Sustainable Development in egg production
-Perceived key challenges farmers face in Germany

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Abbreviations

DEC – if the contribution of SI, improves SUSD when A_{ij} decreases

EES – Economic, Ecological, Social issues

EPS – Egg production Systems

EU – European Union
The European Union is an economic and political union between several countries.

GMO – Genetically modified food

INC – if the the contribution of SI, improves SUSD when A_{ij} increases

NAPE – National Energy Efficiency Action Plan
The National Energy Efficiency Action Plan was launched by the German Federal Government in 2014 and targets a comprehensive energy strategy for Germany.

NDR – Norddeutscher Rundfunk (Northern German Broadcasting)
The Norddeutscher Rundfunk is a public radio and television broadcaster which is located in Hamburg, Germany.

SAI – Sustainable Agriculture Initiative
The Sustainable Agriculture Initiative platform is an organisation created by the food industry to communicate and to actively support the development of sustainable agriculture on a global scale.

SI – Sustainability Indicator
Sustainability indicators enable measurements of performances and improvements on specific areas of sustainability.

SUSD – Sustainable Development
Sustainable Development can be seen as a process for meeting human development objectives whilst maintaining the capacity of natural systems to continue to allocate the natural resources and ecosystem services upon which the economy and humanity depends.

TBL – Triple Bottom Line Approach
The Triple Bottom Line Approach is a concept dealing with three value dimensions such as economics, ecology and social issues. All three value dimensions can be considered as equal sustainability dimensions and can be interconnected in the discourse of sustainable development.

UNCED – United Nations Conference on Environment and Development
The United Nations Conference on Environment and Development is also known as the Rio Summit, Rio Conference, and Earth Summit and was a key conference of the United Nations hosted in Rio de Janeiro in 1992.
WCED – World Commission on Environment and Development
The World Commission on Environment and Development aims at uniting countries to pursue sustainable development together.
Abstract. The subject matter of this paper is a comparative review of egg production systems for their contribution to sustainable development of egg production in order to assess the perceived challenges of egg farmers in Germany. The thesis features a case study which presents two farms located in Germany, and implementing different farming methods. The floor-range farming method and the organic system illustrate this example. The methodological approach is based on a three-phase framework, in which significant issues concerning sustainable development are presented (Phase 1), the significant issues are translated into sustainable indicators (Phase 2), and the contribution of sustainable indicators to sustainable development is assessed (Phase 3). Phase 1 and 2 build on an extensive literature review and farmers consultation. Phase 3 relies on numerical comparisons. A comparative analysis of the empirical data is based on theories and the developed conceptual framework. Based on the comparison of two specific farms, the results of this work indicate that the organic farming system reveals the least negative contribution to sustainable development of egg production in Germany. The floor-range farming system shows a slightly more negative contribution to sustainable development compared with the organic EPS. The organic farming system, therefore, is considered the better animal-friendly system. It is certainly noteworthy to mention that the organic system however fail to contribute to sustainable development from an economic perspective. Thus, the main perceived challenge for the organic farmer is to operate his organic business in a more profitable way. The floor-range system on the other hand, succeeds to contribute to sustainable development in economic terms, but fails to contribute positively from an ecological and social perspective. Therefore, the farmer operating the floor-range EPS needs to improve the ecological as well as social conditions on his farm in order to achieve an equal positive contribution to sustainable development.

Keywords: Sustainable development, Sustainability indicators, Sustainability indicator assessment, egg production system, comparative method

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Summary: An often-quoted and also generally accepted definition of sustainable development established by the World Commission on Environment and Development (WCED) in 1987, says that sustainable development satisfies the needs of the present generations without impairing the capability of future generations to meet their needs and wants. Sustainable development is recognised as not only rooted in ecological but also in economical and social structures. Hence, sustainable development includes economic, ecological and social dimensions that all need to be addressed concurrently. For numerous years now, laying hen farming systems have been placed in relation to sustainable development by scientific research, since intensive livestock has raised concerns about environmental, social and economic aspects. In addition, conventional cage systems have been banned in several European member states because a species- appropriate and livestock-friendly farming method was not given. Alternative laying hen farming methods have been introduced in recent years, in an attempt to reconcile animal welfare with consumer, farmers, industry as well as environmental needs. Nevertheless, alternative farming systems do not enjoy the best reputation among farmers due to the fact that they are mostly known as unprofitable. Given the above situation, the question arises if farmers are and prospectively will be able to produce their eggs under economically feasible but at the same time also sustainable conditions.

This study serves as a comparative review of egg production systems in Germany linked to sustainable development. It is intended to make this issue more comprehensible and so generate informed and rational discussion of the subject which so often causes great emotions. The objective is to illustrate the perceived challenges of operating alternative farming systems in egg production with regard to sustainable development from the farmer’s point of view. Based on the comparison of two specific farms, the results of this work indicate that the organic farming system reveals the least negative contribution to sustainable development of egg production in Germany. The assessment of research in sustainable agriculture in particular in laying hen rearing systems is very complex due to the fact that dynamic social, economic and environmental aspects in farming systems need to be considered. The definitions and understandings of the term sustainable development show a discrepancy depending on from whom and in what context it is used, and oblique or non-tangible aspects pose a challenge for assessment. The main difficulty of this approach is to develop a transparent collection procedure in order to circumvent a subjective assessment. Guidelines for the indicator choice are set on a data-intensive context, by considering selection criteria and reviewing methodological issues.

Keywords: Sustainable development, Sustainability indicators, Sustainability indicator assessment, egg production system, comparative method

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1. Introduction

The following chapter deals with the underlying background and problem of this study subject. Subsequently, the aim and research questions are presented, followed by an outline of the thesis report.

1.1. Problem background

Poultry provides humans with meat and eggs for more than 4,000 years (BMEL 2014). The domestic fowl is the most common farm animal in Germany. Following France, Germany is the second largest producer of poultry in the EU (ibid.). In addition to the large sector of broilers for meat production, the egg production holds an important position in the German economy (ibid.). Currently, the poultry sector not only faces the European ban on battery cage systems, but also a public discussion on the welfare of laying hens (BMEL 2016).

According to Rakojnac, et al. (2014, p.94), the development of laying hen farming systems took place extremely fast. During the 1950s, laying hens for the most part were kept in rural shelters, the caging spread predominantly in the 60s and 70s in North America and all over Europe (ibid.). Improved hygienic conditions, lower workload, easily monitored production as well as low production costs convinced the laying hen farmers and consumers. Moreover, technological progress and the changes in market policy led to a shift in production of eggs from conventional farms to specialised companies with high livestock numbers. Until the 1940s, when the egg-production started to become more and more professional, many farmers kept their laying hens for self-sufficiency (NDR, 2015). Nowadays, the focus lies on laying hens that are almost exclusively specialized on high laying performances. Until the 1940s, when the egg-production started to become more and more professional, many farmers kept their laying hens for self-sufficiency (NDR, 2015). Nowadays, the focus lies on laying hens that are almost exclusively specialized on high laying performances. Yearly production capacities of 300 eggs per year have been reached due to special breeding practices and feed (ibid.). According to the NDR guidebook (2015), the laying hens have almost reached the limit of their biological capacity. The laying hens can maintain their high performance for about 80 to 90 weeks, and then the animals are usually slaughtered and replaced by young hens (NDR.de 2015). The resistance of the animal rights activists protesting against the methods by which hens are farmed put the industry under severe pressure.

In view of these developments, the laying hen industrialism has more and more become the focus of public debate in Germany. A social change regarding the responsibility towards the animals and therefore their husbandry is emerging (BMEL 2015). Consumers increasingly pay attention to a species-appropriate and livestock-friendly farming method (ibid.). Nowadays, one distinguishes between four different farming methods for laying hens in Germany:

- Small-group housing or “enriched cage” systems,
- Floor-range production systems,
- Free-range production systems and
- Organic production systems.

All these types of farming methods provide room for the hen’s natural behaviour such as areas for scratching, dust bathing, perches, nests, feeding and watering stations, so that the animals can live out species-typical characteristics. However, they differ in particular in terms
of the space available in the stable, the barn equipment, the group size and the possibilities for outlet. Table 1 gives a brief overview of the different types of farming.

Table 1. Summary and Overview of the essential facts of farming methods for laying hens in Germany. (based on Flath, Schockemöhle & Alfs 2012, p. 7)

<table>
<thead>
<tr>
<th>Criteria/Production method</th>
<th>Small group housing</th>
<th>Floor-range</th>
<th>Free-range</th>
<th>Organic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space available in animals per m²</td>
<td>~13</td>
<td>9</td>
<td>9 per m² in the stable 1 per 4m² outdoors</td>
<td>No information available</td>
</tr>
<tr>
<td>Maximum group size</td>
<td>approx. 30 per housing unit</td>
<td>approx. 6000 per housing unit</td>
<td>approx. 6000 per housing unit</td>
<td>approx. 3000 per housing unit</td>
</tr>
<tr>
<td>Barn equipment</td>
<td>Cages equipped with perches, nests, and scratching mats</td>
<td>Aviaries equipped with perches, nests, scratching area</td>
<td>Stable equipped aviaries, nests, perches, scratching area, additional outlet</td>
<td>Stable equipped with aviary, additional outlet, nests, perches, scratching areas, conservatory</td>
</tr>
<tr>
<td>Prospects for species-appropriate behaviour</td>
<td>---</td>
<td>+/-</td>
<td>++</td>
<td>+++</td>
</tr>
<tr>
<td>Animal health</td>
<td>+++</td>
<td>+/-</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Supervision costs</td>
<td>++</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Production costs</td>
<td>++</td>
<td>+/-</td>
<td>--</td>
<td>---</td>
</tr>
<tr>
<td>Comment</td>
<td>Very hygienic, no contact with faeces, no parasites, low loss rate</td>
<td>Hygienic conditions, hardly any contact with faeces</td>
<td>Contact with faeces, danger from birds of prey, parasites, high loss rate</td>
<td>100% of fodder from ecological farming, contact with faeces, danger from birds of prey, high loss rate</td>
</tr>
<tr>
<td>Conclusion</td>
<td>Most economical solution, but Animal Welfare isn't sufficiently taken into account, species-typical behaviors can be lived out only to a limited extent</td>
<td>Group size may lead to cannibalism, poor animal care, species-typical behaviors can be lived out only to a limited extent</td>
<td>Animal welfare is a top priority, not as hygienic as small group housing, increased production costs due to increased space availability, higher earnings per egg</td>
<td>Animal welfare is a top priority, not as hygienic as small group housing, increased production costs due to increased space availability, higher earnings per egg, high focus on soil and ecosystems, no use of GMO fodder plants</td>
</tr>
</tbody>
</table>

+++ = Most positive review, --- = most negative review, +/- mediocre

The table above summarises essential facts of the different farming methods for laying hens in Germany. According to the overview, one can conclude that the small group housing method is ranked as the most economical solution, but animal welfare is not sufficiently taken into account, and species-typical behaviours can only be lived out to a limited extent under this farming method. According to table 1, the floor-range system features a group size that may lead to cannibalism, the animal care is seen as rather poor, and the species-typical behaviours can also be lived out only to a limited extent. Under the free-range farming method, animal welfare is a top priority, but not as hygienic as small group housing. Increased production costs due to increased space availability justify higher earnings per egg. The organic production prioritises animal welfare, however this method is not as hygienic as small group housing. Again increased production costs are set due to increased space availability and therefore higher earnings per egg are yield. A high focus is set on soil and ecosystems, and no GMO fodder plants are used.
Both, the German government as well as all individual German states jointly decided to phase out production systems designed for small-group housing (ibid.). The ban of the so-called “enriched cages” will be effective from 2025, which already leads to a further decrease in the number of hens kept in small group housing (ibid.).

Alternative laying hen rearing systems have been quickly adopted in an effort to reconcile poultry health and welfare with consumer, producer, industry and ecological requirements (Rakojnc et al. 2014, p.94). Even before the declared ban of battery cage systems in 2012 for countries in the European Union, positive market opportunities for alternative systems have emerged (Chamber of Agriculture of Lower Saxony, 2010). At that time, many farmers have recognized an imminent change in the egg market. The willingness to invest especially in alternative farming methods has increased significantly after the announcement of the planned ban of battery cage systems (ibid.). On the one hand there was a desire of farmers to expand their existing production, and on the other hand, new opportunities opened up the egg market to other farmers seeking entry in alternative production branches (ibid.). Dairy farmers in particular were interested in new and alternative forms of laying hen farming methods, due to the desolated milk price at that time (ibid.). Also part-time farmers, who more or less already retired from agricultural production, have seen their chance to return to full-time farming activities (ibid.).

Since this study focuses solely on the floor-range and organic farming methods, only the two will be specified in further detail. In floor-range farming systems, laying hens are given the opportunity and freedom to move around within a stable (Schmutz & Flock 2014, p. 3). In these stables, perches are provided for resting, as well as devices for dust bathing, and nest boxes are placed (ibid.). Often floor-range farming methods feature additional levels that can be used as additional space above the ground (see Fig. 8).

![Figure 8. Floor-range farming method (Schmutz & Flock 2014, p. 4).](image)

In Germany, specific legal grounds for the keeping of laying hens in floor-range farming methods apply. The § 13 of the animal protection livestock regulation comprises a list of general requirements for the keeping of laying hens under the different methods mentioned above (Schmutz & Flock 2014, p. 8): The regulation prescribes that all spaces intended to be used for animal husbandry need to have a minimum area of 2.5 m² and must be equipped in such a way that the laying hens can move about in accordance with their ethological and physical needs. Particularly the species-appropriate eating, drinking, resting and dust bathing must be made available to the animals. Moreover, the ability to locate a nest must be given. The lighting has to ensure that firstly the animals recognize each other, and secondly that the persons responsible for the feeding and caring have the possibility to inspect their animals.
Next, the soil must always provide a secure surface for the animals to stand on, and the laying hens must also have equal access to adequately dimensioned and sufficiently distributed feeding devices. The same applies to the provision of drinking facilities. Further, the facilities used for animal husbandry also need to be equipped with a freely accessible nest (at least during the laying period), and the bottom must be designed in such a way that the animals do not get in contact with wire meshes. Account also has to be taken for the requirement to set up a solid bedding area with appropriate bedding material, enabling the hens to satisfy their species-specific needs such as pecking, scratching and dust bathing. Whatever farming method is chosen, it must be allowed that laying hens within their group have the opportunity to rest simultaneously and undisturbed on a perch.

Finally, a sufficient abrasion of claws needs to be guaranteed, possibly by the application of special devices. There exist also specific requirements on the rearing of hens under the floor-range farming method, these are specified in the appendix on page 57.

In organic farming systems, laying hens are kept in housings that are similar to the standards of floor-range production systems. A remarkable difference is however, that in contrast to floor-range housing units, the hens have a steady access to an outdoor area with vegetation as it can be seen in the Figure 9 (Schmutz & Flock 2014, p. 9). In addition, the organic farming method does not permit beak trimming in contrast to the floor-range method.

![Figure 9. Organic farming method (Schmutz & Flock 2014, p. 4).](image)

Also the organic farming method needs to adhere to specific legal grounds in Germany. The production of eggs under the organic farming method is carried out in compliance with the minimum requirements of the so called “EG Öko-Verordnung” (EG Eco-regulation) in Germany (The German Confederation of the German Poultry Industry e.v., 2015). According to the German central association of the poultry sector BMEL (2015), these are the following characteristics for the organic farming method:

Under organic farming methods, the only farming option for laying hens is free-range. Every hen needs to have access to at least 4 m² of outlet. A minimum of 1/3 of the ground has to be sturdy which means that the floor is not allowed to be slatted or perforated. Additionally, it must be covered with bedding material as for example litter, shavings, sand or turf. Furthermore, the farming facilities for the animals need to be equipped with perches of 18 cm length and exit/entry holes in accordance to the necessary minimum dimension. Not more than 3000 laying hens are allowed to be kept in every facility. The number of animals is limited to 6 hens per m² of usable space. Elevated platforms and “winter gardens” can be defined as husbandry space, but only if the laying hens are allowed to access them permanently. The maximum number of 230 laying hens per hectare of agricultural land is not
allowed to be exceeded. Additionally, animals need to have regular as well as unlimited access to their outlet, provided that the weather and ground conditions allow it.

The right of outlet has to be ensured for at least 1/3 of the hen’s lifetime. It is also specified that the outlet needs to be mainly coated with flora and shielding devices such as suitable shelters, shrubs, or trees. In the husbandry facilities, artificial light can be utilised in order to foster egg-laying performance. However, the artificial and natural light is not allowed to surpass a joint total of 16 hours a day. Finally, in the event of sicknesses, the treatment of laying hens needs to favour natural remedies and homeopathic medicines. Here again, there exist specific requirements on the rearing of hens under the organic farming method which are also specified in the appendix on page 58.

1.2. Problem

Egg producers in Germany are currently facing decisions which will have profound effects on their future type of production due to Germany’s current legal framework. Since 2010, conventional cage systems have been banned in Germany, two years earlier than in other European member states (Science and Information Center Sustainable Poultry Sector 2015, p. 3). But also the so-called “enriched cages” will no longer be permitted by 2025 at the latest in Germany (ibid.). However, according to the Zapf & Damme (2013, p.22), the established non-cage alternative systems are expected to be rather unprofitable compared to the conventional battery cage systems, especially for farmers owning big farms with high numbers of laying hens.

Despite of the fact that the egg is known to be a healthy and indispensable food, the economic situation gets more and more difficult for farmers specialised in egg production in Germany (Zapf & Damme 2013, p.21). On the one hand, they have to comply with the strict regulations of the German government forbidding low cost production procedures, but on the other hand the same farmers face imports from the Netherlands and France where eggs are still produced under illegal cage battery production methods (ibid.). Newspapers (Press.com 2015; Kuhr 2014) report that the real problem for farmers is the price pressure from eggs produced abroad under illegal, but much more feasible conditions. They further argue that all eggs that are processed in the German production sector by alternative farming systems seem to have difficulties to compete with the cheaper eggs from abroad produced by battery cage systems (Press.com 2015). Margins in the egg production have been dropping continuously for years: According to the state-owned Thünen Institute for market analysis (2013), the sales revenues of the agricultural sector from consumer spending - i.e. the percentage that the farmers get from the retail price - declined almost steadily. After deducting all reasonable costs such as the expenses for housing, feed and so forth, farmers earn often less than one cent per egg (NDR.de 2015).

