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DISSERTATION

Sustainability in Poultry Production:
A Comparative Study between Germany and Thailand

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Sakson Soisontes

Abstract

Germany's poultry sector plays an important role in the EU, while Thailand is one of the main broiler exporters on the global market. The intensive production systems used in the vertically integrated poultry industry have increased its competitiveness on the world market. However, concerns are increasingly being raised over the industry's environmental impact, food safety and animal welfare in such highly concentrated and integrated production systems. It is therefore necessary to improve the production systems with a view to sustainability. Thailand and Germany's poultry industries face different agro-ecological and socio-economic circumstances, as well as a variety of regional and national policies on sustainability in poultry production. As a result, this comparative study of Germany and Thailand can contribute to broadening the view on sustainability. This study aims to present recommendations on improving the sustainability of poultry production in the two countries. The two-round Delphi method was used to identify and rank the major sustainability concerns in poultry production by eliciting the opinions of participating experts through successive rounds of questionnaires. A combination of secondary data analysis and in-depth e-mail interviews was employed to analyse the roles of NGOs, animal welfare groups and leading integrated poultry companies in the sustainability of poultry production in order to assess why some sustainability issues are considered highly concerning. Results showed that social, animal welfare and economic issues dominate the current debate on sustainable poultry production. The use of antibiotics in poultry production, the killing of male layer chicks and the role of food retailers are considered highly concerning by the German experts, whilst the Thai experts considered the outbreak of avian influenza and other highly infectious diseases, disease control in neighbouring countries, the use of antibiotics in poultry production, the contamination of meat and eggs with zoonotic microorganisms, and standards for poultry products set by import partners as the most concerning issues. The German poultry companies mainly employed reactive strategies to improve sustainability in response to pressure exerted by NGOs and animal welfare groups. In Thailand, the poultry companies proactively adopted strategies to improve their production systems due to a lack of active NGOs and animal welfare groups within this sector. However, a number of limitations exist in regard to addressing concerning issues in the two countries, such as the use of antibiotics and outbreak of avian influenza due to the trade-offs between economic efficiency and consumer preference, the current availability of technology and innovation, the role of social media, and the level of direct communications between producers and consumers. This study makes a number of recommendations for improving the sustainability of poultry production, including to restrict the use of antibiotics in poultry production; to improve consumer perceptions on the poultry industry; to improve prevention strategies against avian influenza; to support the compartmentalisation of poultry production during avian influenza or Newcastle disease outbreaks; to support the geographic dispersion of genetic stock; to increase international collaboration on the prevention and control of contagious diseases in border areas; to improve existing technologies and practices by developing new technology and innovation; and to promote research on animal feed supply.

Keywords: Sustainability, Poultry Production, Two-Round Delphi Method, Use of Antibiotics, Avian Influenza, NGOs, Animal Welfare Groups, Poultry Company.

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AAAS	American Association for the Advancement of Science
ADP	Genesis Assured Duck Production
AEMAS	ASEAN Energy Manager Accreditation Scheme
ALO	Agricultural Labelling Ordinance
APHIS	Animal Plant Health Inspection Service
ATTRA	Appropriate Technology Transfer for Rural Areas
BDE	Bundesverband Deutsches Ei e.V.
BfT	Bundesverband für Tiergesundheit (BfT)
BMEL	Bundesministerium für Ernährung und Landwirtschaft
BRC	British Retail Consortium
BUND	Bund für Umwelt und Naturschutz Deutschland
BVL	Bundesamt für Verbraucherschutz und Lebensmittelsicherheit
CA-MRSA	Community-associated Methicillin-Resistant *Staphylococcus aureus*
CBD	Convention on Biological Diversity
CGIAR	The Secretariat of the Consultative Group on International Agricultural Research
CIWF	Compassion in World Farming
COP	Conference of the Parties
CPF	Charoen Pokphand Foods Public Company Limited
CSD	Commission on Sustainable Development
EC	European Commission
ECDC	The European Centre for Disease Prevention and Control
EFSA	The European Food Safety Authority
ESBL	Extended Spectrum b-Lactamase
ESCMID	European Society of Clinical Microbiology and Infectious Diseases
EU	European Union
FAO	Food and Agriculture Organisation of the United Nations
FCRN	Food Climate Research Network
GAP	Good Agricultural Practice
GHG	Greenhouse gas
GM	Genetic Modification
GMP	Good Manufacturing Practice
HACCP	Hazard Analysis and Critical Control Point

List of Abbreviations (2)

HA-MRSA	Healthcare-associated Methicillin-Resistant *Staphylococcus aureus*
HPAI	Highly pathogenic avian influenza
IEC	International Egg Commission
IFOAM	International Federation of Organic Agriculture Movement
IFPRI	International Food Policy Research Institute
IFS	International Food Standard
IISD	International Institute for Sustainable Development
IPCC	Integrated Pollution Prevention and Control Directive
IR3S	The Integrated Research System for Sustainability Science
ISDA	Innovation and Sustainable Development in Agriculture and Food
ISPA	Institut für Strukturforschung und Planung in agrarischen Intensivgebieten
IUCN	International Union for the Conservation of Nature and Natural Resources
LA-MRSA	Livestock-associated Methicillin-Resistant *Staphylococcus aureus*
LPAI	Low pathogenic avian influenza
MDH	Minnesota Department of Health
MEG	Marktinfo Eier & Geflügel
MRSA	Methicillin-Resistant *Staphylococcus aureus*
NGOs	Non-Governmental Organisations
NOP	Nachhaltigkeit im Organisch-chemischen Praktikum
OECD	Organisation for Economic Co-operation and Development
OHSAS	Occupational Health and Safety Assessment Series
OIE	World Organisation for Animal Health
RKI	Robert Koch-Institut
RTA	Red Tractor Assurance
SC	Santa Catarina State
SCARM	Standing Committee on Agriculture and Resource Management
SWOT	Strengths, Weaknesses, Opportunities and Threats
UN	United Nations
UNCHE	United Nations Conference on the Human Environment
UNEP	United Nations Environmental Programme
UNFCCC	United Nations Framework Convention on Climate Change
USDA	United States Department of Agriculture

List of Abbreviations (3)

VDP	Verband Deutscher Putenerzeuger e.V.
WBA	Wissenschaftlicher Beirat für Agrarpolitik beim Bundesministerium für Ernährung und Landwirtschaft
WCED	World Commission on Environment and Development
WHO	World Health Organisation
WSSD	World Summit on Sustainable Development
WWF	World Wildlife Fund
ZDG	Zentralverband der Deutschen Geflügelwirtschaft e.V.

Chapter 1
Introduction

1.1 General introduction

Global meat consumption continues to increase rapidly, and is considered one of the fastest growing major agricultural commodities. It is projected to increase to 347 million metric tonnes by 2022, an increase of 6% since 2010 (OECD and FAO, 2013). Poultry meat accounts for half of the global rise in meat consumption. Due to the increasing demands of domestic and international markets, the poultry industry is expanding rapidly. Consumer concerns about diet and health have contributed to a shift from beef and pork to chicken, such as in the United Kingdom (Resurreccion, 2003). Between 1990 and 2010, the global laying hen population increased by 79.6% (Windhorst, 2013a) and the global egg output will reach 89.9 million metric tonnes in 2030 (WATT Executive Guide, 2012). The global poultry meat production rose by 123% between 1990 and 2009 (Windhorst, 2011). The trade in poultry meat and eggs is partly driven by a rising demand in Asian countries. In 2015, more than 67% of the demand for eggs comes from Asia and the major importing Asian countries are expected to trade 8.6 million metric tonnes of poultry meat by 2021 (WATT Executive Guide, 2012).

The rising consumption of poultry meat and eggs has been the main catalyst for the poultry industry to change, both in terms of scale and structure. The industry has shifted from comprising a large number of widely spread, independent and small-scale poultry producers to vertically integrated firms that own and control the entire production process (Saxowsky and Duncan, 1998). The intensive production systems in the vertically integrated poultry industry have increased their competitiveness in the global market. However, concerns are increasingly being raised over the environmental impact of such highly concentrated and integrated production systems. Historically, environmental management has not been a top priority in the industry, making the long-term sustainability of poultry production based on economic profitability, ecological soundness and social acceptance an object of discussion in recent years. In addition to the environmental issues, the general public is increasingly aware of issues of food safety and animal welfare.

Based on consumers' growing concern over food sustainability, as well as non-governmental organisations and animal welfare groups' focus on poultry production, in high-income countries, especially within the EU, there is tremendous pressure on poultry producers to intensify their efforts to promote sustainability within the sector. Meanwhile, in developing and threshold countries, animal husbandry is an important source of income and a top priority for feeding and supporting a growing population in the future.

Today, the poultry industry faces numerous challenges that vary from region to region, which means the sector has to adjust its production systems and strategies in order to meet the demand for sustainable production on the national and global market.

1.2 Sustainability science in sustainable poultry production

Sustainability science has its roots in the concept of sustainable development, which was introduced by the World Commission on Environment and Development (WCED), also known as the Brundtland Commission. They build upon the concept of development by adding economic aspects to the ecological and social aspects of sustainability, and defined sustainable development as *"development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (WCED, 1987, p.37). Since then, efforts have been undertaken to develop sustainability, especially through the Forum on Science and Innovation for Sustainable Development, organised by the John F. Kennedy School of Government, Harvard University and the American Association for the Advancement of Science (AAAS), which resulted in an increased level of collaboration on developing sustainability science on a global scale (Clark, 2007; Komiyama and Takeuchi, 2011).

Due to the complex problems faced by humankind, such as climate change, deforestation and poverty, a single academic discipline cannot solve them. Sustainability science addresses knowledge gaps and limitations in terms of the ability to utilise knowledge in problem solving by linking research with action and reconciling scientific excellence with social relevance (Kate et al., 2001). As a result, sustainability science has integrated the knowledge produced by existing academic disciplines and expertise, bodies of literature and research that can generate innovative solutions and plans of action (Franklin and Blyton, 2011; Fukushi and Takeuchi, 2011).

Sustainability science requires a multi-disciplinary approach (Clark and Dickson, 2003; Becker, 2012), combining social and natural sciences (Mihelcic et al., 2003; de Vries, 2013) to solve complex problems that are often interlinked (Kate et al., 2001; Komiyama and Takeuchi, 2006; Peattie, 2011; Fukushi and Takeuchi, 2011). The project "The Integrated Research System for Sustainability Science (IR3S)", initiated by the University of Tokyo, boosted sustainability science and positioned it as a discipline that guides the way towards a sustainable society (Komiyama and Takeuchi, 2011). Based on this definition, in order to create a sustainable society, a number of sustainability issues have to be addressed, such as global warming, poverty, disease outbreak and religious tensions. To achieve sustainability, problems that threaten society must be solved.

Sustainability science is a comprehensive, holistic and integrated interdisciplinary approach that seeks to identify problems and perspectives related to sustainability. This can refer to any number of systems that require a sustainability framework that provides quantifiable criteria and indicators. Therefore, the methods used to identify problems relating to sustainability have to be refined and adapted to research.

In the context of poultry production, sustainability science can provide guidance for the transition towards sustainable poultry production by identifying and ranking problems or sustainability issues that are concerning, and by putting forward options for improving sustainability.

1.3 Rationale and background

The poultry sector is one of the fastest growing food production industries, driven by rapid population growth and changes in dietary preferences mainly associated with rising incomes and increased urbanisation (Thornton, 2010). The United Nations Organisation (2013) predicted that the global population will reach 9.6 billion by 2050. The demand for dairy and meat products is expected to rise during the same period since the purchasing power of today's poor will also increase (FAO, 2001).

The growing demand for meat and eggs has important implications for producers, who need to continuously adapt to the changing environmental, social, economic, market and trade conditions. Livestock production has responded to the rising demand, primarily through

shifting from extensive, small-scale, subsistence, mixed crop and livestock production systems towards more intensive, large-scale, geographically concentrated, commercially-oriented, specialised production units (FAO, 2006). Currently, poultry meat and eggs in Germany and Thailand are mainly produced in intensive systems and organised through integrators (vertically integrated production). The intensification of livestock production refers to an increased level of inputs, such as compound feed, higher levels of health care and increased mechanisation, resulting in higher outputs (meat, milk or eggs) per animal. It is often associated with large numbers of animals concentrated on a small area of land (van Boeckel, et al., 2012). Intensive livestock production can be achieved by specialising on one breed or a combination of improved breeds, altering the use of feed, increasing the mechanisation of labour and making investments in disease prevention and biosecurity (Otte, et al., 2007). Farmers specialise in the production of a single commodity as a result of intensification, which enables them to invest in more targeted technologies and facilities, and to access distribution markets more readily, leading to improved economies of scale (FAO, 2006).

Unfortunately, the intensification of poultry production leads to the pollution of soil, air and water. It also has a direct impact on the expansion of feed production areas. A large number of animals concentrated in a small area raises concerns over animal welfare. These issues are widely discussed and are considered some of the most pressing challenges for improving the sustainability of poultry production.

Sustainability has become a major concept in global public and political discussions (Becker, 2012). It is considered a key issue in the twenty-first century (Komiyama and Takeuchi, 2006). This term is commonly used in agribusiness as well as in politics and other fields to promote long-term strategies and visions. The concept of “sustainability” was introduced three hundred years ago in German forestry by the miner von Carlowitz (Becker, 1997). The term “Nachhaltigkeit” was used, and it was the most significant forestry concept of the eighteenth century. It has since been refined through the development of important global political documents, such as the Brundtland Report (WCED, 1987), the Rio Declaration (UN, 1992a), the Agenda 21 (UN, 1992b) and the Johannesburg Declaration (UN, 2002), and is now widely recognised and discussed in public and scientific discourse (Becker, 2012).

The most famous definition of "sustainable development" was proposed by the World Commission on Environment and Development (WCED), as stated at the beginning of this chapter. Although sustainability is widely acknowledged as a crucial concept, there is no consensus on its definition. However, elements of sustainability generally include economic, environmental and social aspects. Addressing sustainable poultry production requires additional knowledge on production systems and expertise on developing integrated systems that are economically profitable, ecologically sound and socially acceptable.

A case study on the sustainability of Brazilian poultry production in intensive farming areas was conducted by Spies (2003), in which he developed a list of sustainability indicators through group discussions with industry stakeholders. Mollenhorst and de Boer (2004) identified sustainability issues in egg production in the Netherlands using the participatory SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis. Bonaudo et al. (2010) adapted the participatory method DPSIR (Driving forces, Pressures, State, Impacts and Responses) model to study and compare poultry production systems on a regional scale in France and Brazil. This study supports the argument that in order to assess the sustainability of poultry production, dynamic (market competition) and spatial (characteristics of production system in each area) aspects have to be considered. Spies (2003) and Mollenhorst and de Boer (2004) identified similar and different issues regarding the sustainability of poultry production in Brazil and the Netherlands. This indicates that differences in agro-ecological and socio-economic circumstances as well as public policies in various regions have an impact on the sustainability of poultry production. Thus, understanding the different conditions of each poultry production region is necessary in order to be able to contribute to sustainability.

The poultry industry is one of the most important agricultural sectors, both in Germany and Thailand. Germany's poultry sector plays an important role in the EU, while Thailand is one of the most important poultry producers in Asia and in the world. Germany is one of the EU's leading egg producers, accounting for 12.7% of the total production in 2013 (Windhorst, 2015c). Thailand ranked as the fourth largest poultry meat exporter in 2013, with an export volume of 525,682 metric tonnes (Thai Broiler Processing Exporters Association, 2013). In Germany, poultry farming dominates the State of Lower Saxony, accounting for 66.3%, 48.5%, and 38.7% of the overall domestic broiler, turkey and laying hen places in 2013, respectively (MEG, 2015). Poultry flocks are geographically concentrated in the northwestern part of the state, whilst in Thailand intensive production is located in the provinces adjacent to

Bangkok, Chon Buri, Chachoengsao and Nakhon Nayok, making up for 27.5% of the total production in Thailand in 2013 (Office of Agricultural Economics, 2013).

However, the sustainability issues that currently concern the German and Thai poultry industries have not been investigated further, including the identification and prioritisation of key concerns. Furthermore, a comparison of the various conditions of poultry production in high-income European and middle-income Asian countries would contribute to broadening perspectives on sustainability. This study on sustainability in poultry production in Germany and Thailand aims to reflect the current context of poultry production in these two countries and identify additional sustainability issues that have not been addressed in previous studies. Finally, this study can provide important information for policymakers and stakeholders engaged in the development of strategies for sustainability of poultry production.

1.4 Research questions and objectives of the study

In order to improve the sustainability of poultry production, this study aims to primarily answer the following questions:

- How do sustainability issues pose a challenge to poultry production?
- How has the structure of poultry production developed and how is it organised in the areas under study?
- What are the main sustainability concerns in poultry production?
- What actions are being undertaken by NGOs, animal welfare groups and the leading integrated poultry firms with regard to the sustainability of poultry production?
- What improvements can be made in the poultry sector in order to shift towards sustainable production?

In order to understand the concept of sustainability and make recommendations on improving the sustainability of poultry production in Germany and Thailand, the main objectives of this study are:

- To present an overview of definitions and concepts of sustainability in poultry production;
- To critically review the current sustainability issues in poultry production;
- To analyse the structures, production data, regional concentration and organisational models of poultry production;

- To identify and rank the sustainability issues that currently concern the poultry industry;
- To evaluate and compare the actions undertaken by NGOs, animal welfare groups and leading integrated poultry companies with regard to the sustainability of poultry production;
- To make recommendations on improving the sustainability of poultry production in Germany and Thailand.

1.5 General approach and conceptual framework

This study focuses on the poultry industries in Germany and Thailand. Based on the objectives of the study, the research approach combined a review of relevant literature with an empirical study in order to obtain a comprehensive understanding of poultry production and sustainability. The conceptual framework of this study was developed based on the notion of sustainability science (Komiyama and Takeuchi, 2011) and sustainability research as suggested by Meadows (1998) and de Vries (2013). Figure 1.1 presents the conceptual framework for the study of sustainability in poultry production.

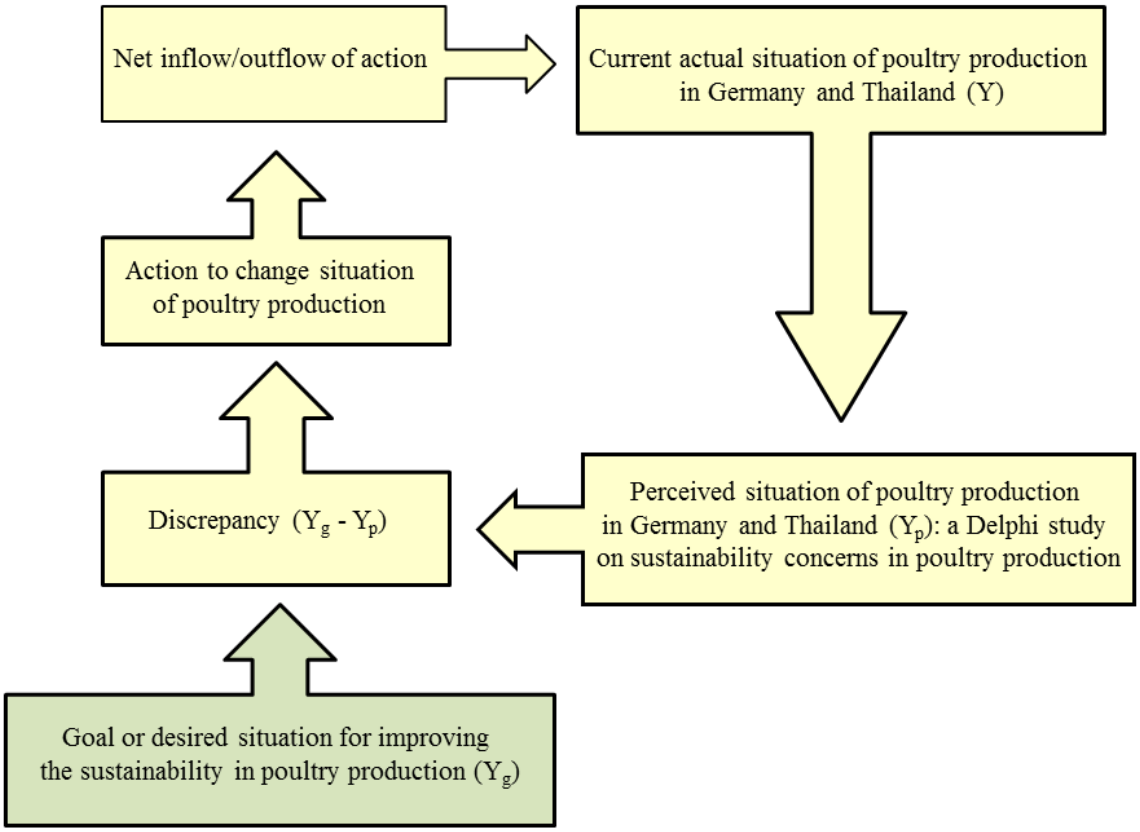


Figure 1.1 The conceptual framework for the study of sustainability in poultry production

Source: Author's design based on Meadows (1998) and de Vries (2013).

The goal of this study is to improve the sustainability of poultry production in Germany and Thailand *(Y_g)*. In other words, this study aims to address those aspects of contemporary poultry production that are concerning by bringing about change, which requires interference with the static variable *Y*. However, it is difficult to directly measure the precise state of poultry production due to its complex and dynamic nature. Thus, an assumption on the actual situation has to be made, which is called perceived situation. This perception of the situation *(Y_p)* is an indicator for the current state of poultry production and may differ from the actual situation *(Y)* due to delays and filtering. It is important to choose an appropriate method to determine the assumed current actual situation of poultry production: if the method is chosen poorly, decisions based on this are ineffective. Misleading assumptions will cause over- or under-reactions, changes that are too weak or too strong to drive the system to make the desired changes. It is therefore essential to understand the current actual situation as precisely as possible in order to make improvements to the system as efficiently as possible.

The Delphi method was applied to estimate the actual situation by identifying and ranking sustainability issues that currently pose concern to the German and Thai poultry industries.

The combination of scientific evidence, such as literature and reports, with expert opinions makes the Delphi method an appropriate and powerful technique to reach this assumption (Dalkey and Helmer, 1969; Lindstone, 1978; Green et al., 1990; Rowe et al., 1991; Murry and Hammons, 1995; Van der Fels-Klerx et al., 2000; Schmidt et al., 2001; Angust et al., 2003; Reinert et al., 2007; Collins et al., 2009; Grabkowsky, 2009; More et al., 2010; Veauthier and Windhorst, 2011; Frewer et al., 2011; Veauthier, 2011; Wilke, Windhorst and Grabkowsky, 2011; Hop et al., 2014). The results of the Delphi study represent the perceived situation of poultry production *(Y_p)*, as the most accurate approximation of the actual situation of poultry production *(Y)*. Recommendations to change the current actual situation of poultry production are developed based on the discrepancy between the desired situation or goal *(Y_g)* and the perceived situation *(Y_p)*. The difference between the goal and the perceived reality drives the desire and action for change.

In this study, Y_p is comprised of the results of the Delphi study, namely the sustainability issues that currently concern the German and Thai poultry industries. In other words, it reflects the current situation of poultry production that needs to be changed or improved. Y_g represents the objective of increasing the sustainability of poultry production. Actions that could change the state of poultry production or recommendations on improving the sustainability of poultry production were identified based on the discrepancy between Y_g and Y_p.

In addition, actions undertaken by NGOs and animal welfare groups, as well as the policies and production strategies adopted by the leading integrated poultry companies, were analysed in order to explain why some sustainability issues are more concerning than others, based on the Delphi study. Finally, the study includes a discussion and summary of the research findings, as well as a general conclusion.

Overall, this study aims to provide an accurate representation of the current state of poultry production in Germany and Thailand, as well as making recommendations on improving its sustainability. The methodology is described in more detail in Chapter 2.

1.6 Outline of the dissertation

The rational flow of this dissertation and the relationship between the chapters and the research approach are depicted in Figure 1.2, which acts as a road map and conceptual framework for this study on sustainability in poultry production in Germany and Thailand.

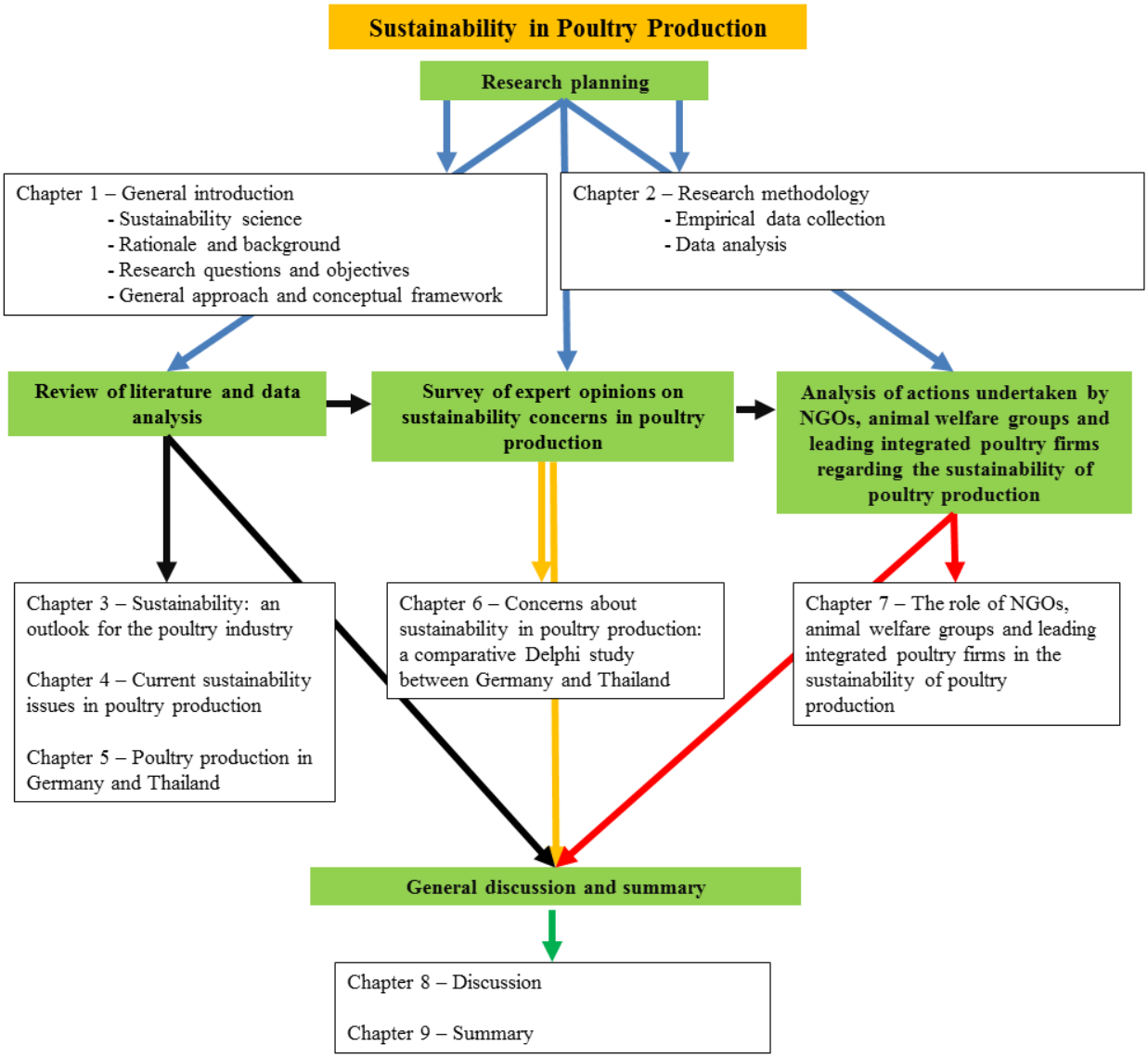


Figure 1.2 The road map and conceptual model of the study on sustainability in poultry production in Germany and Thailand. Arrows represent logical and information links.

Source: Author's design.

Chapter 1 provides a general introduction, the concept of sustainability science, and rationale and background of the study. It defines the research questions and objectives of the study, and outlines the research approach.

Chapter 2 focuses on the research methodology used in this study. The quantitative and qualitative research methods, including the Delphi technique, are described and the rationale for using these methods to study the sustainability of poultry production is presented.

Chapter 3 discusses a broad perspective on sustainability and sustainable intensification. A particular emphasis is placed on reviewing the literature and concepts on sustainable agriculture, particularly livestock production. This chapter concludes with an analysis of the concepts of sustainability and what they mean for the poultry industry.

Chapter 4 critically reviews the current sustainability issues that pose challenges to poultry production.

Chapter 5 gives an overview of the poultry industries in Germany and Thailand, including the structures, production data, regional concentration and organisational models of poultry production in the two countries.

C*hapter 6* presents the results of the Delphi study. The survey provides expert views on the main sustainability concerns in poultry production.

Chapter 7 analyses the actions undertaken by NGOs, animal welfare groups and leading integrated poultry firms with regard to the sustainability of poultry production in order to explain why some sustainability issues are of more concern than others.

Chapter 8 discusses the main findings and limitation of this study, as well as giving recommendations for further research. This chapter also provides suggestions for improving the sustainability of poultry production.

Chapter 9 summarises the final research outcomes and concludes the key findings of the study.

Chapter 2
Research methodology

2.1 General introduction

The general approach of this dissertation comprises an analysis of primary and secondary data to gain a comprehensive understanding of poultry production and its sustainability. The following sections set out the methodology for the secondary data analysis, the different quantitative and qualitative research methods, and the Delphi technique.

2.2 Secondary data

Secondary data are data that have already been collected for purposes other than the problem at hand, including data produced within an organisation, information made available by the private sector and government sources, commercial marketing research firms and computerised databases. The analysis of secondary data is an essential step in the research planning process: primary data should not be collected until the available secondary data have been fully analysed (Malhotra and Birks, 2007).

Malhotra and Birks (2007) distinguish between internal and external secondary data depending on the source, as shown in Figure 2.1. Internal data are those produced within the organisation that is conducting the research study. External data, on the other hand, are those collected by sources outside of the organisation. These data exist in the form of published material, computerised databases and information made available by syndicated services.

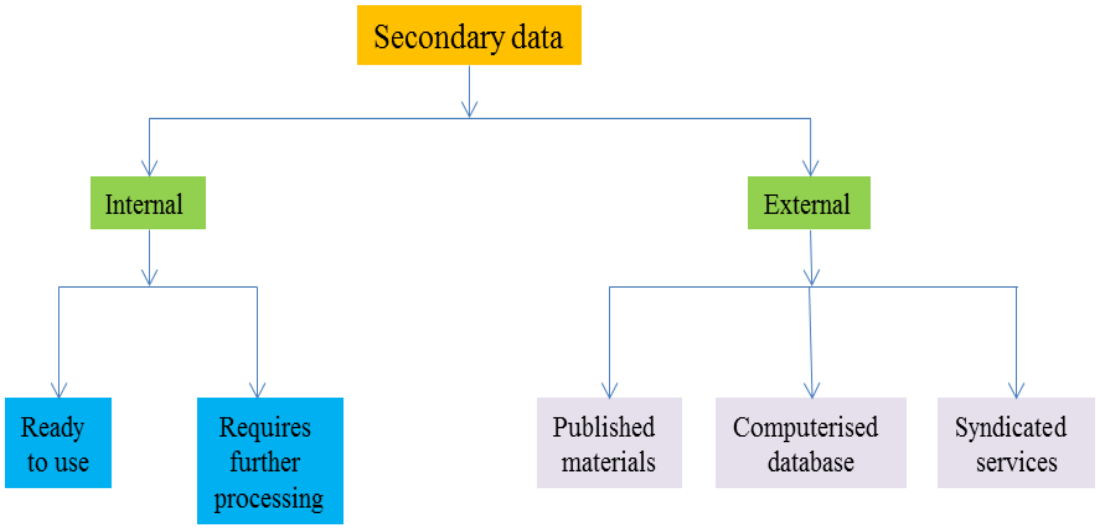


Figure 2.1 Classification of secondary data

Source: Malhotra and Birks (2007, p.100).

Secondary data is useful for a range of purposes, including identifying the research problem, developing an approach to the problem or a sampling plan, conceptualising appropriate research designs, answering research questions, testing hypotheses and validating qualitative findings.

However, the usefulness of secondary data is limited in regards to relevance and accuracy when it comes to addressing the issues at hand. Therefore, in this dissertation primary data must also be collected and analysed to increase the accuracy of critical issues and address current sustainability in poultry production.

2.3 Primary data

Primary data are collected by the researcher for the specific purpose of addressing the research question at hand. The primary data collected can be either quantitative or qualitative.

2.3.1 Definition of quantitative and qualitative research

Quantitative research is a research technique that involves the systematic collection of numerical data, often under conditions of considerable control, and the analysis of the information collected using statistical procedures (Polit et al., 2001). It is a logical and data-led approach which provides a measure of what people think from a statistical and numerical

point of view. An example of a quantitative research question would be finding out how many customers support a proposed change in products and how strongly (on a scale) they would support it.

Qualitative research is a research method that seeks to provide textual descriptions of how people experience a given research issue (Mack et al., 2005). It deals with the systematic collection and analysis of more subjective narrative data by observing what people reflect and express regarding a specific issue (Polit et al., 2001; Malhotra and Birks, 2007). Qualitative research therefore provides information on people's behaviour, perception, opinion and emotions. This research is very useful for identifying intangible factors, such as social norms, socio-economic status, gender roles and religion.

2.3.2 Background of quantitative and qualitative research

Quantitative research seeks to quantify data and is based on numerical data analysed statistically, whereas ***qualitative research*** refers to the collection, analysis and interpretation of data raised by observing what people do and say. The distinction between quantitative and qualitative research is often seen as fundamental, leading people to talk about "paradigm wars" in which quantitative and qualitative approaches are seen as incommensurable fractions at war with each other (Muijs, 2004). The two different approaches are at the heart of opposing world views that split researchers into two paradigms. The ***quantitative view*** is described as positivism (Polit and Hungler, 1999; Muijs, 2004), while the world view underlying ***qualitative research*** is viewed as being subjectivist (Muijs, 2004).

Positivism is a philosophical viewpoint that concentrates on definite fact and avoids speculation. Data derived from sensory experience, which are analysed logically and mathematically, are regarded as the exclusive source of all authentic knowledge. The positivist approach has been a recurrent theme in the history of Western thought. The concept was developed in its modern form in the early 19th century by the philosopher and founder of sociology Auguste Comte. Advocates of the quantitative approach are therefore described as objective scientists (Duffy, 1986; Walker, 2005) committed to the discovery of quantifiable information (Carr, 1994).

Subjectivism is a philosophical way of thinking that believes that reality is only an individual perception and does not exist objectively. It sees subjective experience as fundamental to all measurements and laws. An extreme subjectivist position is obviously just as problematic as an extreme positivistic one, as it would in theory deny that nothing more than social consensus and power differentiates modern science from witchcraft (Muijs, 2004). Therefore, many current researchers, both quantitative and qualitative, take a pragmatic approach to research, using different techniques depending on the research question they are trying to answer.

In order to develop an understanding of what the positivist and subjectivist paradigms mean, Table 2.1 presents the characteristic features of the two paradigms.

Table 2.1 Paradigm features

Issue	Positivist	Subjectivist
Reality	Objective and singular	Subjective and multiple
Researcher-participant	Independent of each other	Interacting with each other
Values	Value free = unbiased	Value laden = biased
Researcher language	Formal and impersonal	Informal and personal
Theory and research design	Simple determinist Cause and effect Static research design Context free Laboratory Prediction and control Reliability and validity Representative surveys Experimental design Deductive	Freedom of will Multiple influences Evolving design Context bound Field/ethnography Understanding and insight Perceptive decision making Theoretical sampling Case studies Inductive

Source: adapted from Creswell (1994 cited in Malhotra and Birks, 2007).

2.3.3 Quantitative research techniques

Parahoo (1997) identifies three levels of quantitative research: descriptive, correlational and causal (experiment). Descriptive research provides an account of the characteristics of individuals, groups or situations that may form the first stage of more complex designs (Walker, 2005). The major objective is to discover new meaning, describe something, determine the frequency with which that something occurs and categorise information (Burns and Grove, 1999). Correlational research seeks to examine the relationships between variables without introducing an intervention. The aim is often to create hypotheses that can be tested in

experimental research (Parahoo, 1997). Experimental research provides a framework for obtaining evidence of cause and effect relationships (Roe, 1994). It requires a planned and structured design as in descriptive research.

In this dissertation, quantitative descriptive research methods will be used to collect primary data. In descriptive research, there are two ways to collect primary data, namely survey and observation techniques.

2.3.3.1 Survey techniques in quantitative research

Survey methods use structured questionnaires that are given to a sample of a population. Questionnaire participants are asked a variety of questions regarding their attitudes, motivation, behaviour, intentions, level of awareness, and demographic and lifestyle characteristics (Malhotra and Birks, 2007). The surveys mainly use fixed-response optional questions that require the participant to choose from a predetermined set of responses. The following example question is designed to measure a dimension of students' attitudes towards the way they are assessed in economic geography classes:

	Strongly agree	*Agree*	*Neutral*	*Disagree*	*Strongly disagree*
I prefer written examinations compared to homework assignments	☐	☐	☐	☐	☐

Advantages of the survey method are that the questionnaire is simple to conduct and the data obtained are consistent because the responses are limited to the options stated. The use of fixed-response questions reduces the variability in the outcomes that could be caused by differences in interviewers. Additionally, the coding, analysis and interpretation of data are simple (Malhotra and Birks, 2007). However, the survey technique has some disadvantages. Respondents may be unable or unwilling to give the desired information. Therefore, structured questions and fixed-response optional questions may not be appropriate for certain types of data such as feelings and beliefs (Malhotra and Birks, 2007).

The survey approach for primary data collection can be applied using four different methods: 1) telephone interviews; 2) personal interviews; 3) mail interviews and; 4) electronic interviews as shown in Figure 2.2.

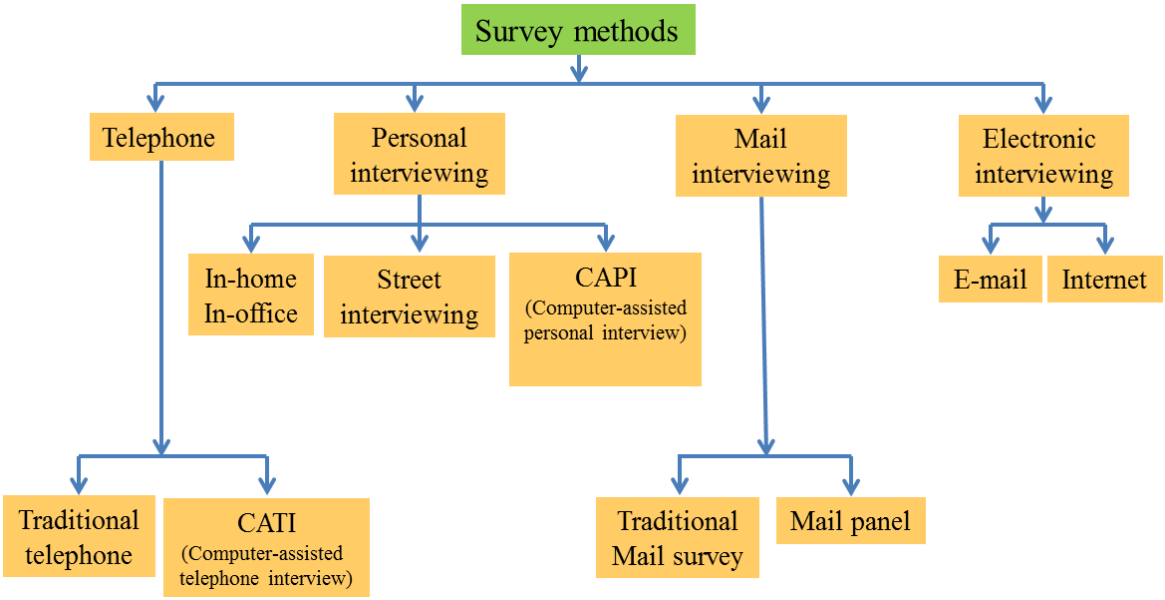


Figure 2.2 A classification of survey techniques

Source: Malhotra and Birks (2007, p.267).

Telephone interviews can be classified as traditional telephone interviews and computer-assisted telephone interviews (CATIs). Personal interviews can be done at home or at the office, as a street interview, or as a computer-assisted personal interview (CAPI). Mail interviews can be administered in the form of traditional mail surveys or mail panels, whereas electronic interviews can be conducted via e-mail or administered over the Internet.

Today's electronic surveys account for 11% of the global total spent on research methods, with Australia spending the most on this technique with 20% (Malhotra and Birks, 2007). E-mail surveys are favourable for respondents because they require no facilities or expertise beyond those used in daily e-mail communications. A list of e-mail addresses is required for conducting an e-mail survey. The questionnaires are written into the body of the e-mail message, which is then sent out via the internet. Respondents enter their answers and return the questionnaire to the interviewer. However, there are several limitations of e-mail interviewing: it is limited to individuals with access to the internet; it may take several days or weeks before an interview is complete and some participants may drop out before the interview is complete (Meho, 2006).

All survey techniques have advantages and disadvantages as presented in Table 2.2. The researcher needs to conduct a comparative evaluation to define which methods are appropriate for each research project.

Table 2.2 A comparative evaluation of survey techniques

	Telephone CATI	In-home, In-office interviews	Street interviews	CAPI	Traditional mail surveys	Mail panels	Email	Internet
Flexibility of data collection	Moderate to high	high	high	Moderate to high	Low	Low	Low	Moderate to high
Diversity of questions	Low	High	High	High	Moderate	Moderate	Moderate	Moderate to high
Use of physical stimuli	Low	Moderate to high	High	High	Moderate	Moderate	Low	Moderate
Sample control	Moderate to high	Potentially high	Moderate to high	Moderate	Low	Moderate	Low	Low to moderate
Control of data collection environment	Moderate	Moderate to high	High	High	Low	Low	Low	Low
Control of field force	Moderate	Low	Moderate	Moderate	High	High	High	High
Quantity of data	Low	High	Moderate	Moderate	Moderate	High	Moderate	Moderate
Response rate	Moderate	High	High	High	Low	Moderate	Low	Low
Perceived respondent anonymity	Moderate	Low	Low	Low	High	High	Moderate	High
Social desirability	Moderate	Low to moderate	Low	Low to high	High	High	High	High
Obtaining sensitive information	Low	High	Low	Moderate	Moderate	Moderate	Moderate	Moderate
Potential for interviewer bias	Moderate	High	High	Low	None	None	None	None
Potential to probe respondents	Low	High	Moderate	Moderate	Low	Low	Low	Low
Potential to build rapport	Moderate	High	Moderate to high	Moderate to high	Low	Low	Low	Low
Speed	High	Moderate to high	Moderate	Moderate to high	Low	Low to high	High	High
Cost	Moderate	High	Moderate to high	Moderate to high	Low	Low to moderate	Low	Low

Source: Malhotra and Birks (2007, p.276).

2.3.3.2 Observation techniques in quantitative research

Quantitative observation methods are extensively used in descriptive research. They involve recording the behavioural patterns of people, objects and events in a systematic manner to acquire information about the phenomenon of interest (Malhotra and Birks, 2007). Observation techniques can be classified by the mode of administration as personal observation, electronic observation, or audit and trace analysis, as shown in Figure 2.3.

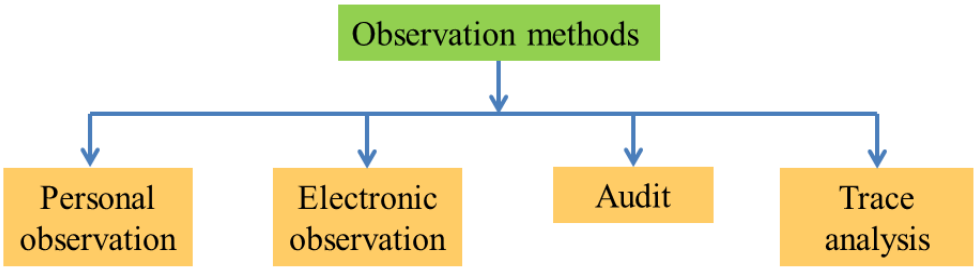


Figure 2.3 A classification of observation techniques

Source: Malhotra and Birks (2007, p.286).

In personal observation, the researcher observes actual behaviour as it occurs live. The observer does not control or manipulate the behaviour being observed but merely records what takes place. In electronic observation, electronic devices are used to record the phenomenon instead of human observers. In an audit, the researchers gather data by examining physical records or performing an inventory analysis. For trace analysis, data collection is based on physical traces or evidence of past behaviour.

Observation techniques, like all other research methods, have their strengths and weaknesses. A comparative evaluation of observation techniques is presented in Table 2.3. Each observation technique is evaluated in terms of structure, disguisability, ability to observe in a natural setting, observation bias, measurement and analysis bias, and additional general factors.

Table 2.3 A comparative evaluation of observation techniques

Criteria	Personal observation	Electronic observation	Audit	Trace analysis
Degree of structure	Low	Low to high	High	Medium
Degree of disguisability	Medium	Low to high	Low	High
Natural setting	High	Low to high	High	Low
Observation bias	High	Low	Low	Medium
Analysis bias	High	Low to medium	Low	Medium
General remarks	Most flexible	Can be intrusive	Expensive	Limited traces available

Source: Malhotra and Birks (2007, p.289).

2.3.3.3 Measurement and scaling in quantitative research

Measurement is the assignment of numbers or other symbols to characteristics of the objects researched according to certain rules (Siegel, 1956). In quantitative research, respondents' perceptions, attitudes, preferences or other relevant characteristics are measured. Scaling is an extension of measurement. It involves generating a continuum upon which measured objects are located. For example, consider a scale for arranging consumers according to the characteristic 'attitude towards horse racing'. Each respondent is assigned a number indicating a favourable attitude (measured as 1), a neutral attitude (measured as 2) or an unfavourable attitude (measured as 3). Measurement is the actual assignment of 1, 2 or 3 to each respondent, whilst scaling is the process of placing the respondents along a continuum with respect to their attitudes towards the characteristic at hand (Malhotra and Birks, 2007).

The scales of measurement can be categorised in four ways: nominal, ordinal, interval and ratio scaling. A ***nominal or classificatory scale*** is a figurative labelling scheme in which the numbers or other symbols are used simply to identify and classify objects, persons or characteristics with a strict one-to-one correspondence between the numbers and objects. It serves as a label or tag. For instance, the numbering of football players provides information about the individual players. Nominal scales represent equivalence and have certain formal properties. These properties give fairly exact definitions of the scale's characteristics. An ***ordinal or ranking scale*** is a scale in which numbers are assigned to objects to indicate the relative extent to which a characteristic is possessed. There is the possibility in an ordinal scale to determine whether an object has more or less of a characteristic than another object,

but not how much more or less. Thus an ordinal scale indicates a relative position, not the magnitude of differences between any objects. For example, there is no guarantee that the distinction between eggs Grade I and II is the same as the difference between Grade II and III. An ordinal scale is usually used to measure relative attitudes, opinions, perceptions and preferences. Measurements of this type include equivalence and 'greater than' or 'less than' decisions from respondents. Any series of numbers can be assigned that maintains the ordered relationship between the objects. An ***interval scale*** is a scale in which numbers are used to rank objects, representing an order and equal distances between any numbers. The scale values in an interval scales are constant. The difference between 3 and 4 is the same as the distinction between 4 and 5, which is the same as the difference between 12 and 13. In this type of measurement, the ratio of any two intervals is independent of the unit of measurement and of the zero point. The unit of measurement and the zero point are arbitrary. A common example of this scale is the temperature scale. However, attitudinal data obtained from rating scales are often treated as interval data in marketing research (Malhotra and Birks, 2007). The ***ratio scale*** is similar to the interval scale, with ranked numbers with equal distances between the numbers throughout the scale, but in addition, it has an absolute zero point. Thus, objects can be identified or classified, ranked, and compared using intervals or differences. For example, the difference between 3 and 8 is not only the same as the distinction between 24 and 29, but also 24 is eight times larger than 3 in an absolute sense. Some common examples of this scale include age, weight, height and money.

Scaling techniques can be classified into comparative and non-comparative scales, as presented in Figure 2.4. Comparative scales enable the direct comparison between stimulus objects. Respondents may for example be asked whether they prefer Coke or Fanta. Comparative scale data require an interpretation in relative terms and have only ordinal or rank order properties. This type of scale includes paired comparisons, rank order, constant sum scales, Q-sort and other procedures. In contrast, non-comparative scales refer to monadic or metric scales, and each object is scaled independently of the other in the stimulus sets. For example, respondents may be asked to evaluate Fanta on a 1-to-6-preference scale (1 = not at all preferred, 6 = greatly preferred). Non-comparative scales can be based on continuous rating or itemised rating scales. The itemised scales can be classified as Likert, semantic differential and Stapel scales. In this dissertation, the Likert itemised rating scale is used to elicit experts' opinions on the sustainability concerns in poultry production.

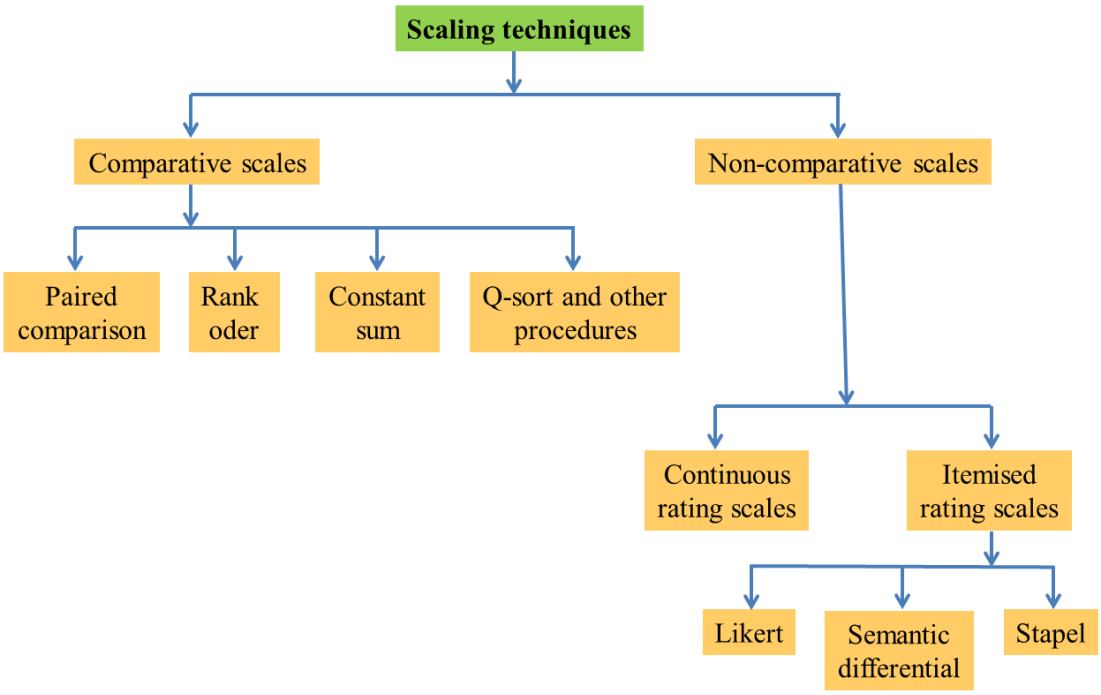


Figure 2.4 A classification of scaling techniques

Source: Malhotra and Birks (2007, p.342).

Likert items/scales were first introduced in 1932 by Rensis Likert to measure respondents' attitudes towards certain issues. Likert items represent an individual issue, whereas Likert scales contain multiple items. Respondents are required to indicate their preferences or opinions on response categories. For example, a five-response category ranging from 'strongly disagree' to 'strongly agree' requires participants to indicate the degree to which they agree or disagree with each of a series of statements about the stimulus objects. The advantage of the Likert scaling technique is that it is simple to construct, administer and understand. However, it consumes more time. The Likert scaling method is widely used in behavioural science but there is still a controversy regarding the analysis of Likert data – whether they should be taken as an ordinal or as an interval scale (Albaum, 1997; Hodge and Gillespie, 2003; Jakobsson, 2004; Weaver, 2005). Brown (2011) argues that whether Likert items are interval or ordinal is irrelevant when using the Likert scale data, since it depends on the researchers' objectives how they interpret the results. Likert scales are often treated as interval scales so that we can calculate average responses (mean) to the statement. Other times they are assumed as ordinal, when the ordering of the responses needs to be stressed (Schmee and Oppenlander, 2010). Table 2.4 summarises the levels of measurement, their properties and appropriate statistics for analysing data based on Siegel (1956) and Malhotra and Birks (2007).

Table 2.4 Levels of measurement and their appropriate statistics

Scale	Basic characteristics	Examples of appropriate statistics	Appropriate statistical tests
Nominal	Numbers identify and classify objects	Percentages, Mode, Frequency, Chi-square, Binomial test	Nonparametric statistical tests
Ordinal	Numbers indicate the relative positions of the objects but not the magnitude of differences between them	Percentile, Median, Frequency, Percentile, Spearman rank order correlation, Mann-Whitney U test, Kendall's coefficient of concordance (W)	
Interval	Differences between objects can be compared; zero point is arbitrary	Range, Mean, Standard deviation, Pearson product-moment correlation, T tests, ANOVA, Regression, Factor analysis	Nonparametric and parametric statistical tests
Ratio	Zero point is fixed; ratios of scale values can be computed	Geometric mean, Harmonic mean, Coefficient of variation	

Source: adapted from Siegel (1956) and Malhotra and Birks (2007).

Nonparametric statistical tests are tests which make no assumptions about the distribution of a statistical population. They are used if the data are along a nominal or ordinal scale. In contrast, parametric statistical tests are tests whose models specify certain conditions about the parameters of the population from which the research sample is drawn. They assume that the variables of interest are measured on at least an interval scale. Most parametric tests have nonparametric versions, if the assumptions for a parametric test application are violated, a nonparametric alternative can be used to analyse the data (Harris et al., 2008). For example, the nonparametric alternative to Pearson's Product Moment Correlation is Spearman's Rank Correlation. This rule is helpful in selecting the appropriate nonparametric alternatives to parametric statistical tests.

