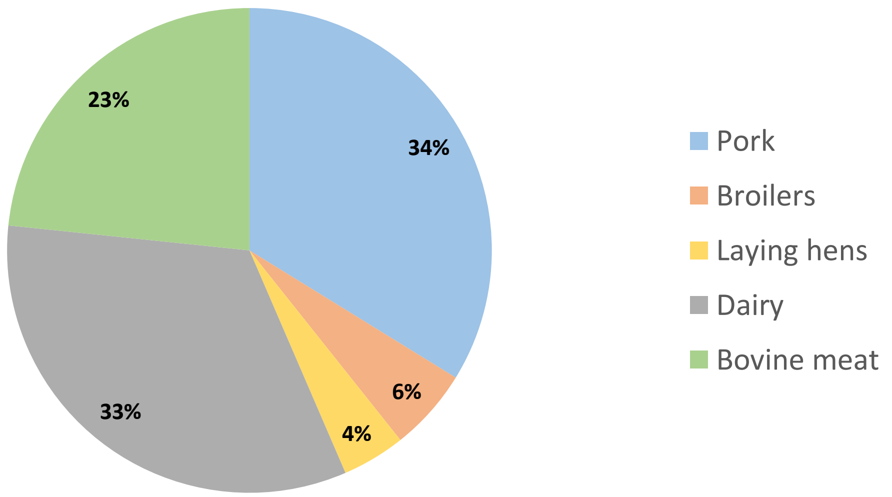

Figure 55. Contribution of each livestock sector to total GHG emissions from the Belgian livestock sector.

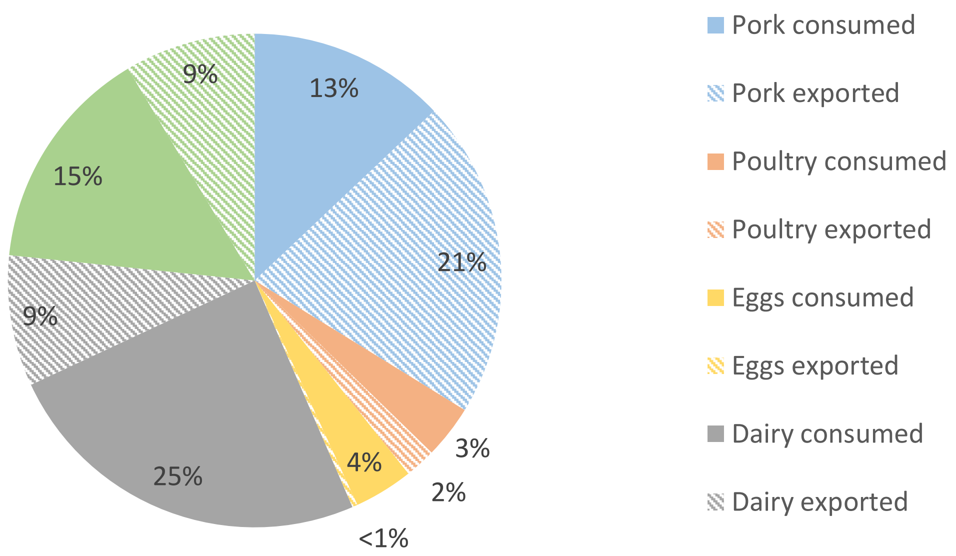

Figure 56. Contribution of each livestock sector total GHG emissions from the Belgian livestock sector and distinction between "consumed" and "exported" emissions.

8.4.2. N emissions

In total, the Belgian livestock sector was responsible for the emissions of 283 kt of N emissions in 2015, of which 67% were emitted by the bovine sector: 36% by the dairy sector (dairy cows and progeny) herd and 31% by the bovine meat sector (suckler cows and progeny). The pork sector was responsible for 25% of the emissions and the poultry sector (broilers and laying hens together) for the remaining 7% (Table 82).

Table 82. Estimated N emissions from the Belgian livestock sector in 2015.

Sector	**N emissions**
	kt N/year
Pork	70
Broilers	11
Laying hens	10
Dairy	103
Bovine meat	89
TOTAL	283

Note: See sector-specific chapters for detailed results (Chapter 4 to Chapter 7)

8.4.1. Biodiversity impacts

As a reminder, the assessment of the biodiversity impact of the livestock sectors is related to their feeding practices and the degree of intensiveness in which the feed is produced (see Section 2.4.7). Intensively-produced crops result in higher Damage Scores than organic crops. Furthermore, arable crops are more impactful than grasslands (see Table 162 in Appendix). According to this methodology, the pork sector is the one which contributes to the most to Biodiversity loss (53% of the total Damage Score; Table 83), followed by the dairy and bovine meat sectors (22% and 18% respectively; Table 83). An explanation of this resides in the important cereal consumption by the pork sector (as shown in Section 8.2.1).

Table 83. Estimated Biodiversity impacts emissions from the Belgian livestock sector in 2015.

Sector	Biodiversity impact
	DS/year
Pork	9.661.238
Broilers	912.876
Laying hens	399.121
Dairy	4.029.748
Bovine meat	3.204.645
TOTAL	18.207.628

Note: See sector-specific chapters for detailed results (Chapter 4 to Chapter 7)

8.4.2. PPP use

The use of phytosanitary products (PPP use) related to the Belgian livestock sector was assessed by estimating the total use of PPP by crop[22] and attributing to the livestock sector the share of the total production which is destined for animal feed[23]. In Wallonia, it is estimated that 46% of the cereals production is used for animal feed (Antier et al., 2017). For whole Belgium, this share rises to 55% and to 62% when maize is included[24] (Actor interviews, 2018; see Table *76*).

An estimation based on this approach is shown in Table 84 for the year 2015, based on PPP consumption levels in Wallonia (interannual averages between 2011-2013) and Flanders (interannual averages between 2005-2011). Considering only the production which is destined for animal feed, the amounts of PPP related to the livestock sector amounted 810 t of active substances (a.s.) in 2015. This figure provides an estimation of the PPP-related impacts of the livestock sector on the Belgian territory. The PPP involved in the production of imported feed for livestock production (which includes ingredients such as soybean meal and all the imports of cereals) are thus not included in such a territorial approach.

[22] No specific data on the use of PPP on food crops vs. The use of PPP on feed crops could be found, although some actors mentioned that feed crops result in lower PPP levels.

[23] Another method to estimate the use of PPP would require knowing the average level of PPP use for each feed ingredient. Based on the feeding practices of each production system (consumption levels and composition of feed), one could estimate the PPP level for each production system. This method would allow to highlight existing differences between systems. Nevertheless, although data on PPP use is available for many crops (Table 84), information is lacking for some specific ingredients (e.g. soybean meal, sunflower meal, oleaginous crops…).

[24] 90% of the maize production is destined for the animal feed industry (Actor interviews, 2018).

Table 84. Estimation of phytosanitary products use in Belgium in 2015 (based on interannual averages between 2011-2013 for Wallonia and 2005-2011 for Flanders).

	Area 2015				PPP WAL	PPP FL	PPP WAL	PPP FL	PPP BE	Estimated use for feed		
	WAL	FL	BXL	BEL	2011-2013	2005-2011						
1. Cereal for grains	ha				kg a.s./ha		t a.s.			% BE	ha	t a.s.
Winter wheat	130.017	68.039	570	198.626	2,82	2,9	367	197	564	55%	109.244	310
Spring wheat	1.751	1.383	9	3.143	2,82	2,9	5	4	9	55%	1.729	5
Spelled	18.457	1.486	69	20.012	2,06	2,6	38	4	42	55%	11.007	23
Rye	292	271	-	563	2,34	2,6	1	1	1	55%	310	1
Winter barley	30.213	13.874	126	44.213	2,15	2,3	65	32	97	55%	24.317	53
Spring barley	2.465	1.422	11	3.898	2,15	2,3	5	3	9	55%	2.144	5
Malting barley	257	10	-	267	2,15	2,3	1	0	1	0%	0	0
Oat	3.242	677	16	3.935	2,34	2,6	8	2	9	55%	2.164	5
Triticale	3.036	2.490	26	5.552	2,34	2,6	7	6	14	55%	3.054	7
Grain maize	5.986	52.310	102	58.398	1,5	1,5	9	78	87	90%	52.558	79
Other cereals	2.904	115	17	3.036	2,34	2,6	7	0	7	55%	1.670	4
Sub-total							511	328	840		208.196	492
2. Industrial crops												
Sugar beet	34.527	17.661	159	52.347	6,81	5,5	235	97	332	0%	0	0
Lin	9.196	4.570	93	13.859			0	0	0	0%	0	0
Rapeseed	10.641	577	52	11.270			0	0	0		0	0
Early potatoes	141	7.968	8	8.117	10,97	15,3	2	122	123	0%	0	0
Conservation potatoes	33.881	34.219	157	68.257	10,97	22,3	372	763	1.135	0%	0	0
Potato plants	830	1.482	-	2.312			0	0	0	0%	0	0
Sub-total							608	982	1.590		262.424	0
3. Forage crops											0	0
Forage peas (harvested dry)	628	378	-	1.006			0	0	0		0	0
Beans (harvested dry)	515	217	11	743			0	0	0		0	0
Other leguminous (harvested dry)	994	1	-	995			0	0	0		0	0
Fodder beet	945	3.153	3	4.101	4,71	4,5	4	14	19	100%	4.101	19
Forage maize	53.225	119.942	169	173.336	1,30	1,4	69	168	237	100%	173.336	237
Pasture	337.046	219.178	622	556.845	0,06	0,2	19	44	63	100%	556.845	63
Sub-total							92	226	318		996.707	318
TOTAL									**2.748**		**1467.327**	**810**

Note: a.s. stands for 'active susbstance'.

8.5. Sector-specific results: comparison of the contribution of each production system to production and environmental externalities

The following tables (Table 85 to Table 90) show the contribution of each production system to both production levels and environmental impact levels within each livestock sector. **In general, the contribution of each system to environmental impacts is closely related to the shares of these systems in terms of population and production. This reflects that overall, different production systems result in small differences in terms of environmental impacts.**

As a consequence, reduction in the national GHG emissions from livestock could mainly be obtained through optimisation (reduction of GHG emissions per kg of product) and reduction of the livestock population and production (reduction in the number of animals raised).

As a reminder, the livestock population is not equally distributed between Flanders and Wallonia (the pork and poultry sectors are strongly concentrated in Flanders whereas the bovine sectors are better distributed; see Figure 11). In terms of GHG emissions, 42% of emissions are located in Wallonia ad 58% in Flanders (according to the Belgian GHG inventory; see Table 8).

Table 85. Contribution of pork systems to production and environmental externalities in Belgium in 2015.

Production system	National production		GHG emissions		N emissions		Biodiversity impact	
	Slaughters	%	kt CO_2e/year	%	kt N/year	%	DS/year	%
Conventional	8.677.286	73%	3.424	73%	51	72%	6.991.680	72%
Certified (Certus)	2.722.053	23%	1.074	23%	16	23%	2.193.280	23%
Differentiated	237.734	2%	100	2%	2	2%	217.062	2%
Differentiated +	237.734	2%	101	2%	2	3%	254.047	3%
Organic	11.887	0%	6	0%	<1	0%	5.168	0%
TOTAL	11.886.693		4.705		70		9.661.238	

Note: DS stands for Damage Score, which is an indicator of the impact of a certain crop or production on biodiversity (De Schryver et al., 2010).

Table 86. Contribution of broiler systems to production and environmental externalities in Belgium in 2015.

Production system	National production		GHG emissions		N emissions		Biodiversity impact	
	Slaughters	%	kt CO_2e/year	%	kt N/year	%	DS/year	%
Conventional	11.013.240	7%	50	7%	0,7	7%	60.939	7%
Certified (Belplume)	148.511.874	90%	678	89%	9.6	89%	821.752	90%
Differentiated	1.311.100	1%	8	1%	0,1	1%	9.909	1%
Differentiated +	1.072.718	1%	8	1%	0,1	1%	9.165	1%
Organic	2.574.524	2%	21	3%	0,3	3%	11.112	1%
TOTAL	164.483.456		766		10.8		912.876	

Note: DS stands for Damage Score, which is an indicator of the impact of a certain crop or production on biodiversity (De Schryver et al., 2010).

Table 87. Contribution of laying hen production systems to production and environmental externalities in Belgium in 2015.

Production system	National production		GHG emissions		N emissions		Biodiversity impact	
	kt eggs/year	%	kt CO_2e/year	%	t N/year	%	DS/year	%
In-cage	100	61%	228	59%	3,8	58%	235.516	59%
Indoor	44	27%	111	29%	1,9	28%	114.899	29%
Free-range	15	9%	37	9%	0,7	10%	41.586	10%
Organic	5	3%	14	4%	0,3	4%	7.120	2%
TOTAL	164		389		6,6		399.121	

Note: This table does not include the environmental impacts of young hens and reproductive animals. DS stands for Damage Score, which is an indicator of the impact of a certain crop or production on biodiversity (De Schryver et al., 2010).

Table 88. Contribution of dairy production systems to production and environmental externalities in Belgium in 2015.

Production system	National production		GHG emissions		N emissions		Biodiversity impact	
	Mo L/year	%	kt CO2e/year	%	kt N/year	%	DS/year	%
Grass Extensive	63	2%	109	2%	2	2%	27.580	3%
Grass Intensive	228	6%	297	6%	5	5%	328.945	7%
Grass and Crops	38	1%	57	1%	1	1%	47.120	1%
Grass and Maize SI	336	10%	564	12%	12	12%	373.660	12%
Grass and Maize Intensive	1.316	37%	1.575	34%	34	33%	1.506.626	33%
Grass, Maize and Crops SI	282	8%	526	11%	13	13%	367.869	12%
Grass, Maize and Crops Int	1.265	36%	1.483	32%	35	35%	1.377.948	32%
TOTAL	3.527		4.611		102		4.029.748	

Note: DS stands for Damage Score, which is an indicator of the impact of a certain crop or production on biodiversity (De Schryver et al., 2010).

Table 89. Contribution of suckler cow production systems to production and environmental externalities in Belgium in 2015.

Production system	National production		GHG emissions		N emissions		Biodiversity impact	
	kt live weight gain/year	%	kt CO2e/ year	%	kt N/ year	%	DS/ year	%
BB Extensive Grass	17	11%	350	13%	12	15%	351.868	13%
BB Extensive Maize	22	13%	366	13%	11	14%	319.475	12%
BB Intensive Grass	19	11%	279	10%	6	8%	363.897	13%
BB Intensive Maize	82	50%	1.288	47%	34	44%	14.67.417	54%
FR Extensive Grass	9	5%	182	7%	6	8%	26.135	1%
FR Extensive Maize	14	9%	266	10%	8	10%	198.336	7%
TOTAL	163		2.731		78		2.727.127	

Table 90. Contribution of bull fattening systems to production and environmental externalities in Flanders in 2015.

Production system	National production		GHG emissions		N emissions		Biodiversity impact	
	kt live weight/year	%	kt CO2e /year	%	kt N/ year	%	DS/ year	%
BB Intensive	52	68%	217	61%	4,8	63%	210.944	66%
BB semi-intensive	16	21%	87	23%	1,9	24%	76.703	24%
FR Semi-intensive	8	11%	43	17%	0,8	13%	30.698	10%
TOTAL FL	76		347		7,6		318.345	
TOTAL BE [1]	*114*		*521*		*11,3*		*477.518*	

Note: [1] The results presented in this table are mainly for Flanders. The bottom line shows the results extrapolated to Belgium.

Chapter 9. Comparison of results with other sources

In this chapter, the results obtained in the previous sections in terms of feed intake, GHG emissions and N emissions are compared to other sources. It must be noted that for poultry and bovine, distinctions between sub-sectors are not always made at the same level in different studies, making the comparison often difficult. This is why only total results are compared (the laying hen and broiler sectors were thus aggregated for poultry; and the dairy and bovine meat sectors were aggregated for bovine).

9.1. Consumption of meat and animal products

The results of the last national survey on food consumption (De Ridder et al., 2016) showed that the average meat consumption amounted 114 g meat/cap/day, of which 99 g of pork, poultry and bovine meat and 15 g of other types of meat (see Table 1). In the previous section, it was shown that the estimated consumption level resulting from this study for 2015 was of 87 g of pork, poultry and bovine meat (other types of meat were not included in the study).

This amount is 12% lower than the consumption mentioned in the national food survey (Table 91). Several elements can contribute to explain this. First, as highlighted in Table 1, the national food consumption survey mentions a real meat consumption level of 114 g meat/cap/day but does not subdivide this amount in different meat types. As there is no statistical data for this subdivision in terms of real consumption, the subdivision was estimated based on the food balances and apparent consumption levels estimated every year from production, export and import data. It is thus possible that the category 'other types of meat' represents a bigger share of total meat consumption in reality. Second, several factors have an influence on the final consumption level resulting from this study. Elements such as the productivity levels assigned to each system, the shares of each systems, the self-sufficiency ratios, the slaughter and carcass yields and the waste factor all contribute to determining the final consumption level and are hence potential factors which could explain the observed difference in consumption levels.

In the following sections of the report it is the value of 87 g meat/cap/day which is used in the calculations.

Table 91. Comparison of meat consumption levels in this study and the national food survey.

Meat consumption	De Ridder et al. 2016 g meat/cap/day	This study g meat/cap/day	Delta %
Pork, Poultry and Bovine meat	99	87	-12%

Source: (De Ridder et al., 2016).

9.2. Feed intake

Regarding feed intake (and more precisely concentrates intake), the results are compared with one national and one international source:

- The Belgian Feed Association (BFA), which keeps annual statistics on concentrates production in Belgium (BFA, 2016);
- Hou et al. (2016), who carried out a global assessment of feed use and nitrogen excretion in the EU-27, with a detail for every country (Hou et al., 2016).

Feed consumption figures can be compared both per sector (pork, poultry and bovine; see Table 92 and Figure 57) or per ingredient category (cereal and energy-rich ingredients, protein sources and others; see Table 93). In general, results from this study follow the same trends as in other studies, with some variations.

Table 92. Comparison of total concentrates intake for different sectors in different studies.

Sector	This study	BFA [1]		Hou et al. 2016 [2]	
	kt feed/year	kt feed/year	Delta (%)	kt feed/year	Delta (%)
Pork	4.100	3.805	7%	4.093	<1%
Poultry (total)	1.146	1.436	25%	1.106	4%
Bovine (total)	1.495	1.508	1%	1.505	1%
TOTAL	6.740	6.749	<1%	6.704	<1%

Sources: [1] (BFA, 2016); [2] (Hou et al., 2016).

Table 93. Comparison of feed intake by the pork, poultry and bovine sectors (PPB) according to this study and according to the BFA in 2015.

	This study		BFA data		Delta
	kt/year	% of total	kt/year	% of total	%
Cereals and energy-rich	3.901	58%	3.577	53%	8%
Protein sources	2.233	33%	2.767	41%	-24%
Others	606	9%	405	33%	33%
TOTAL	6.740	100%	6.749	100%	-1%

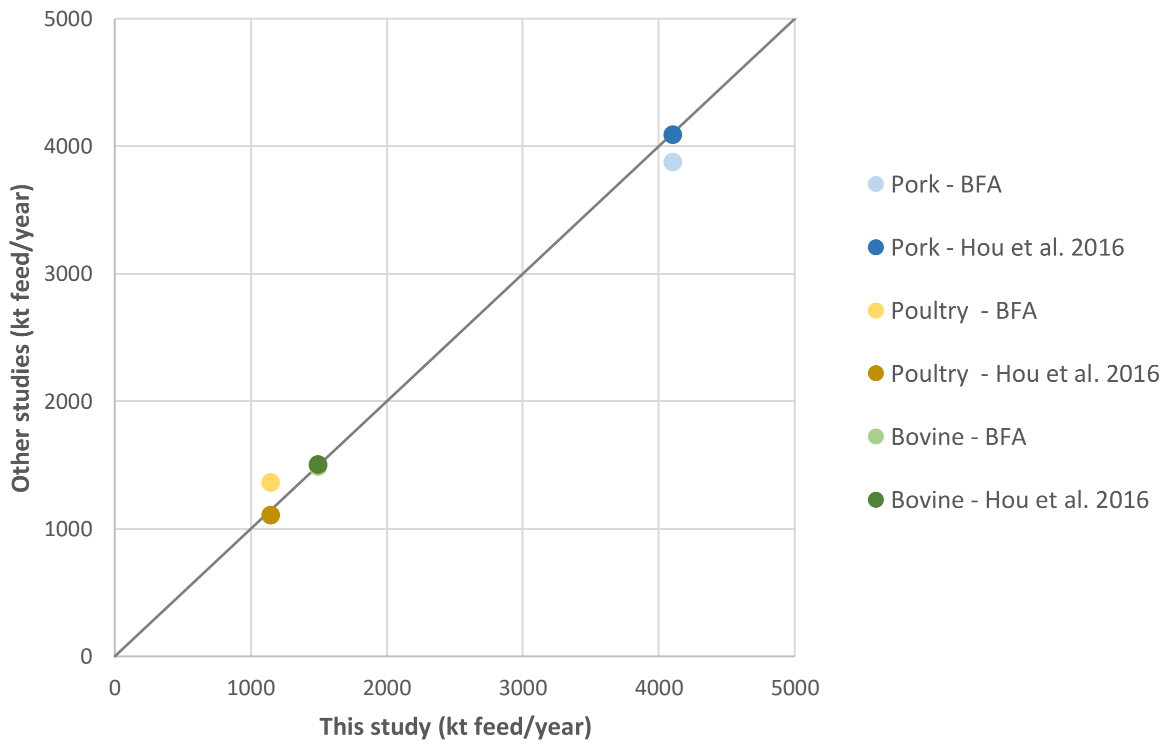

Figure 57. Comparison of total concentrates intake for different sectors in different studies.
Note: The point 'Bovine – BFA' is located behind the point 'Bovine – Hou et al. 2016' and is thus not visible on the chart.

9.3. GHG emissions

The results obtained in this study are compared with figures from the Belgian GHG inventory of 2015 (VMM et al., 2017). This inventory, which is submitted every year by governments in the context of the United Nations Framework Convention on Climate Change (UNFCCC), aggregates all annual GHG emissions from every sector in a country. For this comparison, only enteric fermentation emissions and manure management emissions are considered as feed-related emissions are not included in the inventory. Results are presented in Table 94 and Figure 58.

The results of the study are consistent with the ones of the inventory (6% difference). The only emission source for which a bigger difference can be observed are the manure management emissions from bovine. Nevertheless, over the entire sector, the difference remains small because for bovine, manure management emissions represent a smaller share of the total emissions compared to enteric fermentation emissions.

Table 94. Comparison of GHG emissions of different sectors in this study and the national GHG inventory (including enteric fermentation and manure management emissions only).

Sector	This study	National GHG inventory 2015 [1]	
	kt CO_2e/year	kt CO_2e/year	Delta (%)
Pork (enteric fermentation)	250	250	<1%
Pork (manure management)	820	818	<1%
Pork (total)	1.070	1.068	<1%
Poultry (enteric fermentation) [a]	-	-	-
Poultry (manure management)	39	35	12%
Poultry (total)	39	35	12%
Bovine (enteric fermentation)	4.140	4.272	3%
Bovine (manure management)	987	1.442	46%
Bovine (total)	5.313	5.714	8%
TOTAL	6.237	6.817 [b]	6%

Source: [1] (VMM et al., 2017)
Notes:
[a] Enteric fermentation emissions are assumed to be negligible for poultry (FAO, 2013).
[b] This figure only includes enteric fermentation and manure management emissions from the pork, poultry and bovine sectors. A more comprehensive figure (taking into account other types of livestock and additional emissions) is provided in the national inventory, estimating that total livestock emissions in 2015 at 7.538 kt CO_2e. This figure does however not include feed-related emissions.

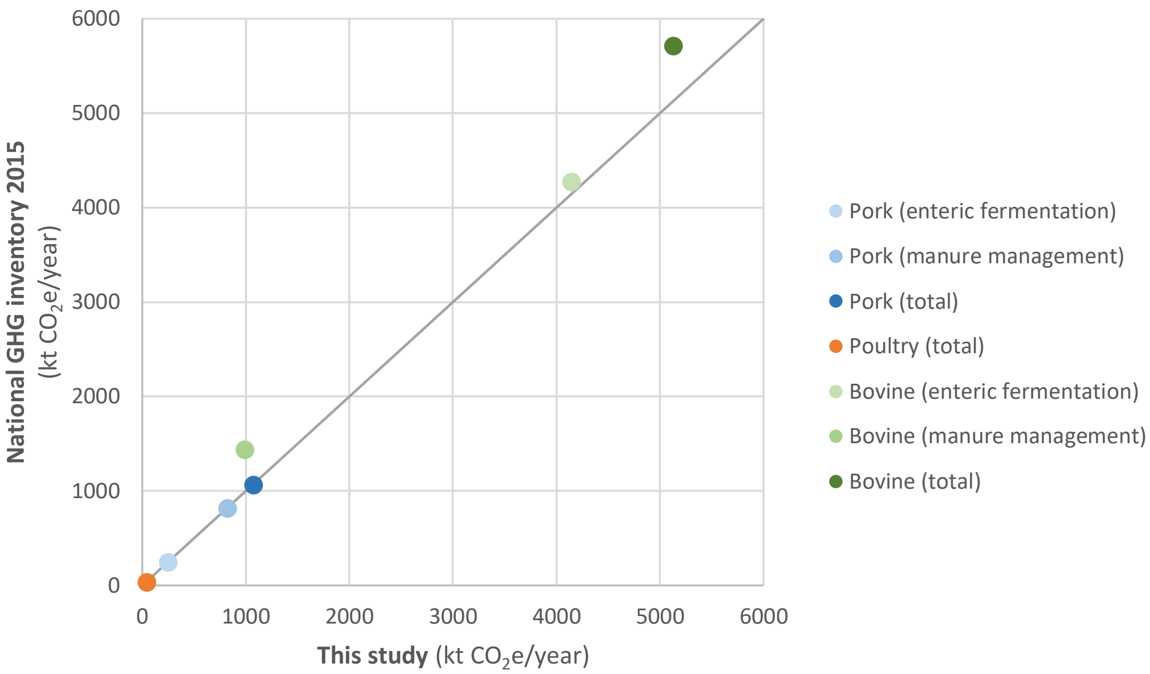

Figure 58. Comparison of total GHG emissions of different sectors in this study and the national GHG inventory.

9.4. N emissions

For results regarding N emissions were compared to one national and one international source:

- The National GHG inventory, which also contains total N emissions by livestock (as this a step to assess GHG emissions from manure) (VMM et al., 2017);
- Hou et al. (2016), who carried out a global assessment of feed use and nitrogen excretion in the EU-27, with a detail for every country (Hou et al., 2016).

Results from this study follow the same trends as in other studies, but with some variations (Table 95 and Figure 59). Depending on the sector, N emissions levels found in this study are close to ones mentioned in the national inventory but show a greater difference when compared to results from Hou et al. (2016).

Several reasons could explain these differences. First, Hou et al. (2016) based their assessment on the period 2009-2011 whereas the results of both this study and the national GHG inventory are based on the year 2015. Although the livestock populations did not change dramatically over that period (Figure 12), this might still have a small impact.

Second, for poultry, which is the sector which shows the greatest difference, it seems that the emissions levels found by Hou et al. (2016) for Belgium are very low. They mention relative emissions levels of 0,65 kg N per laying hen per year and 0,26 kg N per broiler per year for Belgium. This is substantially lower than the results of this study which are of 0,81 kg N per laying hen per year and 0,62 kg N per broiler per year. However, these numbers come much closer to the European averages mentioned in Hou et al. which are 0,74 kg N per laying hen per year and 0,73 kg N per broiler per year.

A similar situation can be observed for the pork sector as the relative emissions mentioned by Hou et al. (2016) for Belgium are of 11,1 kg N per pig per year. The results of this study on the other hand are of 9,7 kg N per pig per year, which is closer to the European average found by Hou et al. (2016) of 9,9 kg N per pig per year.

Table 95. Comparison of total N emissions for different sectors in different studies.

Sector	This study	National GHG inventory 2015 [1]		Hou et al. 2016 [2]	
	kt N/year	kt N/year	Delta (%)	kt N/year	Delta (%)
Pork	70	62	12%	71	1%
Poultry (total)	21	20	3%	13	37%
Bovine (total)	192	166	12%	152	19%
TOTAL	283	248	12%	236	17%

Sources: [1] (VMM et al., 2017); [2] (Hou et al., 2016).

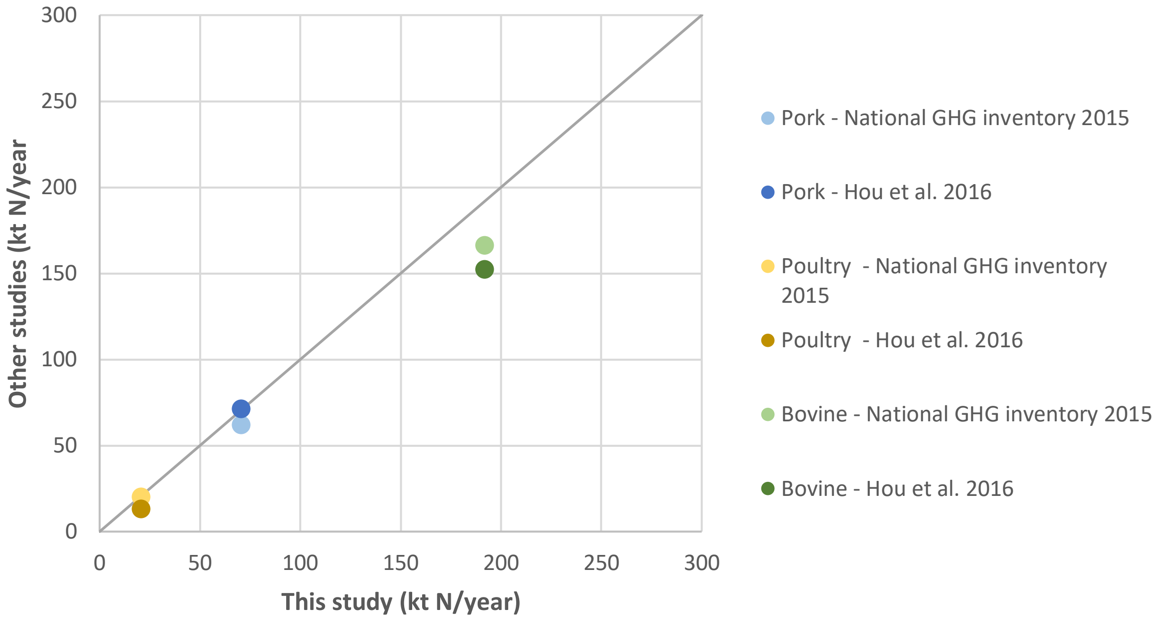

Figure 59. Comparison of total N emissions for different sectors in different studies.

PART II. Challenging the trends with a diversity of scenarios

(a) Overview of the scenarios

After describing the current situation of the livestock sector (Chapter 3 to Chapter 9), three scenarios towards 2050 were designed to compare trends and alternative pathways (Figure 60):

- **the Business as usual (BAU) scenario is based on trends from the past ten years (Chapter 10);**
- **the Transition 1 (T1) scenario is based on a shift towards extensive systems (organic or not) and local feed (cereal feed only from national origin) and seeks to significantly reduce livestock GHG emissions (Chapter 11);**
- **the Transition 2 (T2) scenario is based on a shift towards exclusively organic systems by 2050[25] and feed from EU origin. It also seeks to significantly reduce livestock GHG emissions (Chapter 12);**
- **Chapter 13 looks at the potential evolutions in terms of consumption patterns;**
- **A comparative assessment of all scenarios is carried out in Chapter 14.**

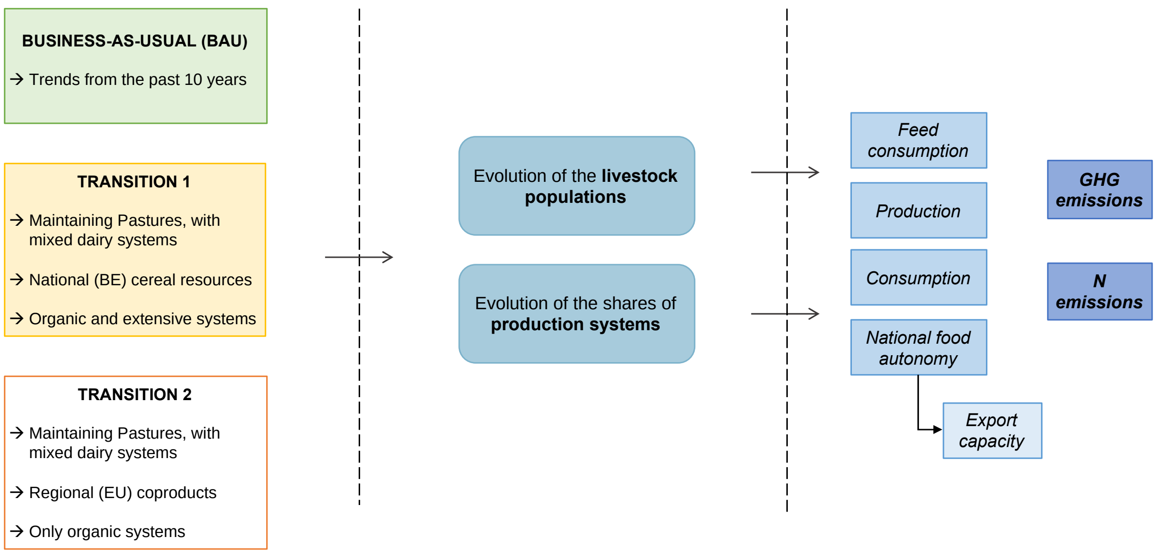

Figure 60. Methodology for the development of the business as usual and transition scenarios.

Transition scenarios (especially T2) were designed in consistency with Greenpeace's guidelines for "better meat" - including criteria related to animal welfare, no food-feed competition, non-GMO and pesticides-free feed (Tirado et al., 2018) - as well as with the perspective of significantly reducing livestock sector's environmental impacts in order to reach environmental targets, as exposed in Table 139 in section 14.2 (in terms of GHG emissions, N emissions, and biodiversity).

Other scenarios for pursuing a reduction in GHG emissions and based on different strategies (such as focusing on intensive systems with lower emissions per unit of product) were not developed in this study.

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[25] in order to follow as closely as possible Greenpeace's criteria for better meat (Tirado et al., 2018).

(b) Main parameters and hypotheses of the scenarios

The parameters considered for the modelling of each scenario are the following (Table 96):

- Regarding livestock populations:
    - They vary according to trends in BAU scenario until 2030 and are considered stable after that;
    - They vary according to available feed resources in the transition scenarios: national cereal resources in Transition 1 and regional (EU origin) coproducts in Transition 2.
- Regarding the shares of production systems:
    - They vary according to trends until 2050 in the BAU scenario.
    - Only organic and extensive systems are considered in the transition scenarios, reaching a proportion of 30% and 70% in 2050 in Transition 1, and 100% of organic systems in Transition 2 (see details in Chapter 11 and Chapter 12).
- Regarding consumption patterns (see Chapter 13):
    - They are estimated to follow the trends from the past ten years in the BAU scenario;
    - Changes in food patterns are proposed in the transition scenarios in order to fit with the production potential.
    - An additional consumption pattern in line with nutritional recommendations was considered for BAU and Transition 1.

The evolution of technical parameters was estimated in the calculations (Table 97). The assessment of technical improvements is further detailed in Box 3 below and a comparison of results with and without technical improvements is provided in the appendix (Table 210 and Table 211).

Table 96. Main parameters used for the modelling of scenarios.

	BAU scenario	Transition 1	Transition 2
Livestock populations	Vary according to trends until 2030 and remain stable after that.	Vary according to available resources.	Vary according to available resources.
Feed sources	National production & world-wide import.	- No import of cereals; based on available national cereal resources for feed. -No soybean meal.	- National and regional (EU) sources of coproducts. - No soybean meal.
Shares of production systems	Vary according to trends until 2050.	70% extensive and 30% organic systems in 2050	100% of organic systems in 2050.
Consumption patterns	Vary according to trends until 2050 OR follow the recommendations.	Changes in food patterns are proposed in order to fit with the production potential. The nutritional recommendations pattern was also considered for T1.	
Optimisation of technical parameters[26]	From 0% to 15% between 2015 and 2050 depending on livestock sectors and measures.		

[26] Gains in efficiencies or productivities and implementation of GHG emissions reduction measures (e.g. reductions in enteric fermentation through dietary additives, reduction of manure management emissions through the implementation of biogas installations, etc). Reduction in emissions can also result indirectly from gains in efficiencies or productivities.

Box 3. Estimation of technical improvements.

In order to account for future technical improvements in the livestock sector, the optimisation potentials mentioned in Table 97 were applied to each production in the developed scenarios. These technical improvements can either result in direct reductions of emissions, through the implementation of reduction measures (e.g. reductions in enteric fermentation through dietary additives, reduction of manure management emissions through the implementation of biogas installations, etc.). Reduction in emissions can also be a result of indirect measures, such as gains in efficiencies or productivities, which are expected to occur in the coming years.

The factors were defined based on estimates found in the literature (such as (IPCC, 2014)) and expert knowledge collected during focus groups. Given the complexity and incertitude of estimating the reduction potential of each measure as well as their future implementation[27], the applied factors are on the conservative end of the range provided by the literature (see Figure 94 and Figure 95 in the Appendix). It is also possible that additional optimisation measures will appear in a further future, e.g. between 2030 and 2050. Nevertheless, as it is not possible to predict this today, no optimisation factors which would take such hypothetical measures into account were considered in the calculations.

[27] For example, it seems realistic to consider that not all actors will implement the entirety of the measures.