Given this situation, the question arises if farmers are and prospectively will be able to produce their eggs under economically feasible but at the same time also sustainable conditions. The European and the German policy broach the issue of sustainability in different farming systems (Silva and Marta-Costa 2013, p. 1). Ideally, alternative farming systems should ensure animal welfare, environmental protection, as well as economic efficiency (ibid.). Therefore, farmers are increasingly concerned with the conformity of their egg production systems with the current policies (ibid.). In this context, a twofold and often conflicting challenge is faced by farmers and their farming systems in order to perform
successfully. On the one hand, farmers need to maximise their socio-economic performances, but on the other hand they have to consider environmental and natural resource protection \( (ibid.) \). Farmers have to fulfil these two conditions when implementing more sustainable farming systems.

Vaarst, Steenfeldt & Horsted (2015, p.610) agree that the conception of Sustainable Development \( (SUSD) \) is in many ways controversial. Dealing with all aspects of SUSD associated with a single sector within agriculture is mostly considered as challenging, given the connections with so many other sectors and developments.

The main statement of sustainable development aims at keeping economic, social and environmental interests in equilibrium \( (ibid.) \). It is, according to Marta-Costa and Silva (2013, p. 274), a dynamic concept aiming to reach a balance between space and time, a concept which is exposed but also influenced by other factors. Problematic is that these systems were thought to be linear and predictable but the reality seems to be different. Sustainable farming systems turned out to be non-linear, unstable and vulnerable to dramatic changes \( (ibid.) \). Are farmers able to cope with, adapt and transform to these dynamic? Can farmers and their farming methods take economic, social and environmental aspects simultaneously into consideration? What challenges farmers face in implementing alternative farming systems with regard to sustainable development?

Questions related to sustainable development challenges tend to become a very great concern to society (BMEL 2014, p.1). Therewith the work of farmers increasingly moves to the fore. Farmers are the first link in the chain of food supply, and they hold an important role here, representing a key stakeholder group for implementing higher standards and greater sustainability for alternative farming methods, as they are mostly not contractually bound to downstream production stages. It is important to reveal how farmers address sustainability in agriculture. An overview of the farmer’s understanding of sustainability in different types of egg production seems to be not existent so far. However, in order to estimate the willingness of German farmers to implement sustainable alternative farming systems, and better identify potential barriers to the implementation of such systems at an early stage, it is necessary to determine what current understandings of benefits and challenges prevail among German farmers in terms of sustainable development. While it is true that numerous studies already examined the expectations of consumers for sustainable farming systems, studies dealing with expectations and preferences other stakeholders, especially farmers, can be found so far only to some extent. For a proper establishment of a sustainable farming system segment, in the egg market for example, this gap in research is pronounced.

In the context of agrarian systems, sustainability is extensively discussed and is understood as vital for the transition towards sustainable development on an international level (Binder & Feola 2013, p. 34). Accordingly, multiple methods and frameworks have been designed in order to evaluate sustainable development from an agricultural perspective. After an extensive literature review, it seems that most of these methods and frameworks bring solely the ecological aspects into focus. According to Binder & Feola (2013, p.34), numerous methods or frameworks show four major limitations in assessing agricultural sustainability: First, most sustainability assessment methods or frameworks do not fully take the multifunctionality in agriculture into account. Second, as already mentioned above, an imbalance between the three sustainability pillars (environmental, social, and economic aspects) can be found in the modelling and assessment procedures of these methods or frameworks, which often prioritise the environmental dimension. Third, a lot of previous studies have confined themselves to fill existing gaps in technology and knowledge, but have not incorporated the procedures of using
and implementing the gathered knowledge. Fourth, the findings obtained from the assessments are rather difficult to apply in a decision-making process, due to the fact that incompatible goals and the relation between different indicators have not been adequately taken into account. Due to the wide variety of methods and frameworks, differing in for example goals, methods, or assessment processes, many different outcomes can be anticipated with respect to their contribution to the four limitations already mentioned above. Binder and Feola (2013, p. 35) suggest either integrated participatory or transdisciplinary approaches in order to overcome the above-mentioned bias.

1.3. Aim and Research Questions

The aim of this study is to explain perceived challenges associated with sustainable development in egg production from a farmer’s perspective. In order to reach this aim, the following research questions are formulated:

- What are the perceived key challenges farmers in Germany face with regard to sustainable development in their egg production?
- What are the sustainable indicators (SI) for ecological, social as well as economic (EES) issues in the specific example of egg production?

This study serves as a comparison of facts about different methods of German egg production linked to sustainable development. It is intended to make this issue more comprehensible and so generate informed and rational discussion of the subject which so often causes great emotions. The objective is to illustrate the perceived challenges of operating alternative farming systems in egg production with regard to sustainable development from the farmer’s point of view. This work discusses current publicly debated issues, and make it attractive reading for farmers, students of farming, and all those having an interest in the future of laying hen farming systems in Germany.

1.4. Delimitations

Even though the European Union is considered to be one of the world's biggest producer and exporter of poultry meat and poultry products (European Commission 2015), poultry production is not the focus of this study. No analysis of significant trends within the poultry sector is offered. However, since the European Union is also considered to be the second biggest egg producer and exporter worldwide (European Commission 2015), egg production will be an important theme in the following discussion. Therefore, the distinction of different bird species such as chicken, broilers, turkeys, and gees is not necessary due to the fact that only laying hens play an important role in egg production. As already mentioned above, the European Union holds an important stand in the world’s egg production. However, this study is not concerned with European based patterns of laying hen farming systems due to the fact that this would be a too broad issue to analyse. This study just concentrates on the egg production and their respective farming methods in Germany and its regional patterns.
The organisation of egg production points out an extensive variety from small farming entities producing for their own needs or neighbouring markets to large farming entities supplying domestic as well as international markets (European Commission 2015).

The following chapters do not take farms with small-sized egg production units into account. The study focuses rather on egg farms characterised as large-scale industrial egg production units with 3000 or more laying hens, and specialised either in floor-range or organic farming methods. Conventional farming methods as well as the free-range farming method are not taken into consideration.

This choice is explained by three different circumstances: First, the cage production systems, which belong to the conventional farming systems, have already been banned in Germany since 2010 (Science and Information Center Sustainable Poultry 2015, p. 3). Therefore, it would not make sense to focus this research on cage production systems since German farmers who operated conventional systems had to convert them a while ago. Second, also the so-called “enriched cages” will no longer be permitted by 2025 at the latest in Germany (ibid.). This implies that the enriched cage systems do not belong to the future of German farming methods. Third, the free-range farming method is very similar to the organic farming method (see table 1). In order to avoid analysing two comparable farming methods, the more animal-friendly method (Zapf & Damme 2013, p.18) was chosen out of the two in order to be able to create a noticeable contrast between two very different farming systems (floor-range and organic).

Regarding theoretical delimitations, evaluators should have a clear picture of different limitations regarding the application of evaluation frameworks which assess sustainable egg production systems. These limitations are portrayed as follows:

**No collective definition of sustainable development.** People such as scientists, economists, or socialists do not have the same viewpoint on sustainable development (Lewandowski, Hardtlein & Kalschmitt, 1999, p. 186). According to Waltner-Toews (1994, p. 11), the non-existent standard definition of sustainable development is attributable to diverse ideologies. Whereas there is an overall conformity that sustainable agriculture has to be firmly ecological, there is less conformity about their economic and social soundness (ibid.). The different viewpoints on sustainable development impede the establishment of sustainable indicators. In the underlying study, the triple bottom line approach was relied upon, including environmental, economical as well as social dimensions.

**Chosen indicators might not adequately replicate the desired level of sustainability.** Despite the fact that indicators facilitate the measurement process, they can also be characterised as ambiguous (Hayati, Ranjbar & Karami 2010, p. 78). Indicators cannot be simply transmitted from one situation to another. It may even be risky to simplify them over space, time and several societies (ibid.). Due to the seasonal nature of agriculture, some indicators seen as positive at a specific time may not be seen in the same way and with the same impact at posterior times (Suvedi, den Biggelar, & Morford, 2008, p. 448).

**Little possibility to consistently reveal underlying links between sustainability indicators and research suggestions on management decisions.** A lot of non-research factors such as policies, markets, or cultural traditions, influencing farm management decisions exist. Therefore, it can be challenging to set up underlying links between research suggestions and farm management decisions (ibid.). For the purpose of this study, the researcher had to realise
that is rather difficult, if not impossible to state underlying relationships by using valuation frameworks in isolation when measuring sustainability in egg production systems. Thus, a combined conceptual framework was used offering the best options for comparing sustainability in different farming methods.

**Fairness issues.** In discussion of measuring sustainability, an important question arises: From whom perspective is sustainability measured? What group of people and what level decide upon the different criteria and indicators for the assessment? These questions have not been ignored during the course of this study, especially when choosing indicators. It is important to realise that no assessment process is able to “do it all”. Therefore, it was necessary to understand what needed to be achieved with this work, and to develop an assessment process able to gauge these expectations.

1.5. Outline

This study begins with the Introduction (Chapter 1), that offers a first insight into the particular problem and it’s solving approach. It further contains the research questions leading the analytical course of action and the delimitations of this research. The Literature Review accomplished in Chapter 2 enables a multidisciplinary perspective on sustainability indicators, their utilisation, and reveals the difficulties within these conceptions. This is followed by the conceptual framework of this thesis (2.7), where the triple bottom line approach in sustainable agriculture and indicator based measurement approaches are combined. Chapter 3 presents the methodological approach of this study, explaining all procedural choices made, their consequences for the outcome, ethical considerations, as well as steps taken to guaranty research quality. Then, the empirical background (Chapter 4) and the empirical results (Chapter 5) are covered. These findings are scrutinized in Chapter 6 using the theories and the conceptual framework for assistance. Chapter 7 entails a comparison of the outcome of this study to other research statements. In conclusion, Chapter 8 recalls the aim pursued of this thesis and recapitulates the main results. In addition, reasonable implications and propositions for prospect research are introduced.
2. Literature Review and Theoretical Framework

This chapter encloses a discussion of some recent perceptions on sustainability especially with regard to sustainable development. It further attempts to gather and develop useful tools for sustainability measurement. Additionally, the review of literature covers a multidisciplinary view on sustainability indicators, their utilisation, and reveals the difficulties within these conceptions. Finally, all these sections are assembled in order to form the conceptual framework for this study.

2.1. The Concept of Sustainable Development

The concept of sustainable development was introduced by the so-called “Brundtland” Report from 1987 (Hoffmann – Müller and Lauber 2013, p. 255). With the United Nations Conference on Environment and Development (UNCED), and the Rio Convention (UNCED 1992 “Rio Earth Summit” and Agenda 212) the concept was developed further in international politics (ibid.). The concept of sustainability has since become in many countries a guideline for policy and has led to the establishment of sustainable development strategies worldwide.

Europe pursues a sustainable development strategy introduced by the European Union (EU) since 2006, and Germany, as many other European countries, pursues a national sustainability strategy since 2002 which is updated on a regular basis (Hoffmann-Müller and Lauber 2013, p. 256). In Germany, the Federal Statistical Office supports the strategy by publishing indicator reports about sustainable development, most recently with the indicator report from 2012 (Destatis 2016).

By consulting different literature, it can be recognized that the idea of implementing indicators as a measurement approach for sustainability has become very liked by numerous governments and agencies dedicating considerable efforts to establish or test indicators.

2.1.1. Definition of Sustainability

Although there exists a generally accepted definition of sustainable development established by the World Commission on Environment and Development (WCED) in 1987, the definition and understanding of the term sustainable show a discrepancy depending on from whom and in what context it is used. Whereas almost everyone agrees on the fact that sustainability connotes “not cheating on further generations”, a more transparent definition has seemed to be not easily definable. With regard to the literature read in this context, it can be concluded that more or less every piece of writing on sustainability lament about a too broad conception and a lack of a common consensus. Despite the overall difficulty to define sustainability concretely, the omnipresent use and popularity of this concept seem to be rather unexpected at first sight. How can such an obscure conception be so popular worldwide? In discussion of this problem, Schaller (1993, p.91) has stated the following:

“As a destination, sustainability is like truth and justice –concepts not readily captured in concise definitions. ’We all want truth and justice; but what these mean can also vary greatly from individual to individual and between societies. My justice may be your exploitation, and my truth may be your lies!’
This ambiguity in the definition of sustainability has not harmed the popularity of the notion. In fact, the definition’s flexibility may even be an advantage on a very diverse planet. People have to live under different environmental, social as well as economic conditions all over the world. Assuming that humans had solely one definition of sustainability to apply on their diverse life situations would be both inconvenient and risky. Kidd (1992, p.23) reminds us that: “there is not, and should not be, any single definition of sustainability that is more logical and productive than other definitions”. One way to operationalise sustainable development is the Triple Bottom Line approach (TBL). An illustrative review of the TBL concept can be found in the following.

2.1.2. Triple Bottom Line Approach

The concept of sustainability was established by Elkington in 1997 and was modelled as “triple bottom line” (TBL). The concept deals with three value dimensions such as economics, ecology and social issues (see Fig. 1).

All three value dimensions can be considered as equal sustainability dimensions and can be interconnected in the discourse of sustainable development (Spindler 2011, p.12). In this context, the operationalisation of the sustainability principle is carried out as sustainable development, in which the objectives of the three dimensions are pursued simultaneously, and based on an integrated perspective (Schaper 2000, p.75).
2.2. Concept of Sustainable Development in Agriculture

By consulting different literature, one can argue that agriculture has been an integral part of the sustainability discussion for two reasons:

1. First, agrarian systems take a dominant lead over large areas of land, in general much more land than any other sector or industry (Bell & Morse 2008, p.8). Thus, incidents occurring within farming usually have a vast impact on the environment.

2. Second, in most cases the final product resulting from agriculture is food, and food is consumed by everyone. Hence, agriculture can be interpreted as one of the fundamentals of human society.

As consequence, sustainable agriculture has been heavily promoted and also other concepts such as agro-ecology, alternative agriculture, ecological food production, low-input sustainable and organic agriculture have been put up for discussion. The Sustainable Agriculture Initiative (SAI) Platform developed principles and practices for sustainable agriculture illustrated below, discussing four main focal points (Fig. 2).

![Figure 2. Issues Related to the Principles of Sustainable Agriculture (SAI Platform, 2010).](image)

According to the SAI Platform (2010), sustainable agriculture is “the efficient production of safe, high quality agricultural products, in a way that protects and improves the natural environment, the social and economic conditions of farmers, their employees and local communities, and safeguards the health and welfare of all farmed species.” This quotation is visualized in Figure 2. The guiding principle of sustainable development in agriculture is securing the efficiency required for the satisfaction of the needs of future generations, with simultaneous reduction of ecological risks. This development equally takes environmental, economic, and social targets into account, so that it becomes permanently active. The SAI
Platform states (ibid.), that the German Federal Government and the German Farmers’ Association have formulated the above mentioned mission statement as follows: Economically, farms taking the lead in sustainability strive for a market-oriented, cost-effective economy, using modern production processes in order to successfully compete in the marketplace for food and raw materials, or for the provision of socially desirable services. From an environmental point of view, farms declared as pioneers and role models are characterized by an eco-friendly production and management approach. These include among other things reduced emissions of substances that are harmful to the environment, improved energy efficiency, high soil fertility, and the greatest possible use of material cycles. In social terms, farmers acting in accordance with sustainable guideline principles should achieve a fair income, be supported in their social integration, be allowed to act independently, and ensure a species-appropriate keeping of their farm animals.

2.3. Sustainability in Practice

Presumed that sustainable development is an applicatory aim to be achieved by some sort of involvement, it is necessary to determine if a particular system or state is still unsustainable or if the aim of sustainability has been achieved. Clearly, this judgement will be based on one’s own understanding of sustainability however, as soon as the aim has been precisely defined, one has to verify if the target has been achieved. Given the need for a contextual understanding as expressed by Heinen (1994), sustainable development is discussed in terms of indicators:

“Sustainability must be made operational in each specific context (e.g. forestry, agriculture), at scales relevant for its achievement, and appropriate methods must be designed for its long-term measurement.” (Heinen 1994, p. 26).

2.3.1. Sustainability Indicators

For several years now, indicators have been extensively used by biologists in order to determine ecosystem health; therefore indicators have been viewed by numerous as the key component in operationalising sustainability (Bell & Morse 2008, p.29). Indicators can be defined as “observable phenomena that represent an intended and / or actual condition of situations, programs, or outcomes.” (Suvedi, den Biggelaar & Morford 2008, p. 436). Research in sustainable agriculture is seen as rather complex due to the fact that the assessment of environmental, social, and economic factors within farming systems needs to be addressed interactively (ibid.). Sustainability definitions as well as indicators differ extensively among farmers, and the difficulty to measure oblique and intangible factors need to be taken into account. Keeping the subject of this study in mind, it is important to be aware of the fact that sustainability includes a variety of dimensions, and a number of indicators are surely needed. The model is illustrated in Figure 3.
As depicted in the Figure above, the values of the different SIs are measured. The researcher needs to understand and interpret the findings, as well as make full use of the interpretation. Problematic may be the uncertainty about the number and type of indicators used in this theory. Due to a limited timeframe, not every SI which might possibly be accessible, and a component of simplification, as well as simultaneously maximize exclusive and appropriate information, is indispensable. In this study, they play a significant role as a tool of assessment allowing the researcher to measure changes over time and space. A framework categorizing individual indicators or a set of indicators is helpful in order to successfully manage the data gathering process.