2.3.3.4 Quantitative data analysis

There are different statistical tests used for quantitative data analysis as shown in Table 2.4. In this dissertation, frequency, percentage, measure of central tendency (mean), measure of dispersion (standard deviation) and measure of relationship (Kendall's coefficient of concordance (W)) will be used to analyse quantitative data. Thus, these statistical instruments will be explained more in detail.

Frequency or absolute frequency of a particular value is the number of times that a certain value occurs in an experiment or study.

Percentage displays a value for a variable in relation to a whole population as a fraction of one hundred. A percentage is calculated by first dividing the absolute frequency by the total number of values for the variable (relative frequency) and then multiplying this number by 100.

Mean or average value is used to estimate data when they have been collected using an interval or ratio scale. The data display a central tendency, with most of the responses distributed around the mean. The mean, $\bar{X}$, is calculated by

$$\bar{X} = \frac{\sum_{i=1}^{n} X_i}{n}$$

where

X_i = observed values of the variable X

n = number of observations (sample size).

Standard deviation is the square root of the mean squared deviation from the mean (variance). It is used to indicate the distribution of an observed value from the mean of the entire population. The standard deviation of a sample, s, is calculated by

$$s = \sqrt{\sum_{i=1}^{n} \frac{\left(X_i - \bar{X}\right)^2}{n-1}} \ .$$

Kendall's coefficient of concordance (W) measures the agreement between judges or raters who are assessing a given set of n objects or issues. Depending on the application field, the 'judges' can be variables. The null hypothesis (H_0) of Kendall's test is that the p judges produced independent rankings of the objects. It is calculated as

$$W = \frac{12S}{p^2\left(n^3 - n\right) - pT}$$

(Siegel, 1956; Siegel and Castellan, 1988) where n is the number of objects, p the number of judges. T is a correction factor for tied ranks:

$$T = \sum_{k=1}^{m} \left(t_k^3 - t_k\right)$$

in which t_k is the number of tied ranks in each (k) of m groups of ties. S is a sum-of-squares statistic over the row sums of ranks R_i. $\bar{R}$ is the mean of the R_i values. S can be obtained from the following formula:

$$S = \sum_{i=1}^{n} \left(R_i - \overline{R}\right)^2 .$$

2.3.4 Qualitative research methods

Qualitative research encompasses a variety of methods that can be applied in a flexible manner to enable respondents to reflect, express their opinions and observe their behaviour. As it is not always possible or desirable to use structured quantitative techniques to obtain information from participants or to observe them, qualitative techniques can be alternatively used for the following reasons: preferences and/or experience of the researcher; preferences and/or experience of the research participant; sensitive information; subconscious feelings; complex phenomena; the holistic dimension; developing new theory; and interpretation (Malhotra and Birks, 2007).

Qualitative research techniques can be classified as either direct or indirect as shown in Figure 2.5. A direct approach is a research technique that openly discloses the purpose of the study to the respondent, or the purpose of the study is obvious to them based on the questions asked.

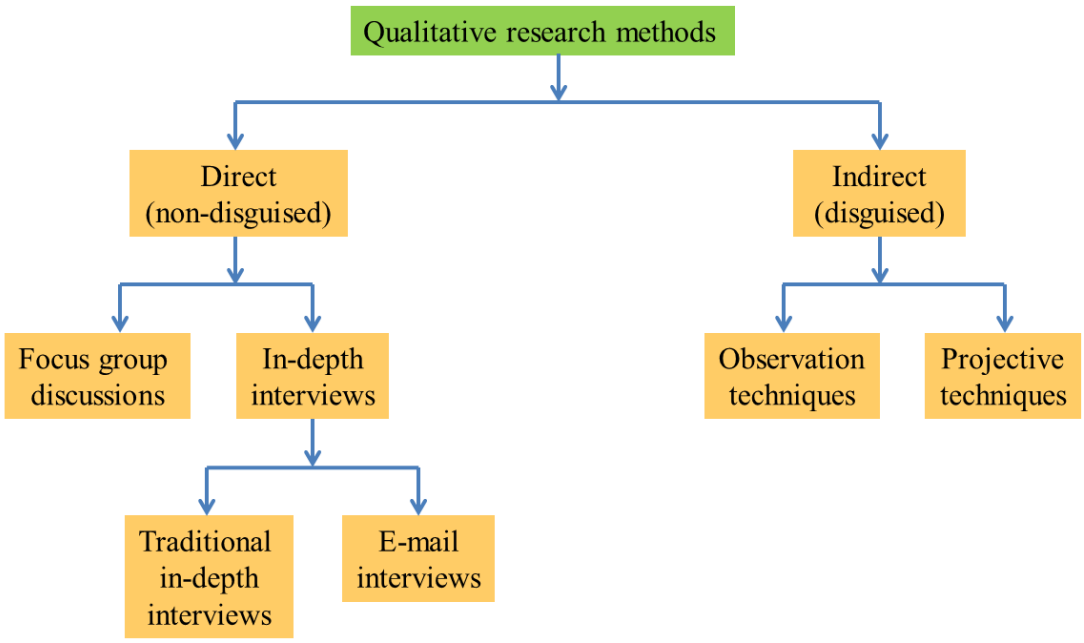


Figure 2.5 A classification of qualitative research techniques

Source: adapted from Malhotra and Birks (2007).

Focus groups and in-depth interviews are the most commonly used direct techniques. In contrast, an indirect approach conceals the purposes of the research study from the participants. In this approach, the researcher wants participants to behave as naturally as possible, without the research study influencing their behaviour. Observation and projective techniques are the main indirect approaches. In observation or ethnographic techniques, consumers are observed shopping, choosing products and interacting with other people and objects in a natural environment and a natural manner, whilst the projective techniques are used to discover underlying motivation, beliefs, attitudes or feelings regarding consumer behaviour.

In this dissertation, in addition to an analysis of secondary data, qualitative in-depth e-mail interviews are used to obtain information on the actions undertaken by NGOs, animal welfare groups and the leading integrated poultry firms regarding the sustainability of poultry production. In-depth e-mail interviewing is described in detail in the following section.

2.3.4.1 E-mail interviewing in qualitative research

A traditional in-depth interview is an unstructured, direct and personal interview in which a single respondent is probed by an experienced interviewer to uncover underlying motivation, beliefs, attitudes and feelings towards a certain issue. The interviews are conducted in face-to-face conversations. In contrast, an in-depth e-mail interview is conducted via e-mail, involving multiple e-mail exchanges between the interviewer and interviewee over an extended period of time. The objective of qualitative interviews is to derive meaning through the interpretation of what the study participant says (Malhotra and Birks, 2007).

E-mail interviewing has become increasingly popular for conducting qualitative research, as concluded by Meho (2006) in his work. Prominent studies using e-mail interviewing as a research method were conducted by Murray (1995, 1996), Kennedy (2000), Curasi (2001), Karchmer (2001), Kim et al. (2003), Meho and Tibbo (2003), Lehu (2004) and Murray (2004).

As with other qualitative research methods, e-mail interviewing has its advantages and disadvantages, which are presented in Table 2.5. Thus, researchers have to plan carefully and choose the most appropriate methods for their research study.

Table 2.5 Advantages and disadvantages of e-mail interviewing

	Advantages	Disadvantages/Challenges
Interviewers and participants	Allows access to individuals often difficult or impossible to reach or interview face-to-face or via telephone Allows access to diverse research subjects Allows access to individuals regardless of their geographic location Allows interviewing of individuals who do not or cannot express themselves as well in talking as they do in writing Allows interviewing of individuals who prefer online interaction over face-to-face or telephone conversation	Limited to individuals with access to the Internet Requires skills in online communication from both interviewer and interviewees Requires expertise in technology from both interviewer and interviewees
Cost	Eliminates expenses of calling and traveling Eliminates expenses of transcribing Decreases cost of recruiting large/geographically dispersed samples	Can be high for participants
Time	Eliminates time required for transcribing Eliminates the need to schedule appointments Allows interviewing more than 1 participant at a time	May take several days or weeks before an interview is completed
Recruitment	Done via e-mail, listservs, message boards, discussion groups, and/or web pages	Invitations to participate in the study may be deleted before they are read (if they are classified as spam)
Participation	Done by e-mail	Low rate of deliverance (e.g., due to inactive e-mail addresses)

Table 2.5 (Continued)

	Advantages	Disadvantages/Challenges
Medium effects	Allows participants to take part in the interviews in a familiar environment (e.g., home or office) Allows participants to take their time to answer questions Allows participants to express their opinions and feelings more honestly (because of the sense of anonymity) Encourages self-disclosure Eliminates interruptions that take place in face-to-face/telephone interviews Eliminates transcription errors Eliminates interviewer/interviewee effect resulting from visual and nonverbal cues or status differences between the two (e.g., race, gender, age, voice tones, dress, gestures, disabilities) Cues and emotions can be conveyed through use of certain symbols or text	Empowers participants, essentially allowing them to be in control of the flow of the interview Does not allow direct probing Requires questions to be more self-explanatory than when posed face-to-face or by telephone to avoid miscommunication and misinterpretation Loses visual and nonverbal cues due to inability to read facial expressions or body language and hear the tones of voice of each other May narrow participants' interpretations and, thereby, constrain their responses Requires meticulous attention to detail Participants may lose focus
Data quality	Allows participants to construct their own experiences with their own dialogue and interaction with the researcher Facilitates a closer connection with interviewee's personal feelings, beliefs, and values Data are more focused on the interview questions asked Responses are more thought out before they are sent	One-dimensional (based on text only) In-depth information is not always easily obtainable

Source: Meho (2006, p.1292).

2.3.4.2 Qualitative data analysis

There are several research approaches to analyse qualitative data such as grounded theory and content analysis.

Grounded theory is an approach used to generate theory through the systematic and simultaneous process of data collection and analysis. This approach is commonly applied to the following: generating new theory in fields where little is already known; providing a fresh

perspective on existing knowledge, i.e. to supplement existing theories; and challenging existing theories. However, grounded theory has been criticised for its failure to acknowledge implicit theories (Malhotra and Birks, 2007).

Content analysis is a technique that makes inferences by systematically and objectively identifying special characteristics in messages (Holsti, 1969). Krippendorp (2004) defines it as a research method that makes replicable and valid inferences from texts (or other meaningful matter) to the contexts of their use. Texts analysed range from the content of brochures or advertising copy, to dialogues held in interviews. It is a classical method for analysing textual material or communications rather than behaviour or physical objects. Despite its frequent and widespread use in qualitative data collection and analysis, content analysis is limited when it comes to involve the issues of manifest content, data fragmentation and quantification.

In this study, the qualitative data is analysed using a generic process based on Malhotra and Birks (2007), consisting of the four stages outlined in Figure 2.6.

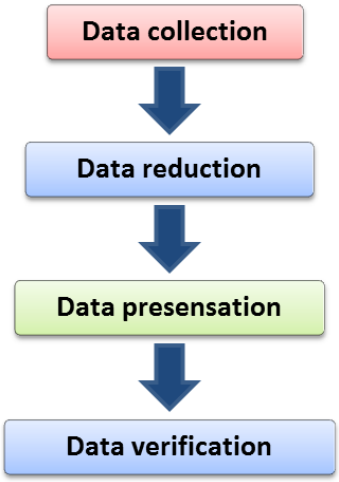


Figure 2.6 Stages of qualitative data analysis

Source: adapted from Malhotra and Birks (2007).

Data collection means the gathering of data from a variety of sources, including: notes taken during interviews; reflection of researchers involved in the data collection process; theoretical support from secondary data or literature sources; documents produced by or sourced from participants; and photographs, drawings or diagrams, i.e. still visual images.

Data reduction is the process of organising and structuring the data. The transcripts are a useful data source for this process. Reducing the data involves coding the data, which breaks down the qualitative data into discrete chunks and attaches a reference to them. Coding enables the researcher to identify what he or she sees as meaningful and sets the stage for drawing conclusions and interpreting the meaning. In general, the coding process involves the following stages: set up a broad group of coding categories; work through the data to uncover chunks of data that may be put into brackets, underlined or highlighted; review the descriptions given to the codes; examine differences between different participant types; develop models of interconnectivity between the coded categories; and iterate between the code descriptions and the developing model.

Data presentation is the organised and compressed gathering of information that allows the researcher and reader alike to draw conclusions and inspire further action. Data may be displayed in the form of matrices, graphs, charts and networks. Data presentation also gives insights into how the researcher made connections between the different data chunks.

Data verification is a process that involves seeking alternative explanations based on other data sources and theories. When final conclusions have been made, researchers need to demonstrate that they data they collected have a valid meaning. Secondary data and the academic literature can be used to place the meaning of the data within the wider context. In addition, data verification can be made through examining similar research findings and applying explanations given for different contexts and timeframes and by different researchers. The process of data verification gives qualitative researchers the confidence that the participant views they represent are in fact valid.

2.4 The Delphi method

The Delphi method was developed in the 1950s by the RAND Corporation in Santa Monica, California, in an attempt to develop a technique to obtain a reliable consensus from a group of experts (Dalkey and Helmer, 1963) by allowing them to express their own opinions on an issue, while taking into account the other respondents' views by means of controlled feedback. It is named after the ancient Greek oracle at Delphi, which offered visions of the future to those who sought advice (Gupta and Clarke, 1996).

2.4.1 Characteristics of the Delphi method

Dalkey and Helmer (1969) define the Delphi method as a technique of eliciting and refining group judgements for subject matters where precise information or exact knowledge is lacking. It is also used to collect expert opinions and obtain a consensus between experts on the various unknown factors under consideration (Green et al., 1990). The Delphi technique is based on structural surveys and the use of the experiences and knowledge of experts in the relevant fields. The method was developed to overcome the shortcomings of face-to-face meetings (Torrance, 1957). It is assumed that the method makes better use of group opinions (Rowe et al., 1991).

The Delphi technique has four main features (Rowe et al., 1991): anonymity, iteration, controlled feedback and statistical group response. ***Anonymity*** is accomplished by using formal questionnaires. Group members can freely express their opinions without being influenced by other group members by completing the questionnaires in their own homes or offices, which is a way of reducing the effects of dominant individuals. ***Iteration and controlled feedback*** are done during the Delphi process. The survey is conducted in several iterations with carefully controlled feedback, giving the group members the chance to comment and revise their previous answers in each succeeding round. ***Statistical group response*** is obtained at the end of each round where group judgements are expressed as means, medians, interquartile ranges or standard deviations based on the numerical ratings of each item. In the final round, the group opinions are aggregated and presented as a simple statistical summary. These four basic features are seen as the strength of the Delphi study (Linestone and Turoff, 1975), since they minimise the biasing effects of dominant individuals, irrelevant communications and group pressure towards conformity.

2.4.2 Advantages and disadvantages of the Delphi method

The main advantage of the Delphi method is that it employs group decision-making techniques by involving experts in the field: It helps to overcome the shortcomings of either solely relying on just one expert's opinions, or conducting a round table discussion which can be biased and dominated by opinionated leaders. The Delphi procedure forces participants to consider the issue being researched logically and to provide written responses, leading to a consensus being reached by the group that reflects reasoned opinions (Murry and Hammons,

1995). The technique guarantees anonymity because responses will never be publicly attributed to each individual. Since the interviews are done through regular mail or e-mail, there is no need to travel during the study which eliminates the complications of organising a meeting, reducing the cost of research and removing geographic boundaries. The results of a Delphi study allow for analyses, ranking and priority-setting. The method forces participants to think about possible future scenarios and provides respondents with the opportunity to think deeply and collect further information between the rounds (Grobbelaar, 2007).

However, there are some disadvantages to using the Delphi method. Since the Delphi process requires time for the panellists to respond to the questionnaire between rounds, it is a fairly time-consuming method and it difficult to convince people to answer a questionnaire twice or more often. The questionnaire design and selection of expert panellists have to be prepared carefully and the researcher needs to be very familiar with this method.

2.4.3 Application of the Delphi method

The Delphi method is extensively used in information management, decision science, risk analysis, supply chain management and related fields to identify, rank and prioritise issues, as well as to make future projections (Akkermans et al., 2002: Lummus et al., 2005). For example, it has been used to identify the most important emerging occupational safety and health risks for workers in Europe (Reinert et al., 2007); determine the level of social acceptance and problems in the utilisation of renewable energy sources for different uses (Iniyan et al., 2001); identify and assess the environmental impact of tourism development (Green, et al., 1990); identify risk factors for clinical bovine respiratory disease (BRD) in young dairy livestock in the Netherlands (van der Fels-Klerx et al., 2000); determine a set of best practices to reduce nitrogen emissions from a poultry unit under the Integrated Pollution Prevention and Control Directive (IPCC) (Angus et al., 2003); evaluate the stakeholder perceptions of equine welfare (Collins et al., 2009); identify emerging needs in international or European agrifood policy (Frewer et al., 2011); elicit opinions from experts and farmers on non-regulatory animal health issues facing the Irish livestock industries (More et al., 2010); explore changes in future production structures within the cross-border region of the Netherlands, North Rhine Westphalia and Lower Saxony by 2020 (Hop et al., 2014); study food risk analyses in the European Union (Wentholt, 2009); analyse risk factors for the introduction of *Salmonella spp.* and *Campylobacter spp.* in poultry farms (Wilke, Windhorst

and Grabkowsky, 2011); assess risk of Avian Influenza (Grabkowsky, 2009); and study economic competitiveness of the German swine industry (Veauthier, 2011) and poultry industry (Veauthier and Windhorst, 2011).

2.4.4 Considerations in using the Delphi method

The Delphi technique is best used in fields of study where the knowledge is limited or there is no historical data available (Gupta and Clarke, 1996). However, it should be noted that the Delphi method might be unsuitable for more complex issues where the theme cannot be reduced or simplified, and for studies with the key objective of inspiring reflection and discussions on alternatives (Eto, 2003). With the growing use of the Delphi method, there has also been a growing impact of the methodology on both corporate planning and government policy-making. Because the results are generated from judgments it is important that the methodology is used properly and the outcomes are interpreted carefully (Story et al., 2001). Since in each succeeding round of questionnaires in the Delphi process the range of responses will presumably decrease, maintaining participant interest in the Delphi study is a challenge (Beech, 1999). Thus, in order to apply the Delphi method successfully, the questionnaire design and expert selection process need to be done carefully.

2.4.5 The process of Delphi study on sustainability concerns in poultry production

In this dissertation, a Delphi study is conducted to identify the sustainability concerns in poultry production in Germany and Thailand. This method is able to incorporate different expert opinions on the sustainability concerns in poultry production and is particularly appropriate for situations where a consensus among the experts is not necessary. This Delphi study consists of four steps: questionnaire design, selection of the expert panellists, survey, and data analysis, as presented in Figure 2.7.

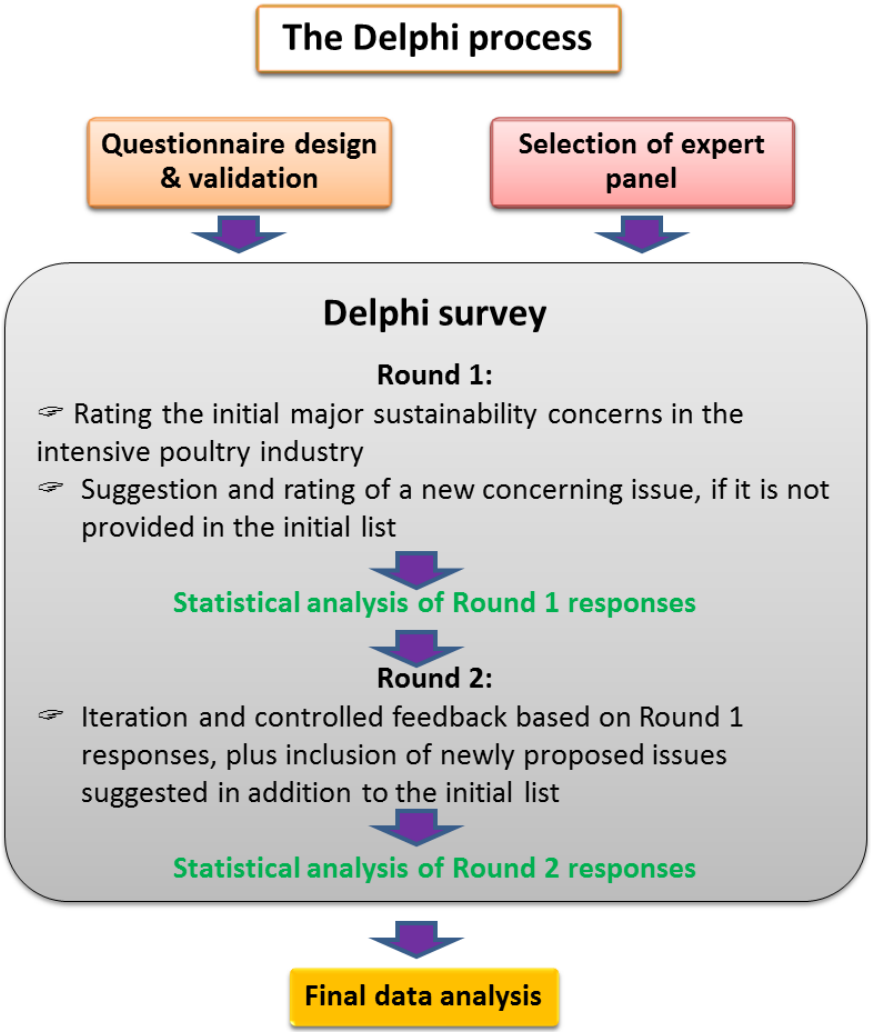


Figure 2.7 The process of the Delphi study

Source: Author's design.

2.4.5.1 Questionnaire design and validation

For this step, a literature review was conducted to identify the main sustainability concerns in poultry production. This exploration focused on peer-reviewed articles, books, magazines, conference papers and reports published in English, German and Thai. The environmental, economic, social, political and animal welfare issues were taken into consideration while framing the Delphi questionnaire. Copies of this questionnaire were distributed to 7 experts as a preliminary test to check its validity. Based on their comments, necessary changes were made and a final version of the Delphi questionnaire was developed.

2.4.5.2 Selection of the expert panellists

The Delphi study is a group decision mechanism requiring qualified experts who are specialists on the issues being researched. Thus, choosing the panel members is a crucial prerequisite for a successful Delphi study (Martino, 1993). The experts were proposed by staff members of the Science and Information Centre for Sustainable Poultry Production (WING), University of Vechta, as well as from browsing organisation websites and journal databases. The selection of experts follows the guidelines of Delbecq et al. (1975) and Okoli and Pawlowski (2004), and was based on the experts' professional experiences in the poultry industry, including publications in the field, conference participation, project references and years of experience in academia, government, NGOs or the private sector. A four-step procedure for selecting the experts is shown in Figure 2.8.

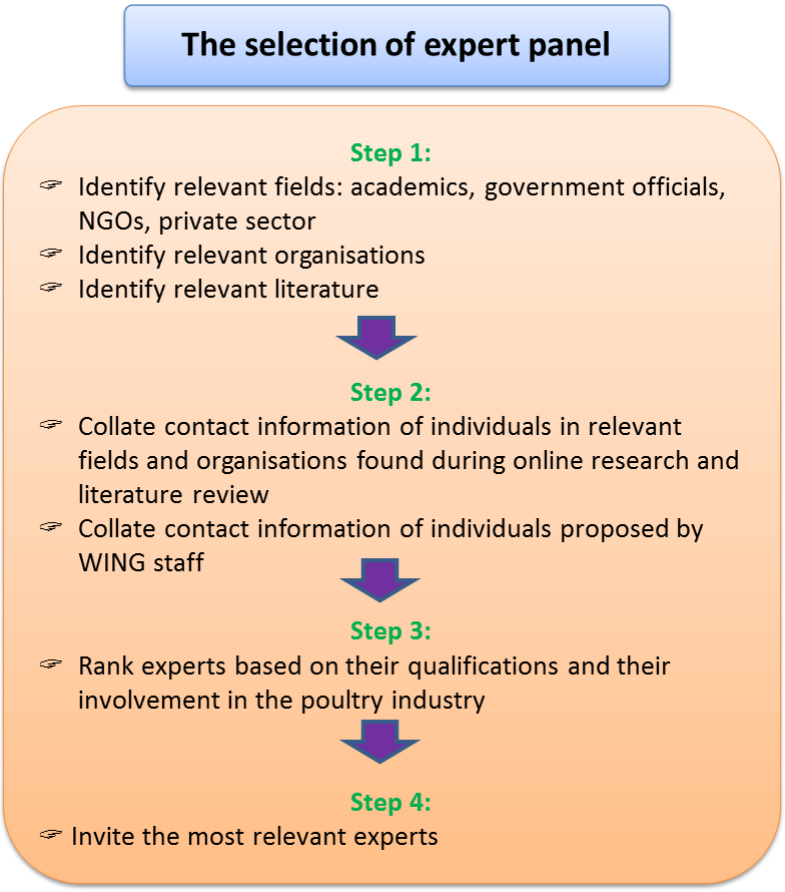


Figure 2.8 The procedure for selecting expert panel

Source: Author's design.

Linestone and Turoff (1977) argue that there is no optimum size of respondents for a Delphi study, but propose a minimum of 4 – 7 experts. Adler and Ziglio (1996), in contrast, suggest 20 – 30 participants for each issue. The reliability of the group responses can be increased by a higher number of participants (Dalkey et al., 1972). All in all, however, the literature is divided on the issue of the optimal size of a Delphi panel (Williams and Webb, 1994).

The objective of this Delphi study was to identify and explore relevant sustainability concerns in poultry production. Thus, for this study, 45 experts from Germany and 50 experts from Thailand were identified and invited to participate in the Delphi study. This study was conducted from March to June 2014 and August to November 2014 for the case studies in Germany and Thailand, respectively.

2.4.5.3 Delphi survey

Before the first questionnaire was distributed to the respondents, the formal invitation describing the project was sent out via e-mail to the selected experts asking them participate in the Delphi study and allocate 15 minutes of their time to each round of questionnaires. They were asked to respond 3 weeks before the first round of questionnaires.

The first round of questionnaires (R1) was sent to the experts representing different sectors in the poultry industry, including non-governmental organisations (NGOs), animal welfare groups, researchers, the private sector (retailers and firms related to the poultry industry), government officials and politicians, who had previously agreed to participate in the Delphi study. They were asked to: a) rate their level of concern regarding the sustainability issues in poultry production provided in the questionnaire based on scientific literature and reports; and b) suggest further concerning issues, if they are not included in the list, and rate them using a five-point Likert scale rating system. This first questionnaire aimed to evaluate to what extent the experts are concerned about sustainability issues in poultry production and collect additional issues that respondents thought are relevant to the study. This process ensured that all issues were considered and that the analysis was not limited by the design capability of the researcher. Thus, participants were given the opportunity to indicate where they felt the questionnaire did not sufficiently address issues. Respondents were given a period of two weeks to complete their questionnaires.

The second round of questionnaires (R2) was based on the responses from the first round (R1). It was an iteration of R1 which gave the participants the chance to revise their answers given in R1. Here, the responses from R1 were presented using percentage to reflect the group opinions, so that respondents could compare their previous responses to the rest of the group. In addition, the new concerning issues proposed by the expert panels in R1 were added to the initial list of sustainability concerns which were then rated by the respondents in R2.

In a next step, the responses from the first and second rounds of questionnaires were compared. If the results showed only minor changes for the level of concern over sustainability issues and there were no newly proposed issues, the Delphi survey could be terminated after the second round of questionnaires. On the other hand, if the outcomes presented a significant change for the level of concern over sustainability issues and there are still additional issues proposed, the Delphi survey can be continued in another round.

The final results will be summarised as frequency, percentages, means, standard deviations and Kendall's coefficient of concordance (W) and reported back to the panel in an easily understandable way.

2.4.5.4 Data analysis of the Delphi study

The opinions of the expert panels on the main sustainability concerns in poultry production are expressed on a five-point Likert scale rating system which is based on Vagias (2006): 1 = not at all concerning issue, 2 = slightly concerning issue, 3 = somewhat concerning issue, 4 = fairly concerning issue, and 5 = very concerning issue. For each issue, the frequencies, percentages, mean values and standard deviations are calculated. The Kendall's coefficients of concordance (W) are computed for the level of agreement between the experts assessing a given set of concerning issues. A more detailed explanation of these four statistic values is included in the previous section 'quantitative data analysis'. The Statistical Package for Social Science (SPSS) computer programme is used for entering and analysing the data collected. The interpretation of statistical values is set out as follows:

Frequency or absolute frequency is used to express the number of times that a certain value appears in a statistical study. It is often graphically represented in histograms.

Percentage is a particularly useful value for expressing the relative frequency of survey responses and other data.

Mean value (MV) is used to identify the levels of concern. It is selected because the purpose of the Delphi method is to include all opinions. Reinert et al. (2007) uses the mean value to evaluate the emerging occupational safety and health risks in a Delphi study. Based on the definition of the five-point Likert scale used in this Delphi study, the mean value is interpreted following the guidelines created by the Australian government for internal purposes (Wrench, 2013) as shown in Table 2.6.

Table 2.6 The interpretation of mean value in identifying the level of concerns

Mean value (MV)	Level of concerns
1.00 – 1.80	Not at all concerned
1.81 – 2.60	Slightly concerned
2.61 – 3.40	Somewhat concerned
3.41 – 4.20	Fairly concerned
4.21 – 5.00	Very concerned

Source: adapted from Wrench (2013).

Standard deviation (SD) reflects the level of consensus on one item amongst the expert panels in this Delphi study. Grobbelaar (2007) proposes decision criteria for the level of consensus reached in the Delphi study as presented in Table 2.7. A decreasing standard deviation indicates an increase in the consensus between experts on an issue.

Table 2.7 Decision criteria for the level of consensus reached in the Delphi study

Standard deviation (SD)	Level of consensus achieved
$0.0 \leq SD < 1.0$	High level
$1.0 \leq SD < 1.5$	Reasonable/fair level
$1.5 \leq SD < 2.0$	Low level
$SD \geq 2.0$	No consensus

Source: adapted from Grobbelaar (2007).

Kendall's coefficient of concordance (W) indicates the level of agreement between the expert panellists assessing a given set of concerning issues. Schmidt (1997) proposes the interpretation of Kendall's W value as described in Table 2.8.

Table 2.8 Interpretation of Kendall's W

W	Interpretation	Confidence in Ranks
0.1	Very weak agreement	None
0.3	Weak agreement	Low
0.5	Moderate agreement	Fair
0.7	Strong agreement	High
0.9	Unusually strong agreement	Very high

Source: Schmidt (1997, p.767).

Kendall's W value can vary from *0* to *1*. If the test result *W* is *1*, then all the expert panels agree unanimously, and each expert has assigned the same order to the list of objects or concerns. If *W* is *0*, then there is no overall consensus between the experts, and their responses may be regarded as essentially random. Intermediate values of *W* indicate a greater or lesser degree of unanimity between the various experts.

2.5 Summary of research methodology for data collection and analysis

This study on sustainability in poultry production in Germany and Thailand employs both primary and secondary data analyses. Secondary data are used to: document a broad perspective on sustainability concepts (*Chapter 3*); and review the current sustainability issues in poultry production (*Chapter 4*). Qualitative and quantitative analyses of primary and secondary data are used to analyse the structures, production data, regional concentration and organisational models of poultry production in Germany and Thailand (*Chapter 5*). The Delphi method is used to identify and rank the main sustainability concerns in poultry production (*Chapter 6*). A qualitative in-depth e-mail interview and secondary data analyses are applied to evaluate and compare actions undertaken by NGOs, animal welfare groups and the leading integrated poultry firms regarding the sustainability of poultry production (*Chapter 7*). The results of the main findings of this study (*Chapter 3 – 7*) will be discussed and provide recommendations on how to improve the sustainability in poultry production (*Chapter 8*). Finally, the summary of this study and conclusions will be provided (*Chapter 9*).

Chapter 3
Sustainability: an outlook for the poultry industry

3.1 Introduction

This chapter provides a broad overview of the sustainability issues faced by agriculture and the poultry industry. The literature review will cover the following topics: 3.2) The sustainability concept; 3.3) Sustainable agriculture and the concept of sustainable intensification; 3.4) Assessment of sustainability in agriculture and poultry production; and 3.5) Conclusion.

3.2 The sustainability concept

Issues such as climate change, poverty, biodiversity loss/conservation, food security and animal welfare represent serious challenges for mankind and have warranted a range of strategies and innovations devised to mitigate and avert their negative impacts. The problem solving process for such complex issues is usually highly time-consuming and needs to be modified according to social and natural conditions. The concept of sustainability has emerged as a holistic approach to addressing these concerning issues and securing human well-being. Due to the diversity found in society, culture, environment and economics across the world, the concept of sustainability emerged over a long period of time and in different locations. To understand the concept of sustainability and its application, the emergence and meaning of this concept need to be discussed.

3.2.1 The emergence of sustainability and sustainable development

The idea of "sustainable development" was first mentioned in accounts of the history of Irokese tribes in Northern America (Mergelsberg, 2000). According to these accounts, when making decisions the chieftains took into consideration what impact actions in the present would have on the needs of future generations. Three hundred years ago, the concept of "sustainability" was taken up again and developed further in the German forestry sector by the miner von Carlowitz (Becker, 1997). He discussed the problem of extensive deforestation without considering consequential reforestation, and used the term "Nachhaltigkeit" - equivalent to "sustainability" - to describe the idea of maintaining the long-term productivity

of a timber plantation supplying construction poles for the mining industry. Hartig (1795) published the paper *"Instructions for the Taxation and Characterisation of Forests"* as an approach to using forests as efficiently as possible whilst considering the needs of future generations (Greis, 1997).

A wider societal discussion on sustainability was initiated by Malthus (1798) in his work *"An Essay on the Principle of Population"*, linking population growth to food supply. Mill (1848) also raised the point that the world's population and wealth would not be able to continue increasing indefinitely. Hardin (1968) built upon this idea in his work *"The Tragedy of the Commons"* and argued that there is no technological solution to the challenge of population growth (Onuki and Mino, 2011). However, Daly (1977) argued in his book *"Steady-State Economics"*, that to prevent the depletion of the Earth's resources and the destruction of the natural environment, the total number of people and physical goods must be capped at a reduced level.

Carson's (1962) work *"Silent Spring"*, a powerful book describing the risks of agricultural pesticides for wildlife and human health, was considered a turning point for society's understanding of the interdependent relationship between the environment, economy and social well-being of communities. Since then, the journey towards sustainable development has been marked by many significant milestones (IISD, 2012), such as the Ramsar Convention of 1971 with the mission to use wisely and conserve wetlands and their resources in a move towards global sustainability (Ramsar Convention, 1971).

Sustained population growth, resource availability and use, economic growth, quality of life and environmental sustainability motivated The Club of Rome to publish *"Limits to Growth"*, arguing that if humanity continues along its present course, food shortages, natural resource depletion and environmental degradation will inevitably lead to a disastrous scenario involving radical attrition of the population (Meadows et al, 1972). Several studies on mankind's interaction with the environment (Vogt, 1949; Carson, 1962; Hardin, 1968; Ehrlich, 1968) and an increasing awareness of "green" issues have resulted in a number of major international meetings to address the interactions between development and environment, which are often considered as "milestones" in the history of sustainable development (Morse, 2010).

1972 was considered as a landmark year for environmental action, when the United Nations Conference on the Human Environment (UNCHE) took place in Stockholm. It was the first major international meeting to discuss sustainability and the links between environment and development at a global scale. The Stockholm conference was dedicated to environmental issues due to increased pollution and acid rain problems in northern Europe. This was preceded by a special publication of *"The Ecologist"* magazine entitled *"Blueprint for Survival"* which remains highly influential to this day (Morse, 2010). It led to the establishment of the United Nations Environmental Programme (UNEP) and the founding of numerous national environmental protection agencies. The recommendations from the Stockholm Conference were further elaborated in the *"World Conservation Strategy"* published by the International Union for the Conservation of Nature (IUCN), the United Nations Environmental Programme (UNEP) and the World Wildlife Fund (WWF), which first coined the term "sustainable development" (IUCN-UNEP-WWF, 1980). This work aimed to promote sustainable development by identifying priority conservation issues and key policy options (UN, 2010).

Sustainability and sustainable development gained recognition almost overnight when the United Nations World Commission on Environment and Development, also known as the Brundtland Commission, published its report *"Our Common Future"*. They linked the term to development, and added economic aspects to the former ecological and social aspects of sustainability by defining sustainable development as *"development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (WCED, 1987, p.37). Another prominent definition of sustainable development was published in *"Caring for the Earth"* by the IUCN, the UNEP and the WWF. The term was defined as *"development that improves the quality of human life while living within the carrying capacity of supporting ecosystems"* (IUCN-UNEP-WWF, 1991, p.10).

"Our Common Future" provided the momentum for the landmark 1992 Earth Summit, which was held in Rio de Janeiro. The United Nations Conference on Environment and Development (UNCED), more commonly known as the "Earth Summit", adopted the Rio Declaration on Environment and Development and Agenda 21, a global plan of action for sustainable development (UN, 2010). The declaration mentioned the economic and environmental concerns that had been the main focus of sustainability, but added social issues like peace, poverty, and the role of women and indigenous people (Blackburn, 2007). Three

seminal instruments of environmental governance were established at the Earth Summit: the United Nations Framework Convention on Climate Change (UNFCCC), the Convention on Biological Diversity (CBD) and the non-legally binding Statement of Forest Principles (UN, 2010). Following the recommendations of Agenda 21, the United Nation General Assembly officially created the Commission on Sustainable Development (CSD) later that year. The Earth Summit was very successful from a political viewpoint: it received global attention, and virtually every national leader was present and expressed their commitment to the cause. However, it was not without its challenges: firstly, too much of an emphasis was placed on the "environment pillar" during negotiations, and secondly, not enough implementation targets were set out in Agenda 21, particularly related to development aid and cooperation (UN, 2010).

In 1996, the German Enquete-Commission on "Protection of Man and Environment" of the German Bundestag proposed legislation on solving ecological and social problems within the country. In its final report *"Concept Sustainability, from Theory to Application",* general rules were defined (Enquete-Kommission, 1998). Following the Earth Summit, the first Conference of the Parties (COP) to the United Nations Framework Convention on Climate Change (UNFCCC) was held in 1995 in Berlin. In 1997, the Conference of the Parties (COP-3) was held in Tokyo and the Kyoto Protocol was adopted, committing 40 industrialized nations to cut their average annual greenhouse gas emissions (GHGs: carbon dioxide, nitrous oxide, methane, two types of fluorocarbons and sulphur hexafluoride) between 2008 to 2012 by at least 5 per cent compared to 1990 emissions (Sawa, 2011).

The World Summit on Sustainable Development (WSSD) was held in 2002 in Johannesburg, with an emphasis on the linkages between poverty and environmental degradation. Education was mentioned as an important foundation for sustainable development, which is still an important ongoing area of work. In 2012, the United Nations Conference on Sustainable Development or Rio +20 was again held in Rio de Janeiro, where the global community reconvened in an effort to secure an agreement on "greening" the world's economy through a range of smart measures for clean energy, decent jobs and a more sustainable and equitable use of resources (IISD, 2012). The conference produced a politically-oriented document which contains clear and practical measures for implementing sustainable development.

Since the 1980s, there has been an obvious shift in thinking from a primarily environmental understanding of sustainability towards the three dimensions of environmental, social and economic pillars. This broader approach is embraced by today's concept of sustainable development, commonly framed as the need to improve the quality of life for all people now and in the next generation (WCED, 1987; UNCED, 1992a). Figure 3.1 provides a timeline of the development of the concepts of sustainability and sustainable development.

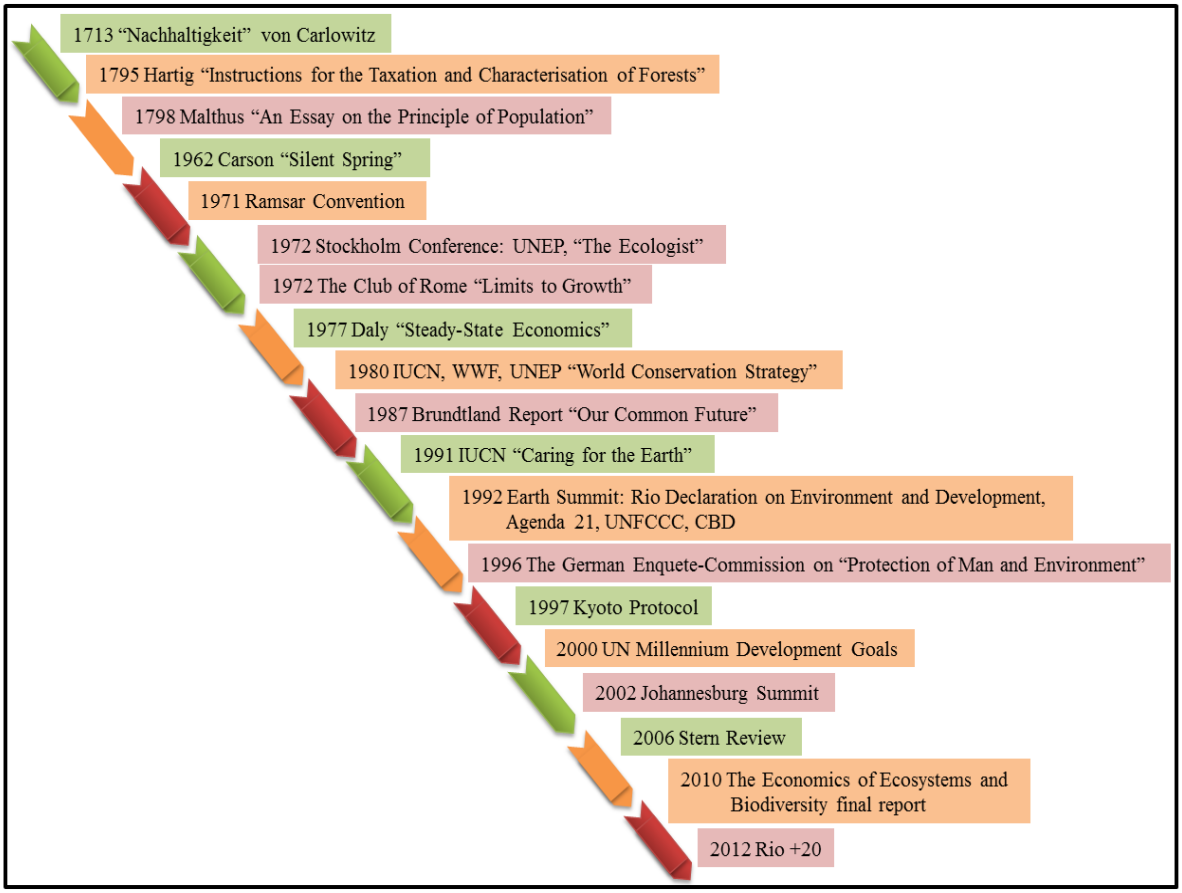


Figure 3.1 Timeline of sustainability and sustainable development

Source: Author's design.

3.2.2 Overview of sustainability definitions and concepts

The concept of sustainability featured frequently in important global political documents such as the Brundtland Report (WCED, 1987), the Rio Declaration (UN, 1992a), the Agenda 21 (UN, 1992b), and the Johannesburg Declaration (UN, 2002), and has been recognized by and discussed widely in public and scientific discourse (Becker, 2012). In the Agenda 21, the terms "sustainability and "sustainable development" were used interchangeably (Dresner, 2008). Since the concept of sustainability emerged, numerous definitions have been

presented. Thus, the next section will give a broad explanation of the modern sustainability concept in more detail by contrasting the widely used Brundtland Report definition, other scholars's definitions, philosophical perspectives and the German Enquete-Commission's definition.

3.2.2.1 The Brundtland Report and other scholars' definitions of sustainability

A prominent and widely used definition of sustainable development was given by the United Nations World Commission on Environment and Development, also known as the Brundtland Commission in its report *"Our Common Future"* in 1987. They added economic aspects to the previously discussed ecological and social aspects of sustainability by defining sustainable development as *"development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (WCED, 1987, p.37). This definition contains two key concepts: 1) the concept of "needs", in particular the essential needs of poor people around the world, who will often unknowingly destroy the immediate environment to survive; and 2) the idea of "limitations" created by technology and social organisation regarding the environment's ability to meet present and future needs. The Brundtland's definition sees the crucial tenets of sustainable development in meeting basic needs, recognising environmental limits and principles of equity both within and between generations.

Pearce et al. (1989) describe sustainability in economic terms. Sustainability can be interpreted in two different ways: a) As *weak sustainability* centered around non-declining total capital, which allows man-made capital (e.g. machinery, infrastructure) to substitute for natural capital and environmental deterioration; or b) as *strong sustainability* centered around non-declining natural capital, which does not allow critical ecological assets to be compensated for by other forms of capital. Strong sustainability is usually preferred by advocates of sustainable development because first of all many environmental assets have no substitutes; secondly, there is a high degree of uncertainty regarding man-made technology being able replace natural assets and society being "risk averse"; thirdly some losses of natural resources cannot be recovered in any circumstances, for example, the loss of species; and lastly, there the issue of equity is highly relevant to environmental degradation, since poor people are often the most affected (Spies, 2003).

The International Union for the Conservation of Nature and Natural Resources (IUCN), the United Nations Environmental Programme (UNEP) and the World Wildlife Fund (WWF) define sustainable development as *"development that improves the quality of human life while living within the carrying capacity of supporting ecosystems"* (IUCN-UNEP-WWF, 1991, p.10). This definition aims to minimise the depletion of non-renewable natural resources.

Gladwin et al. (1995) propose five principle components to define sustainability research: a) inclusiveness - embracing both environmental and human systems, both near and far, in both in the present and in the future; b) connectivity - developing an understanding of the world's problems as systemically interconnected and interdependent; c) equity - pursuing fair distribution of resources and property rights, both within and between generations; d) prudence - keeping life-supporting ecosystems and interrelated socio-economic systems resilient, avoiding irreversibility and keeping the scale and impact of human activities within regenerative and carrying capacities; and e) security - ensuring as safe, healthy and high a quality of life for present and future generations as possible.

The Organisation for Economic Co-operation and Development (OECD) (2008) sees sustainable development as a conceptual framework for changing the predominant world view into one that is more holistic and balanced; a process for applying the principles of integration – across space and time – to all decisions; and an end goal, identifying and fixing the specific problems of resource depletion, health care, social exclusion, poverty and unemployment.

Today, the concept of sustainability generally encompasses social, economic and environmental aspects, also known as people, profit and planet (Swinkels, 2012). The three pillars of sustainability are interconnected as shown in Figure 3.2. However, it should be noted that the economic, social and environmental dimensions can develop a certain degree of synergy. Concurrently, they can compete with each other. Thus, the achievement of sustainability goals requires a balance between the three elements, as mentioned by the European Commission (EC) (2001, p.3): *"political choices concerning one out of these three elements must at least ensure that certain minimum standards with respect to the other two are observed"*.

Figure 3.2 Sustainability practices (at the intersection between the three pillars) allow for satisfactory outcomes for people and the environment while fulfilling the social and economic needs of present and future generations.

Source: adapted from Curran (2009).

3.2.2.2 Sustainability from a philosophical perspective

Becker (2012) identifies the concept of sustainability from a philosophical perspective in his work *"Sustainability Ethics and Sustainability Research"*. There are three main characteristics at the basis of the modern concept of sustainability:

a) The meaning of continuity

The term "sustainability" literally means the ability to keep up, to keep going, to cause, to maintain and to continue in a certain state. Sustainability refers to the continued existence of something over time. When using this concept, it refers to a system (e.g., an ecosystem, an economic system), a certain entity (e.g., a species, building, capital) or a process (e.g., evolution, an activity). In addition, the term sustainability allows for two interpretations: it can be understood as the ability of a system, entity or process to maintain itself, or the ability of humans to maintain a certain system, entity or process. Examples for the first interpretation are ecosystems, species, or biological evolution. Examples of the second case would be ecosystems used for economic purposes, such as forests or land used for grazing. With its basic meaning of continuity, the term sustainability refers to the idea of stability over time. It is the idea of distinguishing stable factors in the context of dynamics and change.

b) The meaning of orientation

The modern use and understanding of the term sustainability shows an inherent normative and evaluative meaning. Today, sustainability is widely used as a norm. A normative dimension of sustainability has already been recognised by Becker (1997), Newton (2003), Ott and Thapa (2003) and Clark et al. (2004). Sustainability is regarded as something positive or something for which we should strive. It is seen as a major aim and an orientation for long-term human actions. The main political statements on sustainability clearly demonstrate this meaning of orientation. For instance, the crucial United Nations international agreement Agenda 21 states that *"sustainable development should become a priority item on the agenda of the international community"* (UN, 1992b, p.4) and sustainability is included in the fundamental guiding principles of the international community (UN, 2000).

c) The meaning of fundamental relationships

Relationships are crucial for the modern meaning of sustainability. This is obvious when referring to the most widely used definition of sustainable development, given by the Brundtland report *"Our Common Future"*, which defines it as *"development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (WCED, 1987, p.37). The most important part of this definition is its reference to two fundamental human relationships: Firstly, the relationship between humans and their contemporaries – that is, between different individuals and groups within the current generation − and, secondly, the relationship between the present generation and future generations. In addition to the relationship between contemporaries and the relationship with future generations, there is a third relationship involved in the modern idea of sustainability: the relationship between humans and nature. This relationship is addressed both indirectly and directly.

The human-nature relationship is indirectly affected by both the relationship among contemporaries and the relationship with future generations. Both relationships are heavily influenced by environmental actions. Particularly, our relationship with future generations is to a large extent an indirect and asymmetrical one, mediated by the long-term effects of our environmental actions and resulting environmental changes. Thus, when we address our relationship with future generations using the modern concept of sustainability, the relationship between humans and nature plays a crucial role. This has been recognised and

expressed in a variety of major international political statements on sustainability (WCED, 1987; UN, 1992a; UN, 2002).

Moreover, the relationship between humans and nature is also addressed directly by the modern concept of sustainability. Sustainability is also about the self-maintaining ability of nature − ecosystems or evolutionary processes − and mankind's impact on that ability. This is not just discussed in regards to the impacts on other humans or future generations, but also in regards to the impacts on nature itself, although this distinction is often not strict and explicit. We can see a direct referral to the human-nature relationship in crucial political statements such as the Johannesburg Declaration (UN, 2002) or the Brundtland report, which states: *"in its broadest sense, the strategy for sustainable development aims to promote harmony among human beings and between humanity and nature"* (WCED, 1987, p.50). The human-nature relationship is also at the core of many natural science approaches to sustainability, that is, the continuity, of certain natural systems as an externally given factor.

Thus, the modern term sustainability refers to three fundamental human relationships, which are often called sustainability relations (Figure 3.3):

(a) The relationship between humans and their contemporaries
(b) The relationship between current and future generations
(c) The relationship between humans and nature

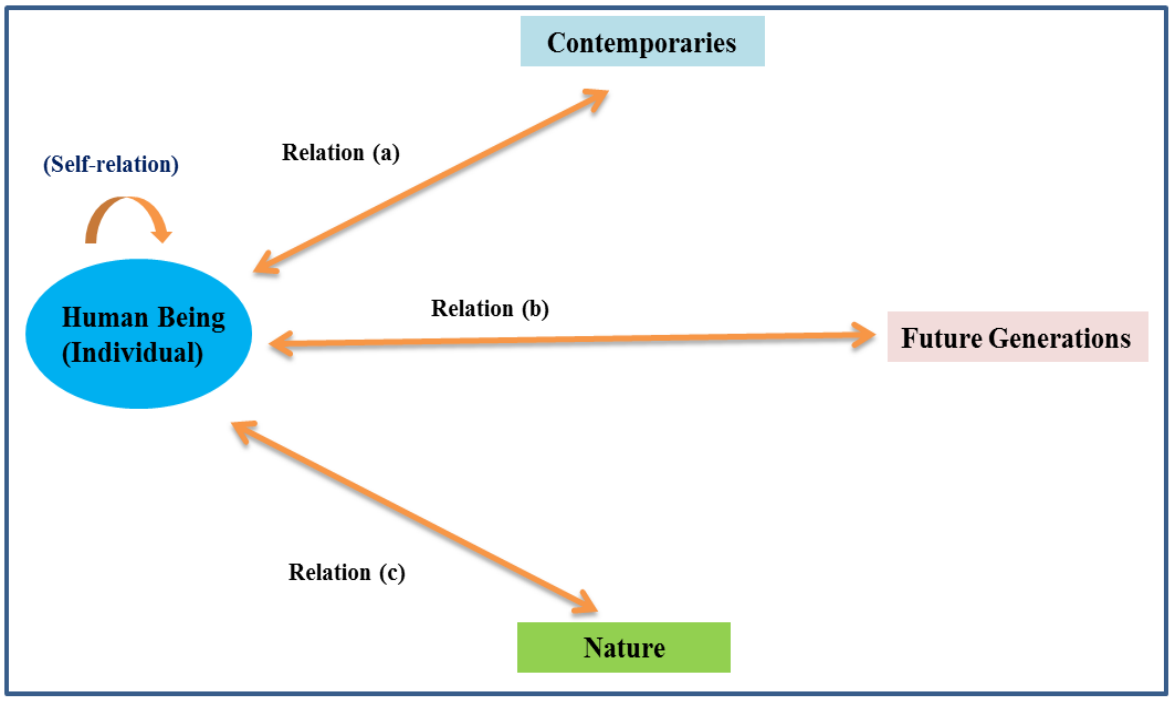


Figure 3.3 Sustainability relations

Source: adapted from Becker (2012).