Table 97. Description of technological gains applied to each sector in the developed scenarios and their magnitude.

Process	Sector	Gain	Measure(s)	Source
Gains in efficiency or productivity	Pork	10%	FCR could decrease by about 10% by 2050.	Expert advice during focus group and (Vrints and Deuninck, 2014).
	Broiler	10%	FCR assumed to decrease by about 10% by 2050.	Expert advice during focus group.
	Laying hens	10%	No gain in FCR or productivity but decrease in replacement rate of laying hens (longer production cycle, up to 500 days).	Expert advice during focus group.
	Dairy	10%	Increase in milk productivity (L/cow/year).	Expert advice during focus group and (Van der Straeten, 2015) and (Petel et al., 2018).
	Bovine meat	0%	No significant evolution in productivity, based on data between 2009-2013.	(Vrints and Deuninck, 2015).
Enteric fermentation	Pork	10%	Measures to reduce enteric fermentation include: improved forage; dietary additives; ionophores/antibiotics; propionate enhancers; archaea inhibitors; improved breeds with higher productivity; etc. No enteric fermentation emissions for poultry.	Based on (IPCC, 2014).
	Broiler	0%		
	Laying hens	0%		
	Dairy	10%		
	Bovine meat	10%		
Manure management	All sectors	15%	Considered the same for all sectors. Measures to reduce **CH_4** emissions include: improved bedding and storage conditions; anaerobic digestion; biofilters, etc. Measures to reduce **N_2O** emissions include: dietary additives; soil-applied and animal-fed nitrification inhibitors; urease inhibitors; fertiliser type, rate and timing; etc.	Based on (IPCC, 2014).

Note: FCR stands for Feed Conversion Ratio.

Chapter 10. Business as usual scenario

10.1. Estimation of the evolution of livestock populations

In the business as usual scenario, livestock populations in 2030 are estimated based on their average growth rate between 2005 and 2015 in each region (see Appendix 14 – BAU scenario: Evolution of livestock populations). Populations are then assumed to remain stable between 2030 and 2050 [28].

According to the trends, at the Belgian level, the livestock population would remain approximately stable in the pork sector (+1%), while it would decrease in the dairy, eggs production, and bovine meat productions (respectively -3%, -7% and -26%) and increase in the poultry meat sector (+26%).

It must be acknowledged that more recent data could have been used to estimate the evolution of the livestock populations. In particular, for the laying hen sector, the development of the sector is hard to predict given the ban on battery cages in 2012 which had an important negative impact on the laying hen population. Yet, between 2013-2017, the laying hen population has grown by 20%. Hence, considering this period would result in different estimations for the laying hen population. Nevertheless, as 2015 was considered as the reference year throughout the entire study and all other populations were estimated based on the years 2005-2015, the evolution of laying hen population was assessed over this period too, in order to remain consistent. These considerations must however be kept in mind.

Table 98. Estimated livestock populations in 2030, based on 10-year growth rates.

		Flanders	Wallonia	Belgium
Pigs population	2015	5.981.191	382.973	6.364.164
	2030	6.024.460	410.433	6.433.718
	Growth rate	1%	7%	1%
Broilers population	2015	19.930.414	3.907.768	23.838.182
	2030	23.949.462	4.730.933	28.680.213
	Growth rate	20%	21%	20%
Laying hens population	2015	6.933.062	1.176.404	8.109.466
	2030	6.415.228	1.088.451	7.503.679
	Growth rate	-7%	-7%	-7%
Dairy cows population	2015	304304	203.086	507.390
	2030	322.344	168.022	484.454
	Growth rate	6%	-17%	-5%
Suckler cows population	2015	153.268	240.327	393.595
	2030	126.472	166.920	291.665
	Growth rate	-17%	-31%	-26%

Note: 10-year growth rates (GR) were calculated from 2005 to 2015 and used to estimate population in 2030. Details of calculation are provided in (Evolution of livestock populations).

[28] Predicting the evolution of the livestock population in a longer term would not be possible with a relevant level of precision.

10.2. Projected shares of production systems in 2030 and 2050 in consistency with trends

The figures below illustrate the evolution of the shares of each production system in each sector in a business as usual scenario, between 2015 and 2050.

These evolutions are based on the current trends in livestock populations calculated above as well as on actor interviews. The resulting scenarios were discussed during focus groups with experts from each sector and were modified according to the resulting feedback when possible.

- Pork sector

In the pork sector, when looking at current trends, it is assumed that the organic sector will grow but will remain very small. The differentiated systems are assumed to grow as well. The certified (Certus) system is assumed to grow, resulting in smaller shares for the conventional system.

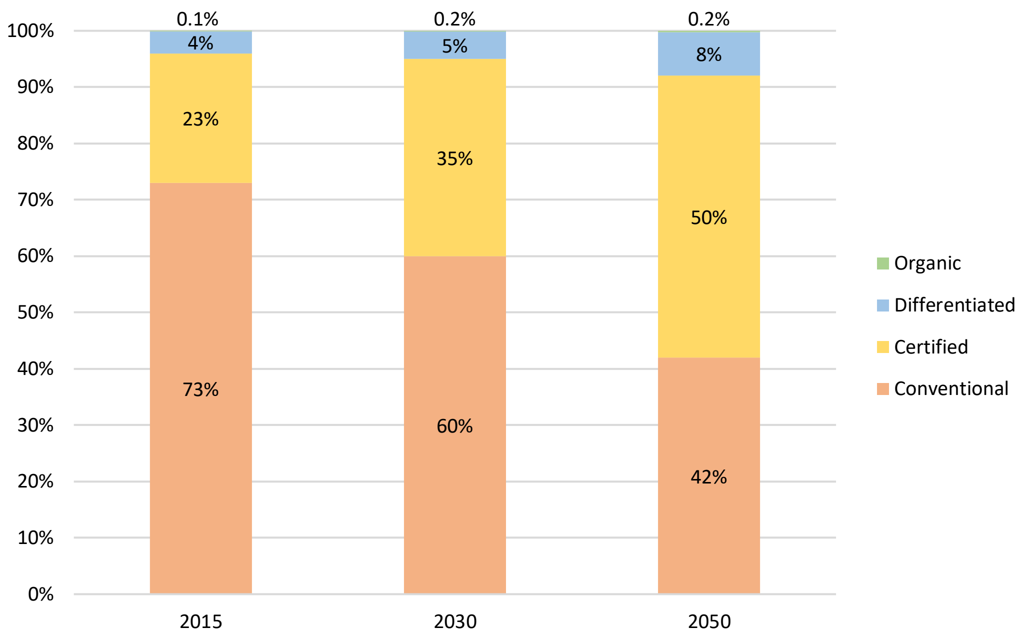

Figure 61. Evolution of the shares of production systems in the Belgian pork sector between 2015 and 2050, according to the business as usual scenario.

- Laying hen sector

In the laying hen sector, the alternative models are assumed to grow quite importantly. The important increase of the organic sector in the last years is assumed to continue, especially until 2030, after which it is assumed it will grow at a slower rate. Enriched cage systems are assumed to be progressively replaced by indoor systems. According to some experts who participated in the focus group, it is even likely that enriched cage systems will have completely disappeared by 2050. The assumption made here can thus be seen as rather conservative.

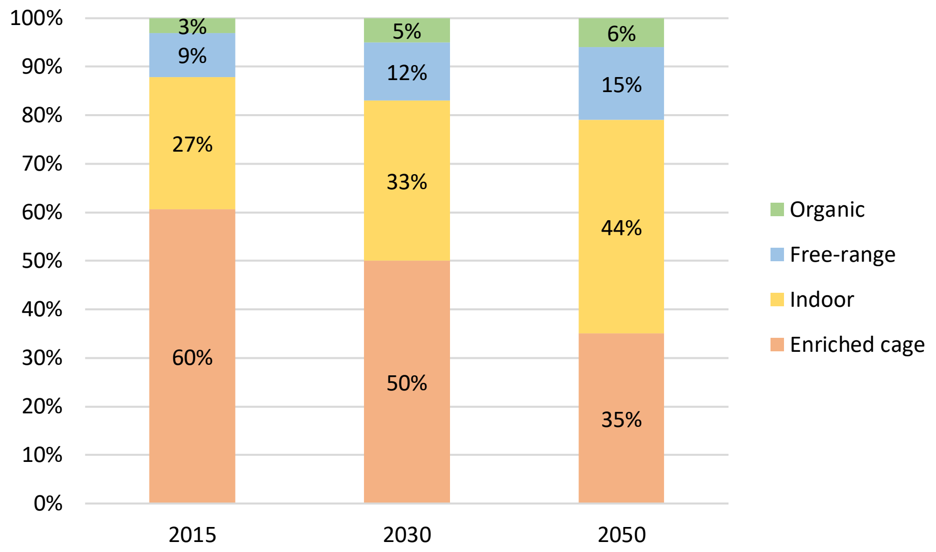

Figure 62. Evolution of the shares of production systems in the Belgian laying hen sector between 2015 and 2050.

- Broiler sector

In the broiler sector, it assumed that the organic and differentiated systems will grow to some extent, reaching an overall 6% in 2050 and that all remaining conventional systems will become certified (Belplume), which are already predominant in 2015.

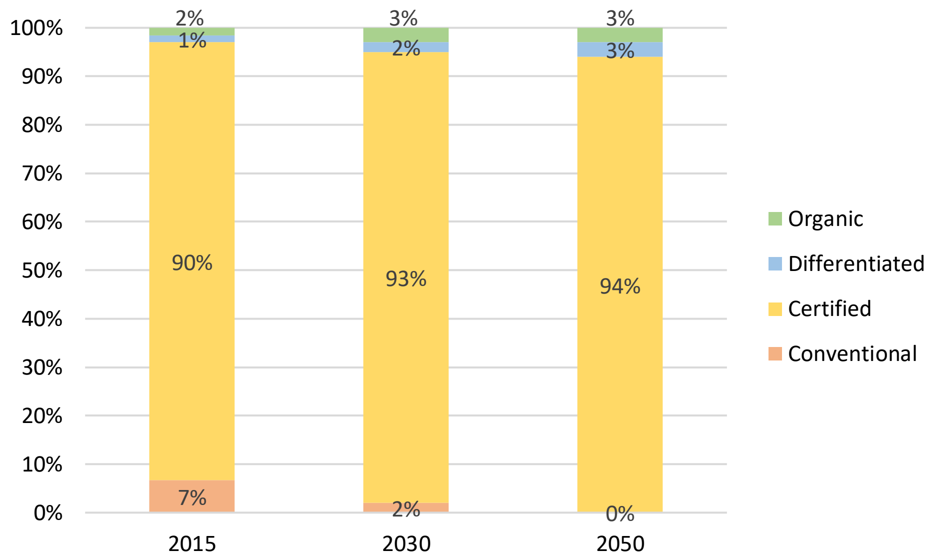

Figure 63. Evolution of the shares of production systems in the Belgian broiler sector between 2015 and 2050.

- Dairy sector

Figure 64 below shows the evolution of the dairy sector at the Belgian level. This evolution is based on the assessment carried out by Petel et al. (2018) in Wallonia and completed with the assumed evolution in Flanders (Figure 96 and Figure 97 in the appendix).

It is assumed that intensive systems will continue to grow and that systems will become more reliant on maize and grass and on external sources for concentrates (systems with other crops will thus decrease). The intensive grass system, which is only present in Wallonia, is expected to disappear because it relies on important amounts of external feed sources but with lower productivity levels than other intensive systems. The semi-intensive grass-maize system is assumed to disappear as well because of the low productivity of this system. Farms under this system are likely to cease their activities or to become more intensive.

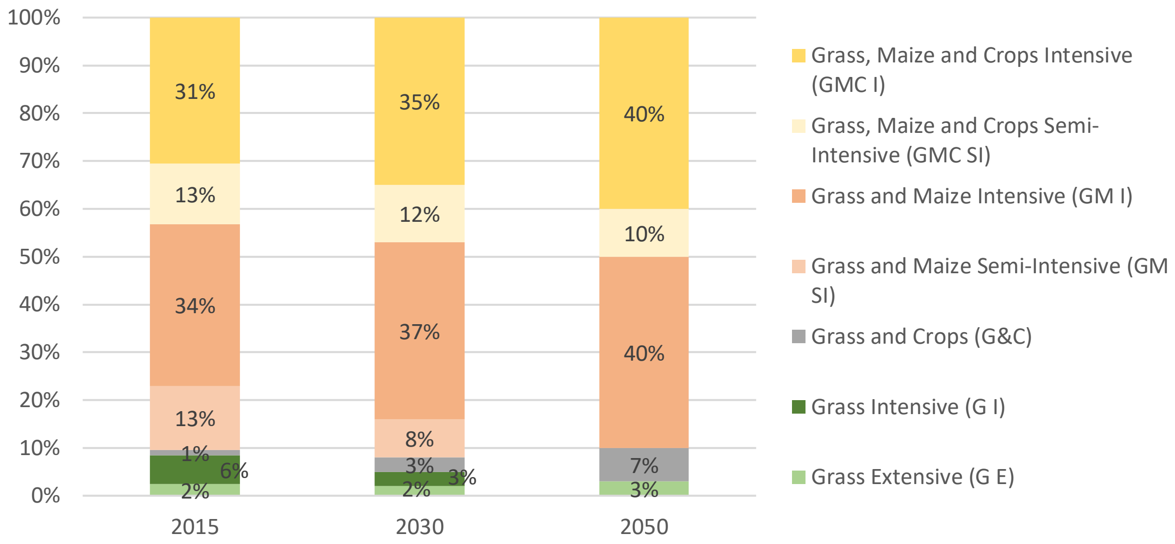

Figure 64. Evolution of the shares of production systems in the Belgian dairy sector between 2015 and 2050.

- Bovine meat sector

Figure 65 reflects the situation that is assumed to occur in the breeding sector in Wallonia, based on the assessment carried out by Petel et al. (2018).

For the fattening sector (in Flanders), it is assumed that French breeds will become more common, resulting in decreasing shares of Belgian Blue systems, which will nevertheless still remain predominant (Figure 66).

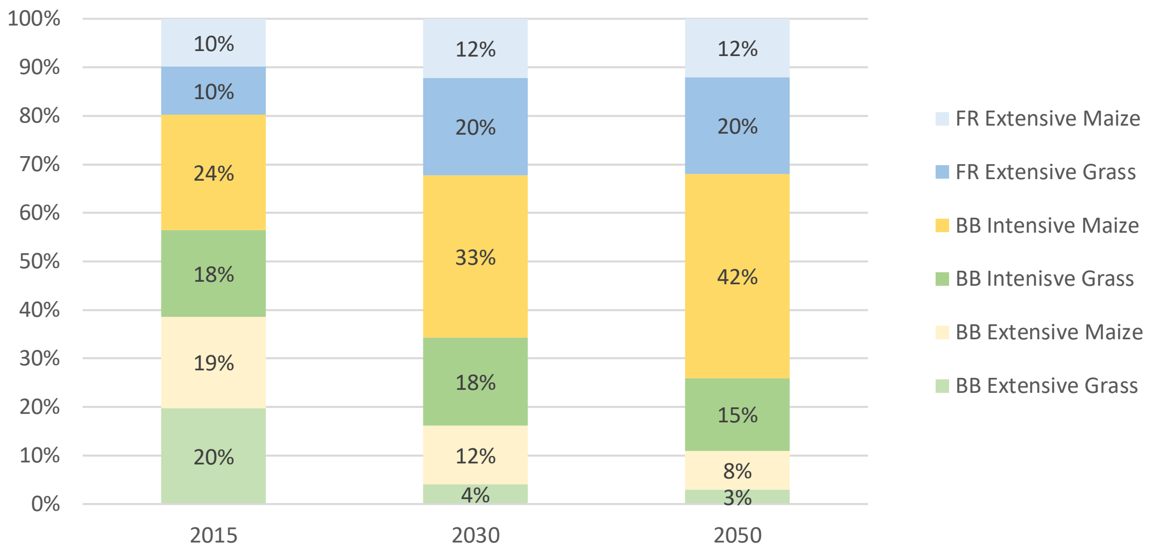

Figure 65. Evolution of the shares of breeding systems in the bovine meat sector in Wallonia between 2015 and 2050 (Petel et al. 2018).

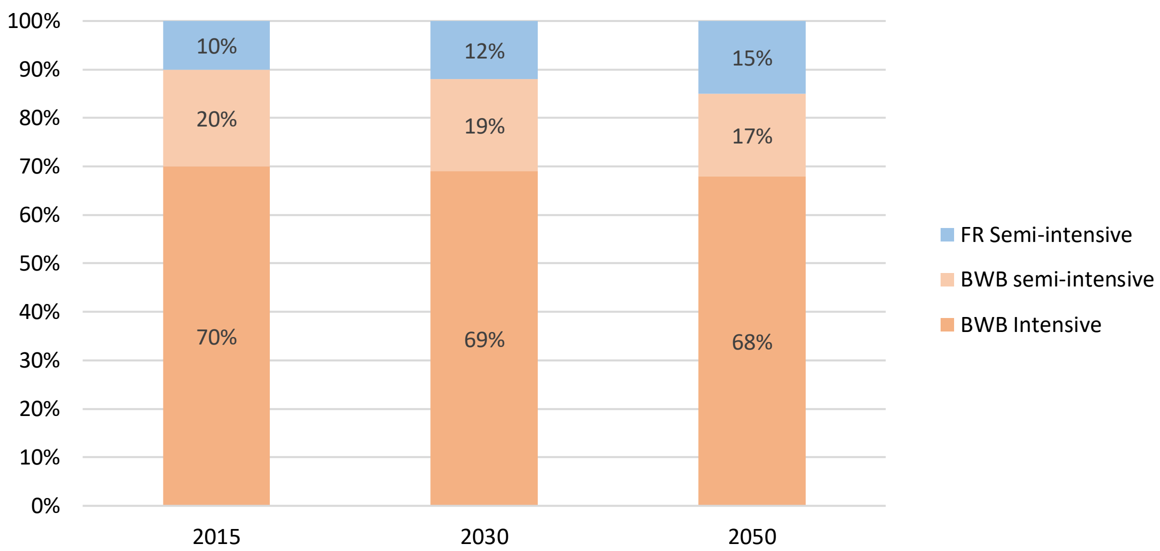

Figure 66. Evolution of the shares of fattening systems in Flanders between 2015 and 2050.

10.3. Consequences in terms of production and food consumption

Table 99 shows the impacts of the business as usual scenarios on production levels. The changes in production are mainly due to changes in livestock populations rather than changes in shares of production systems. This is nevertheless not the case for the dairy production. Indeed, due to the predicted increase in production, the growth rate is higher for the evolution of production than for the evolution of population.

In terms of consumption, the scenario is assessed under two consumption patterns, which are presented in Chapter 13. Results are presented and compared in section 14.1.2.

Table 99. Production from estimated livestock populations in 2030 (in tons live meat, number of eggs and million litres of milk), and evolution of the production level vs 2015.

Sector	Unit	Production 2015	Production 2050	Delta 2050-2015	Population 2050-2015
Pork	kt carcass/year	1.037	1.052	+1%	+1%
Broilers	kt carcass/year	261	313	+20%	+20%
Laying hens	kt eggs/year	164	151	-8%	-7%
Dairy	mo L milk/year	3.527	4.026	+14%	-3%
Bovine meat	kt carcass/year	268	208	-22%	-26% [1]

Note: For the 'Bovine meat (fattening)' line, the growth rate is assumed to be the same as for suckler cows as the fattened bulls originate from the suckler cow (breeding) sector.

10.4. Consequences on environmental externalities

As in the present situation, the dairy and the pork sector are the biggest emittors and feed represents the biggest emission source (Table 100).

Compared to 2015 emission levels, the business as usual scenario in 2050 results in a reduction of 13% of GHG emissions (Table 101). This is when technological improvements are taken into account (see Table 211 in Appendix 15 for an assessment which does not take technological improvements into account).

Expressing the GHG emissions per unit of output, it appears that the BAU scenario results in reduced emissions for all sectors (Table 102). The dairy sector in particular experiences strong reductions when expressed per unit of ouptut. This is explained by the fact that both the productivity expected to increase and the emission intensity is expected to decrease. The reduction of GHG emissions thus benefits from a double effect.

A comparative assessment of the consequences of this scenario with the results of the transition scenarios is carried out in Chapter 14 (including not only GHG emissions but also N emissions, the use of PPP and impacts on biodiversity).

Table 100. Contribution of emission sources to GHG emissions in different Belgian livestock sectors in a BAU scenario in 2050.

Sector	Feed[a]	Enteric fermentation	Manure management	TOTAL	
	kt CO2e/year				%
Pork	3.314	229	703	**4.246**	35%
Broilers	808	0	21	**828**	7%
Laying hens	515	0	14	**528**	4%
Dairy	1.752	2.052	426	**4.230**	35%
Bovine meat	737	1.196	300	**2.233**	19%
TOTAL	**7.126**	**3.478**	**1.463**	**12.066**	100%
%	59%	29%	12%	100%	

Note: [a] Includes Luc for soy.

Table 101. GHG emissions from estimated livestock populations in 2050 according to a business as usual scenario, and comparison with 2015 levels.

Sector	GHG emissions 2015	GHG emissions 2050	Delta GHG 2050-2015	Population 2050-2015
	kt CO2e/year	kt CO_2e/year	%	
Pork	4.705	4.246	-10%	+1%
Broilers	766	828	+8%	+20%
Laying hens	587	528	-10%	-7%
Dairy	4.611	4.230	-8%	-3%
Bovine meat	3.252	2.233	-31%	-26%
TOTAL	13.920	12.066	-13%	

Table 102. Average GHG emissions per unit of output in each Belgian livestock sector in a BAU scenario in 2050.

	Unit	2015	BAU 2050	Delta
Pork	kg CO_2e/kg live meat	3,58	3,19	-11%
Broilers	kg CO_2e/kg live meat	2,11	1,91	-10%
Laying hens	kg CO_2e/kg egg	3,57	3,49	-2%
Dairy	kg CO_2e/L	1,32	1,05	-20%
Bovine meat	kg CO_2e/kg carcass	11,70	10,74	-8%
Meat[1]	kg CO_2/kg meat	18,8	16,2	-14%
Protein[2]	kg CO_2/kg protein	46,0	38,3	-17%

Notes:

[1] Includes pork, poultry and bovine meat, after applying slaughter and carcass yields, as well as a waste factor.

[2] Includes all five considered animal products, expressed in terms of protein content after applying slaughter and carcass yields (for meat products) as well as a waste factor.

Chapter 11. National resources scenario: Transition 1

11.1. Guiding principles for the conception of the 'transition' scenarios

The two transition scenarios illustrate a significant change in livestock production, with a multiple perspective: reducing GHG emissions[29], relying on local resources and making organic production more common. In the Transition 1 (T1) scenario, the livestock sectors' production level is shaped by the resources available locally, in particular: a. the available grasslands for pasture; and b. the national cereal production available for animal feed (no imports of cereals for feed). Furthermore, this scenario exclusively considers extensive and organic production systems (see section 11.2 below, as well as Figure 60 and Table 96). Food consumption, environmental consequences and production resulting from this scenario are discussed altogether. The design process of the scenario is illustrated in Figure 67, along with the guiding principles for scenario T2, which is developed in Chapter 12.

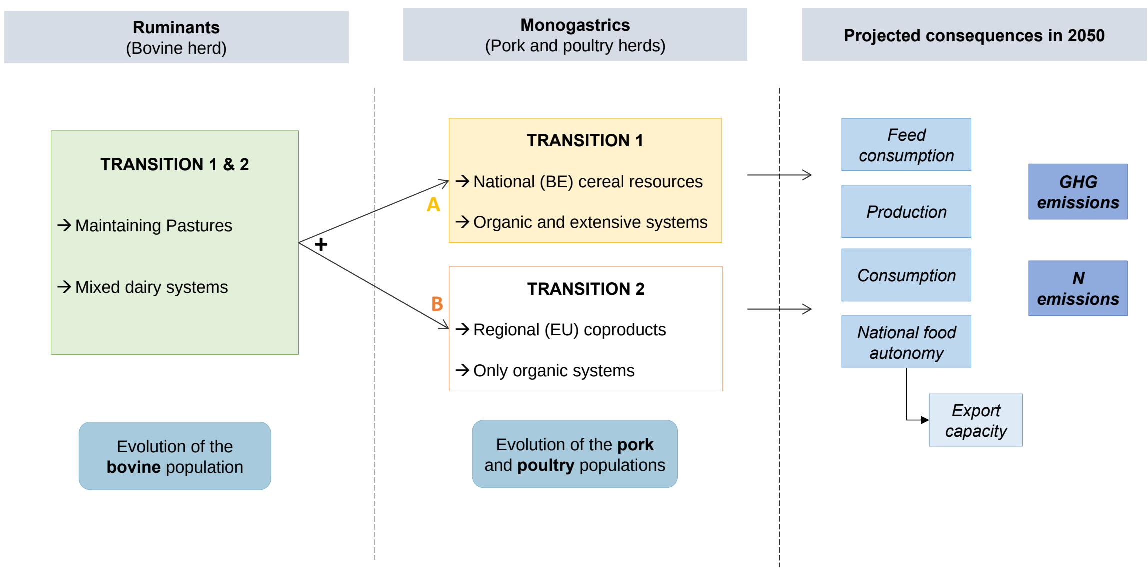

Figure 67. Approach for the design of the transition scenarios.

11.2. Ecological livestock systems in consistency with Greenpeace criteria

11.2.1. General assumptions

This scenario relies only on organic and extensive systems. The choice of systems is based on a series of criteria established by Greenpeace to define ecological livestock. Systems which are consistent with Greenpeace's criteria are favoured, followed by systems which are close to these criteria. The criteria and the consistency assessment are shown in the appendix (Table 185 to Table 190)[30].

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29 The target set by Greenpeace at a global level is to reduce production and consumption of animal products by 50% by 2050, which would lead to a 64% reduction in GHG emissions from the agriculture sector (Figure 98 in the appendix) (Tirado et al., 2018). As a comparison, the French scenario Afterres (Couturier et al., 2016) pursues a 50% reduction of agriculture GHG emissions by 2050.

30 The assessment is made on the basis of the current state of affairs. Nevertheless, it is entirely conceivable that conventional systems might come closer to Greenpeace's criteria in the future (for example, by adjusting their animal welfare standards, source of feed, animal health approach, etc.).

Organic systems are the most consistent with Greenpeace guidelines. Nevertheless, reaching 100% of organic production by 2050 would represent a very significant change[31]. Scenario T1 is therefore designed with a proportion of 30% of organic systems in 2050 which is seen as an ambitious yet realistic target (see Box 4 below). The additional 70% of the production is provided by other extensive systems, which present favourable situations on issues such as animal welfare compared to intensive systems.

Box 4. Share of organic livestock systems: setting an ambitious yet realistic target for the T1 scenario.

Currently, organic systems are a minority (0,1% of pork production, 2% of poultry meat production and 3% of eggs production)[32]. Over the past years, organic production has been growing and would reach – if current trends remain similar – 0,2% of pork production, 3% of poultry meat production and 6% of eggs production in 2050 (Chapter 10). Beyond those trends, the transition scenario aims at illustrating the consequences of a larger development of organic (and extensive) systems.

In order to elaborate an ambitious yet realistic target for organic systems, data about the development of the organic sector in EU countries were analysed on two aspects: (1) The growth rate of organic livestock populations since 2002 in European countries; and (2) The share that has been reached so far (see Table 191 to Table 193 in the appendix). The shares of the livestock population raised under organic standards have increased over the years in all countries but remain below 10% in most of the countries and below 30% in all countries in 2015. The highest shares are: 21% of live bovine (Portugal), 10% of live swine (Denmark and Greece) and 29% of laying hens (Greece). Based on this data, the target is set at 30% of organic systems in 2050[33].

11.2.2. Detailed assumptions for each sector

For pork and poultry meat production, 'organic' and 'differentiated' systems are the more consistent with Greenpeace's criteria. For laying hens, these align best with 'organic' and 'free-range' systems. For dairy production, systems relying on lower use of concentrates and on more important use of pasture and grasslands are more consistent with the criteria (i.e. 'grass extensive', 'grass and crops' and 'grass and maize semi-intensive'). For bovine meat, it is assumed that the production will happen through the slaughtering of dairy cows at the end of their production cycle. Indeed, as it is assumed that the consumption of meat will be lower in this scenario, the demand for it will decrease as well. As a consequence, the use of specialised meat breeds based on suckler cows is thus left behind.

Box 5. Systems selected in the transition scenario:

- **Pork sector**: 'Differentiated' and 'organic' systems (70% and 30% of slaughters);
- **Broiler sector**: 'Differentiated+' and 'organic' systems (70% and 30% of slaughters);
- **Laying hen sector:** 'Free-range' and 'organic' systems (70% and 30% of laying hen);
- **Bovine (dairy) sector:** 'Grass extensive' and 'grass and crops' systems in Wallonia (50% of the herd each); 'Grass and Maize semi-intensive in Flanders.

[31] A scenario based exclusively on organic systems called T2 is presented in Chapter 12.

[32] The share of the systems is expressed in terms of slaughters for pork and poultry meat, and in terms of number of animal stocks for laying hens.

[33] This target is also in line with a similar study carried in Germany by FIBL for Greenpeace (Wirz et al., 2017).

11.3. Production potential based on grassland resources: the bovine sector

In the transition scenario, the size of the bovine herd is calculated from the available grassland resources. As explained above, the production of bovine meat would in this case predominantly come from cull dairy cows which have reached the end of their production cycle. The production of bovine meat through suckler cows and the fattening of their young bulls is left behind.

11.3.1. Available grassland resources and current situation

In 2015, there were 556.223 ha of pastures available in Belgium (Table 103). Over all Belgium, the dairy herd utilised 53% of the total grassland resources in 2015. In Flanders, 75% of the pasture resources are utilised by the dairy herd, whereas in Wallonia, the dairy herd only occupies 38% of the total grassland area (see Table 194 and Table 195 in the appendix for details about the usage of the pastures by the Belgian dairy herd and the total Belgian dairy production).

Table 103. Grassland resources in Flanders, Wallonia and Belgium in 2015.

Region	Permanent pastures	Temporary pastures	Total	Share
	ha	ha	ha	%
Flanders	169.012	50.166	219.178	39%
Wallonia	306.441	30.604	337.046	61%
Total in Belgium	475.452	80.770	556.223	100%

Source: Statistics Belgium (2016).

11.3.2. Milk and meat production potential

In the calculations, it is considered that the current available pasture area is maintained and entirely used by extensive 'mixed' dairy systems.In Flanders, 100% of the herd is composed of Grass and Maize Semi-intensive systems (GM SI). In Wallonia, 50% of the herd is composed of Grass Extensive systems, the remaining 50% is composed of Grass and Cultures (G&C) systems (see Chapter 6)[34].

In terms of animal population, the number of milk-producing cows would increase compared with 2015 (+36%). The milk production would increase too (+15%), but to a lesser extent given that the remaining mixed systems are less productive[35] (Table 104). The total population of cows (dairy and suckler cows) would decrease by 24% due to the disappearance of specialised suckler cow systems.

In this "all-dairy" scenario, there would be no meat production from young bulls coming from suckler cow systems. The slaughters of cows would be lower too as there would be no old suckler cows to slaughter. Overall, this would result in a 50% decrease in terms of bovine meat production (

Table *105*). It must be mentioned that animals selected for meat have higher slaughter and carcass yields than specialised dairy cows. As the results presented here do not account for this difference, it is possible that the figures overestimate the meat production potential in such a scenario. Nevertheless, as this scenario focuses on the use of double-purpose breeds, which are not selected for one single production, this difference will be minimised.

[34] These systems were selected because their productivity levels correspond to what can be expected for dual-purpose breeds. In Flanders, it was not considered realistic to work with systems without maize.
[35] The lower productivity of extensive systems is largely compensated by the increase in the dairy herd.

Table 104. Milk production potential based exclusively on extensive systems and on the total pasture area.

Region	Maintained pasture area	Herd size	Delta 2015	Production	Delta 2015
	ha	Dairy Cows	%	mo L/year	%
Flanders	219.178	337.196	+11%	18.32	-38%
Wallonia	337.046	351.089	+73%	2.212	+56%
Belgium	556.223	688.286	+36%	4.044	+15%

Table 105. Meat production in an "all-dairy" scenario.

Animal type	2015 [1]		"All-dairy"		Delta 2015 [1]
	No slaughters	Weight (kg)	No slaughters	Weight (kg)	%
Veals	353.474	57.129.871	479.742	77.537.798	+36%
Young bovine	9.294	1.817.930	12.614	2.467.331	+36%
Beef	1.171	452.327	0	0	-100%
Bulls	166.823	79.027.742	0	0	-100%
Cows	332.106	126.668.254	132.492	50.533.567	-60%
Heiffers	9.680	2.781.331	13.138	3.774.878	+36%
TOTAL		267.877.455		**134.313.574**	-50%

Source: [1] Statistics Belgium (2017).
Note: [1] The difference is calculated in terms of slaughter weight.

11.4. Production potential based on cereal resources: the pork and poultry sectors

The production potential of pigs, broilers and laying hens is estimated based on the Belgian production of cereals, as these are essential ingredients in animal feed (they represent more than 50% in pork and poultry feeds – see Table 13, Table 25 and Table 35 for typical pig, laying hen and broiler feeds).

11.4.1. Cereals production and consumption

Currently, the consumption of cereals by the pork, poultry and bovine sectors is estimated at 3.717 kt per year (of which 72% is consumed by the pork sector, 20% by the poultry sectors and 8% by the bovine sectors; see Table 75). At the same time, the national production of cereals amounted 3.283 kt in 2015, of which 62% (2.048 kt) was used for animal feed. The Belgian cereal production thus covers 55% of the cereal needs of the livestock sector (see Table 76 and Table 77 in section 8.2).

The Transition 1 scenario seeks reaching national autonomy in terms of cereals for animal feed. To reach this objective, the surfaces dedicated to cereals for feed should either be increased or the livestock population should be decreased. In order to avoid further food-feed competition, the scenario focuses on this second possibility.

In addition, in order to remain consistent with the scenario's objectives, the production of cereals in the T1 scenario should be achieved with a larger share of organic cereals compared with 2015. According to a scenario developed for the Walloon cereal sector (Antier et al., 2017), a significant shift in practices could be obtained with 42% of the cereal area under organic practices[36].

[36] See 'Transition 2' scenario in (Antier et al., 2017). The results of this scenario developed for the Walloon region are here extrapolated to Belgium as a whole.

In such a scenario, because of the lower average yields of organic production, the total cereal production in 2050 would decrease by 15% compared with 2015 and reach 2.790 kt. Assuming that the same share as in 2015 is destined for animal feed (62%), this would leave an amount of 1.741 kt cereals available for livestock feed in 2050. This is summarised in Table 106. This configuration does however not allow for a sufficient production of cereals to cover national demand of cereals for food (see section 14.3).

Table 106. Self-sufficiency of Belgian cereals for the livestock sector (total cereal production, share destined for the livestock sector and total consumption by the livestock sector) in the current situation and in the T1 scenario.

Parameter	Unit	2015	Transition 1 2050
Share of organic practices	% cereal area	3%	42%[1]
Total Belgian cereal production	kt/year	3.283	2.790
Delta of production vs. 2015	*%*	-	*-15%*
Share of Belgian cereals used for animal feed	%	62%	62%[2]
Belgian cereals used/available for animal feed	kt/year	2.048	1.741
Delta vs. 2015	*%*	-	*-15%*
Total cereal consumption by the livestock sector	kt/year	3.717	1.741[3]
Delta vs. 2015	*%*	-	*-53%*
Self-sufficiency of cereals for animal feed	%	55%	100%[3]

Notes:
[1] As per a transition scenario based on organic and extensive systems for the cereal sector (Antier et al., 2017);
[2] As per the current situation (see Table 76);
[3] In the scenario, the availability of cereals for animal feed determines the size of the herds.

11.4.2. Sizes of livestock populations

In order to assess the sizes of the pig, broiler and laying hen populations, this amount of cereals is assigned to pigs, broilers, laying hens and cattle with the same proportions as in 2015 (72% consumed by the pork sector, 20% by the poultry sectors and 8% by the bovine sectors; see Table 75). As a result, 1.252 kt of cereals are available for the pork sector, 191 kt for the broiler sector, 110 kt for the laying hen sector (and an additional 55 kt for the reproductive birds) and 132 kt for the mixed dairy herd (Table 107).

Based on the previous section, the sizes of the livestock populations that can be fed with the national available cereal resources are then calculated. As announced in section 11.2, only organic and extensive production systems are considered (see Box 5). Table 108 shows the impacts on production levels for each sector in such a scenario. Section 11.6.1 explains these consequences on production in more detail.

Table 107. Shares of cereals available for each livestock sector in 2050 in T1 scenario.

Sector	Share of total [1]	Cereals available for the livestock sector in 2050 in T1 scenario
	%	kt cereals/year
TOTAL	**100%**	1.741
Productive pork animals	63%	1.088
Reproductive pork animals	9%	164
Broilers	11%	191
Laying hens	6%	110
Other poultry	3%	55
Bovine [2]	8%	132

Notes:

[1] The shares of the total cereal consumption attributed to each livestock sector in 2050 was considered the same in 2050 as in 2015 (72% for the pork sector, 20% for the poultry sectors and 8% for the bovine sectors).

[2] The amount of cereals made available for the bovine sector is consistent with the size of the mixed dairy herd which was calculated based on the available grassland resources in Section 11.3.1.

Table 108. Comparison of pork, broiler and laying hen production levels in 2015 under the T1 scenario in 2050.