According to Bell & Morse (2008, p.28) SIs are frequently classified in different ways based on what dimension or facet of sustainability they are aiming to measure. In their views, the easiest way to classify SIs could be a division into two groups (ibid.):

1. Possible SIs. They are being explored on the basis of economic, ecological, and social (EES) issues.

2. Final SIs. They are selected out of the possible SIs and are based on five selection criteria (see table 2).
Table 2. Five selection criteria for final sustainable indicators. (de Boer & Cornelissen 2002, p. 174)

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Information is accessible in order to be able to measure sustainable indicator.</td>
</tr>
<tr>
<td>2</td>
<td>The possible SI needs to be quantifiable.</td>
</tr>
<tr>
<td>3</td>
<td>The possible SI needs to be credible and understandable for its users.</td>
</tr>
<tr>
<td>4</td>
<td>The possible SI needs to discriminate among the different Egg Production Systems.</td>
</tr>
<tr>
<td>5</td>
<td>It must be possible to establish a target value or trend such as political goals or expert assessment which then can be determined for possible SI.</td>
</tr>
</tbody>
</table>

Table 2 summarises the necessary selection criteria for the final sustainable indicators. According to this criteria list, it is necessary that enough information is retrievable and easily accessible to measure the indicators. Further, the possible indicator needs to be measurable, reliable, and clear. In addition, the possible indicators need to discriminate among the existing egg production systems and also need to have a target value that can be established to determine the final indicators.

2.3.2. Measuring Difficulties

Due to the complex characteristics of sustainable agriculture which incorporates three inter-reliant and interactive dimensions (economic, ecological, and social), the monitoring process proves itself to be rather difficult (Hayati, Ranjbar & Karami 2010, p. 78). Norman et al. (1997, p. 46) also claim that three major difficulties remain when selecting indicators:

1. The present existing measurement tools are often not fully developed for gauging the relations and interdependencies between the three dimensions as well as the tradeoffs of one element at the expense of another.

2. Most of the existing measurement tools or indicators are not practical or too cost and time intensive to assess, especially for farmers in their daily work. This makes it more difficult for them and their families to supervise progress regarding sustainability in agrarian systems. In fact, this is seen as particularly unfortunate since a lot of the issues regarding sustainability in agricultural systems are site or situation specific.

3. Generally, indicators give an idea about a certain progress or no progress to particular factors of sustainability. However, they often fail in assisting to resolve cause/effect relationships that help in gauging existing problems and offer advice on what can be done in order to guarantee sustained steps towards sustainability.
Hayati, Ranjbar & Karami (2010, p. 78) add that strategies regarding agricultural sustainability often call for 5-10 years of implementation before they produce any noticeable or accessible result which constitutes another challenge. When it comes to the topic of sustainable indicators, the literature shows that a large variety of indicators have been generated, but they fall short in covering all three dimensions as well as different levels illustrated in Table 3.

Table 3. Basic dimensions and conforming levels to assess agricultural sustainability according to von Wirén-Lehr (2001, p. 118)

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normative</td>
<td>Ecological aspects</td>
</tr>
<tr>
<td></td>
<td>Economic aspects</td>
</tr>
<tr>
<td></td>
<td>Social aspects</td>
</tr>
<tr>
<td>Spatial</td>
<td>Local</td>
</tr>
<tr>
<td></td>
<td>Regional</td>
</tr>
<tr>
<td></td>
<td>National</td>
</tr>
<tr>
<td>Temporal</td>
<td>Long-term</td>
</tr>
<tr>
<td></td>
<td>Short-term</td>
</tr>
</tbody>
</table>

In the above table three basic dimensions and their respective conforming levels necessary to assess agricultural sustainability are depicted. First, the normative dimension is shown and consists of three levels such as the ecological, economic, and social aspects. Next, the spatial dimension is based on the national, regional and local level. Finally, the temporal dimension includes a long-term and short-term level.

Rasul and Thapa (2003, p. 333) suggest that due to discrepancies in biophysical and socioeconomic conditions, indicators consulted in one geographical dimension do not have to be automatically be helpful in other s.

Seeing that, indicators should be site specific, built within the current socioeconomic situation. Next, sustainable agriculture is interpreted as a dynamic concept (Hayati, Ranjbar & Karami 2010, p. 79). This leads to the fact that what may apply to sustainability nowadays, may not be applicable when the system alters. Consequentially, sustainable agriculture needs a high degree of monitoring and skills that have the ability to adapt to change. Under those circumstances, sustainability is viewed as a process that do not provide ultimate and fixed outcomes by itself which makes it even more challenging to observe and gauge (Normal et al.1991, p. 50).

Despite the above mentioned drawbacks of indicators’ measurement techniques, this work is still making use of an indicator measurement approach in order to measure challenges for farmers regarding sustainable development in egg production systems. The assessment of sustainable development in egg production systems (EPS) in this study builds on a calculation model developed by de Boer & Cornelissen (2002, p. 174). The selection criteria that identify the use of the final SIs relate to their application in the sustainable development assessment process. In this context de Boer & Cornelissen (2002, p. 174) assume the following basic conditions:

- \( \text{SI}_i \ (i = 1,...,n) \) stands for sustainability indicator \( i \),
- \( \text{EPS}_j \ (j = 1,...,m) \) represents egg production system \( j \),
• Ti corresponds to the target value of SIi and
• Aij signifies the actual value of SIi for EPSj.

In order to measure the contribution of SIi to sustainable development (SUSD), Aij is compared to the target value Ti.

This emphasizes that the analysis is reliant on the behaviour of SIi concerning a contribution to SUSD (ibid.). They further argue that SIi behaves in two ways (see Table 4):

1. SIi is DEC if the contribution of SIi improves SUSD when Aij decreases, or
2. SIi is INC if the contribution of SIi improves SUSD when Aij increases.

Table 4. Explanation of DEC or INC (the behaviour of sustainability indicators), in order to measure the contribution Dij of sustainability indicator i for egg production system j to sustainable development of egg production. (de Boer & Cornelissen 2002, p. 174)

<table>
<thead>
<tr>
<th>Behaviour</th>
<th>Dij &lt; 0</th>
<th>Dij = 0</th>
<th>Dij &gt; 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEC¹</td>
<td>Fails</td>
<td>Succeeds</td>
<td>Succeeds</td>
</tr>
<tr>
<td>INC²</td>
<td>Succeeds</td>
<td>Succeeds</td>
<td>Succeeds</td>
</tr>
</tbody>
</table>

¹DEC = the contribution of SI1 to sustainable development improves when the actual value of SI1 decreases;
²INC = the contribution of SI1 to sustainable development improves when the actual value of SI1 increases.

In order to make this rather abstract equation more comprehensible, the following situation is exemplified: Let production cost be a contribution of SI which improves SUSD when its value decreases (DEC), due to the fact that real costs need to be decreased to enhance SUSD. But production revenue for example, can be a contribution to SI which only enhances SUSD when its value increases (INC), due to the fact that real revenues have to increase to ameliorate SUSD.

2.4. A Conceptual Framework

Even though there is much incongruity regarding the use and characteristics of the SIs, there is an overall conformity that SIs shows the way forward (Lebacq et al. 2013; Niemeijer & de Groot 2008; Dale & Beyeler 2001; Bell & Morse (2008)). Nevertheless, the choice over what SIs to use is important for the end result. In order to encourage some understanding of assessment and to assist in classifying indicators, numerous researchers have created some models for assessment and supervision (Lebacq et al. (2013; Niemeijer & de Groot 2008; Dale & Beyeler 2001; Bell & Morse 2008)). For the purpose of this research project the model (see figure 3) developed by Bell & Morse (2008) was used as a foundation for the conceptual framework. This basis was combined with several elements of other indicator-based models in order to build up and suggest a composite conceptual framework for the appraisal. The conceptual framework for this work is depicted in Figure 4.
Although sustainability is viewed as a global concept contrasting a farm which is seen as small subsystem interrelated with a variety of other surrounding systems, indicators are important to measure whether a farming system is becoming more or less sustainable (Hayati, Ranjbar & Karami 2010, p. 95). This conceptual framework describes a possible approach enabling a comparison of the egg production systems for their contribution to sustainable development of egg production. These findings shed light on the challenges farmers have to face if they are or want to design their production systems more sustainable.

Two different EPS constitute the core of this framework. Both systems need an assessment to be able to measure how sustainable these different farming systems really are. However, not all indicators are appropriate for conducting such assessment (Lebacq, Baret & Stilmant 2013, p. 323). Therefore, the conditions for use as well as the interpretation of indicators need to be carefully examined during the collection stage (ibid.).

The indicator collection is characterised as an important step in all indicator-based measurements due to the fact that it has an effect on the findings of the study (Lebacq, Baret & Stilmant 2013, p. 316). According to Niemeijer & de Groot (2008, p. 16), a precise and clear course of action is required to increase trustworthiness and a reproducibility of the assessment. Also Dale & Beyeler (2001, p. 5) recognise that “lack of robust procedures for selecting indicators makes it difficult to validate information provided by those indicators.” The collection of sustainability indicators (see stage 1 and 2) in this conceptual framework incorporates three focal steps:

1. Contextualization of the appraisal,
2. Contrasting indicators based on a choice of criteria,
3. Collection of a final set of indicators.
1. Contextualisation, or “preliminary choices and assumptions” as named by Bockstaller et al. (2008, p. 140) means defining the intention of the investigation. The definition of a sustainability notion and a goal setting constitute a challenge which affects the choice of indicators (Lebacq, Baret & Stilmant 2013, p. 317). However, it is recognised that this step entails normative choices given that several problems are considered as more important than others contingent on different backgrounds and regional views (Halberg et al. 2005, p. 43). The introductory stage of this framework also entails the definition of which stakeholders will be integrated in this work and what relevance they are going to have on the assessment process. Several authors who have devoted themselves to the topic agree that a participatory process is vital for defining a sustainability conception, and choosing goals and a set of indicators which consistently correspond to the system assessed (Binder et al. 2010; Ramos and Caeiro 2010). In addition, it is essential to identify the type of end users of the measurement because it is rather doubtful that the identical indicators will be selected for several groups simultaneously such as scientists, farmers, or consumers (Bockstaller et al. 2008, p. 142).

2. The collection criteria intend to contrast and appraise indicators gained from the literature in order to constitute the collection process in a clear way. In general a lot of collection criteria are used in sustainability evaluations, and their significance depends on the perspective and purpose of the study (Lebacq, Baret & Stilmant 2013, p. 319). Widespread collection criteria used in sustainability appraisals have been classified into four groups (based on de Boer & Cornelissen 2002): (1) Accessibility: Information is available and can be accessed in order to be able to measure SI. (2) Quantification: The possible SI needs to be quantifiable. (3) Credibility: The possible SI needs to be credible and understandable for its users. (4) Differentiation: The possible SI needs to discriminate among the different egg production systems (EPS). (5) Target value orientation: It must be possible to establish a target value or trend such as political goals or expert assessment which then can be determined for possible SI.

3. Moreover, indicators should be viewed as a set, and not on an isolated basis (Lyytimäki and Rosenström 2008, p. 309). Also Niemeijer and de Groot (2008, p.18) concede that for a truthful interpretation, a single indicator must be part of a reliable and complete set. Binder et al. (2010, p. 75) do not deny that the challenge is to choose a set of indicators being able to systematically and consistently represent the complex nature of the system, its present environmental, social and economic situation, and its shift towards sustainability.

Stage 3 of the conceptual framework represents the DEC or INC evaluation process. As previously illustrated in detail (see Table 4), this process stands for the behaviour of sustainability indicators. The DEC and INC evaluation process enables the researcher to measure the contribution of sustainable indicators for egg production systems to sustainable development.

The final stage (4) provides an interpretation of the findings. There is a need for the researcher to understand and interpret the findings, as well as make full use of the interpretation. This reflection gives rise to prospective application and implementation for the end users of the egg production systems.

This conceptual framework (fig. 4) essays to give the reader an idea about how different conceptions and tools developed by sustainable indicator based theories can be combined and jointly applied in order to measure specific challenges in sustainable development in egg
production. Figure 4 represents not only the conceptual framework for this study; it also serves as review of the literature review. The conceptual framework is applied in Chapter 5 and 6 in order to identify the challenges for German farmers in their egg production systems from a sustainable point of view.
3. Method

In the following chapter, all decisions associated with the methodological approach are introduced. First, the approach and design of the research are outlined. The literature and case study approaches are presented next. A presentation of quality assurance measures taken in the research process and ethical aspects of the study are also offered. Finally, the limits of the methodological approach are stated.

3.1. Research Approach and Design

This study builds on a qualitative research approach. Defined as a study which is “conducted in a natural setting” (Soiferman 2010, p. 6), the qualitative approach is mainly of exploratory nature. It involves the analysis and attempt to reveal the importance of human behaviour and experience, incorporating opposing viewpoints, behaviour patterns and sentiments (von Andreas Bauer & Mulley 2008, p.1). The qualitative research approach is often said to be inductive since it moves from particular observations about personal incidents to wider generalizations, and is often referred to as bottom-up approach (Soiferman 2010, p. 6). This choice enables the researcher to understand farmer’s reasons, opinions as well as motivations relevant for this project. It may also help to reveal target values or trends in thought, and give a more detailed insight into the farming system problem.

The farmers play a decisive role in this project and need to be understood as phenomenon in its settings and not as independent group since their understanding of sustainable development and challenges in this field are connected to the whole egg production cycle. Even if this study is illuminated from a rather broad perspective, it does not aim to generalize farmer’s challenges in the entire agricultural sector. The focus lies on two specific farming systems in the egg production industry. Under a qualitative research approach it was understood that researchers attempt to obtain a rich and multifaceted understanding of people’s experience, and not gain information that can be applied to other groups in general (von Andreas Bauer & Mulley 2008, p.1).

In this study, a three-phase Framework (eg. Bossel, 1999, Mitchell et al., 1995, Bell & Morse, 1999, de Boer & Cornelissen, 2002) was used in order to help the researcher to communicate effectively with the farmers, condense information resulting from different sources, and recognize potential information gaps. The framework is depicted in Figure 5. De Boer & Cornelissen (2002, p. 174) argue that this framework “prevent ad hoc selection of SI and includes all relevant issues.” Furthermore, it highlights that a method to measure the input of single SI’s to sustainable development is needed in order to establish prospect strategies in egg production.
Phase 1 demonstrates significant issues concerning sustainable development in egg production using the German example. The following phase (2), converts EES issues into sustainability indicators (SI) by structuring the conversion as follows:

- Identifying the **possible SI**
- Develop **final SI** on the following criteria:
  - Information is accessible in order to be able to measure SI
  - The possible SI needs to be quantifiable
  - The possible SI needs to be credible and understandable for its users.
  - The possible SI needs to discriminate among the different Egg Production Systems (EPS)
  - It must be possible to establish a target value or trend such as political goals or expert assessment which then can be determined for possible SI

Phase 3 finally compares the contribution of SI to sustainable development.

### 3.2. Literature Review

In order to start an academic research properly, a methodological review of precedent literature is important (Levy & Ellis 2006, p. 181). The necessity to reveal what have been previously discovered in terms of knowledge before starting any research project should not be taken too lightly (*ibid.*). According to Hart (1998, p. 1), a literature review can be defined as “the use of ideas in the literature to justify the particular approach to the topic, the selection of methods, and demonstration that this research contributes something new”. In his book, he further states that for a proper literature review “quality means appropriate breadth and depth, rigor and consistency, clarity and brevity, and effective analysis and synthesis” (Hart 1998, p. 1). Shawn (1995, p. 326) for example argues that the procedure of a literature review should “explain how one piece of research builds on another”. In Webster and Watson’s (2002, p. 13) view, a helpful literature review “creates a firm foundation for advancing knowledge. It facilitates theory development, closes areas where a plethora of research exists, and uncovers areas where research is needed”.

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*Figure 5. A three-phase framework (based on Boer & Cornelissen 2002, p. 174).*
In order to develop an appropriate framework for this thesis, a wide variety of literature is conducted on a multidisciplinary basis. Databases such as Google Scholar, Uppsala University Library, University and State Library Münster, Business Source Premier and Destatis are used to conduct the search, and have three central topic areas significant for the study’s aim: Current trends in laying hen farming systems including the debate about the no longer permitted conventional farming systems; Sustainability in agrarian systems; Sustainable development measurement approaches with a strong focus on the indicator-based approach. Numerous articles addressing different aspects of poultry science and management in Germany and other countries are also incorporated.

As already mentioned above, the literature review constitutes an integral part of this study, therefore its quality has to be assured. In order to ensure that no significant article is overlooked, a wide range of important journals in poultry production science, agricultural systems, and sustainable development are strongly considered, *e.g.* World’s Poultry Science Journal, Agricultural Systems Journal, and International Journal of Sustainable Development of World Ecology. Simultaneously, journals dealing with multifaceted disciplines enable to develop a wide-ranging and dynamic point of view. A lot of the incorporated articles are well received and frequently cited in their respective fields, and all of them are scrutinised in order to guarantee the credibility of the theoretical framework. On an overall basis, a great deal of literature exists that discusses sustainability in agrarian systems, permitting to construct a concrete framework for thus study.

### 3.3. Case Study

In order to explain unexplored and current problems in the egg production sector in Germany, a case study is used for clarification purposes. Considering different literature, one can notice that there exist numerous different conceptions about what a case study is. Nevertheless, a point frequently agreed upon by case study researchers (Yin 1994; Merriam 1994; Stake 1995, 1998; Miles & Huberman 1994; Gillham 2001) is that a case study should have a “case” representing the objective of a study. Further, this “case” needs to possess the following characteristics (*ibid.*):

- The case needs to be a compound functioning unit.
- The case should be considered in its usual environment, including a large number of different methods.
- The case should be current.

However, the above-mentioned researchers call attention to different characteristics and uses different definitions to portray multitude case studies. Yin (2013) for example classifies case studies as explanatory exploratory, or descriptive. Further, case studies are not just seen as research conducted on an individual or situation. The case study research approach enables the handling of simplistic and more compound situations (Baxter & Jack 2008, p.556). It additionally permits the researcher to consider how a phenomenon is affected by the situation within which it is placed (*ibid.*).