3.2.2.3 The German-Enquete Commission

In 1996, the German Enquete-Commission on "Protection of Man and Environment" of the German Bundestag suggested regulations on how to obtain the goal of sustainability. Thus, economic, ecological and social principles are defined for sustainable development (Enquete-Kommission, 1998; NOP, 2008):

a) Economic guidelines

The Enquete-Commision proposed the following economic guidelines for achieving the goal of sustainable development:

1) The economic system should efficiently satisfy individual and societal needs. For this purpose, the economic order has to be shaped in a way that promotes personal initiative (own responsibility), and individual interest serves the common interest (common responsibility) for the sake of securing the well-being of present and future generations. It has to be organised in a way which reconciles private and common interests. Each member of society benefits from the social system according to personal contributions made and special needs.

2) Prices must always serve as an essential guiding tool for the market. They should reflect the availability of resources, production, goods and services.

3) The conditions for competition need to allow for the creation and maintenance of well-functioning markets, the stimulation of innovations, long-term decision-making and the promotion of social improvements that consider future needs.

4) The economic efficiency of a society; its production base and social relationships should be sustained at all times. They should increase not only in terms of quantity, but also in terms of quality.

b) Ecological guidelines

The Enquete-Commission also proposed the following ecological guidelines for sustainability:

1) The rate of the use of renewable resources should not exceed the rate of regeneration of resources.

2) Emissions should not exceed the capacity of the individual ecosystems into which they are released.

3) The timeframe of anthropogenic impacts on the environment must be in line with the timeframe of the environment to react with the relevant natural processes.

4) Dangers and risks for human health resulting from anthropogenic activities have to be minimised.

c) Social guidelines

Finally, the Enquete-Comission suggested the following social guidelines for sustainable development:

1) The social constitutional state should sustain and promote the dignity of man and the freedom for present and future personal development in order to keep social peace.

2) Each member of society has access to social benefits according to former contributions to the social security system but also based on special needs.

3) Each member of society has to pay contributions to the community according to his or her capability.

4) Social security systems can only grow to the same extent as economic standards.

5) Society's potential for productivity should be maintained, for present and future generations.

3.3 Sustainable agriculture and the concept of sustainable intensification

The Green Revolution, a phenomenal growth in agricultural production as a result of massive public investments in modern scientific research on agriculture, took place from the late 1960s onwards (IFPRI, 2002). Today, the impacts of the Green Revolution can be felt in all corners of the world: The efficiency of agricultural production has increased dramatically through the application of modern agricultural technologies such as irrigation, crop rotation, plant and animal breeding, quality control and management practices. Farmers can produce more crops, vegetables, milk and meat on the same amount of land compared to the used of traditional farming methods. Production has shifted from meeting local consumption demands to globally exporting agricultural products. However, as a result of intensive agricultural production, there is a rising societal concern over sustainability in agriculture related to issues of environmental pollution, animal welfare, food safety and social acceptance.

3.3.1 Sustainable agriculture

Agriculture is crucial to the history of mankind. As an industry, it has played an important role in sustainable development, based on the following reasons (Morse, 2010):

a) The end product of agriculture if often food, and as such, agriculture is one of the foundations of human society.

b) Agricultural systems occupy large areas of land, far more than any other industry, with the possible exception of forestry.

c) Agriculture on a global scale has undergone vast changes over the last century, and in a number of developed countries has moved from subsistence to agribusiness, with a visible impact on the environment.

d) Agriculture is an important livelihood strategy, either directly for producers or indirectly for traders, processors and retailers.

Sustainable agriculture is defined according to the type of a production system, be it crop production, livestock production or mixed system, depending on the background of the stakeholders, ranging from farmers and consumers to researchers and policy makers (Attamimi, 2011). The contemporary term “sustainable agriculture” was first used in 1977 by Balfour at the International Federation of Organic Agriculture Movement (IFOAM) Conference in Switzerland (Balfour, 1977). The scientific debate on agricultural sustainability

has traditionally been agro-ecologically oriented, although since the publication of the "Brundtland Report" economic and social aspects of agricultural sustainability have increasingly gained attention (Pesek, 1994; Marsden et al., 2010; Hildén et al., 2012). Many definitions of sustainable agriculture have been proposed by institutions and scholars such as the following:

"Sustainable agriculture is one which achieves production combined with conservation of the resources on which that production depends, thereby maintaining the maintenance of productivity" (Young, 1989, p.10).

"Sustainable agriculture is one that, over the long term, enhances environmental quality and the resource base on which agriculture depends; provides for basic human food and fibre needs; is economically viable; and enhances the quality of life for farmers and society as a whole" (American Society of Agronomy, 1989 cited in Morse, 2010, p.20).

"Sustainable agriculture means an integrated system of plant and animal production practices having a site-specific application that over the long term will: satisfy human food and fibre needs; enhance environmental quality and the natural resource base upon which the agricultural economy depends; make the most efficient use of non-renewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls; sustain the economic viability of farm operations; enhance the quality of life for farmers and society as a whole" (United States Congress, 1990 cited in Norman at el., 1997, p.3).

"Sustainable agriculture is one that equitability balances concerns of environmental soundness, economic viability and social justice among all sectors of society" (Allen et al., 1991, p. 37).

"Sustainable agriculture is one that produces abundant food without depleting the earth's resources or polluting its environment. It is agriculture that follows the principles of nature to develop systems for raising crops and livestock that are, like nature, self-sustaining. Sustainable agriculture is also the agriculture of social values,

one whose success is indistinguishable from vibrant rural communities, rich lives for families on the farms, and wholesome food for everyone" (ATTRA, 2005, p.1).

Thus, the essence of sustainable agriculture can be summarised as an agricultural practice that upholds food and bio-material production whilst at the same time benefitting the society, ensuring economic well-being for the producers and preserving natural resources and ecosystems.

Douglass (1984) identifies three different views on sustainability: The first view is called "sustainability as food sufficiency", which seeks to maximise food production within the constraint of profitability. The second view is "sustainability as stewardship", defined in terms of controlling environmental damage. The third view is "sustainability as community", defined in terms of maintaining or reconstructing economically and socially viable rural systems. Smith and McDonald (1998) conclude that agricultural sustainability consists of biophysical, economic and social factors operating at the field, farm, watershed, regional and national levels.

The European Commission (EC) (2001) addresses the core issues for sustainable agriculture and rural development, which are: the maintenance of a certain level of capital stock (natural, human and man-made capital); efficiency of resource use; and intra- and intergenerational equity. Three core issues were considered within the ecological, economic and social dimensions of sustainability, as shown in Table 3.1.

Table 3.1 The main issues for sustainable agriculture and rural development

		Environmental dimension	Economic dimension	Social dimension
Sustainable agriculture and rural development	Stock	Maintenance of sufficient capital stocks (environmental, man-made, human); employment, cultural capital, social cohesion		
	Efficiency	• Environmental efficiency	• Optimal utilisation of the factors of production, in particular labour, increase of agricultural productivity • Assurance of the availability of supplies • Competitive agricultural sector • Viability of holdings	• Maintenance and creation of employment • Institutional efficiency (regulatory framework, informal relationships and Steering mechanisms)
	Equity	• Setting of reference level as a basis for the application of the Polluter-Pays-Principle/ Payment for environmental services	Over space: • Contribution to viability of rural areas / a balanced pattern of development / the maintenance of vibrant and active rural communities	Over sectors and space: • Fair standard of living for the agricultural and rural communities Over social groups: • Equal opportunities Ethics: • Labour conditions • Ethical production methods and animal welfare

Source: EC (2001, p.8).

As can be seen in Table 3.1, the ecological dimension refers to the management of natural resources with a view to ensure that they remain available in the future. However, it also includes issues such as the protection of landscapes, habitats and biodiversity, as well as the quality of drinking water and air. The economic dimension relates to the efficient use of resources, the competitiveness and the viability of the sector as well as its contributions to the viability of rural areas. Efficient agricultural structures, appropriate technologies and the diversification of income sources for farming households are important elements of this dimension. Efficiency of resource use is an important basis for the viability of rural areas. The social dimension relates to questions of labour opportunities and access to resources and services for agricultural households compared to other economic agents in rural areas. Equal opportunity issues and societal ethical concerns regarding agricultural production methods can also be considered as part of to the social dimension of sustainable agriculture (EC, 2001).

Although there is no consensus on its definition, sustainable agriculture refers to long-term production systems that are: a) economically viable - responding efficiently and innovatively to current and future demands for an adequate, safe and reliable supply of food and raw materials; b) environmentally sound - conserving agriculture's natural resource base for future generations, while maintaining or enhancing other ecosystems influenced by agricultural activities; and c) socially viable - meeting the wider values of society such as supporting rural communities and addressing cultural/ethical issues such as animal welfare concerns. The Standing Committee on Agriculture and Resource Management (SCARM) (1998 cited in Spies, 2003, p.34) identifies basic components of agriculture presented in Figure 3.4. All elements are equally important for sustainable agriculture.

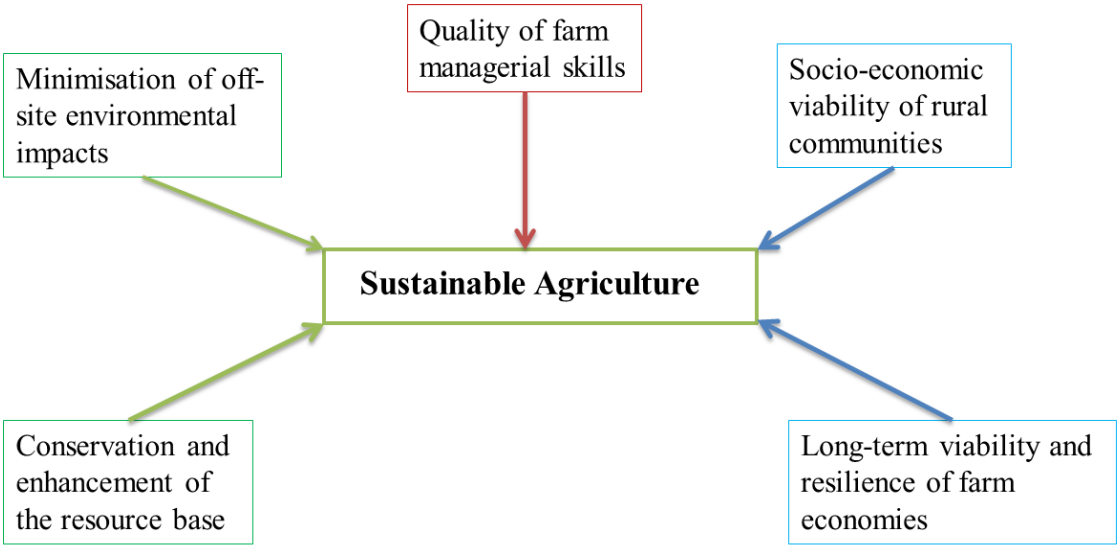


Figure 3.4 Basic components of sustainable agriculture

Source: adapted from SCARM (1998 cited in Spies, 2003).

The focus of sustainable agriculture has mainly been on crop production systems. This is due to their impact on the environment being more obvious than that of livestock production. However, the Food and Agriculture Organisation (FAO) (2006) demonstrated clearly that today's animal production is having a strong negative impact on the environment through their emissions into the air, water and soil. Additionally, concerns are increasingly being voiced over animal welfare, the size of farms and potential threats to human health (zoonotic diseases and antibiotic resistance in humans arising from the use of antibiotics in livestock). Thus, there is a clear need to improve the sustainability of livestock production.

Vavra (1996) defines sustainable livestock production as a production system that is indefinitely able to harvest the same amount of animal products from a given land-base. In other words, the harvested products do not decrease the ability of the land to continue producing the products in the future. Goodwin et al. (1994) identify sustainable livestock production as good husbandry with health and welfare as a first priority; the reduction of stress due to more natural rearing systems; optimal nutrition promoting animal health; housing conforming to ethological needs; limitation of group size; absence of mutilation; limitation of transport time to slaughter (8 hours maximum); and high standards in abattoirs. Liinamo and Neeteson-van Nieuwenhoven (2003) propose two important features of breeding in sustainable production: a) building on a long economic and productive life of animals without disturbing welfare in specific environments; and b) optimising input/output and feed efficiency with sustainable feed resources.

De Boer (2012) highlights the crucial role that innovation plays in our current livestock production systems. Her research concentrates on the global impact of innovation on sustainable livestock production systems, with a special focus on innovation's impact on the environment, animal welfare and livelihoods (Figure 3.5). Innovation is the process of making changes to something already established by introducing something new: these changes can be small or large; radical or incremental (O'Sullivan and Dooley, 2009). It may involve either new technologies or ideas (Juma et al., 2013). Innovations can be found in feeding, breeding or farming technology.

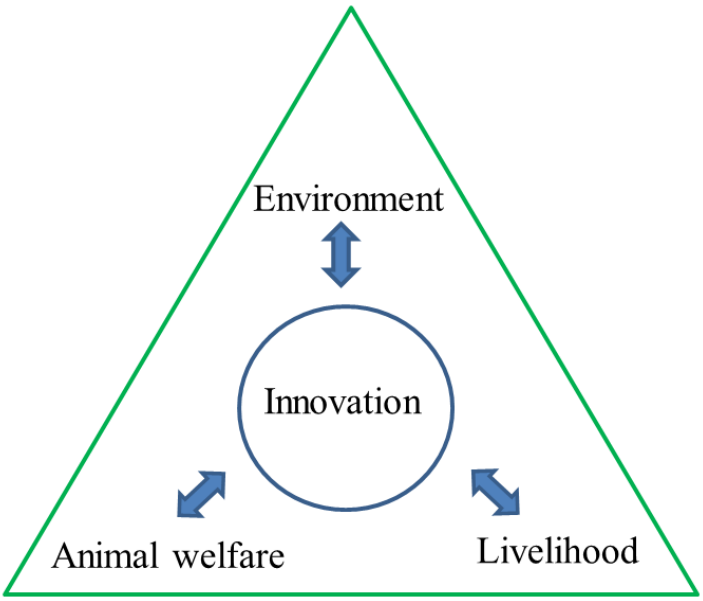


Figure 3.5 The role of innovation in sustainable livestock production

Source: de Boer (2012, p.5).

Agricultural production is a complex system. Improvements in food production should consider the role of science and innovation as well as the interconnectedness of social, economic and environmental elements, as shown in Figure 3.6 (The Royal Society, 2009).

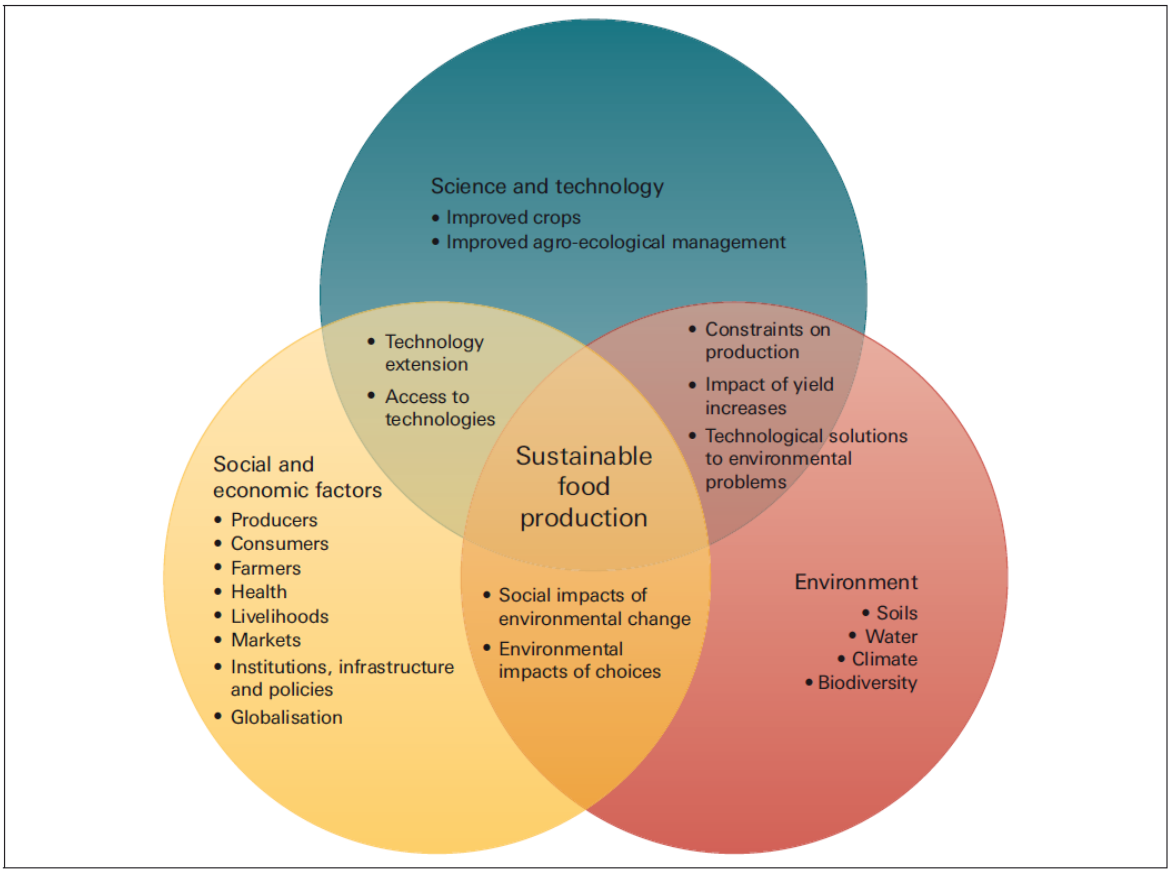


Figure 3.6 The complexity of agricultural systems

Source: The Royal Society (2009, p.5).

In order to improve the sustainability of livestock production, Blaha (2000) suggests that each farming practice in a given ecosystem must be evaluated in terms of its ability to contribute to a set of economic, environmental and social goals, such as lasting farming production; stewardship of land, water, livestock and wildlife; and improved quality of life for farmers, their families, rural communities and the consumers of the food produced. In the context of sustainable poultry production, sustainable practices should concurrently consider the needs of the poultry, farmers, planet and consumers (Swinkels, 2012).

3.3.2 The concept of sustainable intensification

Continued population growth has a direct impact on the agricultural sector, as it needs to produce more food on the same amount of farmland. This challenge requires an increased rate of food production on existing agricultural land in ways that reduce the pressure on the environment and do not hamper our capacity to continue producing food in the future. Thus, the term “sustainable intensification” has been used in discussions on the future of agriculture;

a term which along with "food security" is becoming more frequently used (Garnett and Godfray, 2012). In 2009, The Royal Society defined sustainable intensification as a form of production wherein *"yields are increased without adverse environmental impact and without the cultivation of more land"* (The Royal Society, 2009 cited in Garnett and Godfray, 2012, p.8). In this sense, the primary goal of sustainable intensification is to raise productivity on the same area of cultivated land whilst conserving resources and reducing negative impacts on the environment. The required "intensity" of productivity to meet an increasing demand for food will depend on progress in governance, waste reduction, dietary changes and population growth policies (Garnett and Godfray, 2012). Therefore, sustainable intensification should be seen as a complement to and not a substitute for actions on these fronts (Figure 3.7).

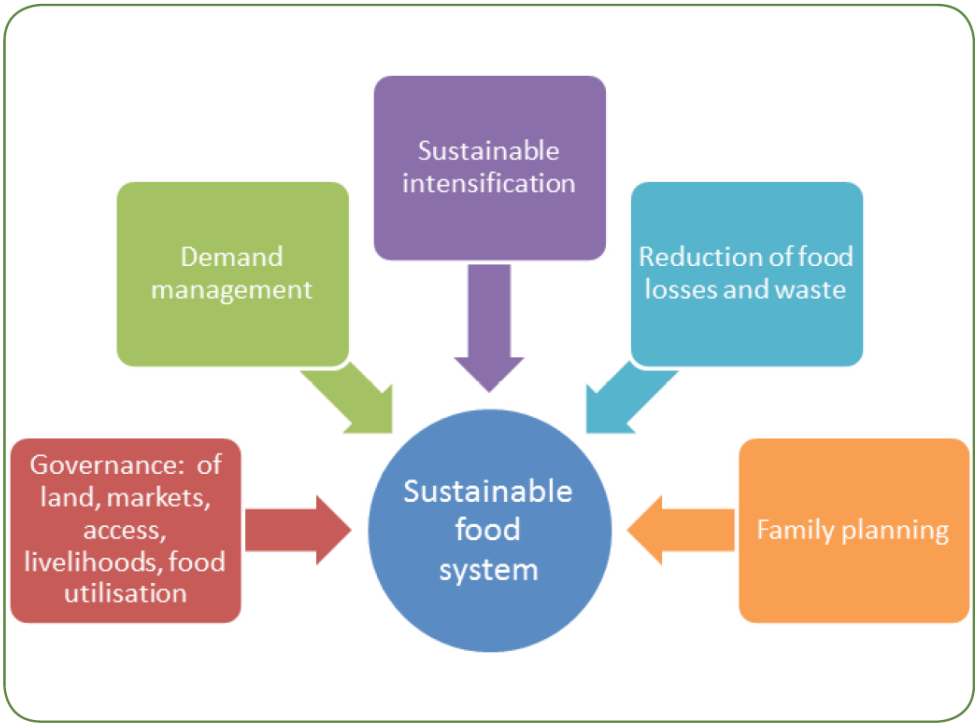


Figure 3.7 Sustainable intensification in relation to food demand, waste, governance and population

Source: Garnett and Godfray (2012, p.15).

Garnett et al. (2013) define four underpinning premises of sustainable intensification:

a) The urgent need to increase production and moderate demand for resource-intensive foods (such as meat and dairy products), reduce food waste and develop systems of governance that improve the efficiency and resilience of the food system, as well as making food accessible and affordable to all.

b) Increased production must be met through obtaining higher yields because increasing the area of land used for agriculture comes at large environmental cost.

c) Food security requires that as much attention be paid to increasing environmental sustainability as to raising productivity.

d) Sustainable intensification denotes a goal but does not specify a priori how it should be attained or which agricultural techniques to use. The merits of diverse approaches - conventional, agro-ecological, or organic - should be rigorously tested and assessed, taking biophysical and social contexts into account. Building the social and natural science evidence base to enable the formulation of context-dependent sustainable intensification strategies is a research priority.

Many concepts related to sustainable intensification have featured in present discussions such as ecological intensification, agroecology, permaculture, organic agriculture, ecofunctional intensification, climate smart agriculture and eco-efficiency. Garnett and Godfray (2012) argue that it is still not clear what sustainable intensification might look like on the ground; how it might differ amongst production systems, in different places, and given different demand trajectories; and how the trade-offs that inevitably arise might be balanced. However, McDermott et al. (2010) state that sustainable intensification could provide a framework for exploring which mix of approaches might work best based on the existing biophysical, social, cultural and economic contexts and a growing body of work is starting to emerge that explores what implementation might look like in practice.

FAO (2011) proposes an ecosystem approach to sustainable intensive crop production, which is highly productive on the same area of land while conserving resources, reducing negative impacts on the environment and enhancing natural capital and the flow of ecosystem services. This approach draws on nature's contributions to crop growth such as providing soil and organic matter, water flow regulation, pollination and bio-control of insect pests and diseases. It offers a rich toolkit of relevant, adoptable and adaptable ecosystem-based practices that can help the world's 500 million smallholder farming families to obtain higher productivity, profitability and resource use efficiency, whilst increasing natural capital.

Today, the debate on sustainable intensification is dominated by environmental concerns, animal welfare and human nutrition. The environmental argument is founded on three principles (Garnett and Godfray, 2012):

a) The consequences of converting more land for agricultural use are so harmful to the environment that any increase in production must be achieved with as little additional land conversion as possible.

b) Producing more from same amount of land must be done in ways that reduce the direct negative environmental impacts of food production. This will require a much more efficient use of water, energy and other inputs (increased production must be accompanied by increased productivity) and attention must be paid to the long-term sustainability of agro-ecosystems. Opportunities for positive environmental impacts (for example carbon sequestration on agricultural land) should be pursued where possible.

c) While some growth in food demand is inevitable, the extent of the increase will depend on how far policies on the demand side are successful in modifying diets, reducing waste and reducing the rate of population growth. However, relying on successes in these areas to achieve food security is as risky as relying on increases in production alone. Action is needed on all fronts in order to keep food supply and food prices within socially accepted margins; and the role of sustainable intensification is to deliver productivity gains in ways that are environmentally and societally acceptable.

Animal welfare and ethical arguments for sustainable intensification mainly focus on animal health; unpleasant effective states such as fear, pain and frustration; and to what extent animals can express natural behaviour in farms. The discussion on nutritional issues is focused on malnutrition in low-income consumer groups, overconsumption in rich consumer groups, and the quality and safety of food products. Additionally, the issue of genetically modified crops in the intensive food industry has been highly criticised.

3.4 Assessment of sustainability in agriculture and poultry production

Sustainability is a complex concept. It is difficult to measure and requires the use of appropriate indicators for assessment (Zinck and Farshad, 1995). Pannell and Schilizzi (1999) argue that sustainability indicators are practical and reasonable instruments for measuring multi-faceted sustainability. As our understanding of the complex relationship between

agriculture and the environment has increased, many indicators have been developed as a tool to quantitatively represent the sustainability issues faced in practical planning and farm design (Bell and Morse, 1999; Cornelissen, 2003; Mollenhorst, 2005). A good indicator should be unbiased, sensitive to temporal changes and spatial variability, predictive, referenced to threshold values; and the data it measures should be transformable, integrative and easy to collect and communicate (Liverman et al., 1988). The European Commission (EC) (2001) suggests that sustainability indicators should meet the following criteria: policy-relevance; conceptual soundness; definition at an appropriate level of aggregation; effectiveness, statistical validity; analytical soundness; technical feasibility; and cost-efficiency.

There are two main methods used for devising indicators, namely top-down and bottom-up approaches. The "top-down" approach develops indicators through professional staff. All relevant indicators are listed, covering all sustainability dimensions that appear in the literature, which are then scrutinized by experts (Hardi and Zdan, 1997). This approach can expose trends across regions and over time that might be missed by a more casual observation (Attamimi, 2011). However, this approach tends to treat every production system similarly, without considering distinctions in objectives, resources and management of the systems. It often fails to engage local communities as the end-user of the indicators. The "bottom-up" approach produces indicators through the participation of stakeholders (EC, 2001; Mollenhorst, 2005). This method is more adapted to and appropriate for assessing sustainability issues at farm level, since all indicators are developed in accordance with the availability of resources and their relevance to the particular farming system. However, it is difficult to determine the level of participation of stakeholders in this approach (Hardi and Zdan, 1997; Mollenhorst, 2005). Additionally, indicators derived by a participatory approach alone may be not enough to monitor sustainability accurately (Rigby et al., 2001). Thus, there is an increasing tendency towards developing a third approach, which combines the top-down with the bottom-up approach to capture better indicators (Attamimi, 2011).

The participatory approach has been widely adapted to study the sustainability of agriculture. For example, Vilei (2010) used this approach to study the sustainability of farming systems in the Philippines. Christen et al. (2013 cited in Schulze, 2013) developed indicators for assessing sustainability of crop production at farm level, corresponding to the three elements of sustainability including ecological, economic and social indicators as described in Table 3.2.

Table 3.2 Indicators and analysis areas of sustainability certification systems in agriculture

Areas of analysis	Indicators	Operational analysis
	Ecological aspects	
Climate effects	Greenhouse gas emissions	Emissions inventory
Resource use	Energy intensity	Energy balance, P-loss potential
Biodiversity	Agrobiodiversity	Operating organisation/Process design
	Plant protection intensity	Treatment index
Soil conservation	Soil compaction, Erosion, Humus balance	Degree of compaction, Soil erosion, Humus formation process
Water and air pollution	N-balance	N-loss potential
	Economic aspects	
Profitability	Operating income, Factor remuneration	Value added of operation/Remuneration of production factors
Liquidity	Debt service limits	Economically possible debt service
Stability	Profit rate, Net investment, Change in equity	Stability of operation, Operating investment, Standard of living
	Social aspects	
Labour and employment	Wage and salary, Average workload, Vacation, Education and training, Occupational safety, Worker participation	Rewards for employees, Working Hours, Holidays and training
Social commitment	Communication with the public, cooperation, Regional engagement	Activities/Initiatives of entrepreneur
Quality assurance	Use of quality assurance systems	Product quality assurance/Food safety

Source: Christen (2013 cited in Schulze, 2013, pp.28-29).

Attamimi (2011) analysed the sustainability of beef production with Bali cattle in smallholder farms on Ceram Island, Indonesia, while Spies (2003) developed a framework for assessing the sustainability of pig and poultry production in Santa Catarina, Brazil. He suggests that in order to achieve sustainability in the pig and poultry industry, issues of environmental impact, economic competitiveness and social acceptance need to be considered during the decision-making process, as depicted in Figure 3.8.

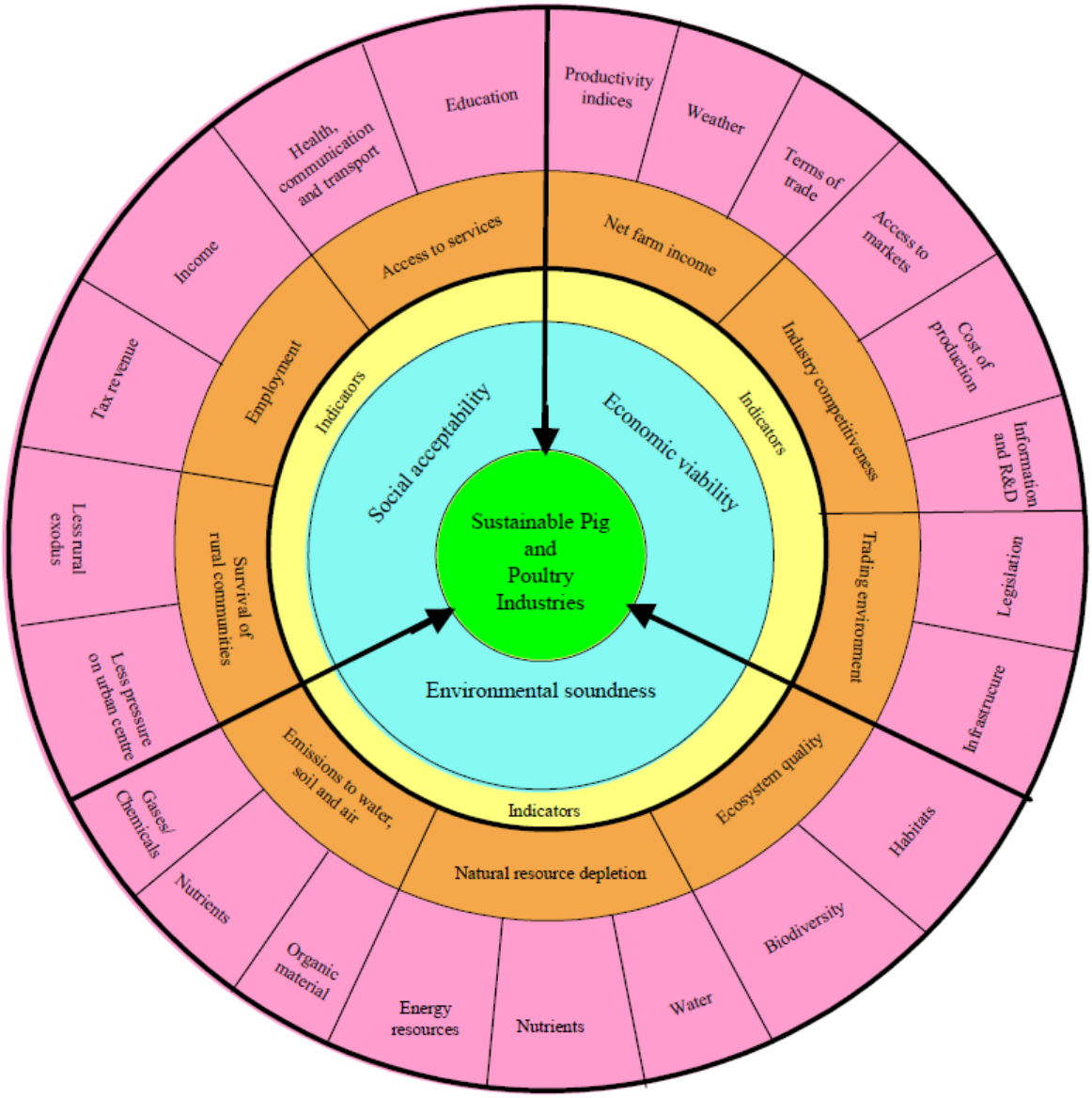


Figure 3.8 Framework for sustainable pig and poultry industries in Santa Catarina, Brazil

Source: Spies (2003, p.299).

Mollenhorst and de Boer (2004) identified sustainability issues in egg production in the Netherlands based on a participatory approach engaging stakeholders and experts in the process. Issues were quantified using a four-step methodology: a) description of the situation; b) identification and definition of relevant economic, environmental and social issues; c) selection and quantification of suitable sustainability indicators for each issue; and d) final assessment of the contribution to sustainable development. The outcome of this study proposed five main issues for sustainable egg production in the Netherlands. The issues were animal welfare and health, environment, quality of eggs, ergonomics and economics. This method was further used to develop indicators for evaluating economic, ecological and social performance in broiler production systems at farm level in the Netherlands (Bokkers and de

Boer, 2009). Indicators for economic, ecological and social performance were: net farm income; acidification and eutrophication, fossil fuel use and climate change, land use; and animal welfare and health, food safety, product quality, and working conditions for the farmers. Bonaudo et al. (2010) adapted the participatory method to study and compare poultry production systems at a regional scale in France and Brazil. This study supports the argument that in order to assess the sustainability of poultry production, dynamic (market competition) and spatial (characteristics of production system in each area) aspects have to be considered.

3.5 Conclusion

Despite different definitions of sustainability, both in general and in agriculture, there is a broad consistency between definitions. Sustainability is a concept that encompasses economic, environmental and social aspects. The three components interact with each other and tend to be locational or site-specific at field, farm, community, national and international levels.

In this study, sustainable poultry production is defined as *"an improvement of a poultry production system that optimises the overall sustainability aspects, including environmental, economic, social, political and animal welfare issues"*. In the context of poultry production, sustainable production needs to consider these five elements on the basis of spatial and temporal scales. All stakeholders should work together to find an effective way to develop strategies to improve the sustainability of poultry production.

Chapter 4
Current sustainability issues in poultry production

4.1 Introduction

This chapter reviews the background of the most prevailing concerns in society with regard to the sustainability of poultry production by analysing literature and reports. The following topics derived from the previously covered sustainability issues will be discussed, including 4.2) use of antibiotics in poultry production, 4.3) contamination of meat and eggs with zoonotic microorganisms, 4.4) outbreak of avian influenza, 4.5) regional concentration of production, 4.6) de-beaking, and 4.7) killing of day-old male layer chicks.

4.2 Use of antibiotics in poultry production

The use of antibiotics in animal production raises concerns over the risk of multi-drug resistant bacteria, especially Methicillin-Resistant *Staphylococcus aureus* (MRSA) and Extended Spectrum b-Lactamase (ESBL) producing bacteria, which make the treatment of these diseases in humans more difficult. MRSA is a type of bacteria frequently found on human skin or the mucous membranes of the nose and mouth (CIWF, 2011a). It leads to the infection of wounds and is resistant to numerous antibiotics, including methicillin, amoxicillin, penicillin and oxacillin. There are 3 types of MRSA: healthcare-associated MRSA (HA-MRSA), community-associated MRSA (CA-MRSA) and livestock-associated MRSA (LA-MRSA). ESBL is an enzyme produced by bacteria such as *Escherichia coli*. ESBL producing bacteria are normally found in the human bowel and can cause urine, lung, wound and blood infections. Infections caused by MRSA and ESBL producing bacteria can be more difficult to treat due to their resistance to antibiotics, since the options for treatment with the most commonly used antibiotics are limited. Research shows that the transfer of resistant bacteria or resistance genes between humans and animals is possible in both directions (Fischer et al., 2012; Fischer et al., 2013).

Antibiotics are used in livestock production for three reasons: a) for the treatment of diseases (therapeutic use), b) for the prevention of diseases (prophylaxis), and c) for the promotion of growth (CIWF, 2011b). Antibiotics have been used in animal feed to promote growth in the poultry industry since 1946. The sub-therapeutic use of antibiotic growth promoters helps

chicken put on weight. However, the regular disbursement of low doses of antibiotics in livestock production can increase the risk of resistant microbes surviving and evolving, which in turn contributes to the rise in antibiotic resistant infections in humans. As a result, the use of antibiotic growth promoters was banned in Sweden in 1986, in the European Union in 2006 and in the Republic of Korea in 2011 (Kemmet, 2015). The European Union member states voted to prohibit the prophylactic use of antibiotics in animal production in 2011. The use of antibiotics is only permitted for therapeutic reasons and under the supervision of veterinarians.

In Germany, according to the Bundesverband für Tiergesundheit (BfT), almost 900 tonnes of antibiotics were used in livestock production in 2010. The State of Lower Saxony reported that 83% of their broiler and 92% of their turkey farms used antibiotics in 2011. Tests undertaken on MRSA in turkey meat samples in 2009 concluded that 42.2% were positive, with 22.3% of broiler meat testing positive for MRSA (Hartung and Käsbohrer, 2011).

Increasing domestic and international concerns over the use of antibiotics in livestock production have resulted in the enforcement of a compulsory antibiotics monitoring system on 1 April 2014 (Koeleman, 2014). This approach aims to reduce the use of antibiotics in livestock production and limit the spread of resistant bacteria by regulating the non-therapeutic use of antibiotics. Cattle, pig, broiler and turkey farmers have to report to the veterinary authorities on their use of antibiotics as well as the size of their herds and flocks every six months. The authorities analyse and compare the data between farms, and if the use of antibiotics on a farm is above average then the respective farm owner has to cooperate with veterinarians to reduce its use. If the use of antibiotics is 25% higher than the average, a written action plan must be developed (Koeleman, 2014). If the farm owner fails to comply with the action plan, financial penalties can be applied. German farmers and farm owners can compare the use of antibiotics with other farms via an online system.

In September 2015, the German Poultry Association (ZDG) published a new Poultry Charter which aims to make Germany the best country in the world for poultry (Linden, 2015a). The issue of antibiotic use in poultry production is one of the main topics covered by this Charter, which commits the German poultry sector to support the use of antibiotics in a sustainable way (ZDG, 2015a).

The current therapeutic antibiotic sales in Germany continue to decrease. According to the Federal Office of Consumer Protection and Food Safety (BVL) (2015a), the total amount of antibiotics sold by the pharmaceutical industry for therapeutic veterinary use was 1,238 tonnes in 2014 (see Table 4.1).

Table 4.1 Veterinary antibiotic sales from 2011 to 2014 in tonnes

Drug class	Quantity (tonnes) 2011	Quantity (tonnes) 2012	Quantity (tonnes) 2013	Quantity (tonnes) 2014	Difference (tonnes) between 2011 and 2014
Aminoglycosides	47	40	39	38	-9
Cephalosporins, 1st generation	2.0	2.0	2.0	2.1	+0.1
Cephalosporins, 3rd generation	2.1	2.5	2.3	2.3	+0.2
Cephalosporins, 4th generation	1.5	1.5	1.5	1.4	-0.1
Fluoroquinolones	8.2	10.4	12.1	12.3	+4.1
Folic acid antagonists	30	26	24	19	-11
Fusidic acid*					
Ionophore*	-	-			
Lincosamides*	17	15	17	15	-2
Macrolides	173	145	126	109	-64
Nitrofurans*					
Nitroimidazole*					
Penicillin	528	501	473	450	-78
Phenicol	6.1	5.7	5.2	5.3	-0.8
Pleuromutilin	14	18	15	13	-1
Polypeptide antibiotics	127	124	125	107	-20
Sulfonamide	185	162	152	121	-64
Tetracyclines	564	566	454	342	-222
Total**	1,706	1,619	1,452	1,238	-468

Source: BVL (2015a). *Confidential data **Possible deviation due to rounding

The major veterinary antibiotic sales included pennicillins (450 tonnes), tetracyclines (342 tonnes), sulphonamides (121 tonnes), macrolides (109 tonnes) and polypeptide antibiotics (colistin) (107 tonnes). The total therapeutic antibiotic sales volume in 2014 decreased by 15% (214 tonnes) and 27% (468 tonnes) compared to 2013 and 2011, respectively. However, antibiotic sales with a special significance for human therapy (Highest Priority Critically Important Antimicrobials) remained almost constant compared to 2013 (approximately 12 tonnes fluoroquinolones and 4 tones cephalosporins 3rd and 4th generation). Fluoroquinolones

sales for therapeutic veterinary use in 2014 (12.3 tonnes) compared to 2011(8.2 tonnes) increased by 4.1 tonnes, an increase of 50% compared to the total quantity sold in 2011.

Figure 4.1 shows the regional distribution of therapeutic antibiotic sales in Germany in 2014 (BVL, 2015a). Between 2011 and 2014, antibiotic sales have decreased in many regions.

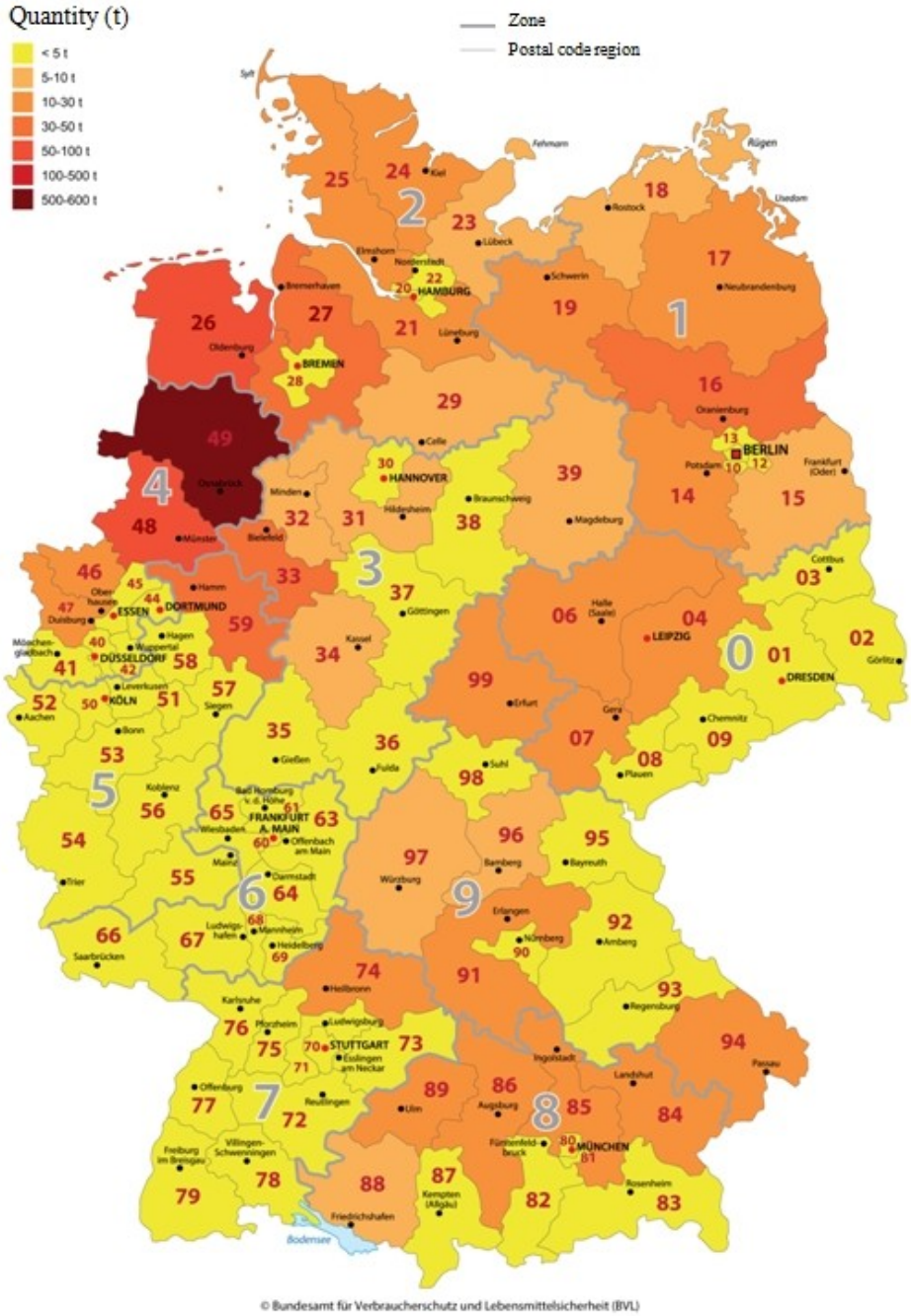


Figure 4.1 Regional distribution of therapeutic antibiotic sales in Germany (2014)

Source: BVL (2015a).

The postal code region 49 had the highest antibiotic sales out of all the regions. This region accounts for a reduction of approximately 197 tonnes (from 703 tonnes in 2011 to 506 tonnes in 2014). In the postal code regions 25, 26, 27, 29, 33, 39, 46, 48, 59 and 94, antibiotic sales declined by more than 10 tonnes. In particular, a strong reduction of antibiotic sales, approximately 40 tonnes, was found in postal code region 48. However, an increase of antibiotic sales by approximately 15 tonnes is documented in the postal code region 16.

Other European countries, such as Denmark, Sweden, Norway, Austria and the Netherlands, have also published regulations on the use of antibiotics in livestock production (Merle et al., 2014).

However, the use of antibiotics in livestock production can only be reduced to a certain level since there is still a need for antibiotics for disease prevention in susceptible animals, especially turkeys. Hafez (2014) states that high standards for farm management and biosecurity controls are not sufficient to protect against certain diseases and syndromes in turkeys, thus making a case for antimicrobial control. Further research on the development of antimicrobial resistance in various geographical regions is necessary in order to obtain more knowledge on resistance patterns, especially since the introduction of the ban on the use of antibiotics as growth promoters in animal feed. This would help to assess the impacts of controlling the use of antibiotics in poultry production and make future interventions more effective.

Today, the trend towards raising chicken without the use of antibiotics is widely discussed in society. As a result, major food retailers and fast food chains are providing alternative antibiotics-free poultry meat for consumers. This trend reflects the need for the meat-producing sector to continue improving its production methods by reducing or ceasing the use of antibiotics as much as possible in an effort to increase social acceptance.

4.3 Contamination of meat and eggs with zoonotic microorganisms

Zoonotic microorganisms are frequently reported as a cause for food-poisoning in humans, often contaminating poultry meat and eggs, such as *Salmonella* and *Campylobacter*. *Salmonella* spp. are gramme-negative and rod-shaped in structure and commonly found in the intestines of wild and domestic animals, which can cause an acute intestinal inflammation in

humans (BVL, 2015b). *Campylobacter* spp. are gramme-negative, spiral-shaped or rod-shaped in structure and commonly found in the intestines of various wild, domestic and farm animals without symptom presence (BVL, 2015b), which can cause diarrhea, abdominal pain and cramps, fever and vomiting in humans (MDH, 2015). These two groups of microbes are naturally transmissible, such as through contaminated foodstuffs, as well as between animals and humans. Infections can vary from mild symptoms to life-threatening conditions.

In European countries, the prevalence of *Salmonella enterica* serovars Typhimurium and Enteritidis and *Campylobacter jejuni* are the most common causes of diarrheal disease in humans, with campylobacteriosis and salmonellosis being the first two most commonly confirmed cases of human infections (EFSA and ECDC, 2014).

According to an analysis of the prevalence of zoonoses and food-borne outbreaks in the 27 European Union Member States (EFSA and ECDC, 2014) in 2012, contamination with *Campylobacter* in broiler meat remained high at the European level, whereas *Salmonella*-contaminated eggs and broiler meat were in obvious decline. Based on the food safety report provided by BVL (2015b), in Germany in 2013, broiler cecal contents and carcass (neck) skin samples taken after slaughter tested positive for *Salmonella* spp., 1.0% and 11.5% of the time, respectively. There was no equivalent study from Thailand. The successful implementation of *Salmonella* control programmes within the European Union resulted in a 4.7% decrease in confirmed cases of salmonellosis in humans in 2012 compared to 2011 (EFSA and ECDC, 2014), while in Germany, the confirmed salmonellosis cases in humans declined by about 9% in 2013 compared to 2012 (RKI, 2014).

Campylobacter spp. is the most common infection found in broiler meat samples in the EU (EFSA and ECDC, 2014). In Germany, in 2013 broiler cecal contents and carcass (neck) skin samples taken after slaughter tested positive for *Campylobacter* spp., 25.3% and 52.3% of the time, respectively (BVL, 2015b). The prevalence of *Campylobacter* spp. in broiler ceca and carcass (neck) skin samples taken after slaughter in Thailand in 2011 amounted to 11.2% and 51%, respectively (Chokboonmongkol et al., 2012), which is a relatively high prevalence in comparison to *Salmonella*. In the European context, confirmed human campylobacteriosis cases decreased by 2.7% in 2012 compared to 2011 (EFSA and ECDC, 2014). However, there was an increase of 1.1% in confirmed human campylobacteriosis cases in Germany in 2013 compared to 2012 (RKI, 2014).

Although there has been a reduction in cases of meat contaminated with *Salmonella*, risks of a renewed outbreak and the prevalence of *Campylobacter* remain crucial challenges for the poultry industry. *Campylobacter* is common and can contaminate a range of foodstuffs, such as fresh meat, raw milk and dairy products. Climatic factors play a particularly important role in an outbreak since *Campylobacter* is thermophilic: It does not multiply outside of the host animal and does not develop further in meat or on the skin of chilled poultry. Furthermore, this bacterium does not grow at a temperature below 30°C, with an optimum temperature for growth of 42°C, which is close to the poultry's body temperature (Robertson, 2015). As a result, poultry is considered the major reservoir for this bacterium.

4.4 Outbreak of avian influenza

Avian influenza viruses are generally fairly common in the wild; they are most frequently found in aquatic wild birds, such as ducks, swans, geese, waders and gulls (Webster et al., 1992; Olsen et al., 2006; Alexander, 2007; de Jong et al., 2009). These birds carry low pathogenicity strains of avian influenza (LPAI), which can occasionally cross over to domestic poultry, such as turkeys and chickens, and cause mild disease symptoms (Daly, 2013). The migration of wild birds plays an important role in the spatial spread of various zoonotic agents (Reed et al., 2003), which has been shown to disseminate LPAI viruses along migratory flyways in Asia, Africa, and the Americas (Webster et al., 1992; Spackman et al., 2005; Munster et al., 2007). When domesticated poultry species are infected, the low pathogenic strains (LPAI) can mutate into highly pathogenic avian influenza strains (HPAI), which spread throughout the individual's body and cause death within 24-48 hours (Webster, 2004; Webster and Hulse, 2004). These highly pathogenic strains are very contagious.

There are a number of subtypes of LPAIs and HPAIs. The classification of avian influenza viruses is determined by their exterior glycoproteins that comprise one of the 16 hemagglutinin (H) proteins H1-H16 and on of the 9 neuraminidase (N) proteins N1-N9, which lead to a variety of strains within the subtypes (Brockotter, 2015a). Some influenza A virus subtypes, such as H5 and H7, are highly pathogenic for both humans and poultry, and raise global concerns over potential pandemics.

The highly pathogenic avian influenza (HPAI) virus H5N1 first appeared in Hong Kong's wet markets and chicken farms in 1997 (Daly, 2013). By 2003, avian influenza had spread all over

Asia, Africa and Europe. For example, the outbreak of HPAI A virus subtype H7N7 in the Netherlands in 2003 led to the culling of 30 million birds (Stegeman et al., 2004). In 2004, Thailand faced a severe outbreak of HPAI A virus subtype H5N1, which resulted in a loss of more than 62 million birds (Tiensin et al., 2005). Since 2003, avian influenza is considered a major threat to the global poultry industry and human health. The spread of the virus caused the death of over 100 million birds by 2005 (Normile, 2005), with outbreaks of LPAI and HPAI continuing to spread throughout Europe, North America, Asia and Africa.

The highly pathogenic avian influenza virus H5N8 was spread throughout poultry farms in the Netherlands, Germany and the United Kingdom (UK) in November 2014, a subtype which was already reported in Asia in 2010 (ECDC, 2014), where the subtype H5N8 was first detected in domestic ducks in China (Wu et al., 2014). From early 2014 onwards, H5N8 was found in poultry and wild birds in South Korea, China and Japan (ECDC, 2014).

In Canada, the highly pathogenic avian influenza virus subtype H5N2 was identified in Fraser Valley in British Columbia in December 2014 (Canadian Food Inspection Agency, 2014) and the subtype H5N1 was also found in this area early 2015 (Canadian Food Inspection Agency, 2015). In addition, H5N2 and H5N8 were reported in April and May 2015, respectively (OIE, 2015).

In 2015, several outbreaks of HPAI were reported in Cambodia (H5N1), Iran (H5N1), Laos (H5N6), Myanmar (H5N1), South Korea (H5N8), Taiwan (H5N2, H5N3, H5N8), Vietnam (H5N1, H5N6), Israel (H5N1), the Palestinian Autonomous Territories (H5N1), Cote d'Ivoire (H5N1), Ghana (H5N1), Libya (H5N1), Niger (H5N1), Nigeria (H5N1), Mexico (H7N3), Turkey (H5N1), France (H5N1), Germany (H7N7), Hungary (H5N8) and the UK (H7N7) (OIE, 2015). Figure 4.2 presents the global outbreaks of HPAI between December 2014 and November 2015, with the red symbol indicating continuing cases of outbreaks in domestic birds , dark orange presenting the ongoing cases of outbreaks in wild birds, and the blue and green symbols showing the resolved cases in domestic and wild birds, respectively.