Step	Unit	Current 2015	Transition 1 2050	Delta
Pig population	no animals	6.364.164	2.341.876	-63%
Pig slaughters	no animals	11.886.693	4.374.048	-63%
Pork production	kt live weight	1.312	525	-60%
	kt carcass weight	1.037	415	-60%
Broilers population	no animals	23.838.182	7.206.922	-70%
Broiler slaughters	no animals	164.483.456	49.727.762	-70%
Broiler meat production	kt live weight	363	119	-67%
	kt carcass weight	261	86	-67%
Laying hen population	no animals	8.109.466	3.557.827	-56%
Egg production	kt egg	164	71	-57%

11.5. Implications in terms of protein sources for animal feed

The sizes of the pork and poultry populations were established based on the cereal intakes of the considered production systems and the available Belgian cereals (see 11.4.2.). However, it is also interesting to look at the availability and consumption of protein sources in the scenario as these constitute equally important ingredients in animal feeds.

In particular, given the significant reductions of the livestock populations, it is interesting to assess to what extent this scenario offers a possibility to decrease or even entirely avoid the use of controversial protein sources such as soybean meal or palm oil meal (given their high environmental impact compared to other protein sources such as rapeseed meal or sunflower meal; see Table 165).

In 2015, the calculated protein needs (protein-rich and olea/proteaginous ingredients) for the livestock sector (pork, poultry and bovine sectors) amounted 2.233 kt of feed ingredients (of which 995 kt of soybean meal ; see Table 78 in 8.3.1). In the Transition 1 scenario, the protein needs amount 1.182 kt (Table 109), of which 36% for the pork sector, 11% for poultry sectors and 53% for bovine sector.

As presented in 8.3.1, the BFA estimates that half of the Belgian protein sources for animal feed are from Belgian or EU-origin and hence soybean free, as this ingredient is considered to come almost exclusively from South America (Actor interviews, 2018). This represents 1.384 kt of protein-rich feed ingredients from Belgian/EU-origin (of which 1.282 kt come from coproducts; Table 80), which is sufficient to meet the protein needs of the livestock sector in the Transition 1 scenario (1.182 kt).

It is thus realistic to consider that the animal feed protein needs in this scenario could be covered exclusively by Belgian/EU origin protein sources (such as rapeseed meal, sunflower meal, etc.) and hence be soybean-free (Table 109). However, moving away from soybean meal, it is important to highlight that all protein sources do not necessarily have the same nutritional value (e.g. in terms of protein content). Replacing soybean meal by other protein-rich feed ingredients might thus not be possible on a 1 for 1 basis. This factor was considered in the development of the Transition 1 scenario; see Box 6 below for further information.

Box 6. Replacement of soybean meal by other protein-rich feed ingredients

1. Assessing the replacement rate (conversion factor)

On the one hand, soybean meal has a relatively higher protein content compared to most alternative protein sources (e.g. soybean meal has a protein content of about 45% vs. about 35% for rapeseed meal). On the other hand, although some protein sources have higher protein contents (e.g. 80% for wheat gluten meal or 60% for maize gluten meal), these protein sources have less complete amino acid profiles (less lysine in particular) (BFA, 2017).

For these reasons, replacing soybean meal by alternative protein sources is not always possible on a 1 for 1 basis. A conversion factor was thus considered in the calculations. On the basis of the main available alternative protein sources (mainly rapeseed meal and sunflower meal), this conversion factor was estimated at 70% (i.e. for 0,7 kg of soybean meal, 1 kg of alternative protein source is needed). Taking this factor into account to replace soybean meal in the T1 scenario, the needs for protein-rich feed ingredients of the scenario rise to 1.351 kt of protein sources[37], which can still be met by the 1.384 kt of EU/BE origin. Replacing soybean meal is thus possible but it leads to an increase of the feed volume for the livestock sector.

2. Assessing environmental consequences

The replacement of soybean meal by alternative protein sources has an impact on the environmental consequences of the livestock sector (particularly its GHG emissions).

In the calculations, the emissions related to the replacement of soybean meal by alternative protein sources were attributed to sunflower meal as a proxy. This ingredient was chosen over rapeseed meal because out of the two ingredients which are likely to be the main replacements for soybean meal, sunflower meal has a higher impact (see Table 165). This is thus a conservative hypothesis.

[37] Assuming no change in the livestock feeds, the needs for protein-rich feed ingredients of the T1 scenario amount 1.182 kt, of which 394 kt of soybean meal. However, considering a 70% replacement rate, these 394 kt of soybean meal could be replaced by 563 kt of alternative protein sources, which represents an increase of 169 kt of protein-rich feed ingredients. In a soybean-free case, the total needs for protein-rich animal feed thus rise to 1.351 kt.

Table 109. Consumption of protein-rich feed by livestock in 2015 (according to this study and other sources) and in Transition 1 in 2050.

Parameter	Unit	2015	T1 2050
Needs of protein-rich ingredients	Kt/year	2.233	1.182[1]
Available amount of protein-rich feed from BE/EU origin	Kt/year	1.384	1.384
Reliance on protein imports from outside EU (e.g. soy)	-	Yes	No

Note: [1] This figure does not yet consider the replacement of soybean meal by other protein sources. Considering a conversion factor of 70% for soybean meal vs. alternative protein sources, the figures rises to 1.351 kt, which can still be met by the available amounts of protein-rich feed from BE/EU origin (see Box 6).

11.6. Consequences of the transition 1 scenario: production, GHG emissions and consumption

11.6.1. Impacts on production

In the transition 1 scenario, all productions are more than halved compared to 2015 levels, except for the production of milk (Table 110). In particular, the production of poultry meat through broilers is greatly affected (-68-7%), followed by the production of pork (-60%), the production of eggs (-57%) and the production of bovine meat (-50%). It should be noted that for the production of poultry meat, only broilers are considered. Nevertheless, laying hens which are slaughtered at the end of their cycle also contribute to this production.

Table 110. Production of animal products in the Transition 1 scenario, and comparison with 2015.

Production	Unit	Present 2015	T1 2050	Delta (%)
Milk	mo L	3.527	4.044	+15%
Bovine meat	kt carcass	268	134	-50%
Pork	kt carcass	1.037	415	-60%
Poultry meat. (from broilers)	kt carcass	261	86	-67%
Eggs	kt eggs	164	71	-57%

11.6.2. Environmental impacts

In terms of GHG emissions, the biggest emitter is the mixed dairy sector, which represents 73% of total emissions in such a scenario, followed by the pork sector (22% of total). The poultry sectors represent 6% of total emissions together (Table 111). Compared to 2015, such a scenario would result in a significant decrease (-48% in 2050 vs. 2015) in the emissions occurring in the livestock sector (Table 112).

Expressed per unit of output, as a result of the technological improvements and the abandoning of soybean meal, the emissions per unit of output decrease substantially for the pork, broiler and laying sectors and remain rather stable for the dairy sector compared to 2015 (Table 113).

The assessment of other environmental impacts (including N emissions, Biodiversity impacts and PPP use) is carried out in Chapter 14, with a comparison with the results from other scenarios.

Table 111. GHG emissions of the Belgian livestock sector in 2050 resulting from the Transition 1 scenario.

Sector	Feed [a]	Enteric fermentation	Manure	TOTAL	
	kt CO2e/year				%
Pork	1.186	95	292	**1.572**	22%
Broilers	215	0	10	**225**	3%
Laying hens	175	0	7	**182**	3%
Mixed dairy	1.813	2.881	560	**5.253**	73%
Bovine meat	0	0	0	**0**	0%
TOTAL	**3.388**	**2.975**	**868**	**7.231**	100%
%	47%	41%	12%	100%	

Note: [a] This scenario considers a replacement of soybean meal by alternative protein sources, which leads to an increase in total feed consumption but lower environmental imapcts (see Section 11.5).

Table 112. GHG emissions from the livestock sector in the Transition scenario, and comparison to 2015 levels.

Sector	Present 2015	Transition 2050	Delta
	kt CO2e/year		%
Pork	4.705	1.572	-67%
Broilers	766	225	-71%
Laying hens	587	182	-69%
Dairy	4.611	5.253	+14%
Bovine meat [1]	3.252	0	-100%
TOTAL	13.920	7.231	-48%

Note: The specialised bovine meat herd has disappeared in Transition 1 and is replaced by a mixed dairy herd, which concentrates the entirety of the bovine sector's emissions.

Table 113. Average GHG emissions per unit of output in each Belgian livestock sector in a BAU scenario in 2050.

	Unit	2015	Transition 1 2050	Delta
Pork	kg CO2e/kg live meat	3,58	2,99	-16%
Broilers	kg CO2e/kg live meat	2,11	1,88	-11%
Laying hens	kg CO2e/kg egg	3,57	2,57	-28%
Dairy	kg CO2e/L	1,31	1,30	-1%
Bovine meat [1]	kg CO2e/kg carcass	12,14	0	-100%

Note: The specialised bovine meat herd has disappeared in Transition 1 and is replaced by a mixed dairy herd, which concentrates the entirety of the bovine sector's emissions. The 0 emissions for the bovine meat sector is explained by the fact that all the emissions are allocated to the production of milk.

11.6.3. Impacts on consumption

The T1 scenario implies significant drops in terms of production levels compared to 2015. Additional calculations allow to express the production levels shown above in terms of consumption potentials of the scenario. These are obtained after applying slaughter and carcass yields to the live weight meat results obtained previously. A 'losses' factor which accounts for potential losses and waste across the food chain is applied too. As presented in earlier chapters, this factor was estimated to 25%. The per capita results also account for the projected growth in the Belgian population.

In this scenario, the consumption of meat amounts 65 g meat/cap/day (pork, poultry and bovine meat). The total consumption potential of animal derived protein amounts 40 g protein/cap/day (Table 114). A more detailed analysis of the consumption possibilities of this scenario under different consumption patterns is presented in Chapter 13 and section 14.1.2.

Table 114. Consumption potential of animal products in the Transition 1 scenario.

Animal product	Carcass meat	Unboned meat	Consumed product			Protein
	kt carcass	kt meat	kt consumed	kg/cap/ year	g/cap/ day	g prot/ cap/day
Bovine meat	134	94	70	6	15	4
Pork	415	243	183	14	39	10
Poultry meat	86	62	47	4	10	3
Eggs	-	-	53	4	11	1
Milk	-	-	3.041	239	654	22
TOTAL	-	-	-	-	-	40
- *Of which meat*	635	399	300	24	65	17

Notes:
Accounts for predicted population growth. Belgian population in 2050: 12.736.357 inhabitants (Statistics Belgium, 2018).

Chapter 12. Low-cost livestock and 100% organic scenario: Transition 2

12.1. Guiding principles for the conception of the scenario

The second transition (T2) scenario was designed in order to follow as closely as possible Greenpeace's eight criteria which define ecological livestock (see Table 185 to Table 190 in Appendix 15). As a consequence, the scenario was built around two main aspects:

(a) The use of organic systems:

Among the systems which were described in previous chapters, organic systems are the ones which fit the best Greenpeace's criteria: they perform better in terms of animal welfare; they do not rely on the use of synthetic pesticides and fertilisers and they do not use GMO-feed.

(b) The use of regionally sourced coproducts as feed:

The conceptual framework which was followed for this scenario is the one which is exposed in Van Zanten et al. (2018) in which the authors argue for low-cost livestock systems. In such a scenario, livestock is fed exclusively with low-opportunity cost feedstuff, i.e. biomass which does not result in a food-feed competition, such as grassland, leftovers, crop residues, coproducts, etc. The authors reviewed several studies which adopted this approach and found that the production potential could range between 7-30g animal source protein/capita/day if such a scenario was applied worldwide (see Table 124) (Van Zanten et al., 2018).

In the present scenario, the size of the bovine herd was assessed assuming a mixed dairy herd, the size of which was estimated based on the available grassland resources (similarly as was done in the T1 scenario; see Section 11.3). Regarding the bovine herd, T1 and T2 thus share the same results.

The sizes of the pork and poultry populations were estimated based on the available coproduct resources, as explained in the next paragraphs. Similarly to Transition 1, the objective is to rely on regional resources. Nevertheless, while Transition 1 was designed based on cereals available for feed at a national level, T2 is designed based on coproducts available at the EU level. In addition to national sources of coproducts, the import of EU-origin coproducts in Belgium was thus considered too for the design of this scenario. The choice to include EU-origin coproducts is mainly because there is no available data to estimate the exact share of coproducts specifically produced in Belgium. Nevertheless, setting the boundary at the EU-level already allows for important considerations. Indeed, highly debated feed ingredients such as soybean meal come almost exclusively from South America. Leaving this feed ingredient behind and replacing it by EU-origin ingredients such as rapeseed meal or sunflower meal can thus represent an opportunity to avoid the environmental consequences associated with soybean in South America, as well as pursuing protein autonomy at EU level.

In the Transition 2 scenario, the livestock populations were thus estimated using the technical parameters of organic production systems and data on available coproducts as feed sources. The results were then compared to the ones found in Van Zanten et al. (2018), that serves here as a reference study. Figure 67 in Chapter 11 illustrates the conceptual differences between both transition scenarios.

12.2. Available regional coproducts

As presented in Section 8.3.1, data from the BFA shows that of the 7.180 kt of feed produced in Belgium in 2015, 6.749 kt were destined for the pork, poultry and bovine sectors (Table 79). The rationale for this scenario is to assess the production potential of a low-cost livestock scenario based on organic livestock and the use of local (BE/EU) coproducts. Hence, a focus on these ingredients shows that the pork, poultry and bovine sectors used 3.442 kt of coproducts in 2015, of which 1.721 kt (50%) are from BE/EU origin. Of these 439 kt are considered as cereal equivalents and 1.248 kt[38] are considered as protein sources (see Figure 68 and Table 80).

These available EU coproducts were used to assess the sizes of the livestock populations in the Transition 2 scenario. Two assessments were carried out:

- The first one is based on the available cereal-equivalent coproducts (439 kt) and the cereal consumption level of organic production systems;
- The other one is based on the available protein source coproducts (1.248 kt) and the consumption levels of protein-rich feed ingredients in organic systems.

As already explained, the size of the bovine herd in this scenario was determined based on the available grassland resources (section 11.3). Nevertheless, in each assessment, a share of coproducts was attributed to the bovine herd in order to make sure that their feeding requirements are met.

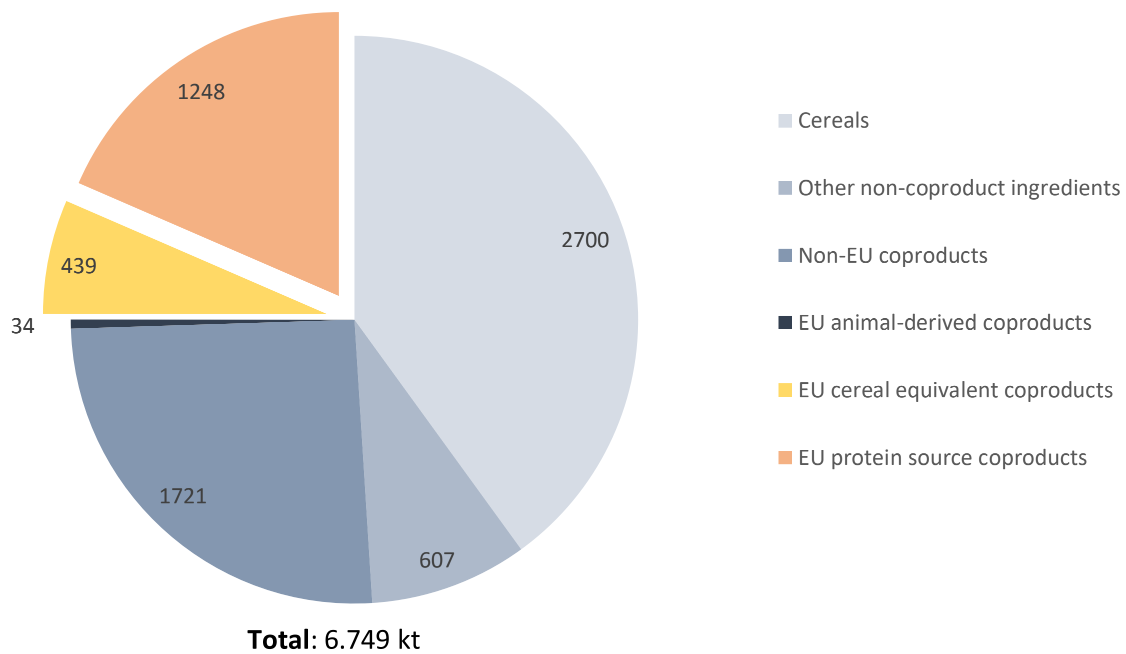

Figure 68. Feed consumption by the pork, poultry and bovine sectors in 2015 and cereal equivalent coproducts and protein source coproducts available for the T2 scenario according to BFA data (in kt).
Source: (BFA, 2016)

[38] This amount (1.248 kt) is slightly different from the 1.282 kt present in Table 80 because animal-derived coproducts (which represented 34 kt in 2015) were not considered in this context, in order to be in line with Greenpeace's criteria. It must be noted that coproducts from the biofuel industry were included.

12.3. Production potential of low-cost livestock based on available coproducts

The production potentials are assessed first according to the available Belgian/EU cereal-equivalent coproducts (439 kt) and then according to the available protein-source coproducts (1.248 kt).

It is important to note that the calculations are based on 2015 coproduct levels. However, in an attempt to seek more sustainable feed sources, one could assume that the use of coproducts for animal feed will increase in the future. The numbers used here might thus be an underestimation of the actual level of coproducts use in 2050. Another element to consider is that the coproducts considered here are not necessarily organic. Yet, as mentioned earlier, only organic livestock systems are selected for this scenario. Hence, the level of coproducts used for the calculations might be an overestimation of the amounts of organic coproducts which will be available in 2050. As these two elements might balance each other out, no specific assumptions were made regarding the evolution of conventional and organic coproducts towards 2050, but these elements are important to keep in mind.

12.3.1. Production potential based on cereal equivalents.

The available cereal-equivalent coproducts of national and EU origin amounted 439 kt in 2015, as presented in Figure 68. A share of this amount is attributed to each livestock sector in the same proportions as in 2015 and taking into account the size of the bovine herd which was determined based on the grassland resources (Table 115). Based on these figures and the cereal consumption levels of organic production systems (determined in Chapters 4.2, 5.2 and 5.3), one can calculate the potential livestock populations and the resulting production.

It appears quite clearly that such a scenario would result in important decreases in pig and poultry populations. Productions would be similarly affected, with a decrease of about 90% for all sectors compared with 2015 levels (Table 116).

Table 115. Shares of cereal equivalent coproducts available for each livestock sector in 2050 in T2 scenario.

Sector	Share of total [1]	Cereal equivalent coproducts available for the livestock sector in T2 2050
	%	kt/year
TOTAL	**100%**	439
Productive pork animals	63%	248
Reproductive pork animals	9%	37
Broilers	11%	44
Laying hens	6%	25
Other poultry	3%	13
Bovine [2]	8%	72

Notes:

[1] The shares of the total cereal equivalent coproducts consumption attributed to each livestock sector in 2050 was considered the same as in 2015 (72% for the pork sector, 20% for the poultry sectors and 8% for the bovine sectors) but taking into account the cereal needs of the mixed dairy herd.

[2] The amount of cereal equivalent coproducts made available for the bovine sector is consistent with the size of the mixed dairy herd which was calculated based on the available grassland resources in Section 11.3.1.

Table 116. Pork and poultry production potentials based on the use of cereal-equivalent coproducts (T2 scenario).

	Unit	2015	Transition 2 2050	Delta 2015
Pork	Slaughters	11.886.693	1.038.186	**-91%**
	kt live weight	1.312	125	-91%
Broilers	Slaughters	164.483.456	11.939.531	-93%
	kt live weight	363	29	-92%
Laying hens	Hen population	8.109.466	811.106	-90%
	kt egg	164	16	-90%

Note: all animals are raised in organic systems in Transition 2.

12.3.2. Production potential based on protein sources.

The available protein-source coproducts of national and EU origin amounted 1.248 kt in 2015, as presented in Figure 68. A share of this amount is attributed to each livestock sector in the same proportions as in 2015 and taking into account the size of the bovine herd which was determined based on the grassland resources (Table 117). Based on these figures and the protein-rich feed consumption levels of organic production systems (determined in Chapters 4.2, 5.2 and 5.3), one can calculate the potential livestock populations and the resulting production.

Compared to the assessment based on cereal equivalents, Table 118 shows that populations and production levels would decrease too (ranging between -58% and -72% compared to 2015), but less significantly than in the previous case.

Comparing the two assessments, it appears that the availability of cereal-equivalent coproducts is the limiting factor to feed the considered livestock sectors with coproducts (whereas the availability of protein-rich coproducts is higher)[39].

Table 117. Shares of protein-source coproducts available for each livestock sector in 2050 in T2 scenario.

Sector	**Share of total [1]**	**Protein-source coproducts available for the livestock sector in T2 2050**
	%	kt/year
TOTAL	**100%**	1.248
Productive pork animals	40%	510
Reproductive pork animals	6%	77
Broilers	8%	105
Laying hens	3%	47
Other poultry	2%	23
Bovine	42%	486

Notes: [1] The shares of the total protein-source coproducts consumption attributed to each livestock sector in 2050 was considered the same as in 2015.

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[39] Less animals can be raised based on cereal-equivalent coproducts than based on protein-source coproducts. As a consequence, designing a scenario based on the latter option would lead to a food-feed competition given that there would not be enough cereal equivalent coproducts to feed the entire livestock population. Additional cereal resources should then be mobilised. An intermediate situation could be imagined in which cereal-equivalent coproducts are complemented by a small share of the national cereals production. This seems achievable as national human consumption needs could be met with 56% of the total cereals in a 100% organic cereals scenario (see Section 14.3.2).

Table 118. Pork and poultry production potentials based on the use of protein-rich coproducts (T2 scenario).

	Unit	2015	Transition 2 2050	Delta 2015
Pork	Slaughters	11.886.693	4.089.935	-66%
	kt live weight	1.312	491	-63%
Broilers	Slaughters	164.483.456	45.401.662	-72%
	kt live weight	363	109	-70%
Laying hens	Hen population	8.109.466	3.385.857	-58%
	kt egg	164	66	-60%

Note: all animals are raised in organic systems in Transition 2.

12.4. Consequence on consumption levels

12.4.1. Consumption potential

Additional calculations allow to express the production levels shown above in terms of consumption potentials, for both coproducts scenarios (based on cereal-equivalent coproducts in Table 119 and protein-source coproducts in Table 120). These consumption potentials are obtained after applying slaughter and carcass yields to the live weight meat results obtained previously. A waste factor which accounts for potential losses and waste across the food chain is applied too. As presented in earlier chapters, this factor was estimated to 25% [40]. The per capita results also account for the projected growth in the Belgian population (estimated to be 12.736.357 inhabitants in 2050 according to Statistics Belgium (2018)).

The results confirm that the cereal-equivalent coproducts are limiting compared to protein-source coproducts as the consumption potential is higher in the latter case: 39 g animal protein/capita/day compared to 29 g animal protein/capita/day in the cereal-equivalent case. The importance of the bovine herd in such a scenario is non-negligible as in both cases it provides 26 g protein/capita/day (Table 119 and Table 120). This potential could meet a substantial share of our daily protein needs, which range between 52-62g per capita (Conseil Supérieur de la Santé, 2016).

A more detailed analysis of the consumption possibilities of this scenario under different consumption patterns is presented in Chapter 13 and section 14.1.2.

Table 119. Consumption potential of a low-cost livestock scenario (T2) based on cereal-equivalent coproducts.

Animal product	Carcass meat	Unboned meat	Consumed product			Protein
	kt carcass	kt meat	kt consumed	kg/cap/ year	g/cap/ day	g prot/ cap/day
Bovine meat	134	94	70	6	15	4
Pork	98	58	43	3	9	2
Poultry meat	21	15	11	1	2	1
Eggs	-	-	12	1	3	0,3
Milk	-	-	3041	239	654	22
TOTAL	-	-	-	-	-	29
- Of which meat	253	166	125	10	27	7

[40] According to some experts, it is assumed there are less losses when working with organic systems. Applying a 25% factor might thus be overestimation in this case, which could result in an underestimated consumption level.

Table 120. Consumption potential of a low-cost livestock scenario (T2) based on protein-rich coproducts.

Animal product	Carcass meat	Unboned meat	Consumed product			Protein
	kt carcass	kt meat	kt consumed	kg/cap/ year	g/cap/ day	g prot/ cap/day
Bovine meat	134	94	70	6	15	4
Pork	388	228	171	13	37	10
Poultry meat	78	57	43	3	9	3
Eggs	-	-	49	4	11	1
Milk	-	-	3041	239	654	22
TOTAL	-	-	-	-	-	39
- of which meat	600	378	284	22	61	16

12.4.2. Comparison with other sources and way forward

Table 124 shows the review of studies adopting a similar 'low-cost livestock' approach carried out by Van Zanten et al. (2018), with the inclusion of the present study's results. Compared to previous studies, the results found here are on the higher end of the range (Figure 69). The results come closest to the ones found by (Röös et al., 2017a, 2017b), which are based on the situation in Western Europe.

As the objective of this scenario is to assess the outcomes of a livestock sector relying exclusively on coproducts, the following calculations were realised assuming the lower estimate, i.e. the cereal-equivalent scenario resulting in a potential consumption level of 29 g animal protein/capita/day. Indeed, although the production potential based on protein-source coproducts is higher, the available cereal-equivalent coproducts are not sufficient to meet the cereal needs of the livestock population in such case. In this situation, a certain share of the cereal production would thus still need to be used as animal feed, resulting in a food-feed competition situation. On the contrary, using the cereal-equivalent case means there would be an excess of protein-source coproducts. Nevertheless, as these are of EU origin, they could still be used in other member states and it would give a greater chance to Belgium to be self-sufficient on that aspect as well.

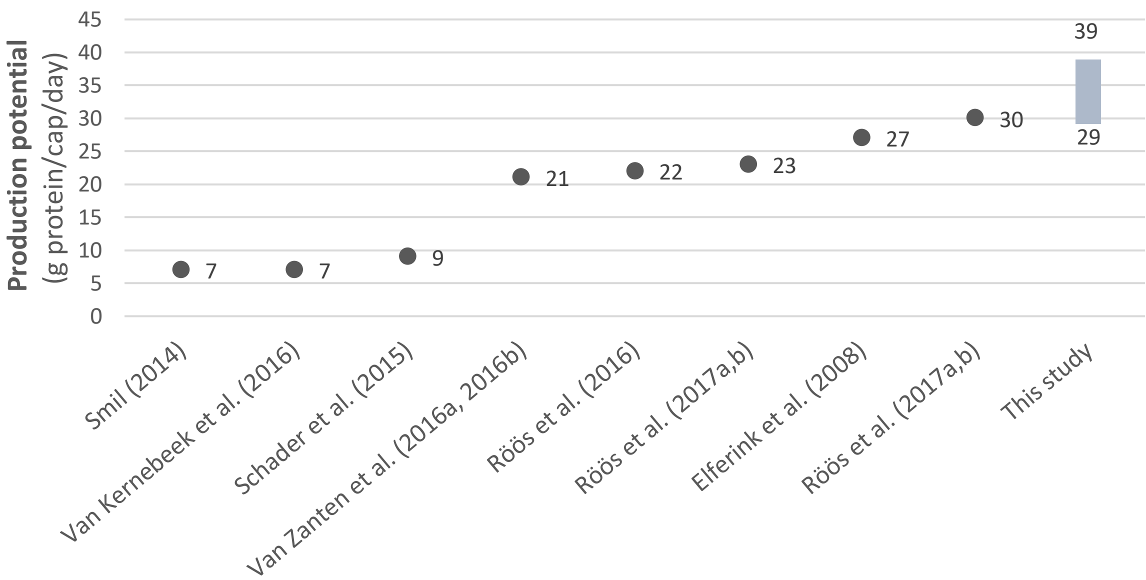

Figure 69. Comparison of production potentials for low-cost livestock systems according to several studies.
Note: Based on Van Zanten et al. (2018), see Table 124 for further information on the scope of each study, etc.

12.5. Environmental consequences of a low-cost livestock scenario

Looking at GHG emissions in such a scenario, it appears that the vast majority of these emissions (92%) are concentrated in the bovine sector (Table 121). This is coherent with the fact that the bovine sector is the one which provides the majority of animal protein in such a scenario.

Compared with 2015 emissions levels, Transition 2 results in a significant reduction of 59% of the livestock sector's GHG emissions (Table 122). Large decreases of about 90% are observed for the pork and poultry sectors, but these are partially compensated by the important emissions of the mixed bovine herd. Nevertheless, when the entire bovine sector is considered, there is a 33% decrease in its total emissions (7.863 kt CO_2e in 2015 vs. 5.276 kt CO_2e in 2050).

The assessment of other environmental impacts (including N emissions, Biodiversity impacts and PPP use) is carried out in Chapter 14, with a comparison with the results from other scenarios.

Table 121. GHG emissions resulting from a coproduct livestock scenario (Transition 2) and share of emissions sources.

Sector	Feed[a]	Enteric fermentation	Manure	TOTAL	Share of sector
	kt CO2e/year				%
Pork	280	22	69	**371**	6%
Broilers	55	0	1	**56**	1%
Laying hens	41	0	2	**43**	1%
Mixed dairy	1.836	2.881	560	**5.276**	92%
Bovine meat	0	0	0	**0**	0
TOTAL	**2.212**	**2.903**	**632**	**5.747**	100%
%	38%	51%	11%	100%	

Note: [a] Because this scenario relies on EU/BE-origin coproducts, no soybean meal is used for feed. Implications in terms of replacement and environmental impacts are explained in the Box 6 in Section 11.5.

Table 122. Comparison of GHG emissions in the Transition 2 scenario with 2015 levels.

Sector	2015	'Transition 2' 2050	Delta
	kt CO2e/year		%
Pork	4.705	371	-92%
Broilers	766	56	-93%
Laying hens	587	43	-93%
Mixed dairy	4.611	5.276	+14%
Bovine meat [1]	3.252	0	-100%
TOTAL	13.850	5.747	-59%

Note: [1] In Transition 2 only a mixed dairy herd is considered. All the emissions of the bovine sector are allocated to the production of milk, explaining the 0 value for bovine meat.

Table 123. GHG emissions of the livestock sector in Belgium in 2050 per unit of output in Transition 2 scenario.

	Unit	2015	Transition 2 2050	Delta
Pork	kg CO2e/kg live meat	3,58	2,98	-17%
Broilers	kg CO2e/kg live meat	2,11	1,97	-7%
Laying hens	kg CO2e/kg egg	3,57	2,72	-24%
Dairy	kg CO2e/L	1,31	1,30	-1%
Bovine meat [1]	kg CO2e/kg carcass	12,14	0	-100%

Note: [1] In Transition 2 only a mixed dairy herd is considered. All the emissions of the bovine sector are allocated to the production of milk, explaining the 0 value for bovine meat.

Table 124. Review of studies by Van Zanten et al. (2018) adopting a 'low-cost livestock' approach, their associated production potentials and comparison with this study. Adapted from Van Zanten et al. (2018).

Article	Scale	Input - Leftover stream				Output - Animal source food		
		Co-product	Food waste	Grass-land	Crop-residue	Product	g/cap/day	g prot/cap/day
Smil (2014)	Global	x		x	x	Pork	12	2
						Beef	9	2
						Poultry	14	3
						TOTAL	**-**	**7**
Van Kernebeek et al. (2016)	Netherlands	x	x	x	x	Beef	2	0
						Milk	208	6
						TOTAL	**-**	**7**
Schader et al. (2015)	Global	x		x	x	Pork	19	4
						Beef	7	1
						Milk	138	4
						Egg	2	0
						TOTAL	**-**	**9**
Van Zanten et al., (2016a, 2016b)	Global	x	x	x		Pork	72	14
						Beef	27	15
						Milk	49	2
						TOTAL	**-**	**21**
Röös et al. (2016)	Sweden	x		x		Pork	46	9
						Beef	10	2
						Milk	257	8
						Poultry	26	3
						TOTAL	**-**	**22**
Röös et al. (2017a, 2017b)	Global	x	x	x		Pork	26	5
						Beef	51	10
						Milk	275	8
						TOTAL	**-**	**23**
Elferink et al. (2008)	Netherlands	x				Pork	135	27
						TOTAL	**-**	**27**
Röös et al. (2017a, 2017b)	Western Europe	x	x	x		Pork	22	4
						Beef	55	10
						Milk	519	16
						TOTAL	**-**	**30**
This study	**Belgium**	**x**		**x**		**Pork**	**9-37**	**2-10**
						Beef	**15**	**4**
						Poultry	**2-9**	**1-3**
						Milk	**654**	**22**
						Egg	**3-11**	**0-1**
						TOTAL	**-**	**29-40**

Chapter 13. Evolution of consumption patterns towards 2050

In order to account for possible changes in consumption patterns along time, the evolution in the consumption of meat and other animal products was considered according to different patterns in the scenarios.

13.1. Evolution of consumption patterns according to trends

The consumption of meat and other animal products has shown significant changes over the last ten years (2005-2015). According to the two last food consumption surveys, the consumption of meat decreased by 6% between 2004 and 2014, which represents an average annual rate of reduction of -0,6% (De Ridder et al., 2016) [41]. The consumption of eggs and dairy products has remained rather stable over the last ten years (average annual growth rates are close to 0%).

Extending this trend towards 2050 leads to a decrease of the meat consumption level from 87g meat/cap/day in 2015 to 79 g meat/cap/day in 2030 and 70 g meat/cap/day in 2050[42] while the consumption of eggs and dairy products in 2050 remain close to the ones observed in 2015. Altogether, the animal protein intake would decrease from 43 g prot/cap/day in 2015 to 41 g prot/cap/day in 2030 and 38 g prot/cap/day in 2050 (Table 125).

Those trends were taken into account in the BAU scenario.

Table 125. Evolution of meat consumption levels in 2030 and 2050 according to trends between 2005 and 2015.

Animal product	Unit	Consumption 2015	Yearly Growth Rate [1]	Consumption 2030	Consumption 2050
Pork, Poultry & Bovine	g meat/cap/day	87	-0,6%	79	70
Eggs	g egg/cap/day	24	<0,1%	24	24
Dairy products	ml milk/cap/day	480	<0,1%	478	476
All animal products	g prot/cap/day	43	-	41	38

Note: [1] The yearly growth rates are based on the evolutions of meat, eggs and dairy products consumption between 2004 and 2014 mentioned in the last survey on food consumption (De Ridder et al., 2016).

13.2. Consumption patterns in the transition scenarios

The consumption patterns in the transition scenarios are determined by the production potential. Nevertheless, an additional consumption pattern, corresponding to the nutritional recommendations, was used as a point of comparison for T1 (Table 126).

[41] Here, the evolution of meat consumption is discussed based on the real consumption measure (obtained through nutritional survey) as it gives a direct indication of consumption patterns. As mentioned in Chapter 3, two measures give an indication of consumption levels: **1. Apparent consumption** levels can be deducted from the food balances provided every year by Statistics Belgium. **2. Real consumption** levels are provided by the national survey on food consumption reflect what is really ingested by the Belgian population.

[42] This only includes the consumption of pork, poultry and bovine meat. Other types of meat were not assessed in this study.

13.3. Summary of food patterns

In conclusion, four dietary patterns were considered for 2050 (Table 126):

1. The **'Trends 2050'** pattern follows the trends from the last ten years in terms of animal products consumption and extends them to 2050. It reduces the consumption of pork, poultry and bovine meat in 2050 by 19% compared to 2015. This is the smallest change among patterns compared to 2015.
2. The **'Intermediate 2050'** pattern aligns the consumption of meat with the production potential of the Transition 1 scenario. It reduces meat consumption in 2050 by 25% compared to 2015 - and is therefore quite close to the trends pattern.
3. The **'Nutritional Recommendations' (NR)** pattern aligns the consumption of meat with the nutritional recommendations. As mentioned earlier in the report (Table 1), the meat consumption recommendations are of 57 g meat/cap/day and include all kinds of meat without specific recommended levels for each type of meat (De Ridder et al., 2016). Based on the current share of meat types in apparent consumption data, pork, poultry and bovine meat would represent 50g meat/cap/day together. The remaining 7 g meat/cap/day would be for other types of meat. Following the nutritional recommendations lowers meat consumption in 2050 by 42% compared to 2015.
4. The **'Low-meat 2050' (LM)** pattern aligns the consumption of meat with the production potential of the Transition 2 scenario. It is the most restrictive consumption pattern as it reduces meat consumption in 2050 by 69% compared to 2015.

Table 126. Comparison of pork, poultry and bovine meat consumption levels under different consumption patterns in 2015 and 2050.

Dietary pattern	Amount g meat/cap/day	Delta vs. 2015 %
Present 2015	87	na
'Trends 2050'	70	-19%
'Intermediate 2050' (Int)	65	-25%
'Nutritional recommendations' (NR)	50	-42%
'Low-meat 2050' (LM)	27	-69%

Each scenario was assessed under different consumption situations, which fitted the best the hypotheses of each scenario. These are summarised in the table below. The Transition 2 scenario was assessed exclusively under the 'low-meat' pattern.

Table 127. Summary of considered consumption patterns for each scenario.

Scenario	Assessed consumption pattern 1	Assessed consumption pattern 2
BAU	'Trends'	'Nutritional recommendations'
T1	'Intermediate'	'Nutritional recommendations'
T2	'Low-meat'	-

Chapter 14. Comparison of the BAU and transition scenarios

The comparison of the scenarios is done at a national level in section 14.1. Results are then assessed against environmental boundaries (section 14.2). Additional hypotheses regarding the production of cereals are considered in section 14.3. Finally, a sector by sector analysis is presented in section 14.4.