For this research purpose a case study is seen as an opportunity to take a great insight into the egg production case. Due to the ban on the battery-cage system within the European Union, farmers were forced to orient themselves to alternative farming methods for egg production.
However, an implementation of more animal-friendly farming methods on a large scale needs a comparison of alternative farming methods in a wider EES context. Therefore, a case study will compare the perceived challenges with regard to sustainable development of farmers happened to operate two different farming methods which are common in Germany: the floor-range and the organic farming method. Using a case study, researchers have more opportunities to explore as well as concentrate on different issues as they come up in their research (ibid.). Moreover, due to the more flexible design of case studies, researchers start their experiment with wide questions and get increasingly focused along the progress path (ibid.). There is no attempt to predict potential results prior to the end of research. In order to grasp as much as possible from a specific issue, case studies have the advantage to specialise in “deep data” (ibid.), which means that information built on specific contexts may let appear research findings under a more human face. This feature can assist in bridging the gap between conceptual research and actual practice. A case study is a useful tool for this project to contrast the observations personally obtained with the findings obtained through secondary data.

3.3.1. Choice of Case and Unit of Analysis

In discussion of case studies, one important issue is determining the case or the unit of analysis. Baxter and Jack (2008, p. 545) define a case as a “phenomenon of some sort occurring in a bounded context”. One can conclude from this that the case is seen as the unit of analysis. One farm implementing floor-range EPS in Lower Saxony and one organic farm in North-Rhine Westphalia were chosen for the following reasons:

First, both farms feature the exact right farming method which needs to be scrutinized for the aim of the project, namely the floor-range and organic farming method. Second, the organic farm is situated in a near district, and the farm implementing the floor-range method is located within a reasonable distance which makes it convenient for the researcher to conduct the interviews on site.
Third, both farmers were agreed to a personal meeting and welcomed the researcher to have a look around. This made it considerably easier to conduct the interviews and gather all necessary information in a casual atmosphere.

3.3.2. Data Collection

One important feature of case study research is that numerous data sources are considered, an approach that also increases data reliability (Patton, 1990; Yin, 2003). In case study research, data gathered from these numerous sources are not handled separately, the data is rather congregated in the process of examination (Baxter & Jack 2008, p. 554). In this underlying study every set of data is seen as one piece of a puzzle that contributes to the researcher’s grasp of the full phenomenon. The convergence process helps to strengthen the results due to the fact that the numerous data sets are united to provide a better comprehension of the case (ibid.). Even though the possibility to collect data from numerous and diverse sources is attractive as rigour can be related to this method, there are some risks. One risk could be gathering a vast amount of data too broad to manage or analyse (ibid.). To overcome this risk and being able to organise the data sets properly, a computerised data base is used in order to manage the huge amount of data. Apart from the literature review, this study is based on empirical data.
This data is collected via structured personal interviews and numerous secondary sources composed of journal and newspaper articles, websites, reports, and other scientific documents.

According to Currie (2005, p.89), primary research includes data which is solitary obtained directly from an initial source. In this present type of primary research, direct contact has been established to the initial source of data (farmers). In addition to primary research, primary data is defined as “data that were previously unknown and which have been obtained directly by the researcher for a particular research project” (Currie 2005, p.89). The data collection approach within a qualitative research design usually incorporates a compilation of a large set of data on a rather small, purposive sample (Hox & Boeije 2005, p. 593). One major benefit of gathering data at first hand is that the operationalisation of the research design, theoretical framework, and data collection approach can be aligned to the research question (Hox & Boeije 2005, p. 594). This in turn makes sure that the study project is conclusive and that the information gathered really assists in solving the underlying problem (ibid.). However, the major disadvantage of gathering data at first hand is that this process is cost-intensive and time-consuming (ibid.) There are different techniques that can be used to collect this set of data and the techniques the researcher chooses is determined by the type of data necessary for the study (ibid.).

For the purpose of this study, the interview method was used. Structured interviews were used to gather data for this project. With structured interviews, the interviewer reads out a number of close-ended questions specifically ordered and takes down the interviewee's answers. Structured interviews were used as a primary data collection approach for this project because of the following advantages:

1. First, structured interviews are composed of a fixed set of closed questions that are simple to quantify, and therefore easy to test for credibility (McLeod 2014).

2. Second, in order to organise the process as efficient as possible, an interview method was chosen that is fairly quick and easy to conduct. The structured and closed set of questions allows the researcher to conduct interviews within a short amount of time, and simultaneously reveal important information in a simple and structured way (ibid.).

However, structured interviews are known to have some limitations as well. According to McLeod (2014), structured interviews are characterized as not flexible. During the course of the interview it is not possible to ask new questions because a predetermined interview schedule must be adhered to (ibid.). McLeod (2014) also argues that structured interviews generate quantitative data due to the fact that solely closed questions are asked and their replies therefore lack of detail.

Within the framework of the possibilities offered, the structured interview method was still chosen in order to ensure and create an authentic result. Open ended questions often lead to interpretational problems and more subjectivity. In an effort to stay as objective as possible, the structured interview method was chosen which do not research why a person behaves in a certain way. The interview process that was used in this study is shown in table 5.
Table 5. Interview process in the case study.

<table>
<thead>
<tr>
<th>Respondent</th>
<th>Function</th>
<th>Type of Farm</th>
<th>Type of Interview</th>
<th>Validation</th>
<th>Interview Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anonymous</td>
<td>Farmer/Independent Entrepreneur</td>
<td>Floor-range farming method</td>
<td>Personal Interview</td>
<td>Direct oral</td>
<td>2016-07-07</td>
</tr>
<tr>
<td>Overesch, Rudolf</td>
<td>Organic Farmer</td>
<td>Organic farming method</td>
<td>Personal Interview</td>
<td>Direct oral</td>
<td>2016-07-08</td>
</tr>
</tbody>
</table>

In the interviewing phase, it is very enlightening to talk to people from habitats that can be seen as experts in a particular given issue. They provide the necessary external perspective and external demand for the interviewer. These interlocutors can give their insight into the image and the perception of laying hens systems, and provide important feedback from their perspective. The participation in these personal interviews is on a voluntary basis. The person in charge ensures that all data collected is kept strictly confidential and is solely used for the agreed purpose. In order to ensure data protection, a confidential agreement is drafted which all participants need to sign before the actual interview (see Interview sheet in the Appendix, p.). The gathered data is validated by direct oral validation. All interview responses are repeated to the interviewees once again after the interview. Then, the interviewee has the possibility to rectify or even refrain from certain statements if he wants to.

When suitable information on the research subject is available, the reuse of this information promises benefits. Secondary data can help to solve the research question in providing the researcher with a greater choice for testing different understandings at far lower costs and with greater pace (Hox & Boeije 2005, p. 594). One major disadvantage of secondary data is that the data were initially gathered for a totally different reason which may classify this data as not ideal for the underlying research problem (ibid.).

A literature review can be defined as “critical review of existing knowledge on areas such as theories, critiques, methodologies, research findings, assessments and evaluations on a particular topic” (Chan 2009). It also incorporates a sceptical appraisal which discovers resemblances and discrepancies between present literatures (ibid.). Based on the consisting knowledge, researchers are given the opportunity to develop innovative ideas and theories in the following course of their dissertation. Essentially, secondary data offers and present background information for this research, and also positively contributes to the primary data. In other words, this study is built on various data collection approaches: structured personal interviews and secondary information. The data is not meant to be contrasted statistically, rather a completion for each other.

3.3.3. Quality assurance

There exist a great variety of frameworks that can be used to assess the rigour or evaluate the credibility of qualitative data. Numerous essential aspects to this study design and implementation are considered that improve the overall thesis quality or credibility.
At this point, the researcher wants to make sure that sufficient details are presented in order to give the readers the opportunity to evaluate the validity or trustworthiness of this study (see Table 6). To attain this, the researcher has the responsibility to consider the following points (Russell, Gregory, Ploeg, DiCenso, & Guyatt, 2005, p.126): (1) the research question is precisely formulated and substantiated; (2) the research and case study design is suitable for the research question; (3) target-oriented strategies suitable for case study research are taken into consideration; (4) relevant data is gathered and organised systematically; and (5) the data is analysed properly.

*Table 6. Methods for ensuring credibility and liability (based on Russell, Gregory, Ploeg, DiCenso, & Guyatt, 2005, p.126; Baxter & Jack 2008, p. 556; established by the author)*

<table>
<thead>
<tr>
<th>Case Study Design</th>
<th>Example of relevant methods</th>
<th>Applied in this study</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ensuring Validity</strong></td>
<td>triangulation of data sources</td>
<td>manifold sources of evidence are used, via personal interviews, secondary data and perspectives of different actors</td>
</tr>
<tr>
<td></td>
<td>establish profound knowledge of the phenomenon to recognise different viewpoints</td>
<td>Good relation to farmers is established due to profound knowledge of the problematic so that different viewpoints can be gathered and recognized</td>
</tr>
<tr>
<td></td>
<td>process of “participant examination”</td>
<td>the data interpreted by the researcher is shown to the interviewees for validation</td>
</tr>
<tr>
<td><strong>Internal Validity</strong></td>
<td>compliance with consistency</td>
<td>interview findings and data gathered from other sources are analysed with the help of the same framework</td>
</tr>
<tr>
<td></td>
<td>validity through visuals</td>
<td>plotted models are illustrated in the analytical part to support clarification</td>
</tr>
<tr>
<td><strong>External Validity</strong></td>
<td>precise and detailed information predetermined</td>
<td>project’s extent and limitation are presented in the research design to deal with analytic generalisations</td>
</tr>
<tr>
<td></td>
<td>continuous conformity</td>
<td>selected approach comprises continuous conformity between data and the current literature.</td>
</tr>
<tr>
<td><strong>Reliability</strong></td>
<td>Confidentiality statement in interview sheet</td>
<td>Interviewees have to read and agree with confidentiality statement</td>
</tr>
<tr>
<td></td>
<td>Reflection phase</td>
<td>work is put relation to the knowledge acquired during the process</td>
</tr>
</tbody>
</table>
The research design principles lead to several strategies which encourage data reliability or “truth value”. One strategy that can be applied and also would promote the principle in case study research where the phenomena is seen and investigated from numerous viewpoints is the triangulation of data sources (Baxter & Jack 2008, p. 556).

This thesis uses manifold sources of evidence, such as personal interviews, secondary data and perspectives of different actors. The gathering and comparing of this data increase data quality premised on the fact that ideas or thoughts are converged and research findings are confirmed (ibid.).

In this project, the researcher also intends to have either an extended or deep coverage of the phenomenon to establish a healthy rapport to the farmers so that different viewpoints can be gathered and recognized. Possible social interest answers in interviews might be decreased as well. While data is gathered and analysed, the researcher incorporates the process of “participant examination” (ibid.). In this case, the data interpreted by the researcher is shown to the interviewees, and the interviewees are given the possibility to discuss and explain the interpretation, and add novel or supplementary insights on the particular issue.

In order to guarantee internal validity, the analysis of both interviews and secondary sources are based on the same framework, and plotted models are illustrated in the analytical part to support clarification. The project’s extent and limitation are presented in the research design to deal with analytic generalisations, and the selected approach comprises continuous conformity between data and the current literature. This procedure enables an enhanced external validity of this project.

Further strategies frequently applied to qualitative studies in order to ensure trustworthiness incorporates a reflection phase, the conduct of field notes and peer audit of the gathered data. According to Baxter & Jack (2008, p. 556), all these actions can enhance the case study with good scientific quality.

### 3.4. Ethical Considerations

Ethical considerations need to play an important role in the interviewing process in order to make sure that not only influential personalities define sustainability, but also those people working among the farm such as the farmers themselves and their families or employees. Interviews constitute an integral part in this evaluation process and therefore need to take ethical standards into account. Since interviews are seen as something personal and conservational (Minter, 2003, p.1), a few ethical issues are considered in the following.

The ethical considerations in this study are divided into four sub-areas, as suggested by Baxter & Jack (2008, p.555): confidentiality; risk assessment; informed consent; and reciprocity. In order to ensure all of them, the following steps are taken:

Due to the fact that the interviewees share confidential information, the researcher explains beforehand how the provided data is intended to be used. Further, the researcher deals with the promised level of confidentiality honestly and speaks about it openly with the participants. The aim is to keep the interviewees confidentiality as important ethical factor in mind while analyzing the data.
All possible risks of the interview are carefully considered and incorporated in the informed consent by the researcher. In this process the researcher is aware of the importance to consider the impact of using data gathered, particularly if the use of data could have negative consequences for the interviewee. When farmers agree to an interview, they give the researcher consent to acquire data from them. Acquiring consent is a crucial point associated with the way a researcher wants to use this data. In order to leave the option open to use testimonials, the farmers are asked to give permission to use their individual’s names or to state their quotes anonymously.

An important question the researcher addresses is: “What is the benefit to the participants?” Could it be possible that the farmers or the regions they live in benefit from the study result? The researcher decided to hand out a copy of the final study to the farmers as well as provide all participants with a small thank you gift.

3.5. Data Analysis

In contrast to quantitative research, the qualitative research method deals with interpretations of verbal material, so non-numeric material is used (von Andreas Bauer & Mulley 2008, p.1). It implies that experienced reality is verbalised, or graphically displayed. Furthermore, von Andreas Bauer & Mulley (2008, p.2) argue that quality material happens to appear “richer” because more details are becoming visible than in statistical material. Qualitative interviews emphasize this richness of statements and its consideration in the analysis. For this project, the interview questions are built on the theoretical framework, and the findings are considered correspondingly to observe relationships, organise and present data for the continuing analysis. The qualitative data method is an analytical process that is situation specific and not entirely predictable (von Andreas Bauer & Mulley 2008, p.1). Particularly in case of different narratives, newly formed categories can arise contributing to the original contextual framework. For this study, different narratives are analysed based on numerous data sources, and different methods, such as conforming and managing information in tabular form and graphics that helps to code and categorise. For this project a comparative analysis has been conducted, weighing two farming systems equally and explaining where both show crucial differences or commonalities.

3.6. Limitations

This study incorporates a single case study approach using structured interviews, and representing one of the main tools for data gathering. This choice of method has already been subject to a critical review. According to Willis (2014), one of the most common concerns are inter-related issues of methodological precision, external validity, and researcher subjectivity. Zeev Maoz (2002, pp. 164-165) for example argues that “the use of the case study absolves the author from any kind of methodological considerations. Case studies have become in many cases a synonym for freeform research where anything goes”. Consistent with this argument, Yin (2009, pp. 14-15) agrees that the lack of methodical approaches for case study research represent one of the greatest drawbacks because of the absence of systematic guidelines.
However, for the purpose of this case study the researcher has strived to elucidate and develop consistent methodological techniques and tools based on an epistemological foundation.

A second concern is the researcher’s subjectivity in single case study analysis. This debate is eligible, but usually seen as methodical critique since methods used are less formalised and more researcher dependent. Nevertheless, Berg and Lune (2010, p. 340) counter that “quantitative measures appear objective, but only so long as we don’t ask questions about where and how the data were produced... pure objectivity is not a meaningful concept if the goal is to measure intangibles [as] these concepts only exist because we can interpret them”. Also Flyvbjerg (2006, p. 237) states that case studies entail no greater biased regarding authentication than alternative techniques of investigation. He further notices that “on the contrary, experience indicates that the case study contains a greater bias toward falsification of preconceived notions than toward verification” (ibid).

Thirdly, the potentially most famous critique of single case study analysis is the concern of generalisation (Willis 2014, p.35). A single case study is often criticised for being “mitigated by the fact that its capability to do so [is] never claimed by its exponents; in fact it is often explicitly repudiated”, as acknowledged by Eckstein (1975, p.134). However, criticising generalisation is rather less relevant when the goal is particularisation.

4. Empirical Background

The following chapter offers background information on the two farming systems relevant for this study. It incorporates a detailed description and comparison of both systems. Thereafter, these systems are illuminated in the context of sustainable development.

4.1. Present Laying Hen Farming Situation in Germany

According to the Federal Ministry of food and agriculture (BMEL, 2016), 233 eggs per person per year are currently consumed in Germany. Modern laying hen farming methods mainly take place in large agricultural enterprises (ibid.). In Germany four types of farming are generally distinguished:

- Small-group housing or “enriched cage” systems,
- Floor-range production systems,
- Free - range production systems and
- Organic production systems.