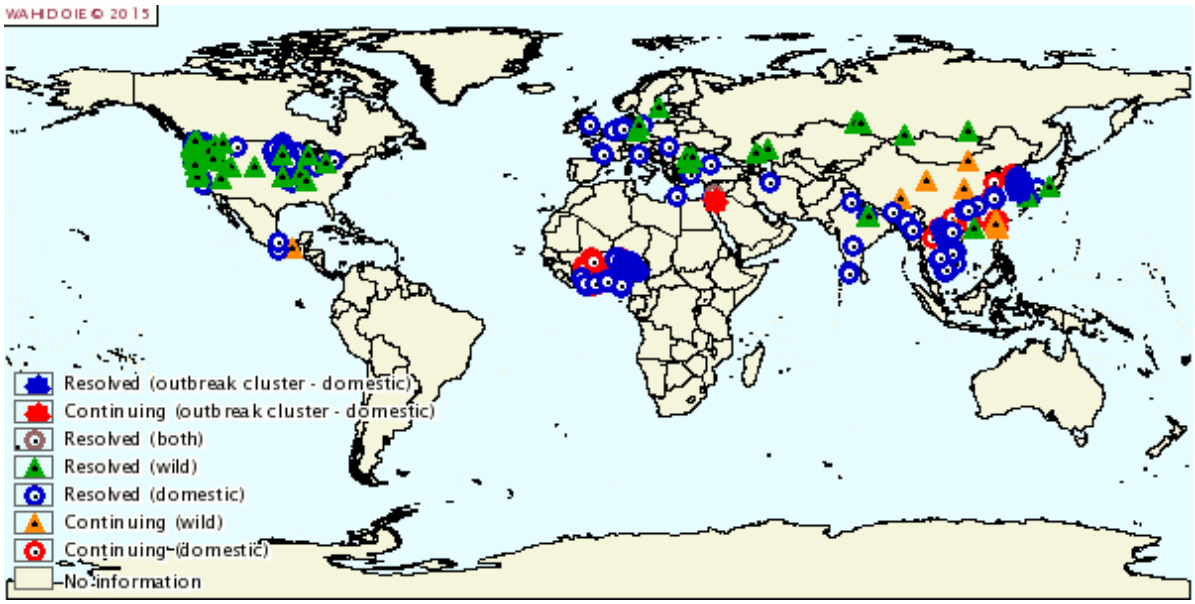


Figure 4.2 Highly pathogenic avian influenza outbreaks between December 2014 and November 2015

Source: OIE (World Organisation for Animal Health) (2015).

A massive outbreak of HPAI virus subtypes H5N8 and H5N2 occurred in the USA between December 2014 and June 2015, with a total of 42.10 million laying hens and 7.55 million turkeys being affected (Windhorst, 2015a). The HPAI outbreak in commercial turkey and layer farms in the upper Midwest in April and June 2015 was considered the most serious and expensive animal health emergency ever faced by the USDA (Shane, 2015). The HPAI outbreak in the USA in 2015 had a significant economic impact on the poultry sector. According to Shane (2015), the cost of the 2015 HPAI epidemic is estimated as followed:

- US$1 billion to egg producers and US$500 million to turkey producers in costs for the direct loss of poultry flocks, including integrators, individual farmers and independents
- US$500 million to suppliers for the turkey and egg industries and to communities in costs for plant closures and layoffs
- US$600 million to the public sector (Animal Plant Health Inspection Service (APHIS) and states) in costs for disease control
- US$2 to US$3 billion to the consumers as a result of increased prices for eggs and food containing egg products (depends on how long it takes for prices to normalise)
- US$1.2 million in export revenue to broiler producers as a result of trade embargos imposed by some nations on the USA as a whole, which is contrary to the World Organisation for Animal Health's (OIE) principle of regionalisation.

The state of Iowa was the most seriously affected by the outbreak of avian influenza in the USA in December 2014 and June 2015 with a loss of 42.5% of its laying hen places, accounting for a loss of approximately US$1.2 billion (Windhorst, 2015a). Although the US broiler producers were not affected by the HPAI outbreaks, they lost their export markets due to trade embargos imposed by some countries, such as China, the Republic of Korea, Japan and South Africa, causing an estimated loss of 16% in export value in the first half of 2015 (Windhorst, 2015a; Windhorst, 2015b).

Other consequences of massive HPAI outbreaks include the loss of millions of birds in a short period of time due to depopulation and the disposal of carcasses (Windhorst, 2015a; Wiehoff, 2015). The depopulation method used in the US outbreaks included a water-based foam and carbon dioxide gas, which was used to cull birds (Wiehoff, 2015). However, only 100,000 birds can be killed with carbon dioxide gas per day (Windhorst, 2015a; Wiehoff, 2015). As a result, the euthanasia process at large farms for multi-tier layer cages with 4 to 5 million birds can take several weeks, which increases the risk of spreading the virus in the surrounding environment (Windhorst, 2015a). APHIS proposed to shut off ventilation systems and let the birds die from overheating and suffocation (Wiehoff, 2015), which could reduce the spread of the virus to the surrounding environment (Windhorst, 2015a). However, this method raises concerns over animal welfare (Windhorst, 2015a; Wiehoff, 2015). Carcass disposal is also a very important issue when it comes to spreading the virus. Incineration, decomposition and landfills were commonly used to dispose of dead birds in the USA (Wiehoff, 2015).

Although the primary source of virus introduction to the affected poultry holdings is still unclear, migration patterns among wild birds have been associated with the spread of the H5N1 virus from December 2003 to December 2006 (Si et al., 2009). The outbreak of H5N8 in Europe in 2014 may also be associated with the migration of wild birds during the spring season from eastern Asia to breeding grounds in Central Asia since the virus strain was genetically close to a virus from the Republic of Korea (FAO, 2014). In addition, the outbreak of HPAI in the USA in 2015 occurred along the Mississippi Americas Flyway where the states of Iowa, Minnesota, South Dakota, Nebraska and Wisconsin were most affected (Shane, 2015). Therefore, the migratory routes of wild birds may play an important role in the spread of the virus over long distances (see Figure 4.3).

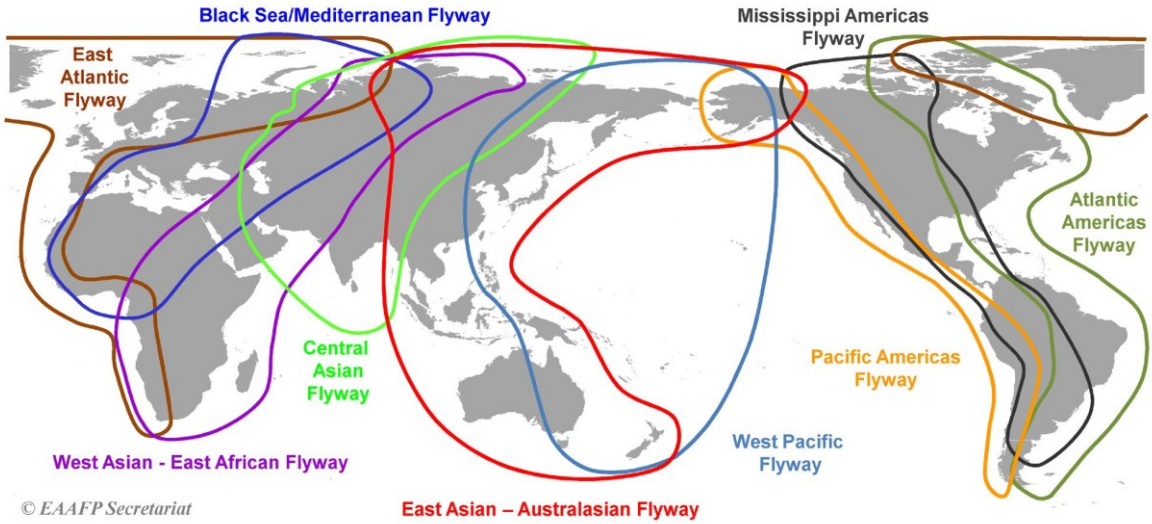


Figure 4.3 Major global flyways for waterbirds

Source: Wetlands International (2014).

According to Boere and Stroud (2006), a flyway is defined as "the entire range of a migratory bird species (or groups of related species or distinct populations of a single species) through which it moves on an annual basis from the breeding grounds to non-breeding areas, including intermediate resting and feeding places as well as the area within which the birds migrate". Wetlands International (2014) has recognised 9 major global flyways for waterbirds, including the East Atlantic Flyway, Black Sea/Mediterranean Flyway, West Asian-East African Flyway, Central Asian Flyway, East Asian-Australasian Flyway, West Pacific Flyway, Pacific Americas Flyway, Mississippi Americas Flyway and Atlantic Americas Flyway. As can be seen in Figure 4.3, there are several overlapping areas between major flyways which may play a significant role in the spreading of the bird flu virus.

In addition to wild birds introducing the virus into farms, biosecurity procedures at the farm also play a significant role in the lateral spread of avian influenza between farms. According to an epidemiological study conducted by APHIS (2015), only 43% of 81 surveyed turkey farms affected by H5N2 in the USA were implementing biosecurity audits or assessments. Fomites, such as humans, shared equipment (e.g. live haul loaders, pre-loaders, feed trucks, poultry trailers, trucks, washer) and shared mortality bins were considered causes for transmitting HPAI in several cases. In addition, airborne transmission may also cause the spread of HPAI viruses.

Avian influenza not only impacts on wild and domestic birds, but also on human health. Avian influenza virus subtypes H5N1 and H7N9 can be transmitted to humans and lead to severe or even fatal diseases (European Parliament, 2015). The World Health Organisation (WHO) reported 447 deaths and 840 cases of human infection with the highly pathogenic avian influenza H5N1 virus between 2003 and 1 May 2015 (Clements, 2015b). Figure 4.4 shows the confirmed cases of human avian influenza A (H5N1) reported to the WHO between 2003 and 2015.

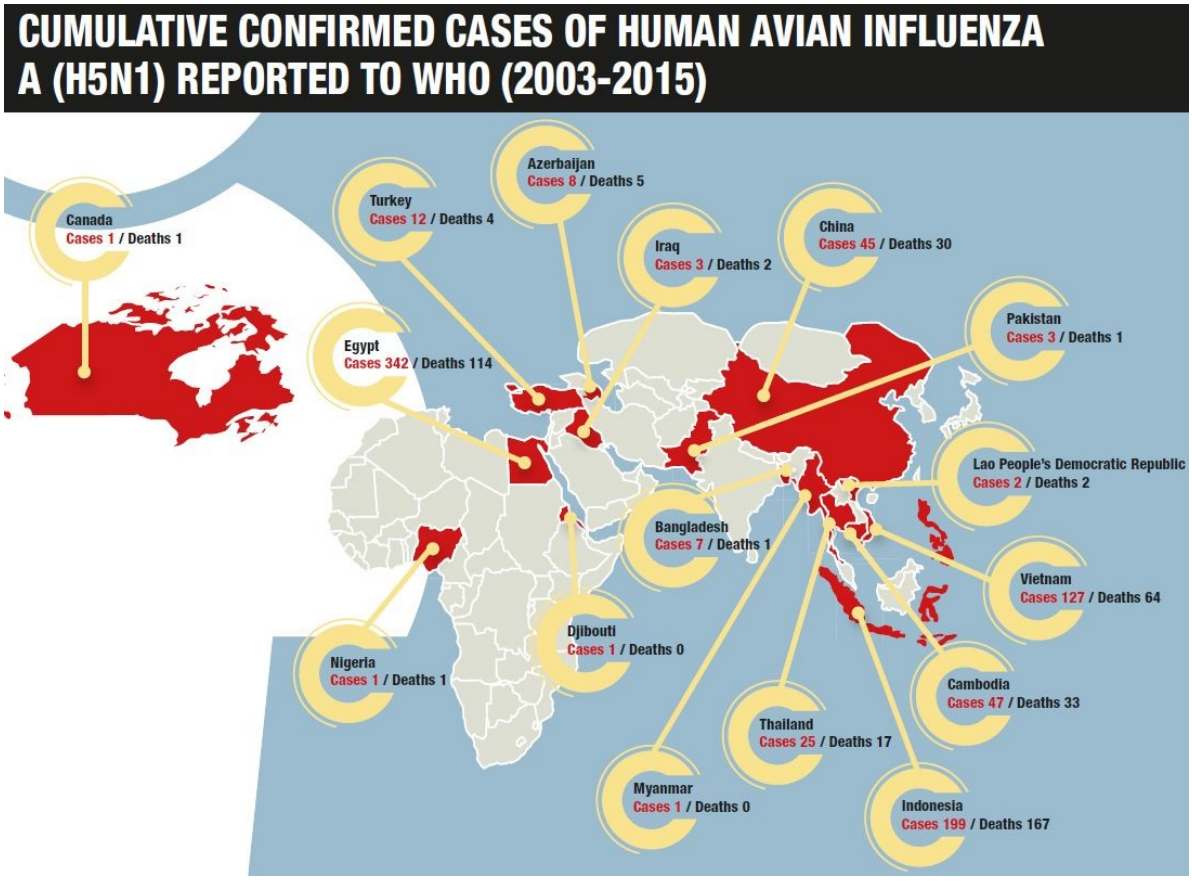


Figure 4.4 Confirmed cases of human avian influenza A (H5N1) between 2003 and 2015

Source: Clements (2015b).

Egypt recorded the most confirmed infection cases in humans with 342 patients, of which 114 cases resulted in mortality. The most mortality cases - 167 in total - were reported by Indonesia. 127 infections and 64 mortality cases were recorded in Vietnam, while 30 mortality cases were recorded in China. In addition, a low-pathogenic avian influenza subtype H7N9 that emerged in China early 2013 was reported as causing more than 100 infections in humans within the country (Clements, 2015c). It is clear that the majority of human infections and deaths occurred in developing countries, where poor biosecurity measures, poverty, the

lack of resources and ignorance play an important role in the spread of avian influenza, especially in the case of Egypt (Clements, 2015b).

It can be concluded that the current spread of avian influenza can be associated with the migration of infected wild birds (Alexander, 2007; de Jong et al., 2009), low levels of biosecurity control (Ssemantimba et al., 2013), poverty and lack of resources (Clements, 2015b), as well as the popularity of intensive farming (Daly, 2013). Large flocks of fast-growing birds raised on an intensive poultry farm increase the risk of influenza viruses emerging and spreading due to optimum conditions in the chicken houses and the birds' low immunity to disease. Areas of intensive poultry production located near watershed areas or along the migration routes of wild waterfowl are considered high risk zones for avian influenza outbreaks (Grabkowsky, 2010). According to a study conducted by Ssematimba et al. (2013) on the risks of introducing the virus to poultry farms, the riskiest forms of contact are between birds when thinning and restocking the flock, between humans and birds when accessing poultry houses, and between different poultry farms located in close proximity to each other. The overall risk posed by humans, equipment and premises-only contact was considered medium for both broiler and layer farms. An improvement in biosecurity measures would therefore be beneficial for controlling the spread of avian influenza.

4.5 Regional concentration of production

Areas of intensive poultry production face the following complex issues: an oversupply of organic nutrients, higher risks of epidemics, and higher greenhouse gas emissions in the form of nitrous oxide from large-scale farming (Klohn and Windhorst, 1998; Mose et al., 2007). Poultry manure can be used to produce biofuels or fertilise crops. However, when it overused and managed poorly, the nutrients in poultry manure can pollute both ground and surface water, resulting in eutrophication and a high concentration of nitrate in the ground water that is ultimately used to produce drinking water (Edwards and Daniel, 1992; Pelletier, 2008). The intensification of poultry farming can increase the risk of infectious diseases emerging due to the changes in production modifying patterns of disease transmission (Slingenbergh et al., 2004). The emission of odours and the growth in fly and insect populations at poultry farms are problematic for residents living nearby.

However, the spatial concentration of poultry farming can have positive effects, such as positive cluster effects and regional value chains. Individual units of interconnected producers, feed mills, slaughter houses and processing plants are located in close proximity to one another, which could lower production costs. Coupled with a well-developed transport infrastructure, this can significantly increase competitiveness (Gerber et al., 2008).

Thus, the challenge is how to balance the advantages and disadvantages of different concentration patterns. The various levels of policy, from the local to central government, can contribute to optimal distribution results over time.

4.6 De-beaking

De-beaking, also referred to as beak trimming, is often performed in an attempt to reduce the risk of welfare and health issues caused by feather pecking and cannibalism in flocks of fattening turkeys and laying hens. The causes of feather pecking are multifactorial, but it is most frequently associated with foraging (Blokhuis, 1986; Dixon et al., 2008; Ramadan and von Borell, 2008).

The procedure of de-beaking involves using a red-hot blade or an infra-red beam to damage the beak to the extent that its tip is shed. Hot-blade beak trimming employs a guillotine-type blade heated to 750°C or more that cuts and cauterises the beak tissue when chicks are 5 to 10 days old. A second beak trimming may be required on birds when they are 5 to 8 weeks of age if a trimmed beak grows back (Cheng, 2010; Jendral and Robinson, 2004). Infra-red beak trimming is an automated process performed at the hatchery on day-old chicks (Dennis and Cheng, 2010). The chicks are immobilised using a head restraint and infra-red energy is focused onto the tip of the beak. A high intensity (radiant at 50 to 60 Watt) beam of heat is directed through the beak's corneum layer into the corneum-generating basal tissue where it prevents further germ layer growth (Cheng, 2010). After treatment, the corneum layer remains intact for another 7 to 10 days, when the treated beak tip will slowly soften and erode away (Cheng, 2010; Dennis and Cheng, 2010).

However, beak trimming using the traditional hot-blade method or the new infra-red procedure can have a negative impact on poultry welfare (Kuenzel, 2007; Marchant-Forde et al, 2008), including trauma during the procedure, pain due to tissue damage and nerve injury,

the loss of normal functions due to a reduced ability to sense materials with the beak, and the loss of integrity in a living animal (Pickett, 2009).

Concerns were raised in some European countries that the prohibition of beak trimming could result in higher levels of feather pecking and cannibalism in turkeys and laying hens. However, studies suggest that feeding hens a diet rich in fibre could reduce the likelihood of feather pecking (van Krimpen et al., 2005) and prevent cannibalism in laying hens (Hetland et al, 2004). The use of appropriate species and sound farm design and management could also prevent feather pecking and cannibalism (Pickett, 2009).

The Scandinavian countries, Switzerland and Austria have already prohibited de-beaking in the poultry industry. Other European countries, such as Germany, the United Kingdom and the Netherlands, are currently discussing a ban. In Germany, some retailers, including REWE and EDEKA, have already started to sell eggs from non-trimmed layer hens in Lower Saxony State. These eggs are produced by a model farming project that aims to stop beak trimming by late 2016 based on the increasing concerns raised over animal welfare in Germany.

4.7 Killing of day-old male layer chicks

Millions of day-old male layer chicks are culled each year the world over because they are not commercially profitable. Until the 1960s, chickens were raised in people's backyards: Hens laid eggs and once their productivity declined they were used as stewing hens, while male chicks were used for broiler production (Fröhlingsdorf, 2013). Today, with an increasing global population and a growing demand for eggs and poultry meat, the industry has responded by developing different breeds, with egg-laying breeds raised for egg production only, and others raised only for meat production. As a result, male layer chicks are discarded because they do not lay eggs and are not suitable for meat production.

However, growing concerns over animal welfare are being raised in many developed countries such as Germany, the Netherlands, the United Kingdom, the USA, Australia and New Zealand. The killing of day-old male layer chicks has been criticised both in public debates and in political discussions due to ethical concerns. The egg production industry has therefore been investigating this issue further in order to find a solution that benefits both society and the industry itself. Potential alternative methods have been identified, such as the

use of combination breeds (dual purpose: suitable for egg and meat production) and in-ovo determination of the embryo's sex, either before incubation or at an early stage in the egg incubation phase, to avoid the potential pain and suffering of the currently used euthanasia methods (Leenstra et al., 2008; Windhorst, 2013b; Bruijnis et al., 2014; Weissmann et al., 2014). However, at present these alternatives are not yet utilised in practice.

In developing countries such as Thailand, male layer chicks are raised for meat production and sold on the local market as well as being exported to neighbouring countries, since the meat of male chicken is very popular in this region (Soisontes, 2015). However, this issue remains a challenge for egg-producing countries, especially in Europe, because markets are still limited and production costs are high.

4.8 Conclusion

In addition to the issues mentioned above, additional sustainability issues in poultry production are also discussed in the literature, such as the export of poultry meat to Africa (Veauthier, 2014) and the possibility of reducing soybean imports by producing domestic soybeans in European countries (Veauthier et al., 2013).

Chapter 5
Poultry production in Germany and Thailand

5.1 Introduction

This chapter introduces the structures, production data, regional concentration and organisational models of poultry production in Germany and Thailand, which is based on a qualitative and quantitative analysis of primary and secondary data. The next sections are organised as follows: 5.2 Structure of poultry production in Germany; 5.3 Structure of poultry production in Thailand; 5.4 Geographical concentration of poultry production; 5.5 Production and trade; 5.6 Organisational models in the poultry industry; 5.7 Comparison of poultry production between Germany and Thailand; and 5.8 Conclusion.

5.2 Structure of poultry production in Germany

5.2.1 Structure of broiler production

In 2013, Germany had 4,500 broiler farms with places for a total of around 97 million birds, as shown in Table 5.1. About 66% of broiler places (production capacity per one cycle) were located in Lower Saxony, while the majority of broiler farms were located in Bavaria (1,900 farms), followed by Lower Saxony with 1,100 farms. The average flock size in Germany was 21,588 birds per farm, with the largest flock sizes recorded in Lower Saxony, Mecklenburg-Western Pomerania, Saxony-Anhalt and North Rhine-Westphalia with an average of 58,507; 45,520; 29,030; and 12,965 birds per farms, respectively.

Table 5.1 Regional distribution of the German broiler production (2013)

State	Number of broilers in 1,000	Share (%)	Number of broiler farms	Average number of broilers per farm
Baden-Württemberg	950	1.0	300	3,167
Bavaria	5,658	5.8	1,900	2,978
Berlin	n.d.	n.d.	n.d.	n.d.
Brandenburg	n.d.	n.d.	n.d.	n.d.
Bremen	n.d.	n.d.	n.d.	n.d.
Hamburg	n.d.	n.d.	n.d.	n.d.
Hesse	n.d.	n.d.	200	n.d.
Mecklenburg-Western Pomerania	4,552	4.7	100	45,520
Lower Saxony	64,358	66.3	1,100	58,507
North Rhine-Westphalia	5,186	5.3	400	12,965
Rhineland-Palatinate	36	0.0	n.d.	n.d.
Saarland	n.d.	n.d.	n.d.	n.d.
Saxony	n.d.	n.d.	100	n.d.
Saxony-Anhalt	2,903	3.0	100	29,030
Schleswig-Holstein	1,541	1.6	200	7,705
Thuringia	273	0.3	n.d.	n.d.
Total	97,146	100	4,500	21,588

Source: MEG (2015). *n.d. = no data

According to MEG (2015), approximately 62% of broiler farms had places for less than 100 birds per farm in 2013, with around 84% of farms of this size located in Bavaria. 15.6% of broiler farms had places for between 10,000 and 49,999 birds, with 36.4% and 25% of these farms located in Lower Saxony and North Rhine-Westphalia, respectively. Farms that had places for more than 49,999 birds were mainly located in Lower Saxony with a share of 45.5%.

Figure 5.1 shows the regional distribution of broiler places in Germany in 2013. Broilers are clearly concentrated in the state of Lower Saxony.

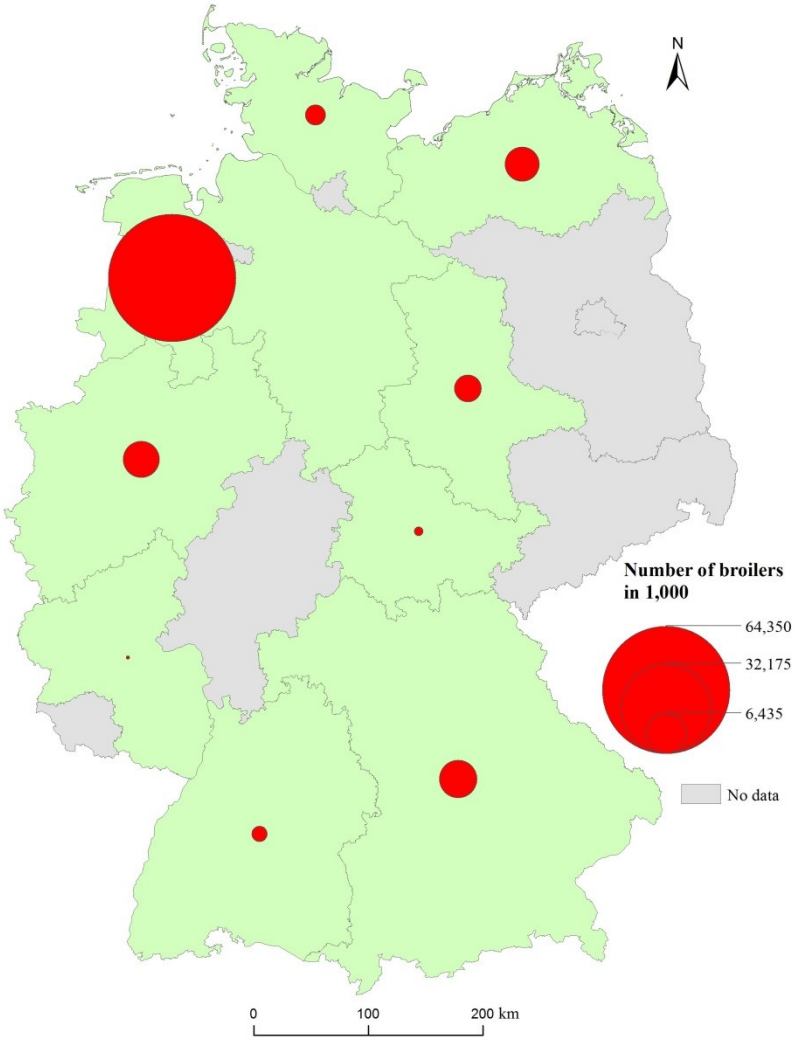


Figure 5.1 Regional distribution of broilers in Germany by state (2013)

Source: MEG (2015); Author's design.

5.2.2 Structure of turkey production

In 2013, Germany had 1,900 turkey farms with places for a total of approximately 13 million birds, as presented in Table 5.2.

Table 5.2 Regional distribution of the German turkey production (2013)

State	Number of turkeys in 1,000	Share (%)	Number of turkey farms	Average number of turkeys per farm
Baden-Württemberg	1,002	7.6	200	5,010
Bavaria	812	6.1	n.d.	n.d.
Berlin	n.d.	n.d.	n.d.	n.d.
Brandenburg	1,383	10.4	100	13,830
Bremen	n.d.	n.d.	n.d.	n.d.
Hamburg	n.d.	n.d.	n.d.	n.d.
Hesse	106	0.8	n.d.	n.d.
Mecklenburg-Western Pomerania	590	4.5	100	5,900
Lower Saxony	6,424	48.5	500	12,848
North Rhine-Westphalia	1,537	11.6	200	7,685
Rhineland-Palatinate	n.d.	n.d.	n.d.	n.d.
Saarland	0	0.0	0	0
Saxony	196	1.5	100	1,960
Saxony-Anhalt	963	7.3	100	9,630
Schleswig-Holstein	57	0.4	n.d.	n.d.
Thuringia	163	1.2	n.d.	n.d.
Total	13,256	100	1,900	6,977

Source: MEG (2015). *n.d. = no data

About 48.5% of turkey places were concentrated in Lower Saxony, followed by North Rhine-Westphalia, Brandenburg and Baden-Württemberg with a share of 11.6%, 10.4% and 7.6%, respectively. With 500 farms, Lower Saxony had the most turkey farms in Germany, followed by Baden-Württemberg and North Rhine-Westphalia with 200 turkey farms each. Flock size averaged at 6,977 birds per farm, with Brandenburg reporting the highest flock size with an average of 13,830 birds per farm.

According to MEG (2015), almost 58% of turkey farms had places for less than 100 birds per farm in 2013. 26.3% of turkey farms had places for more than 9,999 birds, with 50% and 40% of these farms located in North Rhine-Westphalia and Lower Saxony, respectively. About 15.8% of turkey farms had places for between 1,000 and 9,999 birds.

Figure 5.2 shows the regional distribution of turkey places in Germany in 2013. The state of Lower Saxony clearly dominates the country's turkey production.

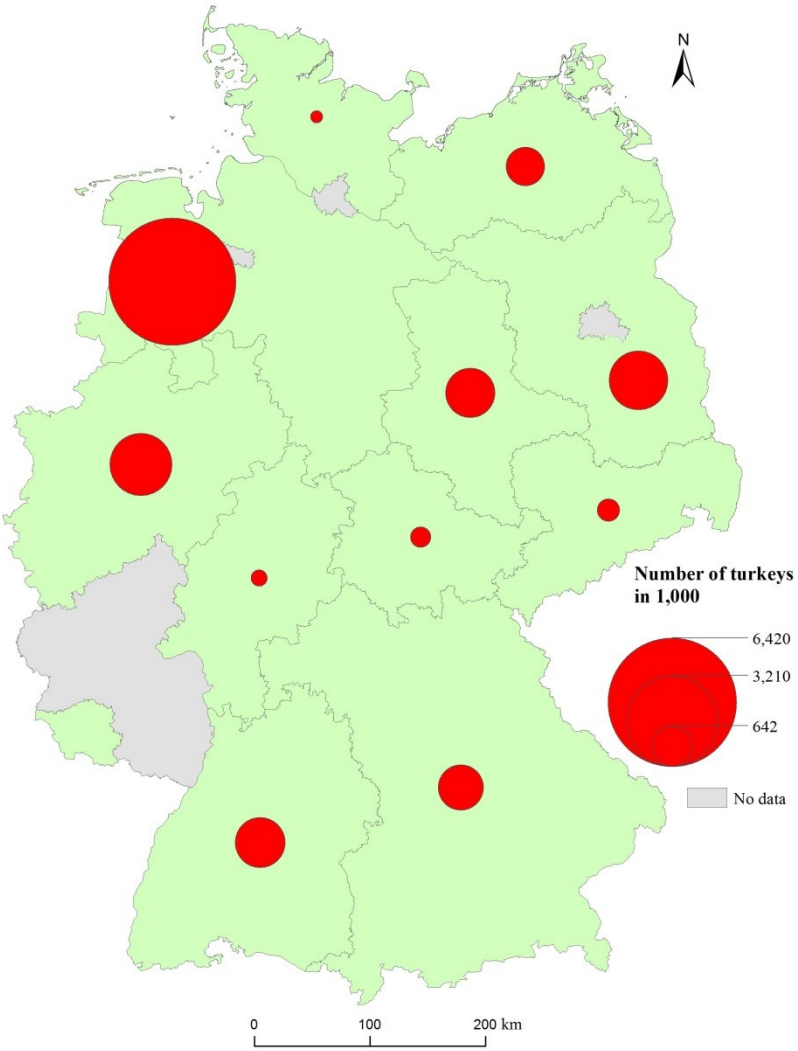


Figure 5.2 Regional distribution of turkeys in Germany by state (2013)

Source: MEG (2015); Author's design.

5.2.3 Structure of laying hen husbandry

In 2013, Germany had 54,100 layer farms with places for a total of approximately 48 million birds, as illustrated in Table 5.3. Lower Saxony dominated the field with a share of 38.7% of the total laying hen capacity. Bavaria registered the most layer farms with 26,200 facilities. The average flock size in Germany was 887 birds per farm, with Saxony-Anhalt, Mecklenburg-Western Pomerania, Brandenburg and Lower Saxony reporting the largest flock size with an average of 7,948; 4,332; 3,883 and 3,645 birds per farm, respectively. The smallest flock size of laying hens was raised in Bavaria with an average of 146 birds per farm.

Table 5.3 Regional distribution of the German laying hen husbandry (2013)

State	Number of laying hens in 1,000	Share (%)	Number of layer farms	Average number of laying hens per farm
Baden-Württemberg	2,538	5.3	8,400	302
Bavaria	3,837	8.0	26,200	146
Berlin	n.d.	n.d.	n.d.	n.d.
Brandenburg	3,495	7.3	900	3,883
Bremen	n.d.	n.d.	n.d.	n.d.
Hamburg	n.d.	n.d.	n.d.	n.d.
Hesse	983	2.1	3,200	307
Mecklenburg-Western Pomerania	2,599	5.4	600	4,332
Lower Saxony	18,589	38.7	5,100	3,645
North Rhine-Westphalia	3,598	7.5	3,600	999
Rhineland-Palatinate	901	1.9	1,400	644
Saarland	125	0.3	200	625
Saxony	3,830	8.0	1,600	2,394
Saxony-Anhalt	3,974	8.3	500	7,948
Schleswig-Holstein	1,536	3.2	1,500	1,024
Thuringia	1,974	4.1	800	2,468
Total	47,987	100	54,100	887

Source: MEG (2015). *n.d. = no data

According to MEG (2015), the majority of layer farms (91.5%) had places for less than 100 birds per farm in 2013. A mere 4.6% of layer farms had places for between 100 and 999 birds. Only 0.4% of layer farms had places for more than 49,999 birds, mainly located in Lower Saxony, which accounted for 2% of its total farms.

Figure 5.3 shows the regional distribution of laying hen places in Germany in 2013. Laying flocks are clearly concentrated in the state of Lower Saxony.

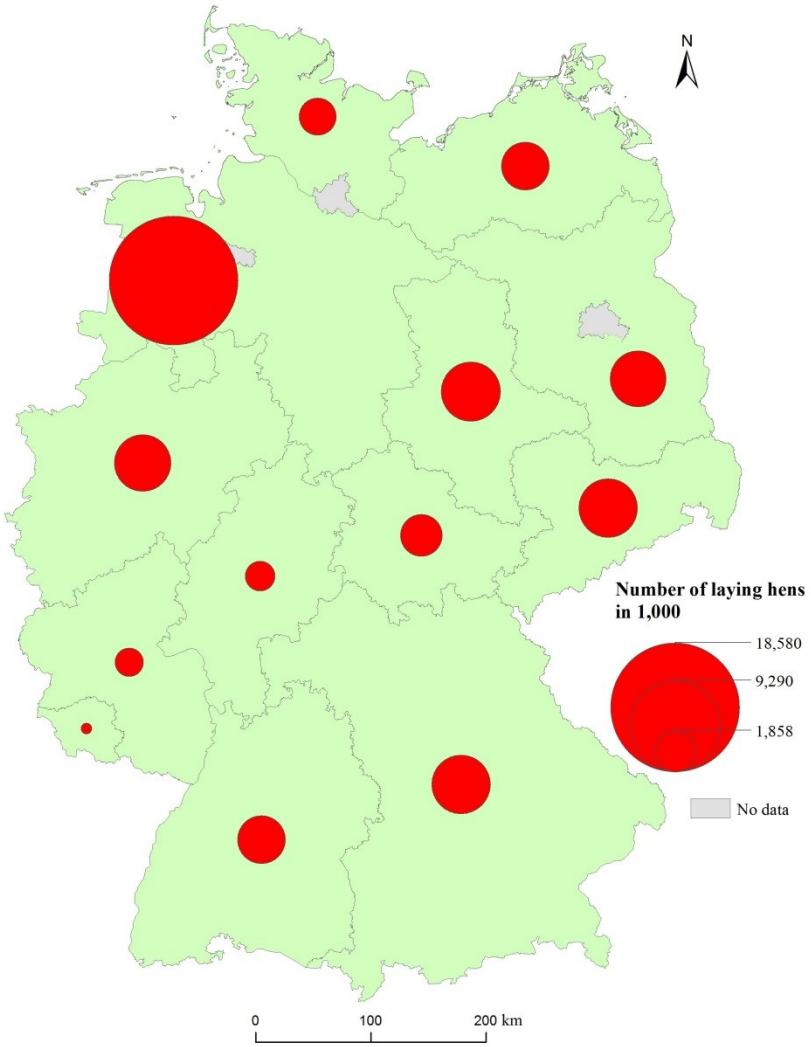


Figure 5.3 Regional distribution of laying hens in Germany by state (2013)

Source: MEG (2015); Author's design.

5.3 Structure of poultry production in Thailand

5.3.1 Structure of broiler production

In 2013, Thailand had 6,735 commercial broiler farms with places for a total of 149.9 million birds, as shown in Table 5.4. Around 65.8% of broiler places were concentrated in the Central region, followed by the Northeastern region with 18.2%. The majority of broiler farms were located in the Central region (3,020 farms) where the flock size was also the largest, with an average of 32,652 birds per farm. The Southern region had the smallest flock size with an average of 9,577 birds per farm.

Table 5.4 Regional distribution of the Thai broiler production (2013)

Region	Number of broilers in 1,000	Share (%)	Number of commercial broiler farms	Average number of broilers per farm
Northern	13,844	9.2	1,046	13,235
Northeastern	27,317	18.2	1,609	16,977
Central	98,610	65.8	3,020	32,652
Southern	10,130	6.8	1,060	9,557
Total	149,900	100	6,735	22,257

Source: Office of Agricultural Economics (2013); Department of Livestock Development (2014).

Table 5.5 presents the major five provinces with the highest number of broiler places in 2013. Chon Buri had the highest number of broiler places in the country, accounting for 18.6% of the total broiler places, followed by Rayong, Chachoengsao, Prachin Buri and Nakhon Nayok with a share of 7.2%, 7.2%, 6.7% and 5.9%, respectively. The top five provinces accounted for approximately 45.5% of the total broiler places in Thailand. 1,144 broiler farms were located in these five provinces, with an average flock size of 59,633 birds per farm. Nakhon Nayok had the largest flock size out of the top five provinces with an average of 131,132 birds per farm.

Table 5.5 Top 5 provinces with the highest number of broiler places (2013)

Rank	Province	Number of broilers in 1,000	Share (%)	Number of commercial broiler farms	Average number of broilers per farm
1	Chon Buri	27,836	18.6	415	67,075
2	Rayong	10,790	7.2	194	55,616
3	Chachoengsao	10,761	7.2	188	57,237
4	Prachin Buri	10,048	6.7	280	35,884
5	Nakhon Nayok	8,786	5.9	67	131,132
Total of major 5 provinces		68,220	45.5	1,144	59,633
Total of Thailand		149,900	100	6,735	22,257

Source: Office of Agricultural Economics (2013); Department of Livestock Development (2014).

Figure 5.4 shows the regional distribution of broiler places in Thailand in 2013. Broilers are concentrated in the Central region, especially in the provinces of Chon Buri, Rayong and Chachoengsao.

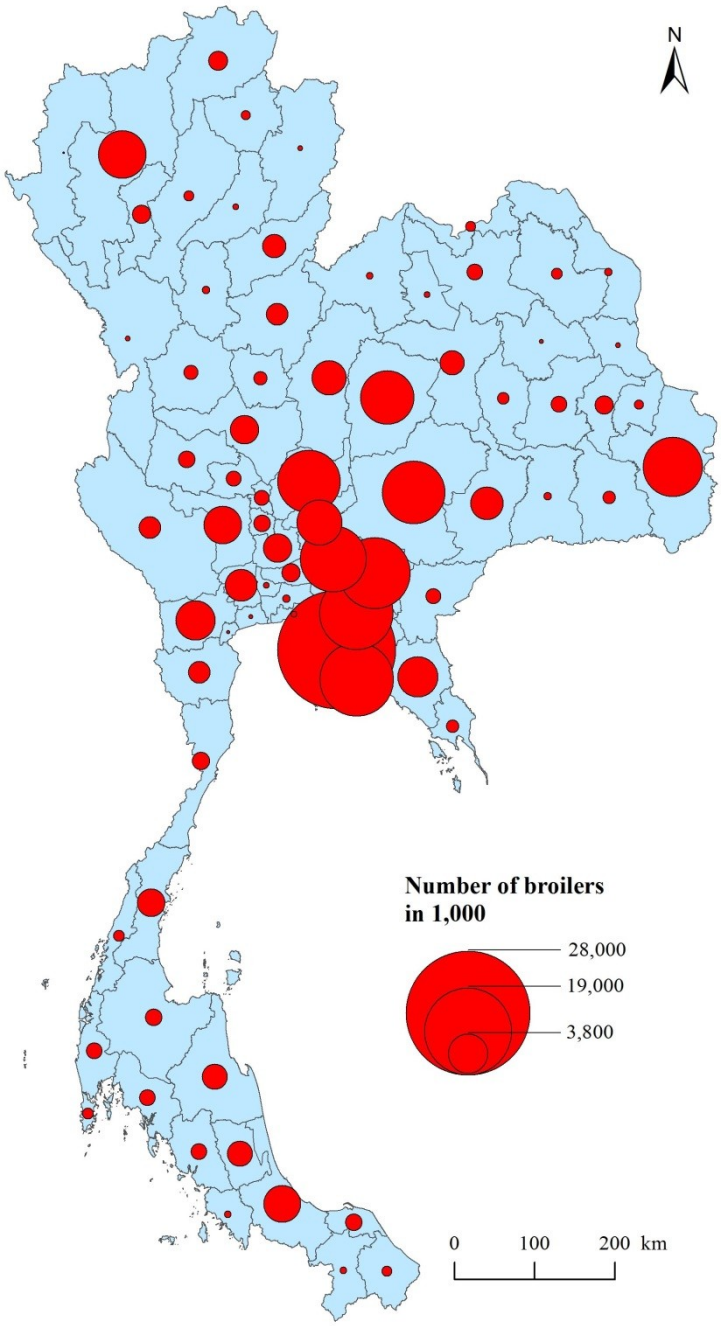


Figure 5.4 Regional distribution of broilers in Thailand by province (2013)

Source: Office of Agricultural Economics (2013); Author's design.

5.3.2 Structure of laying hen husbandry

In 2013, Thailand had 1,925 commercial layer farms with places for a total of approximately 44.3 million birds, as presented in Table 5.6. Around 56.7% of laying hen places were concentrated in the Central region. The average flock size was 23,013 birds per farm in Thailand, with the Central region reporting the biggest flock size with an average of 45,926 birds per farm. The Northeastern and Northern regions recorded the most layer farms with 601 and 600, respectively. The Southern region had the lowest number of layer farms (177), while the Northern region had the smallest flock size with an average of 10,522 birds per farm.

Table 5.6 Regional distribution of the Thai laying hen husbandry (2013)

Region	Number of laying hens in 1,000	Share (%)	Number of commercial layer farms	Average number of laying hens per farm
Northern	6,313	14.3	600	10,522
Northeastern	7,938	17.9	601	13,208
Central	25,121	56.7	547	45,926
Southern	4,928	11.1	177	27,842
Total	44,301	100	1,925	23,013

Source: Office of Agricultural Economics (2013); Department of Livestock Development (2014).

Table 5.7 shows the top five provinces with the highest number of laying hen places in Thailand in 2013. Chachoengsao reported the highest amount of laying hen places in the country, which accounted for 10%, followed by Nakhon Nayok (7.4%), Phra Nakhon Si Ayutthaya (7.2%), Chon Buri (5.9%) and Suphan Buri (5.7%). In total, 36.3% of Thailand's laying hen places were occupied by 257 commercial farms in these five provinces. Amongst the top five, Chon Buri had the most layer farms (106 farms), while Suphan Buri and Nakhon Nayok had the biggest flock size with an average of 363,201 and 204,946 birds per farm, respectively.

Table 5.7 Top 5 provinces with the highest laying hen places (2013)

Rank	Province	Number of laying hens in 1,000	Share (%)	Number of commercial layer farms	Average number of laying hens per farm
1	Chachoengsao	4,448	10.0	91	48,881
2	Nakhon Nayok	3,279	7.4	16	204,946
3	Phra Nakhon Si Ayutthaya	3,198	7.2	37	86,421
4	Chon Buri	2,620	5.9	106	24,722
5	Suphan Buri	2,542	5.7	7	363,201
Total of major 5 provinces		16,088	36.3	257	62,598
Total of Thailand		44,301	100	1,925	23,013

Source: Office of Agricultural Economics (2013); Department of Livestock Development (2014).

Figure 5.5 illustrates the regional distribution of laying hen places in Thailand. Laying flocks are clearly concentrated in the Central provinces of Chachoengsao, Nakhon Nayok and Phra Nakhon Si Ayutthaya.

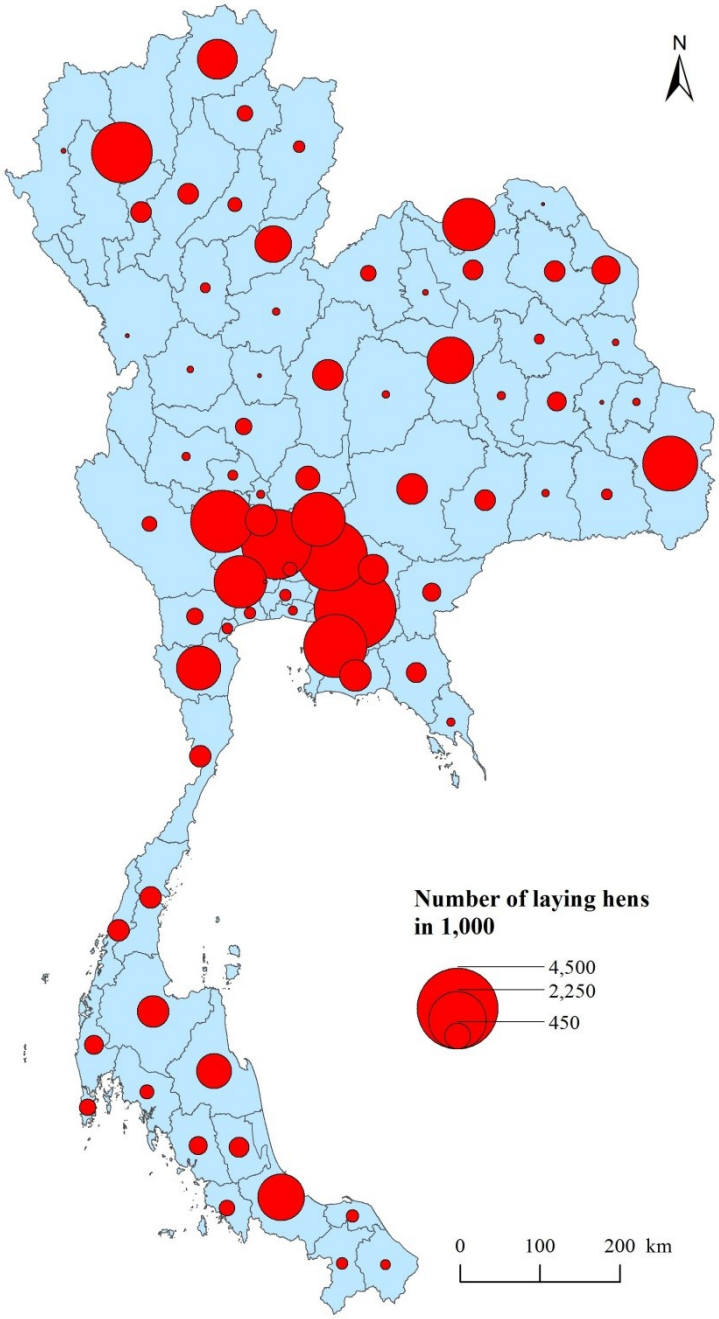


Figure 5.5 Regional distribution of laying hens in Thailand by province (2013)

Source: Office of Agricultural Economics (2013); Author's design.

5.3.3 Other poultry production in Thailand

The production of other kinds of poultry in Thailand is shown in Table 5.8, including native chickens, meat ducks and laying ducks. In 2013, Thailand had approximately 65 million native chicken, 9.6 million meat duck and 5.6 million laying duck places. Native chickens and meat ducks were concentrated primarily in the Northeastern region, accounting for 50.3% and 52.5% of Thailand's total native chicken and meat duck places, respectively. The Northern region reported the highest number of laying duck places, with a contribution of 54.4%. The Central region had the lowest number of native chicken places with a share of 9.8%. The Southern region only accounted for a small number of native chicken, meat duck and laying duck places with shares of 14.9%, 5.5% and 5%, respectively.

Table 5.8 Regional distribution of the Thai native chicken, meat duck and laying duck husbandry (2013)

Region	Number of native chickens in 1,000	Share (%)	Number of meat ducks in 1,000	Share (%)	Number of laying ducks in 1,000	Share (%)
Northern	16,192	24.9	504	5.2	3,063	54.4
Northeastern	32,744	50.3	5,056	52.5	441	7.8
Central	6,395	9.8	3,544	36.8	1,841	32.7
Southern	9,710	14.9	527	5.5	281	5.0
Total	65,041	100	9,631	100	5,626	100

Source: Office of Agricultural Economics (2013).

Figure 5.6 shows the regional distribution of poultry places in Thailand in 2013, including laying hens, broilers, native chickens, meat ducks and laying ducks. The Central region dominates the production of broilers and laying hens, while the production of native chicken is more concentrated in the Northeastern, Northern and Southern regions.

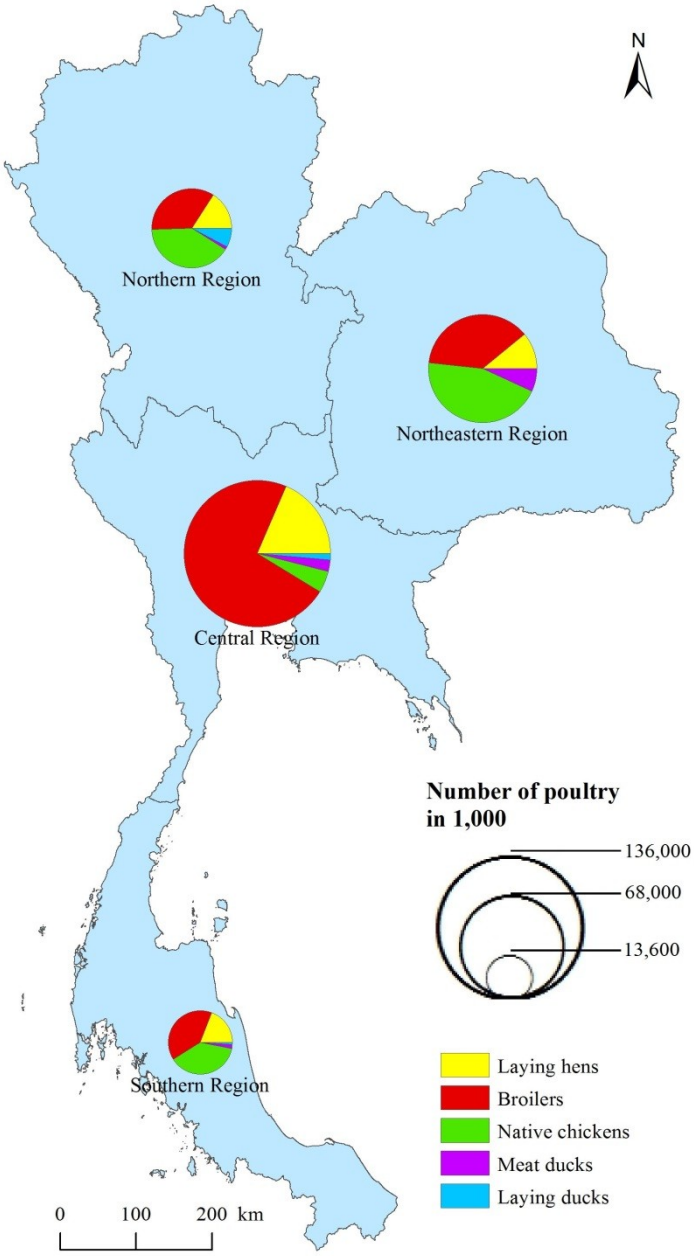


Figure 5.6 Regional distribution of poultry in Thailand by region (2013)

Source: Office of Agricultural Economics (2013); Author's design.

Figure 5.7 shows the regional distribution of laying duck places in Thailand in 2013. Laying duck flocks are clearly concentrated in the provinces of Kamphaeng Phet, Phichit and Phitsanulok.

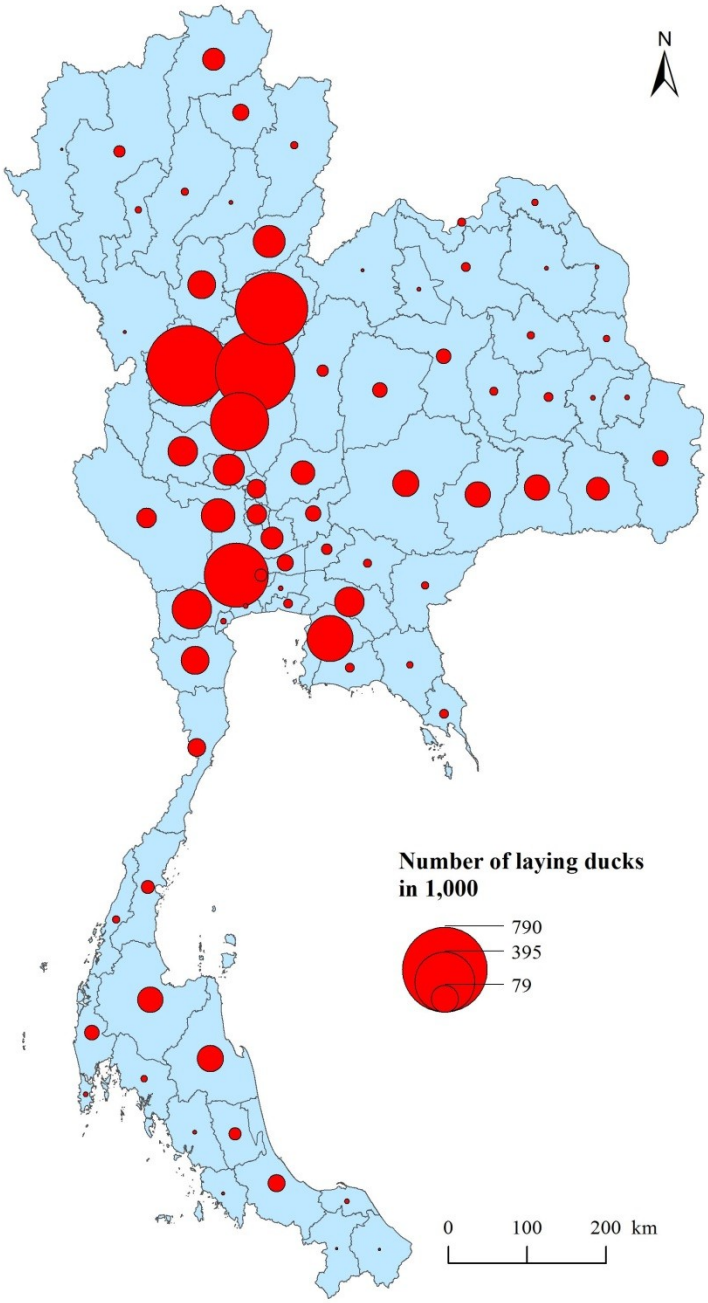


Figure 5.7 Regional distribution of laying ducks in Thailand by province (2013)

Source: Office of Agricultural Economics (2013); Author's design.