14.1. Total consequences at national level

14.1.1. General comparison of scenarios

A general comparison of the results of the scenarios is presented in Table 128 in terms of meat production and consumption levels, export capacity, feed autonomy (for cereals) and environmental impacts. The following sections of the chapter expand on the comparison of these results.

Table 128. Comparison of the consequences of the scenarios.

Indicator	Unit	Present 2015	BAU 2050	T1 2050	T2 2050
Production [1]					
Meat - Total	kt meat	740	743	300	125
Meat - Per capita	g meat/cap/day	181	160	65	27
Delta Total vs. 2015	%	Na	<1%	-59%	-83%
Protein - Total	kt protein	303	315	188	136
Protein - Per capita	g protein/cap/day	74	68	40	29
Delta Total vs. 2015	%	Na	4%	-38%	-55%
Consumption					
Meat	g meat/capita/day	87	70 [2]	65 [2]	27
Delta vs. 2015	%	Na	-19%	-25%	-69%
Protein	g protein/cap/day	43	38 [2]	40 [2]	29
Delta vs. 2015	%	Na	-11%	-7%	-32%
Export capacity					
Self-sufficiency of meat	%	209%	228%	100%	100%
Feed (cereals)					
Feed autonomy (cereals)	%	55%	55%	100%	Na [3]
Share of cereals for feed	%	62%	62%	62%	0%
Environmental impacts					
GHG emissions - Total	kt CO_2e	13.920	12.066	7.231	5.747
GHG emissions - Relative	kg CO_2e/kg prot	46,0	38,3	38,5	42,4
Delta Total vs. 2015	%	Na	-13%	-48%	-59%
N emissions - Total	Kt N	283	253	171	145
N emissions - Relative	kg N/kg prot	0,93	0,80	0,91	1,07
Delta Total vs. 2015	%	Na	-10%	-40%	-49%
Biodiversity – Total [4]	DS	18.207.628	16.619.789	7.827.840	4.400.502
Biodiversity - Relative	DS/kg prot	0,060	0,053	0,042	0,032
Delta Total vs. 2015	%	Na	-9%	-57%	-76%
PPP use – Total [5]	t a.s.	810	765	254	0
PPP use - Relative	g a.s./kg prot	2,7	2,4	1,4	0
Delta Total vs. 2015	%	Na	-6%	-69%	-100%

Notes: See next page.

Notes Tables 128:
[1] The production levels are expressed after slaughter and carcass yields, as well as a waste factor are taken into account.
[2] BAU and T1 were assessed under several consumption patterns. The results presented here are for the 'Trends' pattern for BAU and the 'Intermediate' pattern for T1. Additionally, both scenarios were assessed under a 'Nutritional recommendations' pattern which presents a consumption level of 50g meat/cap/day and 31 g animal prot/cap/day.
[3] Feed autonomy in Transition 2 was not assessed in terms of cereals strictly. Nevertheless, this scenario relies exclusively on the use of regional coproducts (from Belgian and EU origin).
[4] The damage score (DS) gives an indication of the Biodiversity impact of crops which are involved in the livestock production.
[5] The PPP use was estimated for the Belgian crops destined for livestock feed.

14.1.2. Production, consumption and excess

Analysing a specific scenario under one or another consumption pattern does not affect its production potential or environmental impacts (GHG emissions, etc.) but it affects the share of the production which is consumed nationally and hence it influences the export capacity of the scenario.

As an illustration, considering the BAU scenario under the 'trends' pattern results in a self-sufficiency ratio of 228% (in terms of pork, poultry and bovine meat), which is quite similar to the situation in 2015 (209%). Analysing the same scenario under the 'Nutritional recommendations' pattern increases the export capacity of the scenario and its self-sufficiency ratio to 322%, meaning that less than a third of the produced meat is consumed nationally in this scenario. As shown on Table 129 and Figure 70, this situation presents the biggest export capacity of all the considered scenarios.

In the Transition 1 scenario, the consumption potential resulting from the production level (65g of meat/cap/day) - called 'Intermediate' pattern - is very close to the trends pattern illustrated in the BAU scenario (70 g of meat/cap/day). This shows that is thus possible to keep consuming meat according to the trends in a case in which the production decreases significantly under the condition of drastically reducing export. Considering the Transition 1 scenario under the 'Nutritional recommendations' pattern results in a share of the production in 'excess' that could thus be exported. This highlights that is thus possible to move towards a production system based on organic and extensive systems and a consumption pattern which is in line with recommendations and still keep a certain export capacity.

Finally, the Transition 2 scenario corresponds to a 'low-meat' situation in which the consumption of meat has decreased substantially compared to 2015 (-69%) and there is no export capacity left.

Table 129. Comparison of pork, poultry and bovine meat production and consumption levels in 2050 according to each scenario and different consumption patterns.

Scenario	Consumption pattern	Production g meat/cap/day	Consumption g meat/cap/day	Excess g meat/cap/day	Self-Sufficiency[1] %
Present 2015	Present	181	87	94	209%
BAU 2050	Trends	160	70	90	228%
	Nutritional	160	50	110	322%
T1 2050	Intermediate	65	65	0	100%
	Nutritional	65	50	15	130%
T2 2050	Low-meat	27	27	0	100%

Note:
[1] The 'Self-Sufficiency Ratio' is the ratio between the production and consumption. It gives an indication of the share of the production which is exported vs. consumed nationally.

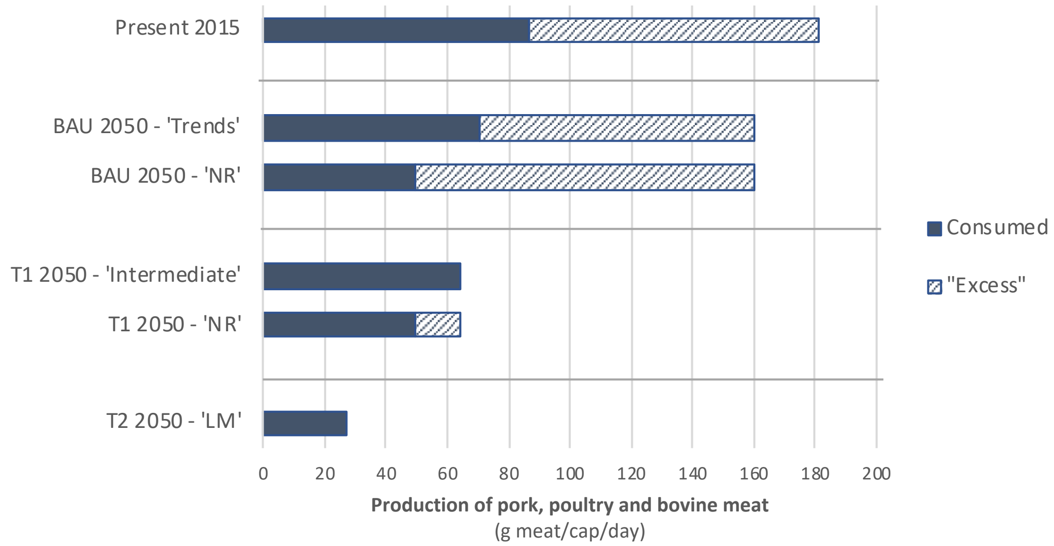

Figure 70. Comparison of pork, poultry and bovine meat production and consumption levels in 2050 according to each scenario and different consumption patterns. 'NR' stands for 'Nutritional recommendations'; 'LM' stands for 'Low-meat'.

14.1.3. Meat consumption

Compared to 2015, all scenarios result in lower meat consumption levels compared to 2015. It is interesting to note that the consumption level in the 'Trends' pattern (BAU scenario) and in the 'Intermediate' pattern (T1 scenario) are close (70 g meat/cap/day vs. 65 g meat/cap/day). The 'Nutritional recommendations' patterns assessed in BAU and T1 imply the same consumption level (50 g meat/cap/day) but the shares of each meat type differ.

The shares of meat types depend on the production potentials of each sector in each scenario. They remain the same in BAU compared to 2015 (for both consumption patterns); i.e. 50% of pork and 25% for poultry and bovine meat each. In T1, the share of pork increases to 62% (for both consumption patterns). Bovine meat decreases slightly to 23% and poultry meat decreases to 16%. In T2, bovine meat represents the biggest share (54%), followed by pork (36%) and poultry meat (9%) (Figure 71).

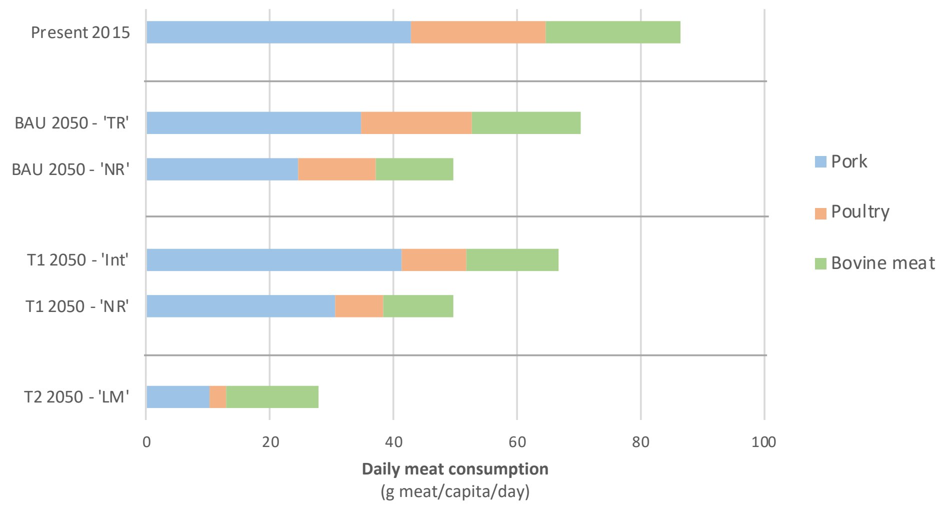

Figure 71. Comparison of pork, poultry and bovine meat consumption in different scenarios and consumption patterns. NR' stands for 'Nutritional recommendations'; 'LM' stands for 'Low-meat'.

14.1.4. *Protein consumption from animal products*

Figure 72 shows the consumption levels in terms of protein intake (considering all five animal products).

The highest animal protein intake is obtained through scenario T1 with its 'intermediate pattern' (40 g of animal proteins/cap/day). This ‘Intermediate’ pattern actually results in a higher total protein intake than the ‘Trends’ pattern (BAU scenario), which presented a higher meat consumption level. This is due to the importance of dairy products in the ‘Intermediate’ pattern and highlights the change implied by the Transition scenarios within animal protein consumption towards lower meat consumption levels but higher consumption levels of other animal products, in particular dairy products.

Interestingly, the Transition 2 scenario and its ‘Low-meat’ pattern, which in terms of meat intake involved an important reduction compared to 2015 and other scenarios (see Figure 71), shows results which come very close to the ‘Nutritional recommendations’ patterns when expressed in terms of protein intake. Compared to the nutritional recommendations, the ‘low-meat’ pattern compensates its low meat consumption level with a higher intake of other animal products, in particular milk and dairy products. Furthermore, this scenario could contribute to balancing out the shares of animal and vegetal sources of protein. Indeed, total protein needs are estimated to amount between 52-62 g prot/cap/day (according to gender) (Conseil Supérieur de la Santé (2016)) and it is advised to consume both types (animal and vegetal) of protein in similar proportions. As the animal protein consumption level resulting from the ‘low-meat’ pattern amounts nearly 30 g prot/cap/day, it could contribute to more balanced situation between animal and vegetal protein sources. It must be noted that the results observed for the ‘Nutritional recommendations’ pattern go in the same direction.

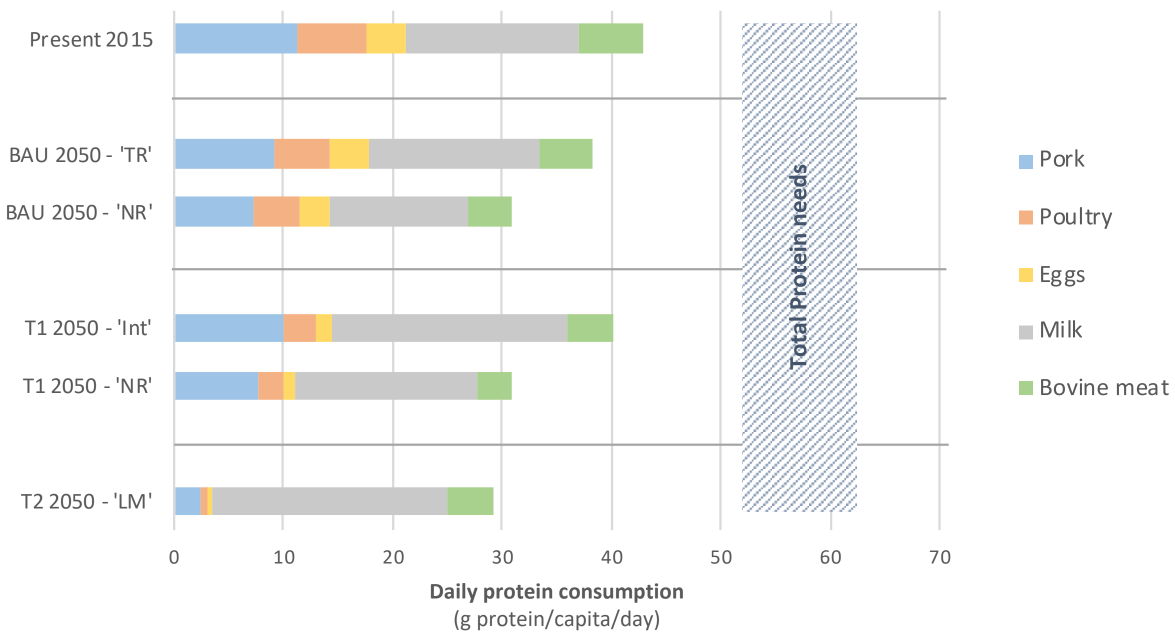

Figure 72. Comparison of animal protein consumption in different scenarios and consumption patterns and against total protein needs.

Notes: NR’ stands for ‘Nutritional recommendations’; ‘LM’ stands for ‘Low-meat’. The total protein needs range between 52-62 g prot/Cap/day according to gender (Conseil Supérieur de la Santé, 2016).

14.1.5. GHG emissions

The contributions of each sector to the total livestock GHG emissions vary from one scenario to another. In general, the same trend can be observed as for the protein levels, i.e. the bovine sector contributes the most to the total emissions and its share increases in the transition scenarios (56% of total emissions in 2015 vs. 92% of total emissions in Transition 2). In terms of total emissions, Transition 2 represents a 59% reduction in GHG emissions compared to 2015. Transition 1 reduces emissions by 48% compared to 2015 and BAU by 13% (Table 130 and Figure 73)

When expressed per unit of meat (kg CO_2e/kg meat), BAU is the scenario with the lowest relative emissions whereas Transition 2 has the highest (16,2 vs. 46,0 kg CO_2e/kg meat). However, differences between scenarios are much smaller when results are expressed per unit of protein. Transition 2 still has the highest emission level (42,4 kg CO_2e/kg protein) but these are much closer to the lowest emission level, which is observed in BAU (38,3 kg CO_2e/kg protein). This contrasting situation is due to the low meat production potential resulting from Transition 2 which is compensated by its important dairy production levels (Table 131 and Figure 73).

Table 130. Total GHG emissions from the Belgian livestock sector in 2015 and in 2050 in each scenario.

Scenario	Pork	Broilers	Laying hen	Dairy	Bovine meat [1]	TOTAL
	kt CO2e/year					
Present 2015	4.705	766	587	4.611	3.252	**13.920**
BAU 2050	4.246	828	528	4.230	2.233	**12.066**
Transition 1 2050	1.572	225	182	5.253	0	**7.231**
Transition 2 2050	371	56	43	5.276	0	**5.747**

Note: [1] In the transition scenarios, only a mixed dairy herd is considered which concentrates all the bovine sector's emissions, explaining the 0 value for the Bovine meat category for Transition 1 and 2.

Table 131. Relative GHG emissions from Belgian livestock productions in 2015 and in 2050 in each scenario.

Scenario	Meat	Protein
	kg CO2e/kg meat	kg CO2e/kg prot
Present 2015	18,8	46,0
BAU 2050	16,2	38,3
Transition 1 2050	24,1	38,5
Transition 2 2050	46,0	42,4

Note: The impacts per kg of meat are for pork, poultry and bovine meat. The impacts per kg of protein are for all animal products (including dairy and eggs). Figures include slaughter and carcass yields (for meat products) as well as waste factor.

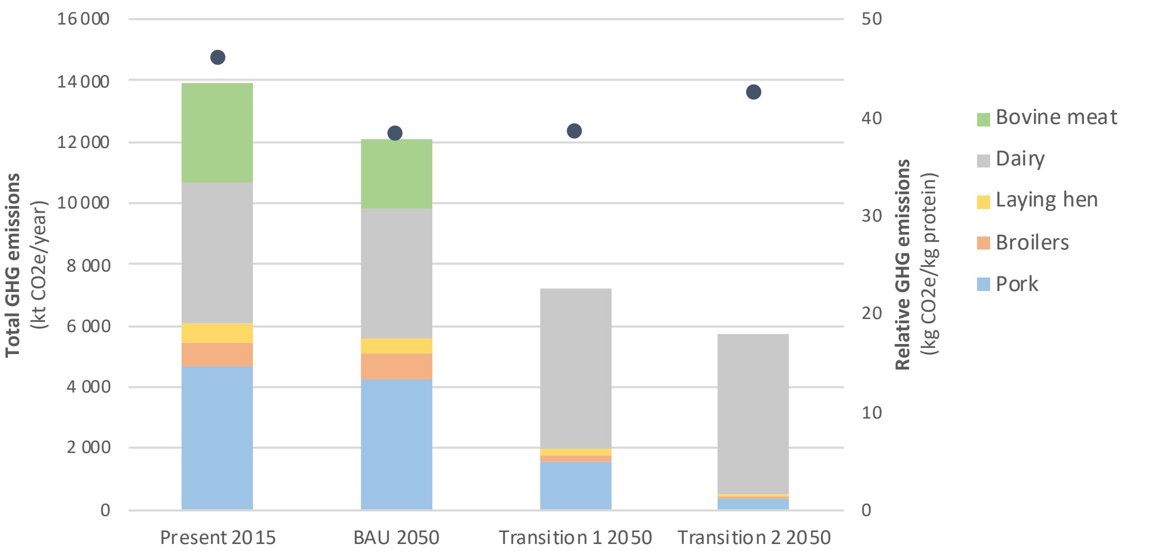

Figure 73. Comparison of scenarios in terms of total and relative GHG emission levels.

Note: In the transition scenarios, there is no specialised bovine meat sector, which is replaced by a mixed dairy sector which concentrates the entirety of the bovine herd, and hence its emissions too.

14.1.6. N emissions

In all scenarios, the dairy sector is the biggest contributor to total N emissions, and all the more so in the transition scenarios. Compared to 2015, BAU reduces N emissions by 10%, Transition 1 by 40% and Transition 2 by 49% (Table 132 and Figure 74).

In terms of relative emissions, the same trend as for GHG emissions can be observed, i.e. the important gap in emission levels between BAU and T2 expressed per unit of meat (0,34 kg N/kg meat vs. 1,16 kg N/kg meat respectively) is partially closed when expressed per unit of protein (0,80 kg N/kg protein for BAU vs. 1,07 kg N/kg protein in T2). T1 presents an intermediate situation (Table 133 and Figure 74).

Table 132. Comparison of scenarios in terms of total N emissions.

Scenario	Pork	Broilers	Laying hen	Dairy	Bovine meat	TOTAL
	kt N/year					
Present 2015	70	11	10	103	89	283
BAU 2050	65	12	9	102	65	253
Transition 1 2050	30	5	5	131	0	171
Transition 2 2050	7	1	1	135	0	145

Note: [1] In the transition scenarios, only a mixed dairy herd is considered which concentrates all the bovine sector's emissions, explaining the 0 value for the Bovine meat category for Transition 1 and 2.

Table 133. Comparison of scenarios in terms of relative N emissions (per unit of meat and per unit of protein).

Scenario	Meat	Protein
	kg N/kg meat	kg N/kg prot
Present 2015	0,38	0,93
BAU 2050	0,34	0,80
Transition 1 2050	0,57	0,91
Transition 2 2050	1,16	1,07

Note: The impacts per kg of meat are for pork, poultry and bovine meat. The impacts per kg of protein are for all animal products (including dairy and eggs). Figures include slaughter and carcass yields (for meat products) as well as waste factor.

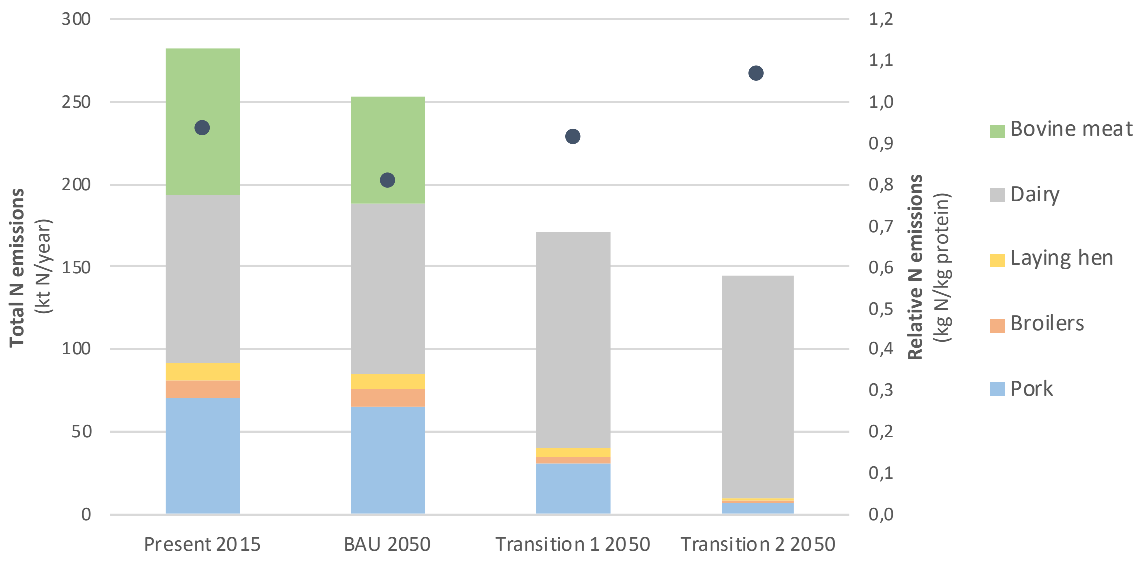

Figure 74. Comparison of scenarios in terms of total and relative N emissions.
Note: In the transition scenarios, there is no specialised bovine meat sector, which is replaced by a mixed dairy sector which concentrates the entirety of the bovine herd, and hence its emissions too.

14.1.7. Biodiversity impacts

Again, the dairy sector is the biggest contributor to livestock's biodiversity impact. Compared to 2015, the Damage Score (DS) decreases by 9% in BAU, by 57% in Transition 1 and by 76% in Transition 2 (Table 134 and Figure 75 Table 135).

In terms of relative impact (per unit of protein), Transition 2 leads to the lowest impacts, followed by Transition 1 and BAU (Table 135 and Figure 75). Per unit of meat, the situation is less contrasted. This situation is explained by the higher shares of organic productions in these scenarios, which have lower biodiversity impacts (see Table 162 in the Appendices).

Table 134. Comparison of scenarios in terms of total Biodiversity impacts.

Scenario	Pork	Broilers	Laying hen	Dairy	Bovine meat[1]	TOTAL
	DS/year					
Present 2015	9.661.238	912.876	399.121	4.029.748	3.204.645	18.207.628
BAU 2050	8.867.819	985.814	372.732	4.094.864	2.298.560	16.619.789
Transition 1 2050	3.571.457	290.615	152.977	3.812.791	0	7.827.840
Transition 2 2050	415.112	41.532	19.535	3.924.324	0	4.400.502

Note: [1] In the transition scenarios, only a mixed dairy herd is considered which concentrates all the bovine's sector's emissions, explaining the 0 value for the Bovine meat category for Transition 1 and 2.

Table 135. Comparison of scenarios in terms of relative Biodiversity impacts (per unit of meat and epr unit of protein).

Scenario	Meat	Protein
	DS/kg meat	DS/kg prot
Present 2015	0,025	0,060
BAU 2050	0,022	0,053
Transition 1 2050	0,026	0,042
Transition 2 2050	0,035	0,032

Note: The impacts per kg of meat are for pork, poultry and bovine meat. The impacts per kg of protein are for all animal products (including dairy and eggs). Figures include slaughter and carcass yields (for meat products) as well as waste factor.

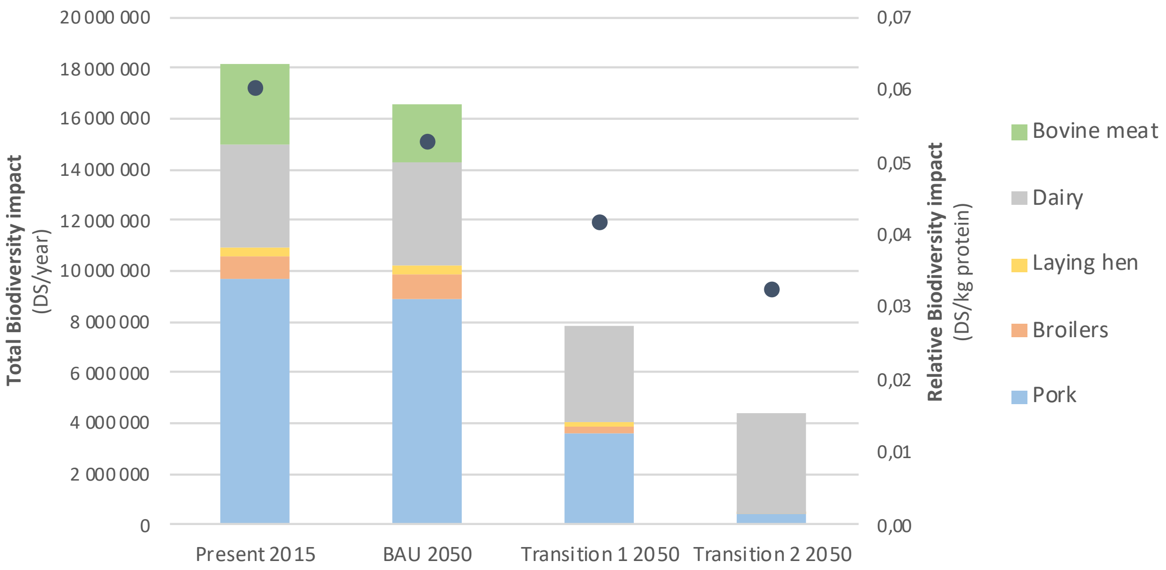

Figure 75. Comparison of scenarios in terms of total and relative Biodiversity impacts.
Note: In the transition scenarios, there is no specialised bovine meat sector, which is replaced by a mixed dairy sector which concentrates the entirety of the bovine herd, and hence its emissions too.

14.1.8. PPP use

As the level of PPP use could not be characterised directly for each production system and based on tha available data, the evolution of this indicator in the different scenarios was estimated based on the evolution of feed intake in each scenario, and in particular of the most PPP-intensive crops, i.e. cereals and forage maize (see Table 136). The share of organic systems was also taken into account (30% of the livestock population in T1 and 100% in T2) as the use of PPP is forbidden in such systems. As a result, the use of PPP is reduced by 6% in BAU compared to 2015, by 69% in Transition 1 and by 100% in Transition 2 (

Table *137* and Figure 76). This trend is also observed when results are expressed in relative terms (

Table *138* and Figure 76).

Table 136. Evolution of feed ingredients consumption by the Belgian livestock sector in 2015 and 2050 under different scenarios.

Feed category	2015	BAU 2050	Delta 2015	T1 2050	Delta 2015	T2 2050	Delta 2015
	kt/year	kt/year	%	kt/year	%	kt/year	%
Cereals	3.713	3.448	-7%	1.632	-56%	428	-88%
Oleaginous	564	526	-7%	237	-58%	65	-89%
Protein-rich	1.668	1.619	-3%	1.114	-33%	823	-51%
Others	795	675	-15%	213	-73%	105	-87%
TOTAL Concentrates (CC)	6.740	6.269	-7%	3.197	-53%	1.420	-79%
Maize	5.052	5.006	-1%	2.005	-60%	2.005	-60%
Pasture	4.452	3.566	-20%	3.993	-10%	3.993	-10%
Other forage	112	112	0%	140	25%	140	25%
TOTAL FORAGES	9.617	8.685	-10%	6.138	-36%	6.138	-36%
TOTAL CC+FORAGES	16.357	14.953	-9%	9.335	-43%	7.558	-54%

Table 137. Use of PPP associated to the livestock sector in 2015 and 2050 under different scenarios.

Scenario	Cereals	Forage maize	Others	TOTAL
	t a.s./year			
Present 2015	492	237	81	810
BAU 2050	456	235	74	765
Transition 1 2050	151	66	36	254
Transition 2 2050	0	0	0	0

Note: Organic systems are associated with no use of PPP. Their share amounts 30% in Transition 1 and 100% in Transition 2.

Table 138. Comparison of scenarios in terms of relative livestock-related PPP use (per unit of meat and per unit of protein).

Scenario	Meat	Protein
	g a.s./kg meat	g a.s./kg prot
Present 2015	1,1	2,7
BAU 2050	1,0	2,4
Transition 1 2050	0,8	1,4
Transition 2 2050	0,0	0,0

Note: The impacts per kg of meat are for pork, poultry and bovine meat. The impacts per kg of protein are for all animal products (including dairy and eggs). Figures include slaughter and carcass yields (for meat products) as well as waste factor.

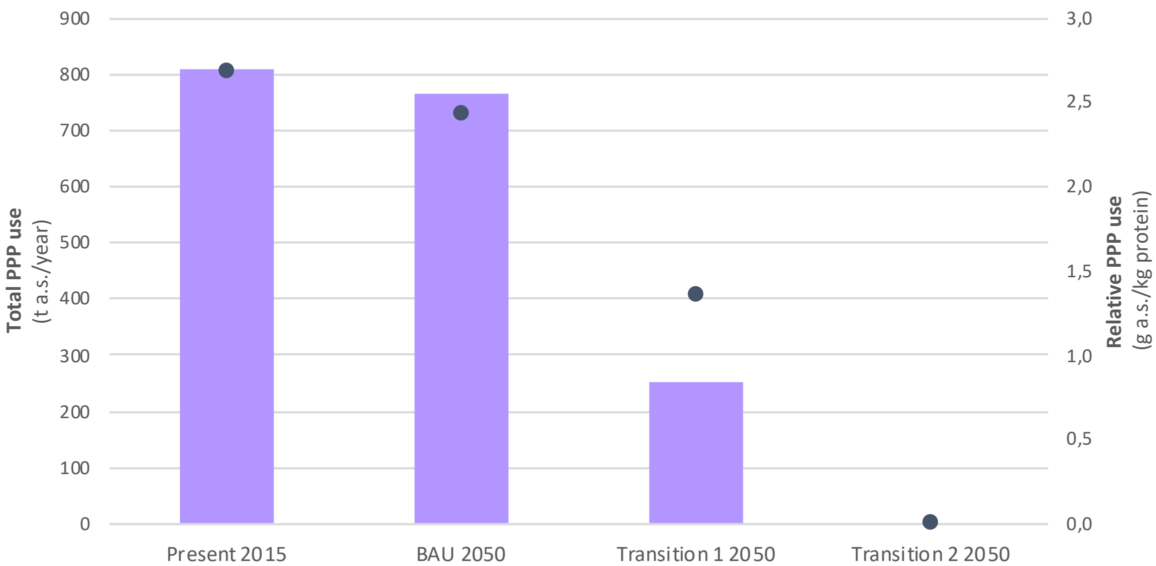

Figure 76. Comparison of scenarios in terms of total and relative livestock-related PPP use in Belgium.

14.1.9. *Summary: consumption and GHG emissions*

In order to get a good overview of the results of each scenario, it seems important to combine both their production and consumption potentials (expressed here in protein terms in order to include all animal products) and their environmental consequences, here under the form of total GHG emissions.

As shown on Figure 77, the highest animal protein consumption level is that of the present situation (2015). Nevertheless, this situation also comes with the highest GHG emissions.

In the BAU scenario, the GHG emissions decrease slightly compared to 2015 (-13%). In terms of protein consumption, both consumption patterns were assessed. The 'Nutritional recommendations' pattern implies lower animal protein consumption than the 'Trends' pattern but implies a greater 'excess' production, which could potentially be exported.

Transition 1 results in greater GHG emissions reductions (-48% compared to 2015). The potential animal protein consumption level resulting from this scenario ('Intermediate' pattern) is very close to protein intake in 2015 but this situation comes with no excess production and hence no export potential. Analysing this scenario under the 'Nutritional recommendations' pattern does not modify its GHG emissions but lowers the consumption of animal products, hence resulting in a small share of the production being in excess compared to the population needs and which could thus potentially be exported.

Finally, Transition 2 results in the lowest GHG emission (-59% compared to 2015) and the lowest animal protein intake consisting in a 'Low-meat' diet. In this situation, the entirety of the production must be consumed by the national population and there is no export potential.

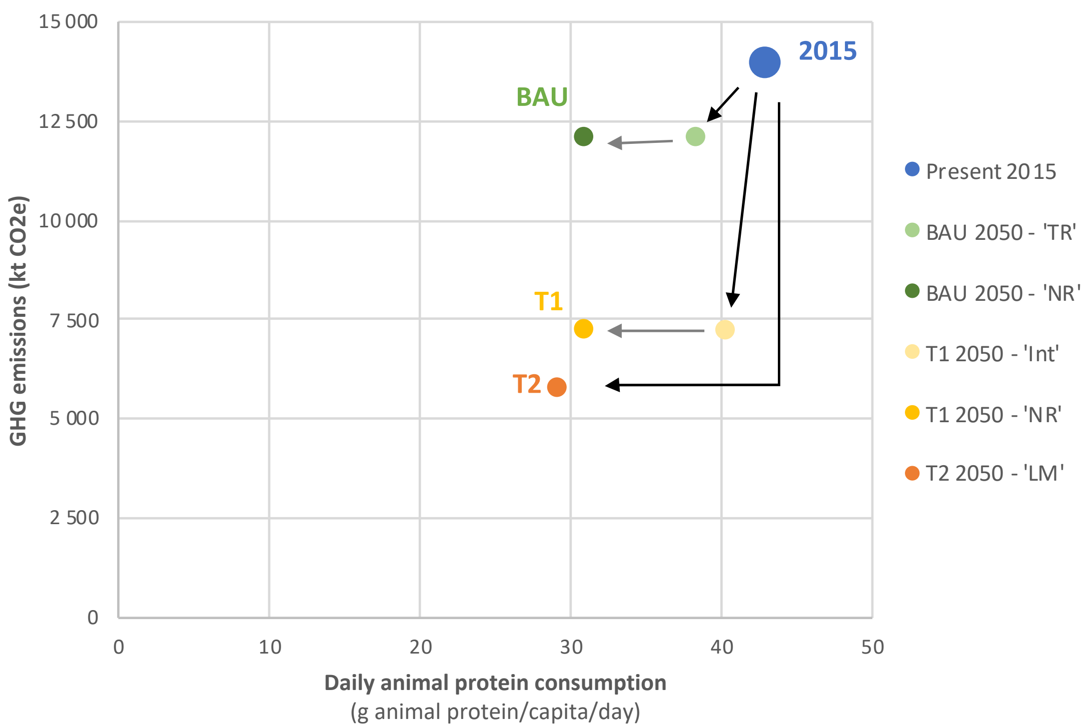

Figure 77. Comparison of scenarios in terms of potential protein consumption levels and total GHG emissions. ('TR' stands for 'Trends' pattern; 'NR' stands for 'Nutritional recommendations' pattern and 'Int' stands for 'Intermediate' pattern).

14.2. Comparison of results against planetary boundaries

In order to assess the environmental results of the developed scenarios, these are compared to environmental boundaries and political targets. Table 139 and Table 140 provide an overview of these targets and the results of the scenarios, which are presented in more detail in the following sections.

Table 139. Targets towards 2050 in order to stay within environmental boundaries.

Environmental measure	Target	Reference
GHG emissions	-80%	EU targets (European Commission, 2011)
	-50%	Afterres 2050 report (Couturier et al., 2016)
N fixation	-37%	RISE report (Buckwell and Nadeu, 2018)
Stocking rate	0,5 to 1 LSU/ha	RISE report (Buckwell and Nadeu, 2018)
	2 LSU/ha	EU organic regulations (Biowallonie, 2016)

Table 140. Comparison of the results of the scenarios against environmental boundaries.

Environmental measure	Target	Scenario	Result vs. 2015
GHG emissions	**-50%**	BAU	-13%
		Transition 1	-48%
		Transition 2	-59%
N emissions	**-37%**	BAU	-10%
		Transition 1	-40%
		Transition 2	-49%
Cattle stocking rate	**1,5 LSU/ha**	BAU	1,48 [a]
		Transition 1	1,24 [a]
		Transition 2	1,24 [a]

Note: [a] The cattle stocking rates presented here for the scenarios only include cows but not their progeny. The total stocking rates (including all cattle) are thus higher than the values presented here.

14.2.1. GHG emissions

Comparing GHG emissions to national and international (EU) reduction targets is not necessarily a straightforward task.

At the national level, there are no specific targets for the livestock or agriculture sector. These are included in the objectives set for the non-ETS sector.[43] The Belgian targets are to reduce non-ETS GHG emissions by 15% by 2020 and by 35% by 2030 compared with 2005 levels (Table 141).