Since the amendment of the marketing standards and the ban on conventional battery cage systems, the production takes place mainly in floor-range systems as depicted in Figure 6.
Furthermore, the German government decided to phase out production systems designed for small-group housing (BMEL 2015). The ban of the so called “enriched cages” will be effective from 2025 on. The Federal Statistical Office (Destatis, 2016) most recently quoted the following numbers and statistics for farms with at least 3,000 laying hens (see Table 7):

![Figure 6. Laying hens classified by rearing systems (Destatis 2016).](image)

Table 7. Farms with laying hen rearing systems, egg production and laying performance in Germany in April 2016 (Destatis, 2016)

<table>
<thead>
<tr>
<th>Farming methods</th>
<th>Farms</th>
<th>Husbandry places</th>
<th>Laying hens</th>
<th>Eggs produced</th>
<th>Laying performance (per month)</th>
<th>Laying performance (per day)</th>
<th>Utilisation of husbandry capacity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>1 675</td>
<td>47 938 169</td>
<td>40 069 073</td>
<td>959 605</td>
<td>23,9</td>
<td>0,80</td>
<td>83,3</td>
</tr>
<tr>
<td>Floor-range</td>
<td>1 009</td>
<td>30 069 676</td>
<td>25 497 475</td>
<td>609 557</td>
<td>23,9</td>
<td>0,80</td>
<td>84,7</td>
</tr>
<tr>
<td>Free-range</td>
<td>466</td>
<td>8 236 346</td>
<td>7 117 035</td>
<td>171 584</td>
<td>24,1</td>
<td>0,80</td>
<td>86,3</td>
</tr>
<tr>
<td>Enriched cages</td>
<td>109</td>
<td>4 889 162</td>
<td>3 295 658</td>
<td>81 035</td>
<td>24,6</td>
<td>0,82</td>
<td>63,5</td>
</tr>
<tr>
<td>Organic</td>
<td>356</td>
<td>4 742 985</td>
<td>4 158 907</td>
<td>97 429</td>
<td>23,4</td>
<td>0,78</td>
<td>89,0</td>
</tr>
</tbody>
</table>

The above table shows that the farms practicing the floor-range farming method occupy an especially dominant position under all farms in Germany. They offer the most husbandry places for laying hens (30.069676) and therefore have also the highest number of livestock (25.497475). Consequentially, eggs produced under the floor-range method surpass the number of eggs produced under other farming methods. It can be noticed that the farms with enriched cages are in the minority due to their upcoming ban from 2025 on (BMEL 2015). Remarkable is, that the laying hen performance per month and per day are relatively close.
4.2. Laying Hens

The domestic fowl stems from the Bankiva chickens domiciled in Asia (Flath, Schockemöhle & Alfs 2012, p. 3). Approximately 5,000 years ago, humans began to breed chickens in order to meet their specific needs. The resultant breeds had particular characteristics, such as for example an increased laying performance (*ibid.*). Laying hens, which can be found on layer farms today, are hybrids of these breeds (*ibid.*). They combine the features of many breeds, making them ideally adapted to the demands of the intensive livestock farming and production and are therefore more efficient. The hybrid chickens are the result of long-standing breeding, and are characterized by their high laying performance with little use of resources (*ibid.*). Before laying hens reach the layer farms, they have to pass through different stations in the operational value chain, that are depicted in Figure 7 and explained in the following (Flath, Schockemöhle, Alfs 2012, pp.3-4).

First, specifically bred chickens need to be paired with each other in specific establishments intended for this purpose (1). The freshly-laid and fertilized eggs are then placed in a hatchery where they are hatched under regulated and idealized conditions (2). Thus, several thousand chicks can hatch out simultaneously. The chicks are vaccinated on the spot and separated according to their gender. The females are brought into specialised pullet farms (3), where they reach laying maturity. The males are neither suitable for the layer farms, nor for the mast, because they put on too little meat due to special breeding lines. Therefore, male laying hybrids are either killed and processed into animal feed or sold as “day-old” chicks. When reaching their laying maturity, the laying hens are sent out to their respective layer farms, where they remain stabled up to 1 ½ years and lay about 300 eggs per year (4). Shortly before the moult they are carted away by truck towards the slaughterhouse (5), where they are processed into boiling fowl (6).
4.3. Who is Responsible for Farm Inspections?

Because of Germany's federal constitution, the liability for inspecting all farming premises, is given to the administration of the Länder also called federal states (BMEL, 2015). In this regard, the federal states act individually and within their own area of jurisdiction when it comes to control farms and punish farmers who do not act in accordance with the requirements of the Animal Welfare Act as well as the legislation on food and animal feed.

In order to make sure that the EU legislation on organic farming are implemented and adhered to, specific inspection procedures are employed. These inspections are performed by private inspection organisations in Germany, all of them officially recognised and government-controlled (BMEL, 2015). Here again the liability for the 20 official inspection authorities presently in force is given to the administrative bodies of the federal states. The Federal Ministry of Food and Agriculture (BMEL, 2015) further states, that in case of actual violations, the federal states in charge have to take action. The same also refers to violations of the commonly legitimate regulations on the food and animal feed legislation as well as the Animal Welfare Act. The state-certified private inspection bodies verify every farm minimum once a year, sometimes also multiple times if needed (ibid.). The Ministry (ibid.) adds that the verifications take place on site and are carried out from a risk-oriented and procedural perspective.

4.4. Current Topics of Discussion with Regard to Laying Hen Rearing Systems

Since the German government decided to phase out production systems designed for small-group housing (effective from 2025), not many farms converted their caging systems into small group housing systems (Flath, Schockemöhle & Alfs 2012, p.10). Consumers increasingly reject eggs from small group housing systems, which is why these eggs are mainly processed in egg products within the industry (ibid.). Since the small group housing will be phased out by the year 2025, a better management of floor-range framing systems is currently heavily discussed (BMEL, 2016). Research attempts to improve the husbandry conditions.

Bintz (2015, p.65), reports that another current issue regarding laying hen farming methods are the cropping of the beak and the killing of male chicks (see "stages in the life of a laying hen"). By sorting out the male chicks, around 50 million chickens are killed every year in Germany (ibid.). But, there is research that endeavours to find out the gender of the animal already in the egg that would prevent the killing (ibid.).

Problems associated with beak trimming, needs to be mainly improved in the field of husbandry conditions. For example current investigation try to find out if hacking amongst the hens can be reduced when implementing a specific lighting, what group size supports a stable hierarchy or how the equipment of the stable affects the animals' behaviour (ibid.).
5. Empirical Results

This chapter presents the empirical results of this project. They are identified through literature analysis and consultation of experts and refer to two themes that represent important steps towards sustainability indicator comparison. The first theme (5.1) contains the identification of relevant EES issues gathered from secondary data. The second theme (5.2) explains and presents the interview findings that serve as a foundation for the analysing chapter.

5.1. Identification of Relevant Issues

In order to enable a comparison of two egg production systems (EPS) with regard to sustainable development, and thereby identify current challenges farmers have to face in their egg production, significant EES issues in this field need to be identified and presented in detail. Identifying relevant EES issues is necessary to build a basic framework for the interviews of this research.

5.1.1. Economic Issues

In Germany egg production is market-driven (MEG 2016). Currently, egg products are again enjoying a high degree of popularity with consumers in Germany (see Fig. 10).

Figure 10. Per capita consumption of eggs in Germany till 2015 (Destatis 2016).

The statistic shows the food consumption of eggs per capita in Germany from 2006 to 2015. In 2015, the consumption in Germany was on average around 233 eggs per capita. However, the German producers and marketers still face hard competition from international competitors (MEG 2016). This is expressed by the self-sufficiency rate (see Fig. 11) on the German egg market, which remained just above 70% this year (Destatis 2016).
Figure 11: Self-sufficiency rate in eggs in Germany from 1995 to 2015 (Destatis 2016).

Figure 11 shows a statistic about the self-sufficiency in Germany in eggs from 1995 to 2015. The self-sufficiency rate is an indication that quantifies how much of the needed agricultural products are produced in their own country. In the case of deficiency (less than 100 percent) imports are necessary. Last year in 2015 the self-sufficiency in eggs in Germany was at 70.5%. This means that Germany had to import additional eggs to meet its demand.

Generally, farmers anticipate a reasonable income, first to ensure farm continuity and second to raise net assets to the maximum (Chamber of Agriculture North Rhine Westphalia 2013, p. 2). In order to be able to benefit from loans, spread risks, and to ensure a pension provision, sufficient capital resources are essential. To be paid a sufficient income, farmers intend to avoid economic losses induced by harmful impacts on production (ibid.).

Egg production is also affected by disease and mortality. Both cause economic losses because of their negative impact on egg production.

Therefore, the decisive economic issues concerning egg production in Germany are:

- To ensure farm continuity,
- raise net assets,
- and avoid economic losses.

5.1.2. Ecological Issues

As a matter of fact, animal production in Germany shows adverse effects on the environment (Institute for Agricultural Climate Protection, 2012). Emerging primarily from animal production, the Ammonia (NH3) emissions for example are said to be jointly responsible for the acidification of forests and eutrophication of surface water (Lekkerkerk, Heij & Hootsmann 1995, p. 11). Agriculture in Germany produces more than 90% of the national NH3 emissions caused by animal production and nitrogen fertilization (Institute for Agricultural Climate Protection, 2012). As part of an international agreement on air
pollution, Germany has agreed to comply with a national ceiling amount of NH3 emissions. According to the international clean air Convention (Luftreinhalteverordnung, LRV), Germany is not allowed to emit more than 550,000 tons of ammonia annually since 2010 (Federal Environmental Agency, 2014). The states that are party to the Swiss Clean Air Convention have jointly agreed on an amendment of the multi-component protocol in May 2012, stipulating further emission reductions (ibid.). By 2020, Germany has to reduce its ammonia emissions by 5 % compared to its emissions in 2005. Poultry farms should not exceed an ammonia emission threshold of 10,000 kg per year (ibid.).

The energy demands of agricultural farms rise continuously through a steadily increasing growth of farm plants (BLE, 2016). The associated increase in energy costs, but also political demands for the reduction of CO2 emissions, make it necessary to achieve an energy usage as efficient as possible (ibid.). For a successful energy transition it is not only crucial to increase energy efficiency, but also to reduce absolute energy demand. For this reason, the German Federal Government has set a goal formulated in its energy policy, to reduce the overall consumption of energy in Germany by 10 % (compared with the value of 2008) in 2020, and by 25 % in 2050 (The German Federal Government, 2016). Improving energy efficiency is an important component of the European and German energy policy. The German federal government presented a report on the future efficient strategy with The National Energy Efficiency Action Plan (NAPE) on 3 December 2014 (BLE, 2016). The federal program aims to promote activities that increase energy efficiency in agriculture, and is an element to achieve the objectives set out in the NAPE, including various measures to increase the energy saving potential (ibid.). Financial resources are made available for NAPE’s implementation prospectively for the years 2016 to 2018.

In order to accomplish the mandatory hygienic standards, the German poultry production makes use of high amounts of detergents, disinfectants, and pesticides. Nevertheless, the usage of these plant protection products can lead to diseases resistance of germs, chemical remnants in animal products and adverse effects on the environment (de Boer & Cornelission 2002, p. 176). Currently, no political directive concerning the usage of detergents and disinfectants in the egg production in Germany is existent. The European and the German plant protection law however assure that only plant protection products are placed on the market that have been tested for their environmental compatibility (Federal Environmental Agency, 2016).

Hence, significant environmental issues concerning egg production in Germany concerns:

- NH3 emissions,
- energy efficiency,
- the usage of detergents, disinfectants, and pesticides.

5.1.3. Social Issues

The laying hen industrialism has more and more become the focus of public debate in Germany. The battery cage systems in egg production gave rise to public disquiet concerning the laying hens’ welfare. A social change regarding the responsibility towards the animals and therefore their husbandry is emerging (BMEFL 2015). Consumers increasingly pay attention to a species-appropriate and livestock-friendly farming method.
An important issue linked with social issues is animal welfare, and egg production system impinges on animal welfare (Sandilands & Hocking 2012, p.62). There exist numerous factors that influence the welfare of laying hens such as diseases, skeleton and foot health, parasite and pest infections, behaviour, stress situations, nourishment and genetics (Lay et al. 2011, p. 1). Consulting different literature, one can notice that even though it is widely known that there exist a necessity to assess the influence of these factors, the respecting research is still in the beginning phase. Particular characteristics of different EPS influence laying hen welfare, and EPS which have comparable characteristics influence in the same way (ibid.). The battery cage systems for example, (formerly authorised), affected animal health positively due to the fact that a cleaner and consequentially less morbid environment was provided than in alternative farming systems (Appleby & Hughes, 1991, p. 115). EPS that provide environments with litter and soil as for example the outdoor systems, take a greater risk of diseases and parasites infections (Lay et al. 2011, p. 1). If an EPS’ environment is big and complex, it is more complicated to keep it clean. Also, if the EPS’ laying hen group size is big, diseases and parasites spread easier (ibid.).

In their work, Lay et al. (2011, p.1) state that more space and a more complex environment can constitute advantages but also disadvantages for the respective EPS: On the one hand, generous space give the laying hens the opportunity to perform more species-typical behaviours. On the other hand, some species-typical behaviour, such as cannibalism can easily occur among a bigger group without spatial separation. Further they (Lay et al. 2011, p. 1) mention that it is proven that a complex environment enhances behavioural expansion, but it also attracts challenges with regard to diseases and pest controls. Whilst reading through several literatures about hen welfare, it does seem to be less comprehensible how stress affects the laying hen welfare and how to link this issue to different EPS. It appears that every single system has its specific difficulties.

Different egg production systems have also an effect on egg quality (Sandilands & Hocking 2012, p.62). Egg quality can be determined by internal as well as external egg quality (Van Niekerk 2014, p. 1). The internal egg quality stands for the egg content, whereas the external egg quality focuses on the egg shell. Van Niekerk (2014, p.1) adds that the size of the eggs are also decisive especially for the egg producers, because smaller eggs cannot be marketed as table eggs, and bigger eggs are more likely to crack.

An egg’s internal quality (see Fig.12) focuses on the following attributes (ibid.):

- composition of egg white
- composition of yolk
- potential enclosures (fresh, blood)
- freshness (because an egg begins to mature right after laying)
As depicted in Figure 12, the egg consists of several layers of egg yolk and egg white. The calcareous shell protects it from external influences. The egg membrane demarcates the egg white from the shell and ensures a bacteria-free environment. The air chamber would ensure the sustenance of the embryo when the egg had been fertilized. The chalaza holds the yolk in a central position and protects it from vibrations. The oval shape of the egg ensures that eggs cannot roll out of the nest.

An egg’s external quality focuses on the following attributes (Van Niekerk 2014, p. 2).

- Shell colour,
- cleanliness,
- integrity (cracks, strengths),
- and shape

According to de Menezes et al. (2012, p. 2065), dirty eggs can have several origins, such as manure or urine. They further state that possible blood strains on the eggs can result from vent picking. Cracks on the egg surface are usually not easily detectable (Van Niekerk 2014, p. 2). Van Niekerk (2014, pp.2-3) acknowledges that although micro cracks become aware by candling, it is often the case that they are made visible only a couple days after storage. He further mentions that the shell strength is based on a genetic background since brown eggs feature stronger egg shells than white eggs. Additionally, shell strength also depends on the age of the laying hens where egg shells that have thinner shells and more cracks are more likely to stem from older hens. The egg shape also provides information about the external egg quality, since larger eggs can be easier destroyed than smaller eggs.

Egg production systems in Germany do not only affect hen’s welfare, but also farmer’s welfare by aspects such as total number of working hours per day, allocation of working hours, working climate and ergonomic aspects (Vogt-Kaute et al. 2010, p. 5).

Odours play a crucial role in daily life. Odour nuisances are generally considered as environmental stressor and can be the cause of variety complaints (Tappler 2010, p.2).
As particularly harmful considered are very unpleasant odours or odours associated with dangerous situations and some odours actually reveal an unhealthy mixture of substances (ibid.). After all, egg production systems induce an odour nuisance caused by NH₃ emissions of housing establishments, manure storage plants, and manure dispersal (ibid.).

Significant social issues concerning egg production in Germany relate to the following objectives:

- enhance hen welfare,
- increase egg quality,
- ameliorate farmer welfare,
- as well as reduce odour nuisance.

5.2. Presentation of the Interview Findings

This section provides an overview of the interview findings and incorporates further explanations of how these findings are interpreted.

5.2.1. Economic Issues Related Findings

Agricultural revenues are essential for farm continuity as well as own capital (Chamber of Agriculture North Rhine Westphalia 2013, p. 2). Both ameliorate when agricultural income rises. Production revenues determine the income of the farm, and are therefore understood as labour profit (ibid.). In order to determine the farmer’s labour profit they were first asked to state if their farms are profitable, which means if their revenues exceed their production costs. Both farmers, as depicted in Table 8, agreed and answered yes. Given the fact that they were not willing to quote their monthly gross income, they were instead asked to state if they earn more than 2150 euro or less than 2150 euro gross per month? The farmer (Pers. com., Anonymous, 2016) operating the floor-range EPS indicated that he earns more than 2150 € a month whereas the organic farmer said he earns less than that (Pers. com., Overesch, 2016).


<table>
<thead>
<tr>
<th>Economic Issues</th>
<th>Determined factor</th>
<th>Floor-range EPS</th>
<th>Organic EPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labour Profit</td>
<td>Profitable farm</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Gross income / month</td>
<td>&lt; 2150 €</td>
<td>&gt; 2150 €</td>
</tr>
<tr>
<td>Diseases &amp; Mortality</td>
<td>Likelihood of infections</td>
<td>Lower in floor-range EPS</td>
<td>Higher in organic EPS</td>
</tr>
<tr>
<td></td>
<td>Likelihood of metabolic diseases</td>
<td>Higher in floor-range EPS</td>
<td>Lower in organic EPS</td>
</tr>
</tbody>
</table>
Since egg production is also affected by disease and mortality, it was seen as necessary to include questions about these incidences in the interview sheet. Both cause economic losses because of their negative impact on egg production. According to both farmers (see Table 8), occurrences of diseases spread due to direct contact among laying hens is supposed to be more frequent in organic than floor-range egg EPS (Pers. com., Anonymous, 2016; Pers. com., Overesch, 2016). However, both also said that occurrences of metabolic diseases such as fatty liver or kidney syndrome is supposed to be at higher risk in farms operating with floor-range farming methods (ibid.).

5.2.2. Ecological Issues Related Findings

Agriculture is with a percentage of 95%, the main emitter of the air pollutant ammonia (NH3) in Germany (Federal Environmental Agency, 2014). According to the international clean air convention, Germany is not allowed to emit more than 550.000 tons of ammonia annually since 2010 (ibid.). So poultry farms should not exceed an ammonia emission threshold of 10.000 kg per year. Given this regulation it seemed to be necessary to ask the farmer if they are personally aware of the recommended value for NH3 emissions. Both farmers were personally aware of this recommended value (Pers. com., Anonymous, 2016; Pers. com., Overesch, 2016). Nevertheless, none of them was willing to give me an exact percentage of how high their NH3 emissions really are. But, in response to further questioning, the farmer representing the floor-range system acknowledged that the emissions from his production surpass 10.000kg per year (Pers. com., Anonymous 2016), whereas the organic farmer (Pers. com., Overesch, 2016) claimed that his production emissions fall below 10.000 kg per year (see Table 9).