Figure 5.8 presents the regional distribution of meat duck places in Thailand in 2013. Meat ducks are clearly concentrated in the provinces of Khon Kaen, Prachin Buri and Nakhon Ratchasima.

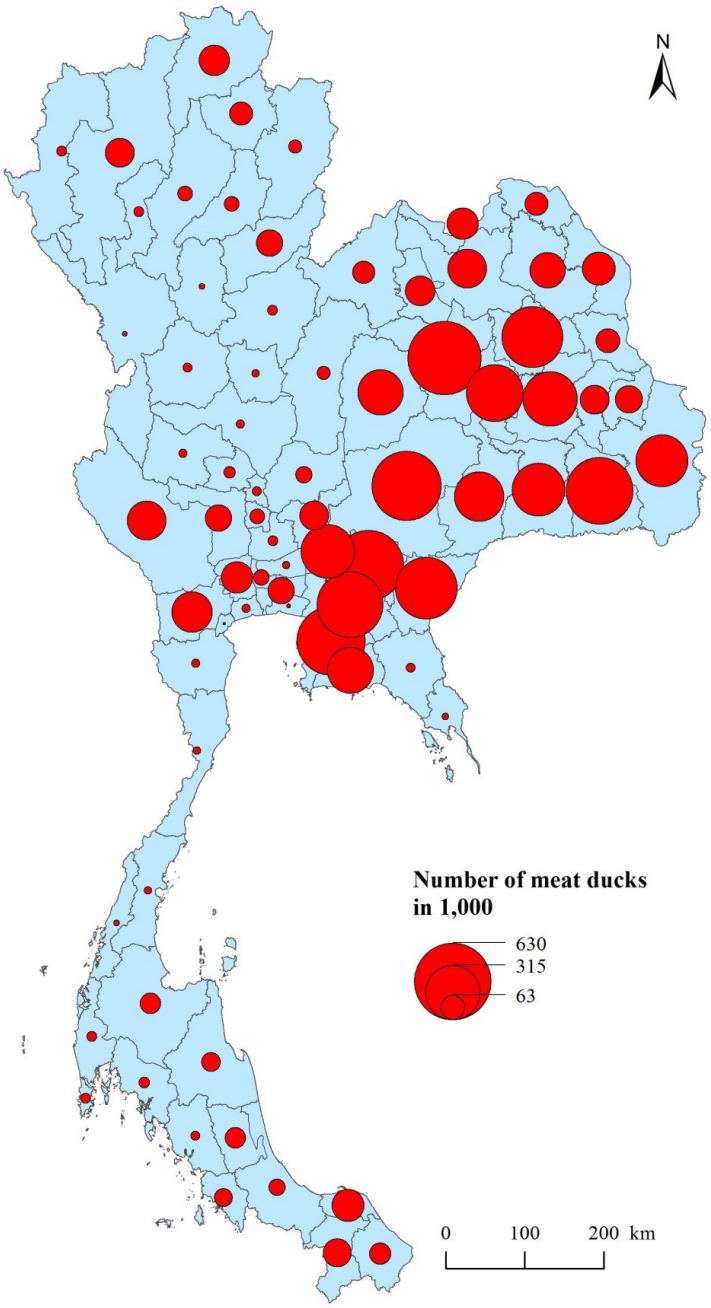


Figure 5.8 Regional distribution of meat ducks in Thailand by province (2013)

Source: Office of Agricultural Economics (2013); Author's design.

Figure 5.9 illustrates the regional distribution of native chicken places in Thailand in 2013. Native chickens are clearly concentrated in the provinces of Nakhon Ratchasima, Ubon Ratchathani and Nakhon Si Thammarat.

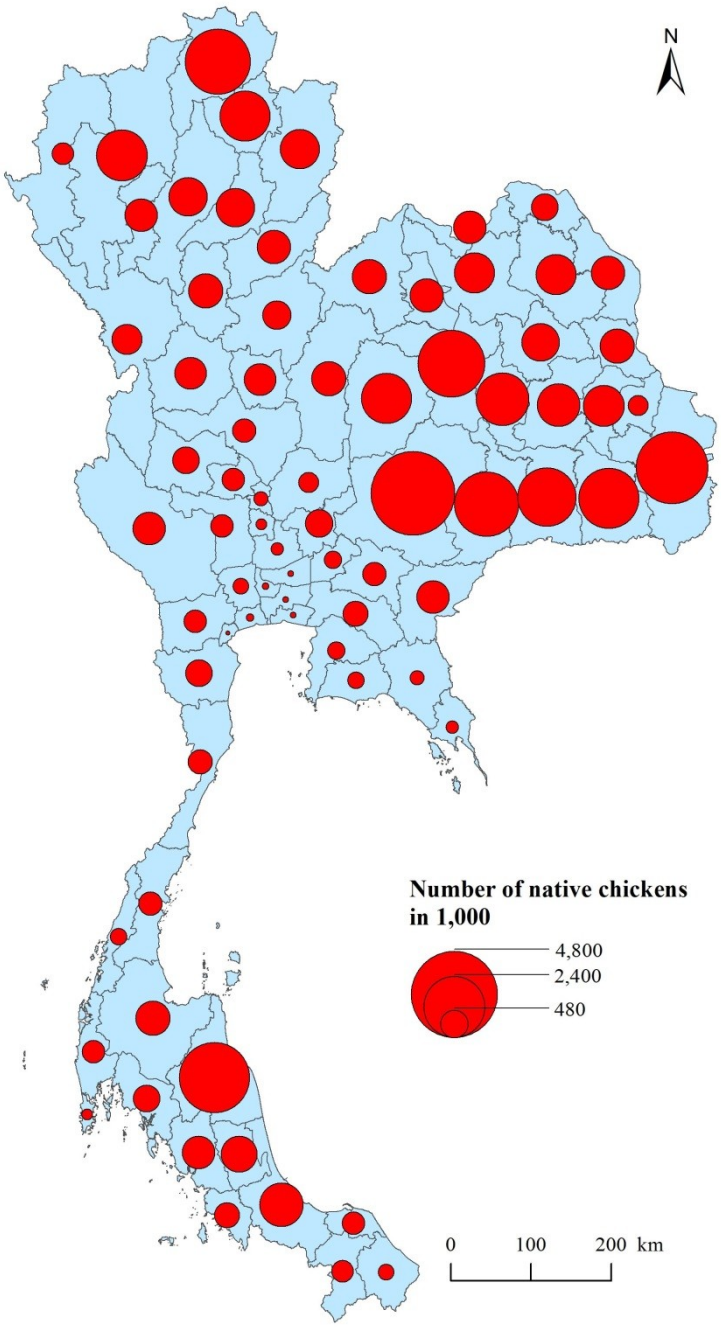


Figure 5.9 Regional distribution of native chickens in Thailand by province (2013)

Source: Office of Agricultural Economics (2013); Author's design.

5.4 Geographical concentration of poultry production

The geographical or regional concentration measures the geographical distribution of a sector or an industry in a certain territory (Ceapraz, 2008). In order to measure the geographical concentration of poultry production in Germany and Thailand, Lorenz curves are plotted and Gini coefficients are then calculated to find out whether the distribution of poultry production is the same in the two countries.

The concentration of production refers to the inequality or difference with which production is distributed between regions or countries. Inequality of production is often presented by the concentration curve, commonly called the "Lorenz curve". The Lorenz curve was introduced by Max Lorenz in 1905 to present the distribution of a particular attribute − in this case poultry production − across a country's various regions.

First, the percentage of poultry production per region is ordered from smallest to largest. The cumulative percentage per producing region is then plotted against the cumulative percentage of production accounted for by those regions. If all regions have identical production, the curve is a straight line through the diagonal (line of equality). However, a difference in poultry production from region to region causes the concentration curve to fall below the line of equality. The greater the inequality, the bigger is the area between the curve and the line of equality (McBride, 1997).

The Gini coefficient is associated with the Lorenz curve. It is the accurate measure of inequality (Morgan, 1962) and is named after its developer, Corrado Gini (1912), an Italian statistician and sociologist of the early 20th century. In relation to the Lorenz curve, the Gini coefficient is defined as the ratio of the area that lies between the Lorenz curve and the line of equality (marked *A* in the diagramme) over the total area under the line of equality (marked *A* and *B*) which $G = \frac{A}{(A+B)}$, as presented in Figure 5.10 (McBride, 1997). Therefore, the Gini coefficient is a positive fraction between *0* and *1*. With regard to poultry production, a Gini value of *0* indicates that all the production regions within a country account for an equal share of production, while a Gini value of *1* means that production is fully concentrated in just one region within the country. Pyratt et al. (1980) and McBride (1997) proposed the calculation of the Gini coefficient value by using the following formula:

$$G = \frac{2\mathrm{COV}(Y,F(Y))}{\overline{Y}}$$

where G is the Gini coefficient; $\overline{Y}$ is the mean level of production; $F(Y)$ is the cumulative distribution of production; and $COV(Y, F(Y))$ is the covariance between production Y and the cumulative density function value for this production level.

In this analysis, the Gini coefficient is calculated based on the ratio of the area that lies between the Lorenz curve and the line of equality over the total area under the line of equality, as presented in Figure 5.10.

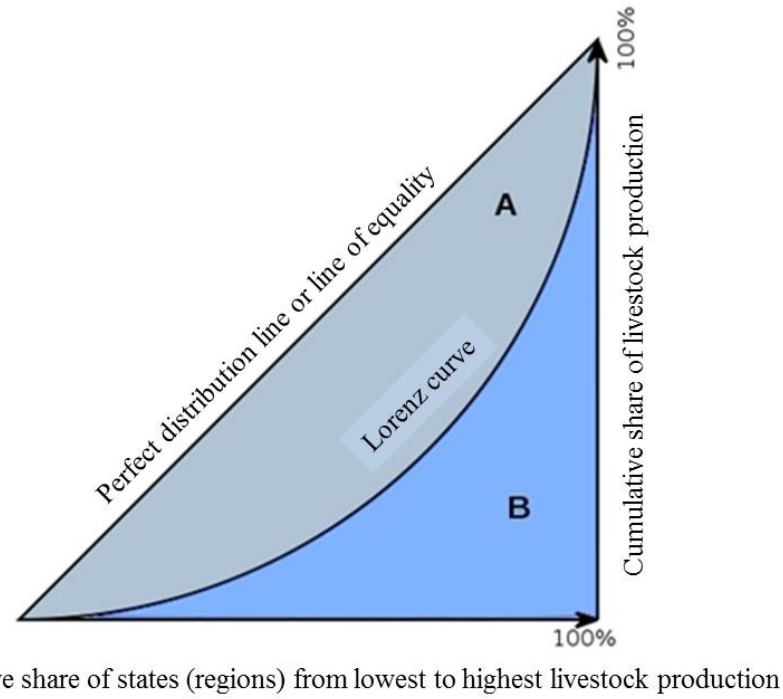


Figure 5.10 Example of the Lorenz curve for the Gini coefficient calculation, which is equal to the area A divided by the sum of the areas marked A and B. The Gini coefficient is also $2*A$ due to the fact that $A + B = 0.5$ (since the axes scale from 0 to 1).

Source: adapted from Wikipedia (2015).

In this analysis, province level data from the 2013 census on poultry production in Thailand (Office of Agricultural Economics, 2013) and state level data from the 2013 census on poultry production in Germany (MEG, 2015) are used to plot Lorenz curves and calculate Gini coefficients in order to examine the geographical concentration of poultry production in these two countries. The types of poultry production measured in this study include:

a) Broiler, laying hen and turkey husbandry in Germany;

b) Broiler, laying hen and native chicken, as well as meat duck and laying duck husbandry in Thailand.

The calculation of Gini coefficient was based on the data of poultry places (production capacity per one cycle) from both countries in 2013.

5.4.1 Geographical concentration of poultry production by federal state in Germany

The 2013 census on poultry production collected data on 16 states in Germany. However, due to the unavailability of reliable data, the states of Berlin, Bremen and Hamburg are excluded from this analysis. In addition, data on broiler production in the states of Brandenburg, Hesse, Saarland and Saxony and turkey husbandry in the state of Rhineland-Palatinate is unavailable. Thus, data on broiler places for 9 states, turkey places for 12 states, and laying hen places for 13 states, is used to analyse and present the geographical or regional concentration of poultry production in Germany.

According to the analysis of Gini coefficients, the major poultry production was highly concentrated in certain regions in Germany in 2013 (see Table 5.9). The Gini coefficients for broiler, turkey and laying hen husbandry are 0.7412, 0.6290 and 0.4761, respectively. This implies a relatively high level of inequality between states in broiler and turkey husbandry. Consequently, there is a high level of concentration in a single region. Laying hen husbandry also has a potentially high density in a certain region.

Table 5.9 Estimated Gini coefficients for the geographical concentration of poultry production in Germany (2013)

Major poultry production	Gini coefficient
Broilers	0.7412
Turkeys	0.6290
Laying hens	0.4761

Source: Author's calculation based on MEG (2015).

Figure 5.11 shows the distribution line (Lorenz curve) for poultry production in Germany (2013). The greater the area between the Lorenz curve and the line of equality, the greater is the degree of geographical (regional) concentration of poultry production. With regard to poultry places by state based on the Lorenz curves, broiler and turkey production are highly concentrated in a single region, while laying hen husbandry also has a potentially high concentration in a certain region.

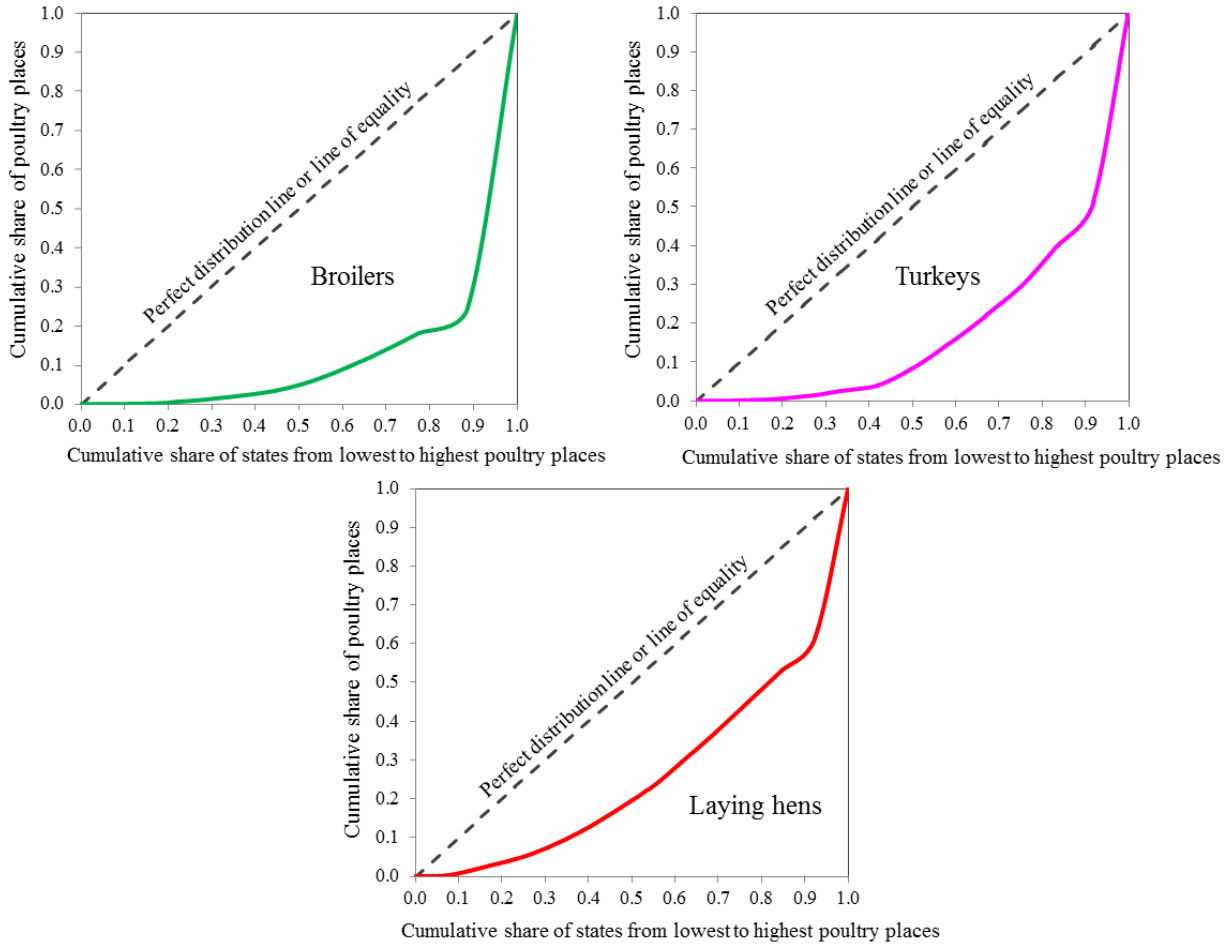


Figure 5.11 Lorenz curves for the geographical concentration of poultry production in Germany (2013)

Source: Author's calculation and design based on MEG (2015).

5.4.2 Geographical concentration of poultry production by province in Thailand

In order to analyse and present the geographical concentration of poultry production in Thailand, including broilers, laying hens, native chickens, meat ducks and laying ducks, the Lorenz curves and Gini coefficients were calculated based on the data of poultry places provided by the 2013 census of poultry production in 77 provinces in Thailand.

According to the analysis of Gini coefficients, the geographical concentration of poultry production in 2013 in Thailand was particularly high in certain provinces, as presented in Table 5.10. The Gini coefficients for laying duck, broiler, laying hen, meat duck and native chicken husbandry are 0.7563, 0.7352, 0.6778, 0.6394 and 0.5196, respectively. This indicates that the production of laying ducks is the most geographically concentrated type of poultry production in Thailand, followed by broilers, laying hens, meat ducks and native chickens, respectively.

Table 5.10 Estimated Gini coefficients for the geographical concentration of poultry production in Thailand (2013)

Major poultry production	Gini coefficient
Laying ducks	0.7563
Broilers	0.7352
Laying hens	0.6778
Meat ducks	0.6394
Native chickens	0.5196

Source: Author's calculation based on Office of Agricultural Economics (2013).

Figure 5.12 presents the distribution line (Lorenz curve) for poultry production by province in Thailand (2013). The Lorenz curves show that the production of native chicken is the most equally distributed type of poultry production in Thailand. In contrast, laying duck and broiler husbandry are the two most geographically concentrated types of poultry production, as they demonstrate a bigger area between the Lorenz curve and the line of equality.

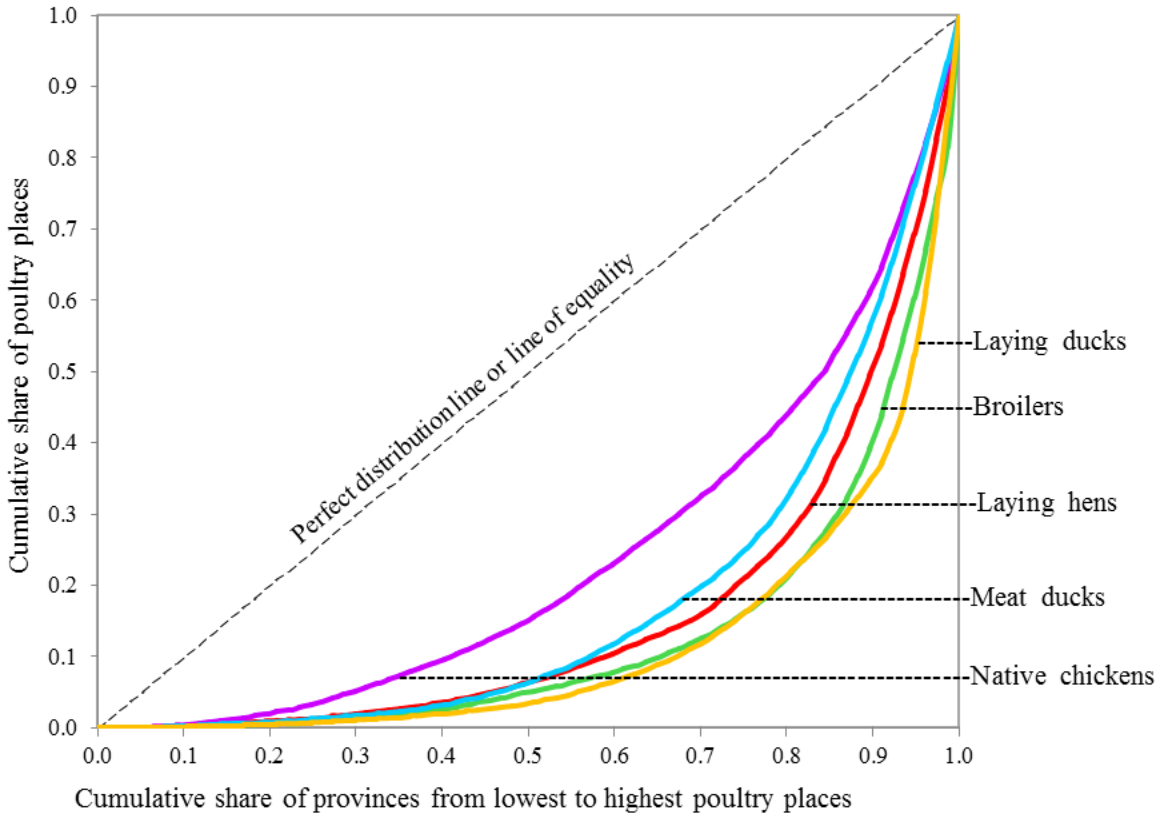


Figure 5.12 Lorenz curves for the geographical concentration of poultry production in Thailand (2013)

Source: Author's calculation and design based on Office of Agricultural Economics (2013).

5.4.3 Discussion of Gini coefficient as an instrument for sustainability

The Gini coefficient is a useful measure of distribution within a determined population, especially in terms of measuring inequalities (Bellù and Liberati, 2006). In addition to measuring the concentration of agricultural production in a certain period of time, the Gini coefficient can also indicate how the distribution of production has changed over time. It is thus possible to compare the level of production concentration and see if distribution is increasing or decreasing. However, the Gini coefficient provides different outcomes when applied to individuals instead of population groups. When comparing different countries, the population needs to be defined consistently and carefully in order to ensure the interpretation is clear and valid (Garret, 2010).

The analysis of regional concentration using the Gini coefficient in this study could provide the more accurate picture of poultry production within Germany and Thailand in combination with the quantitative regional distribution data as presented in Figures 5.1, 5.2 and 5.3 for the case of Germany and Figures 5.4, 5.5, 5.7, 5.8 and 5.9 for the case of Thailand. According to the result of Gini coefficient analysis for poultry production in Germany, broiler, turkey and laying hen husbandry were relatively highly concentrated in a single region (the state of Lower Saxony), as can be seen in Figures 5.1, 5.2 and 5.3. The Gini coefficient values for the case of Thailand showed that the geographical concentration of poultry production was also relatively highly concentrated in certain regions depending on type of poultry, as clearly shown in Figure 5.4, 5.5, 5.7, 5.8 and 5.9.

In the context of sustainability, the high concentration of poultry production in certain regions as represented by the Gini coefficient values potentially indicates strong economic activity in that region (Gerber et al., 2008) or the possible risks in areas of intensive farming, including environmental problems (Klohn and Windhorst, 1998; Mose et al., 2007), outbreaks of infectious diseases (Slingenbergh et al., 2004) and land use conflicts on the urban fringe or in areas where there is significant rural residential development (Henderson and Epps, 2000). Thus, the Gini coefficient is a useful instrument for addressing sustainability issues, especially regarding environmental concerns posed by the high regional concentration of poultry production. In addition, the Gini coefficient could be used as fundamental data for improving land use management (Zheng et al., 2013) and water consumption (Cullis and van Koppen,

2007) in agriculture, which could benefit the agricultural sector, environment and surrounding society.

5.5 Production and trade in 2013

5.5.1 Germany

According to MEG (2014), Germany produced 1.48 million tonnes of poultry meat and 12.59 billion shell eggs for consumption in 2013, as presented in Table 5.11. The self-sufficiency rate of poultry meat and shell egg production was 109.1% and 71.0%, respectively. Germany imported 531,291 tonnes of poultry meat, with 43% sourced from the Netherlands, 16% from Poland and only 2% from outside the EU. In addition, 5,895.7 million shell eggs were imported, mainly from the Netherlands (74%) and Poland (13%). A total of 496,618 tonnes of poultry meat was exported by Germany, with 25% destined for the Netherlands and 9% for France and Austria, respectively. Germany also exported 1,969 million shell eggs in 2013, with 53% being transported to the Netherlands. In the meantime, 72,826 tonnes of egg products were imported, mainly from the Netherlands (77%). The leading poultry companies in Germany are PHW-Group (broilers and turkeys), Rothkötter-Group (broilers), Sprehe-Group (broilers), Heidemark (turkeys) and Deutsche Frühstücksei (laying hens).

Table 5.11 Production and trade of poultry products in Germany (2013)

Poultry product	Production	Trade		Self-sufficiency rate (%)
		Import	Export	
Poultry meat (tonnes)	1,481,000	531,291	496,618	109.1
Hen eggs, in shell (1,000)	12,593	5,895.7	1,969	71.0
Egg products (tonnes)	-	72,826	26,157	-

Source: MEG (2014).

5.5.2 Thailand

In 2013, Thailand produced 1.51 million tonnes of poultry meat and 11.15 billion shell eggs for consumption, as shown in Table 5.12. The self-sufficiency rate of poultry meat and shell egg production was 153.9% and 101.7%, respectively. A total of 525,682 tonnes of poultry meat was exported by Thailand, with 46.5% destined for the EU and 40.2% for Japan. Thailand imported 1,933 tonnes of egg products, mainly from Italy and France, and exported a total of 3,882 tonnes of egg products, mainly to Japan. In addition, around 85% of the total export of shell eggs was destined for Hong Kong. The leading poultry companies in Thailand are Charoen Pokphand Foods PCL., Betagro Group, GFPT Group and Laemthong Corporation Group.

Table 5.12 Production and trade of poultry products in Thailand (2013)

Poultry product	Production	Trade		Self-sufficiency rate (%)
		Import	Export	
Poultry meat (tonnes)	1,513,415	9,892	525,682	153.9
Hen eggs, in shell (1,000)	11,148	-	197	101.7
Egg products (tonnes)	-	1,933	3,882	-

Source: Office of Agricultural Economics (2013); Office of Agricultural Economics (2014); Thai Broiler Processing Exporters Association (2013).

5.6 Organisational models in the poultry industry

Three common organisational models dominate the poultry industry, namely sole organisation, horizontal integration and vertical integration (Windhorst, 2013c).

5.6.1 Single entity

This refers to individual farms, which have free, open market relationships with their suppliers and customers, and do not have any horizontal or vertical strategic alliances with other organisations (Manning and Baines, 2004). The operation is owned by the farm manager. All the work is carried out by family members and a few additional labourers. Business decisions are taken by the manager, who also bears the economic risk. The procurement of resources and product marketing are undertaken by the farm manager. The number of such enterprises is very low in the poultry industry because most companies are involved in horizontal or vertical integration. Most likely they occur in the production of

organic products where direct marketing (farm shops, weekly farmers' markets) still plays an important role (Windhorst, 2013c).

There are advantages and disadvantages of this model (Manning and Baines, 2004):

a) Advantages:

- Single entity that can react quickly to changes in the market and can be flexible in implementing new protocols;
- Independence in decision making;
- Potential for the organisation to have a national, regional or individual identity; and
- Able to provide personal contact with suppliers or customers.

b) Disadvantages:

- Weaker procurement terms due to limited purchasing power compared with group purchasing;
- May not be able to reduce the fixed costs of direct (employees) and indirect labour, e.g. marketing, quality assurance, technical costs, sales and financial departments that affect the profit margin;
- Inability to overcome trade barriers and thus compete on a global scale;
- Unable to gain access to markets because the continuity of supply cannot be assured;
- Unable to access capital finance to expand the business, so options for growth are more limited; and
- Unable to access technology and the potential cost savings it can provide.

5.6.2 Horizontal integration

Horizontal integration is defined as the formation of individual farms that produce similar products or different components of one product with the purpose of joint procurement of equipment and/or marketing of products. This form is particularly common in broiler production, where producer groups rally together to purchase gas, feed and litter, or negotiate buying agreements with slaughtering and processing plants. However, horizontal integration is rarely found in egg production in northern Germany (Windhorst, 2013c).

This form of organisation has advantages and disadvantages (Manning and Baines, 2004):

a) Advantages:

- Reduced logistics and administration costs for individual organizations;
- Improved procurement terms through group purchasing power;
- Lowering of the fixed costs of indirect labour, e.g. marketing, quality assurance, technical costs, sales and financial departments;
- Improved access to markets because the continuity of supply can be assured; and
- Horizontal integration may overcome financial barriers to trade.

b) Disadvantages:

- Loss of independence in decision making;
- Potential loss of close contact between individual organisations and their suppliers or customers due to the centralisation of decision making;
- Potential to lose the national, regional or individual identity of an organisation; and
- Decisions are taken for the benefit of the horizontal association rather than the individual businesses.

5.6.3 Vertical integration

Vertical integration is a form of organisation in which all units within a production chain (supply chain) of agricultural production are linked and under the control of a single firm (Klohn and Windhorst, 2003). The hatchery, feed mill and processing plants are owned and controlled by the integrating company. Breeder or broiler farms can belong to the integrator, too. However, many integrators operate based on contracts to connect the broiler or breeder farm to the integrator. The integrator provides the day-old chicks and the feed, and the birds belong to the integrator at all times. The farmers are paid a set rate for their input in terms of labour, housing and variable costs (van Horne, 2007). It is also possible for farmers to buy the day-old chicks, raise them and sell the broilers back to the integrator. This trade is financed based on the live weight of the broilers. Production is organised at the industrial scale. Vertical integration utilises migrant workers and accrues a high share of foreign capital in order to keep costs low. These companies usually have a high market share (Windhorst, 2013c).

The key benefits of this organisational model are as follows (Manning and Baines, 2004; Howells and Wood, 1993):

a) Control benefits:

- Continuity of supply;
- Access to management information;
- Free communication and co-operation;
- Product customisation possibilities;
- Direct influence over manufacturing "deliverables" such as quality, delivery and cost.

b) Economic benefits:

- Spread of overhead costs;
- Coordination as a single system (improved knowledge on all aspects of operations);
- Reduced logistical costs;
- Reduced change-overs in system management;
- Speed of data flow.

However, this model also has its weaknesses (European Parliament, 2010):

- Farmers forgo the opportunity to receive high levels of revenue when market conditions are favourable;
- There are limited possibilities for farmers to become entrepreneurs;
- Farmers are totally dependent on the integrator, who is the decision-maker for most management choices;
- Farmers face potentially large fluctuations in income due to changes in input and output prices;
- It requires large capital investments, tending to create dependence upon loans and vulnerability to changing interest rates for farmers;
- There is no strong incentive for maximising efficiency within the production chain.

In Germany and Thailand, the leading poultry companies, such as PHW-Groups and CP-Groups, are most commonly vertically integrated. Figure 5.13 shows the organisational structure of vertical integration in the German broiler production chain, while figure 5.14 presents the vertical integration model in the German egg production chain.

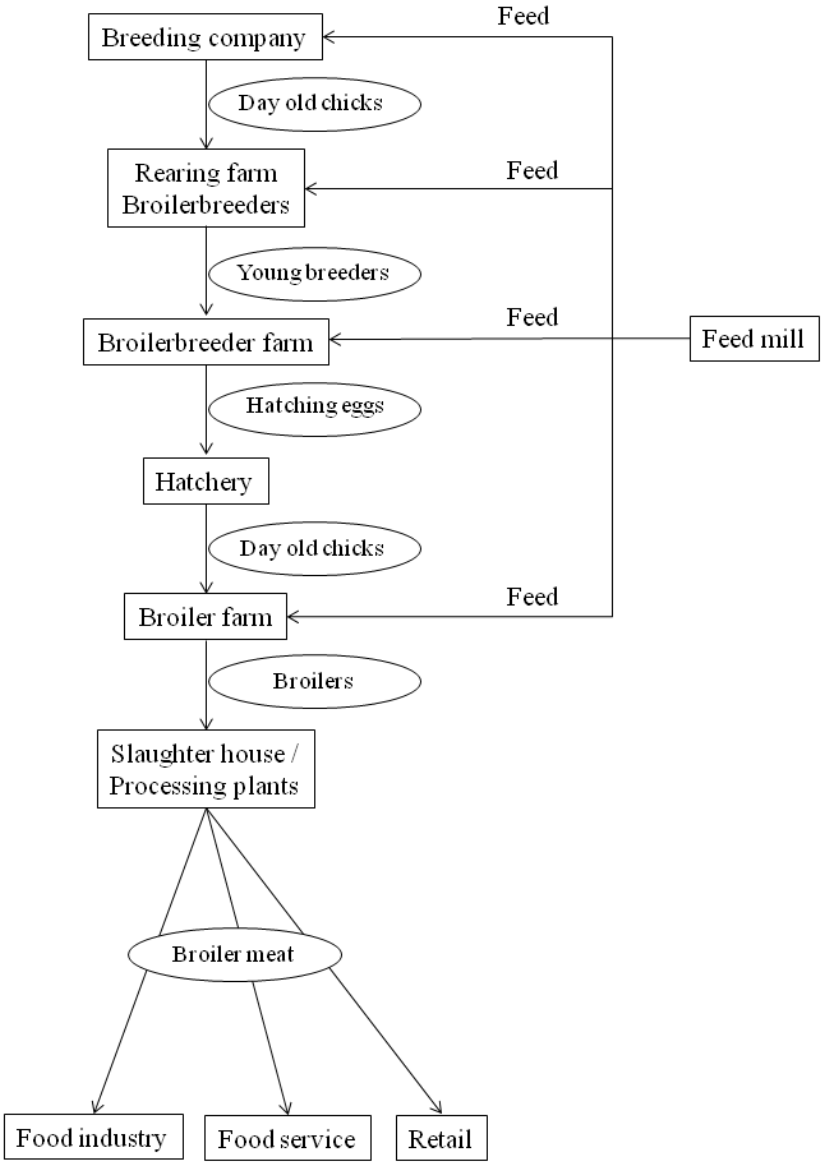


Figure 5.13 Vertical integration model in the German broiler production

Source: adapted from van Horne (2007).

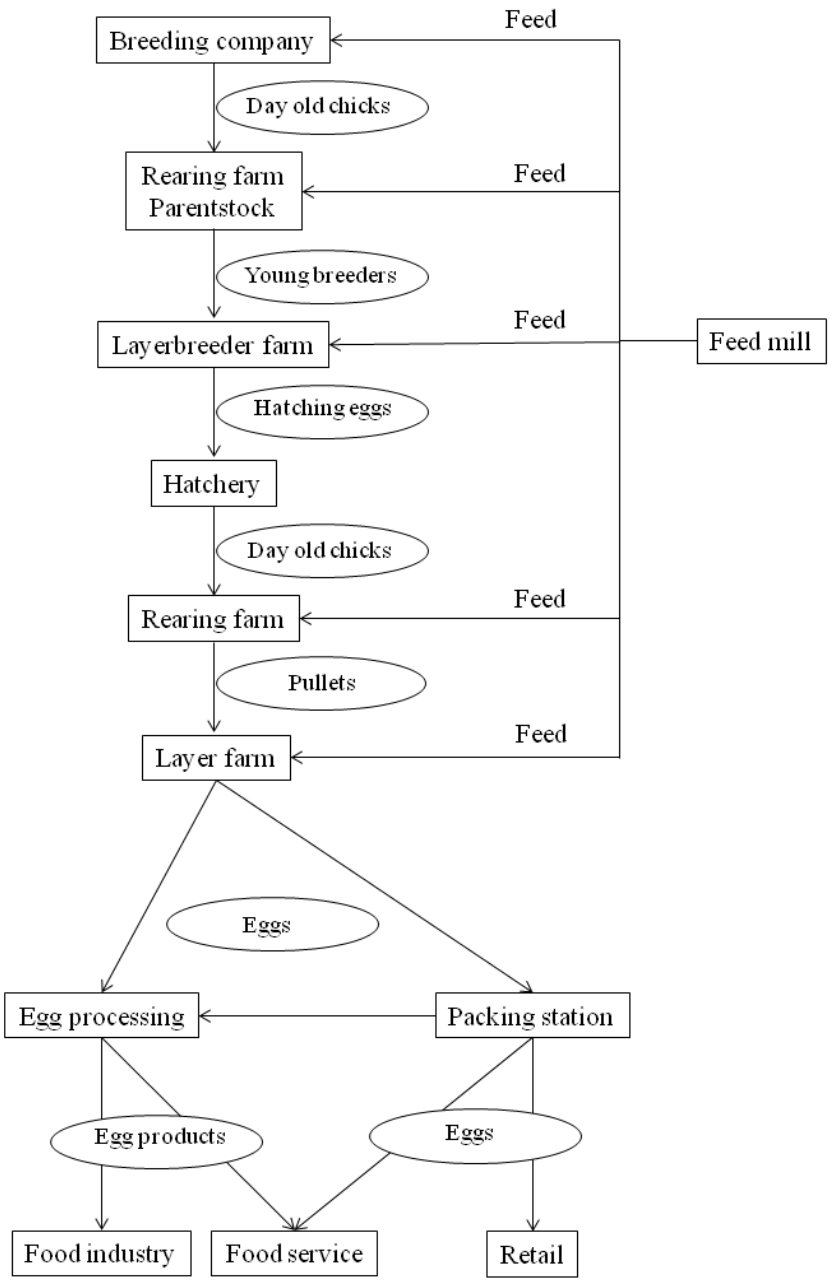


Figure 5.14 Vertical integration model in the German egg production

Source: adapted from van Horne (2007).

Figure 5.15 illustrates the vertical integration model in the Thai broiler production chain.

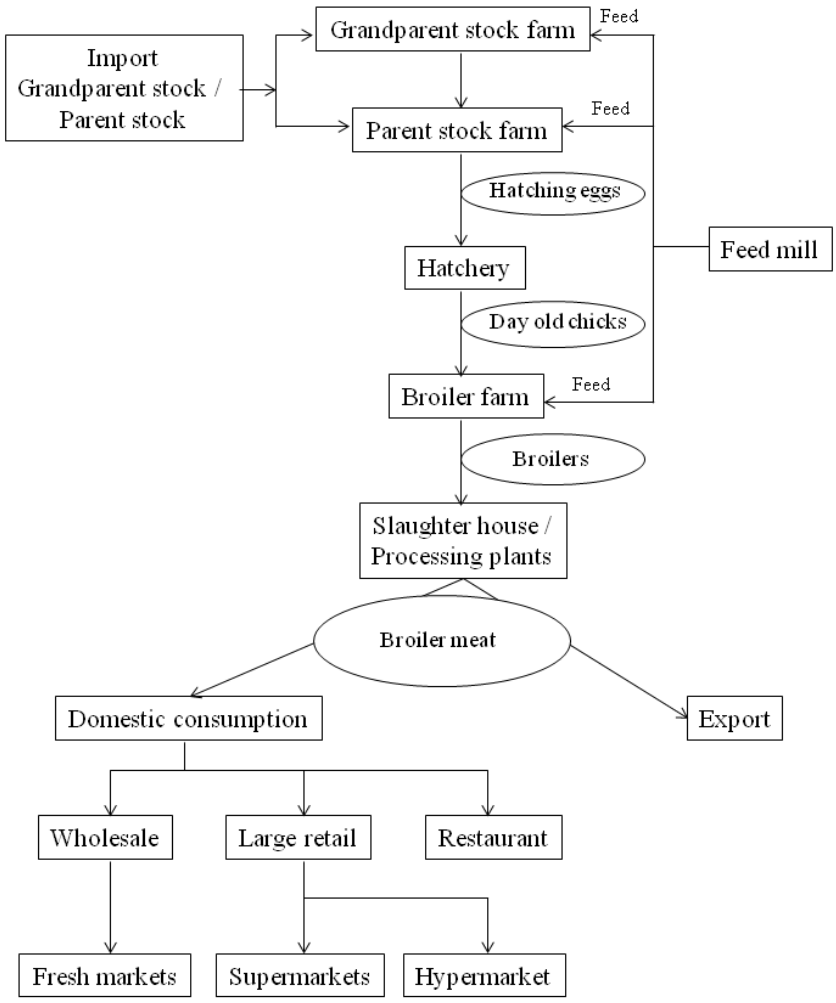


Figure 5.15 Vertical integration model in the Thai broiler production

Source: adapted from Na Ranong (2008).

Figure 5.16 shows the vertical integration model in the Thai egg production chain.

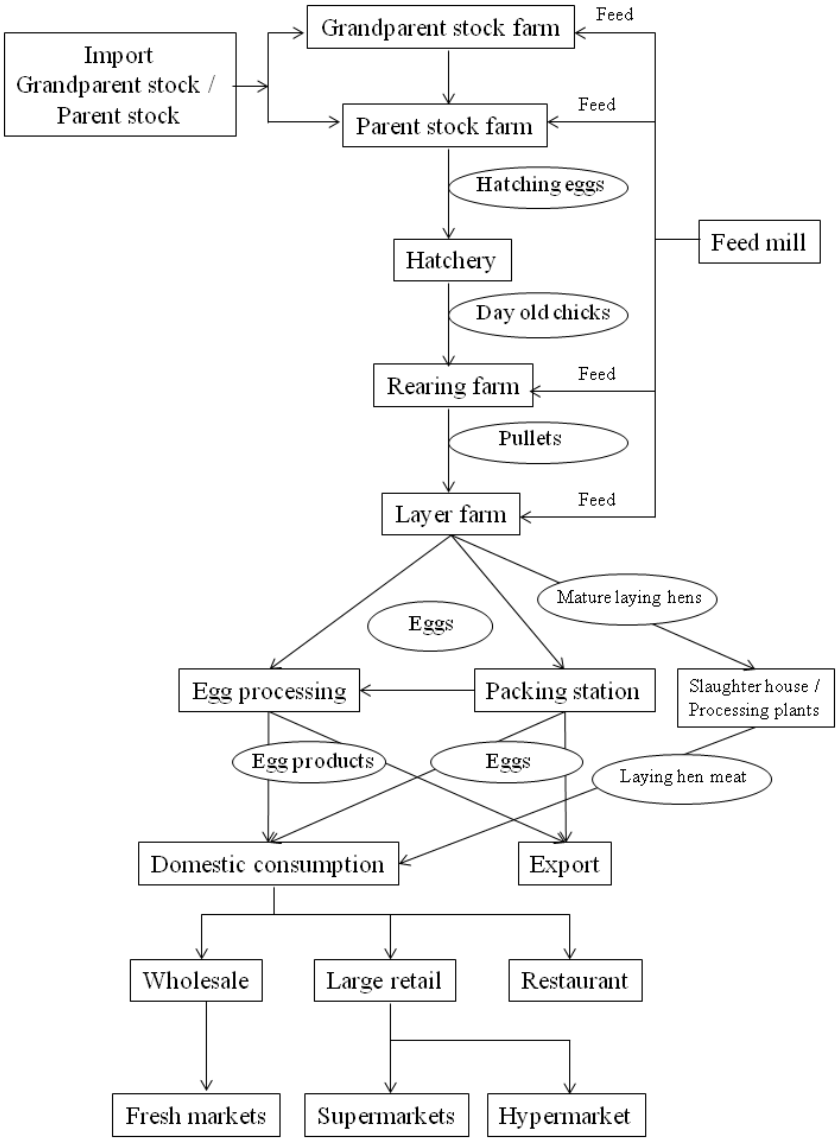


Figure 5.16 Vertical integration model in the Thai egg production

Source: adapted from Na Ranong (2008) and Heft-Neal (2008).

5.7 Comparison of poultry production between Germany and Thailand

Table 5.13 gives an overview of poultry production in Germany and Thailand in 2013.

Table 5.13 Comparative data on poultry production in Germany and Thailand (2013)

Item	Germany	Thailand
Poultry meat production (tonnes)	1,481,000	1,513,415
Poultry meat consumption, in kg (per head/year)	19.4	15.4
Poultry meat export (tonnes)	496,618	525,682
Poultry meat import (tonnes)	531,291	9,892
Major export destination for poultry meat	EU	EU and Japan
Egg production, in shell (1,000)	12,593	11,148
Egg consumption, in shell (per head/year)	224	168
Self-sufficiency rate of poultry meat production (%)	109.1	153.9
Self-sufficiency rate of shell egg production (%)	71.0	101.7
Number of broiler places in 1,000	97,146	149,900
Average number of broilers per farm	21,588	22,257
Number of laying hen places in 1,000	47,987	44,301
Average number of laying hens per farm	887	23,013
Gini coefficient for broilers	0.7412	0.7352
Gini coefficient for laying hens	0.4761	0.6778
Major organisational model	Vertical integration	Vertical integration
Leading poultry meat producer	PHW-Group	CPF
Leading egg producer	Deutsche Frühstücksei	CPF

Source: MEG (2014); MEG (2015); Office of Agricultural Economics (2013); Office of Agricultural Economics (2014).

Approximately 1.51 million and 525,682 million tonnes of poultry meat were produced and exported by Thailand, respectively, while Germany produced (1.48 million tonnes) and exported (496,618 tonnes) slightly less poultry meat than Thailand. The import quantity of poultry meat was much higher by Germany (531,291 tonnes) than Thailand (9,892 tonnes). The major export destinations for poultry meat from Thailand are the EU and Japan; the EU is also the main market destination for German poultry meat.

Germany (12.59 billions) produced about 1.44 million shell eggs more than Thailand (11.15 billions). There is a higher consumption rate of poultry meat (19.4 kg/head/year) and eggs (224 shell eggs/head/year) in Germany than in Thailand (15.4 kg/head/year, 168 shell eggs/head/year). The self-sufficiency rate of poultry meat production in both countries is more

than 100%, 109.1% for Germany and 153.9% for Thailand. Thailand produced slightly more shell eggs than were consumed domestically (101.7% of self-sufficiency rate), while Germany has a self-sufficiency rate of only 71.0%.

Thailand (149.90 millions) had a higher number of broiler places than Germany (97.15 millions). However, Germany (47.99 millions) had more laying hen places than Thailand (44.30 millions). The average broiler and layer flock sizes are higher in Thailand (22,257 broilers per farm, 23,013 laying hens per farm) than in Germany (21,588 broilers per farm, 887 laying hens per farm).

The regional concentration of broiler and egg production is relatively high in Thailand, as expressed by the Gini coefficient values of 0.7352 and 0.6778 for broiler and laying hen husbandry, respectively. The regional concentration of broiler production is also high in Germany, with a Gini coefficient of 0.7412, while the concentration of laying hen husbandry is also potentially high in a single region with a Gini coefficient of 0.4761.

The major organisational model in poultry meat and egg production in the two countries is vertical integration. PHW-Group and Deutsche Frühstücksei are the leading poultry meat and egg production companies in Germany, respectively. CPF is the leading poultry meat and egg production company in Thailand.

5.8 Conclusion

Poultry production is highly concentrated in the northwestern region of Germany and in Central Thailand. The leading poultry companies in both countries are vertically integrated in order to gain a competitive edge in the markets. The increased specialisation and concentration of poultry production within a few regions has become a serious issue for society. Academic researchers and policy makers in particular see reasons for concern due to the growing impacts on the environment, human health and animal welfare.

Chapter 6
Concerns about sustainability in poultry production: a comparative Delphi study between Germany and Thailand

6.1 Introduction

This chapter presents the results of the Delphi study on sustainability concerns in poultry production in Germany and Thailand. This study was conducted from March to June 2014 and August to November 2014 for the case studies in Germany and Thailand, respectively.

6.2 The process of Delphi

The two-round Delphi study was conducted to identify and rank the major sustainability concerns in poultry production in Germany and Thailand based on expert judgement and scientific evidence, as described in Chapter 2. The economic, environmental, social, political and animal welfare aspects were taken into consideration when designing the Delphi questionnaire. Copies of this questionnaire were distributed to seven experts as a preliminary test to check its validity. Based on their comments, necessary changes were made and a final version of the Delphi questionnaire was developed. Then the first round of questionnaires was sent to 32 and 36 participants for the case studies in Germany and Thailand respectively, representing different sectors of the poultry industry, including non-governmental organisations (NGOs), animal welfare groups, researchers, the private sector (retailers and firms related to the poultry industry), government officials and politicians. Respondents were given a period of two weeks to complete their questionnaires for each round. The timeframe for each round was approximately 15 minutes. The responses were then analysed using frequency, percentage, mean, standard deviation and Kendall's coefficient of concordance.

6.3 Results for the case study in Germany

6.3.1 Composition of the Delphi panel

Experts were selected based on their experience in the German poultry industry. There were 29 and 26 responses to the two rounds of questionnaires of this Delphi study, resulting in an average response rate of about 90% (see Table 6.1). Most of the answers were derived from

the private sector, government officials and researchers, with 9, 7 and 6 participants in the two rounds of research, respectively. 26 experts responded to both rounds. This stability amongst responses contributed to the validity of the research, as the same experts evaluated all concerning issues regarding the sustainability of poultry production in both rounds. Due to a small number of experts from NGOs, animal welfare groups and politicians, opinions from these three groups were not used in the final results of identifying sustainability concerns by stakeholder groups.

Table 6.1 Response rates across the panellists and rounds for the case study in Germany

Group (initial size)	Invitations sent to join Delphi panel (45)	1st round (32)	2nd round (29)
NGOs	2	1	1
Animal welfare groups	2	2	2
Researchers	9	7	6
Private sector	10	10	9
Government officials	7	7	7
Politicians	2	2	1
Responses	32	29	26
Response rate	71.11%	90.63%	89.66%

Source: Author's design.

6.3.2 Identification of major sustainability concerns in poultry production

The 26 initial sustainability concerns in poultry production were identified based on literature and reports. The 15 additional issues were proposed by the Delphi panellists in the first round of surveys. A total of 41 issues including environmental, economic, social, political and animal welfare aspects were identified and rated. Table 6.2 summarises the results of Delphi round one and two, giving:

(a) Sample size (N);

(b) The mean value (MV) and standard deviation (SD) for each issue;

(c) The Kendall's coefficient of concordance (W) for the first 26 issues in the first and second round, and for all 41 issues in round two.

Table 6.2 Summary of first- and second-round Delphi results for Germany

Sustainability concerns/issues in poultry production	Round 1			Round 2		
	N	Mean	SD	N	Mean	SD
1. Acidification, eutrophication and global warming potential	29	3.17	1.04	26	3.19	0.98
2. Manure management	29	3.31	1.11	26	3.46	1.14
3. Use of pesticides in poultry feed production	29	3.00	1.31	26	3.15	1.22
4. Resource use	29	3.52	1.12	26	4.00	0.85
5. Biodiversity	29	3.10	1.11	26	3.54	0.86
6. Labour wages	29	2.76	1.06	26	3.12	0.91
7. Industry competitiveness/Farm income	29	3.76	1.06	26	3.54	0.90
8. Feed supply	29	3.48	0.99	26	3.42	0.86
9. Consumer demand	29	3.41	1.21	26	3.38	1.20
10. Role of food retailers	29	3.69	1.20	26	4.27	0.87
11. Breeding	29	3.79	1.05	26	3.77	1.03
12. Efficiency of feed conversion	29	3.34	1.47	26	3.27	1.31
13. Pressure on/from urban centres	29	3.07	0.96	26	2.85	1.08
14. Workers in slaughter houses	29	3.14	1.16	26	3.54	0.90
15. Contamination of meat and eggs with zoonotic microorganisms	29	3.31	1.39	26	3.46	1.33
16. Use of antibiotics in poultry production	29	4.21	1.15	26	4.50	0.99
17. Outbreak of avian influenza and other highly infectious diseases	29	3.66	1.08	26	3.81	0.80
18. Negative image of the poultry industry portrayed by the media	29	3.72	1.19	26	3.81	1.30
19. Communication between producers and consumers	29	3.55	1.06	26	3.73	0.92
20. Food labelling	29	2.90	1.14	26	2.81	1.17
21. Introduction of new laws and regulations/legal framework	29	4.00	1.04	26	3.88	1.24
22. Transportation	29	3.31	1.00	26	3.31	0.74
23. Slaughter (procedure/process)	29	3.24	1.02	26	3.31	0.84
24. De-beaking	29	3.97	1.09	26	4.08	1.09
25. Killing of male layer chicks	29	3.97	1.32	26	4.54	0.86
26. Housing system	29	3.86	1.09	26	3.88	0.99
27. Regional concentration of production/Mass production	3	5	0.00	26	4.04	1.08
28. Space per animal/Stocking density	1	5	-	26	3.92	1.02
29. Consumer responsibility	1	5	-	26	3.73	0.96
30. Societal acceptance	1	5	-	26	3.92	1.02
31. The role of NGOs and activist groups	1	4	-	26	3.58	1.39
32. Lacking efforts to prevent avoidable deficiencies within the industry	1	5	-	26	3.54	1.10
33. Excess of national poultry meat production	1	4	-	26	3.08	1.23
34. Custom growing (fattening)	1	3	-	26	2.50	1.10
35. Poultry mortality rate	1	5	-	26	3.46	1.10
36. Growth rate of poultry	2	4.5	0.71	26	3.65	1.13
37. Current status of environmental laws and regulations	1	5	-	26	3.46	1.36
38. Rating value of foods	1	4	-	26	3.81	0.85
39. Genetic diversity of native poultry	1	4	-	26	3.19	1.36
40. International trade in poultry products	1	4	-	26	3.46	1.03
41. Efficiency of using poultry by-products	1	4	-	26	3.27	1.08
Kendall's coefficient of concordance (W) (*$p < 0.01$)	W^* (1-26) = 0.141			W* (1-26) = 0.208 W* (1-41) = 0.185		

Source: Author's design.