At the international level, the EU has set specific targets, including for the agriculture sector. In order to keep global warming below the 2°C, the objective set out by the EU is to reduce GHG emissions by 80% to 95% by 2050 compared with 1990 levels (economy-wide target). Specific agriculture emissions are to decrease by about 50% by the same date (Table 141). It is acknowledged that, compared to other sectors, the agricultural sector presents a lower reduction potential, explaining the lower target for this sector (European Commission, 2011; Buckwell and Nadeu, 2018). The prospective scenarios developed in the context of the Afterres 2050 study which analysed the French food and agricultural system result in a 50% reduction of agriculture GHG emissions (Couturier et al., 2016).

[43] The EU Emissions Trading Scheme (EU ETS) is a 'cap and trade' environmental policy set out by the EU. The policy covers certain sectors (such as power and heat generation, energy intensive industries such as oil refineries, steel and iron industries, etc.) for which an overall cap of GHG emissions is set. Emission allowances are distributed to the companies and can be traded between companies. Non-ETS sectors, which do not fall under this scheme, include agriculture, transports, buildings, etc.

As shown in Table 140, the reduction potentials resulting from the scenarios range from -13% for BAU to -48% and -59% for Transition 1 and 2 respectively, in comparison with 2015. These numbers confirm that reaching an 80% reduction target is very complicated for the livestock/agriculture sector. Compared to national and international objectives, BAU presents limited potential to reach the objectives. Transition 1 and Transition 2 come closer to the objectives set out by the EU. It must nevertheless be noted that the targets are set against 1990 or 2005 and not 2015. Comparing the results of the scenarios against 1990 emissions levels would result in lower reduction potentials. A 50% reduction in emissions is in line with the results found in the Afterres 2050 study in which emissions from the agriculture sector are expected to decrease by 54% between 2010 and 2050 (Couturier et al., 2016). An important consideration to keep in mind when analysing the results presented here is that they only include the livestock sector's emissions. In order to get a full and comprehensive picture of the situation in 2050, changes in other sectors' emissions must be considered too.

Table 141. EU and Belgian GHG reduction targets.

Year	**EU targets** [1]		**Belgian targets** [1]
	All sectors	Agriculture	Non-ETS sectors
2020	-	-	-15% vs. 2005 [2]
2030	-40%	-36% to -37%	-35% vs 2005 [2]
2040	-60%	-	-
2050	-80% to -95%	-42% to -49% [3]	-

Sources:
For EU targets: (European Commission, 2011). For Belgian targets: (Marghem et al., 2015).
Notes:
[1] Unless specified otherwise, reduction targets are against 1990 levels.
[2] 2005 emissions: 79.620 kt CO_2e. Objective for 2020: 67.677 kt CO_2e. Objective for 2030: 51.753 kt CO_2e.
[3] The objective for 2050 is for the agricultural sector to represent one third of all EU's emissions.

14.2.2. N emissions

According to a recent report which aimed at defining a 'safe operating space' for EU livestock, Belgium exceeds the N fixation boundary by 37% (this is with a per capita fixation boundary of 8,6 kg N/capita/year. Belgium should thus reduce its N fixation by 37% (Buckwell and Nadeu, 2018).

T1 and T2 are in line with these numbers and allow for this reduction. BAU on the other hand falls short of the objective as it only allows for a 10% reduction (Table 140). Nevertheless, it must be noted that the results from the presented scenarios only include N emissions from livestock. Other N sources such as biological fixation by leguminous crops or the industrial fixation of N_2 in ammonia are not included. The results presented here thus just provide an indication that the Transition scenarios could help to reduce the N pressure caused by livestock and contribute to staying within the N boundary.

14.2.3. Stocking rate (LSU/ha)

Regarding stocking rate, the same report indicates stocking densities of 0,5 and 1 LSU/ha. This range provides an estimate of the minimum number of ruminant animals needed to preserve and manage pasture in the EU (Buckwell and Nadeu, 2018). The authors acknowledge that this number is lower than what is usually considered for farming systems. In fact, according to EU regulations, the maximum stocking rate for organic systems is 2 LSU/ha. A safe operating space would thus range between those upper and lower boundaries. As shown in Table 140, all three scenarios fall under this range, although it must be noted that the presented values only include cows, and not the rest of the cattle herd.

14.3. Vegetal production: Additional hypotheses on the evolution of the Belgian cereals area and production

Each scenario has implications not only for the livestock sector but also for vegetal productions and in particular the production of cereals for feed. Specific scenarios on the cereals sector resulting from a similar study in Wallonia (Antier et al., 2017) were used to assess the interactions between the livestock and cereals sectors in the different prospective situations. Each livestock scenario was assessed in the light of the best corresponding cereals scenario (C-BAU corresponds to BAU, C-Tr1 to T1 and C-Tr2 to T2). It must be noted that the cereal scenarios were developed at the scale of the Walloon region. Their results were here extrapolated to whole Belgium.

14.3.1. Additional hypotheses on the cereals area and production levels

Table 142 and Table 143 below summarise the additional hypotheses resulting from the cereals scenarios in terms of cereals area and production levels. The scenarios were designed with the hypothesis that the total cereals area in Belgium remained constant (Table 142)[44]. Nevertheless, several other parameters vary from one scenario to another:

1. **The share of organic cereals in the scenarios:** The shares of organically produced cereals in the cereals scenarios increase to similar rates as the ones observed for the livestock scenarios. In the C-BAU scenario, organic production of cereals rises to 7% of total area. In C-Tr1, the share of organic cereals reaches 42% of the total area and in C-Tr2 it represents 100% of the area (Antier et al., 2017; Table 142).
2. **Evolution of cereals production:** The cereal production levels vary from one scenario to another, which is related to the evolution of the shares of organic production, which tend to have lower yields (the average yields decreases from 9,6 t/ha in 2015 to 6,5 t/ha in C-Tr2), thus affecting total production levels. In C-BAU, the production decreases by 1% compared to 2015. In the C-Tr1 and C-Tr2 however, it does so by 15% and 32% respectively (Antier et al., 2017; Table 143).
3. **Use of cereals for feed and food in the scenarios:** In 2015, it was estimated that 62% of cereals were destined for the animal feed industry (see section 8.2 in Chapter 8; actor interviews, 2018). Due to the lack of statistical data in this regard, this share was supposed to remain the same in BAU. In Transition 1 too the same share was used as the purpose of the scenario was to estimate the production potential of the livestock sector based on the available national cereal resources. In Transition 2 however, the food-feed competition disappears as livestock feeding would rely exclusively on the use of coproducts. The entirety of the cereals area and production could thus be destined for non-feed purposes (including human consumption but also biofuels, exports, etc.)[45] (Figure 78 and Figure 79).

[44] The area destined for cereals production remained rather stable over the past years (341.620 ha in 2015).

[45] It must nevertheless be noted that as T2 relies on the use of cereal coproducts, the cereal area cannot entirely disappear and be used for other crops/purposes as cereals must still be produced in order to have available coproducts for animal feed. Yet, as these coproducts are not usually destined for human consumption, this scenario does not result in a food-feed competition.

Table 142. Evolution of the cereals area in Belgium according to each cereal scenario.

Scenario	Total area	Share organic [1]	Organic area	Share for feed [2]	Feed area	Non-feed area
	ha	ha	%	%	ha	ha
Present 2015	341.638	3%	10.050	62%	211.816	129.822
C-BAU 2050	341.638	7%	23.969	62%	211.816	129.822
C-Tr 1 2050	341.638	42%	142.182	62%	211.816	129.822
C-Tr 2 2050	341.638	100%	341.638	0%	0	341.638

Sources: [1] (Antier et al., 2017) ; [2] (Actor interviews, 2018).

Notes:

[1] The shares of organic production were estimated for Wallonia by Antier et al. (2017) and extrapolated to Belgium.

[2] The share of the production used for feed purposes was estimated through actor interviews. In Transition 2 it drops to 0% as all animal feed comes from coproduct sources and there is thus no food-feed competition.

Table 143. Evolution of the cereals production in Belgium according to each scenario.

Scenario	Total production [1]	Delta vs. 2015 [1]	Average yield	Share Feed [2]	Production for feed	Non-feed production
	kt/year	%	t/ha	%	kt/year	kt/year
Present 2015	3.283	0%	9,6	62%	2.048	1.235
C-BAU 2050	3.250	-1%	9,5	62%	2.027	1.222
C-Tr 1 2050	2.790	-15%	8,2	62%	1.741	1.049
C-Tr 2 2050	2.232	-32%	6,5	0%	0	2.232

Sources: [1] (Antier et al., 2017) ;

Notes:

[1] The changes in production levels were estimated for Wallonia by Antier et al. (2017) and extrapolated to Belgium.

[2] The share of the production used for feed purposes was estimated through actor interviews. In Transition 2 it drops to 0% as all animal feed comes from coproduct sources and there is thus no food-feed competition.

14.3.2. Availability of cereal for human consumption

The previous considerations have implications on the amounts of cereals available for animals but also for human consumption, and other purposes (biofuels, export…).

Regarding human consumption, the cereal needs are estimated to amount 281 g/cap/day (Couturier et al., 2016), which represents 1.150 kt in 2015 and 1.306 kt in 2050. In the BAU scenario, the total production amounts 3.250 kt of cereals which is equivalent to 802 g/cap/day, of which the equivalent of 263 g/cap/day are destined for non-feed purposes (Table 144). This amount is thus not sufficient to cover the cereal needs of the population, all the more so considering that this includes cereals destined for biofuels production. This implies that cereals need to be imported to cover the needs of the Belgian population.

The situation is rather similar in Transition 1 as non-feed production is equivalent to 226 g/cap/day, which does not cover the human consumption needs. In Transition 2 however, the non-feed production amounts the equivalent of 480 g/cap/day (i.e. the entirety of the production as there is no food-feed competition in this scenario). This amount could largely cover the needs of the Belgian population and significant shares would still be available for other uses. An intermediate situation in which a small share of the cereals production was used for animal feed to complement limiting coproduct sources could even be imagined (Figure 79).

Table 144. Total and per capita cereals consumption and distinction between feed and non-feed production in different cereal scenarios.

Scenario	National demand		Total production [3]		Production for feed [4]	Non-feed production [4]	
	Kt/year[1]	g/cap/day[2]	kt/year	g/cap/day	kt/year	kt/year	g/cap/day
Present 2015	1.150	281	3.283	802	2.048	1.235	302
BAU 2050	1.306	281	3.250	699	2.027	1.222	263
T1 2050	1.306	281	2.790	600	1.741	1.049	226
T2 2050	1.306	281	2.232	480	0	2.232	480

Sources:
[1] Belgian population in 2015: 11.209.044 inhabitants. Predicted Belgian population in 2050: 12.736.357 inhabitants.
[2] Based on Couturier et al. (2016)
[3] Based on Antier et al. (2017); see Table 143.
[4] Based on actor interviews; see Table 142 and Table 143.

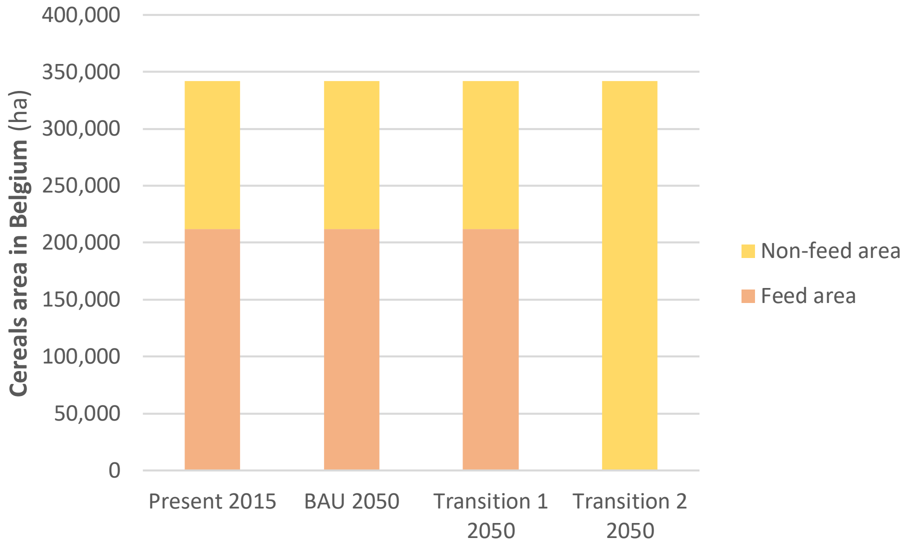

Figure 78. Evolution of the cereals area in Belgium according to each scenario.

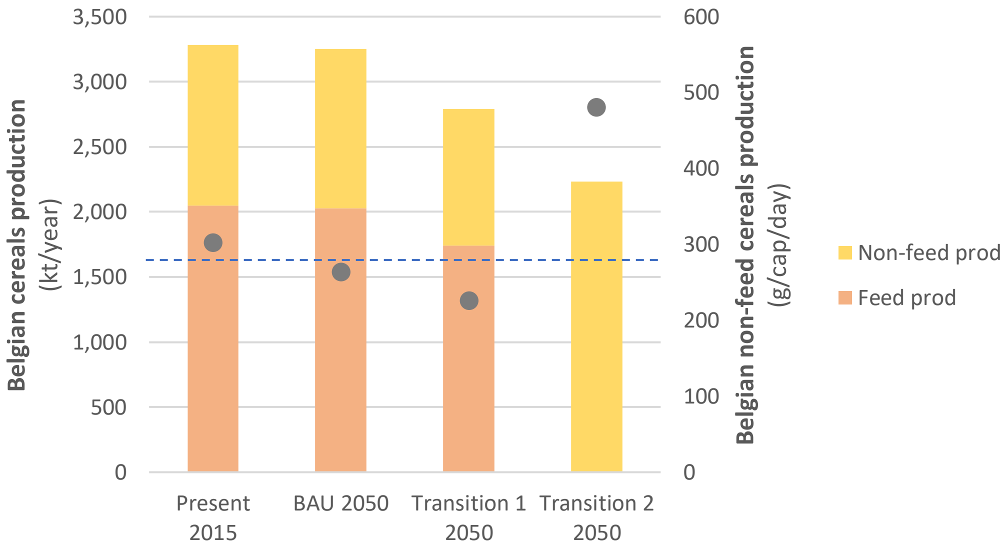

Figure 79. Evolution of the cereals production in Belgium according to each scenario.
Note: The dotted line indicates the recommended cereal consumption level (281 g/cap/day).
Source: (Couturier et al., 2016).

14.4. Environmental impacts of the livestock sector in 2005

Although the study mainly focuses on the period 2015-2050 with a prospective approach, additional information from 2005 are provided below in order to allow for a larger timeframe analysis. The size of livestock populations in 2005 are provided and the share of production systems at that time are estimated (see section 14.4.1). GHG emissions, N emissions and biodiversity impact, as well as use of PPP related to livestock in 2005 are then calculated and compared to those in 2015 and in 2050 according to scenarios (see sections 14.4.2 to 14.4.5).

GHG emissions (and other environmental aspects) in 2005 were estimated with a similar methodology to those in 2015. The technical parameters of the production systems in 2005 were considered similar to 2015 (production cycles, final weights, feed conversion ratios, feed compositions, etc.). The only exception is the milk productivity level of dairy cows, for which a 10% increase in productivity was considered between 2005 and 2015, in accordance with statistical data.

14.4.1. Livestock populations and share of production systems in 2005

Livestock populations and slaughters as well as shares of production systems in 2005 were estimated (see Appendix 16 - Estimation of livestock populations and slaughters in 2005 and share of production systems). At the national level, the pigs' population did not change significantly (+1% between 2005 and 2015). The broilers population grew of 13%. The population of laying hens, dairy cows and suckler cows populations decreased respectively by 5%, 3%, and 18%. The share of production systems did not radically change between 2005 and 2015, although the share of organic systems became slightly higher and conventional systems were partly replaced by certified systems.

14.4.2. Livestock-related GHG emissions in 2005

The GHG emissions from the livestock decreased by 4% between 2005 and 2015 (Table 145 to Table 146). This decrease is due to lower emission levels in both bovine sectors (dairy and bovine meat) in 2015 compared with 2005 - resulting mainly from the decrease in their population (see above and in Appendix 16) - whereas the emissions in other sectors increased (+3% in the pork sector, +13% in the broiler sector and +2% in the laying hen sector).

These results are consistent with GHG emission levels reported by the national inventory (VMM et al., 2017), according to which agriculture emissions decreased by 3% between 2005 and 2015 (from 10.312 kt CO_2e in 2005 to 10.003 kt CO_2e in 2015[46]) and livestock-related emissions (only manure management and enteric fermentation emissions) remained quite stable between 2005 and 2015 (from 6.914 kt CO2e in 2005 and 6.817 kt CO2e in 2015).

[46] These numbers only include the emissions sources which are officially considered under agriculture emissions by the Belgian national GHG inventory, i.e. emissions from enteric fermentation, manure management, agricultural soils, liming and urea application. This explains the difference with the value presented in Table 8 which also includes emissions from fertiliser production and fuel combustion in the agriculture sector.

Table 145. Comparison of GHG emission levels of the Belgian livestock sector in 2005 and 2015.

Sector	2005 kt CO_2e	2015 kt CO_2e	Delta 2005-2015 %
Pork	4.554	4.705	+3%
Broilers	675	766	+13%
Laying hens	578	587	+2%
Dairy	4.697	4.611	-2%
Bovine meat	3.944	3.252	-18%
TOTAL	14.448	13.920	-4%

Note: Emissions sources included in the calculations are feed-related emissions, manure management emissions and enteric fermentation emissions.

Table 146. Comparison of GHG emission levels of the Belgian livestock sector in 2050 according to scenarios with emissions in 2005 and 2015.

Sector	2005 kt CO_2e	2015 kt CO_2e	BAU 2050 kt CO_2e	T1 2050 kt CO_2e	T2 2050 kt CO_2e
Pork	4.554	4.705	4.246	1.572	371
Broilers	675	766	828	225	56
Laying hens	578	587	528	182	43
Dairy	4.697	4.611	4.230	5.253	5.276
Bovine meat	3.944	3.252	2.233	0	0
TOTAL	14.448	13.920	12.066	7.231	5.747
Comparison to 2015			*-13%*	*-48%*	*-59%*
Comparison to 2005		*-4%*	*-16%*	*-50%*	*-60%*

Note: Emissions sources included in the calculations are feed-related emissions, manure management emissions and enteric fermentation emissions.

Table 147. Comparison of manure management and enteric fermentation GHG emissions of the Belgian livestock sector in 2050 according to scenarios with emissions in 2005 and 2015.

Sector	2005 kt CO_2e	2015 kt CO_2e	BAU 2050 kt CO_2e	T1 2050 kt CO_2e	T2 2050 kt CO_2e
Pork	1.014	1.070	932	386	92
Broilers	19	21	21	10	1
Laying hens	18	18	14	7	2
Dairy	2.951	2.866	2.478	3.440	3.440
Bovine meat	2.752	2.261	1.496	0	0
TOTAL	6.953	6.237	4.941	3.843	3.535
Comparison to 2015			*-21%*	*-38%*	*-43%*
Comparison to 2005		*-10%*	*-29%*	*-45%*	*-49%*

Notes:

[1] Emissions sources included in this table are **only** manure management emissions and enteric fermentation emissions.

[2] In the national inventory, those emissions reach 6.914 kt CO_2e in 2005 and 6.817 kt CO_2e in 2015, which are very close to figures obtained in this study.

14.4.3. N emissions in 2005

In terms of N emissions, the 2005-2015 period led to a 6% reduction in emissions (283 kt N in 2015 vs. 301 kt N in 2005; see Table 148). This is mainly the result of an important decrease in the N emissions of the bovine meat sector (-18%). Emissions slightly decreased in the laying hen and dairy sectors (-2% and -1% respectively) and increased in the pork and broiler sectors (+3% and +13% respectively).

Table 148. Comparison of N emission levels of the Belgian livestock sector in 2005 and 2015.

Sector	2005 kt N	2015 kt N	Delta 2005-2015 %
Pork	68	70	+3%
Broilers	10	11	+13%
Laying hens	10	10	-2%
Dairy	104	103	-1%
Bovine meat	109	89	-18%
TOTAL	301	283	-6%

14.4.4. Biodiversity impact in 2005

Overall, the biodiversity impact of the Belgian livestock sector remained stable during the 2005-2015 period. Significant evolutions can however be observed at the sector-specific level. Indeed, the biodiversity impact of the pork and broiler sector increased by 9% and 12% respectively, which was compensated by a 4% decrease in the laying hen sector and more importantly a 21% decrease in the bovine meat sector.

Table 149. Comparison of the biodiversity impact of the Belgian livestock sector in 2005 and 2015.

Sector	2005 DS	2015 DS	Delta 2005-2015 %
Pork	8.841.881	9.661.238	+9%
Broilers	813.713	912.876	+12%
Laying hens	416.312	399.121	-4%
Dairy	4.026.848	4.029.748	<+1%
Bovine meat	4.027.970	3.175.294	-21%
TOTAL	18.126.725	18.178.277	<+1%

Note: DS stands for Damage Score, which gives an indication of the biodiversity damage of the crops grown for animal feed.

14.4.5. PPP use in 2005

The use of phytopharmaceutical products (PPP) related to the Belgian livestock sector was estimated by assessing the PPP use on various Belgian crops and assessing the share of each crop destined for animal feeding purposes. As such, it was not possible to specifically attribute amounts of PPP use to different sectors and production systems. This was done for the year 2015. The assessment for 2005 is based on the evolution of feed intake between 2005 and 2015. More specifically, the evolution of the three most PPP intensive crops was analysed, i.e. cereals, forage maize and other forage (pasture and sugar beet). It appears that the overall livestock-related PPP use remained stable over the 2005-2015 period (810 t of active substances in 2015 vs. 817 t a.s. in 2005; see Table 150).

Table 150. Comparison of the PPP use related to the Belgian livestock sector in 2005 and 2015.

Sector	2005 t a.s.	2015 t a.s.	Delta 2005-2015 %
Cereals	481	492	+2%
Forage maize	240	237	-1%
Other forage	96	81	-15%
TOTAL	817	810	-1%

Note: a.s. stands for "active substances" in phytopharmaceutical products.

14.5. Compared consequences per sector

A First series of figures (Figure 80 to Figure 84) illustrates the evolution of livestock populations and production systems in 2015 and 2050 according to the different scenarios and for each livestock sector.

A second series of figures (Figure 85 to Figure 89) shows the consequences of all three scenarios in terms of production, GHG emissions and consumption for each sector. The upper parts of the figures show the GHG emissions in perspective of the production levels. It must be noted that for the bovine sectors, total emissions are compared, i.e. emissions from the dairy and bovine meat sector together.

The BAU scenario can result in quite different situations from one sector to another. For the pork sector, production increases slightly while emissions decrease slightly compared to 2015. A similar situation with increased production and reduced emissions can be observed for the dairy sector. In the broiler sector, both production and GHG emissions are expected to increase. The bovine meat and laying hen sectors have lower production levels in BAU which are accompanied by lower GHG emissions. In the Transition scenarios, the trend is towards lesser productions and GHG emissions except for milk production which increase compared to 2015.

The lower parts of the figures show whether the production levels of each scenario can meet the consumption levels under certain dietary patterns and whether there is a potential excess 'production which could be exported. It must be noted that in the case of egg production in the BAU scenario and under the 'Trends' pattern, there is a deficit situation. This indicates that the predicted production level in this scenario cannot meet the predicted egg consumption in 2050. Nevertheless, as noted in Section 10.1, the laying hen population in 2050 (and hence the resulting egg production) might have been underestimated as a result of the ban on battery cages which came into force in 2012 and had imported consequences on the laying hen sector.

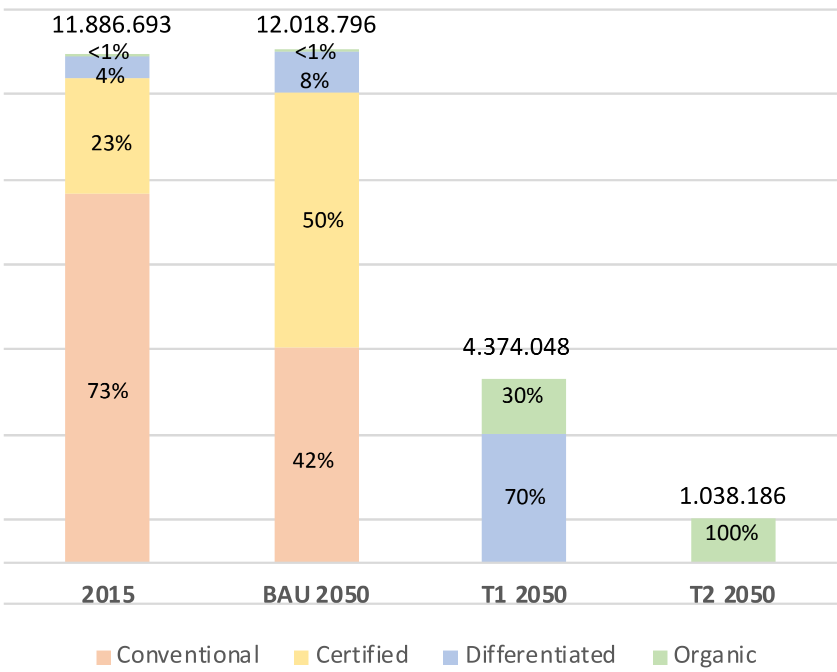

Figure 80. Evolution of pig slaughters in 2015 and 2050 according to different scenarios.

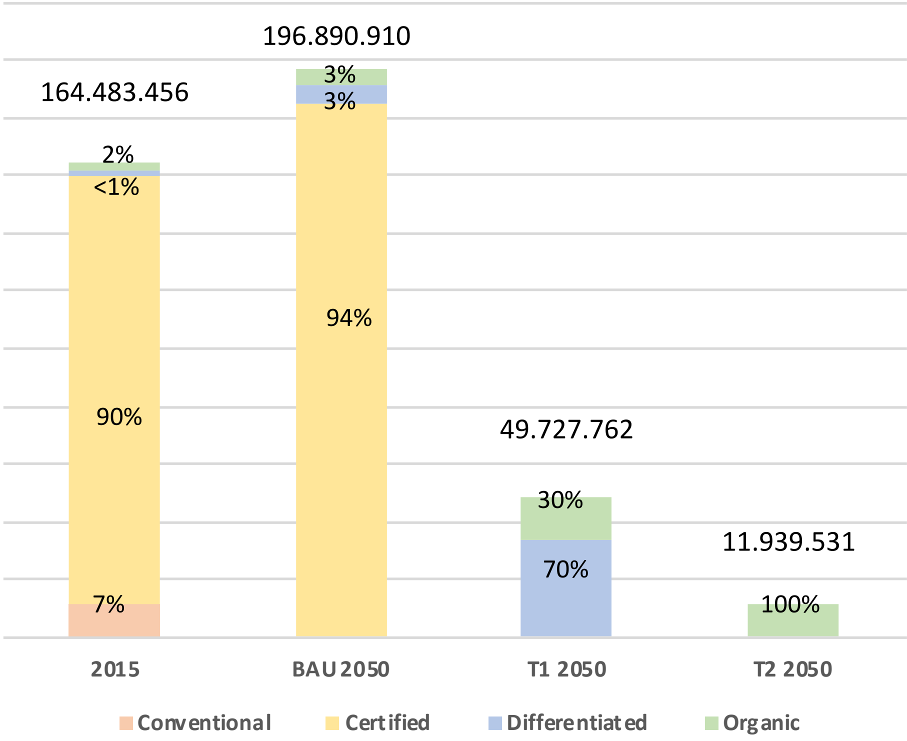

Figure 81. Evolution of broiler slaughters in 2015 and 2050 according to different scenarios.

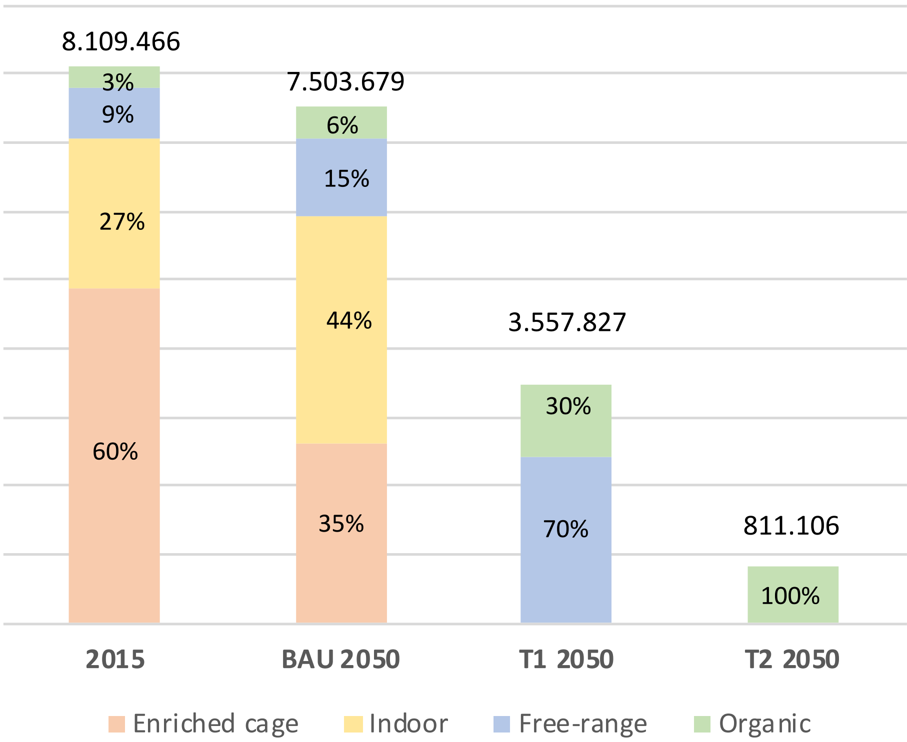

Figure 82. Evolution of the laying hen population in 2015 and 2050 according to different scenarios.

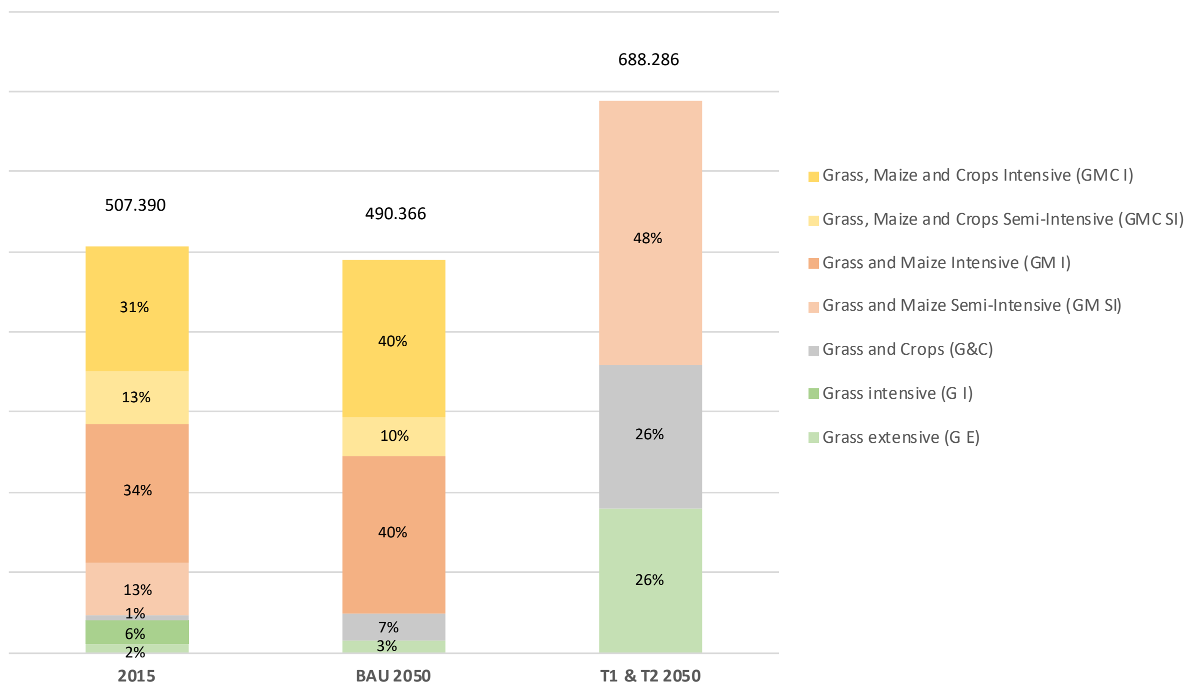

Figure 83. Evolution of the dairy cow population in 2015 and 2050 according to different scenarios.

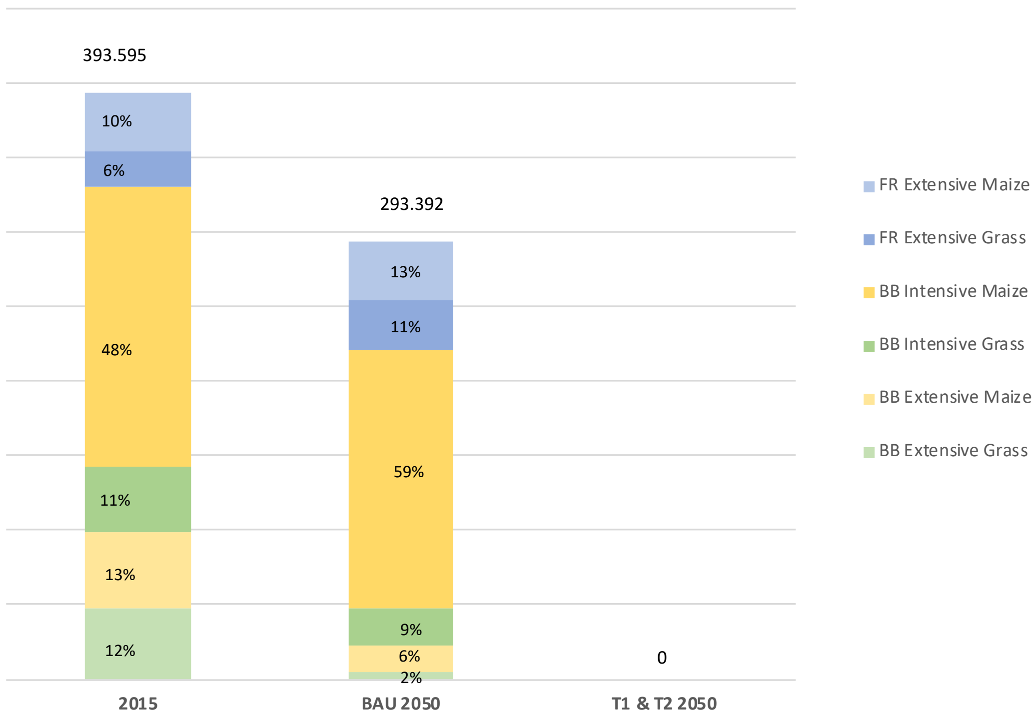

Figure 84. Evolution of the suckler cow population in 2015 and 2050 according to different scenarios.

Note: In the transition scenarios (T1 and T2), only a mixed dairy herd is considered, which explains the zero value for this case.

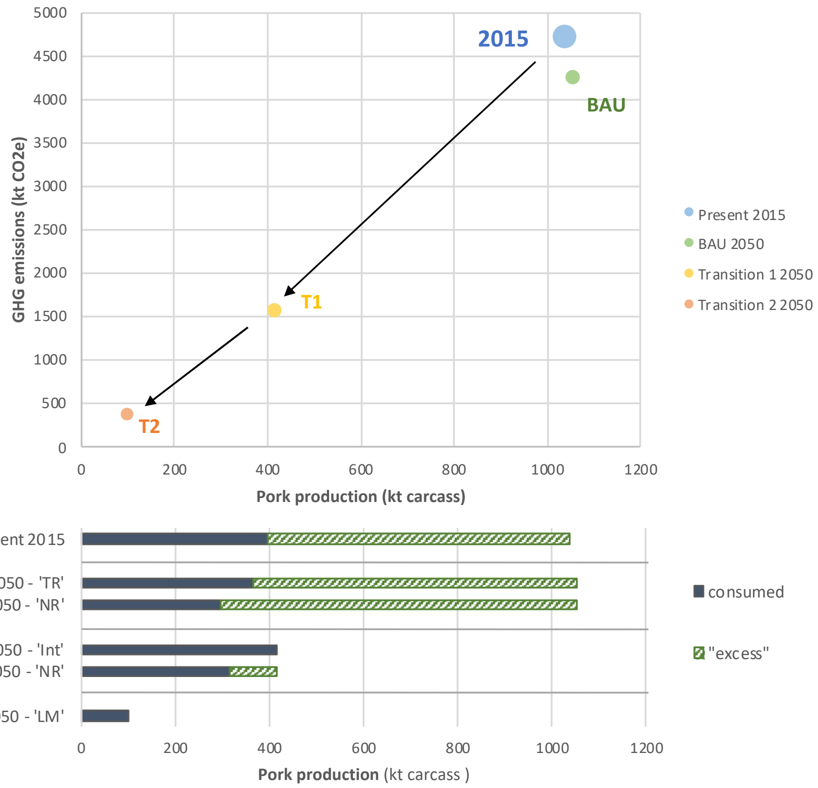

Figure 85. Consequences of the three scenarios in terms of production and GHG emissions for the pork sector.
Note: The excess illustrates whether the production exceeds the consumption in a particular scenario and under a particular consumption pattern. No excess means the entire production is consumed.