<table>
<thead>
<tr>
<th>Ecological Issues</th>
<th>Determined factor</th>
<th>Floor-range EPS</th>
<th>Organic EPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>NH3 Emissions</td>
<td>Value for NH3 emissions</td>
<td>&gt; 10.000 kg/yr</td>
<td>&lt;10.000 kg/yr</td>
</tr>
<tr>
<td>Direct energy use</td>
<td>Farm’s direct energy consumption</td>
<td>3 kWh/ hen place</td>
<td>1 kWh/ hen place</td>
</tr>
<tr>
<td>Detergents, disinfectants</td>
<td>Detergents management</td>
<td>Control only in the event of an actual infestation</td>
<td>Control in accordance to a specific cycle</td>
</tr>
<tr>
<td>&amp; pesticides</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 9. Ecological Issues related Findings based on the Interviews with both farmers (Personal communication, Anonymous, 2016; Personal communication, Overesch, 2016).

There exist variations in the use of electricity in different EPS. On the basis of regulatory policies in Germany, the annual amount of 1,4 kWh per laying hen place is not allowed to be exceeded in order to raise efficiency in fossil energy. For the researcher it was important to find out if the preset annual amount of 1,4 kWh from the German policy is a realistic and attainable value for the farmers that were interviewed.

The organic farmer agreed that an annual amount of 1, 4 kWh per laying hen place is a correct assumption for a farm’s direct energy consumption (Personal communication, Overesch, 2016). He further add (see table 9) that his annual kWh per laying hen place would amount to a total of 1 (ibid.). The farmer with the floor-range rearing on the other hand disagreed. He stated an amount of 3kWh /Hp per year (Pers. com., Anonymous, 2016).
The usage of detergents, disinfectants and pesticides generally depends on the farm management of the respective EPS. For the purpose of comparison it is helpful to know how both EPS handle incidents of detergents or pesticides in food. The organic farmer, as illustrated in table 9, works in accordance to a specific cycle, but was not willing to give more details about their time periods (Pers. com., Overesch, 2016). The farmer representing the floor-range farming method stated that he reacts only in the event of an actual infestation (Anonymous 2016, p.4).

5.2.3. Social Issues Related Findings

The relative Hen Welfare Index (r-HWI) can be used to assess how animal production systems affect hen welfare. It is represented on a scale from 0 to 1, where 0 stands for an unreasonable contribution to hen welfare, and 1 signifies a reasonable contribution to hen welfare. Both farmers were asked to rate the hen’s welfare in their respective farming systems (see Table 10). The organic farmer rated the welfare of his hens to 0, 9 which represents the second highest attainable contribution to hen welfare (Pers. com., Overesch, 2016). The farmer representing the floor range system rated the welfare of his laying hens to 0, 7 (Pers. com., Anonymous, 2016).

Table 10. Ecological Issues related Findings based on the Interviews with both farmers (Personal communication, Anonymous, 2016; Personal communication, Overesch, 2016)

<table>
<thead>
<tr>
<th>Social Issues</th>
<th>Determined factor</th>
<th>Floor-range EPS</th>
<th>Organic EPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hen welfare</td>
<td>Relative Hen Welfare Index</td>
<td>0,7</td>
<td>0,9</td>
</tr>
<tr>
<td>External egg quality</td>
<td>Percentage of 2nd quality produced eggs/ month</td>
<td>0,19%</td>
<td>3%</td>
</tr>
<tr>
<td>Working climate</td>
<td>concentrations in stables due to thoracic dust</td>
<td>No information available</td>
<td>No information available</td>
</tr>
<tr>
<td></td>
<td>concentrations in stables due to NH3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The external egg quality is determined by the egg form, shell strength, percentage of perforated and broken eggs, and cleanliness. The percentage of second quality eggs produced indicates a way to measure external egg quality, and therefore the farmers were asked to state how many second quality eggs they produce on an average scale per month (see Table 10). The examined farm, working with the floor-range farming method, produces 0, 19% of second quality eggs per month (Pers. com., Anonymous, 2016). 3% of second quality eggs are produced every month on the organic farm (Pers. com., Overesch, 2016).

Working climate shows considerable discrepancies among the different EPS, mostly due to dissimilarities in air composition within the stables. Existent measures such as concentrations of thoracic dust (little dust particles which are inhaled deep into the lungs) and NH3 can be used to assess working climate for the two EPS. Both farmers were asked if they were aware of any secondary health damages which may result from concentrations in their stables due to thoracic dust or NH3. The participant representing the floor-range EPS was aware of the health risk due to higher concentration of dust he inhales everyday whilst working. When asked (see table 10), no exact concentration amount of thoracic dust was stated (Pers. com., Anonymous, 2016). The organic farmer was aware of secondary health problem resulting from dust or NH3 concentrations, but also did not know more about that matter (Pers. com., Overesch, 2016).
6. Analysis

The following chapter analyses the empirical results on the basis of the theories and the conceptual framework presented in Chapter 2. First the translation from issues into sustainability indicators (6.1) is explained. Then, the analysis focus shifts towards the assessment of sustainable development (6.2).

6.1. Translation from Issues into Sustainability Indicators

Indicators have been viewed by numerous researchers as the key component in operationalising sustainability (Bell & Morse 2008, p.29). Research in sustainable agriculture is seen as rather complex due to the fact that the assessment of environmental, social, and economic factors within farming systems needs to be addressed interactively (Suvedi, den Biggelaar & Morford 2008, p. 436). Keeping the subject of this study in mind, it is important to be aware of the fact that sustainability includes a variety of dimensions, and a number of indicators are surely needed. Nevertheless, the choice over what SIs to use is important for the end result. In order to encourage some understanding of assessment and to assist in classifying indicators, the conceptual framework developed in chapter 2 is used as a foundation for the analysis part. The framework assists in enabling a comparison of the egg production systems for their contribution to sustainable development of egg production. These findings shed light on the challenges farmers have to face if they are or want to design their production systems more sustainable. This sub chapter focuses on the translation process from relevant EES issues to sustainable indicators as depicted in Figure 13.

Figure 13. Conceptual Framework developed in chapter 2.
The two different EPS constitute the core of this framework. Both systems need an assessment to be able to compare how sustainable these different farming systems really are. However, not all indicators are appropriate for conducting such assessment (Lebacq, Baret & Stilmant 2013, p. 323). Therefore, the conditions for use as well as the interpretation of indicators need to be carefully examined during the collection stage (ibid.). The indicator collection is characterised as an important step in all indicator-based measurements due to the fact that it has an effect on the findings of the study (Lebacq, Baret & Stilmant 2013, p. 316). In order to be able to collect indicators for this study purpose, relevant EES issues has been presented in the previous chapter (Empirical Results) and serve as groundwork for the following indicator collection process. The collection criteria illustrated in Table 11 intend to contrast and appraise indicators gained from the literature and interviews in order to constitute the collection process in a clear way.

Table 11. Five selection criteria for final sustainable indicators developed in Chapter 2 (de Boer & Cornelissen 2002, p. 174)

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Information is accessible in order to be able to measure sustainable indicator.</td>
</tr>
<tr>
<td>2</td>
<td>The possible sustainable indicator needs to be quantifiable.</td>
</tr>
<tr>
<td>3</td>
<td>The possible sustainable indicator needs to be credible and understandable for its users.</td>
</tr>
<tr>
<td>4</td>
<td>The possible sustainable indicator needs to discriminate among the different Egg Production Systems.</td>
</tr>
<tr>
<td>5</td>
<td>It must be possible to establish a target value or trend such as political goals or expert assessment which then can be determined for possible sustainable indicator.</td>
</tr>
</tbody>
</table>

Collection criteria used in this work have been classified into five groups (based on de Boer & Cornelissen 2002): (1) Accessibility: Information is available and can be accessed in order to be able to measure SI. (2) Quantification: The possible SI needs to be quantifiable. (3) Credibility: The possible SI needs to be credible and understandable for its users. (4) Differentiation: The possible SI needs to discriminate among the different egg production systems (EPS). (5) Target value orientation: It must be possible to establish a target value or trend such as political goals or expert assessment which then can be determined for possible SI.

6.1.1. Economic Issues Translated into Sustainability Indicators

Agricultural revenues are essential for farm continuity as well as own capital (Chamber of Agriculture North Rhine Westphalia 2013, p. 2). Both ameliorate when agricultural income rises. Production revenues determine the income of the farm, and are calculated as followed (ibid.):
The total egg production indicated in kg needs to be multiplied with the price per kg of eggs, minus the variable and fixed costs. Variable costs normally represent expenditures for feed, water, electricity and health provisions, whereas fixed costs comprise the depreciation of the farm buildings for example (Chamber of Agriculture North Rhine Westphalia 2013, p. 3). According to farm economic principles (ibid.), this indicator is defined as labour profit. Illustrated in Table 12, labour profit is seen as assessable (SC1), discriminates among the different EPS (SC2), and information are not only understandable for its users (SC3), but also obtainable (SC4).

Table 12. The two-step process to translate economic issues into economic SI.

<table>
<thead>
<tr>
<th>Relevant Issues</th>
<th>Possible SI¹ Possible SI²</th>
<th>SC1 Measurable</th>
<th>SC2 Discriminate</th>
<th>SC3 Information</th>
<th>SC4 Target value</th>
<th>Final SI³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farm continuity and equity capital</td>
<td>Labour profit</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Disease incidence</td>
<td>✓</td>
<td>✗</td>
<td>-</td>
<td>-</td>
<td>✓</td>
</tr>
<tr>
<td>Economic losses</td>
<td>Mortality rate</td>
<td>✓</td>
<td>✗</td>
<td>-</td>
<td>-</td>
<td>✓</td>
</tr>
</tbody>
</table>

¹SI = Sustainability Indicator.
² ✓ = Selection criteria has been met; ✗ selection criteria has not been met; - selection criteria has not been considered.

Assuming that the farmer wants to cover at least the expenditures for labour input, the target value (SC4) is determined by the average labour costs accrued on farm on a monthly basis. According to GTAI (2016), the average gross income for farmers amounts to 2150 € per month. Labour profit is chosen as a final SI that indicates the sustainability concerns to farm continuity and farmers’ own capital.

Egg production is also affected by disease and mortality (de Boer & Cornelission 2002, p. 178). They cause economic losses because of their negative impact on egg production (ibid.). Divergence in agricultural management on farms grounds huge discrepancies of disease occurrences within different EPS (de Boer & Cornelission 2002, p. 178). Furthermore, data on disease occurrence in different EPS are not promptly available. Therefore, disease occurrence is not determined as final SI. Mortality is known to have diverse sources in various EPS, and also reveals great differences within EPS (ibid.). That is why mortality rate is not discriminating among EPS and is therefore not determined as final SI.
6.1.2. Ecological Issues Translated into Sustainability Indicators

According to the Institute for climate protection (2012), the German regulatory policy targets 39% decrease in NH3 emission from manure spreading, manure storage, as well as housing units till 2030. In order to be able to contrast both EPS, only the NH3 emissions from housing units are decisive and they are measured in kg per year (ibid). Since 2008, it is mandatory to keep laying hens in low emissions stabl emit a maximum of 10,000kg NH3 annually (Federal Environmental Agency, 2014). Hence, as illustrated in Table 13, NH3 emissions is chose as final SI, and the maximum NH3 emission set in 2008 determines the target value.

Table 13. The two-step process to translate ecological issues into ecological SI.

<table>
<thead>
<tr>
<th>Relevant Issues</th>
<th>Possible SI¹</th>
<th>Selection criterion² (SC)</th>
<th>Final SI</th>
</tr>
</thead>
<tbody>
<tr>
<td>NH emission</td>
<td>NH emission</td>
<td>SC1 Measurable</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>from housing</td>
<td>SC2 Discriminate</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>unit</td>
<td>SC3 Information</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SC4 Target value</td>
<td>Yes</td>
</tr>
<tr>
<td>Energy use</td>
<td>Direct energy</td>
<td>SC1 Measurable</td>
<td>Yes</td>
</tr>
<tr>
<td>Efficiency</td>
<td>use (Energy</td>
<td>SC2 Discriminate</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>use)</td>
<td>SC3 Information</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SC4 Target value</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Indirect</td>
<td>SC1 Measurable</td>
<td>Yes</td>
</tr>
<tr>
<td>Use of</td>
<td>energy use</td>
<td>SC2 Discriminate</td>
<td>×</td>
</tr>
<tr>
<td>detergents,</td>
<td>(Feed</td>
<td>SC3 Information</td>
<td>-</td>
</tr>
<tr>
<td>disinfectants</td>
<td>conversion)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>and pesticides</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Actual use</td>
<td>SC1 Measurable</td>
<td>SC2 Discriminate</td>
<td>×</td>
</tr>
</tbody>
</table>

¹ = Sustainable Indicators.
² ✓ = Selection criteria has been met; × selection criteria has not been met; - selection criteria has not been considered.

The measurement of energy use in EPS differentiates between direct and indirect energy use (BLE, 2016). Direct energy use comprises the usage of fuel, electricity, and gas on farms and indirect energy use incorporates the energy necessary for production, processing as well as transportation (ibid.). Mainly, direct energy use in different EPS includes electricity for ventilation and illumination, and also for drying manure (ibid.). There exist variations in the use of electricity in different EPS. On the basis of regulatory policies in Germany, the annual amount of 1,4kWh/HP, which is set as the target value, is not allowed to be exceeded in order to raise efficiency in fossil energy use (Die Bundesregierung, 2016). On the basis of these information, direct energy fulfils the requirements for final SI as shown in Table 13. In EPS, the use of indirect energy is in general set by the production and transport of feed. Due to the fact that the composition of feed used in different EPS is not based on the same grounds (BMEL, 2014), feed conversion is not determined as final indicator for indirect energy.
The usage of detergents, disinfectants and pesticides generally depends on the farm management of the respective EPS (de Boer & Cornelission 2002, p. 176). Unfortunately, inadequate data is available on this issue (see Table 13) especially when it comes to assess the actual use of these chemicals among different EPS. Therefore, no final SI is chosen that correspond to this matter.

6.1.3. Social Issues Translated into Sustainability Indicators

The relative Hen Welfare Index (r-HWI) can be used to assess how animal production systems affect hen welfare (Sandilands & Hocking 2012, p.62). It is represented on a scale from 0 to 1 (see figure), where 0 stands for an unreasonable contribution to hen welfare, and 1 signifies a reasonable contribution to hen welfare. The r-HWI for the organic farming method (0, 1) is determined as target value (see table 14).

*Table 14. The two-step process to translate societal issues into societal SI.*

<table>
<thead>
<tr>
<th>Relevant Issues</th>
<th>Possible SI</th>
<th>Selection criterion⁴ (SC)</th>
<th>Final SI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hen welfare</td>
<td>Hen welfare index</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Egg quality</td>
<td>Internal Quality</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>External quality (Second quality egg)</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Farmer welfare</td>
<td>Total working hours</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Distribution working hours</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Thoracic dust</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>NH³ concentration in air of housing unit</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Odor nuisance</td>
<td>Working posture</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Degree of odor nuisance in relationship to NH³ emission</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Internal and external egg quality traits constitute the quality of eggs (Van Niekerk 2014, p. 1.) Yolk colour, odour and taste, albumen, medication and feed residuals as well as blood and meat spots determine the internal egg quality (ibid.). Due to the fact that internal egg quality is dependent on the actual farm management, it consequentially does not discriminate among different EPS which is also depicted in table 11 (de Menezes et al. 2012, p. 2065). Furthermore, medication is seldom used in egg production, as there is a high chance of medication residuals in the egg (ibid.). The external egg quality is determined by the egg form, shell strength, percentage of perforated and broken eggs, and cleanliness. The percentage of second quality eggs produced indicates a way to measure external egg quality (Van Niekerk 2014, p.2). Van Niekerk (2014, p.2) and de Menezes et al. (2012, p. 2066) both are of the opinion that in organic EPS, the production of spruce eggs is harder than in floor-range EPS. But they also mention that laying hens in floor-range EPS produce more perforated or broken eggs because less open space and therefore less exercise is provided (Van Niekerk 2014, p.2; de Menezes et al. 2012, p. 2066). The percentage of second quality eggs produced in floor-range systems is therefore set as the target value (see Table 14).

The overall amount of working hours per day as well as the allocation of these working hours can be one unit of measure for farmer welfare (de Boer & Cornelission 2002, p. 178). But, information readily available on different EPS is premised on a fixed number of working hours (ibid.). For that reason, the overall amount and allocation of working hours are not chosen as final SI.

Working climate shows considerable discrepancies among the different EPS, mostly due to dissimilarities in air composition within the stables (Tappler 2010, p.1). Existent measures such as concentrations of thoracic dust (little dust particles which are inhaled deep into the lungs) and NH3 can be used to assess working climate for the two EPS (ibid.). On the basis of an average 8 hours working day, the highest reasonable concentrations are 0.23 mg/m³ for thoracic dust and 18 mg/m³ for NH3 (Federal Environmental Agency, 2014). These are also set as the target values.

NH3 emissions from stables are mainly responsible for odour nuisance in different EPS (Tappler 2010, p.2). However, since no impartial relationship between the amount of odour nuisance and the intensity of NH3 emission is readily obtainable, no final SI is set corresponding this issue.

Summing up the findings from the interviews and secondary literature, 7 final SI have been determined to compare two EPS for their contribution to sustainable development of egg production. All of them feature different units of measure and target values as depicted in table 15.
Table 15. Final sustainability indicators SI\textsubscript{i}, units of measure, and target values (T\textsubscript{i}).