A comparison of mean values between the first and second round showed only minor changes for the major concerning issues in poultry production and there were no new potential concerning issues proposed in the second round of questionnaires, so that the Delphi survey could be terminated after the second questionnaire.

Despite the reduction in panel size, from 29 to 26, there is an obvious reduction in standard deviation and increase in the Kendall's coefficient of concordance (W) over the two Delphi rounds, showing an increasing level of agreement between panellists. The final results show that the standard deviation values varied between 0.80 and 1.39, which shows that the level of consensus between the expert panels for each issue ranged from reasonable to high (see Table 2.7). The values of Kendall's coefficient of concordance (W) increased in the second round survey compared to the first round, indicating a decrease in uncertainty between the expert panels assessing the full set of concerning issues.

The 41 major concerning issues society has regarding the sustainability of poultry production identified by the Delphi study were placed in rank order by mean value of the final round survey (Round 2) in Figure 6.1. The mean values of concerning issues ranged from 2.50 to 4.54 based on a five-point Likert scale rating system where 1 is *not at all concerned*, 2 is *slightly concerned*, 3 is *somewhat concerned*, 4 is *fairly concerned* and 5 is *very concerned*. All concerning issues can be categorised into 5 levels of concern based on mean value (MV) (see Table 2.6).

Based on Figure 6.1, it can be concluded that the major sustainability concerns in poultry production in Germany as identified by the Delphi study are ranked in order as follows:

(a) Category 5: very concerning issue

- *Killing of male layer chicks*
- *Use of antibiotics in poultry production*
- *Role of food retailers*

(b) Category 4: fairly concerning issue

- *De-beaking*
- *Regional concentration of production/mass production*
- *Resource use*
- *Societal acceptance*

- *Space per animal/stocking density*
- *Housing system*
- *Introduction of new laws and regulations/legal framework*
- *Outbreak of avian influenza and other highly infectious diseases*
- *Rating value of foods*
- *Negative image of the poultry industry portrayed by the media*
- *Breeding*
- *Communication between producers and consumers*
- *Consumer responsibility*
- *Growth rate of poultry*
- *The role of NGOs and activist groups*
- *Biodiversity*
- *Industry competitiveness/farm income*
- *Workers in slaughter houses*
- *Lacking efforts to prevent avoidable deficiencies within the industry*
- *International trade in poultry products*
- *Poultry mortality rate*
- *Manure management*
- *Contamination of meat and eggs with zoonotic microorganisms*
- *Current status of environmental laws and regulations*
- *Feed supply*

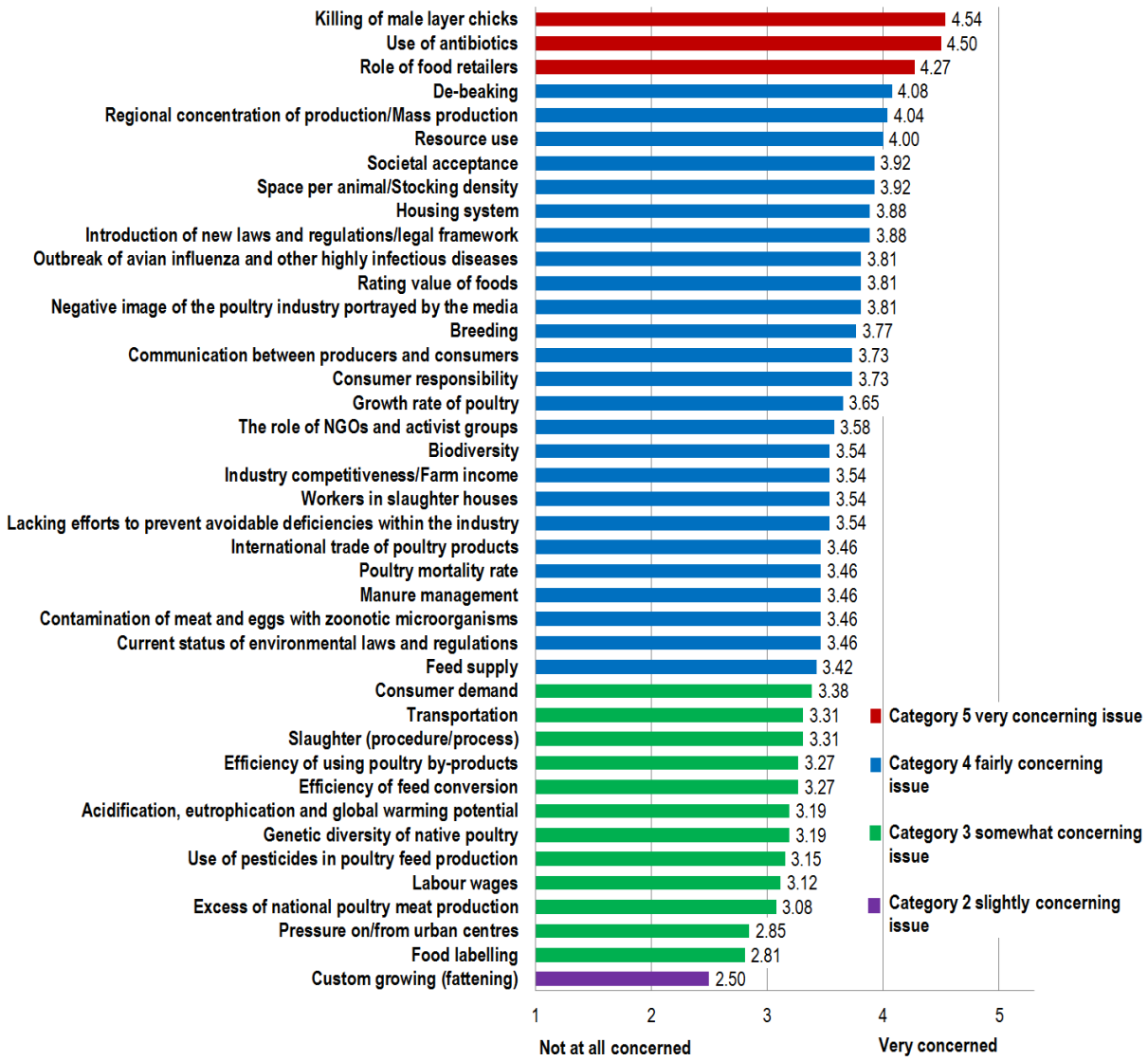


Figure 6.1 Levels of concern for sustainability issues in poultry production in Germany ranked by mean value in the final round of the Delphi survey (Round 2). The x-axis ranges from a mean value of 1 (not at all concerning issue) to 5 (very concerning issue).

Source: Author's design.

(c) Category 3: somewhat concerning issue

- *Consumer demand*
- *Transportation*
- *Slaughter (procedure/process)*
- *Efficiency of using poultry by-products*
- *Efficiency of feed conversion*
- *Acidification, eutrophication and global warming potential*
- *Genetic diversity of native poultry*

- *Use of pesticides in poultry feed production*
- *Labour wages*
- *Excess of national poultry meat production*
- *Pressure on/from urban centres*
- *Food labelling*

(d) Category 2: slightly concerning issue

- *Custom growing (fattening)*

The biggest number of concerning issues was in categories 4 and 3 comprising 25 and 12 issues, respectively. There were only 3 issues considered as very concerning and just one issue as slightly concerning.

The 41 major concerning issues in poultry production can be categorised into the 5 dimensions of sustainability, including environmental, social, economic, political and animal welfare aspects, as presented in Figure 6.2. The biggest number of concerning issues was in the social dimension, accounting for 15 issues, followed by the economic, environmental, animal welfare and political dimensions accounting for 13, 9, 7 and 2 issues, respectively.

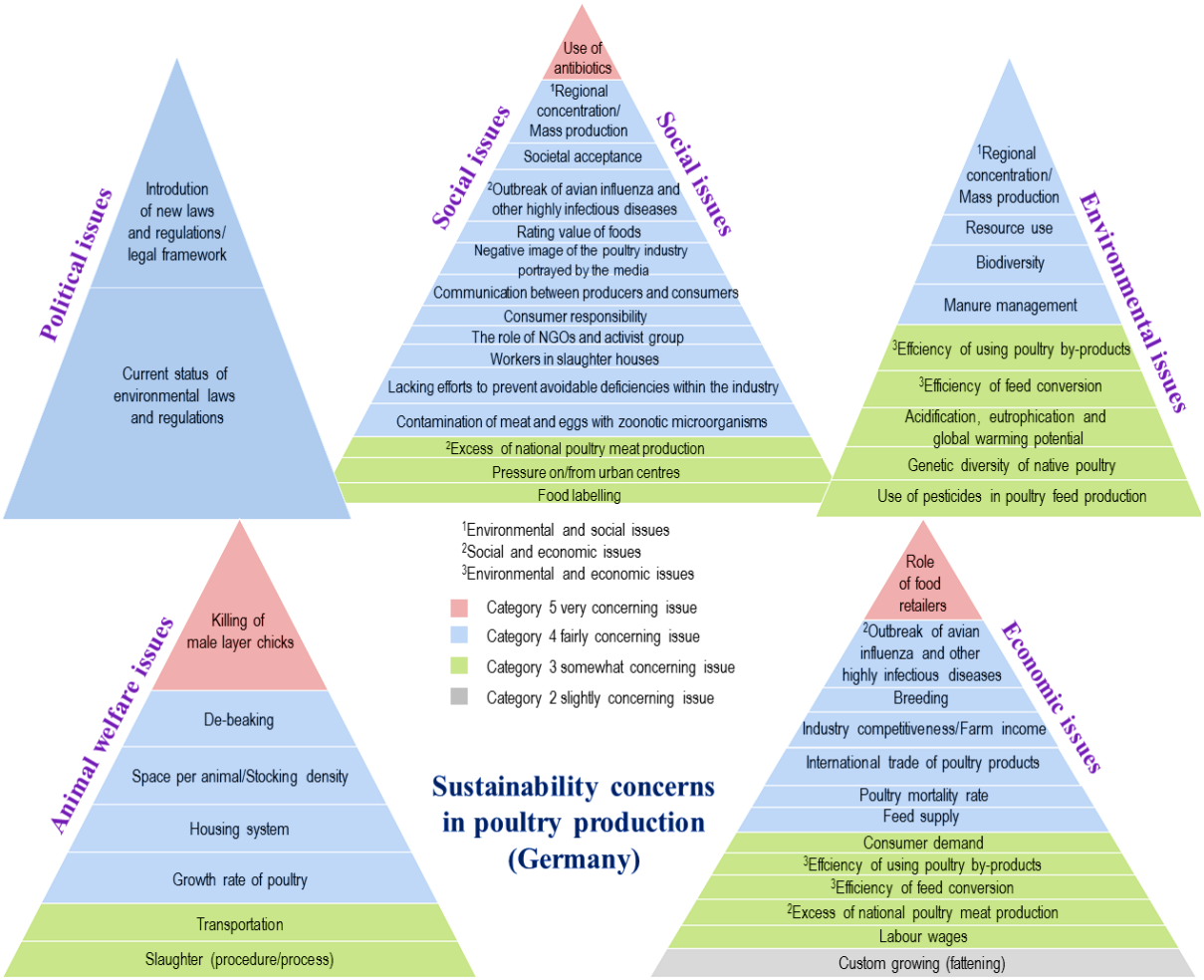


Figure 6.2 Major issues in poultry production in Germany categorised into the 5 dimensions of sustainability, ranked in order, with the tip of the pyramid representing the highest level of concern.

Source: Author's design.

Five concerns bridged two different dimensions, including *regional concentration/mass production* (environmental and social dimensions), *outbreak of avian influenza and other highly infectious diseases* (social and economic dimensions), *excess of national poultry meat production* (social and economic dimensions), *efficiency of using poultry by-products* (environmental and economic dimensions), and *efficiency of feed conversion* (environmental and economic dimensions). The *use of antibiotics* in poultry production was the most concerning issue (Category 5) in the social dimension, with *killing of male layer chicks* and *role of food retailers* rated as very concerning issues (Category 5) within the animal welfare and economic dimensions, respectively. The two concerning issues in the political dimension were both considered as fairly concerning issues (Category 4), including *introduction of new laws and regulations/legal framework*, and *current status of environmental laws and*

regulations. Environmental concerns were raised on the issue of *regional concentration of production/mass production* (Category 4), with the *use of pesticides in poultry feed production* considered as a less concerning issue (Category 3) within this dimension. Besides *killing of male layer chicks*, *de-beaking* and *space per animal/stocking density* were considered as fairly concerning issues (Category 4) within the animal welfare dimension. While the *role of food retailers* was a very concerning issue (Category 5) within the economic dimension, *labour wages* (Category 3) and *custom growing* (Category 2) were considered less concerning for this dimension. The social dimension consisted of the biggest number of concerning issues, with the *use of antibiotics* as a very concerning issue (Category 5), and the issues of *pressure on/from urban centres* and *food labelling* as less concerning issues (Category 3).

The level of consensus between the panellists in the final round of Delphi (Round 2) on identifying the major concerning issues within the five sustainability dimensions, as indicated by the Kendall's coefficient of concordance (W), varied between 0.138 and 0.272, as shown in Table 6.3. The Delphi panel had a higher certainty/level of consensus rating animal welfare issues (W=0.272) compared to the other four dimensions. Opinions were almost equal rating environmental (W=0.139) and political (W=0.138) issues, and economic (W=0.196) and social (W=0.193) issues.

Table 6.3 Kendall's W across the sustainability dimensions

Aspects of sustainability	N = 26	
	Number of issue (*46)	Kendall's W
Environmental dimension	9	0.139**
Economic dimension	13	0.196**
Political dimension	2	0.138
Social dimension	15	0.193**
Animal welfare dimension	7	0.272**

Source: Author's design. *Five issues were categorised in two aspects. **$p < 0.01$

6.3.3 Identification of major sustainability concerns in poultry production by stakeholder groups

To further differentiate the results of the major sustainability concerns in poultry production, the mean value of the final round (Round 2) of the Delphi study was analysed by the six stakeholder groups, including NGOs, animal welfare groups, researchers, the private sector, government officials and politicians, as presented in Table 6.1. The number of respondents in each of the stakeholder groups varied between one and nine experts per group. However, in this study, we only looked at and compared the results between three stakeholder groups - researchers (6 participants), the private sector (9 participants) and government officials (7 participants), because the three remaining stakeholder groups of NGOs (1 participant), animal welfare groups (2 participants) and politicians (1 participant) were too small a sample size to represent group results.

The most concerning issues regarding the sustainability of poultry production evaluated by three stakeholder groups are summarised in Figure 6.3. The issues were ranked based on mean value. The levels of consensus within each stakeholder group were higher than the consensus of the entire Delphi panel (W=0.185). The certainty of panellists is higher amongst the private sector (W=0.338) than government officials (W=0.308) and researchers (W=0.281).

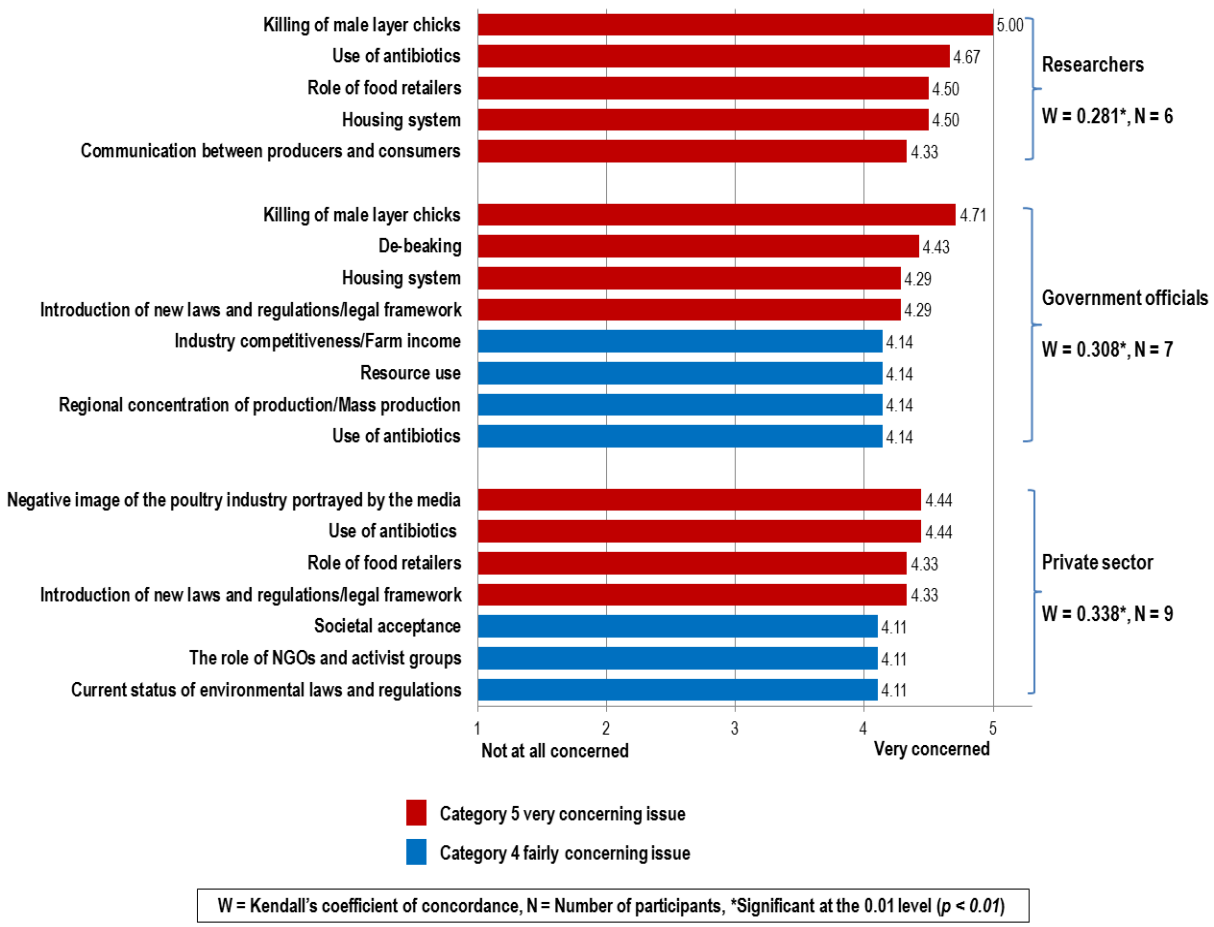


Figure 6.3 The most concerning issues identified by the three stakeholder groups, including researchers, government officials and the private sector, ranked by mean value in the final round of the Delphi survey (Round 2). The x-axis ranges from mean value 1 (not at all concerning issue) to 5 (very concerning issue).

Source: Author's design.

Researchers and government officials rated *killing of male layer chicks* (Category 5) most highly, while the private sector considered *negative image of the poultry industry portrayed by the media* as the most concerning issue (Category 5). The *use of antibiotics* in poultry production was considered as a very concerning issue (Category 5) by the researcher and private sector groups, and as a fairly concerning issue (Category 4) by the government officials. The private sector and researchers ranked the *role of food retailers* in Category 5, but this issue was not considered amongst the top five most concerning issues by government officials. The *housing system* was ranked as a very concerning issue (Category 5) by researchers and government officials, while it was not considered amongst the top five most concerning issues by the private sector. Only government officials considered the issue of *de-beaking* as a very concerning issue (Category 5). The political issue, *introduction of new laws*

and regulations/legal framework, was ranked very concerning (Category 5) amongst government officials and private sector groups. Researchers were the only group that considered *communication between producers and consumers* as a very concerning issue (Category 5). The issues of *industry competitiveness/farm income, resource use,* and *regional concentration of production/mass production* were considered fairly concerning (Category 4) by government officials, while *societal acceptance, the role of NGOs and activist groups,* and *current status of environmental laws and regulations* were fairly concerning (Category 4) for the private sector.

6.4 Results for the case study in Thailand

6.4.1 Composition of the Delphi panel

Fifty experts were invited based on their experience and engagement in the Thai poultry industry, including representatives of NGOs, animal welfare groups, researchers, the private sector (retailers and firms related to the poultry industry), politicians and government officials. About 72% of the invited experts agreed to participate in this Delphi study. The representatives of NGOs, animal welfare groups and politicians declined participation in the survey because NGOs, animal welfare groups and politicians in Thailand did not concentrate their activities in the poultry industry during the survey in 2014. Therefore, this Delphi panel consisted of three groups, including researchers, the private sector and government officials. There were 33 and 28 responses to the two rounds of questionnaires, respectively, resulting in a response rate of around 92% for the first survey and around 85% for the second survey (see Table 6.4). The group of researchers provided the most responses with 14 participants, followed by the groups of government officials and representatives of the private sector, with 8 and 6 respondents in the two rounds of research, respectively. All in all, there were 28 experts participating in three groups: researchers, government officials and the private sector involved in the two rounds.

Table 6.4 Response rates across the panellists and rounds for the case study in Thailand

Group (initial size)	Invitations sent to join Delphi panel (50)	1st round (36)	2nd round (33)
NGOs	0	0	0
Animal welfare groups	0	0	0
Researchers	21	19	14
Private sector	7	6	6
Government officials	8	8	8
Politicians	0	0	0
Responses	36	33	28
Response rate	72%	91.67%	84.85%

Source: Author's design.

6.4.2 Identification of major sustainability concerns in poultry production

The 41 sustainability concerns in poultry production listed in the initial surveys are based on a literature review and the results of the case study in Germany. The 14 additional issues were proposed by the experts in the first round of surveys. A total of 55 issues, including economic, social, environmental, political and animal welfare aspects, were identified and rated. Table 6.5 summarises the results of Delphi rounds one and two, including the:

(a) Sample size (N);

(b) The mean value (MV) and standard deviation (SD) for each issue;

(c) The Kendall's coefficient of concordance (W) for the first 41 issues in the first and second round, and for the entire 55 issues in round two.

Table 6.5 Summary of first- and second-round Delphi results for Thailand

Sustainability concerns/issues in poultry production	Round 1			Round 2		
	N	Mean	SD	N	Mean	SD
1. Acidification, eutrophication and global warming potential	33	2.58	0.94	28	2.57	0.69
2. Manure management	33	2.79	1.11	28	2.86	0.89
3. Use of pesticides in poultry feed production	33	3.42	1.23	28	3.64	0.83
4. Resource use	33	3.15	1.03	28	3.21	0.79
5. Biodiversity	33	2.52	1.06	28	2.36	0.87
6. Labour wages	33	3.79	0.86	28	3.61	0.69
7. Industry competitiveness/Farm income	33	3.27	1.13	28	3.54	0.79
8. Feed supply	33	3.30	1.05	28	3.32	0.72
9. Consumer demand	33	2.85	0.97	28	3.07	0.54
10. Role of food retailers	33	2.88	0.93	28	3.04	0.79
11. Breeding	33	3.30	1.38	28	3.75	1.14
12. Efficiency of feed conversion	33	2.79	1.22	28	3.11	0.92
13. Pressure on/from urban centres	33	3.55	1.15	28	3.79	0.83
14. Workers in slaughter houses	33	3.12	0.96	28	3.18	0.61
15. Contamination of meat and eggs with zoonotic microorganisms	33	3.48	1.28	28	4.32	0.82
16. Use of antibiotics in poultry production	33	3.58	1.17	28	4.36	0.73
17. Outbreak of avian influenza and other highly infectious diseases	33	4.03	1.21	28	4.57	0.63
18. Negative image of the poultry industry portrayed by the media	33	3.67	1.19	28	4.11	0.57
19. Communication between producers and consumers	33	3.15	0.91	28	3.39	0.83
20. Food labelling	33	2.76	1.06	28	2.71	0.94
21. Introduction of new laws and regulations/legal framework	33	3.21	1.05	28	3.43	0.74
22. Transportation	33	2.94	0.97	28	3.18	0.77
23. Slaughter (procedure/process)	33	2.70	1.13	28	2.93	0.86
24. De-beaking	33	2.76	1.00	28	2.79	0.83
25. Killing of male layer chicks	33	1.00	0.00	28	1.00	0.00
26. Housing system	33	2.61	1.25	28	2.46	1.07
27. Regional concentration of production/Mass production	33	3.24	1.28	28	3.39	0.99
28. Space per animal/Stocking density	33	2.82	1.16	28	2.71	1.01
29. Consumer responsibility	33	3.45	1.03	28	3.68	0.98
30. Societal acceptance	33	3.12	1.05	28	3.18	1.06
31. The role of NGOs and activist groups	33	3.00	1.12	28	2.86	0.97
32. Lacking efforts to prevent avoidable deficiencies within the industry	33	3.00	1.17	28	2.89	0.92
33. Excess of national poultry meat production	33	2.73	0.91	28	2.43	0.74
34. Custom growing (fattening)	33	3.21	1.19	28	3.25	1.00
35. Poultry mortality rate	33	2.76	0.97	28	2.86	0.85

Table 6.5 (Continued)

Sustainability concerns/issues in poultry production	Round 1			Round 2		
	N	Mean	SD	N	Mean	SD
36. Growth rate of poultry	33	2.73	1.01	28	3.00	0.94
37. Current status of environmental laws and regulations	33	3.39	0.97	28	3.32	0.72
38. Rating value of foods	33	3.06	1.06	28	3.50	0.75
39. Genetic diversity of native poultry	33	2.88	1.05	28	3.14	0.97
40. International trade in poultry products	33	3.52	1.09	28	3.96	0.69
41. Efficiency of using poultry by-products	33	2.94	1.12	28	2.68	0.98
42. Development of value added products	1	3.00	-	28	2.86	0.97
43. Public policy on poultry industry	3	3.67	0.58	28	3.54	0.84
44. Poultry welfare during growing phase	1	2.00	-	28	2.89	0.99
45. Poultry welfare in slaughter houses	2	4.00	1.41	28	3.39	0.96
46. Quality of poultry meat and products	2	3.50	0.71	28	3.36	0.99
47. Fodder from genetically modified plants	1	3.00	-	28	3.07	1.09
48. The establishment of the ASEAN Economic Community (AEC)	2	5.00	0.00	28	3.93	1.05
49. Disease control from neighbouring countries	1	5.00	-	28	4.43	0.84
50. Perception of poultry meat and products	1	4.00	-	28	3.36	0.78
51. EU and Islamic regulations for slaughter process	1	5.00	-	28	3.71	1.05
52. Standards for poultry products required by importing countries	1	4.00	-	28	4.25	0.75
53. Use of native chicken species	1	4.00	-	28	3.46	0.88
54. Compartmentalisation of poultry production	1	3.00	-	28	3.36	0.83
55. Role of small-scale family farming	1	4.00	-	28	3.71	0.71
Kendall's coefficient of concordance (W) (*$p < 0.01$)	W^* (1-41) = 0.191			W^* (1-41) = 0.394 W^* (1-55) = 0.360		

Source: Author's design.

From Table 6.5 it can be concluded that there was a slightly change in the mean values in the first and second round on the main concerns society has about poultry production surveys. In the second round, no new potential issues were proposed. Therefore, the Delphi survey could be concluded after the second round.

The panel size went down from 33 to 28 over the two Delphi rounds. The standard deviation values obviously declined in the second round compared to the first round survey, explaining an increased level of consensus between the experts for each issue. The results for the final round show that the standard deviation values varied from 0.00 to 1.14, which means the level of consensus between the expert panellists for each issue ranged from reasonable to high (see Table 2.7). 47 out of 55 issues recorded a high level of agreement (SD<1) amongst the panellists, especially the issue *killing of male layer chicks* which 100% of respondents agreed with (SD=0). The values of Kendall's coefficient of concordance (W) increased from 0.191 in the first round survey to 0.394 for the 41 initial issues and to 0.360 for the 55 total issues in

the second round of surveys, indicating a clear increase in consensus between the experts assessing the full set of concerns.

The 55 major concerns over sustainability in poultry production identified by the Delphi panel are ranked by mean value for the final round survey (Round 2) in Figure 6.4. As a result of the Delphi study on the main sustainability concerns in poultry production in Thailand, the issues identified by the panellists are ranked in the five categories based on Figure 6.4 as follows:

(a) Category 5: very concerning issue

- *Outbreak of avian influenza and other highly infectious diseases*
- *Disease control from neighbouring countries*
- *Use of antibiotics in poultry production*
- *Contamination of meat and eggs with zoonotic microorganisms*
- *Standards for poultry products required by importing countries*

(b) Category 4: fairly concerning issue

- *Negative image of the poultry industry portrayed by the media*
- *International trade in poultry products*
- *The establishment of the ASEAN Economic Community – AEC*
- *Pressure on/from urban centres*
- *Breeding*
- *EU and Islamic regulations for slaughter process*
- *Role of small-scale family farming*
- *Consumer responsibility*
- *Use of pesticides in poultry feed production*
- *Labour wages*
- *Public policy on poultry industry*
- *Industry competitiveness/farm income*
- *Rating value of foods*
- *Use of native chicken species*
- *Introduction of new laws and regulations/legal framework*

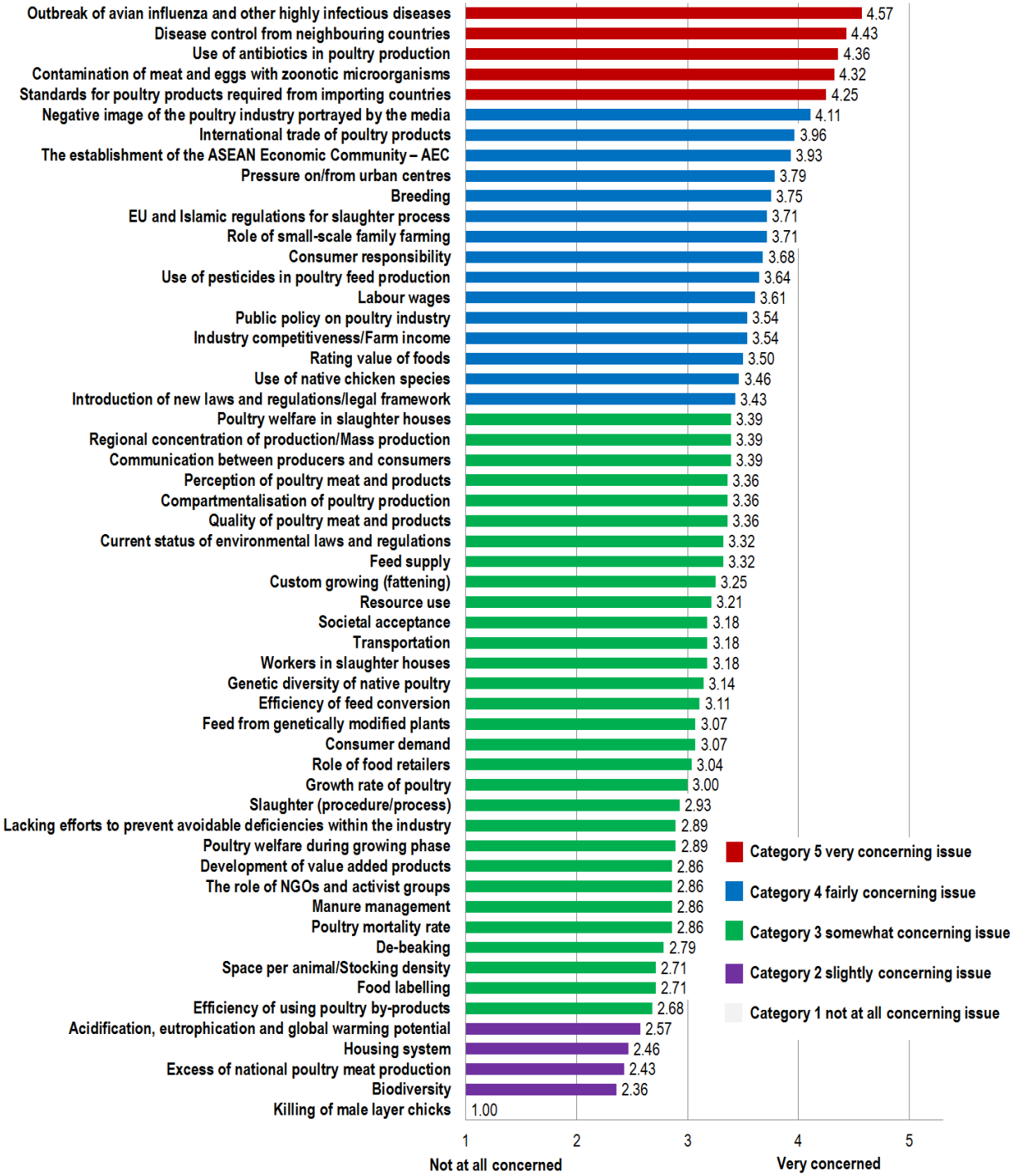


Figure 6.4 Levels of concern for sustainability issues in poultry production in Thailand ranked by mean value in the final round of the Delphi survey (Round 2). The x-axis ranges from a mean value of 1 (not at all concerning issue) to 5 (very concerning issue).

Source: Author's design.

(c) Category 3: somewhat concerning issue

- *Poultry welfare in slaughter houses*
- *Regional concentration of production/mass production*
- *Communication between producers and consumers*
- *Perception of poultry meat and products*
- *Compartmentalisation of poultry production*
- *Quality of poultry meat and products*
- *Current status of environmental laws and regulations*
- *Feed supply*
- *Custom growing (fattening)*
- *Resource use*
- *Societal acceptance*
- *Transportation*
- *Workers in slaughter houses*
- *Genetic diversity of native poultry*
- *Efficiency of feed conversion*
- *Feed from genetically modified plants*
- *Consumer demand*
- *Role of food retailers*
- *Growth rate of poultry*
- *Slaughter (procedure/process)*
- *Lacking efforts to prevent avoidable deficiencies within the industry*
- *Poultry welfare during growing phase*
- *Development of value added products*
- *The role of NGOs and activist groups*
- *Manure management*
- *Poultry mortality rate*
- *De-beaking*
- *Space per animal/stocking density*
- *Food labelling*
- *Efficiency of using poultry by-products*

(d) Category 2: slightly concerning issue

- *Acidification, eutrophication and global warming potential*
- *Housing system*
- *Excess of national poultry meat production*
- *Biodiversity*

(e) Category 1: not at all concerning issue

- *Killing of male layer chicks*

The majority of issues was considered as somewhat concerning (Category 3), comprising 30 out of the 55 issues, while 15 issues were rated fairly concerning (Category 4). Five issues were rated as very concerning (Category 5). Only 4 issues were considered slightly concerning (Category 2) and just one issue was rated not at all concerning (Category 1).

The 55 major concerning issues in poultry production in Thailand can be categorised into the 5 dimensions of sustainability, including economic, environmental, political, social and animal welfare aspects, as presented in Figure 6.5. The biggest number of concerning issues is in the economic dimension, accounting for 21 issues, followed by the social dimension with 19 issues. Environmental and animal welfare dimensions both accounted for 9 issues, while 4 issues were in the political dimension. Seven concerns bridged two different dimensions, including *regional concentration/mass production* (environmental and social dimensions), *outbreak of avian influenza (AI) and other highly infectious diseases* (social and economic dimensions), *excess of national poultry meat production* (social and economic dimensions), *efficiency of using poultry by-products* (environmental and economic dimensions), *efficiency of feed conversion* (environmental and economic dimensions), *disease control from neighbouring countries* (social and economic dimensions), and *the establishment of the ASEAN Economic Community (AEC)* (political and economic dimensions).

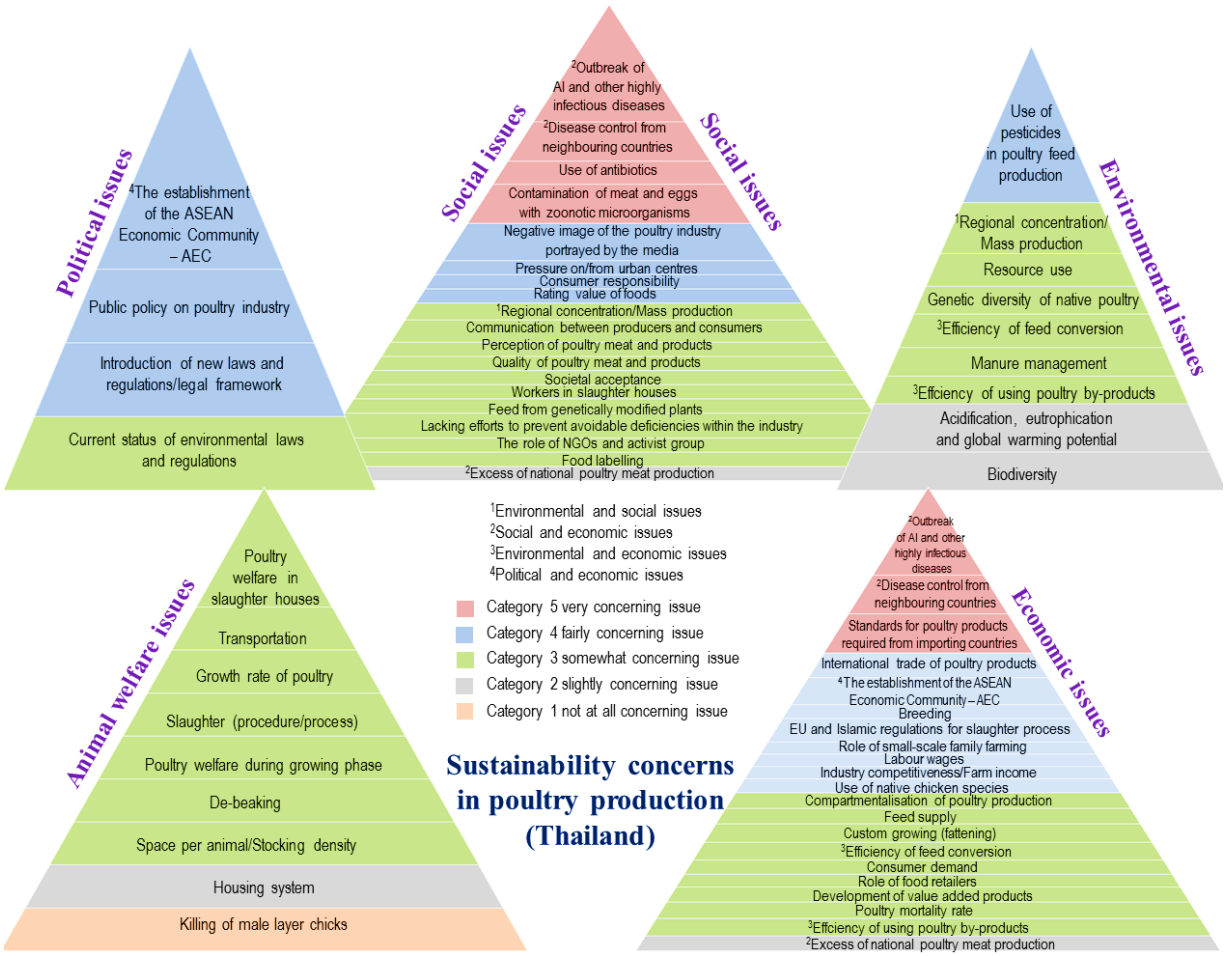


Figure 6.5 Major issues in poultry production in Thailand categorised into the 5 dimensions of sustainability, ranked in order, with the tip of the pyramid representing the highest level of concern.

Source: Author's design.

The *outbreak of avian influenza and other highly infectious diseases* and *disease control from neighbouring countries* were the two most concerning issues (Category 5) in the social and economic dimensions, while the *excess of national poultry meat production* (Category 2) was only considered slightly concerning within these two dimensions. The issues *use of antibiotics in poultry production* and *contamination of meat and eggs with zoonotic microorganisms* were also considered very concerning (Category 5) within the social dimension, while the *standards for poultry products required by importing countries* were rated as a very concerning issue (Category 5) in the economic dimension. Three issues in the political dimension, including *the establishment of the ASEAN Economic Community (AEC)*, *public policy on poultry industry*, and *introduction of new laws and regulations/legal framework*, were considered fairly concerning (Category 4). Animal welfare issues were mainly rated as somewhat concerning (Category 3), such as *poultry welfare in slaughter houses*,

transportation, *growth rate of poultry* and *de-beaking*, while *housing system* (Category 2) and *killing of male layer chicks* (Category 1) were not listed as concerns within this dimension. Environmental concerns, including the *use of pesticides in poultry feed production* (Category 4), *regional concentration of production/mass production* (Category 3), *resource use* (Category 3), *acidification, eutrophication and global warming potential* (Category 2), and *biodiversity* (Category 2) were considered less concerning issues. Within the social dimension, the *negative image of the poultry industry portrayed by the media* and *pressure on/from urban centres* were considered fairly concerning issues (Category 4), while the *role of NGOs and activist groups* and *food labelling* were less concerning (Category 3) within this dimension. Besides *standards for poultry products required by importing countries*, the issues of *international trade in poultry products*, *breeding*, *role of small-scale family farming*, *labour wages*, and *use of native chicken species* were considered fairly concerning (Category 4) issues within the economic dimension.

The level of agreement between the expert panellists in the final round of the Delphi survey (Round 2) on the identification of the major concerning issues within the five sustainability dimensions, as indicated by the Kendall's coefficient of concordance (W), varied between 0.173 and 0.431, as shown in Table 6.6. There was a higher consensus amongst the panellists when rating animal welfare (W=0.431) and social (W=0.411) issues compared to the other three dimensions. Opinions were less certain when rating economic (W=0.352) and environmental (W=0.286) issues, while political issues received the lowest level of consensus (W=0.173) in the expert panel.

Table 6.6 Kendall's W across the sustainability dimensions

Aspects of sustainability	N = 28	
	Number of issue (*62)	Kendall's W
Environmental aspect	9	0.286**
Economic aspect	21	0.352**
Political aspect	4	0.173**
Social aspect	19	0.411**
Animal welfare aspect	9	0.431**

Source: Author's design. *Seven issues were categorised in two aspects. **$p < 0.01$

6.4.3 Identification of major sustainability concerns in poultry production by expert groups

In order to look at and compare the opinions of the stakeholder groups in Thailand, the mean value of the final round (Round 2) of the Delphi study was analysed by three stakeholder groups, including researchers, the private sector, and government officials, as presented in Table 6.4. 14 researchers, 6 private sector representatives and 8 government officials participated in this stage.

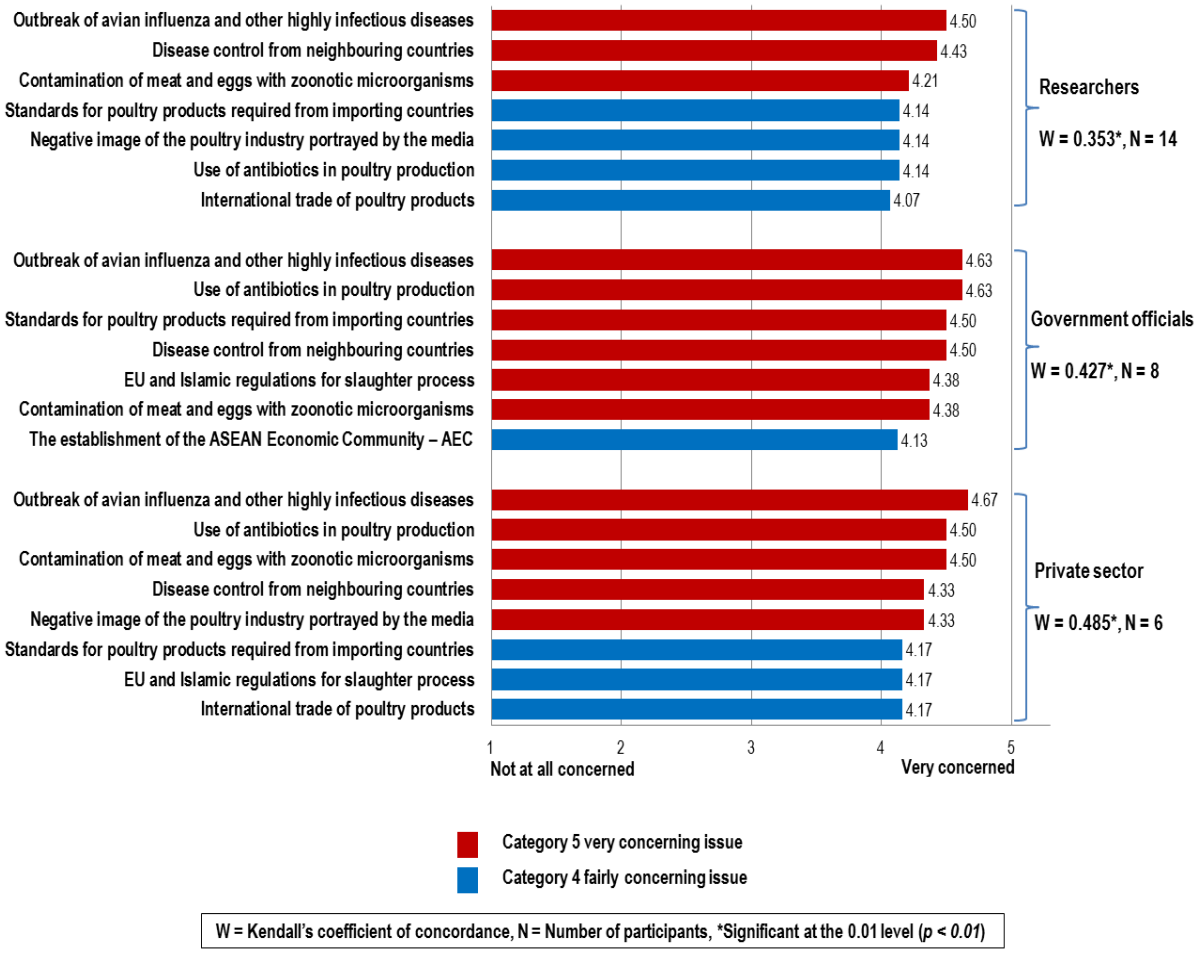


Figure 6.6 The most concerning issues identified by the three stakeholder groups, including researchers, government officials and the private sector, ranked by mean value in the final round of the Delphi survey (Round 2). The x-axis ranges from mean value 1 (not at all concerning issue) to 5 (very concerning issue).

Source: Author's design.

Figure 6.6 shows the most concerning issues regarding the sustainability of poultry production in Thailand as determined by the three expert groups. Mean value was used to rank the issues. The level of consensus between experts was higher within the private sector group (W=0.485) than between the groups of government officials (W=0.427) and researchers (W=0.353). All three stakeholder groups raised substantial concerns over the *outbreak of avian influenza and other highly infectious diseases*, *disease control from neighbouring countries*, and *contamination of meat and eggs with zoonotic microorganisms* (Category 5). The private sector and government officials both rated the *use of antibiotics in poultry production* as Category 5, while this issue was less concerning (Category 4) for the group of researchers. The *standards for poultry products required by importing countries* was ranked as a very concerning issue (Category 5) by government officials, while it was only considered a fairly concerning issue (Category 4) by the private sector and researchers. The issue of the *negative image of the poultry industry portrayed by the media* was rated Category 5 by the private sector and Category 4 by the researchers, however it was not considered amongst the most concerning issues by government officials. The private sector and researcher groups considered *international trade in poultry products* as a fairly concerning issue (Category 4). The *EU and Islamic regulations for slaughter process* was ranked as Category 5 by the government officials and Category 4 by the private sector. Government officials were the only group who felt *the establishment of the ASEAN Economic Community (AEC)* might be a concern (Category 4) for poultry production in Thailand.

6.5 Comparison of results between current situation of poultry production in Germany and Thailand

In this section, the results of the Delphi studies on sustainability concerns in poultry production in Germany and Thailand were compared. The opinions of German and Thai experts on issues regarding the sustainability of poultry production at present and with the current sector conditions were presented (2014).

In order to present an accurate picture of concerns regarding the sustainability of poultry production in the two countries, the ten most and least concerning issues, as well as the 41 similar issues were categorised into the five dimensions of sustainability: environmental, economic, social, political and animal welfare aspects. In a next step, a comparison was undertaken.

Figure 6.7 highlights the 10 most concerning issues regarding the sustainability of poultry production in Germany and Thailand. The issue *use of antibiotics in poultry production* was considered as a top concern (Category 5) in both countries. The German experts were also highly concerned over the *killing of male layer chicks* and the *role of food retailers*, while the Thai experts felt the *outbreak of avian influenza and other highly infectious diseases*,

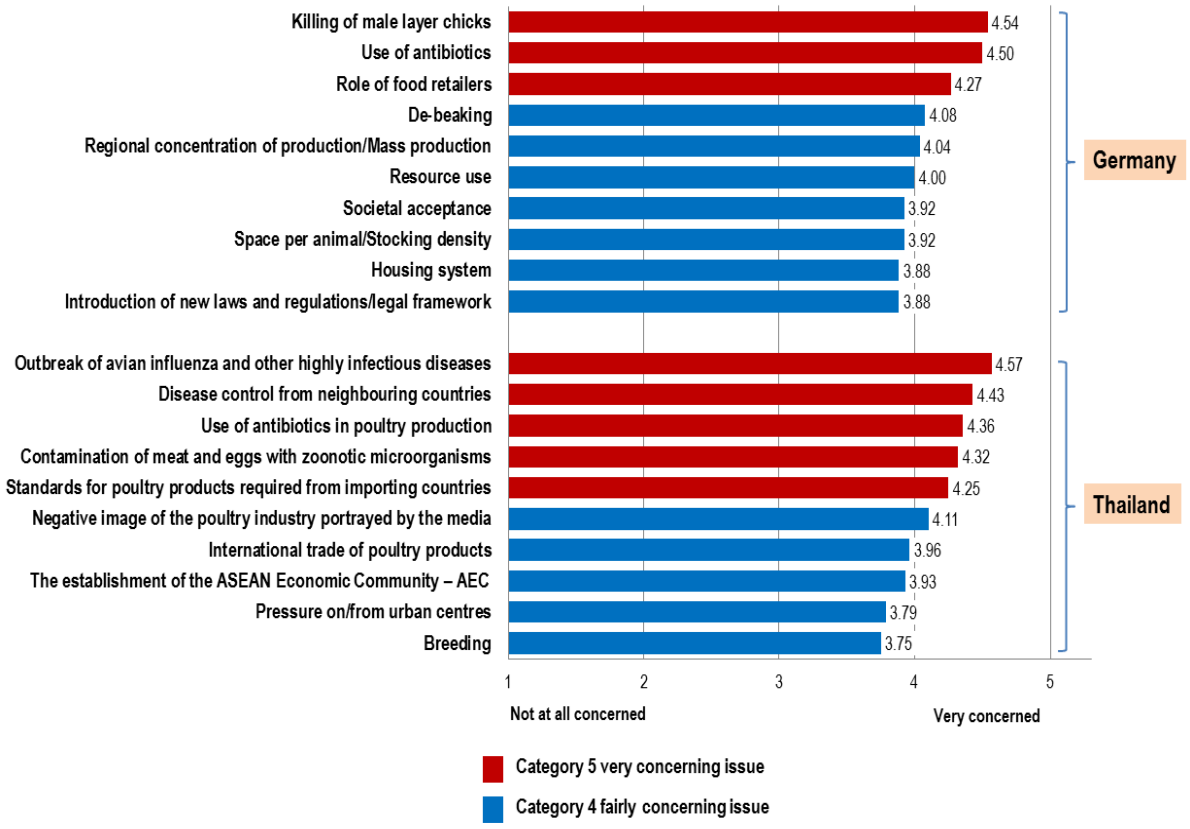


Figure 6.7 The 10 most concerning issues identified by experts from Germany and Thailand, ranked by mean value in the final round of the Delphi survey (Round 2). The x-axis ranges from a mean value of 1 (not at all concerning issue) to 5 (very concerning issue).

Source: Author's design.

disease control from neighbouring countries, contamination of meat and eggs with zoonotic microorganisms, and *standards for poultry products required by importing countries* were the top concerns (Category 5) for poultry production in Thailand. The German and Thai experts had different opinions on the remainder of the ten most concerning issues for poultry production. *De-beaking, regional concentration of production/mass production, resource use, space per animal/stocking density, housing system,* and *introduction of new laws and regulations/legal framework* were fairly concerning (Category 4) in Germany. In contrast, the *negative image of the poultry industry portrayed by the media, international trade in poultry*

products, the establishment of the ASEAN Economic Community (AEC), pressure on/from urban centres, and *breeding* were the fairly concerning (Category 4) issues in Thailand.