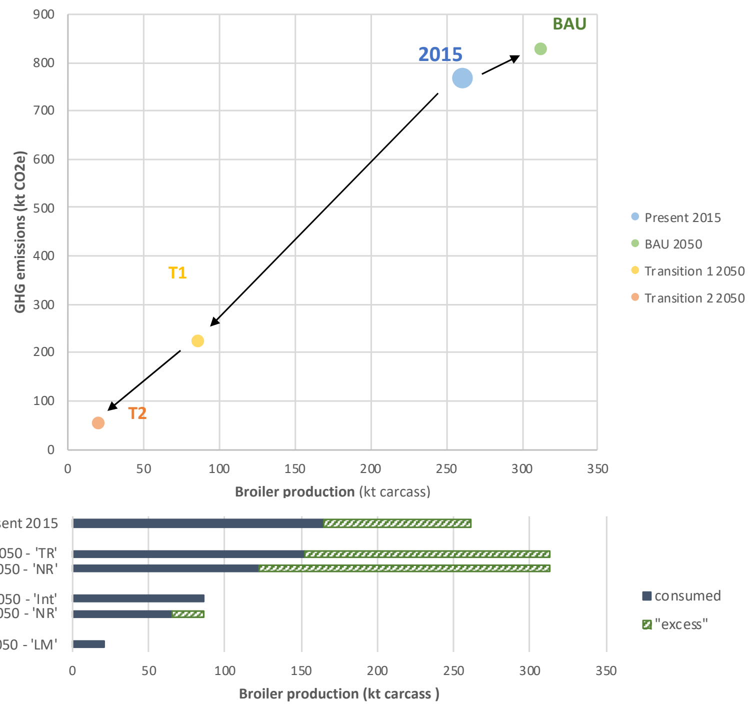

Figure 86. Consequences of each scenario in terms of production and GHG emissions for the broiler sector.
Note: The excess illustrates whether the production exceeds the consumption in a particular scenario and under a particular consumption pattern. No excess means the entire production is consumed.

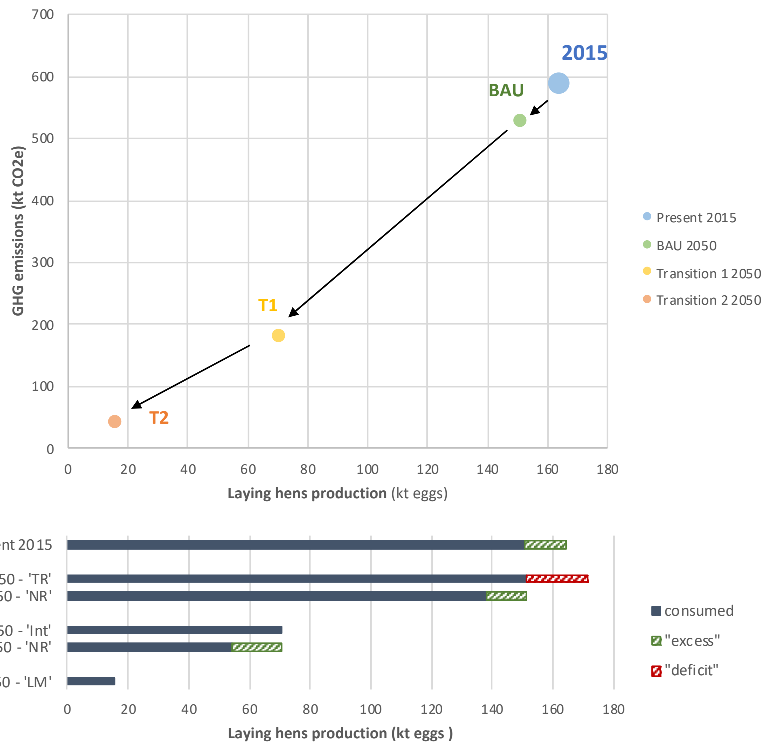

Figure 87. Consequences of each scenario in terms of production, GHG emissions and consumption for the laying hen sector.

Note: The excess illustrates whether the production exceeds the consumption in a particular scenario and under a particular consumption pattern. No excess means the entire production is consumed. A deficit indicates that the production level is lower than the supposed consumption level under the assessed consumption pattern.

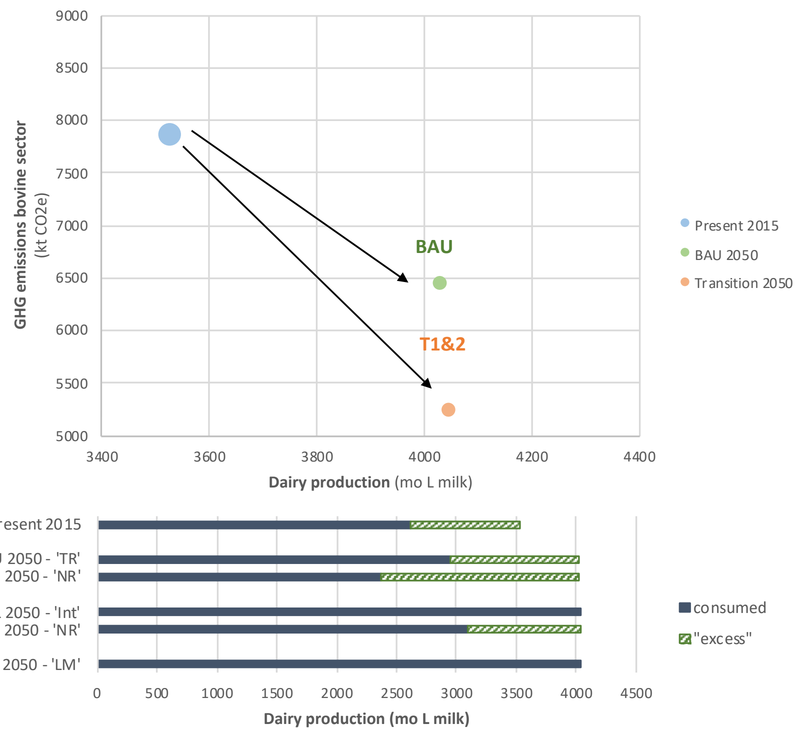

Figure 88. Consequences of each scenario in terms of production, GHG emissions and consumption for the dairy sector.

Note: The excess illustrates whether the production exceeds the consumption in a particular scenario and under a particular consumption pattern. No excess means the entire production is consumed.

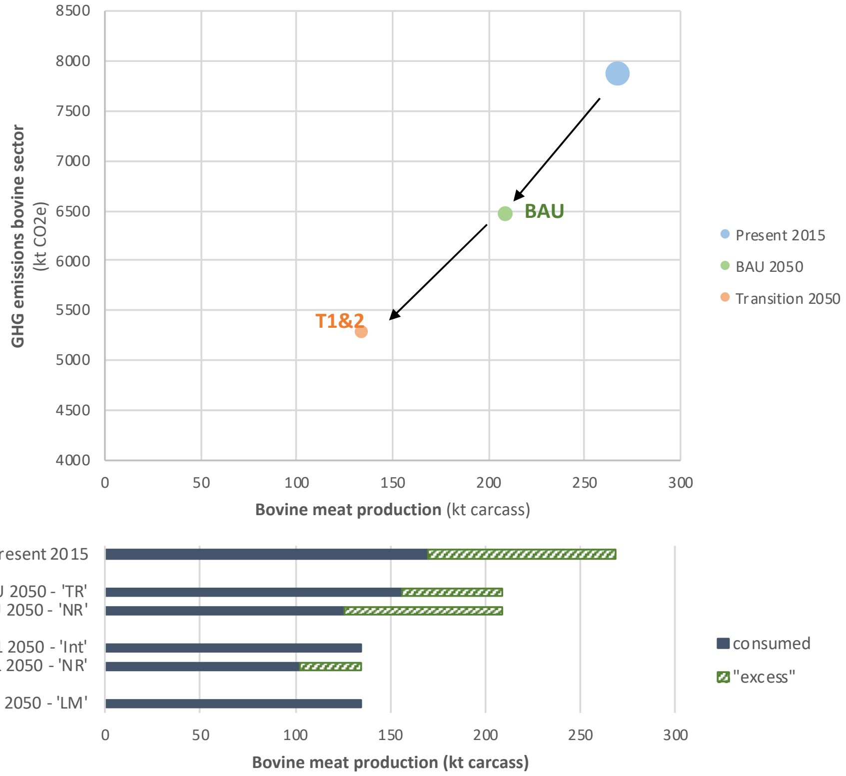

Figure 89. Consequences of each scenario in terms of production, GHG emissions and consumption for the bovine meat sector.

Note: The excess illustrates whether the production exceeds the consumption in a particular scenario and under a particular consumption pattern. No excess means the entire production is consumed.

PART III: Feedback and assessment processes of the study

Two main processes allowed to get feedback on the study during its preparation. On the one hand, feedback from actors from the livestock sector was obtained through participative focus groups. On the other hand, national and international experts were consulted and given the opportunity to give their feedback on the study through a peer-review process.

1. Focus groups

1.1. Methodology

As mentioned in Chapter 2, focus groups were organised for each livestock sector. In the continuity of the individual actor interviews carried out in the first stages of the project, these discussions were an opportunity to collect feedback on the study, its data sources and preliminary results. Furthermore, and equally importantly, they allowed for a collective discussion around each sector and its potential development options for the future.

As such, the objectives of these focus groups were three-fold:

(i) Collect feedback and validate the preliminary results;
(ii) Discuss the developed scenarios and the future of each sector;
(iii) Get an understanding of conflicting and unifying points among the sectors' stakeholders.

Four focus groups were organised in total. Only Flemish actors were contacted given that the pork and poultry sectors are importantly concentrated in Flanders, and that for the bovine sectors, focus groups had already been organised in Wallonia in the context of a similar study by the UCL (Petel et al., 2018a, 2018b). About twenty stakeholders were invited to each session, although in practice only six actors participated to each focus group (see Table 151). Each focus group lasted 3 to 4 hours, during which a presentation of the results was given, followed by a discussion with the participants.

The discussions were recorded and analysed afterwards by two students from the Universiteit Gent who attended the sessions. They compiled the comments which arose during the discussions and identified topics which were subject to consensus and/or debate among the participants.

Table 151. List of organisations which participated in the focus groups.

	FG pork 29/06 AM	FG dairy 02/07 AM	FG bovine meat 02/07 AM	FG poultry 16/07 AM
Farmer Union	1. ABS	1. Boerenbond 2. ABS	1 & 2. Boerenbond 3. ABS	
Research	2. ILVO	3. ILVO	4. ILVO	1 & 2. ILVO
Authorities	3. Dep Landbouw & Visserij	4 & 5. Dep Landbouw & Visserij	5. Dep Landbouw & Visserij	3. Dep Landbouw & Visserij
Sector organisations	4. BFA 5. Varkenslokket			4. Bioforum
Others	6. DGZ	6. DGZ	6. DGZ	5. DGZ 6. VEPYMO

BFA: Belgian Feed Association / **DGZ:** Veterinary services / **Varkenslokket:** Information platform on the pork sector / **Bioforum:** Sectoral organisation of the Flemish organic sector / **VEPYMO:** hatcheries.

1.2. Main results of the focus groups' discussions

In accordance with the objectives which were set for the focus groups, several points can be noted:

(i) Collect feedback and validate the preliminary results:

During the discussions, the participants made a series of comments on the methodology, the typologies, the use of certain sources, etc. These comments were compiled and listed in a document. Some comments were outside the original scope of the study and were thus not considered. They were nevertheless listed and contribute to the limits of the study. The other comments, which were in-scope, were taken into account as far as possible and modifications to the study were made accordingly. Nevertheless, even within the in-scope comments, some aspects could not be processed for time and/or resource availability reasons. These aspects were also listed and also contribute to the limits and potential ways of improvement of the study.

(ii) Discuss the developed scenarios and the future of each sector:

Two scenarios were discussed during the focus groups: the BAU scenario and Transition 1.[47]

According to the participants, the BAU scenarios seemed rather realistic in terms of evolutions of animal populations and shares of production systems. The main remark regarded the fact that technical improvements were at that time not considered in the calculations. This point was however dealt with afterwards and several optimisation factors were applied to each sector (see Table 97).

The first transition scenario on the other hand was much more debated, both in terms of rationale and in terms of feasibility. The choice to focus on the use of national resources as a starting point was much debated and the reasons for designing such a scenario in the current situation (globalised, European context) were not well understood. In general, it was considered a non-realistic scenario.

(iii) Get an understanding of conflicting and unifying points among the sectors' stakeholders:

As stated above, the approach adopted to analyse the discussions was to identify elements of debate which were controversial and/or consensual among the participants. Analysing the discussions under this framework showed that in general, the participants shared a common vision of their sector and agreed with each other on many topics. The rather limited number of participants can contribute to explaining this. Nevertheless, despite the rather low participation rate, a diversity of actors was represented (as illustrated in Table 151). Furthermore, even though they did not always agree with the study's results, the participants showed interest in the subject and generally appreciated the opportunity to meet up and discuss these matters. Additionally, this can highlight the difficulty to organise a debate with people who do not see each other very often.

[47] The Transition 2 scenario was developed after the focus groups, in part as a result of the comments which arose during the discussions. In particular, expanding the scope of feed sources to EU-origin feed in Transition 2 was a result of the strong debate generated by the choice to focus on national resources in Transition 1.

1.3. Presentation of results in Wallonia

As stated above, no real focus groups were organised in Wallonia given the strong sectoral concentrations of the pork and poultry sectors in Flanders and the fact that discussions had already been organised for the bovine sectors. Nevertheless, in order to give the actors from that region the opportunity to give collective feedback (and not only through individual interviews) on the study, a meeting was organised to present the general results and findings of the study. This meeting was held in September 2018, i.e. towards the end of the study period.

About fifteen actors from the Walloon livestock sector were present, with a good diversity among them.

Table 152. List of organisations which participated in the presentation of results in Wallonia.

Participant n°	Organisation	Type
1	FWA	Farmer union
2	FWA	Farmer union
3	FUGEA	Farmer union
4	UNAB	Farmer union
5	UNAB	Farmer union
6	UNAB	Farmer union
7	Biowallonie	Sectoral organisation
8	AWE	Sectoral organisation
9	SOCOPRO	Sectoral organisation
10	SOCOPRO	Sectoral organisation
11	SOCOPRO	Sectoral organisation
12	Dumoulin	Feed company
13	FoodBlue	Consulting services
14	CRA-W	Research
15	CRA-W	Research
16	UCL	Research

2. Peer-review

2.1. Methodology

Apart from the focus groups, feedback was also obtained through a peer-review process. Three scientific experts from different institutions participated in the process. Two of them were national experts (for Flanders and for Wallonia) and one was an international expert (Table 153).

A preliminary version of the study's results was sent to reviewers B and C in June 2018. The third reviewer (A) received an updated version at the end of August 2018. This allowed to get comments on different versions of the document and hence improve the overall accuracy of the study.

The main objective for this process was to collect feedback on the general methodology of the study, its approach, the proposed typologies, the numbers which were used for the calculations, the design of the scenarios and their results, etc.

Table 153. Organisations which participated in the peer-review process.

N°	Reviewer	Organisation	Level
1	A	KULeuven	National (Flanders)
2	B	Collège des Producteurs	National (Wallonia)
3	C	Solagro	International (France)

2.2. Results of the peer-review

Each reviewer communicated their comments in a 2 to 3-page document. These comments were compiled and listed with the remarks that resulted from the focus group sessions. Similarly, some comments were out of scope and thus left behind. As far as possible, the other comments were processed. As stated above, the untreated comments were considered and listed as limits of the study and potential ways of improvement.

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Appendix 1 – List of participating actors

Individual actor interviews

No	Type	Organisation	Sector(s)
1	Farmer union	ABS	Pork
2	Farmer union	Boerenbond	Pork & Poultry
3	Farmer union	Boerenbond	Dairy & Bovine meat
4	Farmer union	Landsbond (Pluimvee)	Poultry
5	Farmer union	FUGEA	Pork & Poultry
6	Producer organisation	VPOV	Pork
7	Cooperative	Porcs Qualité Ardenne	Pork
8	Professional union	UNAB (Groupement prods porc bio)	Pork
9	Interprofessional union	SOCOPRO (Collège des producteurs)	Poultry
10	Research	ILVO	Pork
11	Research	ILVO	All
12	Education/Research	Biotechnische hoge school Sint Niklaas	Bovine meat
13	Research	CRA-W	Poultry
14	Research	CRA-W	Pork
15	Sectoral organisation	Bioforum	All
16	Sectoral organisation	Biowallonie	All
17	Authorities/Research	Departement Landbouw & Visserij	Pork
18	Authorities/Research	Departement Landbouw & Visserij	Poultry
19	Authorities/Research	Departement Landbouw & Visserij	Poultry
20	Authorities/Research	Departement Landbouw & Visserij	Dairy
21	Authorities/Research	Departement Landbouw & Visserij	Bovine meat
22	Feed	BFA	All
23	Feed/Slaughterhouse	Huys voeders	All
24	Feed	SCAR	All

Collective focus groups

	FG pork 29/06 AM	**FG bovine meat** 02/07 AM	**FG dairy** 02/07 PM	**FG poultry** 16/07 AM
1	BFA	Boerenbond	Boerenbond	Bioforum
2	ABS	Boerenbond	ABS	ILVO
3	ILVO	ABS	ILVO	ILVO
4	DGZ	ILVO	DGZ	DGZ
5	Dep. Landbouw & Visserij	Dep. Landbouw & Visserij	Dep. Landbouw & Visserij	Dep. Landbouw & VIsserij
6	Varkenslokket	DGZ	Dep. Landbouw & Visserij	VEPYMO

BFA : Feed / **ABS ; Boerenbond** : Farmer unions / **ILVO** : RechResearcherche / **DGZ** : Veterinary services / **Dep. Landbouw & Visserij** : Flemish authorities / **Varkenslokket** : Information platform for the pork sector / **Bioforum** : Sectoral organisation of the Flemish organic sector / **VEPYMO :** Hatcheries.

Appendix 2 – Belgian population and the Belgian organic sector

Table 154. Population in Belgium in 2015.

	Wallonia		Flanders		Brussels		Belgium	
	Habitants	Share	Habitants	Share	Habitants	Share	Habitants	Share
Population	3.589.744	58%	6.444.127	32%	1.175.173	10%	11.209.044	100%

Sources: Statbel (2015) Aperçu statistique de la Belgique – Chiffres clés

Table 155. Projected populations in 2030 and 2050.

	2015	2030	2050
Population (habitants)	11.209.044	11.979.356	12.736.357

Source: (Statistics Belgium, 2018)

Organic production remains small (3% of the bovine cattle, 6% of the total poultry population, and less than 1% of the pig population). However, it has shown a significant growth over the last 10 years, especially in the bovine and poultry sector (**Table 156**).

Table 156. Share of the organic sector in livestock production in Belgium in 2015.

	Wallonia		Flanders		Belgium		Situation 2005	
	Pop	% org	Pop	% org	Pop	% org	Pop	Growth
Total bovine	77.704	7%	2.565	<1%	80.269	3%	33.187	+142%
Pigs	6.822	2%	3.452	<1%	10.274	<1%	8.515	+21%
Total poultry	1.956.918	35%	409.097	1%	2.366.015	6%	846.460	+180%

Source : Statbel – Agriculture bio en Belgique (1987, 2003-2016)
http://statbel.fgov.be/fr/statistiques/chiffres/economie/agriculture/biologique/

Appendix 3 – Specifications for the environmental assessments

(a) Animal welfare criteria

Table 157. CIWF welfare criteria for pig husbandry.

Pigs	*Bad*	*Better*	*Best*
Housing	- Barren floor - Fully-slatted floor	- Covered floor (straw…) - Max 10% floor slatted	- Covered floor (straw…) - Outdoor access (free-range)
Mutilation	- Tail docking - Teeth clipping - Surgical castration - Nose ringing	- Immunocastration - Teeth grinding	- No mutilation of any kind
Birth-giving	- Early weaning - Farrowing crates for sows	- Free-farrowing spaces with nesting and bedding spaces	- Natural weaning (min. 8 weeks) - Free-farrowing spaces

Source: (CIWF, 2014)

Table 158. CIWF welfare criteria for broiler husbandry.

Broilers	*Bad*	*Better*	*Best*
Housing	- high stocking densities (> 30 kg bird/m^2) - Barren/fully-slatted floor - Cage systems - Continuous light	- Intermediate stocking densities (Max. 30 kg bird/m^2) - Presence of straw bales - Natural light	- Outdoor access (free-range) - Dark period
Mutilation	- De-beaking - Toe clipping	- No mutilation of any kind	- No mutilation of any kind
Breed	- Fast-growing	- Fast-growing but with monitoring of leg health	- Slow-growing

Source: (CIWF, 2014)

Table 159. CIWF Welfare criteria for laying hen husbandry.

Laying hens	*Bad*	*Better*	*Best*
Housing	- Cage systems	- Barn systems	- Outdoor access (free-range)
Mutilation	- Debeaking - Killing of male chicks	- No mutilation of any kind	- No mutilation of any kind

Source: (CIWF, 2014)

Table 160. CIWF Welfare criteria for beef husbandry.

Beef	*Bad*	*Better*	*Best*
Housing	- Large-scale feedlots - Fully-slatted floors - No bedding areas	- Access to bedding area	- Animals kept in long-term, stable family groups
Feed	- Insufficient roughage - Too much concentrates	- Higher fibre contents	- Access to pasture
Birth-giving	- Routine caesareans - Use of double-muscled breeds (e.g. BB)	- Easy/natural birth-giving	- Easy/natural birth-giving - Natural weaning: min 8 months old

Source: (CIWF, 2014)

Table 161. CIWF welfare criteria for dairy husbandry.

Dairy cows	*Bad*	*Better*	*Best*
Housing/Feed	- Permanent housing without bedding area - No pasture/grazing access	- Good winter housing + pasture - Bedding/resting area	- Access to grazing (choice between in/outdoor) as significant part of diet
Other welfare considerations	- Unsustainably high milk yields - Early induction of birth	- Selection of naturally hornless animals or disbudding with pain-relief	- Dual-purpose breeds - Reasonable production levels

Source: (CIWF, 2014)

(b) Assessment of biodiversity impacts

Table 162. Table of characterisation factors.

Land use type and intensiveness	**CF** [1] /ha/month
Organic arable land	0,36
Less intensive arable land	0,44
Intensive arable land	0,79
Organic fertile grassland	-0,01
Less intensive fertile grassland	0,36
Intensive fertile grassland	0,65

[1] (De Schryver et al., 2010)

Table 163. Crop durations, crop yields and associated CFs.

Crop	**Duration** months	**Yield** [1, 2] kg/ha	**CF crop duration (intensive)** /ha	**CF crop duration (organic)** / ha
Wheat (triticale)	10	6.874	3,95	1,8
Maize	8	11.688	9,48	4,32
Oleaginous/proteaginous (here: beans)	12	4.115	9,48	4,32
Soybean meal	12	2.862	9,48	4,32
Rapeseed meal)	12	4.148	9,48	4,32

[1] Statbel (2016) Average yields over the period 2011-2015

[2] Average soybean yield in Brazil over the period 2011-2015 (https://www.statista.com/statistics/740462/soybean-yield-brazil/)

Table 164. Average yields of different forage crops in Belgium.

Crop	**Yield** t/ha	**Reference**
Permanent pasture	7,0	Fourrages-mieux (2015)
Temporary pasture	10,0	Fourrages-mieux (2015)
Forage maize	45,7	Statistics Belgium (2016) avg for 2011-2015
Forage beet root	99,7	Statistics Belgium (2016) avg for 2011-2015
Alfalfa (luzerne) [1]	3,7	Statistics Belgium (2016) avg for 2011-2015
Other forages [2]	5,0	Statistics Belgium (2016) avg for 2011-2015

[1] Yield for "autres légumineusees récoltées en sec"

[2] Yield for "fèves et féverolles récoltées en sec"

(c) Assessment of GHG emissions

Table 165. Global Warming Potentials (GWP) of feed ingredients.

Ingredient	Unit	GWP
Wheat[1]	kg CO_2e/kg feed	0,837
Maize[1]	kg CO_2e/kg feed	0,488
Barley[1]	kg CO_2e/kg feed	0,281
Oleaginous/Proteaginous (maize glutenfeed) [1]	kg CO_2e/kg feed	0,424
Soybean meal [1]	kg CO_2e/kg feed	3,1 (of which 70% LUC)
Sunflower meal[2]	kg CO_2e/kg feed	0,97
Rapeseed meal[1]	kg CO_2e/kg feed	0,455
Minerals, vitamins…[2]	kg CO_2e/kg feed	0,57

Sources:
[1] Blonk/WUR *in* ERM & Ugent (2011)
[2] Ecoinvent *in* ERM & Ugent (2011)
Note:
These emissions factors include the estimated emissions related to the transportation of the feed to Belgium.
LUC stands for Land Use change

Table 166. Methane emission factors from enteric fermentation and manure management.

Livestock	Enteric fermentation	Manure management
	kg CH_4/head/year	kg CH_4/head/year
Pigs	1,5 [1]	4,47 [2,3]
Poultry	0 [1]	0,023 [2,3]
Dairy cow	143,3 [1,3]	29,13 [2,3]
Dairy cattle <1 year	27,5 [3]	1,2 [3]
Dairy cattle 1-2 years	57,9 [3]	4,3 [3]
Suckler cow	92,7 [1,3]	3,39 [2,3]
Non-dairy cattle <1 year	27,5 [3]	1,05 [3]
Non-dairy cattle 1-2 years	54,33 [3]	2,68 [3]

Sources: [1] (IPCC, 2006a), [2] (IPCC, 2006b), [3] (VMM et al., 2017)
Note: All factors presented here were calculated following the IPCC's guidelines for GHG reporting (IPCC, 2006a, 2006b). Except for the enteric fermentation of pigs and poultry, values were taken directly from Belgium's GHG inventory.

Table 167. Nitrous oxide emission factors from manure management.

Livestock	Direct N_2O emissions	Indirect N_2O emissions: NH_3/NO_X emissions from manure	Indirect N_2O emissions: N_2O from NH_3/NO_x
	% of N emissions	% of N emissions	% of NH_3/NO_x
Pigs & poultry	0,1%	25%	1%
Dairy cattle			
- On pasture	2%	20%	1%
- In stable	0,5%	30%	1%
Non-dairy cattle			
- On pasture	2%	20%	1%
- In stable	0,5%	45%	1%

Source: (ERM and Universiteit Gent, 2011).
Note: Cattle is assumed to spend 50% of the year on pasture (summer months) and 50% in stables (ERM and Universiteit Gent, 2011).

(d) Assessment of N emissions

Table 168. Nitrogen contents of feed ingredients and Nitrogen use efficiency (NUE).

Process	N content (% of DM)
Wheat	2,1%
Maize	1,5%
Barley	1,9%
Soybean meal	6,4%
Sunflower meal	5,4%
Others (minerals, vitamins…)	1,0%
NUE pigs	33%
NUE dairy cows	23%
NUE other cattle	9%
NUE laying hens	26%
NUE broilers	40%

Source: (Hou et al., 2016)

Note: Several interviewed actors mentioned that the NUE values seemed rather low. Nevertheless, the figures provided by Hou et al. (2016) were still used as their study was carried out at a EU-level with a specific assessment for each member state, including Belgium. Furthermore, using these figures presents the advantage of providing values for all kinds of livestock animals in one same source.

Appendix 4 – Specifications for protein conversion

Table 169. Results of the 2014 survey on food consumption expressed in terms of protein.

Type of food	Consumption[1] 2014	Consumption[1] Recommended	Conversion to proteins: Name Aliment [2]	Conversion to proteins: Conversion factor [2]	Protein consumption 2014
	g/capita/day	g/capita/day		g protein/100g	G prot/capita/day
Vegetal-based products					
Cereals (Bread)	107	210-240	*Pain courant français (400g ou boule)*	7,9	8,5
Potatoes	46	-	*Pomme de terre bouillie/cuite à l'eau*	1,8	0,8
+ substitutes (rice, pasta, quinoa…)	142	240-350	*Pâtes sèches standard, cuites, non salées*	3,99	3,8
Vegetables	157	300	*Légumes (3-4 sortes en mélange), purée*	2,19	3,4
Fruits	108	250	*Orange, pulpe, crue*	1,06	1,1
+ Juices and olives	170	250	*Jus d'orange, maison*	0,66	0,4
TOTAL vegetal-based products	576	1000 - 1140		-	18,1
Animal-based products					
Bovine meat [a]	21	-	*Bœuf, steak ou bifteck, grillé*	27,6	5,8
Pork [a]	49	-	*Porc, filet mignon, cuit*	26,1	12,8
Poultry meat [a]	31	-	*Poulet, blanc, sans peau, cuit*	29,2	9,1
Others [a]	12	-	*Lapin, viande cuite*	20,5	2,5
Sub-total meat products	114	57		25	30,1
Eggs	11	20	*Œuf, cru*	12,7	1,4
Milk and Ca-enriched soy products	139	450 ml	*Lait demi-écrémé, UHT*	3,29	4,6
Cheese	32	20	*Gouda*	23,2	7,4
Fish and fish products	25	<100	*Cabillaud, cuit à la vapeur*	24,5	6,1
TOTAL animal-based products	321 (139)	590 (100)		-	49,6
Residual products					
Soft drinks	150	-	*Cola, sucré*	0,093	0,1
Alcoholic drinks	162	-	*Bière "cœur de marché" (4-5° alcool)*	0,39	0,6
Biscuits and cake	42	-	*Biscuit sec petit beurre*	7,73	3,2
Chocolate and sugary food	26	-	*Chocolat, en tablette (aliment moyen)*	7,43	1,9
Salted snacks	32	-	*Chips de pomme de terre, standard*	5,67	1,8
Sauces	29	-	*Mayonnaise (70% MG min)*	1,36	0,4
			TOTAL PROTEIN CONSUMPTION	**-**	**75,9**
			RECOMMENDED PROTEIN CONSUMPTION	**-**	**52-62**

Sources: [1] (De Ridder et al., 2016), [2](ANSES, 2016).

Appendix 5 – Socially responsible soy (BFA standard)

Since 2009, the BFA (Belgian Feed Association) has developed its own Belgian standard for socially responsible soy ('SoRes' in French, 'MV-soja' in Dutch). It is aligned with the international RTRS initiative (Round Table on Responsible Soy).

The standard follows four core principles and comprised 64 sustainability indicators in 2015. Those four principles are (BFA, 2016):

(1) The respect of legislation and good commercial practices;
(2) Adequate working conditions;
(3) The respect of the environment (certified soy does not come from recently deforested areas);
(4) Good agricultural practices.

The feed producing companies which are members of the BFA[48] collectively sign up for a certified soy buying program.

The socially responsible soy standard follows an 'Area Mass Balance' principle. This means that the soy which is used by Belgian feed producing companies is not necessarily certified itself but comes from a region where certified soy crops are cultivated. The standard thus works on the basis of certification/credits (BFA, 2016).

To date, according to the BFA, the purchased volume of socially responsible soy (347.000 t) covers the national demand for soy in the feeding industry (350.000 t) (BFA, 2018).

[48] Together, the members of the BFA represented 94% of total Belgian production of compound feeds in 2015 (BFA, 2016).

Appendix 6 – Belgian GHG inventory

Extract from national inventory (2015) regarding agriculture (culture and livestock) emissions

Source	CO_2	CH_4		N_2O		Total CO_2e
	kt CO_2e	kt CH_4	kt CO_2e	kt N_2O	kt CO_2e	kt CO_2e
A. Fuel combustion agriculture/forestry (1.A.4.C)	**1620,6**	**5,0**	**125,5**	**0,1**	**18,8**	**1765,0**
Stationary combustion	1355,0	5,0	124,6	0,0	2,4	1482,1
Off-road vehicles & machinery	531,2	0,1	1,8	0,1	32,7	565,7
Corrected off-road vehicles & machinery	265,6	0,0	0,9	0,1	16,4	282,9
B. Fertiliser production (2B)	1213,4	0,0	0,0	1,3	375,1	**1589,9**
Ammonia production	1213,4	0,0	0,015			1213,5
Nitric acid production				1,3	375,1	376,4
C. Enteric Fermentation (3.A)	0,0	183,3	4582,8	0,0	0,0	**4582,8**
Dairy cattle	0,0	64,6	1616,2		0,0	1616,2
Non-dairy cattle		106,2	2656,1		0,0	2656,1
Swine		10,0	249,8		0,0	249,8
Poultry		0,0	0,0		0,0	0,0
Sheep		0,9	23,7		0,0	23,7
Goats		0,2	6,0		0,0	6,0
Horses		0,2	6,0		0,0	6,0
Mules and Asses		0,1	2,4		0,0	2,4
Other animals		0,9	22,7		0,0	22,7
D. Manure management (3.B)	0,0	50,2	1254,9	2,5	736,3	**1991,2**
Dairy cattle		13,14	328,6	0,3	103,8	432,4
Non-dairy cattle		6,13	153,3	1,2	354,4	507,7
Swine		29,8	745,0	0,2	73,2	818,3
Poultry		0,9	23,7	0,0	11,1	34,8
Sheep		0,0	0,6	0,0	0,6	1,2
Goats		0,0	0,2	0,0	0,8	0,9
Horses		0,1	2,5	0,0	4,9	7,4
Mules and Asses		0,0	0,2	0,0	0,5	0,6
Other animals (rabbits and fur-bearing)		0,0	0,9	0,0	0,4	1,3
Indirect N2O (atm deposition)		0,0	0,0	0,6	186,6	186,6
E. Agricultural soils (3.D)	0,0	0,0	0,0	11,0	3276,6	**3276,6**
Direct N2O emissions from managed soils			**0,0**	**8,6**	**2567,5**	**2567,5**
1. Inorganic N fertilizers			0,0	2,3	672,4	672,4
2. Organic N fertilizers			0,0	1,6	468,6	468,6
a. Animal manure applied to soils			0,0	1,6	462,1	462,1
b. Sewage sludge applied to soils			0,0	0,0	5,6	5,6
c. Other organic fertilizers applied to soils			0,0	0,0	1,0	1,0
3. Urine and dung deposited by grazing animals			0,0	1,7	501,6	501,6
4. Crop residues			0,0	3,0	905,8	905,8
5. Mineralization/immobilization associated with loss/gain of soil organic matter			0,0	0,0	9,0	9,0
6. Cultivation of organic soils (i.e. histosols)[(2)]			0,0	0,0	10,2	10,2
Indirect N_2O Emissions from managed soils			**0,0**	**2,4**	**709,1**	**709,1**
1. Atmospheric deposition			0,0	0,6	188,8	188,8
2. Nitrogen leaching and run-off			0,0	1,7	520,3	520,3
F. Liming (3.G)	130,7	0,0	0,0	0,0	0,0	**130,7**
Limestone (CaCO3)	62,7		0,0		0,0	62,7
Dolomite (CaMg(CO3)2)	68,0		0,0		0,0	68,0
G. Urea application (3.H)	21,5		0,0		0,0	**21,5**
Livestock emissions	0,0	233,5	5837,7	5,7	1699,9	7537,6
TOTAL Agriculture	2986,3	238,5	5963,2	14,8	4406,8	**13357,6**

Source: (VMM et al., 2017)

Notes on GHG inventory extract and GHG assessment:

(a) Agriculture emissions:

- The emission sources officially reported under agriculture emissions in the Belgian GHG inventory are enteric fermentation, manure management, agricultural soils, liming and urea application. These emissions amounted **10.003 kt CO_2e** in 2015. In 2005, these emissions amounted 10.312 kt CO_2e (see section 14.4.2).
- In the table presented here, emissions from fuel combustion in the agriculture sector and fertiliser production were included too because they are considered related to the sector. Including these two additional emission sources, total emissions from the agricultural sector amounted **13.358 kt CO_2e** in 2015, which is the value presented in Table 8.

(b) Livestock emissions:

- The emissions which were considered to be attributed to the livestock sector include the following categories: enteric fermentation; manure management, animal manure applied to soils and urine and dung deposited by grazing animals. These amounted **7.538 kt CO_2e** in 2015.
- The emission sources highlighted in yellow are the ones which match the emission sources also assessed in this study, i.e. emissions from enteric fermentation and manure management. They constitute the overlapping scope of emissions which were assessed both in the context of this study and in the GHG inventory. These emissions amounted **6.817 kt CO_2e** in 2015 and were used for comparison purposes in section 9.3. In 2005, these emissions amounted 6.914 kt CO_2e (see section 14.4.2).

Appendix 7 – Differentiation initiatives in the pig sector

Table 170. Overview of existing differentiation initiatives in the pig sector in Belgium (Van Buggenhout and Vuylsteke, 2016).

No.	Name	Initiator	Specifications?	Label?	Focus					
					Feed	Breed	Animal welfare/ Health/Medication	Quality	Local/ Short chain	Organic
1	Certus	Sector	X				X	X		
2	Organic (EU Biolablel)	Authority	X	X	X		X			X
3	Porc Aubel	Meat transformer	X	X	X	X		X		
4	Vitaproject	Processing Chain	X		X		X			
5	Beter voor iedereen	Retail (Delhaize)	X	X	X		X	X		
6	Varken van weleer	Retail (Carrefour)	X	X	X		X			
7	Brasvar	Producer	X	X	X	X	X		X	
8	Hof ter Meulen	Producer (individual farm)			X	X	X			
9	Porc Fermier [a]	Producer	X		X	X	X			
10	De donderij	Producer (individual farm)	X		X	X	X			X
11	Duroc d'olives	Producer			X	X		X		
12	Livar Kloostervarken	Producer			X	X	X	X	X	
13	Duke of Berkshire	Feed producer				X		X		
14	Porc Bio [a]	Producer	X				X			X
15	Porc Plein Air [a]	Producer	X			X	X			
16	Pigfijn	Producer (individual farm)		X					X	
17	Doornehoef	Ex-Producer						X	X	

[a] Labels of the cooperative Porcs Qualité Ardenne (PQA)

Appendix 8 – Comparison of GHG emissions in the pig sector

Comparison of GHG emission results with other studies

It appears from Table 171 that there is a great variability of results among studies regarding the GHG emissions involved in pork production.