<table>
<thead>
<tr>
<th>Final SI</th>
<th>SI\textsubscript{i}</th>
<th>Units of measure</th>
<th>T\textsubscript{i}</th>
<th>DEC</th>
<th>INC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labour profit</td>
<td>SI\textsubscript{1}</td>
<td>Euros/month</td>
<td>2,150</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Ammonia emission</td>
<td>SI\textsubscript{2}</td>
<td>kg NH\textsubscript{3}/ per year</td>
<td>10,000</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Direct energy use</td>
<td>SI\textsubscript{3}</td>
<td>Kwh/HP per year</td>
<td>1,4</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Hen welfare</td>
<td>SI\textsubscript{4}</td>
<td>r-HWI\textsuperscript{1}</td>
<td>0,9</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Egg quality (external)</td>
<td>SI\textsubscript{5}</td>
<td>% 2\textsuperscript{nd} quality eggs/month</td>
<td>0,19</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Thoracic dust inhaled (Farmer welfare)</td>
<td>SI\textsubscript{6}</td>
<td>mg dust/m\textsuperscript{3}</td>
<td>0,23</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Ammonia inhaled (Farmer welfare)</td>
<td>SI\textsubscript{7}</td>
<td>mg NH\textsubscript{3}/m\textsuperscript{3}</td>
<td>18,0</td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>

\textsuperscript{1} = Relative Hen Welfare Index

Table 14 illustrates the chosen final sustainability indicators (SI\textsubscript{i}), their units of measure as well as their respective target values (T\textsubscript{i}). In addition, the behaviour of the single SI’s are specified as well. **DEC** stands for the contribution of SI\textsubscript{i} to sustainable development that enhances when the actual SI\textsubscript{i} diminishes. **INC** in turn represents the contribution of SI\textsubscript{i} to sustainable development that enhances when the actual value of SI\textsubscript{i} rises. As can be seen in the table, labour profit (SI\textsubscript{1}) contributes positively towards sustainable development when the actual value of SI\textsubscript{1} increases. The more money a farm has at one’s disposal, the more investments can be made. These investments could be used in favour of the animals, production processes, and innovative technologies.

Ammonia emissions (SI\textsubscript{2}) in turn contribute positively to sustainable development when their actual value decreases. It is not a secret that less emissions means a reduction in the impact of farming activities on the environment. Also direct energy use (SI\textsubscript{3}) needs to be reduced to have a positive impact on sustainable development. Reduced energy usage signifies a lower demand on fossil fuels. The Hen’s welfare (SI\textsubscript{4}) actual value needs to increase to have a positive contribution to sustainable development. The better the treatment of laying hens, the better is the contribution to sustainable development. As the external egg quality is measured by the percentage of second quality eggs, it is favourable that the actual value of SI\textsubscript{5} decreases to obtain a positive contribution to sustainable development. Both indicators for farmer’s welfare (SI\textsubscript{6} and SI\textsubscript{7}) need to decrease in order to increase the positive impact on sustainable development. Thoracic dust and ammonia both have a negative impact on farmer’s health and therefore need to be reduced.
6.2. Contributions to Sustainable Development

Actual values \((A_{ij})\) of SI, for the floor-range system \((j = 1)\), the organic system \((j = 2)\), and the target values \(T_i\) for the single SI’s are presented in below table.

*Table 16. Actual values \((A_{ij})\) for sustainability indicator \((SI_i)\), the contribution of \(SI_i\) for egg production system \(j\) to sustainable development in Germany.*

<table>
<thead>
<tr>
<th>SI</th>
<th>Floor-range system ((j)=1)</th>
<th>Organic system ((j) = 2)</th>
<th>Target Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SI_1</td>
<td>&gt;2150 /month</td>
<td>&lt;2150/month</td>
<td>2150€/month</td>
</tr>
<tr>
<td>SI_2</td>
<td>&gt;10000 kg NH3/year</td>
<td>&lt;10000 kg NH3/year</td>
<td>10000kg NH3/year</td>
</tr>
<tr>
<td>SI_3</td>
<td>3 kWh/HP per year</td>
<td>1 kWh/HP per year</td>
<td>1,4 kWh/HP per year</td>
</tr>
<tr>
<td>SI_4</td>
<td>0,7 r-HWI</td>
<td>0,9 r-HWI</td>
<td>0,9 r-HWI</td>
</tr>
<tr>
<td>SI_5</td>
<td>0,19%/month</td>
<td>3%/month</td>
<td>0,19%/month</td>
</tr>
<tr>
<td>SI_6</td>
<td>-</td>
<td>-</td>
<td>0,23mg/m³</td>
</tr>
<tr>
<td>SI_7</td>
<td>-</td>
<td>-</td>
<td>18.0mg/m³</td>
</tr>
</tbody>
</table>

For the farm implementing the floor-range system, labour profit \((SI_1)\) succeeds to contribute to sustainable development. According to the farmer operating the floor-range farming method (Pers. com., 2016), the average gross income earned with this specific floor-range production system is above 2150 Euros a month (see Table 16). This indicates that the earnings of this floor-range EPS are higher than the average gross income amongst farmers in Germany. Seen from an economic perspective, the floor-range method applied on this particular farm is profitable, which means that the farm operates on a sustainable basis. In order to be economically sustainable farms need to survive on a long-term basis (Doane & MacGillivray 2001, p. 9). Farms that opt for earning long-term profits are those that may in fact be the ones that are best positioned to survive, not only for their own advantage, but also for the overall welfare of society (ibid.). Furthermore, the farm operating with the floor-range system has the capacity to invest the surplus income into sustainable solutions. The behaviour of SI towards this floor-range system is INC which means the contribution to sustainable development improves when the actual value of SI increases (see Table 16). In contrast to that, the farm operating with the organic system fails to contribute economically to sustainable development. As depicted in table 16, the organic system in this specific example earns less than the average gross income amongst farmers in Germany, namely less than 2150 Euros a month. This shows that the farm is not only concerned with its immediate financial performance, but also with its capability to carry on long into the future. In order to be economically sustainable, it is desirable for a farm to operate in a dynamic but also stable environment where money is not a source of concern, so that the farmer’s economic activities can reach fruition (Doane & MacGillivray 2001, p. 15).

The farm implementing the organic system cannot rely on the same financial resources than the farm with the floor-range system in this research. That implies that no positive contribution to its local community, broader society or the planet as a whole can be made in terms of financial investment.
The contribution of SI₂ (Ammonia emissions) to sustainable development is positive under the organic farming method. The target value was set at 10,000 kg NH₃ per year, since it is mandatory to keep laying hens in low emissions stables that emit a maximum of 10,000 kg NH₃ annually (Federal Environmental Agency, 2014). According to Mr. Overesch (Pers. com. 2016), his organic farm’s NH₃ emissions fall below 10,000 kg a year. The German regulatory policy targets a 39% decrease in NH₃ emissions, and therefore reduced the allowed emission value to a maximum of 10,000 kg NH₃ annually (Federal Environmental Agency, 2014). This implies that the organic EPS in this example contributes actively towards the objective to reduce NH₃ emissions. The behaviour of SI₂ towards the organic EPS is DEC which signifies that the contribution to sustainable development improves when the actual value of SI₂ decreases (see Table 16). The selected farm with the floor-range system on the other hand, surpasses the limit of 10,000 kg NH₃ per year (anonymous 2016, p. 4). In contrast to the organic EPS, the floor-range EPS does not actively contribute towards the goal to reduce NH₃ emissions. It is rather counterproductive and therefore fails to contribute to sustainable development.

Also direct energy use (SI₃) has a positive contribution to sustainable development under the particular organic EPS. The overall increase in energy costs, but also political demands for the reduction of CO₂ emissions, make it necessary to achieve an energy usage as efficient as possible (BML 2016). For a successful energy transition it is not only crucial to increase energy efficiency, but also to reduce absolute energy demand. For this reason, the German Federal Government has set a goal formulated in its energy policy, to reduce the overall consumption of energy in Germany (1.4 kWh/HP per year). Since the target value was set at 1.4 kWh per Hen place per year, the questioned organic EPS came off well with a value of 1 kWh per Hen place annually (see Table 16). The behaviour of SI₃ towards the organic EPS is DEC meaning that the contribution to sustainable development improves when the actual value of SI₃ decreases. However, the SI₃ (direct energy use) for the questioned floor-range EPS fails to contribute to sustainable development. The kWh/Hp per year is way higher than the limit value determined by the German Federal Government (see Table 16). That entails that the questioned floor-range EPS is not capable to contribute to the overall goal to achieve an efficient energy usage and reduce the energy demand.

SI₄ represents the relative Hen Welfare Index (r-HWI). It was used to assess how the two EPS affect hen welfare. It is represented on a scale from 0 to 1, where 0 stands for an unreasonable contribution to hen welfare, and 1 signifies a reasonable contribution to hen welfare. Since the r-HWI for the organic farming method (0.9) was determined as target value, it succeeds in contributing to sustainable development. The behaviour of SI₄ towards the organic EPS is INC connoting that the contribution to sustainable development improves, when the actual value of SI₄ increases. The questioned floor-range EPS though, fails to contribute to sustainable development due to the fact that the farmer rated the welfare of his hens to 0.7 which is far less good than the organic EPS rating and therefore also the target value (Pers. com., Anonymous 2016).

The external egg quality represented by SI₅ and expressed by the percentage of second quality eggs (see Table 13) contributes positively to sustainable development this time under the consulted floor-range EPS. The percentage of second quality eggs produced in the floor-range system is lower than the percentage produced by the organic EPS (see Table 16). That means the floor-range EPS in this example produce fewer probably less useful eggs than the organic EPS. The behaviour of SI₅ towards the floor-range EPS is DEC because the contribution to sustainable development improves when the actual value of SI₅ decreases.
The organic EPS then again fails to contribute to sustainable development due to considerable higher percentage of second quality eggs compared to the actual target value and SI3 from the floor-range system.

Unfortunately, the last two sustainable indicators (SI6 and SI7) could not be determined from interviewing the farmers. Both were aware of secondary health damages that may result from concentrations in their stables due to thoracic dust or NH3 emissions. But, none of them had an idea about the exact values. So the indicators for thoracic dust inhaled and ammonia inhaled were not able to be determined.

To conclude, for the floor-range farming method in this example, ammonia emissions (SI2), direct energy use (SI3), and hen welfare (SI4) fail to contribute to sustainable development (SUSD) comparing the actual values with the target values. Since five indicators have been tested and three out of them fail to contribute to SUSD, the overall contribution of the floor-range farming system is slightly negative. For the questioned organic farming method, labour profit (SI1) and egg quality (SI5) fail to contribute to SUSD. Due to the fact that only two out of five indicators failed to contribute to SUSD, the overall contribution to SUSD is slightly more positive than the contribution of the floor-range farming method in this particular comparison.
7. Discussion

The purpose of this chapter is to interpret and describe the significance of the findings which are then related to other research reports. It connects to the introduction chapter, and addresses the research question posed and the literature reviewed. A number of additional questions that were raised in the introductory phase are also considered.

7.1. Interpretation of Research Findings

Based on multidisciplinary research and final SIs, this study reveals that the organic EPS is considered the better animal-friendly farming system compared to the floor-range EPS. However, it should be emphasised that the organic EPS fails to contribute to SUSD in terms of economic issues, whereas the floor-range system succeeds to contribute to SUSD in this field. This result not only conforms with other outcomes (Achilles 2015; Voght-Kaute et al. 2010; Damme 2008), but also collides with some reports and articles published by different institutions and authors (William & Simianer, 2011; Chamber of Agriculture of Lower Saxony, 2010; Pliquett & Reinke, 2016; Weiß et al., 2011; Hoy 2009; Hörning, 2008).

7.2. Research Findings in Relation to other Research Reports

These findings can also be related to the one or other questions rose in the introduction chapter. As sustainable development aims at keeping economic, social and environmental interests in equilibrium, it is understood as a dynamic concept that is non-linear, unstable and vulnerable to dramatic changes (Marta-Costa & Silva 2013, p. 274). In the beginning of this work it was questioned if farmers and their farming methods are able to cope with, adapt and transform to these dynamics, taking economic, social and environmental aspects simultaneously into consideration? According to the results of this research, farmers succeed only to a limited extent to keep all interests in equilibrium and therefore they react only partly to the sustainable development dynamics. The farmer with the floor-range system for example operates economically sustainable, but mainly neglects the ecological as well as social contribution to sustainable development. The organic farmer on the other hand, succeeds in combining ecological and social sustainability, but fails to achieve a great profitability rate. Every egg farmer who wants to achieve a satisfactory operating result must be able to achieve a reduction in production costs per egg and a good position in the egg market (Schmutz & Flock 2014, p. 15). The case study reveals that the floor-range farming system achieves a satisfactory operating result, due to the fact that it is above the average gross income of farmers in Germany. However, the authors Pliquett & Reinke (2016, p. 23) deny that the floor-range farming system is the most profitable rearing alternative under current production conditions in Germany. They acknowledge that a one –off investment in an organic rearing system has a high chance to give good returns (ibid.). Also Hoy (2009, p.5) and Hörning (2008, p. 48) state that organic systems are well positioned on the German egg market due to the fact that a great proportion of consumers would be willing to pay higher prices for organic products. These views are counteracted by Damme (2008, p. 224) who argues that organic rearing systems only pay off if the market accepts the produced eggs with a satisfactory margin which is according to him, not the case yet.
In addition, also the findings from the case study show that the organic system has difficulties to operate profitably due to an income below the average gross income of farmers in Germany. This statement is again underpinned by Achilles (2015, p. 3) who claims that a satisfactory margin cannot be yield, because in the end, the trade and the end consumer decide whether the higher costs of organic production are rewarded. According to him, (Achilles 2015, p.3), most traders and consumers are not willing to pay a higher price for organic produced eggs.

Another outcome of this research that can be related to other research findings is that the floor-range system mainly fails to contribute to sustainable development from an ecological viewpoint.

The ecological perspective focus of this study lies on NH3 emissions, and direct energy usage. According to Schmutz & Flock (2014, p. 20), the floor-range production systems in Germany shows more adverse effects on the environment than the organic EPS. Emerging primarily from animal production, the ammonia emissions (NH3) are said to be higher from closed housing units than stables provided with an open access (ibid.). This conforms to the case study findings where the actual values of NH3 emission were estimated higher in floor-range EPS where the housing units are closed whereas in organic EPS where the hens are allowed to stay outside. Nevertheless, there are some opposing viewpoints saying that there exists no difference in NH3 emissions between different housing systems (Weiß, Pabst & Granz 2011, p. 90). They say that every farming system has its housing unit and since the NH3 emissions steam from them, it would make no difference if they have or have not an outdoor area (ibid.) Also the actual values for energy use in both EPS can be related to other study findings. The energy demand of agricultural farms rise continuously through a steadily increasing growth of farm plants (Vogt-Kaute et al. 2010, p.4). According to the research findings, the actual value for direct energy use in the floor-range system is higher than the organic EPS’ direct energy consumption. William & Simianer (2011, p. 13) dissents that view, and explain that floor-range farming systems provide a constant energy use throughout the entire year because of their closed housing units. Whereas organic systems provide an open run so housing units are exposed to different weather conditions due to side openings for accessing the outdoor area. Consequentially, organic EPS use more direct energy especially during the winter month where the housing unit need to be kept warm (ibid.). Vogt-Kaute et al. (2010, p. 4) take the view though that the direct energy consumption in floor-range systems are in general higher than in organic EPS particular caused by electricity and heating oil. In laying hen rearing systems, direct energy is mainly required for space heating. Electricity is used for ventilation, feeding and lighting (The German Federal Government, 2016). Since floor-range systems are in higher need for ventilation, artificial lighting and space heating, Vogt-Kaute et al. (2010, p. 4) concludes that floor-range EPS have a higher energy consumption than organic EPS, and therefore are considered as more harmful to the environment.

Reflecting the social perspective of the research findings, one can say that both findings (hen welfare and external egg quality) can be advocated by other study results. The most reasonable contribution to hen welfare scored the organic EPS in this case study. Also Achilles (2015, p. 7) and Damme (2008, p. 229) reports that the organic EPS treat laying hens most appropriately due to the fact that hens have the possibility to act out their natural behaviour. They further state that the floor-range systems in general do not provide hens with their natural surroundings and therefore restrict the hen’s possibility to behave naturally.
This opinion is contradicted by William & Simianer (2011, p. 15), mentioning the fact that hens that enjoying life outdoors and living in bigger groups together can become more likely subject to cannibalism than hens kept in smaller groups on a limited surface area. The external egg quality is the only exception where the floor-range system performs better than the organic EPS under a social viewpoint. According to the research findings, the floor-range EPS produces more marketable eggs than the organic EPS in proportional terms. De Menezes et al. (2012, p. 2065) claims that non-marketable eggs, also known as second quality eggs, can have several origins and appear more often in organic EPS than in floor-range EPS.

All in all, it can be noticed that the research results can rely on supportive but also adversary viewpoints in this field of research. It is rather difficult to determine who has the right viewpoint because both sides bring forward plausible arguments. But one might go no wrong in saying that German egg farmers still seem to be stuck in a transition phase in which no one knows how to adhere to the stricter German regulations towards SUSD and simultaneously run a profitable farm. So indeed, farmers are not yet able to cope with, adapt and transform to dynamics, taking economic, social and environmental aspects simultaneously into consideration. As the discussion section has revealed, there are a lot of different opinions circulating on how to run a sustainable farm the best and what challenges to overcome to operate a more sustainable farm. Fact is that every farmer needs to overcome challenges no matter what farming system is chosen in order to act sustainable within all three value dimensions.

7.3. Research Findings in Relation to the Research Question

To address the research question “What are the perceived key challenges farmers in Germany face with regard to sustainable development in their egg production?”; one can answer that this depends on the actual farming method that is implemented on each farm. According to the research findings, the floor-range farmers need to work on their contribution to sustainable development from an ecological as well as social perspective. Based on the analytical results, their actual values were not satisfactory and need to approach the sustainable target values more. The organic farmer on the other hand, relies too much on his successful ecological and social contribution to SUSD. In their daily working process, they pay little attention to their economical situation which needs further improvement.
8. Conclusions

This chapter provides a synthesis of key points and reconnects to the aim of the study. Furthermore, reflections on the methodological approach and recommendation for future research approaches are presented. Finally, practical implications resulting from the research findings are explained.