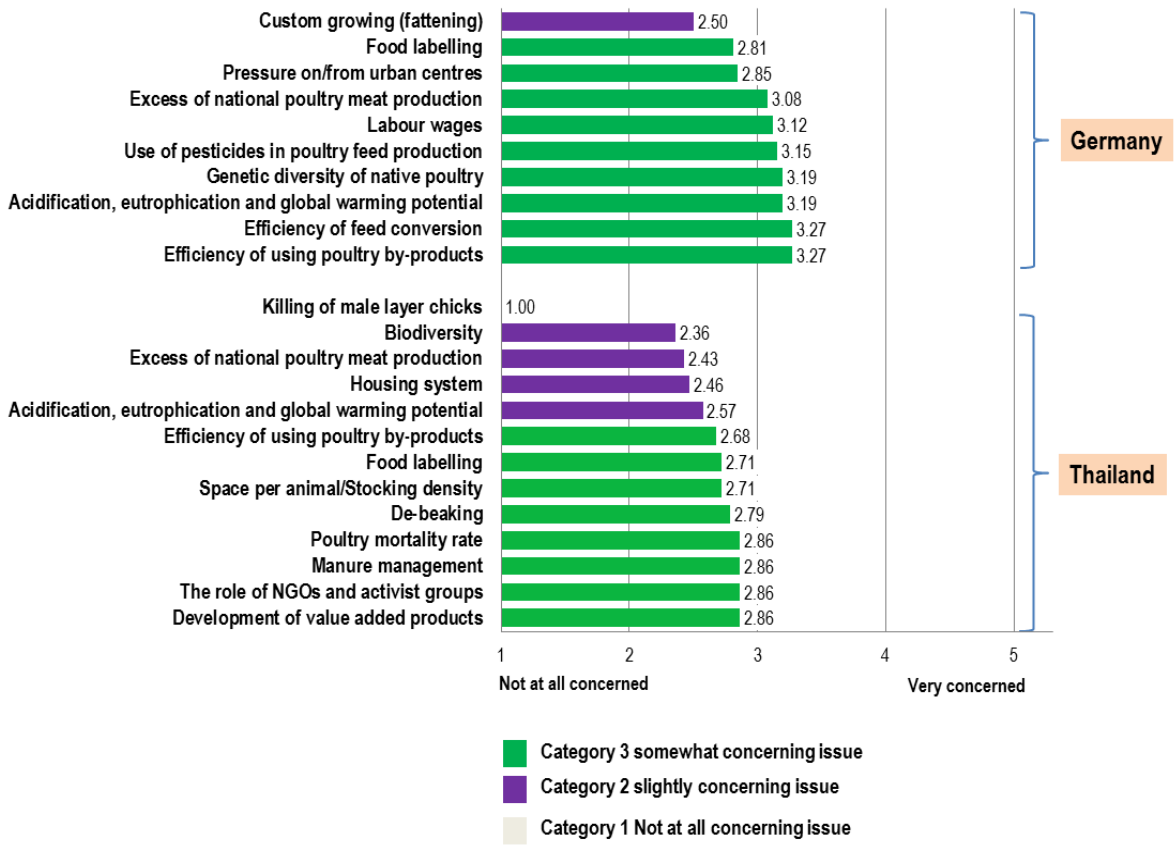
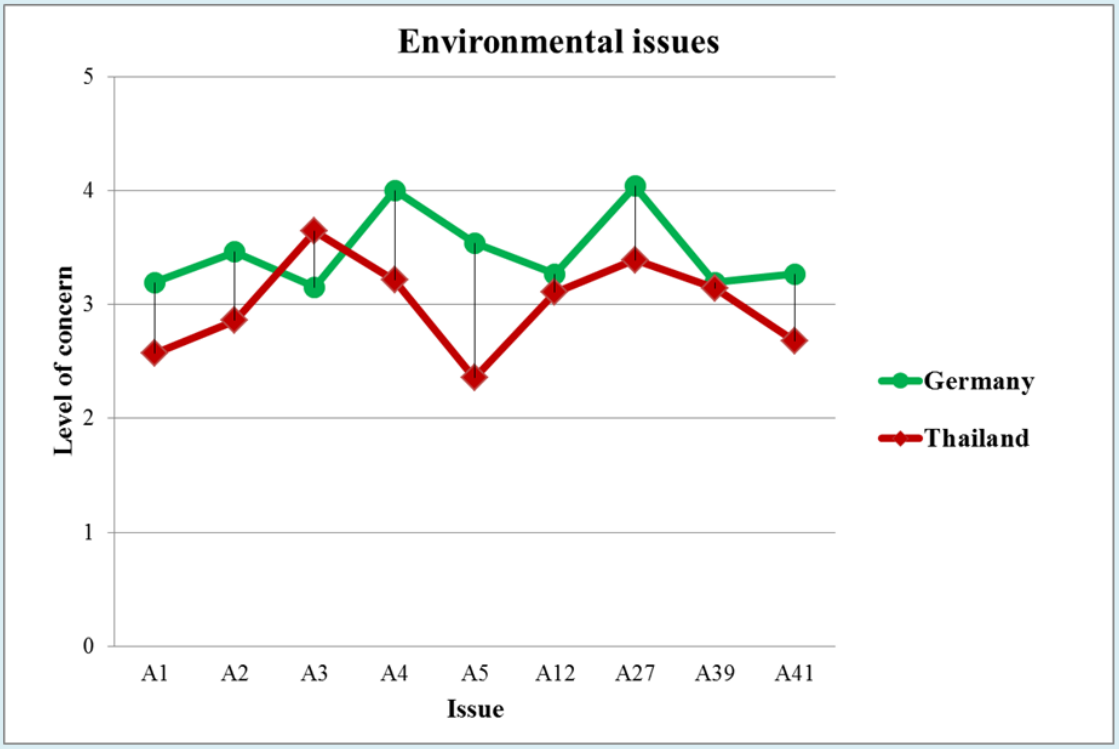


Figure 6.8 The 10 least concerning issues identified by experts from Germany and Thailand, ranked by mean value in the final round of the Delphi survey (Round 2). The x-axis ranges from a mean value of 1 (not at all concerning issue) to 5 (very concerning issue).

Source: Author's design.

As highlighted in Figure 6.8, the issue of *killing of male layer chicks* was not at all concerning (Category 1) and *de-beaking* was somewhat concerning (Category 3) for poultry production in Thailand. The German experts felt *custom growing (fattening)* was only slightly concerning (Category 2), while *biodiversity* and *housing system* were considered slightly concerning (Category 2) by the Thai experts. The *effeciency of using poultry by-products* and *food labelling* were considered somewhat concerning (Caregory 3) in both countries. Interestingly, *acidification, eutrophication and global warming potential*, and *excess of national poultry meat production* were considered somewhat concerning (Category 3) for poultry production in Germany, while these were rated as only slightly concerning (Category 2) in Thailand.

In order to visualise the opinions of the two countries' experts on sustainability concerns in poultry production, 41 similar concerns were categorised into the five dimensions of sustainability, including environmental, economic, social, political and animal welfare aspects, and then compared.

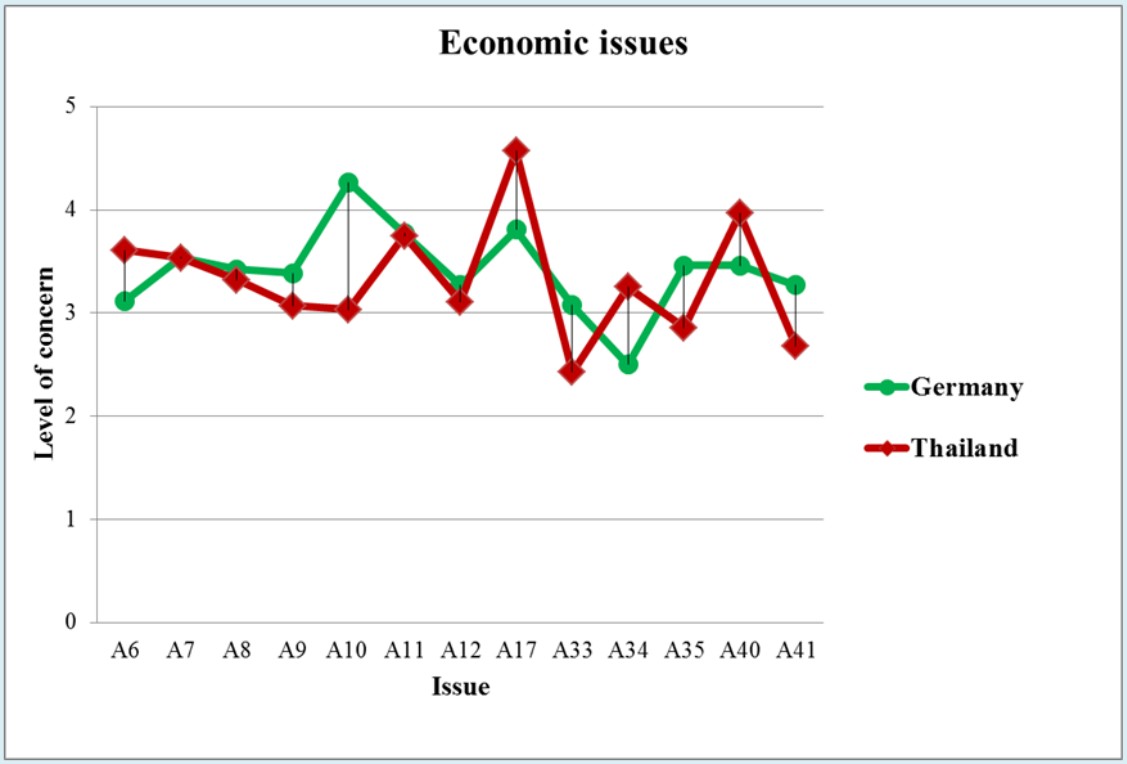


A1 = Acidification, eutrophication and global warming potential
A2 = Manure management
A3 = Use of pesticides in poultry feed production
A4 = Resource use
A5 = Biodiversity
A12 = Efficiency of feed conversion
A27 = Regional concentration of production/Mass production
A39 = Genetic diversity of native poultry
A41 = Efficiency of using poultry by-products

Figure 6.9 Envionmental issues as rated by experts from Germany and Thailand. The y-axis ranges from a mean value of 0 to 5, indicating the level of concern from low to high. The x-axis represents the issues that were rated.

Source: Author's design.

Based on Figure 6.9, it can be concluded that environmental issues, especially *resource use*, *biodiversity* and *regional concentration of production/mass production,* were rated higher in Germany than in Thailand, except the *use of pesticides in poultry feed production*, which was of more concern in Thailand.



A6 = Labour wages
A7 = Industry competitiveness/Farm income
A8 = Feed supply
A9 = Consumer demand
A10 = Role of food retailers
A11 = Breeding
A12 = Efficiency of feed conversion
A17 =Outbreak of avian influenza and other highly infectious diseases
A33 = Excess of national poultry meat production
A34 = Custom growing (fattening)
A35 = Poultry mortality rate
A40 = International trade in poultry products
A41 = Efficiency of using poultry by-products

Figure 6.10 Economic issues as rated by experts from Germany and Thailand. The y-axis ranges from a mean value of 0 to 5, indicating the level of concern from low to high. The x-axis represents the issues that were rated.

Source: Author's design.

If we take a look at the economic issues presented in Figure 6.10, *outbreak of avian influenza and other highly infectious diseases* was considered a more concerning issue for poultry production in Thailand than in Germany. An interesting result is that the *role of food retailers* was raised by the German experts, while this issue was of low concern for Thai experts. *Custom growing (fattening)* was more concerning in Thailand than in Germany.

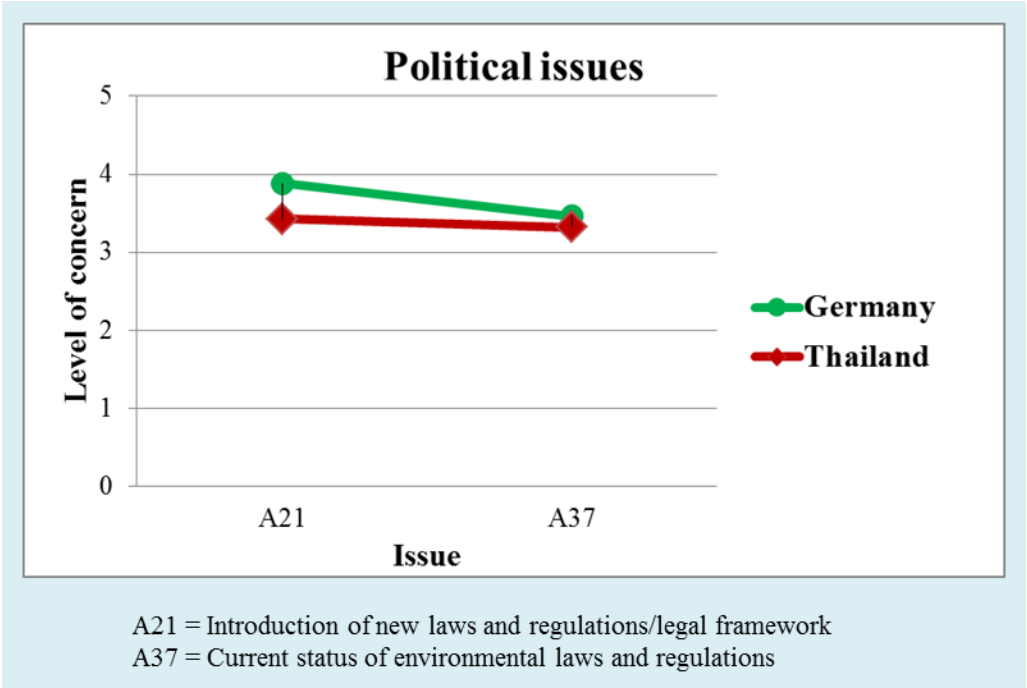
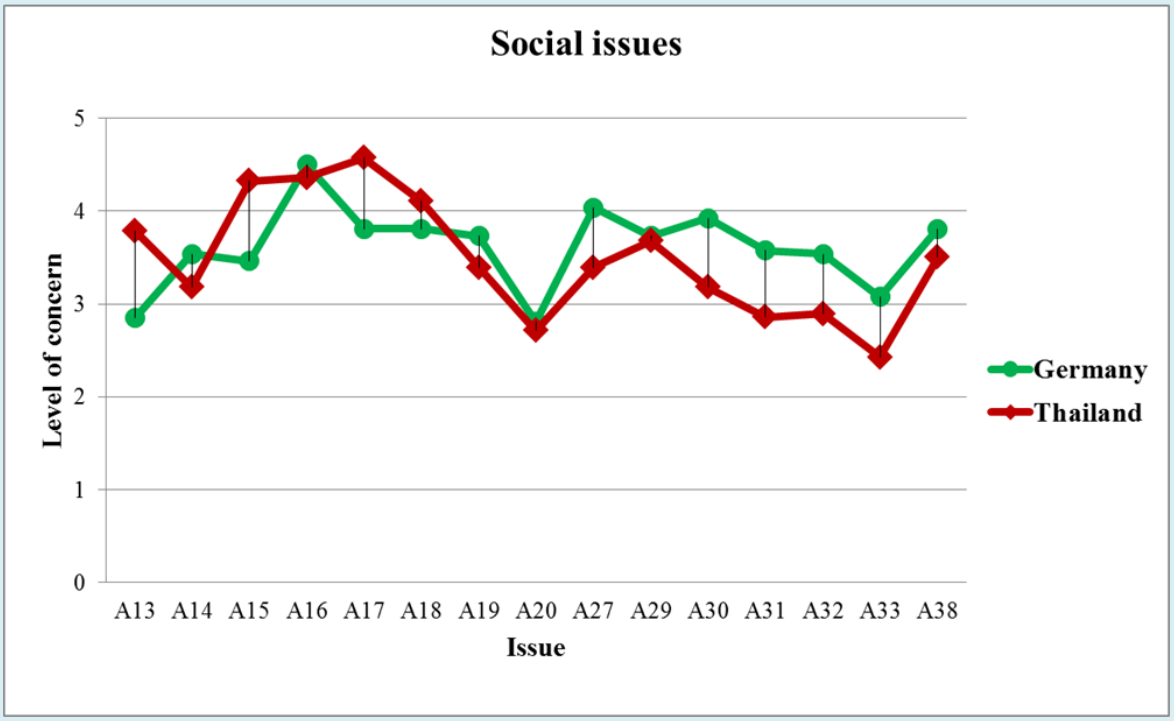


Figure 6.11 Political issues as rated by experts from Germany and Thailand. The y-axis ranges from a mean value of 0 to 5, indicating the level of concern from low to high. The x-axis represents the issues that were rated.

Source: Author's design.

As shown in Figure 6.11, the German experts felt that the *introduction of new laws and regulations/legal framework* could have a larger impact on poultry production than the Thai experts.



A13 = Pressure on/from urban centres
A14 = Workers in slaughter houses
A15 = Contamination of meat and eggs with zoonotic microorganisms
A16 = Use of antibiotics in poultry production
A17 = Outbreak of avian influenza and other highly infectious diseases
A18 = Negative image of the poultry industry portrayed by the media
A19 = Communication between producers and consumers
A20 = Food labelling
A27 = Regional concentration of production/Mass production
A29 = Consumer responsibility
A30 = Societal acceptance
A31 = The role of NGOs and activist groups
A32 = Lacking efforts to prevent avoidable deficiencies within the industry
A33 = Excess of national poultry meat production
A38 = Rating value of foods

Figure 6.12 Social issues as rated by experts from Germany and Thailand. The y-axis ranges from a mean value of 0 to 5, indicating the level of concern from low to high. The x-axis represents the issues that were rated.

Source: Author's design.

The experts highlighted the *use of antibiotics in poultry production* as a highly concerning social issue in the two countries, as shown in Figure 6.12. The issue *contamination of meat and eggs with zoonotic microorganisms* was more of a concern in Thailand than in Germany. The *outbreak of avian influenza and other highly infectious diseases* has both an economic and social impact, since avian influenza could also infect humans and cause health problems. Other issues, such as *workers in slaughter houses*, *negative image of the poultry industry portrayed by the media*, *communication between producers and consumers*, *food labelling, consumer responsibility*, and *rating value of foods* were considered equally concerning in both countries. However, *the regional concentration of production/mass production, societal acceptance, the role of NGOs and activist groups,* and *lacking efforts to prevent avoidable*

deficiencies within the industry were considered more of a concern in Germany than in Thailand. The *excess of national poultry meat production* was discussed more in Germany than in Thailand due to the recent scandal of low quality poultry meat being exported to African countries.

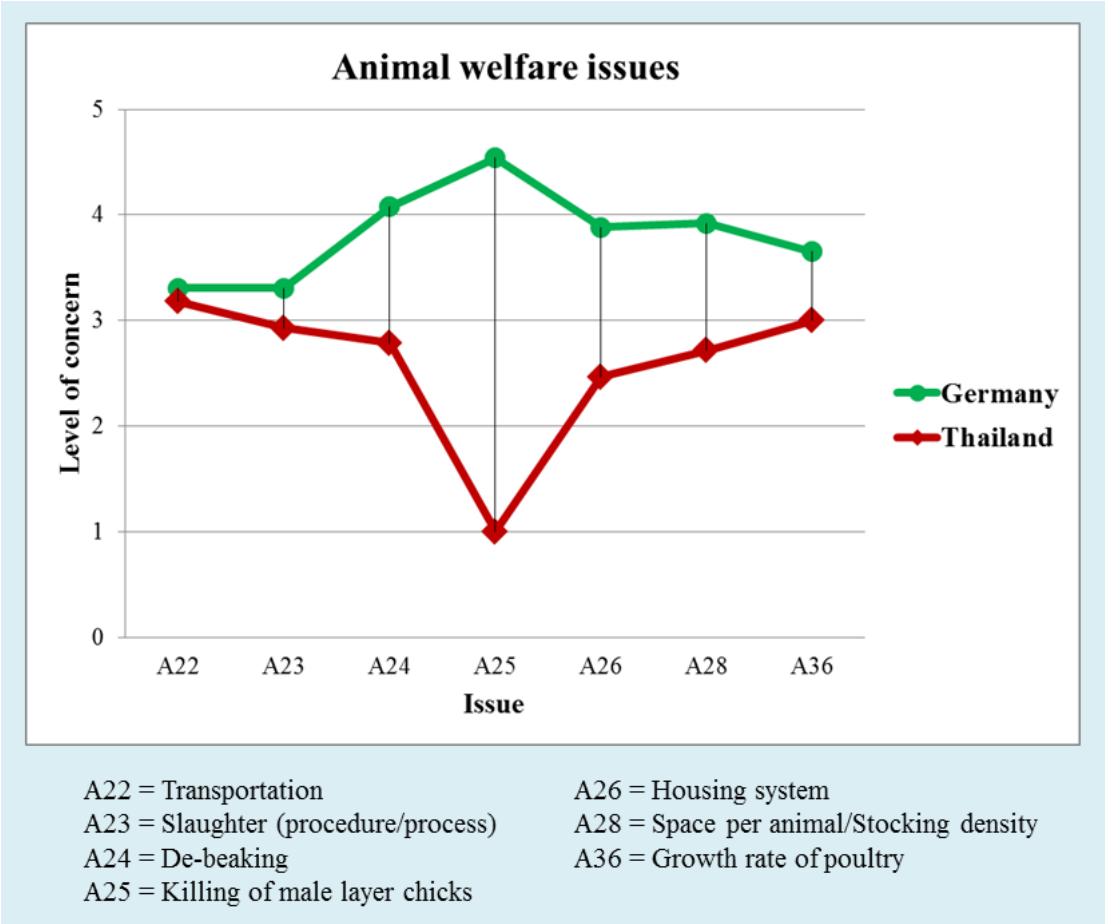


Figure 6.13 Animal welfare issues as rated by experts from Germany and Thailand. The y-axis ranges from a mean value of 0 to 5, indicating the level of concern from low to high. The x-axis represents the issues that were rated.

Source: Author's design.

Experts from Germany and Thailand had different opinions on animal welfare issues in poultry production, as presented in Figure 6.13. It is clear that animal welfare issues were considered more of a concern in Germany than in Thailand. The issues *de-beaking, housing system, space per animal/stocking density*, and *growth rate of poultry* were considered of high concern in Germany, with the *killing of male layer chicks* as a very concerning ethical issue in Germany, while day-old cocks are mainly reared for meat production in Thailand.

Chapter 7
The role of NGOs, animal welfare groups and leading integrated poultry firms in the sustainability of poultry production

7.1 Introduction

This chapter presents the roles of the various stakeholders in the sustainability of poultry production, including NGOs, animal welfare groups and leading integrated poultry companies. Actions taken by NGOs and animal welfare groups as well as policy changes or production strategy alterations adopted by leading integrated poultry companies in Germany and Thailand between 2013 and 2015 were analysed and compared in order to present a realistic picture of poultry production. This analysis can then be used to assess why some sustainability issues are of high concern in poultry production.

7.2 The process of data collection and analysis

In order to capture the roles of NGOs, animal welfare groups and leading integrated poultry companies in the sustainability of poultry production, poultry farming-related advocacy data issued by these three groups to inform the public of sustainability was analysed. This mainly includes electronic materials published on their websites and additional information gathered from in-depth e-mail interviews (unstructured questionnaires) (see Figure 7.1).

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Wissenschafts- und Informationszentrum
Nachhaltige Geflügelwirtschaft

Universität Vechta
University of Vechta

Questionnaire

Study on action undertaken by NGOs to improve the sustainability of the poultry industry

Background: The ongoing intensification of poultry production is hotly debated in public discussions and the media due to problems caused by the poultry industry, such as issues of animal welfare, the development of resistant bacteria, the use of cheap labour, environmental pollution and meat hygiene scandals. As a result, NGOs have criticised the poultry industry with a view to pushing to improve its production systems and increase the sector's sustainability.

Question: From the perspective of your organisation, what have you been doing or disseminating among the public to change the poultry industry? This can include reports on issues of animal welfare, infectious diseases, labour conditions, environmental problems, or awareness raising campaigns to inform the public.

Answer:

Questionnaire

Study on action undertaken by animal welfare groups to improve the sustainability of the poultry industry

Background: The ongoing intensification of poultry production is hotly debated in public discussions and the media due to problems caused by the poultry industry, such as issues of animal welfare, the development of resistant bacteria, the use of cheap labour, environmental pollution and meat hygiene scandals. As a result, animal welfare groups have criticised the poultry industry with a view to pushing to improve its production systems and increase the sector's sustainability.

Question: From the perspective of your organisation, what have you been doing or disseminating among the public to change the poultry industry? This can include reports on issues of animal welfare, infectious diseases, labour conditions, environmental problems, or awareness raising campaigns to inform the public.

Answer:

Questionnaire

Study on action undertaken by the leading integrated poultry companies to improve their public acceptance

Background: At present, the intensive poultry industry is portrayed negatively as a form of "Factory Farming"- especially by the media, animal activists and NGOs. Many issues have been criticised, including the practice of de-beaking, killing male chicks, the use of antibiotics in poultry production, outbreaks of avian influenza and other highly contagious diseases, the use of resources, issues of animal welfare and the use of cheap labour from other countries. As a result, the industry has been developing strategies to improve their social acceptance.

Question: From the perspective of your company, what have you done so far to improve the sustainability of the poultry industry in order to increase the level of social acceptance? This can include environment aspects, the use of antibiotics, animal welfare, labour conditions, communication campaigns, etc.

Answer:

Figure 7.1 Unstructured questionnaires for the study on action undertaken by NGOs, animal welfare groups and leading integrated poultry companies

Action-related advocacy undertaken by these three groups was then categorised by sustainability issue in poultry production to provide an overview of their roles. The method for collecting and analysing secondary data and in-depth e-mail interviews is based on Malhotra and Birks (2007) and Meho (2006) as described in Chapter 2, respectively.

To compare the roles of NGOs/animal welfare groups and leading integrated poultry companies in the sustainability of poultry production, selection criteria were established for these three groups, guided by Freeman (2014), including having an animal farming mission that supports sustainability in poultry production; organising campaigns that provide a variety of poultry farming-related information aimed at the public or the consumer; and a national or international scope.

For the case study in Germany, the following organisations and companies were selected:

- NGOs: Greenpeace and BUND (Friends of the Earth Germany)
- Animal welfare groups: Deutscher Tierschutzbund e.V., Vier Pfoten Germany and PROVIEH
- Poultry companies: PHW-Group and Heidemark Mästerkreis GmbH & Co. KG

Due to the inactive role of NGOs and animal welfare groups in the poultry industry in Thailand (Ursinus et al., 2009), only the following leading integrated poultry companies were selected for the analysis:

- Poultry companies: Charoen Pokphand Foods Public Company Limited (CPF) and GFPT Public Company Limited

7.3 Background information on the selected NGOs, animal welfare groups and poultry companies

7.3.1 Greenpeace

Greenpeace is a non-profit organisation, which was founded by Dorothy and Irving Stowe, Marie and Jim Bohlen, Ben and Dorothy Metcalfe, and Bob Hunter in Vancouver, Canada in 1971, with the primary goal of stopping a second US nuclear weapons test at Amchitka Island in the Aleutians (Greenpeace, 2015a). Environmental protection is Greenpeace's main objective. Its action on environmental issues has spread throughout the world. The main

international headquarters have been located in Amsterdam since 1989, and the organisation has established a network that spans 40 countries.

In Germany, Greenpeace's head office was established in Hamburg in 1980 and currently has approximately 200 employees (Greenpeace, 2015b). The main objective is to raise awareness on environmental problems in order to prevent environmental destruction. A wide range of agricultural production topics, including poultry production, has been the focus of the organisation.

7.3.2 BUND (Friends of the Earth Germany)

BUND is a non-profit association that was founded in 1975, with more than 530,000 members and supporters at present. Its head office is in Berlin, Germany (BUND, 2015a). The association aims to promote environmental protection, organic farming, sustainable land use, more renewable energy resources and less fossil fuel as well as transport policies that combine mobility and environmental protection (BUND, 2015b).

7.3.3 Deutscher Tierschutzbund e.V.

The German Animal Welfare Association (Deutscher Tierschutzbund) was founded in 1881 and has its head office in Bonn, Germany (Deutscher Tierschutzbund, 2015). Currently, it consists of 16 national associations with over 750 local animal welfare organisations from all parts of the country. The association aims to promote environmental conservation and the welfare of all animals, including wild-, domestic and farmed animals.

7.3.4 Vier Pfoten Germany

Vier Pfoten is an international animal welfare organisation, which was founded in 1988 with its headquarters in Vienna, Austria (Vier Pfoten, 2014). Its office in Germany has been in Hamburg since 2004. It also has offices in Romania, Bulgaria, Switzerland, The Netherlands, Hungary, Great Britain, South Africa and the United States. In addition, Vier Pfoten has an office for European Politics in Brussels, Belgium. The aims of the organisation are to inform the public about animal suffering and to improve the welfare of farmed animals, experiment animals and wildlife (Vier Pfoten, 2014).

7.3.5 PROVIEH

PROVIEH is an animal welfare association that was founded in 1973 with its head office in Kiel, Germany (PROVIEH, 2015). It has a branch office in Brussels, Belgium and a technical reference unit in Witzenhausen, Germany. The association informs the public about the abuse of industrial livestock production and its consequences for humans. It runs campaigns on politics and trade to improve the living conditions of farmed animals and shows examples of how farm animal welfare can be integrated throughout the process, from the farm to the supermarket. PROVIEH aims to increase the animal welfare of industrial farmed animals, sustainability in feed production and the quality of animal products (PROVIEH, 2015).

7.3.6 PHW-Group

PHW Group is the largest integrated poultry company in Germany and owns the brand Wiesenhof, which produced chicken, turkey and duck products. Its headquarters are in Rechterfeld, Germany (PHW-Group, 2015). The company also does business in animal feed, animal health, human nutrition and human healthcare. It has approximately 6,000 employees and had a total turnover of more than EUR2.3 billion in 2014 (PHW-Group, 2015).

7.3.7 Heidemark Mästerkreis GmbH & Co. KG

Heidemark is a leading German integrated turkey company with its headquarters in Garrel, Germany (Heidemark, 2015a). In 2014, it had between 201-1000 employees and generated revenues of EUR706.5 million (Statista, 2014). The company produces turkey products for retail food stores, industry and large-scale customers.

7.3.8 Charoen Pokphand Foods Public Company Limited (CPF)

Charoen Pokphand Foods Public Company Limited is the leading Thai integrated agro-industrial and food conglomerate company in the Asia Pacific region (CPF, 2015a). Its headquarters are located in Bangkok, Thailand. The company's core business is animal feed, livestock and aquaculture production, including fodder, broilers, eggs, ducks, swine, shrimp and fish. It is also the largest poultry producer in Thailand. In 2014, the company generated total revenues of approximately EUR1.06 billion (CPF, 2015b).

7.3.9 GFPT Public Company Limited

The GFPT Group is one of the leading Thai integrated poultry companies with headquarters in Bangkok, Thailand. Their poultry products include frozen chicken meat, processed chicken and by-products, which are sold on the domestic and international market (GFPT, 2015a). In 2014, the company reported total revenues of EUR452 million (GFPT, 2015b).

7.4 The role of NGOs, animal welfare groups and leading integrated poultry companies in the sustainability of poultry production in Germany

7.4.1 Actions taken by NGOs and animal welfare groups

In recent years, an increasing number of NGOs and animal welfare groups have shown interest in livestock production in Germany, including the poultry industry. The range of strategies and campaigns developed and implemented by NGOs and animal welfare groups, including awareness raising campaigns, media coverage and information sharing among members of the public, have played an important role in the development of sustainability in poultry production. This section provides an overview on the sustainability issues highlighted by these two groups in their operations.

A study was conducted of the electronic materials published on the websites of Greenpeace, BUND, Deutscher Tierschutzbund, Vier Pfoten Germany and PROVIEH, as well as additional information gathered from in-depth email interviews with these groups, in order to identify activities in 2013-2015 that are associated with the sustainability of poultry production. They were analysed and categorised by sustainability issue as follows:

- *Use of pesticides in poultry feed production*

  The use of pesticides in soybean production, such as glyphosate to control weeds, is a serious area of concern due to their harmful effects on human health and long-lasting persistence in soil and water, as well as the possibility of weeds developing a resistance to pesticides. NGOs and animal welfare groups propose organic farming as an alternative.

- *Feed supply*

Imports of poultry feed produced in South American countries have resulted in a loss of biodiversity and tropical forests in that region. In addition, the use of genetically modified feed in egg and poultry production should be prohibited due to their harmful environmental impact and potential risks for human health.

- *Manure management and acidification, eutrophication and global warming potential*

The intensification of poultry production causes a number of environmental problems, such as the pollution of air (ammonia emission), soil and groundwater (leaching of nitrate). Furthermore, poultry litter should be managed more effectively.

- *Resource use*

Requirements for land, water and energy in poultry production should be controlled better, particularly in regions where feed is produced, which may contribute to deforestation.

- *Biodiversity*

Monocultures for poultry feed production are contributing to a loss of biodiversity among plants and other organisms in production areas.

- *Housing system*

All poultry types should be able to access outdoor areas throughout the year in order to express natural behaviours and instincts, such as pecking and sand bathing.

- *Stocking density*

The current space allocated to poultry in intensive conventional production systems is still too low. The number of poultry per house should be reduced in order to increase welfare standards.

- *Use of antibiotics in poultry production*

Antibiotics should no longer be used in poultry production, especially reserved antibiotics, such as fluorchinolone and tetracycline. The use of antibiotics in livestock production is associated with the development of resistant bacteria.

- *Outbreak of avian influenza*

Avian influenza is a serious concern in poultry production. Intensive production systems with fast-growing breeds face a high risk of disease infection. In response to this, more robust breeds with natural growing rates should be developed and the level of biosecurity measures on farms needs to be improved.

- *Employment of cheap labour from Eastern Europe in slaughterhouses*

This issue has been criticised due to the prevalence of unfair working contracts for labourers from neighbouring countries and harsh living conditions during the period of employment. Labour contracts and arrangements need to be more transparent and fair.

- *Custom growing*

The farming contracts between integrated companies and poultry farmers mean that farmers can make fewer decisions on production plans since the most important decisions are usually made by the integrated companies.

- *Excess supply of domestic poultry meat*

An excess supply of domestic poultry meat can encourage production companies to export poultry meat products to African countries at low prices. These imported products are cheaper than locally produced meat, which damages the competitiveness of local farmers and harms their income generation opportunities in these African countries.

- *De-beaking*

De-beaking or beak trimming is used to prevent feather pecking and cannibalism among turkeys and laying hens. However, this practice harms poultry welfare, including pain caused by tissue damage and nerve injury, and the loss of normal functions due to a reduced ability to sense materials with the beak. Thus, de-beaking should be prohibited as soon as possible.

- *Growth rate in poultry*

The current fast-growing or turbo breeds used in poultry production, especially broilers and turkeys, are very susceptible to diseases, resulting in an increased use of

antibiotics during production. In response, more robust and normal growing breeds should be developed and used.

- *Transportation*

The transportation of broilers and turkeys to slaughterhouses should be restricted to less than 8 hours. Long distance transportation needs to be prohibited and animal welfare standards during transportation need to be improved.

- *Killing of day-old male layer chicks*

Day-old chicks should be no longer culled. Dual-purpose chickens and in ovo sex determination should be applied.

A number of campaigns have been run by NGOs and animal welfare groups to improve the sustainability of poultry production. Table 7.1 summarises the issues raised by NGOs and animal welfare group campaigns.

Table 7.1 Contentious issues raised by NGOs and animal welfare group campaigns

Campaigns against:	**Campaigns calling for government and sectoral support:**
Factory farming	Support organic farming by altering the structure of agricultural subventions
Patent on conventionally bred plants and animals	Increase transparency and information on egg and poultry meat labelling
Use of antibiotics in poultry production	Promote free range production systems
Use of forests and wetlands for poultry feed plantations	Use poultry feed from regional production
Cheap meat	Reduction of chemical fertilisers in feed production
Import of products from other countries with low animal welfare standards	Breeding of robust breeds
	Reduction of meat and animal product consumption
	Promotion of small herd sizes

Table 7.1 (Continued)

Campaigns against:	**Campaigns calling for government and sectoral support:**
Construction of large poultry farms and slaughterhouses	Increase animal welfare standards
Muscovy duck husbandry	Increase quality control of poultry coop designs prior to market release
Feeding geese by gavage	Legislation on turkey husbandry
Use of feathers and down from ducks and geese	Slaughter in the region of origin
De-beaking in laying hens and turkeys	Limitation of domestic transport times to eight hours from poultry farms to slaughterhouses
Killing of day-old male layer chicks	Elimination of export subsidies for live animals
Use of genetically modified feeds in poultry production	Development of animal welfare laws based on equal consideration for consumers and producers
	Improvement of quality assurance system for poultry meat products
	Mandatory labelling of poultry meat fed with genetically modified feed
	Mandatory labelling of eggs and products containing eggs
	Prohibition of the sale of eggs and products containing eggs laid in cage systems

Source: Data based on a literature review of electronic material published on the websites of Greenpeace, BUND, Deutscher Tierschutzbund, Vier Pfoten Germany and PROVIEH, and qualitative in-depth e-mail interviews with these groups (2015).

7.4.2 Policy changes or production strategy alterations adopted by leading integrated poultry companies

Producing poultry meat and eggs more sustainably is a great challenge for the poultry sector, especially the leading poultry companies. Pressure from NGOs and animal welfare groups, as well as consumers, to increase sustainability in the sector has pushed the leading poultry companies to adopt more sustainable production strategies.

A study was conducted of electronic materials published on the websites of PHW-Group and Heidemark, company reports (Heidemark, 2015b) and additional information collected from in-depth email interviews with these groups in order to assess their production strategy shift towards sustainability in 2013-2015. The following was observed:

- *Modernisation of poultry farms and slaughterhouses*

  Poultry companies have increased their investments in the modernisation of farms and slaughterhouses in order to improve animal welfare and hygiene standards.

- *Use of modern technology to increase resource efficiency*

  Modern technology is now applied in the poultry industry to facilitate resource-efficient, energy-optimised and low-emission production. Increasing the efficient use of energy and water as well as waste management could reduce carbon footprints throughout the supply chain even further.

- *Development of feed additives to reduce nitrogen and phosphorus emissions*

  Feed additives improve poultry digestive systems, thus reducing the amount of nitrogen and phosphorus emitted in litter.

- *Use poultry by-products for biofuel production*

  By-products from poultry meat, such as poultry fat, have been used to produce biofuel, which can help reduce the sector's environmental impact.

- *Shorten transport routes between poultry farms and slaughterhouses*

  Reducing transport times and distances could lower production costs and address animal welfare concerns.

- *Promotion of scientific research at universities and institutes*

Collaborating with research institutes promotes the development of knowledge on poultry production, which ensures the increased use of technology and innovation in order to improve the production system in a more effective manner.

- *Promotion of alternative production systems*

Due to the increasing consumer awareness of animal welfare, the company supports alternative production systems, such as providing more space and roofed conservatories for broiler husbandry (Wiesenhof, 2015).

- *Promotion of animal welfare and non-genetically modified feed*

Poultry companies' production standards now comply with regulations and animal welfare standards. The labels "Für mehr Tierschutz" and "Ohne Gentechnik" indicate that poultry products have been produced in line with animal welfare standards and without genetically modified feed. The welfare of animals during transportation and in slaughterhouses has also been taken into account to comply with legal standards.

- *Reduction of antibiotics*

The use of antibiotics poses a direct cost for producers. As a result, companies are increasingly keen to improve their production systems in order to reduce the use of antibiotics and ensure food safety and animal welfare.

- *Research on alternative use of day-old male layer chicks*

Ethical concerns over culling day-old male layer chicks have been brought to the attention of poultry producing companies. In response, the industry has invested in research on alternative solutions.

- *Research on laying hen husbandry without de-beaking*

The poultry industry also addresses de-beaking in poultry production by supporting research on animal welfare in laying hen husbandry without trimming beaks.

- *Traceability and transparency of consumer products*

Clearly labelling poultry meat and eggs helps consumers understand the origin of products and high safety standards.

- *Control of poultry feed production*

Deforestation in feed producing regions is also a concern for production companies. In response, feed production is highly controlled by the companies in order to ensure that plantations do not negatively impact on surrounding forest ecosystems.

- *Promotion of the use of slow-growing breeds*

Slow-growing breeds, such as "Cobb Sasso" and "Hubbard", are increasingly being used in poultry meat production, which means that the birds have more time to develop and more space to access outdoor areas to express natural behaviours, such as sun-bathing and pecking.

- *High level of production standards*

The companies ensure that poultry production meets the high level of hygienic standards through internal and external inspections, such as QS (Quality Scheme for Food), IFS (International Featured Standards), BRC (The British Retail Consortium) and HACCP (Hazard Analysis and Critical Control Points). Quality management systems are applied throughout the entire production chain.

- *Improved working conditions*

Employees have access to training measures and professional skills development. Competitive wages and benefit packages, as well as reasonable working hours, are provided by the companies. The companies also encourage the development of vocational training and education programmes for young adults.

- *Support for farmers*

Developing relationships with contracted farmers and providing support on all relevant matters can generate benefits for the two sides and ensure the highest quality and safety of poultry products.

- *Promotion of constructive dialogue with NGOs and animal welfare groups*

Leading production companies are open to discussions with NGOs and animal welfare groups on improving the sustainability of poultry production. Engaging with the wider community is a key responsibility.

7.4.3 Discrepancies between actions taken by NGOs/animal welfare groups and production strategies adopted by the poultry companies

The efforts undertaken by NGOs/animal welfare groups and the leading integrated poultry companies outlined above show that most sustainability issues criticised by NGOs and animal welfare groups are being taken into account by the poultry production companies. However, a number of issues of lower concern persist, including the following issues taken from the Delphi results presented in the previous chapter:

- *Custom growing*
- *Labelling of poultry products*
- *Pressure on/ from urban centres*
- *Overproduction of poultry meat*
- *Employee welfare*
- *Use of pesticide in poultry feed production*
- *Acidification, eutrophication, and global warming potential*
- *Efficiency of using poultry by-products*
- *Slaughter (procedure/process)*
- *Transportation.*

However, due to trade-offs between economic efficiency and consumer preferences, as well as investment policies and the availability of technology and innovation, not all sustainability issues can be addressed effectively in practice. Furthermore, some issues cannot be addressed by the companies alone, requiring collaboration between all the stakeholders of the poultry sector. The following sustainability issues of the highest concern - based on the Delphi study results - cannot be addressed by the poultry production companies alone:

- *Killing of day-old male layer chicks* and *de-beaking*

  These two practices will be prohibited by laws and regulations supported by NGOs and animal welfare groups in the near future. The poultry companies have been striving to find solutions for these issues, however it has been a long process. Both the *killing of male layer chicks* and *de-beaking* were identified as issues of high concern for the poultry industry during the Delphi study.

- *Use of antibiotics in poultry production*

One of the most concerning issues in poultry production is the use of antibiotics during production due to an increasing awareness of food safety and human health. Although the cost of antibiotics is relatively high for producers, it is still necessary in order to protect against and treat a number of diseases among poultry. This issue requires the collaboration of various actors in order to reduce the use of antibiotics.

- *Role of food retailers*

Food retailers play a central role in communicating between producers and consumers. However, retailers alone cannot make decisions on improving poultry products. Consumer preferences and the ability of poultry companies to produce and meet consumer demands at a reasonable price have to be taken into account. The uncertainty of a retail-oriented economy makes this issue a high concern for the poultry industry.

- *Outbreak of avian influenza*

Although production companies have continually improved biosecurity standards in poultry production, avian influenza is still an ongoing issue the world over due to multiple factors. Avian flu has a hugely damaging impact on the poultry industry, as the outbreaks in the Netherlands (2003), Thailand (2004) and the USA (2015) showed. As long as outbreaks persist, avian influenza remains a highly concerning issue, which needs to be researched further until solutions are found.

Other issues, such as the *regional concentration of production, resource use, stocking density, housing systems, contamination of meat and eggs with zoonotic microorganisms, breeding* and *negative image of the poultry industry portrayed by the media* have been worked on by poultry companies throughout. However, their efforts are still not enough to solve these problems. As a result, these issues are still considered fairly concerning.

7.5 The role of NGOs, animal welfare groups and leading integrated poultry companies in the sustainability of poultry production in Thailand

7.5.1 Actions taken by NGOs and animal welfare groups

Although NGOs and animal welfare groups play an inactive role in the poultry industry in Thailand, they predominantly work on natural resources and wildlife conservation issues, such as elephant conservation and the welfare of domesticated elephants (Ratanakorn, 2002; Ursinus et al., 2009). As a result, NGOs and animal welfare groups had no influence over the sustainability of poultry production during this research.

7.5.2 Production strategies adopted by the leading integrated poultry companies

The poultry industry is one of the most important agricultural sectors in Thailand. The integrated poultry companies play a leading role in producing poultry products for domestic consumption and export. As a result, the companies take high levels of production standards and sustainable production into account.

A study was conducted of electronic materials published on the websites of Charoen Pokphan Foods (CPF) and GFPT, company reports (CPF, 2015b; GFPT, 2015b) and additional information collected from in-depth email interviews with these groups in order to assess their production strategy shifts towards sustainability in 2013-2015. The following observations were made:

- *Development and use of advanced technology and innovation in poultry production*

  The companies have introduced advanced technology and innovation that comply with international standards in order to overcome limitations and improve the efficiency of production, contributing to the high quality, safety and hygiene of products. Products can systematically be traced back to their origin.

- *Provision of opportunities for business partners and communities to participate in the decision-making process*

  The dissemination of knowledge and technology transfer among business partners and communities throughout the value chain, as well as support for increasing standards of

living, have increased competitiveness and fostered mutual growth together with the companies.

- *Efficient use of resources*

Production companies implement the 4Rs concept of "Reduce", "Reuse", "Recycle" and "Replenish" in order to increase the efficiency of the management of energy, water, waste and air. This concept complies with international standards, such as ISO 14001 (Environmental Management), ISO 50001 (Energy Management), AEMAS (ASEAN Energy Manager Accreditation Scheme), ISO 14040 (Environmental Management – Life Cycle Assessment – Principles and Framework), ISO 14044 (Environmental Management – Life Cycle Assessment – Requirements and Guidelines) and ISO 14067 (Greenhouse Gases – Carbon Footprint of Products), which minimise environmental impacts and contribute to the conservation and restoration of biodiversity, as well as the mitigation of climate change.

- *Promotion of employee welfare*

Employees have access to career and skills development training opportunities, and are provided competitive compensation and benefits. The creation of a safe and healthy working environment is taken seriously in every workplace, including farms, production facilities, administrative and support offices, and retail outlets by implementing health and safety standards, such as OHSAS 18001 (Occupational Health and Safety Assessment Series).

- *High level of biosecurity standards and product safety*

In order to ensure product quality and food safety for consumers, production companies have focussed on biosecurity that complies with international standards, such as ISO 9001 (Quality Management), GMP (Good Manufacturing Practice), HACCP (Hazard Analysis and Critical Control Point), GAP (Good Agricultural Practice), BRC (British Retail Consortium) and IFS (International Food Standard). The companies ensure that no hormone growth promoters are used in poultry production and that meat processing complies with international standards.

- *Promotion of human rights*

Human rights policies have been put in place in order to tackle human trafficking, as well as directly sourcing labour brokers in sending countries (CPF, 2015b).

- *Improvement of animal welfare standards*

Animal welfare standards are continually improved in compliance with Thai legislation, EU Directives and international standards, such as the Animal Welfare Standards of the European Union, the United Kingdom's Red Tractor Assurance (RTA) and Genesis Assured Duck Production (ADP), and Switzerland's Agricultural Labelling Ordinance (ALO). Production systems follow animal welfare principles, including site selection and design, animal husbandry systems, feeding and nutrition, healthcare and disease prevention, farm hygiene, animal handling and transportation, documentation and employee training. Broiler production complies with a high level of animal welfare standards, with birds being reared for 45 days to gain 2.5 kg in weight and being kept at a low stocking density of a maximum of 13 birds/m^2 before slaughter.

- *Labelling of poultry products*

In accordance with the law, information on poultry products is provided in an accurate, clear and sufficient manner to support consumer choices, including the place of origin, important ingredients, safe use and storage instructions and nutrition information.

- *Collaboration with retailers*

Production companies cooperate with supermarkets and retail chains to ensure they meet consumer demands for high quality and safe products.

- *Promotion of community livelihoods*

Community livelihood programmes include support for education, local incomes, public health and employment generation. The companies also promote the development of infrastructure and public goods and services, including arts and culture.

- *Support for public policy*

The production company CPF participates in regulatory advocacy on the sustainability of the agricultural and food industries to boost Thailand's competitive edge on the international market, such as enhancing veterinary education standards for universities and educational institutions in Thailand to keep up with advanced technology and compete at the international level, and coordinating on the provision of animal feed and other support measures to help poor farmers (CPF, 2015b).

7.5.3 Discrepancies between actions taken by NGOs/animal welfare groups and production strategies adopted by the poultry companies

Due to the low level of engagement of NGOs and animal welfare groups in the Thai poultry industry, the leading integrated poultry companies faced almost no pressure from these two groups. As a consequence, the Delphi study results directly reflect the effect of company policies and efforts on poultry production.

Thai poultry companies proactively improve production standards in order to increase national and international consumer trust and boost their image, resulting in some sustainability issues being rated as less concerning in the Delphi study results presented in the previous chapter. The following issues were considered not at all concerning or of low concern:

- *Killing of day-old male layer chicks*
- *Biodiversity*
- *Excess supply of domestic production*
- *Housing systems*
- *Acidification, eutrophication and global warming potential*
- *Efficiency of using poultry by-products*
- *Food labelling*
- *Stocking density*
- *De-beaking*
- *Poultry welfare during growing phase*
- *Slaughter (procedure/process)*
- *Role of food retailers*
- *Working conditions in slaughterhouses*

- *Transportation*
- *Social acceptance*
- *Resource use*
- *Custom growing*
- *Feed supply*
- *Quality of poultry products*
- *Perception of poultry products*
- *Poultry welfare in slaughterhouses*

However, some sustainability issues are not yet addressed in practice due to investment policies, technological limitations and lack of innovation, and import requirements. In addition, some issues cannot be solved by Thai companies alone, requiring collaboration with other countries. The following sustainability issues of the highest concern - based on the Delphi study results - cannot be addressed by the poultry production companies alone:

- *Outbreak of avian influenza (AI)*

Although there have been no outbreaks of bird flu in Thailand since 2009, this issue has been considered highly concerning due to the continual spread of avian influenza in neighbouring countries, such as in Cambodia (2015), Laos (2015) and Vietnam (2015), which could spread across into Thailand. A fear of AI outbreaks as experienced in 2004 has driven poultry companies and the government to devise regulations to strictly control production systems. However, outbreaks of AI are associated with multiple factors, which put the poultry industry at risk despite high levels of biosecurity measures.

- *Disease control in neighbouring countries*

Due to lower production standards in neighbouring countries, the likelihood of diseases spreading across the border is very high, especially via the illegal transportation of animal products.

- *Use of antibiotics in poultry production*

Poultry production companies have been researching how to reduce the use of antibiotics in poultry production as much as possible. However, antibiotics are still needed to treat some poultry diseases. Production systems have to be improved further in order to be able to produce antibiotics-free poultry.

- *Contamination of meat and eggs with zoonotic microorganisms*

Although Thailand's leading integrated poultry companies comply with a high level of biosecurity and hygiene standards, the risk of meat and eggs being contaminated with zoonotic microorganisms is considered highly concerning since approximately 10% of meat and eggs are produced on small scale farms, which have lower production standards (Songpaisan, 2013).

- *Standards for poultry products required from importing countries*

External factors, such as production standards and requirements set by import partners that exceed the production capacities of Thai companies, result in the loss of markets and increase the level of investment needed to achieve a certain condition.

- *Negative image of the poultry industry portrayed by the media*

Although the Thai poultry industry is rarely portrayed negatively in the Thai media, negative reports could have a devastating impact on the industry. For example, rumours of an outbreak of avian influenza spread via social media in 2014, which had a number of social and economic impacts, temporarily shook confidence in the poultry industry. As a result, this issue was considered fairly concerning in the survey in 2014.

Other sustainability issues, such as the *international trade in poultry products, the establishment of the ASEAN Economic Community, pressure on/from urban centres, breeding* and *the role of small-scale family farming* are also taken into account by poultry production companies. However, their efforts do not effectively address these concerns. As a result, these issues were ranked as fairly concerning during the Delphi survey.

7.6 Comparison of the roles of NGOs, animal welfare groups and leading integrated poultry companies in the sustainability of poultry production in Germany and Thailand

Table 7.2 summarises the different roles played by NGOs, animal welfare groups and the leading integrated poultry companies in the sustainability of poultry production in Germany and Thailand. NGOs and animal welfare groups in Germany are very active in terms of advocacy and campaigns on issues in the poultry industries, while these actors are inactive in Thailand. Production strategies adopted by the leading integrated poultry companies in Germany are more reactive in response to the pressures exerted by NGOs and animal welfare

groups. Without pressure from NGOs and animal welfare groups, companies in Thailand proactively work on their production strategies to develop a positive image and gain trust from domestic consumers and import partners.

Table 7.2 Comparative roles of stakeholders in the sustainability of poultry production

Role of stakeholders in the sustainability of poultry production	Germany	Thailand
NGOs	active	inactive
Animal welfare groups	active	inactive
Leading integrated poultry companies	reactive	proactive

Source: Author's design.

Chapter 8
Discussion

8.1 Introduction

The main goal of this study is to provide recommendations on improving the sustainability of poultry production in Germany and Thailand. The notion of sustainability science was applied to develop the study's conceptual framework. The Delphi method was used to estimate the current actual state of the poultry industry by identifying and ranking sustainability issues that concerned the German and Thai poultry industries in 2014. Additionally, actions undertaken by NGOs and animal welfare groups, as well as the policy reactions/production strategies adopted by the leading integrated poultry companies, were analysed using a combination of secondary data analyses and qualitative in-depth email interviews, as discussed in Chapter 2, to explain why some sustainability issues are considered concerning for poultry production during the Delphi survey. This chapter focuses on the discussion of the Delphi method, the results of the Delphi study on sustainability concerns in poultry production, and the analysis of the role of NGOs, animal welfare groups and leading integrated poultry companies in the sustainability of poultry production. Lastly, this chapter provides a general discussion of the overall research findings and the study's implications, limitations and recommendations for future research.