The big gap with (Nguyen et al., 2010) can be explained in several ways. First, the GWP of soybean meal used in their study is much higher than the one used in this one (6,86 kg CO_2e/kg soybean meal in (Nguyen et al., 2010) vs 3,1 kg CO_2e/kg soybean meal in this study). Second, they consider a FCR of 3,03 whereas in this study, a FCR of 2,7 (for predominant conventional systems) was used. Third, the share of soybean meal in the feed is higher in (Nguyen et al., 2010) (0,54 kg soybean/kg live weight vs. 0,27 kg soybean/kg live weight). Finally, the manure-related emissions are more important in their study too (1,5 kg CO_2e/kg carcass weight vs. 0,8 kg CO_2e/kg carcass weight). These differences in feeding practices and parameters contribute to explaining the difference in results.

The difference in results with (FAO, 2013) can be explained through differences in feeding practices too. Indeed, feed-related emissions represent 5 kg CO_2e/kg carcass in (FAO, 2013) vs. 3,0 kg CO_2e/kg carcass in this case. This can be explained by two factors. First, they too considered higher FCRs (2,93 for industrial systems in (FAO, 2013) vs. 2,7 in this study), which affects feed intake levels and hence feed-related emissions. Second, the carbon impact of feed is higher in their case (1,2 kg CO_2e/kg feed vs. 0,8 kg CO_2e/kg feed in this study).

Table 171. Comparison of GHG emissions for pork production in different studies.

Reference	Systems considered	Scope	Other study	This study	Delta
			kg CO_2e/kg carcass		%
ERM & UGent (2011)	Conventional	Reduced[1]	4,38	4,02	9%
Belgian GHG inventory (2015)	Average	Reduced[2]	0,99	1,02	3%
(FAO, 2013)	Conventional	Reduced[1]	6,2	4,02	54%
(Nguyen et al., 2010)	Average	-	9,7	4,02	141%

Notes:

[1] For some studies, the scope of the results was reduced in order to only compare emissions which were estimated in both studies, i.e. feed-related emissions, enteric fermentation emissions, manure management emissions and on-farm energy usage emissions. Slaughtering emissions (which were considered by ERM & Ugent (2011) and *(FAO, 2013)*) were left behind.

[2] The comparison with the Belgian GHG inventory is limited to the enteric fermentation emissions and manure management emissions. See Appendix 6 – Belgian GHG inventory for more details on the Belgian GHG inventory.

Appendix 9 – The poultry sector

Table 172. Distribution of laying farms and animals in Flanders in 2013 (Departement Landbouw en Visserij, 2016a).

	Farms		Laying hens	
	Amount	%	Amount	%
20 - 99 laying hens	102	23	3.268	<0
100 - 9999 laying hens	116	26	593.313	5
10000 - 29999 laying hens	112	25	2.147.773	20
30000 - 49999 laying hens	48	11	1.829.729	17
50000 - 69999 laying hens	38	8	2.227.168	21
> 70000 laying hens	32	7	3.929.319	37
TOTAL farms with min 20 laying hens	448	100	10.730.570	100

Table 173. Distribution of broiler farms and animals in Flanders in 2013 (Departement Landbouw en Visserij, 2016a).

	Farms		Broilers	
	Amount	%	Amount	%
20 - 99 broilers	28	5	735	0
100 - 9999 broilers	58	11	250.978	1
10000 - 29999 broilers	169	33	3.218.230	16
30000 - 49999 broilers	107	21	4.121.746	20
50000 - 69999 broilers	65	12	3.795.072	19
> 70000 broilers	93	18	9.148.183	44
TOTAL farms with min 20 broilers	520	100	20.534.944	100

Table 174. Overview of differentiation initiatives in the poultry meat sector in Belgium, including the organic certification (Bergen, 2015).

	Organic	Poulet bio Coq des prés	Poulet de Gibecq	Kot'kot and Poulet basse-cour	Poulet des élevages du Moulin de Val Dieu	Crêtes d'Ardennes - Poulet de Bastogne	Mechelse koekoek (indoor)	Mechelse koekoek	Maïskip
	1	2	3	4	5	6	7	8	9
Chain regulator	Belki	Coprobel	Agrisain and Coprosain	CoqArdenne	Moulin du Val Dieu	Slaughterhouse Ardenne Volaille	Belki	Belki	Belki
Breed	Slow-grow	Slow-grow	Slow-grow	Intermediate-grow	Intermediate-grow	Intermediate-grow	Slow to intermediate grow	Slow to intermediate grow	Intermediate-grow
Max size (ani/building)	4.800	4.800	1.000	6.500	6.500	6.000	-	-	-
(ani/farm)	16.000	16.000	5.000	13.000	-	-	-	-	-
Indoor density (ani/m^2)	10	10	10				15	15-19	15-19
(kg/ m^2)	21	21	21	13	15	15	25	33-42	33-42
Outdoor area (m^2/ani)	4	4	2	2	-	-	-	-	-
Production period (days)	70-81	70-81	70	56	56-63	56-63	56-70	81	49
Final Weight (kg)	2-2,2	2,4	2,3	2,2-2,3	2,45	2,45	2,1	2,3	2,1
Feed	100% vegetal, organic (min 95%), GMO-verified	100% vegetal (65% cereals), organic (min 95%), GMO cerified	100% vegetal (70% cereals), GMO verified	100% vegetal (70% cereals), Omega-3 rich	100% vegetal, maize OR omega-3 rich	100% vegetal, maize OR omega-3 rich	100% vegetal (70% cereals)	100% vegetal (70% cereals)	100% vegetal (70% cereals, of which 50% maize)
Distribution	Delhaize, Colruyt, Match… (not Carrefour)	Short chain, on-farm	Coprosain selling points	Delhaize, Champion and Match	Colruyt		Supermarkets	Supermarkets	Supermarkets

Appendix 10 – The dairy and bovine meat sectors

(a) The dairy sector

Table 175. Composition of concentrates in the dairy sector and associated Global Warming Potential (GWP) of each ingredient .

Ingredient	**Share** (% of mass)	**GWP** (kg CO_2e/kg ingredient)
Soybean meal	22,3%	3,1
Palm oil residue	15%	1,12
Wheat	9,3%	0,837
Dried Distiller Grains with Solubles (DDGS)	15%	0,466
Soybean husks	12,5%	0,945
Rapeseed meal	15,7%	0,455

Source: (ERM and Universiteit Gent, 2011).

(a) The bovine meat breeding sector

Table 176. Composition of composite concentrates in the bovine meat breeding sector and associated Global Warming Potential (GWP) of each ingredient.

Ingredient	**Share** (% of mass)	**GWP** (kg CO_2e/kg ingredient)
Barley	14,4%	0,281
Maize	6,8%	0,488
Maize glutenfeed	26,0%	0,424
Sugarbeet pulp	23,1%	0,11
Soybean meal	5,8%	3,1
Rapeseed meal	14,4%	0,455
Linseed meal	9,6%	0,455

Source: (ERM and Universiteit Gent, 2011).

Note: Linseed meal is assumed to have the same GWP as rapeseed meal as no specific value is available for this ingredient.

Appendix 11 – Chapter 8

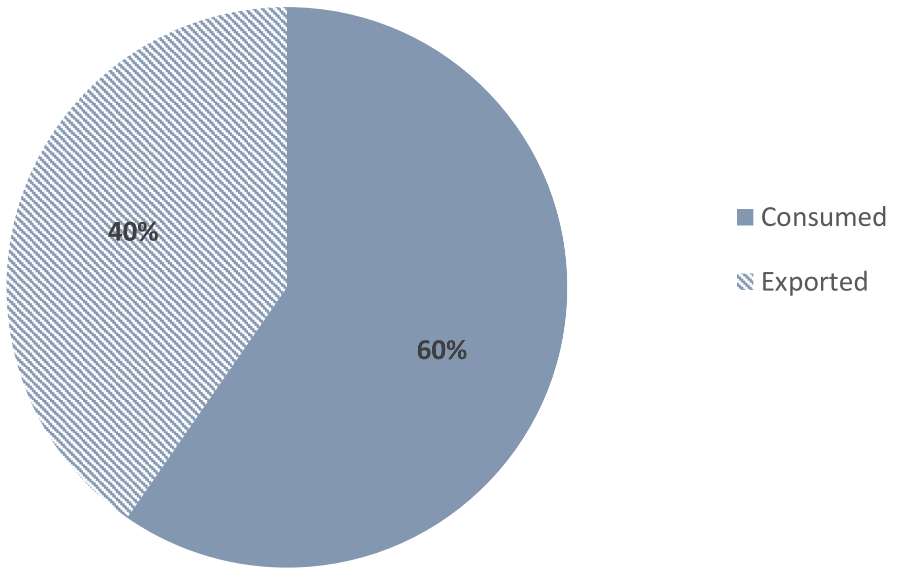


Figure 90. Distinction between "consumed" and "exported" GHG emissions in the Belgian livestock sector.

Appendix 12 – Animal feed

(a) Soy consumption

As shown in Table 78, it is estimated that the pork, poultry and bovine sectors consumed about 995 kt soybean meal in 2015. The pork sector is the biggest consumer of soybean meal (53% of total). The poultry and bovine sectors account for 23% and 24% of total consumption respectively (see table below).

Table 177. Consumption of soybean meal by the Belgian pork, poultry and bovine sectors in 2015.

Sector	**Soybean meal**	
	Kt/year	% of total
Productive pork animals	454	46%
Reproductive pork animals	69	7%
Broilers	126	13%
Laying hens	67	7%
Other poultry	35	3%
Dairy	179	18%
Bovine meat (breeding)	11	1%
Bovine meat (fattening)	54	5%
TOTAL	**995**	100%

The following paragraphs further compare and analyse the soybean meal consumption of the different livestock sector based on the characterisation of their feeding practices in Chapter 4 to Chapter 7

Bovine meat

- On average, over an animal's lifecycle, 1% of its total feed is composed of soybean meal. This amount rises to 9% if only concentrates are considered;
- On average, 443 g of soybean meal are necessary to produce 1 kg of bovine meat. For 1 kg of bovine meat animal protein, this amount rises to 1,6 kg of soybean meal.

Pork

- On average, 13% of pigs' feed is composed of soybean meal;
- On average, 859g of soybean meal are necessary to produce 1kg of pork. For 1 kg of pork animal protein, this amount rises to 3,3 kg of soybean meal [49].

Broiler meat

- On average, 20% of broilers' feed is composed of soybean meal;
- On average, 670 g of soybean meal are necessary to produce 1kg of broiler meat. For 1 kg of broiler meat animal protein this amount rises to 2,3 kg of soybean meal [50].

[49] Considering slaughter and carcass yields of 79% and 59% respectively and a protein content of 26%
[50] Considering a slaughter and carcass yield of 72% each and a protein content of 29%.

Eggs

- On average, 20% of laying hens' feed is composed of soybean meal;
- On average, 617 g of soybean meal are necessary to produce 1kg of eggs. For 1 kg of egg protein this amount rises to 4,9 kg of soybean meal [51].

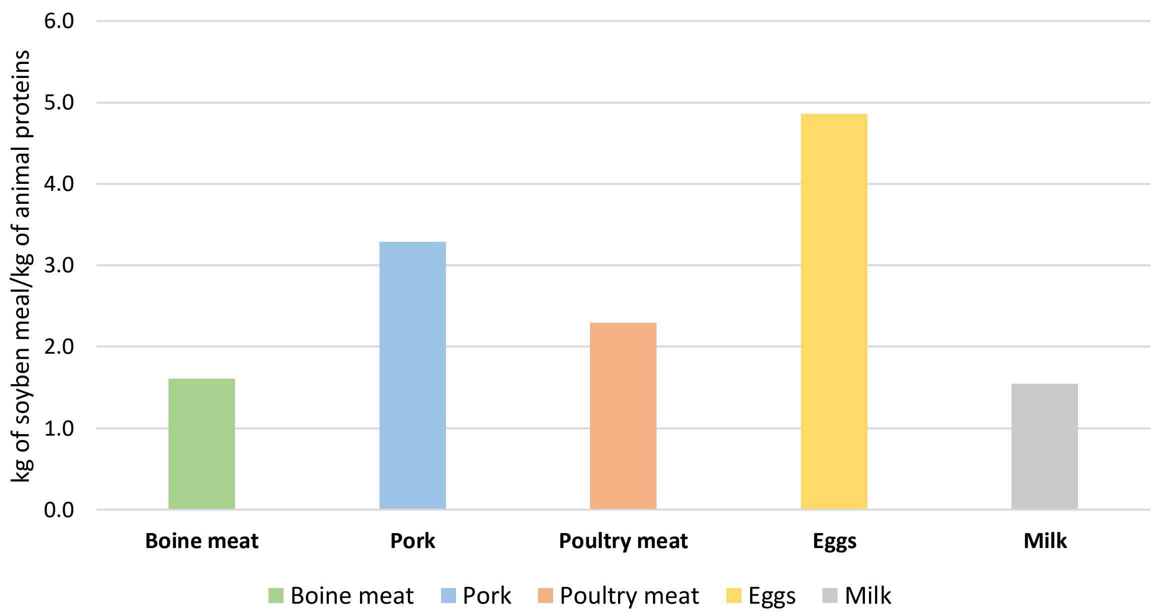
Milk

- On average, 22% of the concentrates feed of the dairy herd is composed of soybean meal. Considering the total feed (concentrates and forage feed), soybean meal accounts for 3%;
- On average, 51g of soybean meal are necessary to produce 1L of milk. For 1 kg of milk protein, this amount rises to 1,5 kg of soybean meal.

Comparison of results

Per kg of animal protein, bovine products (bovine meat and milk) use less soybean meal compared to other animal products. Eggs in particular require important amounts of soybean meal (due to their lower protein content).

	g soybean meal/kg product	kg soybean meal/kg animal protein
Bovine meat	443	1,6
Pork	859	3,3
Broiler meat	670	2,3
Eggs	617	4,9
Milk	51	1,5



[51] Considering a protein content of 13%.

(b) BFA data

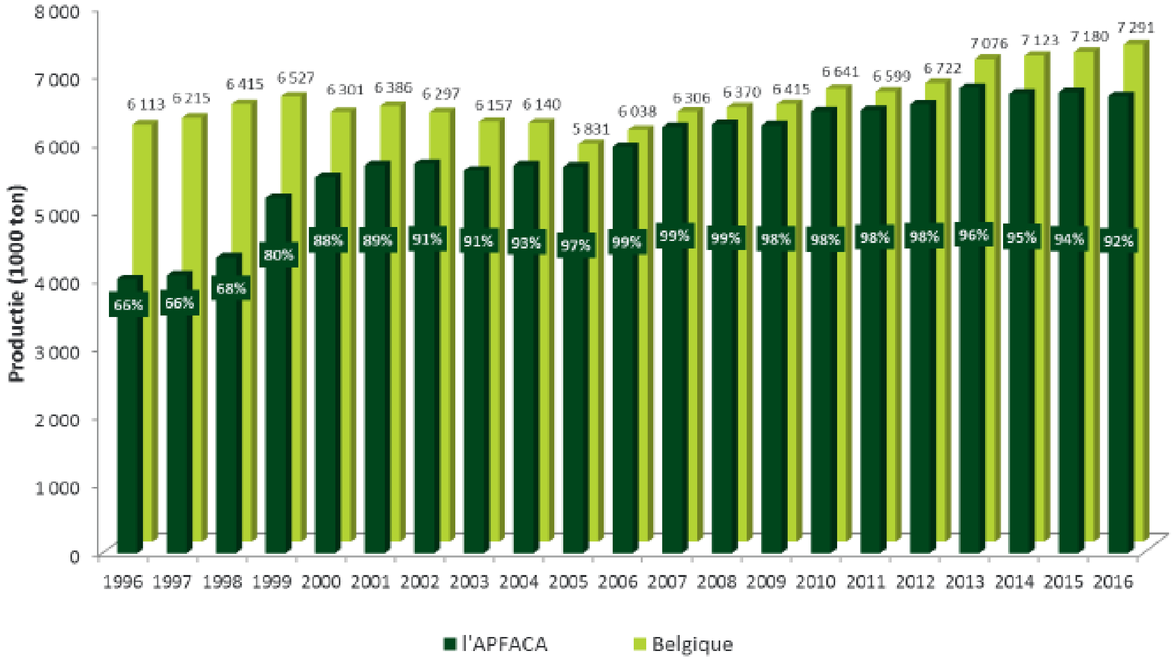


Figure 91. Animal feed production in Belgium between 1996 and 2016 (total and by BFA members).
Source: (BFA, 2016).
Note: According to the BFA, imports and exports balance each other out. The production of animal feed can thus be considered equivalent to the consumption of animal feed by the Belgian livestock sector.

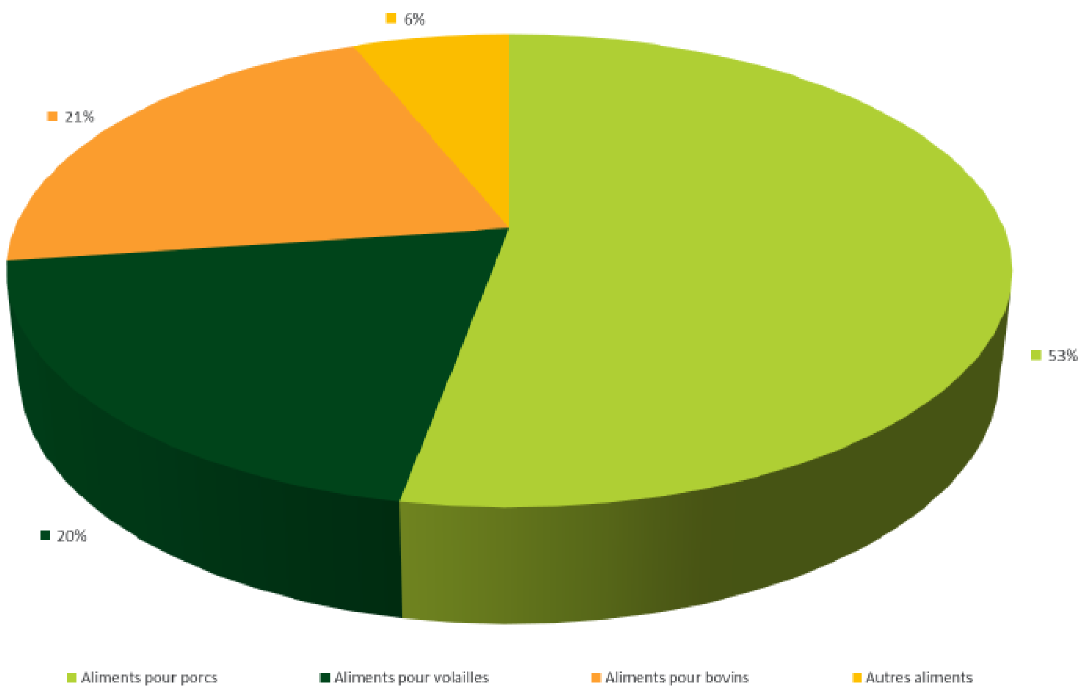


Figure 92. Destination of animal feed in Belgium (per livestock sector) in 2015.
Source: (BFA, 2016).

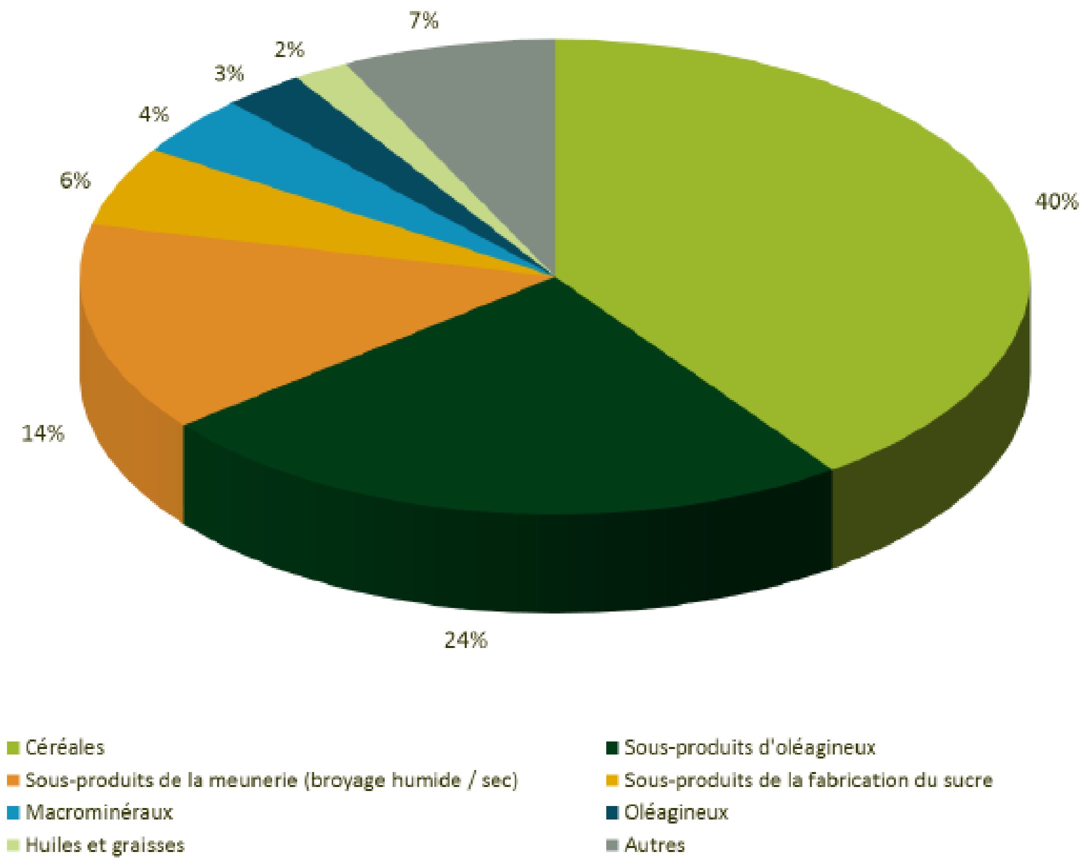


Figure 93. Shares of ingredients used by the Belgian animal feed industry in 2015.
Source: (BFA, 2016).

Appendix 13 – Technical improvements considered in the scenarios

Categories	Practices and Impacts	Technical Mitigation Potential	Ease of Implementation	Timescale for implementation	References
Livestock					
Livestock—feeding	**CH_4**: Improved feed and dietary additives to reduce emissions from enteric fermentation; including improved forage, dietary additives (bioactive compounds, fats), ionophores/antibiotics, propionate enhancers, archaea inhibitors, nitrate and sulphate supplements.	5-15%			50, 51, 52, 53, 54, 55, 56, 57, 58, 59
Livestock—breeding and other long-term management	**CH_4**: Improved breeds with higher productivity (so lower emissions per unit of product) or with reduced emissions from enteric fermentation; microbial technology such as archaeal vaccines, methanotrophs, acetogens, defaunation of the rumen, bacteriophages and probiotics; improved fertility.	5-15%			54, 55, 56, 58, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71
Manure management	**CH_4**: Manipulate bedding and storage conditions, anaerobic digesters; biofilters, dietary additives.	>15%			56, 58, 72, 73
	N_2O: Manipulate livestock diets to reduce N excreta, soil applied and animal fed nitrification inhibitors, urease inhibitors, fertilizer type, rate and timing, manipulate manure application practices, grazing management.	>15%			56, 58, 72, 74, 75, 76, 77, 78

Figure 94. Summary of supply-side mitigation options in the livestock sector.

Technical Mitigation Potential: Animal = percent reduction of enteric emissions. Low = < 5 % (white), Medium = 5 – 15 % (light grey), High = > 15 % (grey).
Ease of Implementation (acceptance or adoption by land manager): Difficult (white), Medium (light grey), Easy, i. e., universal applicability (grey);
Timescale for Implementation: Long-term (at research and development stage; white), Mid-term (trials in place, within 5 – 10 years; light grey), Immediate (technology available now, grey).

Source: IPPC (2014) AR5 – WG3: Chapter 11 - Agriculture, Forestry and Other Land-use (AFOLU).

AEZ regions	Improved feeding practices[b]					Specific agents and dietary additives[c]					Longer term structural/management change and animal breeding[d]				
	Dairy cows	Beef cattle	Sheep	Dairy buffalo	Non-dairy buffalo	Dairy cows	Beef cattle	Sheep	Dairy buffalo	Non-dairy buffalo	Dairy cows	Beef cattle	Sheep	Dairy buffalo	Non-dairy buffalo
Northern Europe	0.18	0.12	0.04			0.08	0.04	0.004			0.04	0.03	0.003		
Southern. Europe	0.18	0.12	0.04			0.08	0.04	0.004			0.04	0.03	0.003		
Western Europe	0.18	0.12	0.04			0.08	0.04	0.004			0.04	0.03	0.003		
Eastern. Europe	0.11	0.06	0.03			0.04	0.01	0.002			0.03	0.07	0.003		

Notes:

[a] The proportional reduction due to application of each practice was estimated from reports in the scientific literature (see footnotes below). These estimates were adjusted for:
(i) proportion of the animal's life where the practice was applicable;
(ii) technical adoption feasibility in a region, such as whether farmers have the necessary knowledge, equipment, extension services, etc. to apply the practice (average dairy cow milk production in each region over the period 2000-2004 was used as an index of the level of technical efficiency in the region, and was used to score a region's technical adoption feasibility);
(iii) proportion of animals in a region that the measure can be applied (i.e. if the measure is already being applied to some animals as in the case of bST use in North America, it is considered to be only applicable to the proportion of animals not currently receiving the product;
(iv) Non-additivity of simultaneous application of multiple measures.
There is evidence in the literature that some measures are not additive when applied simultaneously, such as the use of dietary oils and ionophores, but this is probably not the case with most measures. However, the model used (as described in Smith *et al.*, 2007a) did account for the fact that once one measure is applied, the emissions base for the second measure is reduced, and so on, and a further 20% reduction in mitigation potential was incorporated to account for unknown non-additivity effects. Only measures considered feasible for a region were applied in that region (e.g., bST was not considered for European regions due to the ban on its use in the EU). It was assumed that total production of milk or meat was not affected by application of the practices, so that if a measure increased animal productivity, animal numbers were reduced in order to keep production constant.

[b] Includes replacing roughage with concentrate (Blaxter & Claperton, 1965; Moe & Tyrrell, 1979; Johnson & Johnson, 1995; Yan *et al.*, 2000; Mills *et al.*, 2003; Beauchemin & McGinn, 2005; Lovett *et al.*, 2006), improving forages/inclusion of legumes (Leng, 1991; McCrabb *et al.*, 1998; Woodward *et al.*, 2001; Waghorn *et al.*, 2002; Pinares-Patiño *et al.*, 2003; Alcock & Hegarty, 2006) and feeding extra dietary oil (Machmüller *et al.*, 2000; Dohme *et al.*, 2001; Machmüller *et al.*, 2003, Lovett *et al.*, 2003; McGinn *et al.*, 2004; Beauchemin & McGinn, 2005; Jordan *et al.*, 2006a; Jordan *et al.*, 2006b; Jordan *et al.*, 2006c).

[c] Includes bST (Johnson *et al.*, 1991; Bauman, 1992), growth hormones (McCrabb, 2001), ionophores (Benz & Johnson, 1982; Rumpler *et al.*, 1986; Van Nevel & Demeyer, 1996; McGinn *et al.*, 2004), propionate precursors (McGinn *et al.*, 2004; Beauchemin & McGinn, 2005; Newbold *et al.*, 2005; Wallace *et al.*, 2006).

[d] Includes lifetime management of beef cattle (Johnson *et al.*, 2002; Lovett & O'Mara, 2002) and improved productivity through animal breeding (Ferris *et al.*, 1999; Hansen, 2000; Robertson and Waghorn, 2002; Miglior *et al.*, 2005).

Source: adapted from Smith et al., 2007a.

Figure 95. Technical reduction potential (proportion of an animal's enteric methane production) for enteric methane emissions due to (i) improved feeding practices, (ii) specific agents and dietary additives and (iii) longer term structural/management change and animal breeding[a].

Source: IPCC (2007) AR 4 - WG3: Chapter 8 - Agriculture.

Appendix 14 – BAU scenario: Evolution of livestock populations

Table 178. Evolution of the pigs population between 2005 and 2015 and estimation for 2030.

	Population	**Population**	**Growth**	**Yearly growth rate**	**Estimated population**	**Projected growth**
	2005	2015	from 2005 to 2015 (%)	(%)	2030	from 2015 to 2030 (%)
Flanders	5.952.518	5.981.191	0,5%	0,1%	6.024.460	1%
Wallonia	365.695	382.973	4,7%	0,5%	410.433	7%
Belgium	6.318.213	6.364.164			6.434.892	1%

Table 179. Evolution of pig slaughters between 2005 and 2015 and estimation for 2030.

	Slaughters	**Slaughters**	**Growth**	**Yearly growth rate**	**Estimated Slaughters**	**Projected growth**
	2005	2015	from 2005 to 2015 (%)	%	2030	from 2015 to 2030 (%)
Belgium	10.903.428	11.886.693	9,0%	0,9%	13.530.319	14%

Table 180. Evolution of the laying hen population between 2005 and 2015 and estimation for 2030.

	Population	**Population**	**Growth**	**Yearly growth rate**	**Estimated population**	**Projected growth**
	2005	2015	from 2005 to 2015 (%)	(%)	2030	from 2015 to 2030 (%)
Flanders	7.301.304	6.933.062	-5,0%	-0,5%	6.415.228	-7%
Wallonia	1.238.953	1.176.404	-5,0%	-0,5%	1.088.451	-7%
Belgium	8.540.257	8.109.466			7.503.679	-7%

Table 181. Evolution of the broiler population between 2005 and 2015 and estimation for 2030.

	Population	**Population**	**Growth**	**Yearly growth rate**	**Estimated population**	**Projected growth**
	2005	2015	from 2005 to 2015 (%)	(%)	2030	from 2015 to 2030 (%)
Flanders	17.633.155	19.930.414	13,0%	1,2%	23.949.462	20%
Wallonia	3.440.198	3.907.768	13,6%	1,3%	4.730.933	21%
Belgium	21.073.353	23.838.182	13,1%	1,2%	28.680.395	20%

Table 182. Evolution of broiler slaughters between 2005 and 2015 and estimation for 2030.

	Population	**Population**	**Growth**	**Yearly growth rate**	**Estimated Slaughters**	**Projected growth**
	2005	2015	from 2005 to 2015 (%)	%	2030	from 2015 to 2030 (%)
Belgium	254.191.011	302.961.383	19,2%	1,8%	394.210.242	30%

Table 183. Evolution of the dairy cow population between 2005 and 2015 and estimation for 2030.

	Population 2005	**Population** 2015	**Growth** from 2005 to 2015 (%)	**Yearly growth rate** (%)	**Estimated population** 2030	**Projected growth** from 2015 to 2030 (%)
Flanders	292.842	304304	3,9%	0,4%	322.344	6%
Wallonia	230.439	203.086	-11,9%	-1,3%	168.022	-17%
Belgium	523.281	507.390			490.366	-3%

Table 184. Evolution of the suckler cow population between 2005 and 2015 and estimation for 2030.

	Population 2005	**Population** 2015	**Growth** from 2005 to 2015 (%)	**Yearly growth rate** (%)	**Estimated population** 2030	**Projected growth** from 2015 to 2030 (%)
Flanders	174.217	153.268	-12,0%	-1,3%	126.472	-17%
Wallonia	306.430	240.327	-21,6%	-2,4%	166.920	-31%
Belgium	480.647	393.595			293.392	-26%

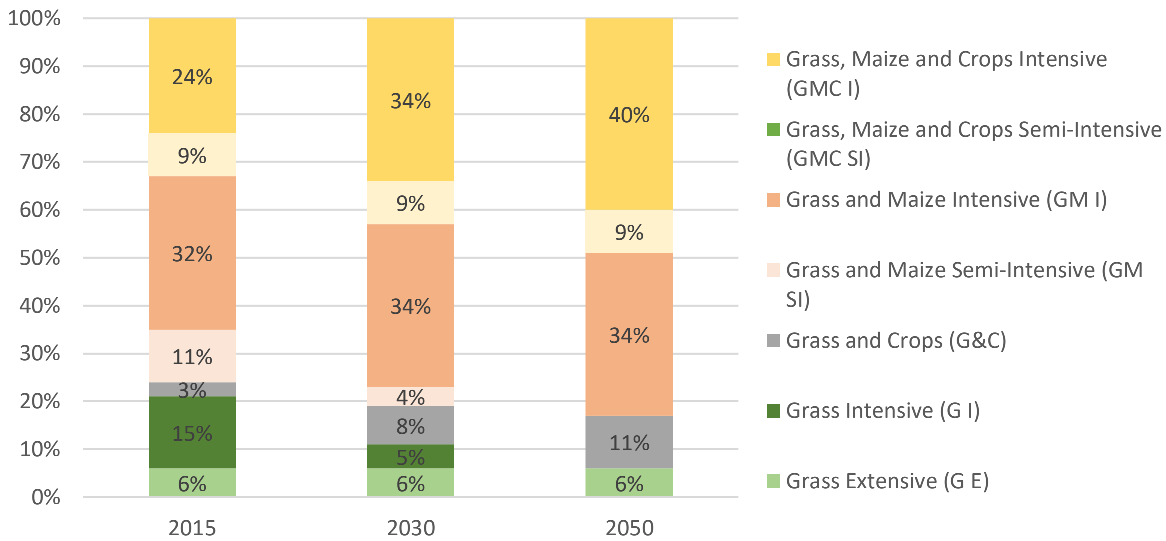


Figure 96. Evolution of the shares of production systems in the Walloon dairy sector between 2015 and 2050.
Source: (Petel et al. 2018)

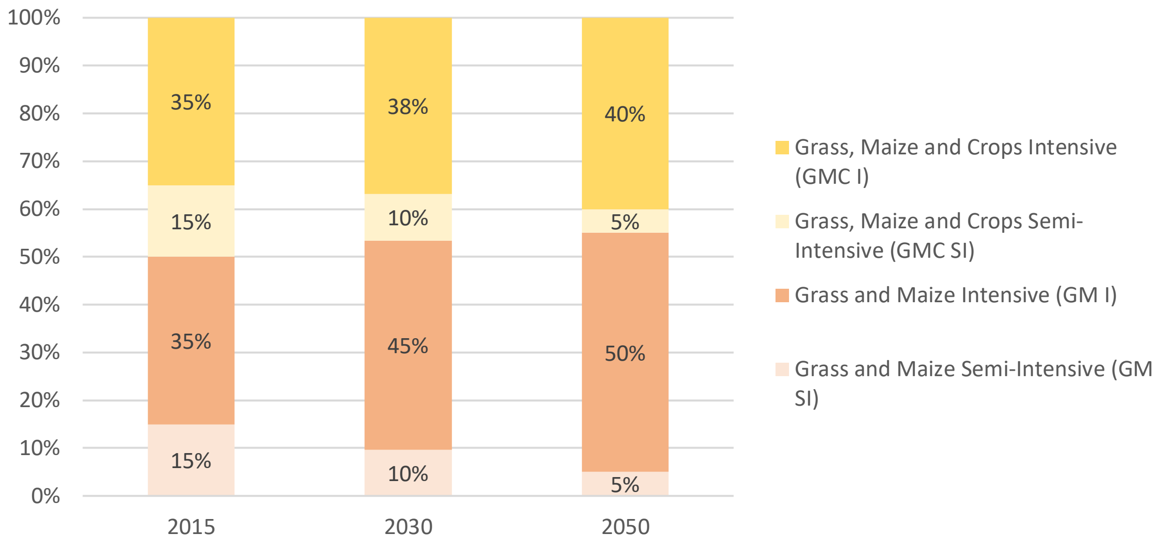


Figure 97. Evolution of the shares of production systems in the Flemish dairy sector between 2015 and 2050.