The aim of this study was to reveal the perceived key challenges farmers face in Germany with regard to sustainable development in their egg production. A comparison of two EPS was conducted to find out their contribution to SUSD. The floor-range system and the organic system illustrated this comparison. Relevant EES issues concerning SUSD of egg production were translated into possible SIs. Final SIs were chosen based on a predetermined set of five selection criteria. The contribution of SI for the two EPS to SUSD was determined by comparing the actual values of SI to their respective target values.

8.1. Methodological Reflections & Recommendations for Further Research

There emerge several methodological aspects that need careful consideration and further research. To begin with, the conclusion with regard to sustainable development is completely dependent on final SI. Regrettably, relevant SI are left out, because they either do not fulfil the selection criteria or the interviewee could not provide the needed information. For example the use of detergents, disinfectants and pesticides are known to differ amongst EPS (de Boer & Cornelission 2002, p. 176), but no final SI was chosen, because no information could be provided for both systems. Hence there is a necessity to conduct further research to improve relevant SI. Second, information about final SI is not retrieved on the same grounds. Even though the method ensure that all actual values can be compared on the same grounds using only percent values or values per hen place, it needs to be clarified that both farms are not of the same size. In order to perform a comparison, the method should identify which farms can be compared to one another. Third, the final SI leave room for improvement. The final SI for the relative hen welfare index, for instances, takes feather pecking not into consideration. Feather pecking however, is considered as a massive problem amongst farmers and can result in cannibalism especially in organic EPS (Achilles 2015, p.7). Thus, an improvement of the relevant SI is needed in the methodological approach. Fourth, it is very important to clarify that the methodical approach entails a case study in which solely two farms were interviewed. That means that the findings cannot be considered as representative for entire Germany. Although the research is not only based on empirical data, but also on an extensive literature review, the actual results cannot be applied in general, since they arise from personal opinions and experiences.
8.2. Practical Implications

Only a cautious conclusion with regard to the perceived key challenges egg farmers face in Germany regarding sustainable development can be drawn, knowing that different methodological parts still long for sophistication. Based on the final SI, and considering equal weights, the organic farming system reveals the least negative contribution to sustainable development of egg production in Germany. The floor-range farming system shows a slightly more negative contribution to sustainable development compared with the organic EPS. The organic farming system, therefore, is considered the better animal-friendly system. It is conspicuous that for the organic system, the ecological and social SIs succeed to contribute to sustainable development. The economic SIs however fail to contribute to sustainable development. For the floor-range system, the SIs behave exactly the other way round. Economic SI succeed to contribute to SUSD, whereas ecological and social SIs (except of egg quality) fail to contribute positively.

It will be difficult to achieve an improvement in economic performances for the organic farmer, as the economic situation for organic EPS is seen as rather critical compared to the floor-range system (Bintz 2015, pp.86; Achilles 2015, p. 6; Schmutz & Flock 2014, p. 22). According to Bintz (2015, pp. 86), the annual costs for feed per hen place are known to be higher in organic EPS than in the floor-range system due to the higher feed consumption when hens have access to an outdoor run and move freely. Second, the fixed costs spent per hen place on an annual basis are also considered as higher than in floor-range systems, since organic farmers keep a smaller number of laying hens per square meter on the floor surface (Flath, Schockemöhle & Alfs 2012, p. 7). Third, the annual labour costs per hen place accounts to a higher amount in organic systems than in floor-range EPS, because of the smaller amount of laying hens in every unit of labour (ibid.) Fourth, a key aspect referencing economical efficiency constitute the pattern in egg consumption. If the egg consumption shifts from eggs produced in floor-range systems to organically produced eggs, the organic EPS and therefore also the organic farmer can be economically competitive (Achilles 2015, p.3). Thus, the main perceived challenge for the organic farmer is to operate his organic business in a more profitable way.

For the farmer operating the floor-range EPS it is essential to improve the ecological as well as social conditions on his farm in order to achieve an equal positive contribution to SUSD. Since 2008, it is mandatory to keep laying hens in low emissions stables that emit a maximum of 10,000kg NH3 annually (Federal Environmental Agency, 2014). The floor-range farm emissions however surpass the prescribed maximum limit. He could reduce his emission by investing in new technologies such as filter plants that keep the emissions as low as possible. Also the maximum energy consumption limit per hen place per year set by the federal government (The German Federal Government, 2016) cannot be fulfilled by the considered floor-range EPS. Again considerable investments to guarantee a successful energy transition for increased energy efficiency and a reduction in absolute energy demand are needed.

Improving hen welfare is considered as a huge challenge and rather difficult due to the fact that floor-range systems do not provide an outdoor section for laying hens which would give them the opportunity to behave naturally (Flath, Schockemöhle & Alfs 2012, p. 7). A more reasonable contribution to hen welfare could be attained by providing the hens with occupation possibilities, but this is once more linked to further investments (ibid.).
To conclude, the three-phase framework facilitates a comparison of floor-range and organic EPS in a wider EES context using sustainable indicators. The comparison allows for a weighting of different SI, and provides a clear overview of the most significant areas of concern.
Acknowledgements

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**Interviews**


Overesch, R. Interviewed by Hernandes, E. (08th July 2016).
Appendix 1. Specific Requirements on the Rearing of Hens

In the following, specific requirements on the rearing of hens under the floor-range and organic farming method are presented.

Floor-range farming system:

The § 13a of the animal protection livestock regulation governs specific requirements for the floor-range farming system (Schmutz & Flock 2014, p. 9): It reveals the distinction between the classic floor-range farming method, the floor-range method with several levels, and both forms in combination with access to open runs. A maximum of nine hens per m² of usable space are allowed to be kept under this farming method, whereas in floor-range systems with additional levels a stocking density of maximum 18 animals per m² of surface area is permitted. The guidelines for watering places, perches, nesting and scratching areas as well as all other dimensions are depicted in table 17.

Table 17. Requirements for floor-range farming metod (Schmutz & Flock 2014, p. 9)

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stocking density</td>
<td>Max. 9 hens per m² per usable space; in floor-range systems with multiple levels max. 18 hens per m² of surface area.</td>
</tr>
<tr>
<td>Levels</td>
<td>Max. 4 levels above one another, whereby the stable floor is seen as the first level; level is recognized only when no faeces can fall on the underlying layer; distances between each level is 45 cm.</td>
</tr>
<tr>
<td>Group size</td>
<td>Without physical separation up to 6000 animals</td>
</tr>
<tr>
<td>Feeding</td>
<td>a) Through (lengthways) Min. 10 cm edge length per animal.</td>
</tr>
<tr>
<td></td>
<td>b) Trough (round) Min. 4 cm edge length per animal.</td>
</tr>
<tr>
<td>Watering place</td>
<td>Round drinkers Min. 2,5 cm; 1 cm edge lengths per animal.</td>
</tr>
<tr>
<td></td>
<td>Nipple drinkers Min. 2 watering places for max. 10 animals, for up to another 10 animals.</td>
</tr>
<tr>
<td>Nests</td>
<td>a) Nests (groups) Min. 1m² per max. 120 animals.</td>
</tr>
<tr>
<td></td>
<td>b) Nests (single) Max. 7 animals per nest (35 x 25 cm).</td>
</tr>
<tr>
<td>Perches</td>
<td>Min. 15 cm per animal; horizontal distance between the perches.</td>
</tr>
<tr>
<td>Bedding area</td>
<td>Min 1/3 of the floor surface area; min 250 m² per animal.</td>
</tr>
<tr>
<td>Cold scratching area</td>
<td>Scratching area for all facilities that have been put into operation since August 2002 with access to open runs (if no constructional or legal grounds make this</td>
</tr>
</tbody>
</table>
Organic Farming method

As a matter of fact, farmers who sell organically produced eggs have to fulfill a number of specific requirements regarding feed. These requirements are explained in the following based on the information of the German Federal Ministry of Food and Agriculture (BMEL, 2015):

In general, it is preconditioned that the animals are always fed with organic fodder. In addition to that, there exist a specific set of rules on feeding that have to be considered in accordance with the EU legislation on organic farming. First, the feeding of the hens has to be performed with exclusively organic feed, preferably with fodder produced on the farm itself in order to maintain the cycle as inferred as possible. Averagely, 30 % of the feed ration (assessed in the form of dry mass) can be composed of inconversion feed. It signifies that the forage area has to conform to the specific requirements of organic farming at least 12 months before the harvesting period begins. Second, farmers have to include roughage, silage, fresh or dried fodder into the ration on a daily basis.
Appendix 2. Interview Guide

I. Foreword/Introduction (B)

In the analysis phase, it is very enlightening to talk to people from habitats that can be seen as experts in a particular given issue. They provide the necessary external perspective and external demand for the interviewer. These interlocutors can give their insight into the image and the perception of laying hens systems, and provide important feedback from their perspective.

Name of the interviewer: Hernandes, Emilie

Name of the interviewee: Anonymous (Farmer wants to stay anonymous)

Role of the person interviewed: Farmer

Type of farm: Floor-range laying hen farm

Business form: Independent Entrepreneur

Location of the farm: Lower Saxony, Germany

Structure of the farm: Agricultural Holding

Number of laying hens: 49.383

Date of the interview: 2016-07-07

Today I would like to conduct an interview with you. The questionnaire deals with the farming method used in your farm. You were selected to participate, because you correspond precisely to the target group and I need your help to determine the degree of sustainability in laying hen farming systems. First, I would like to explain the procedure of the interview briefly.

I’m going to ask you some questions about the floor-range farming method / organic farming method and kindly ask you to answer these questions honestly. I ask you further, while answering the questions to "think out loud", that is telling me what is on your mind, what do you expect or do not understand.

Please keep in mind that we do not scrutinize you as a person, but the laying hen farming methods with regard to sustainable development. So there is nothing you can do wrong. The interview is going to last about 20 minutes. If you need a break, just let me know. Do you have any further questions? If not, then I kindly ask you to read through the confidentiality agreement and sign it.
Confidentiality Agreement:

1. The participation is voluntary: The responsible person for conducting the interview as well as for its scientific evaluation is Emilie Hernandes.
2. The person in charge shall ensure that all data collected will be kept strictly confidential and will be used solely for the agreed purpose.
3. To ensure data protection, the following standards apply: The interview content and the related information, sound and image documents are subject to data privacy that is they cannot be used without permission in publications and exhibitions without anonymization.

The material is treated in accordance with the following privacy agreements:

**Interview documents:**

(a) The person in charge must keep the interview sheet and the material that goes with it closed and have to delete everything after the completion of the investigation or not later than after 3 years.

(b) Access to the materials lies solely by project members or the editor.

**Evaluation and archiving**

(a) Names and location information from interviewees are defaced where necessary.

(b) In publications it is necessary to ensure that an identification of the interviewee is not possible.

I hereby confirm that I have informed the interviewee about the purpose of the survey, explained the details of the above stated Confidentiality Statement, and obtained his / her consent.

[Signatures]

Interviewer

Interviewee
II. Main Part/Interview

A. Economic Issues

i. Profit is the goal of entrepreneurial activity. According to economic principles, a profit is yield when Revenues exceed the production costs.

1a. Do your revenues exceed your production costs?

✘ Yes ☑ No

1b. If so, would you be willing to quote me your monthly gross income?

NO.

1c. Then, would you be willing to indicate if you earn

✘ more than 2150 € or

less than 2150 € gross per month.

ii. Diseases and mortality cause economic losses due to adverse effects on egg production.

2a. Is the risk of infection among your laying hens higher than under the organic/ floor-range system?

Yes ☑ No

2b. Is the risk of metabolic diseases (fatty liver and kidney syndrome) under your farming conditions higher than under the organic/ floor-range system?

✘ Yes ☑ No

B. Ecological issues

i. Agriculture is with a percentage of 95% the main emitter of the air pollutant ammonia (NH3) in Germany. According to the international clean air convention Germany is not allowed to emit more than 550,000 tons of ammonia annually since 2010. So poultry farms should not exceed an ammonia emission threshold of 10,000 kg per year.

1a. Are you personally aware of the recommended values for NH3 emissions?

✘ Yes ☑ No

1b. If yes, would you be willing to state how high the NH3 emissions are?
1c. If not, would you be willing to state if your NH3 emissions:

☒ surpass 10.000 kg/yr or

fall below 10.000 kg/yr?

2a. Is it correct to assume that a farm’s direct energy consumption is about 1.4 kwh/hp?

Yes ☒ No

2b. If not, what would be the right assumption then?

3 kWh/ Hp per year

3. Do you work in accordance with a specific operating cycle or do you react only in the event of an actual infestation?

☒

C. Social issues:

i. The relative Hen welfare Index (r-HWI) can be used to assess how animal production systems affect hen welfare. It is represented on a scale from 0 to 1, where 0 stands for an unreasonable contribution to hen welfare, and 1 signifies a reasonable contribution to hen welfare.

1. On a scale from 0 to 1, how do you rate the hen’s welfare in your farming method?

0 0.1 0.2 0.3 0.4 0.5 0.6 ☒ 0.7 0.8 0.9 1

ii. The external egg quality is determined by the egg form, shell strength, percentage of perforated and broken eggs, and cleanliness. The percentage of second quality eggs produced indicates a way to measure external egg quality.

2. How many 2nd quality eggs do you produce on average?

0.19% per month

iii. Working climate shows considerable discrepancies among the different EPS, mostly due to dissimilarities in air composition within the stables. Existent measures such as concentration of thoracic dust (little dust particles which are inhaled deep into the lungs) and NH3 can be used to assess working climate for the two EPS.

3a. Are you aware of any secondary health damages which may result from concentrations in your stables due to thoracic dust or NH3 emissions?
3b. Are you informed about the exact concentrations of thorax dust or NH3 emissions in your stable?

NO

III. Concluding part

Thank you very much for your time. Do you want to add anything? I now have all the information I need. Thanks again for your participation in the interview. If you like, I am willing to let you know the interview outcomes at a later date.
I. Foreword/Introduction (B)

In the analysis phase, it is very enlightening to talk to people from habitats that can be seen as experts in a particular given issue. They provide the necessary external perspective and external demand for the interviewer. These interlocutors can give their insight into the image and the perception of laying hens systems, and provide important feedback from their perspective.

Name of the interviewer: Hernandes, Emilie

Name of the interviewee: Overesch, Rudolf

Role of the person interviewed: Farmer

Type of farm: Organic Laying Hen Farm

Location of the farm: North Rhine Westphalia

Number of laying hens: 1125

Date of the interview: 2016-07-08

Today I would like to conduct an interview with you. The questionnaire deals with the farming method used in your farm. You were selected to participate, because you correspond precisely to the target group and I need your help to determine the degree of sustainability in laying hen farming systems. First, I would like to explain the procedure of the interview briefly.

I’m going to ask you some questions about the floor-range farming method / organic farming method and kindly ask you to answer these questions honestly. I ask you further, while answering the questions to "think out loud", that is telling me what is on your mind, what do you expect or do not understand.

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**Evaluation and archiving**

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I hereby confirm that I have informed the interviewee about the purpose of the survey, explained the details of the above stated Confidentiality Statement, and obtained his / her consent.

[Signature]

Interviewer

[Signature]

Interviewee
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1a. Do your revenues exceed your production costs?

☒ Yes ☐ No

1b. If so, would you be willing to quote me your monthly gross income?

☐ NO

1c. Then, would you be willing to indicate if you earn

more than 2150 € or

☒ less than 2150 € gross per month.

ii. Diseases and mortality cause economic losses due to adverse effects on egg production.

2a. Is the risk of infection among your laying hens higher than under the organic/ floor-range system?

☒ Yes ☐ No

2b. Is the risk of metabolic diseases (fatty liver and kidney syndrome) under your farming conditions higher than under the organic/ floor-range system?

☒ Yes ☐ No

B. Ecological issues

i. Agriculture is with a percentage of 95% the main emitter of the air pollutant ammonia (NH3) in Germany. According to the international clean air convention Germany is not allowed to emit more than 550,000 tons of ammonia annually since 2010. So poultry farms should not exceed an ammonia emission threshold of 10,000 kg per year.

1a. Are you personally aware of the recommended values for NH3 emissions?

☒ Yes ☐ No

1b. If yes, would you be willing to state how high the NH3 emissions are?
NO

1c. If not, would you be willing to state if your NH3 emissions:

surpass 10,000 kg/yr or

✗ fall below 10,000 kg/yr?

2a. Is it correct to assume that a farm’s direct energy consumption is about 1,4 kwh/hp?

✗ Yes       No

2b. If not, what would be the right assumption then?

1kWh/hp per year (in his case)

3. Do you work in accordance with a

✗ specific operating cycle or do you react only

in the event of an actual infestation?

C. Social issues:

i. The relative Hen welfare Index (r-HWI) can be used to assess how animal production systems affect hen welfare. It is represented on a scale from 0 to 1, where 0 stands for an unreasonable contribution to hen welfare, and 1 signifies a reasonable contribution to hen welfare.

1. On a scale from 0 to 1, how do you rate the hen’s welfare in your farming method?

    1  0,1  0,2  0,3  0,4  0,5  0,6  0,7  0,8  ✗ 0,9  1

ii. The external egg quality is determined by the egg form, shell strength, percentage of perforated and broken eggs, and cleanliness. The percentage of second quality eggs produced indicates a way to measure external egg quality.

2. How many 2nd quality eggs do you produce on average?

3% per month

iii. Working climate shows considerable discrepancies among the different EPS, mostly due to dissimilarities in air composition within the stables. Existent measures such as
concentration of thoracic dust (little dust particles which are inhaled deep into the lungs) and NH3 can be used to assess working climate for the two EPS.

3a. Are you aware of any secondary health damages which may result from concentrations in your stables due to thoracic dust or NH3 emissions?

✘ Yes ☑ No

3b. Are you informed about the exact concentrations of thoracic dust or NH3 emissions in your stable?

NO

III. Concluding part

Thank you very much for your time. Do you want to add anything? I now have all the information I need. Thanks again for your participation in the interview. If you like, I am willing to let you know the interview outcomes at a later date.