Appendix 15 – Background information used for the design of transition scenarios

(a) Greenpeace's GHG objectives

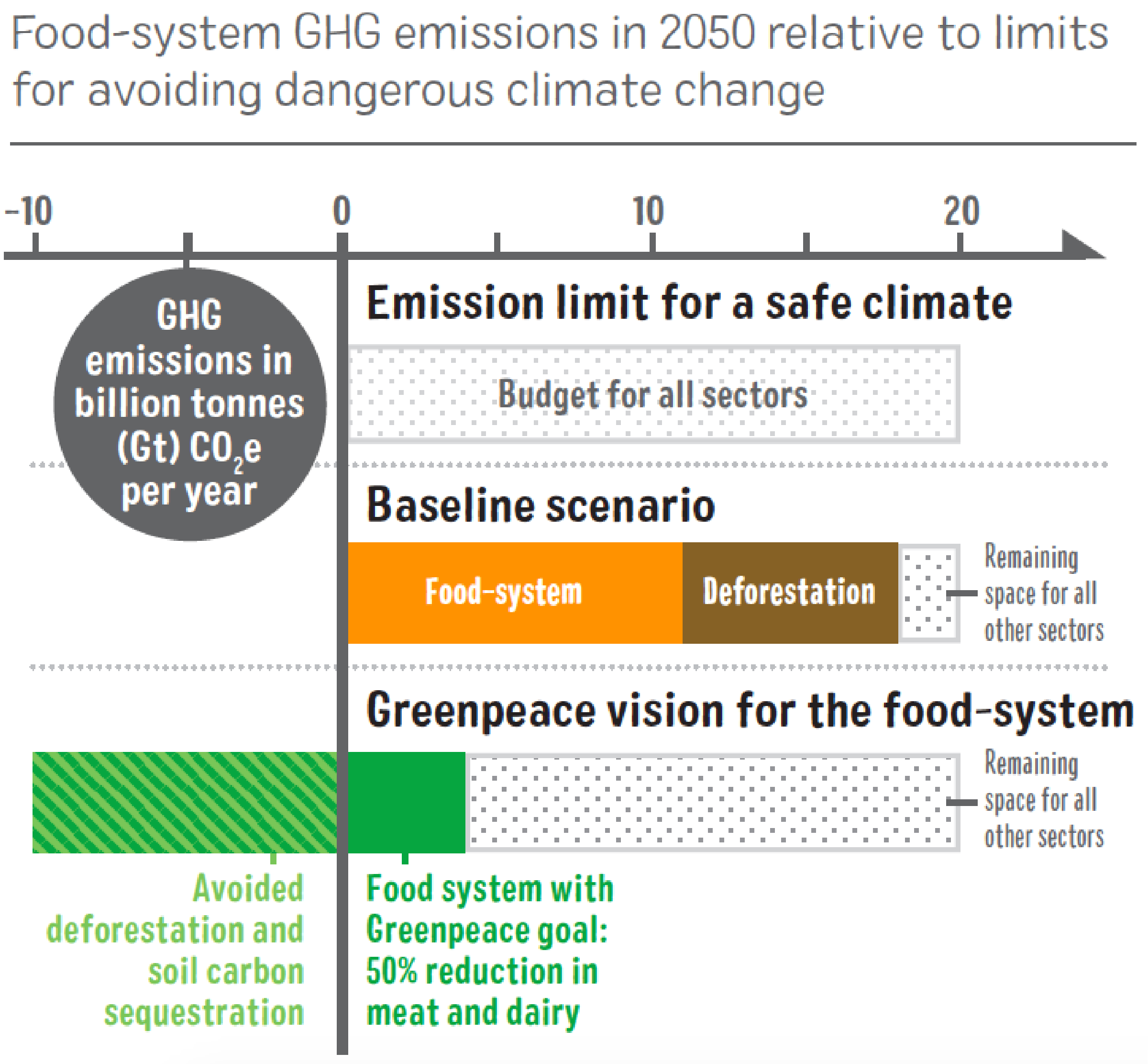


Figure 98. Greenpeace's targets in terms of reduction in GHG emissions from the livestock sector.
Source: (Greenpeace, 2018).
Note: The idea is to limit GHG emissions to a level which would cause a 1,5-2°C global warming situation. In the current situation, the food system (orange bar) and deforestation (brown bar) alone make up for almost the entirety of the GHG budget. Hence, in order to free up more 'GHG budget' for other sectors, the idea is to reduce the food system's emissions by decreasing meat consumption by 50% (green bar).

(b) Comparison of Greenpeace's ecological livestock criteria with current situation

General principle behind the ecological livestock criteria presented in the 'Less is more' report:

« First and foremost, ecological livestock means much less meat than is currently consumed globally. Any criteria should always work to enhance this key principle: better meat means reductions in both production and consumption. » (Tirado et al., 2018).

For Greenpeace, the following eight criteria define ecological livestock (Table 185):

Table 185. Comparison of Greenpeace's ecological livestock criteria with current Belgian livestock systems.

Greenpeace Ecological Livestock criteria		Systems that fits with criteria
1.	**Animals are fed with feed not required for human food, and respecting biodiversity and climate.**	
1.1	No deforestation	Certified soy* is required only under the **Certus, Belplume and Belbeef** labels. (No guidelines regarding soy origin under organic production). *see Appendix 5 on Responsible Soy initiative from BFA in Belgium.
1.2	100% locally produced feed	No conventional systems contain specifications on that aspect. In **organic** production, 20% must be locally or regionally produced (but the definition of regional can vary).
1.3	if possible from waste/coproducts	No systems contain specifications on that aspect. However, BFA has started an initiative since 2006 to increase use of by-products.
1.4	Feed is produced with ecological practices	To date, in Belgium, only **organic** certification ensures that feed is produced without pesticides and chemical inputs.
1.5	Cows: on grasslands and pasture	In dairy and bovine production, the more **extensive systems** are based on grass rather than on maize.
1.6	Pigs and chicken: fed with waste and minimal feed, mostly grown locally.	No systems contain specifications on that aspect. The majority of pigs and chicken are fed with concentrates from feeding companies, with no criteria of origin. Some poultry farmers include some self-produced cereals.
2.	**Ensuring soil fertility is based on manure, compost and the closing of nutrient cycles.**	
2.1	Only compost and organic fertilisers for feed production	Only **organic** systems.

2.2	Fertilizers are produced regionally	No specifications of origin regarding synthetic fertilizers. There are public regulations regarding the origin of organic fertilisers (e.g. manure): they can be used on the same farm or sent and used on other farms but this must be arranged with preliminary contracts.
2.3	Use soil amendments from crop residues	No systems contain specifications on that aspect.
2.4	Use of legume rotations	No systems contain specifications on that aspect.
3.	**Ecological livestock must favour biodiversity on all aspects (pastures, grasslands, breeds and feeds).**	
3.1.	Use of local breeds, adapted to local conditions	Generally speaking, **organic** and **differentiated** systems work with non-conventional breeds, which have slower growing phases and are more robust (but not necessarily local).
3.2.	Start working with mixed crop/livestock systems (e.g. agroforestry)	No systems contain specifications on that aspect.
3.3.	Implement biodiversity measures on production sites	No systems contain specifications on that aspect.
3.4.	Avoid monoculture production of feed	No systems contain specifications on that aspect.
4.	**GHG emissions are minimised.**	
4.1.	Implement grassland conservation	No systems contain specifications on that aspect but more extensive systems contribute to it (lower stocking rates).
4.2.	Feed non-ruminants mostly with waste	No systems contain measures on waste specifically but BFA has started initiative since 2006 to increase the use of by-products.
4.3.	Optimise manure management to reduce emissions.	Regulation on manure emissions in Flanders (Mestaktie plan). In addition, organic systems have maximum stocking rates of 2 Livestock Units/ha (170 kg N/ha).
4.4.	Use practices that increase soil carbon (mulching with crop residues, and practices that increase carbon in the soils (limit on number of animals/ha, cover crops…)	No systems contain specifications on that aspect.
5.	**No use of synthetic pesticides or GMOs.**	
5.1.	Free of chemical pesticides and GMOs.	To date, in Belgium, only **organic certification** ensures that feed is produced without pesticides and chemical inputs
6.	**Limit the use of antimicrobials to the medical treatments of animals.**	

6.1.	Reduce ALL antimicrobials in food-producing animals	**Organic** systems only allow certain substances.
6.2.	Completely restrict use of antimicrobials for growth promotion	Forbidden in organic feeds.
6.3	Completely restrict antimicrobials for prevention of infectious diseases which have not been clinically diagnosed yet	Forbidden in organic feeds.
6.4.	Surveillance and monitoring of antimicrobial agents that are not currently used in food production	No systems contain specifications on that aspect.
6.5.	Eliminate discharges, losses and emissions of antimicrobial agents to the environment.	No systems contain specifications on that aspect.
7.	**Ensure the highest animal welfare standards.**	
7.1.	No factory farm	No systems contain specifications on that aspect.
7.2.	No non-curative, non-essential interventions	Only **organic** systems forbid the use of preventive non-essential measures.
7.3.	Provide a suitable environment	Criteria is not precise enough to be compared to practices in current systems (but both organic and Certus/Belplume/Belbeef labels have specifications around that aspect).
7.4.	Prevent animal cruelty through the entire supply chain	Animal cruelty is hard to measure. In organic systems and Certus/Belplume/Belbeef labels, animal pain is prevented with anaesthesia or analgesia (e.g. pig castration). In organic systems, some practices are still allowed but require authorisations (cutting of pig teeth and tails, debeaking, etc.)
7.5.	Proper measurements and documentation of standards.	The **Certus, Belplume and organic systems** all have documented specifications and standards.
8.	**Ensure human rights along the value chain (farmers, labourers, rural communities, impacted communities).**	
8.1.	Ensure the right of indigenous people are fully respected, including their right to consultation and to give or withhold their consent	No systems contain specifications on that aspect.
8.2.	Ensure the rights of contract farmers in adherence with the UN Right to Food	No systems contain specifications on that aspect.
8.3.	Ensure fair rural livelihoods and just economic transitions for livestock producers.	**Organic systems** get a premium. Differentiated systems often get better prices although this is not necessarily a specification of the system.

(c) Consistency of livestock production systems with Greenpeace ecological criteria

Table 186. Consistency of pork production systems with Greenpeace criteria.

Production system	Consistency with Greenpeace criteria	Reasons
- Conventional - Certified (Certus)	Low	No restriction on the origin of feed or on the use of phytopharmaceuticals (stronger for Certus systems); low animal welfare standards.
- Differentiated - Differentiated +	Intermediary	Selection of more diverse breeds; some criteria on feeding practices.
- Organic	Consistent	Outdoor access; higher animal welfare criteria; organic and non-GMO feed; restrictions on manure emissions.

Table 187. Consistency of poultry meat production systems with Greenpeace criteria.

Production system	Consistency with Greenpeace criteria	Reasons
- Conventional - Certified (Belplume)	Low	No restriction on the origin of feed or on the use of phytopharmaceuticals (stronger for Belplume systems); low animal welfare standards.
- Differentiated - Differentiated +	Intermediary	Selection of more diverse breeds; some criteria on feeding practices.
- Organic	Consistent	Selection of slow-grow breeds; higher animal welfare criteria; organic and non-GMO feed; restrictions on manure emissions.

Table 188. Consistency of laying hen systems with Greenpeace criteria.

Production system	Consistency with Greenpeace criteria	Reasons
- Cage-systems - Indoor	Low	Low animal welfare standards, especially for cage systems.
- Free-range	Intermediary	Higher animal-welfare standards with outdoor access for animals.
- Organic	Consistent	Higher animal welfare criteria; organic and non-GMO feed; restrictions on antimicrobial use; restrictions on manure emissions.

Table 189. Consistency of dairy production systems with Greenpeace criteria.

Production system	Consistency with Greenpeace criteria	Reasons
Intensive systems with high level of concentrates usage and relying on more maize silage and less access to pasture and grasslands. *('Grass intensive'; 'Grass-maize intensive'; 'Grass-maize-crops intensive')*	Low	- Low use of pasture and grasslands and high level of concentrates consumption.
Systems based on grassland and pasture but which still rely on an important use of external concentrates. *('Grass-maize extensive'; 'Grass-maize-crops semi-intensive')*	Intermediary	- Higher level of pasture usage but low level of autonomy in terms of feed and concentrates production
Systems with outdoor access, based on pasture and grasslands and with a higher autonomy in terms of feed production. *('Grass extensive' ; 'Grass and crops)*	Consistent	- Higher use of pasture and grasslands and lower use of concentrates.

Table 190. Consistency of bovine meat production systems with Greenpeace criteria.

Production system	Consistency with Greenpeace criteria	Reasons
Systems with less pasture and more maize silage, based on Belgian Blue. *('BB intensive maize'; 'BB intensive grass')*	Low	- Low use of pasture and grasslands, higher use of concentrates.
Systems with outdoor access, based on pasture and grasslands and with a longer, semi-intensive fattening strategy, based on Belgian Blue (BB). *('BB extensive maize'; 'BB extensive grass)*	Intermediary	- Higher use of pasture and lower use of concentrates but non-natural birth-giving due to BB being a double muscle breed.
Systems with outdoor access, based on pasture and grasslands and with a longer, semi-intensive fattening strategy, based on French breeds. *('FR extensive grass'; 'FR extensive maize')*	Consistent	- Higher use of pasture and lower use of concentrates and natural birth-giving.

(d) Growth of livestock population raised under organic standards in different EU countries

The following tables show the growth of the organic sector for the bovine, swine and laying hen populations in different European countries between 2002 and 2015 (2009 for the laying hens as this is the last available data).

The shares of the livestock population raised under organic standards have increased over the years in all countries but remain below 10% in most of the countries and below 30% in every country in 2015. The highest rate obtained are: 21% of live bovine (Portugal), 10% of live swine (Denmark and Greece) and 29% of laying hens (Greece).

Table 191. Evolution of the total and organic population of live bovine in EU countries between 2002 and 2015.

Country	2002			2015			AAGR
	TOTAL	ORG	% ORG	TOTAL	ORG	% ORG	2002-2015
Belgium	2.758.460	20.732	1%	2.503.260	80.405	3%	11%
Denmark	1.740.000	144.977	8%	1.566.000	157.527	10%	1%
Greece	613.000	7.760	1%	582.000	68.454	12%	18%
Italy	ND	164.536	/	ND	266.576	/	4%
Luxembourg	189.850	952	1%	200.640	3.576	2%	11%
Hungary	770.000	8.661	1%	821.000	18.919	2%	6%
Netherlands	3.780.000	36.373	1%	4.315.000	56.264	1%	3%
Portugal	1.422.080	8.202	1%	1.605.860	97.320	6%	21%
Finland	1.011.750	17.134	2%	903.410	59.700	7%	10%
United Kingdom	10.381.210	91.310	1%	9.816.000	289.899	3%	9%
Switzerland	ND	145.012	/	1.567.140	169.648	11%	1%

Source: (Eurostat, 2018, 2016)

Note: ND means 'No Data', AAGR stands for 'Average Annual Growth Rate'.

Table 192. Evolution of the total and organic population of live swine in EU countries between 2002 and 2015.

Country	2002			2015			AAGR
	TOTAL	ORG	2002-2009	TOTAL	ORG	% ORG	2002-2015
Belgium	6.600.160	5.361	0,1%	6.364.160	10.274	0,2%	5%
Denmark	12.879.000	79.786	0,6%	12.702.000	260.510	2,1%	10%
Greece	1.027.000	1.288	0,1%	877.000	4.203	0,5%	10%
Italy	9.166.000	19.917	0,2%	8.674.790	49.909	0,6%	7%
Luxembourg	76.480	434	0,6%	88.500	908	1,0%	6%
Hungary	5.082.000	1.951	0,0%	3.124.000	4.023	0,1%	6%
Netherlands	11.154.000	47.524	0,4%	12.453.000	69.102	0,6%	3%
Austria	3.304.650	38.921	1,2%	2.845.450	78.246	2,7%	6%
Portugal	1.963.660	3.091	0,2%	2.247.330	833	0,0%	-10%
Finland	1.422.800	4.132	0,3%	1.239.000	6.131	0,5%	3%
United Kingdom	5.330.120	17.758	0,3%	4.422.000	29.171	0,7%	4%
Switzerland	ND	15.144	/	1.494.130	26.882	1,8%	5%

Source: (Eurostat, 2018, 2016)

Note: ND means 'No Data', AAGR means 'Average Annual Growth Rate'.

Table 193. Evolution of the total and organic population of laying hens in EU countries between 2002 and 2009 (last available data).

Country	2002			2009			AAGR
	TOTAL	ORG	% ORG	TOTAL	ORG	% ORG	2002-2009
Belgium	12.160.400	59.714	0,5%	6.483.700	167.312	2,6%	16%
Denmark	3.653.000	658.156	18,0%	3.280.000	816.289	24,9%	3%
Greece	14.722.000	20.455	0,1%	11.983.600	122.115	1,0%	29%

Source: (Eurostat, 2016a, 2016b)

Note: ND means 'No Data', AAGR means 'Average Annual Growth Rate'.

(e) Available grassland and cereal resources in Belgium in 2015

Table 194. Forage and pasture areas needed per milk production system.

Production system	Permanent pasture	Temporary pasture	Forage maize	Other forages	TOTAL pasture	TOTAL forage
	ha/DC&P/year				ha/DC&P/year	
GE	0,98	0,03	-	-	1,01	1,01
GI	0,87	-	-	-	0,87	0,87
G&C	0,77	0,14	-	0,14	0,91	1,05
GM SI	0,64	0,01	0,13	0,01	0,65	0,79
GM I	0,55	0,03	0,15	0,00	0,58	0,73
GMC SI	0,57	0,07	0,18	0,07	0,64	0,89
GMC I	0,33	0,08	0,23	0,04	0,41	0,68

Table 195. Total pasture areas used by the dairy herd in Belgium in 2015 and associated milk production.

Production system	WAL	FL	BE
	Pasture (ha/year)		
Grass Extensive (G E)	12.291	0	12.291
Grass Intensive (G I)	26.469	0	26.469
Grass and Crops (G&C)	5.537	0	5.537
Grass and Maize Semi-Intensive (GM SI)	14.502	29.670	44.172
Grass and Maize Intensive (GM I)	37.644	61.774	99.418
Grass, Maize and Crops Semi-Intesnive (GMC SI)	11.683	29.213	40.896
Grass, Maize and Crops Intensive (GMC I)	19.958	43.668	63.626
TOTAL	128.084	164.324	292.408
Percentage of total available pasture resources	38%	75%	53%
Milk production (mo L)	1.415	2.113	3.527

Table 196. Belgian production of cereals in 2015.

Cereal type	Area 2015 [1] WAL	FL	BXL	BEL	Estimated use for feed	
	ha				% [2]	ha
Winter wheat	130.017	68.039	570	198.626	55%	109.244
Spring wheat	1.751	1.383	9	3.143	55%	1.729
Spelled	18.457	1.486	69	20.012	55%	11.007
Rye	292	271	-	563	55%	310
Winter barley	30.213	13.874	126	44.213	55%	24.317
Spring barley	2.465	1.422	11	3.898	55%	2.144
Malting barley	257	10	-	267	0%	0
Oat	3.242	677	16	3.935	55%	2.164
Triticale	3.036	2.490	26	5.552	55%	3.054
Grain maize	5.986	52.310	102	58.398	90%	52.558
Other cereals	2.904	115	17	3.036	55%	1.670
TOTAL	198.620	142.077	946	341.638		208.196

Source: [1] (Statistics Belgium, 2016b); [2] (Antier et al., 2017) , (actor interviews, 2018)

Note: The share of cereals used for animal feed is estimated to be 55% of the total cereal production.

Appendix 16 - Estimation of livestock populations and slaughters in 2005 and share of production systems

(a) Livestock population and slaughters in 2005

This section provides the total livestock populations and slaughters figures in 2005, at the regional and national level for each livestock sector (Table 197 to Table 201).

Table 197. Pigs population and slaughters in 2005 and 2015 in Belgium.

	Population			Slaughters		
	2005	2015	Evolution	2005	2015	Evolution
Flanders	5.952.518	5.981.191	0,5%	9.101.862	11.139.245	22,4%
Wallonia	365.695	382.973	4,7%	1.801.566	747.448	-58,5%
Belgium	6.318.213	6.364.164	0,7%	10.903.428	11.886.693	9,0%

Source: Statistics Belgium (2016, 2014b).

Table 198. Broilers population and slaughters in 2005 and 2015 in Belgium.

	Population			Slaughters		
	2005	2015	Evolution	2005	2015	Evolution
Flanders	17.633.155	19.930.414	13,0%	Na	Na	Na
Wallonia	3.440.198	3.907.768	13,6%	Na	Na	Na
Belgium	21.073.353	23.838.182	13,1%	254.191.011	302.961.383	19,2%

Source: Statistics Belgium (2016, 2014b).

Table 199. Laying hens population in 2005 and 2015 in Belgium.

	Population 2005	**Population 2015**	**Evolution 2005-2015**
Flanders	7.301.304	6.933.062	-5,0%
Wallonia	1.238.953	1.176.404	-5,0%
Belgium	8.540.257	8.109.466	-5,0%

Source: Statistics Belgium (2016, 2014b).

Table 200. Dairy cow population in 2005 and 2015 in Belgium.

	Population 2005	**Population 2015**	**Evolution 2005-2015**
Flanders	292.842	304.304	3,9%
Wallonia	230.439	203.086	-11,9%
Belgium	523.281	507.390	-3,0%

Source: Statistics Belgium (2016, 2014b).

Table 201. Suckler cow population in 2005 and 2015 in Belgium.

	Population 2005	Population 2015	Evolution 2005-2015
Flanders	174.217	153.268	-12,0%
Wallonia	306.430	240.327	-21,6%
Belgium	480.647	393.595	-18,1%

Source: Statistics Belgium (2016, 2014b).

(b) Shares of production systems in 2005

This section provides estimations of the shares of production systems in 2005 for each livestock sector. Given that available data was limited, supplementary estimations were made, in accordance with the figures for 2015 (Chapters 4 to 7).

Regarding pigs' population and pork production in 2005:

- Population of **organic** pigs in 2005 was 8.515[52], that is 0,1% of total pigs.
- There were 706.987 **Certus** slaughters in 2005[53], 6,5% of total slaughters.
- **Differentiated systems** represented 4% of slaughters in 2015 and were assumed to reach 5% in 2030 in the BAU scenario. Assuming a similar growth trend for the 2005-2015 period, the share of differentiated systems could be estimated at about 3% (1,5% each for Differentiated and Differentiated+ systems).
- **Conventional systems** were estimated to represent the rest of slaughters, i.e. 90%.

Table 202. Estimated share of pork production systems in 2005 and 2015 in Belgium (in % slaughters).

	2005 % of slaughters	**2015** % of slaughters
Conventional	90%	73%
Certified (Certus)	7%	23%
Differentiated	1,5%	2%
Differentiated +	1,5%	2%
Organic	<1%	<1%

Sources and estimations: see in text.

[52] Of which, 1.576 in Flanders and 6.939 in Wallonia. Statbel (2017) Agriculture bio 2003-2016.
[53] Certus 2008 annual report. https://www.certus-info.be/Jaarverslagen.php

Regarding broilers population and slaughters:

- The number of **organic** broilers sold on the Belgian market went from 727.542 in 2005 to 1.905.657 in 2015, i.e. almost a three-fold increase (x2,6)[54, 55]. Assuming that a similar growth rate is observed for organic broilers raised and slaughtered in Belgium, the share of broilers slaughters under organic certification is estimated at 0,7% of the total slaughters in 2005.
- No specific figures could be found for **differentiated** systems. Hence, a similar growth rate as for organic systems was used as a proxy. This results in a share of about 1% for both differentiated and differentiated+ systems in 2005 (which is consistent with the 2015 figures).
- Regarding **Belplume** systems, the number of certified farms was already very high in 2005: nearly 90% of the broiler capacity was certified at the end of 2004[56].
- The remaining broiler slaughters are assumed to be reared in **conventional** systems, which thus represented 8% of slaughters in 2005.

Table 203. Estimated share of broilers systems in 2005 and 2015 in Belgium (in % slaughters).

	2005 Belgium	**2015** Belgium
Conventional	8%	7%
Certified (Belplume)	90%	90%
Differentiated	<1%	1%
Differentiated +	<1%	1%
Organic	1%	2%

Note: Sources and estimations: see in the text.

Regarding laying hen production systems in 2005:

- **Regarding Organic** laying hen populations, data is available at regional level:
  - Flanders: 61.164 laying hens in 2005[57] → 0,8% of laying hens in Flanders.
  - Wallonia: 27.894 laying hens in 2005[58] → 2,3% of laying hens in Wallonia.
  - Belgium: 89.058 laying hens in 2005 → 1,0% of total.
- **Regarding Cage systems:** approximately, 85% of laying hens were raised in cage systems in Belgium in 2005[59] (this includes both battery- and enriched-cages as the former were only banned in 2012);

[54] Departement Landbouw & Visserij (2006) De biologische landbouw in 2005. https://lv.vlaanderen.be/sites/default/files/attachments/de_biologische_landbouw_in_2005.pdf
[55] Biowallonie (2018). *Les chiffres du bio en 2017.* https://mk0biowalloniejo431r.kinstacdn.com/wp-content/uploads/2018/05/Le-bio-en-chiffre-2017.pdf
[56] VILT (2004) Belplume vangt meer dan 1.000 braadkippenbedrijven. http://www.vilt.be/Belplume_vangt_meer_dan_1000_braadkippenbedrijven
[57] Departement Landbouw & Visserij (2006) De biologische landbouw in 2005. https://lv.vlaanderen.be/sites/default/files/attachments/de_biologische_landbouw_in_2005.pdf
[58] Biowallonie (2018). *Les chiffres du bio en 2017.* https://mk0biowalloniejo431r.kinstacdn.com/wp-content/uploads/2018/05/Le-bio-en-chiffre-2017.pdf
[59] According to EU-data, 84% of Belgian laying hens were raised in cage systems in 2007. EU data cited in the German study *Umwelt Bundesamt (2010) Survey of the different chicken housing systems and accumulating form of manure/slurry for the derivative of a standardised form of veterinary drug decomposition in exposition scenarios*. https://www.umweltbundesamt.de/sites/default/files/medien/461/publikationen/3922.pdf

- **Regarding other systems (indoor and free-range) in Belgium:** Together, indoor and free-range systems must therefore represent 14% of the laying hens. A realistic estimation of the shares of each system is 10% of laying hens in indoor systems and 4% of laying hens in free-range systems.
- **Regarding the share of systems (cage, indoor and free-range) at the regional level in Flanders and in Wallonia:** No specific data could be found at regional level apart for organic systems for the year 2005 (see above). The shares of systems at regional levels were therefore estimated in consistency with data in 2015 and based on the assumption that alternative systems are more common in Wallonia and cage-systems more frequent in Flanders. Taking into account the laying hen populations in both regions and the above findings, the following estimations were made:
  - Cage systems: 87% in Flanders and 73% in Wallonia;
  - Indoor systems: 9% in Flanders and 16% in Wallonia;
  - Free-range systems: 3% in Flanders and 9% in Wallonia;
  - Organic systems: 1% in Flanders and 2% in Wallonia.

Table 204. Estimated share of laying systems in 2005 and 2015 in Belgium (in % animal numbers).

	2005			2015		
	Flanders	**Wallonia**	**Belgium**	**Flanders**	**Wallonia**	**Belgium**
Cage	87%	73%	**85%**	63%	43%	**60%**
Indoor	9%	15%	**10%**	28%	23%	**27%**
Free-range	3%	9%	**4%**	7%	22%	**9%**
Organic	1%	2%	**1%**	2%	12%	**3%**

Note: Sources and estimations: see in the text.

Regarding dairy systems in 2005:

- **At the regional level in Flanders and Wallonia:** the same trends which were considered for the 2030 and 2050 projections of the BAU scenario were applied in this case, but backwards (see figures below). These trends were established based on statistical data, and through actor interviews.
  - In **Flanders**, the shares of more intensive systems are smaller in 2005 as a result of the increasing intensification which took place over the years. Semi-intensive systems (both with and without other crops: GM SI and GMC SI) reach 40% in 2005 (vs. 30% in 2015). More intensive systems represent the remaining 60%. As a reminder, it was assumed that all systems in Flanders include forage maize (Actor interviews, 2018).
  - In **Wallonia** too, intensive systems with maize (GM I and GMC I), were less frequent in 2005 compared with 2015. As a consequence, less intensive systems (GM SI and GMC SI) were more frequent in 2005 than in 2015. Regarding grass systems, GE and G&C were assumed to be smaller in 2005 than in 2015 because of the growth of the organic sector (the number

of organic dairy cows doubled between 2005 and 2015[60]). The GI system, which was expected to disappear by 2050 in the BAU scenario is here estimated at 20%.

- **At the national level in Belgium:** The overall shares of each system in Belgium are calculated as a result of the previous region-specific considerations.

Table 205. Estimated share of dairy systems in 2005 and 2015 in Belgium (in % animal numbers)

	2005			2015		
	Flanders	**Wallonia**	**Belgium**	**Flanders**	**Wallonia**	**Belgium**
Grass Extensive (G E)	0%	3%	1%	0%	6%	2%
Grass Intensive (G I)	0%	20%	9%	0%	15%	6%
Grass and Crops (G&C)	0%	2%	1%	0%	3%	1%
Grass and Maize Semi-Intensive (GM SI)	20%	20%	20%	15%	11%	13%
Grass and Maize Intensive (GM I)	30%	25%	28%	35%	32%	34%
Grass, Maize and Crops Semi-Int (GMC SI)	20%	15%	18%	15%	9%	13%
Grass, Maize and Crops Intensive (GMC I)	30%	15%	23%	35%	24%	31%

Note: Sources and estimations: see in the text.

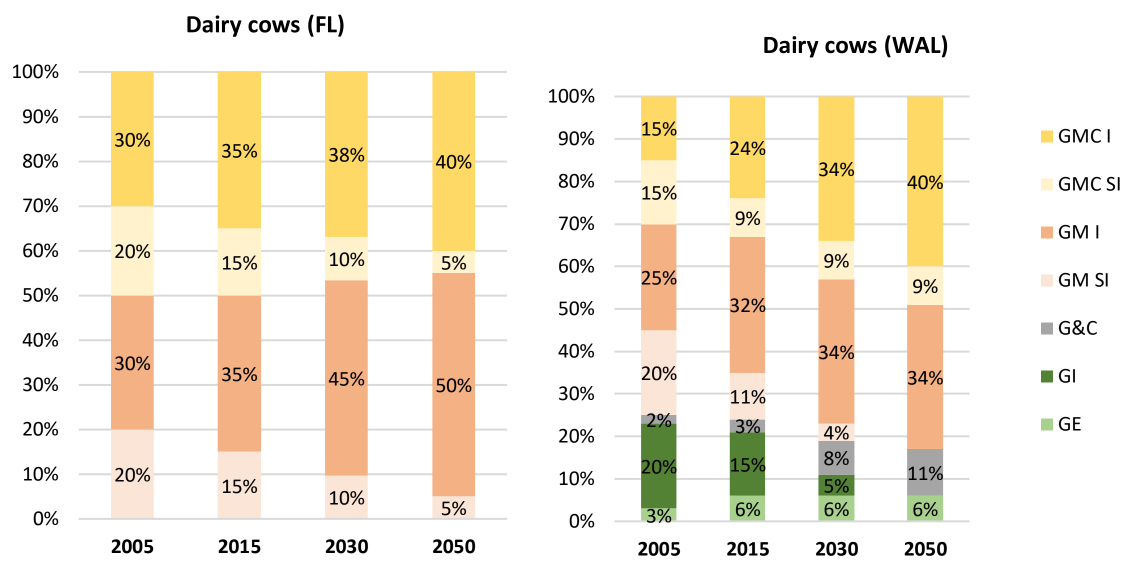


Figure 99 : Evolution of the share of dairy production systems between 2005 and 2050 in the BAU scenario.

[60] Biowallonie (2018) Les chiffres du bio en 2017. https://mk0biowalloniejo431r.kinstacdn.com/wp-content/uploads/2018/05/Le-bio-en-chiffre-2017.pdf

Regarding suckler cows' population:

- **At the regional level in Flanders and Wallonia:** The same approach which was used to estimate the shares of dairy cow systems in 2005 was applied in the case of suckler cow systems, i.e. using a backward projection of the 2030 and 2050 BAU scenario (see figures below).
    - For **Flanders**, on the one hand systems with French breeds are assumed to be smaller than in 2015. On the other hand, the share of more extensive Belgian Blue systems with maize is bigger. The assumption that all Flemish systems include maize was maintained.
    - In **Wallonia** too, the gain in popularity of the French breeds over the years occurs. The increase in organic suckler cow systems (which are mainly considered to correspond to the FR Extensive system) plays an important role (the number of organic suckler cows in Wallonia tripled between 2005 and 2015[61]). More intensive systems based on maize are becoming more important too, resulting in higher shares of the less intensive systems in 2005.
- **At the national level in Belgium:** The overall shares of each system in Belgium are calculated as a result of the previous region-specific considerations.

Table 206. Estimated share of suckler cow breeding systems in 2005 and 2015 in Belgium (in % animal numbers).

	2005			2015		
	Flanders	**Wallonia**	**Belgium**	**Flanders**	**Wallonia**	**Belgium**
BB Extensive Grass	0%	34%	22%	0	20%	12%
BB Extensive Maize	10%	23%	18%	5%	18%	13%
BB Intensive Grass	0%	20%	13%	0	18%	11%
BB Intensive Maize	85%	15%	40%	85%	24%	48%
FR Extensive Grass	0%	3%	2%	0	10%	6%
FR Extensive Maize	5%	5%	5%	10%	10%	10%

Note: Sources and estimations: see in the text.

[61] Biowallonie (2018) Les chiffres du bio en 2017.
https://mk0biowalloniejo431r.kinstacdn.com/wp-content/uploads/2018/05/Le-bio-en-chiffre-2017.pdf

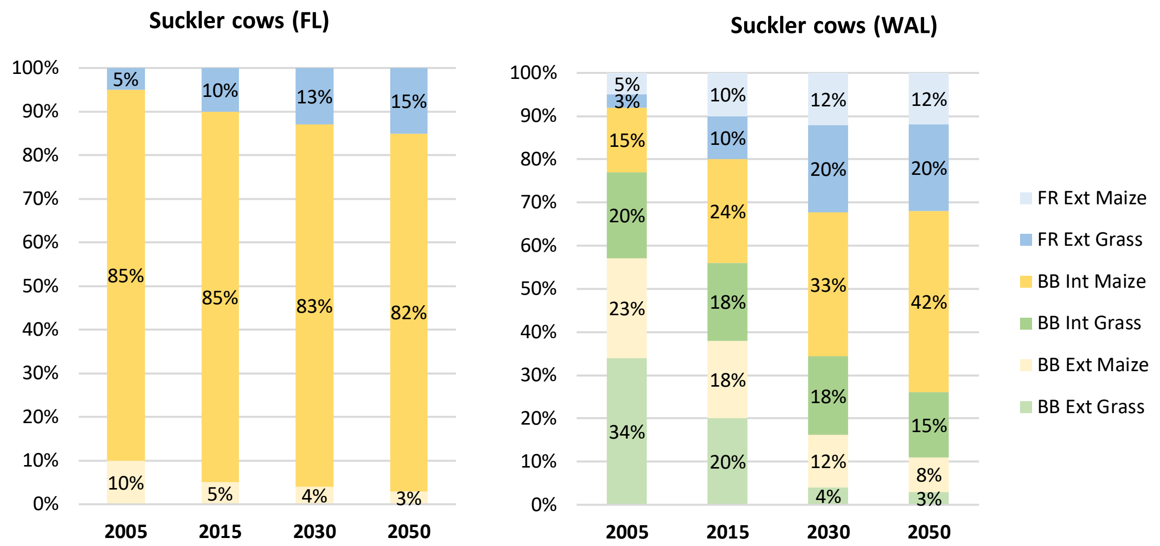


Figure 100 : Evolution of the share of suckler cow systems in the BAU scenario.

Finally, regarding bull fattening systems:

- The fattening of bulls was only studied at the Flemish level given that this activity has been historically concentrated in this region.
- As French breeds showed a recent gain in popularity, their share in 2005 is estimated at a lower level in 2005 (5%) compared to 2015 (10%). The predominance of the Belgian Blue breed is therefore supposed to be even bigger in 2005 (95%) compared with 2015 (90%) (same trends as for the suckler cow systems).

Table 207. Estimated share of Bull fattening in 2005 and 2015 in Flanders (in % slaughters).

	2005	2015
BB Intensive	70%	70%
BB semi-intensive	25%	20%
FR Semi-intensive	5%	10%

Sources and estimations: see in the text.

(c) Production levels in 2005

The production levels in 2005 were estimated and compared to 2015 figures and to national data. Compared with 2015, the productions of pork, poultry meat and milk were lower in 2005 (increases of 9%, 12% and 14% respectively over the 2005-2015 period). The productions of eggs and bovine meat (specifically young bulls here) was on the other hand higher in 2005 compared with 2015 (-6% and -13% respectively over the 2005-2015 period) (Table 208). These results are in line with available national data (Table 209).

Table 208. Production levels of the Belgian livestock sector in 2005 and 2015.

Production	Unit	2005	2015	Growth 2005-2015
Pork	kt carcass	950	1.037	+9%
Poultry meat	kt carcass	233	261	+12%
Eggs	kt eggs	174	164	-6%
Milk	Mo L milk	3.107	3.527	+14%
Bovine meat (young bulls)	kt carcass	85	74	-13%

Table 209. Comparison of livestock production levels in Belgium in 2005 according to this study and according to national data.

Production	Unit	This study	National data	Delta
Pork	kt carcass	950	1012	6%
Poultry meat	kt carcass	233	210-220[a]	6-10%
Eggs	kt eggs	174	179	3%
Milk	Mo L milk	3.107	2.936[b]	5%
Bovine meat (young bulls)	kt carcass	85	74	3%

Notes:

[a] Specific data on the national production of broilers is not available for 2005. Estimates from 2008 were thus used for this comparison.

[b] This figure represents the delivery of milk to milkeries whereas the result of this study represents the production at farm level. It is estimated that there is a 5% difference between the produced and delivered amount. Taking this in consideration, the gap is even smaller (<1%).

Appendix 17 – Comparison of results with and without technical improvements

(a) Production levels

Table 210. Comparison of production levels of the BAU scenario, with and without technical improvements.

Sector	Unit	BAU	
		No Tech	Tech
Pork	kt live meat/year	1.332	1.332
Broilers	kt live meat/year	435	435
Laying hens	kt eggs/year	151	151
Dairy	mo L milk/year	3.660	4.026
Bovine meat (breeding)	kt live meat/year	123	123
Bovine meat (fattening)	kt live meat/year	86	86

(b) GHG emissions

Table 211. Comparison of GHG emissions levels of the BAU scenario with and without technical improvements.

Sector	Unit	BAU	
		No Tech	Tech
Pork	kt CO_2e/year	4.771	4.246
Broilers	kt CO_2e/year	923	828
Laying hens	kt CO_2e/year	549	528
Dairy	kt CO_2e/year	4.533	4.230
Bovine meat	kt CO_2e/year	2.419	2.233
TOTAL	kt CO_2e/year	13.195	12.066