8.2 The Delphi study on sustainability concerns in poultry production

8.2.1 The Delphi method

The Delphi method is an appropriate tool in instances where knowledge is limited or current data is unavailable (Gupta and Clarke, 1996). It is also very useful if individual experts cannot meet in person due to time or cost constraints (Linstone, 1978). The Delphi method has some limitations: it is time-consuming, participants need to know how to use it, and the results may not be representative (Barnes, 1987). However, this technique aims to achieve a consensus on certain issues within a group of experts in the face of uncertainty and insufficient data (Angus et al., 2003). One of the advantages of the Delphi method is that its use can mitigate the bandwagon effect by carefully selecting experts from diverse backgrounds (Angust et al., 2003), and by controlling the feedback and iteration process during the Delphi survey (Rowe

and Wright, 1999). In this study, the Delphi technique was used to engage experts in the identification and ranking of sustainability issues that currently concern the German and Thai poultry industries. The experts were carefully selected based on their knowledge and experience in the poultry industry. The method proved to be particularly useful since the Delphi panellists did not have to meet in person throughout the process, which removed geographical boundaries and saved travel costs. One of the most challenging issues in using this method is maintaining the number of participating experts throughout various iteration rounds. This study overcame this drawback and achieved a response rate of more than 80% in the second round of Delphi surveys in the two countries, which ensured the accuracy of the research findings. The Delphi method is a sound and effective instrument for identifying and ranking issues of concern and providing potential opportunities for improving sustainability (Blackburn, 2007). As a result, the findings provide vital basic information and highlight which points should be taken into further consideration in order to shift poultry production towards sustainability.

8.2.2 Comparison of sustainability concerns in poultry production in Germany and Thailand

By the end of two rounds of Delphi studies, 41 issues were identified and ranked by 26 German experts, and 55 issues were identified and ranked by 28 Thai experts. Dalky et al. (1970) suggest that Delphi results are the most precise after two rounds and become less precise during additional rounds. Since the expert opinions were not affected by the panel size, there was no need to have the same number of panellists in the two countries (Schmidt et al., 2001; Schmidt, 1997). Experts were invited to participate in this study based on their varying levels of expertise in the poultry industry, including NGOs, animal welfare groups, researchers, government officials, the private sector and politicians. The number of participants was limited to the optimal panel size needed in order to identify all the relevant issues, thus increasing the accuracy of the Delphi results (Dalkey and Brown, 1971; Sackman, 1974; Lindstone, 1978; Larreche and Moinpour, 1983; Rowe et al., 1991).

In the next section, the sustainability issues that were identified as concerning in the Delphi study in Germany and Thailand are discussed.

Environmental issues

Environmental issues, especially *resource use*, *biodiversity* and *regional concentration of production/mass production,* were considered more concerning in Germany than in Thailand, apart from the *use of pesticides in poultry feed production*, which was more concerning in Thailand. This is partly due to the lack of a consolidated system for pesticide management, as well as the weak enforcement of regulations, resulting in an increase in environmental contamination and human exposure to pesticides (Panuwet et al., 2012).

Poultry production accounts for a relatively low level of greenhouse gas emissions compared to beef, cattle milk and swine production (FAO, 2013). The lower environmental impact of poultry production compared to other livestock sectors is due to better energy efficiency, lower carbon emissions, higher feed conversion, less land and water requirements, and lower waste production (Williams et al., 2007). However, the environmental impact of poultry production depends on the resource efficiency of each production system, with the standard indoor system generally accounting for lower global warming, eutrophication and acidification potentials as well as lower primary energy use rates than free-range and organic production (Leinonen and Kyriazakis, 2013). This is due to the higher feed efficiency and shorter production cycle of the standard indoor system. While alternative production systems provide improved animal welfare conditions for their livestock, they account for a higher level of greenhouse gas emission intensity (MacLeod et al., 2013; FAO, 2013) and possibly a lower level of land use efficiency.

The main sources of emissions in poultry meat and egg production are feed production (fertilisation and the use of machinery) and manure storage and processing (FAO, 2013). Poultry manure application also significantly increases phosphorus (P) levels, which can easily be released into the environment via surface runoff or leaching, resulting in a rapid increase of phosphorus in water resources (Ranatunga et al., 2013), which can accelerate eutrophication (Carpenter et al., 1998; Daniel et al., 1998). In addition, poultry litter can contain a high level of heavy metals, which can build up over long periods of time and consequently affect soil functions (Zhang et al., 2012; Irshad et al., 2013; Arroyo et al., 2014). Increasing feed efficiency, including the quantity, composition and nutrient content of consumed feed (Pelletier, 2010; Leinonen et al., 2012), as well as improving poultry manure management could potentially reduce the environmental impact of poultry production.

Regional concentration of production is more concerning in Germany than in Thailand. Intensive broiler and laying hen production in the two countries is concentrated in single areas with cost advantages. However, this issue is a site-specific topic (de Boer, 2012). In countries where there is more land available for livestock production due to lower population density rates, alternative production systems could be more favourable than conventional production. Where densely populated areas exert high levels of pressure on available land, conventional systems may be a better option, despite a higher risk of diseases and soil pollution. In production areas where there is not enough space to recycle poultry waste, this may lead to nutrient overloads and pollution (FAO, 2013).

However, there is room for improvement with regard to the sustainability of animal production in areas of intensive farming. If good governance processes are put in place, waste is reduced, population growth stabilises and dietary patterns are altered (Garnett and Godfray, 2012). Investments in efficient production and compensation schemes for poultry farmers who provide environmental services, such as biodiversity conservation, water resource protection and carbon capturing can generate social and environmental benefits if suitable incentive mechanisms are developed and applied (FAO, 2013).

Economic issues

- *Outbreak of avian influenza and other highly infectious diseases*

The *outbreak of avian influenza and other highly infectious diseases* is a serious economic and social concern; avian influenza in particular has a direct impact on poultry flock productivity, temporary trade suspensions and the loss of export markets, as well as human health. Modern poultry production based on a high concentration of flocks on a large farm in concentrated geographic areas can reduce the risk of disease spreading naturally which occurs through the direct transmission from surrounding domestic fowl breeding and feeding sites (Francey, 2015). However, this form of production is more susceptible to serious economic loss from disease outbreaks due to the uniformity of genetic stock, the concentration of poultry flocks on a large farm and lower disease-resistance genes of birds selected mainly for their production traits (Siwek et al., 2010).

This issue was considered more concerning for poultry production in Thailand than in Germany. This can be attributed to the fact that the Thai poultry industry, especially broiler

production, relies predominantly on export. Although Thailand has remained avian influenza-free since 2009, the level of concern on this issue is still very high. This is because outbreaks of bird flu continue to occur in other countries and the risk of the disease spreading to Thailand remains since it can be carried by migratory birds. This could have a devastating effect upon the Thai poultry industry. Importing countries, especially the EU and Japan, banned fresh poultry meat from Thailand during the outbreak of 2004 and only allowed the import of frozen poultry meat from Thailand in 2012, almost 4 years after the last outbreak. In addition, as a result of the outbreaks of avian influenza in 2004 and 2008, domestic consumers in Thailand have become more aware of product quality and tend to prefer certified products with traceability labels, biosecurity measures and surveillance (van Horne and Fiks, 2009). In European countries, avian influenza only had a short-term impact on the market and trade due to an EU financial compensation programme and a short production cycle for poultry, which enables a particularly rapid supply response (European Parliament, 2010).

- *Role of food retailers*

This issue was raised by the German experts, but considered of low concern for Thai experts, the reason being that food retailers dominate the food market in Germany (Rehder, 2012). They provide a variety of poultry products from conventional and organic production systems, which directly impact on consumers' choices. Consumers can make their own purchasing decisions based on preference and affordability. As a result, food retailers' policies on poultry products play an important role in the sustainability of poultry production. For example, the demand of leading food retailers in Germany (e.g. EDEKA, REWE, and Schwarz Groups) to the German Poultry Association (ZDG) to stop using GMO feed for both poultry meat and egg production starting from 1 January 2015, has put a direct pressure on the poultry sector to convert to GMO-free feeding (Engdahl, 2015; Breloh et al., 2015). In response, the PHW Group, the largest German poultry producer, announced in early December 2014 that it will return to using GMO-free animal feed for poultry production (Engdahl, 2015; Breloh et al., 2015). In addition, the food retailers also play an important role in the changing housing system in laying hen husbandry, as they will no longer sell eggs printed with number "3", which stands for cage systems (Windhorst, 2015d). As a result, cage systems (colony nests) will be replaced with barn systems within a few years (Windhorst, 2015d).

In contrast, in Thailand, food products, including poultry meat and eggs, are not only sold by retailers, but also by various private producers on local niche markets, who are still very

competitive on the domestic market. 60-70% of Thai people still buy fresh chicken meat and eggs from local markets (The Poultry Site, 2015).

- *Custom growing (fattening)*

This issue was more concerning for the Thai experts due to the expansion of fully integrated poultry companies to most of the production system, which means the individual farmers who were contracted are less able to make their own decisions and small-scale farming struggles to compete on the market, thus threatening incomes and livelihoods (Isariyodom et al., 2008). Contracted farming to fatten broiler chicken and produce eggs in Thailand is mainly based on guaranteed prices (Poapongsakorn, 2003). The contracting company supplies the contracted farms with everything needed for production, from chicks, layer hens and feed to medication. The contracted farmers have to pay for all these provisions at higher prices than the market price (Poapongsakorn et al., 2003). The contracted farmers are responsible for investing in housing systems that meet the standards set by the contracting companies and they are prohibited from purchasing certain inputs, such as feed and medication, from outside suppliers. According to Isariyodom et al. (2008), contract farming between integrator and farmers in Thailand has several drawbacks for farmers, including unfair contracts, high investment costs in housing systems and resource use, lack of funding, lack of state agency that oversees the fair agreement for both sides, and a taxation system that hinders income growth among contract farmers.

Political issues

The global meat industry is constantly scrutinised by politicians and citizens (Emel and Neo, 2015), especially in the EU, where issues of food safety and animal welfare have become political objectives in response to public concerns. The publication of the Brambell Report (1965) pushed for more EU-wide legislative recognition of farmed species' physiological and behavioural needs. Since then, industrially farmed animals in the EU have increasingly moved into the conceptual realm of political subjectivity, as demonstrated by State regulation of their treatment (Johnston, 2015). A number of EU-wide directives have been developed for broiler and laying hen husbandry, including the barren battery cage prohibition (2012); the alternative housing systems minimum requirements (2007); and mandatory product labels clearly stating the farming methods (2004) for laying hens, as well as maximum stocking densities (2010);

required management practices (2010); and product labelling standards (2010) for broiler hens (Johnston, 2015; Stevenson, 2012).

In response to these political issues, the German experts felt that the *introduction of new laws and regulations/legal framework* could have a larger impact on poultry production than the Thai experts. New laws and regulations, including a total ban on conventional cage systems (Windhorst, 2015c), the prohibition of de-beaking (ZDG, 2015b) and restrictions on the use of antibiotics in poultry production (Koeleman, 2014) have already been implemented in Germany, while they are less frequently discussed in Thailand. The German poultry sector needs to invest in addressing these issues in order to comply with legal regulations and increase social acceptance.

Social issues

- *Contamination of meat and eggs with zoonotic microorganisms*

Avian influenza, Salmonellosis and Newcastle disease are three of the most concerning diseases from a cost and human safety viewpoint (Francey, 2015). This issue was considered more concerning in Thailand than in Germany. The establishment of a labelling system by the Thai Government that includes standards of food safety and animal welfare on a voluntary basis has created two sets of standards in Thailand: high quality products for the export market, and a wide range of product quality on the domestic market (European Parliament, 2010; Bracke, 2009). In Thailand, 70% of broilers are produced at a high level of biosecurity in industrial integrated systems and are marketed commercially, 20% at moderate to high levels of biosecurity in commercial production systems and marketed commercially, and 10% at low to minimal levels of biosecurity in villages or backyard farms (accounts for 90% of total broiler producers) and marketed commercially and consumed locally (Songpaisan, 2013). Thus, there is still a high risk of contamination with zoonotic microorganisms in broiler meat produced at low levels of biosecurity standards on the domestic market.

- *Use of antibiotics in poultry production*

The experts highlighted the *use of antibiotics in poultry production* as a highly concerning issue in both countries. This could be due to the prevalence of antibiotic resistance in the media, which highlights that the threat of multi-drug resistant bacteria associated with the use of antibiotics in livestock production could impact on the treatment of human diseases, such

as Methicillin-Resistant *Staphylococcus aureus* (MRSA) and Extended Spectrum b-Lactamase (ESBL) Enterobacteria (Geflügel-Charta, 2015).

High levels of resistant bacteria detected in poultry meat sold by food retailers and discounters in Europe have resulted in an improved inspection mechanism on the use of antibiotics in agricultural production (Greger, 2010). For example, tests on turkey meat samples in Germany concluded that 42.2% were positive for MRSA, with 22.3% of broiler meat also testing positively (Hartung and Käsbohrer, 2011).

However, there is no apparent link between livestock production and the incidence of MRSA cases in humans. Data from the Robert Koch Institute showed that counties with intensive poultry production have a below-average number of MRSA cases per inhabitant (Geflügel-Charta, 2015). In addition, according to Sharp et al. (2014), the majority cases of colonisations with ESBL-producing *E. coli* among humans cannot be directly linked to livestock and food-producing animals as reservoirs. The genomic analysis study of ESBL-producing *E. coli* found in chicken and human was conducted by de Beem et al. (2013). Results showed that there are relatively large genomic differences observed between chicken, chicken meat and human *E. coli* strains. This reflects the complexity of transmission routes which other reservoirs and sources including human-human interactions have to be taken into account (Sharp et al., 2014).

Therefore, more scientific research is still needed on the role of antibiotics in livestock production and its links to multi-resistant bacteria. In addition, a long-term management plan to decrease the use of antibiotics in animal production is required. The increasing awareness of antibiotic-resistant pathogens has encouraged a number of developed countries to implement a sustainability policy on the use of antibiotics in livestock production, such as: the Netherlands aimed to reduce veterinary consumption of antimicrobials by 50% in 2013, compared to 2009 (Bondt et al., 2012); Belgium set a goal for a reduction of 50% in overall livestock antibiotic use and 75% in the use of the most critical antibiotics by 2020 (Green, 2014); New Zealand aims to stop the use of antibiotics in animal agriculture by 2030 (Hutching, 2015).

- *Societal acceptance*

The public's acceptance of the poultry industry is more concerning in Germany than in Thailand. This could be due to the influence of NGOs and animal welfare groups over the negative portrayal of the industry in the media, as well as the predominantly reactive strategies of the German poultry companies, which failed to address concerns or inform the public in a timely manner (Veauthier, 2013). The gap between public perception on animal husbandry and the real picture of modern animal husbandry plays a significant role in social acceptance (Dürnberger, 2015; Heijne, 2015a; Conway, 2015). As a result, intensive poultry production is seen as factory farming and 51% of people in Germany reject meat from factory farming (Rheingold Salon, 2015). The deficiencies in the area of animal welfare and environmental protection, as well as changed attitudes regarding human-animal relationships, resulted in decreased social acceptance on farmed animal husbandry (WBA, 2015).

The situation is different in Thailand since there is no pressure from NGOs and animal welfare groups (Ratanakorn, 2002; Ursinus et al., 2009), and the Thai poultry companies proactively communicate with the public about their production systems (CPF, 2015b). Therefore, the Thai poultry industry enjoys a relatively positive image.

- *Communication between producers and consumers*

Consumer concerns over the sustainability of livestock production are on the rise worldwide. In response to this, Thai poultry companies are developing proactive strategies on communicating with the media about modern poultry production, including housing systems, food safety and animal welfare standards, in order to improve public perception and acceptance of the poultry industry (CPF, 2015b). As a result, this issue was rated less concerning by the experts in Thailand than in Germany.

In developed countries, the public's increasing awareness of animal welfare issues means it now constitutes part of consumers' purchasing decisions (Napolitano et al., 2010; Jewell, 2015). A survey among broiler consumers in Germany showed that 82% of respondents were willing to purchase chicken raised and processed on farms that comply with animal welfare standards (Makdisi and Marggraf, 2011). In order to improve communication between poultry producers and consumers, the German Poultry Association (ZDG) launched the Poultry Charter in September 2015 to provide an information platform on poultry production and its commitment to sustainability, including the topics animal welfare, disease prevention, the use

of antibiotics and consumer information, with the goal of improving public perception and acceptance (ZDG, 2015b).

According to the Transparency Project in poultry production, organised by the Science and Information Centre for Sustainable Poultry Production (WING) at the University of Vechta with support from the Lower Saxony Poultry Association (NGW). This project aims to provide the general public with a realistic image of the modern poultry production system and thus increase public acceptance (Heijne, 2015a). According to Heijne (2015a), the results of the Transparency Project show that the percentage of skeptical visitors declined visibly after visiting the farms, from 18% prior to the visit to 7.4% after the visit. Visitors from cities (22.4%) had a higher skeptical attitude on the German poultry industry than visitors from villages (16.6%) before farm visits (Heijne, 2015b). However, the majority of both visitor groups left the farm with positive attitudes (78.5% for visitors from cities and 82.5% for visitors from villages) (Heijne, 2015b). The Transparency Project has the potential to contribute to more realistic assumptions about poultry production among members of the public (Heijne, 2015a). Communication is therefore an important instrument for informing the public about on-the-ground production systems and product quality, which can in turn improve the poultry sector's image.

Animal welfare issues

The debate on animal welfare issues in the EU was incited by the publication of "Animal Machines" by Ruth Harrison in 1964. In her work, she describes the routine practices in intensive husbandry in British industrialised farms. Her research led to the establishment of the Brambell Committee, which investigated these practices and subsequently published the Brambell Report (Brambell Committee, 1965). This report highlighted the physiological and behavioural needs of farmed species (Johnston, 2015). Since then, public concern over animal welfare has grown continually, especially in developed countries. For example, in the case of laying hen husbandry in the EU, where the animal welfare discussion was the main driving force for a transformation in housing systems (Windhorst, 2015c), as well as of the change in husbandry practice, including de-beaking and killing of day-old male layer chicks (IEC, 2015a; Windhorst, 2015c).

- *Housing systems*

This issue was considered more concerning in Germany than in Thailand due to ethical concerns about poultry husbandry in the EU. The discussion on animal welfare in the EU has been the main driving force behind the change in housing systems in laying hen husbandry from conventional cages to alternative housing systems (Windhorst, 2015c). According to Windhorst (2015d), innovations in a mechanised housing system and genetic improvements of laying hens with high laying rate and a robust health in the early 1960s, have contributed to a rapid spread of large-scale egg production with conventional cages as this system lowers both production costs and mortality rate, and provides a higher hygiene standard. However, concurrently there has been opposition from animal welfare groups, scientists and political parties in Europe and later in Northern America, especially the Green Party in Germany, against this intensive egg production system that boomed during 1960 and 2000 (Windhorst, 2015d). Thus, conventional cages were prohibited in the EU from 2012 onwards due to animal welfare concerns. This ban initiated a transformation in housing systems from conventional cages to alternative housing systems in the EU member countries, including enriched cages, colony nest systems, barn and free-range systems (Windhorst, 2015d). Although conventional cages in laying hen husbandry were already prohibited in Germany, the discussion on animal welfare against cage systems (colony nests, enriched cages) is still continuing, which push the states of Lower Saxony and Rhineland-Palatinate to plan the withdrawal of laying hen husbandry from cage system by 2025 (Niedersächsisches Ministerium für Ernährung, Landwirtschaft und Verbraucherschutz, 2015).

Meanwhile the issue of animal welfare in the context of laying hen housing systems has not been discussed in Thailand due to two main reasons: first, egg production is predominantly for domestic consumption, meaning that potential pressures regarding animal welfare from external countries do not apply here (Office of Agricultural Economics, 2014). Secondly, there is no pressure from national NGOs or animal welfare groups (Ursinus et al., 2009). Thus, there is no driving force or motivation to change housing systems from conventional cages to alternative housing systems in the country at the moment.

- *Killing of day-old male layer chicks*

Killing of day-old male layer chicks was considered a highly concerning ethical issue in Germany. There has been an ongoing discussion on ending this practice in the German poultry industry, which will be prohibited by law in the near future (Windhorst, 2015c).

According to Brüggemann (2015), the federal advisory board agreed on the proposal submitted by the state of North Rhine-Westphalia to prohibit the killing of day-old male layer chicks in the egg industry. This should be implemented as soon as possible and be legally binding. In addition, the Federal Agriculture Minister Christian Schmidt also stated that this practice should no longer be allowed in the poultry industry from 2017 (BMEL, 2015).

In contrast, in Thailand male layer chicks are predominantly raised for meat production and are sold on local niche markets, since the meat of male chicken is preferred (Soisontes, 2015).

- *Space per animal/stocking density*

This issue was found to be of less concern in Thailand than in Germany. Broiler production in Thailand meets a high level of animal welfare standards, where birds are reared for 45 days to 2.5 kg in weight and are kept at a low stocking density of no more than 13 birds/m^2 in closed poultry houses before slaughter (CPF, 2015b). The main export markets for Thai broiler meat are the EU and Japan, which means that the Thai government has set out standards on food safety and animal welfare. While these standards are voluntary in practice, compliance is required for companies producing for export markets (European Parliament, 2010; Bracke, 2009). The stocking density for broilers in Thailand is generally lower than the EU standards due to its warm climate and low costs of housing (Bracke, 2009).

- *De-beaking*

This issue was considered more concerning in Germany than in Thailand due to ongoing ethical concerns. Therefore, the German poultry industry plans to prohibit de-beaking in laying hens (Windhorst, 2015c) and fattening turkey (ZDG, 2015b) in the near future. A voluntary agreement was made between the Federal Ministry of Food and Agriculture (BMEL) and the German Poultry Association (ZDG), the German Egg Association (BDE) and the Association of German Turkey Producers (VDP) to withdraw from de-beaking in practice (ZDG, 2015b). With this agreement, beak trimming of laying hens will be stopped in practice from 1 August 2016 and stocking pullets with trimmed beaks will no longer be allowed from 1 January 2017 onwards. In addition, the German poultry industry also aims to stop de-beaking in fattening turkeys, however further scientific evidence is required.

8.3 Role of NGOs, animal welfare groups and the leading integrated poultry companies in the sustainability of poultry production

In Germany, NGOs and animal welfare groups play an important role in improving the sustainability of poultry production (BUND, 2015b; Deutscher Tierschutzbund, 2015; Greenpeace, 2015b; PROVIEH, 2015; Vier Pfoten, 2014). Based on the results of this study, their strategies include awareness raising campaigns, grassroots campaigns and media exposure, leading to an increasing awareness among consumers on sustainability issues (Freeman, 2014), such as *de-beaking, stocking density, the use of antibiotics, the killing of day-old male layer chicks* and *the regional concentration of production*.

The pressure exerted by NGOs and animal welfare groups has pushed the leading German integrated poultry companies to adopt sustainable production strategies in order to increase the social acceptance of poultry products. These reactive strategies include the reduction of the use of antibiotics (Heidemark, 2015b), transparency in poultry production (Heijne, 2015a), and the preparation of the discontinuation of de-beaking and killing of day-old male layer chicks (PHW-Group, 2015). However, based on the results of this study, in practice a number of limitations remain in terms of addressing sustainability issues, such as *the use of antibiotics, de-beaking*, *outbreaks of avian influenza* and *the negative image portrayed by the media* due to trade-offs between economic efficiency and consumer preferences, as well as investment policy and the availability of technology and innovation (Thornton, 2010). In addition, poultry production companies have failed to inform the general public about the actual state of poultry production and the industry's efforts to promote sustainability (Veauthier, 2013). Furthermore, they have not managed to develop strategies in a proactive manner, resulting in a widening gap between consumers' perceptions and production realities (Veauthier, 2013).

In Thailand, the poultry sector faces very little to no pressure from NGOs and animal welfare groups. Although NGOs and animal welfare groups in Thailand are not actively engaged in livestock production issues, they play an important role in supporting and promoting the welfare of pets and wild animals, such as the conservation of elephants (Ursinus et al., 2009). As a result, Thai leading integrated poultry companies have adopted proactive strategies by informing the public about modern poultry farming and sustainability through the media in an effort to improve the industry's image and consumer confidence, both nationally and

internationally (CPF, 2015b). This kind of proactive approach is considered one of the most crucial strategies for increasing the sustainability of poultry production (Mulder, 2015). However, the response to some sustainability issues, such as *outbreaks of avian influenza, the use of antibiotics, the contamination of meat and eggs with zoonotic microorganisms* and *disease control in neighbouring countries,* is still limited in practice due to varied biosecurity measures within the country (European Parliament, 2010; Bracke, 2009), investment policies and limitations in terms of technology and innovation, as well as import partners' preferences (Office of Agricultural Economics, 2014).

8.4 Discussion of the overall results

Sustainability in poultry production is one of the most frequently debated topic in current animal production trends (Spies, 2003; Mollenhorst and de Boer, 2004; Bokkers and de Boer, 2009; BONAUDO et al., 2010). Through an empirical study in this research, the major sustainability issues that concerned the German and Thai poultry industries were identified, which clearly mirror the ongoing public debate on the sustainability of poultry production. In order to provide an overview of current poultry production and its future development driven by sustainability trends, the overall main findings are discussed in the following section.

8.4.1 Poultry production in the period of sustainability trends

In recent decades, the livestock sector has experienced economic success due to increased consumption and advanced technology in production (Thornton, 2010), this also includes the poultry industry in Germany (WBA, 2015) and in Thailand (Office of Agricultural Economics, 2014). Genetics and nutrition management have been substantially improved over the past 50 years in the poultry industry (Havenstein et al., 2003), resulting in a reduction in environmental impacts caused by poultry husbandry (Pelletier, 2014). However, concurrently there are a number of substantial deficits in poultry production. The Scientific Advisory Board for Agricultural Policy at the German Federal Ministry of Food, Agriculture and Consumer Protection (WBA) outlines considerable problems associated with intensive livestock production, including animal welfare, environmental protection and consumer protection (WBA, 2015). Today, there is an increase in the debate focusing on the sustainability of animal production, especially on animal welfare, economic, social and

environmental issues (WBA, 2015), as confirmed by the results of this study for the case of poultry production.

The *use of antibiotics* in poultry production is one of the most concerning issues in Germany and Thailand as evaluated by the experts in the Delphi study. The survey of consumer opinions on food safety in Germany in 2015 conducted by BfR also shows that antibiotic resistance is the most concerning issue (72%) which increased by 8% compared to 2014 (BfR, 2015). The government has responded to public pressure on the possible impacts on human health regarding the use of antibiotics in animal production by the enforcement of a compulsory antibiotics monitoring system on 1 April 2014 (Koeleman, 2014) aiming to reduce antibiotic uses in livestock production. The German Poultry Association (ZDG) published the Poultry Charter in September 2015 which it also commits to support the use of antibiotics in a sustainable way within the poultry sector (ZDG, 2015a). The increasing awareness of consumers about food safety has driven the changes in many food chain companies, such as McDonalds, Chipotle and Panera, who have already started to promote the use of chicken raised without antibiotics that affect human health in their restaurants in the USA (also in Canada for McDonalds) (Graber, 2015a; McKenna, 2015). Subway advertises its use of chicken raised with no antibiotics of any kind in its restaurants in the USA from 2016 onwards (Graber, 2015b). The campaign against antibiotics use in animal production in developed countries clearly shows that today's consumers are aware of what they consume, which in turn drives the poultry sector to transform its production systems.

The other food safety issue is the *contamination of meat and eggs with zoonotic microorganisms*, which was consider very concerning issue in Thailand due to a wide range in levels of biosecurity in production system. The export products are produced at high levels of biosecurity standards, while the products for domestic consumption are produced at a wide range of low to high level of biosecurity standards (Europian Parliament, 2010; Bracke, 2009). Poultry that is produced at the low level of biosecurity standards is therefore potentially contaminated with zoonotic microorganisms (Songpaisan, 2013), especially *Salmonella* and *Campylobacter* (EFSA and ECDC, 2014).

With regard to environmental aspects, poultry production is considered as the most efficient resource use compared to other livestock production due to the progress in genetic improvement and nutrition management in the poultry industry (Havenstein et al., 2003).

However, the issue of *regional concentration of production* was considered fairly concerning by the German experts. This corresponds to the claims made by WBA (2015) that environmental problems still occur due to intensive livestock production. The analysis of the Gini coefficient for measuring the regional concentration of poultry production in Germany and Thailand in this study also showed that poultry production, especially broiler and turkey husbandry in Germany and broiler and laying hen husbandry in Thailand, are highly concentrated in single regions. Although environmental impacts per unit of product in poultry production are low (Pelletier, 2014), the high concentration of production in single regions leads to high positive ammonia emissions and nutrient balances (nitrogen and phosphate) in areas of intensive production (Klohn and Windhorst, 1998; Mose et al., 2007; WBA, 2015). The other consequences of such high concentration of production are high risks of infectious diseases outbreaks (Slingenbergh et al., 2004) and land use conflicts in areas where there is significant rural residential development (Henderson and Epps, 2000).

Animal welfare is one of the most frequently discussed sustainability aspects in developed countries, especially in the EU due to the active involvement of animal welfare groups and political parties (Windhorst, 2015c). This is further supported by the results of this study on the roles of NGOs and animal welfare groups in the sustainability of poultry production in Germany. Concerns over animal welfare have been raised by the German experts, in particular the welfare of laying hens regarding *de-beaking*, *killing of day-old male layer chicks* and *housing systems*. The International Egg Commission (IEC) also discussed the issues of *de-beaking* and *killing of male layer chicks* as ethical concerns during its conference in Lisbon in 2015 (IEC, 2015a). The German poultry industry has responded to the pressure from animal welfare discussions by planning to prohibit the practice of *de-beaking* and *killing of day-old male layer chicks* in egg industry in coming years (ZDG, 2015b; Windhorst, 2015b). While the issue of *housing systems* in laying hen husbandry has been discussed concurrently with the development of intensive egg production with battery cages during 1960 and 2000 (Windhorst, 2015d). As a result of the animal welfare movement in the EU, since 2012 the housing systems have been transformed from conventional cages to alternative housing systems. This transformation was also discussed in the USA, Canada, New Zealand and Australia (Windhorst, 2015d). In particular, conventional cages were banned on 1 January 2015 in California (Windhorst, 2015d). Windhorst (2015d) argued that the transformation in laying hen housing systems in the EU, which originally occurred due to food security issues, is no longer a problem. Thus, animal welfare aspects can gain importance (Grandin, 2014)

and drive a change in public attitudes regarding animal husbandry (Windhorst, 2015d). This can be seen in the case of the Netherlands, where a study on the sustainability of egg production in different housing systems was conducted by van Asselt et al. (2015). Although the results show that enriched cages are the most sustainable system compared to barn, free-range and organic systems based on the overall score of sustainability indicators, enriched cages will nonetheless be banned in 2021 in the Netherlands due to dominating public concerns over animal welfare. The situation in most developing and threshold countries is different because food security is still a priority. Different cultural backgrounds and philosophical systems of ethics also come into play, making animal welfare less important or not yet part of the discussion in their society (Windhorst, 2015d). Thus, conventional cages will continue to be the predominant system for housing laying hens in those developing and threshold countries as well as in the Russian Federation and the former Soviet Union countries (Windhorst, 2015d). Low funding for investments in alternative housing systems, limited knowledge among farmers on using alternative systems as well as the high risk of highly infectious diseases in free-range and barn systems with outdoor access, especially in wet regions, as well as the economic advantages of conventional cages are the main obstacles in the transformation to alternative housing system in these developing and threshold countries, including the Russian Federation and the former Soviet Union countries (Windhorst, 2015d).

Another issue of concern in the poultry industry is the *outbreaks of avian influenza.* This issue was highlighted by the Thai experts during the Delphi survey. The outbreaks of highly pathogenic avian influenza (HPAI) in the Netherlands (2003), Thailand (2004) and the USA (2015) not only have economic impacts but also have human health impacts (Clements, 2015b). The 2015 HPAI outbreaks in the USA were considered the most serious and expensive animal health emergency ever faced by the USDA (Shane, 2015). These outbreaks have a large economic impact on the US poultry sector with an estimated total cost of US$3-4 billion, with the affected parties ranging from egg and turkey producers, suppliers, communities, the public sector and consumers to broiler producers' export revenue (Shane, 2015). The 2015 HPAI outbreaks in the USA reflect the vulnerability of biosecurity standards, as only 43% of the 81 surveyed turkey farms affected by H5N2 in the USA implemented biosecurity audits or assessments (APHIS, 2015). The loss of millions of birds in a short period during the HPAI outbreaks led to discussions on depopulation methods and carcass disposal, which is necessary to limit the spread of the virus to the surrounding environment

(Windhorst, 2015a; Wiehoff, 2015). Vaccination against avian influenza was discussed in combination with tightened biosecurity measures to control bird flu outbreaks; however controversy still exists on its efficacy and acceptance in some countries (Brockotter, 2015b). Preparation for resurgences of bird flu outbreaks is necessary in order to mitigate large-scale impacts as in the US case. Therefore, this issue was intensively discussed during the 2015 IEC conference in Berlin (IEC, 2015b). According to OIE (2015), the HPAI outbreaks are continuing to spread, especially in Asia and Africa. The ongoing outbreaks in Asia, especially in the neighbouring countries of Thailand, such as Cambodia, Laos and Vietnam, with lower biosecurity standards raised concerns over the virus spreading. In relation, the Delphi results show that the issue of *disease control in neighbouring countries* was rated as very concerning by the Thai experts. Therefore, improvements to biosecurity systems at farm level and veterinary services, the development of vaccinations, the observation of wild birds, rapid disease diagnosis, the use of information channels and education for farmers, as well as international and sector-wide stakeholder cooperation can minimise the risks of disease outbreaks.

The most concerning economic issue in poultry production raised by the German experts was the *role of food retailers*, which dominate the food market in Germany (Rehder, 2012). Their changing policies with regard to consumer concerns have a direct impact on the poultry sector, as can be seen in the case of GMO-free animal feed (Engdahl, 2015; Breloh et al., 2015) and housing systems in laying hen husbandry (Windhorst, 2015d). As a result, poultry producers have to respond to the demands of retailers in order to sell their poultry products. However, the situation is different in Thailand, where local niche markets are still very competitive regarding poultry meat and eggs for consumers. About 60-70% of the Thai population buy these products on local markets (The Poultry Site, 2015).

Finally, the issue of most concern for the poultry industry is the *negative image of the poultry industry portrayed by the media,* which was raised by the private sector groups both in Germany and Thailand. This reflects the lack of *communication between producers and consumers,* an issue of very high relevance to the German researcher groups in the Delphi study. The combination of issues of animal welfare, environmental protection and consumer protection associated with livestock production as well as changed societal attitudes on animal husbandry have resulted in the decreased social acceptance on farmed animal husbandry (WBA, 2015). In addition, the influence of NGOs and animal welfare groups on the negative

portrayal of the industry in the media contributes to an unrealistic picture of the modern poultry industry (Veauthier, 2013). In order to improve public perception and acceptance of the poultry sector, the German Poultry Association (ZDG) published the Poultry Charter as an information platform for consumers and to ensure that poultry producers take responsibility for their poultry, consumers, staff and the environment now and in the future (ZDG, 2015a). In addition, the Transparency Project in poultry production was launched by the Science and Information Centre for Sustainable Poultry Production (WING) at the University of Vechta in 2012 with support from the Lower Saxony Poultry Association (NGW). This project helps to provide the public with a more realistic picture of modern poultry production systems and thus improve public perception and acceptance of the poultry industry, as the results of the project showed (Heijne, 2015a; Heijne, 2015b). Communication is therefore a powerful instrument to build consumer confidence and the credibility of producers at the same time.

In conclusion, the ongoing improvement in poultry production by the poultry sector itself, especially on issues of concern identified in this study such as the *use of antibiotics, killing of day-old male layer chicks, de-beaking, outbreak of avian influenza, contamination of meat and eggs with zoonotic microorganisms, regional concentration of production* and *housing systems* with the combination with improved *communication between producers and consumers* as well as the support from governments and politics, could ensure consumer confidence and promote sustainability in poultry production within the country.

8.4.2 Newly identified sustainability issues in poultry production

In comparison to previous studies on the sustainability of poultry production, such as those conducted by Spies (2003) using group discussions and by Mollenhorst and de Boer (2004) using participatory methods, this study explores contemporary sustainability issues in the poultry industry using the Delphi method. The list of issues includes the following: *outbreaks of avian influenza and other highly infectious diseases, the use of antibiotics in poultry production, the shortage of measures to address avoidable deficiencies within the industry, the role of NGOs and activist groups, oversupply of domestic production, disease control in neighbouring countries, standards for poultry products set by import partners, the establishment of the ASEAN Economic Community (AEC), breeding, EU and Islamic regulations for slaughter processes, the role of small-scale family farming, the use of native*

chicken species, the compartmentalisation of poultry production and *the development of value-added products*.

8.4.3 Implications for the sustainability of poultry production

Due to increasing concerns over sustainability, the poultry sector will need to comply with an increasing number of standards, such as product quality, poultry health and welfare, environmental impacts, feed efficiency and economic viability, in order to improve production systems. Collaboration between stakeholders is an absolute must. The Delphi method identified and ranked sustainability issues in the German and Thai poultry industries, which can be used to develop strategic plans for poultry companies. This provides an opportunity to take action and bring about change, including the following recommendations:

- *Improve fertilisation management in feed production, manure management, and energy and feed efficiency*

  Feed production and manure management are the main sources of emissions in poultry production. In order to reduce the industry's environmental impact, sound fertilisation and manure management strategies need to be put in place. Furthermore, energy consumption should be reduced and feed efficiency should be increased, for example by improving animal genetics and by using probiotics and prebiotics, such as enzymes and phytogenic feed additives. This would result in reduced emissions, increased nutrient absorption and stronger poultry immune systems, which can reduce feed costs and the use of antibiotics.

- *Promote research on animal feed supply*

  The reliance on imports of poultry feed, mainly soybean meal, from South American countries is concerning in the poultry industry, especially since consumers are increasingly calling for the use of non-genetically modified feed. Alternatives need to be developed and research needs to be conducted on the authorisation process for genetically modified ingredients as well as its long-term effects. Since non-genetically modified feed could increase the costs for EU feed consumers, research should also be conducted on financing options.

- *Restrict the use of antibiotics in poultry production*

  Resistance to antibiotics due to overuse is a huge challenge for the poultry industry. Limiting the use of antibiotics requires collaboration among stakeholders, including veterinarians, researchers, government officials, pharmaceutical companies, human health professionals and producers in order to change attitudes and behaviours in the sector. Targets on the appropriate and responsible use of antibiotics will need to be developed, including deadlines. The use of antibiotics reserved for human treatment should be avoided and strictly controlled. Regulations on the non-therapeutic use of antibiotics in livestock have been in force in Germany since 1 April 2014. However, this strategy will need to be expanded in order to reduce the use of antibiotics successfully. In addition, other strategies to reduce the use of antibiotics in poultry should also promoted, including improved biosecurity standards, appropriate vaccination programmes, genetic selection, and the use of probiotics and prebiotics in poultry feed.

- *Improve consumer perceptions of the poultry industry*

  The industry needs to proactively inform the public about modern poultry production systems, such as housing systems, disease control, biosecurity, herd sizes, costs and profits, vaccination programmes, animal welfare standards, the quality and safety of poultry products, and environmental problems, as well as ongoing efforts to address these issues. The ongoing project "Transparency in the Poultry Industry" in Lower Saxony is considered a role model for communication strategies that increase consumers' perceptions. This project should be scaled up to all of Germany's federal states as well as other countries. In addition, education and training on agricultural extension services and communication methods should be provided for journalists in the field of agriculture in an attempt to provide up-to-date information. This is expected to paint a more neutral or even positive picture in the media, which could minimise the discrepancy between advertising and the reality on farms. The facilitation of journalist visits to poultry farms and the dissemination of factual information to the media could improve consumers' perception of modern poultry production.

- *Improve prevention strategies for avian influenza*

  In addition to developing more robust poultry breeds to reduce the risk of disease infection, biosecurity measures should be also improved in order to minimise the effects of disease. Different potential vectors can transmit viruses, such as flies, rodents, migratory birds, water, air, feed, humans, equipment and transportation. All these factors have to be taken into account throughout the entire production site as well as on transport routes. The use of active and passive surveillance on production sites and rapid identification techniques in laboratories can help solve problems in a timely manner during outbreaks. In addition, the international trade in live animals should be restricted and distances between production sites should be increased in order to reduce the proximity between farms. Furthermore, effective and open communication channels need to be maintained with consumers during outbreaks of bird flu.

- *Promote research on disease-resistant poultry breeds*

  Poultry diseases, such as Newcastle disease and avian influenza, have a large impact on poultry production. One option is to develop disease-resistant poultry breeds, which could reduce the overall number of virus transmissions without requiring vaccinations.

- *Support compartmentalisation during avian influenza or Newcastle disease outbreaks and/or promote the geographic dispersion of genetic stock*

  Alternative risk management strategies are necessary during disease outbreaks and can help avoid a total trade ban. Compartmentalisation separates healthy bird subpopulations from unhealthy birds based on biosecurity management systems to ensure continued production and trade in the event of disease outbreaks in exporting countries that need to be reported to the authorities (see Figure 8.1). Outbreaks of avian influenza generally result in a total trade suspension. Concerns over the impact of trade bans on poultry genetics and broiler meat are growing. As a result, trade should be adjusted in order to facilitate sales of disease-free poultry produced under the compartmentalised system in countries affected by avian influenza. Importing countries should accept and approve the compartmentalised trade concept implemented in exporting countries in line with bilateral agreements between their national veterinary authorities. Another possible strategy is to house additional breeding stock in separate locations to reduce the risk of trade suspension in outbreak regions and to optimise product security and export efficiency.

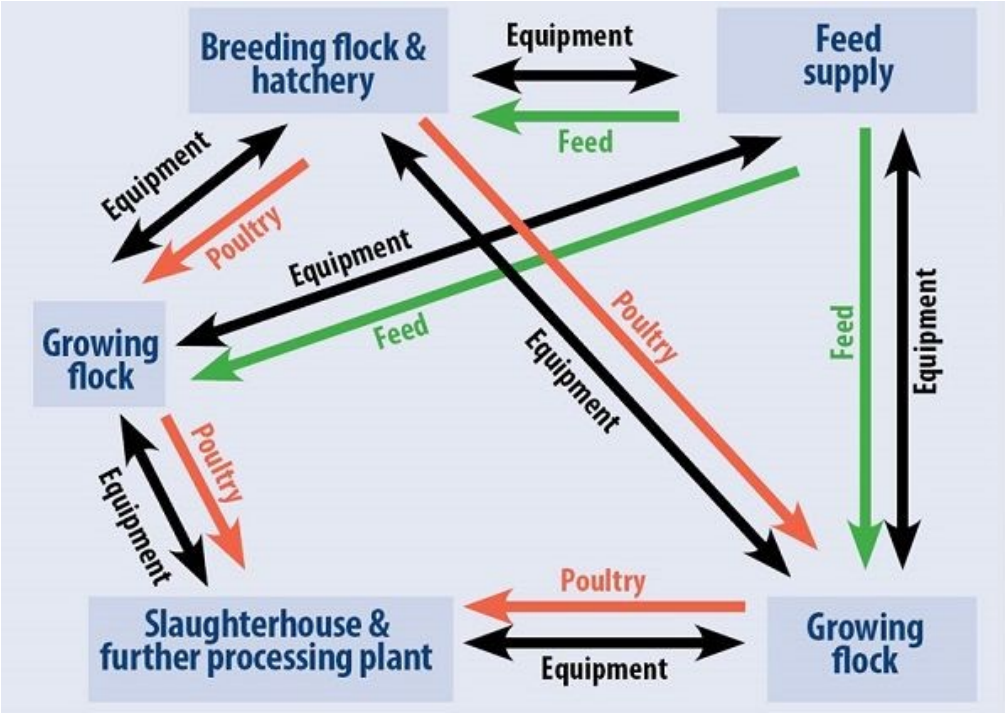

Figure 8.1 Compartmentalisation procedure for the establishment of healthy bird subpopulations based on management and biosecurity factors during disease outbreaks in exporting countries

Source: Clements (2015a, p.16).

- *Improve production management in areas of intensive farming*

  The *regional concentration of production* is a locally specific issue. In areas of intensive farming, environmental impacts and risks of disease outbreaks can be reduced through environmental legislation (Nitrate Directives), efficient manure management, biosecurity measures, de-clustering and technological innovation.

- *Improve collaboration on the prevention and control of contagious diseases across borders*

  Increased cross-border trade can contribute to rising concerns over disease outbreaks and economic risks. Proactive joint disease prevention and control between border regions can eliminate this risk.

- *Enforce one law in all federal states*

  In order to ensure the effective and equal implementation of laws and regulations on poultry production in practice, universal law enforcement should apply to all federal

states in Germany and also EU-wide. Furthermore, milestone objectives should be set for transitional periods.

- *Shorten the European authorisation procedures for GM imports and clarify animal feed policies*

  The EU feed sector relies heavily on imports. However, the suppliers of soybean meal and maize on the global market all apply GM technology. There is therefore only a limited availability of non-genetically modified feed, which is not enough to provide for the entire EU livestock sector. The approval process for GM imports should be accelerated in order to facilitate a more transparent animal feed policy. The pending approval process has resulted in trade disruptions and can lead to potentially large financial losses. Furthermore, since feed importers lack access to approved feed, they may feel forced to use non-approved feed or traces thereof that exceed the prescribed limits.

- *Improve existing technologies and innovative approaches in line with the development of new technology and innovation*

  Technology and innovative approaches are key factors for sustainability in poultry production, especially for the mitigation of environmental impacts and climate change. Innovative technologies, such as genetic selection techniques, feed additives and vaccines, as well as improved manure management practices, could significantly reduce greenhouse gas emissions. However, further research and development is needed before they become feasible mitigation options.

8.4.3 Key drivers of change

Sustainability in poultry production requires the application of proactive governance approaches and regulations. However, a number of factors can significantly influence the transition towards sustainability, such as market forces, advances in knowledge, public policies, individual objectives of farm operators, and the availability of resources for particular farming practices (National Academy of Science, 2010). In order to overcome these obstacles, a strong consensus and joint commitment among stakeholders are needed. This will drive the concerned stakeholders into action.

It must be said that there is no one single path to sustainability due to the diversity of production systems, regions and countries, as well as agro-ecological and socio-economic features. Moving towards sustainable poultry production involves trade-offs between different objectives, such as improving animal welfare and reducing the environmental impact, which represents a huge challenge for sustainability in practice (WBA, 2015). Decision-making processes therefore require public dialogues, scientific proof and socio-economic verification. The stabilisation of population growth, reasonable consumption of animal products and decision-making based on science are necessary in order to move towards sustainability.

Thus, in conclusion, sustainable poultry production requires the development of goals that reflect local conditions and priorities. Decision-makers or policy makers have to set pragmatic long-term objectives and targets that encourage stakeholders to invest in the poultry sector and that reflect scientific knowledge. Trade-offs between different policy objectives have to be taken into consideration and need to be analysed carefully in order to assess which policies need support innovation and investments in sustainability. Joint efforts are required of stakeholders in the poultry sector to support policy and to ensure that existing and future strategies are implemented effectively and efficiently.

8.5 Limitations

This study, conducted in 2014, covers the challenges and sustainability issues that concerned the German and Thai poultry industries during the study period. As a result, research on poultry production in other timeframes and other countries can differ. The results of this study merely represent case studies of the two countries in 2014. However, the findings offer crucial information regarding the turning point for improving sustainability in poultry production in other timeframes and regions.

Furthermore, only a small number of representatives of NGOs and animal welfare groups as well as politicians associated with the German poultry industry participated in the Delphi study. Increased contributions from these three groups in future surveys may broaden the findings on the current state of poultry production since they play a crucial role in the German poultry industry.

8.6 Recommendations for future research

The following issues provide avenues for further research on the topic:

- In order to gain deeper insights into global poultry production in a move towards sustainable production, further research should be conducted on sustainability concerns in other producing countries;
- Individual issues of concern that are identified in this study, such as *the use of antibiotics, the role of food retailers* and *outbreaks of avian influenza,* should be analysed in greater detail in order to improve poultry production in practice;
- In addition, problems faced by individual poultry species in particular should be researched in order to gain more information and develop targeted production strategies to increase sustainability.

The approach applied by this study could be used to research the sustainability of other types of livestock production, which could contribute substantially to the livestock sector's transition towards sustainability.

Chapter 9
Summary

9.1 Summary of the study on the sustainability of poultry production

Sustainability has been a topic of public discussion since the concept was introduced by von Carlowitz in 1713. The ongoing debates on sustainability have their roots in environmental problems caused by human activities. Today, we are concerned not only about environmental issues, but also economic, social, political and animal welfare topics due to population growth, rising incomes, ongoing urbanisation and changing agricultural practices and food preferences.

In the poultry sector, the industry has shifted from a large number of widely spread, independent and small-scale poultry producers to vertically integrated firms that own and control the entire production process in response to the rising consumption of poultry meat and eggs. However, concerns are being raised over these modern intensive production systems, mainly regarding the environmental impact and animal welfare standards of such highly concentrated and integrated production systems. These challenges reflect the fact that a number of sustainability issues in the poultry industry need to be addressed urgently.

Due to different agro-ecological and socio-economic characteristics, as well as public policies, in each poultry-producing region, views on sustainability differ from region to region, especially between high-income and low to middle-income countries. In high-income European countries, such as Germany, consumers are increasingly concerned about sustainable food, especially food safety, animal welfare and environmental issues. In middle-income countries, such as Thailand, animal husbandry is an important source of income and a top priority for feeding a growing population in the future. Thus, the main objective of this study is to provide recommendations on improving the sustainability of poultry production in Germany and Thailand. A comparison of these two different contexts of poultry production can contribute to broadening the view on sustainability.

Chapter 1 outlined the background and objectives of this study. The conceptual framework was developed based on the notion of sustainability science.

Chapter 2 described the methodology used in this study, including primary and secondary data analyses. The Delphi method was used to identify and rank sustainability issues that currently concern the poultry industry.

Chapter 3 reviewed the development of sustainability debates with regard to its definitions, concepts and assessments. Although definitions of sustainability vary, both in general and in agriculture, there is a broad consistency between definitions. Sustainability is a concept that encompasses economic, environmental and social aspects. The three components interact with each other and tend to be locational or site-specific at field, farm, community, national and international levels.

The idea of sustainability has developed based on the problems we face as a result of human activities, with the objective of solving these dilemmas. In order to make a transition towards sustainability, practical improvements have to be made in society or in production systems. In this study, sustainable poultry production is defined as *"an improvement of a poultry production system that optimises the overall sustainability aspects, including environmental, economic, social, political and animal welfare issues"*. In the context of poultry production, sustainable production needs to consider these five elements on the basis of spatial and temporal scales.

Chapter 4 discussed the most prevailing concerns in society with regard to the sustainability of poultry production. Contemporary sustainability issues include *the use of antibiotics in poultry production, the contamination of meat and eggs with zoonotic microorganisms, outbreaks of avian influenza, the regional concentration of production, de-beaking,* and *the killing of day-old male layer chicks.*

Chapter 5 provided an overview of the structures, production data, regional concentration and organisational models of poultry production in Germany and Thailand. In 2013, Germany had 4,500 broiler farms with places for a total of approximately 97 million birds, 1,900 turkey farms with places for a total of around 13 million birds and 54,100 layer farms with places for a total of approximately 48 million birds. Thailand had 6,735 commercial broiler farms with places for a total of approximately 150 million birds and 1,925 commercial layer farms with places for a total of around 44 million birds in 2013.

Broiler, turkey and laying hen husbandry are highly concentrated in the northwestern region of Germany, while broiler and laying hen production are predominantly located in central Thailand. The Gini coefficient value was used to estimate the distribution of poultry production based on a number of poultry places throughout the 9 federal states for broilers, 12 federal states for turkeys and 13 federal states for laying hens in Germany and the 77 provinces of Thailand. The Gini coefficients for broiler, turkey and laying hen husbandry in Germany are 0.7412, 0.6290 and 0.4761, respectively. This implies a relatively high level of concentration in a single region in broiler and turkey husbandry. Laying hen husbandry also has a potentially high density in a certain region. The Gini coefficients for laying duck, broiler, laying hen, meat duck and native chicken husbandry in Thailand are 0.7563, 0.7352, 0.6778, 0.6394 and 0.5196, respectively. This indicates the levels of concentration in certain regions for laying duck, broiler, laying hen, meat duck and native chicken husbandry from high to low, respectively.

In 2013, Germany produced 1.48 million tonnes of poultry meat and 12.59 billion shell eggs for consumption. Thailand produced 1.5 million tonnes of poultry meat and 11.15 billion shell eggs for consumption in 2013. The per capita consumption of poultry meat and eggs in Germany was 19.4 kg/head/year and 224 shell eggs/head/year, respectively. The per capita consumption of poultry meat and eggs in Thailand was 15.4 kg/head/year and 168 shell eggs/head/year, respectively. The self-sufficiency rate of poultry meat production is 109.1% for Germany and 153.9% for Thailand. Thailand produced slightly more shell eggs than were consumed domestically (101.7% of self-sufficiency rate), while Germany has a self-sufficiency rate of only 71%.

In 2013, poultry meat was exported by Germany and Thailand with a total of 496,618 and 525,682 tonnes, respectively. The main exporting destination for German poultry products is the EU, while Thailand mainly exports its poultry meat to Japan and the EU.

The leading poultry companies in the two countries are vertically integrated in order to gain a competitive edge on the markets. PHW-Group and Deutsche Frühstücksei are the leading poultry meat and egg production companies in Germany, respectively. CPF is the leading poultry meat and egg production company in Thailand.

The rising specialisation and concentration of poultry production within a few regions has become a concerning issue for society, especially academic researchers and policy makers, who see reasons for concern due to the growing impact on the environment, human health and animal welfare.

Chapter 6 presented the results of the Delphi study on sustainability concerns in poultry production in Germany and Thailand. Using the Delphi method, the most important sustainability issues were identified and ranked by experts, including non-governmental organisations (NGOs), animal welfare groups, researchers, the private sector (retailers and firms related to the poultry industry), government officials and politicians. Experts from the two countries were extremely concerned about *the use of antibiotics in poultry production* due to the threat of multi-drug resistant bacteria associated with the use of antibiotics in livestock production, which could impact on the treatment of diseases, such as Methicillin-Resistant *Staphylococcus aureus* (MRSA) and Extended Spectrum b-Lactamase (ESBL) Enterobacteria. The *outbreak of avian influenza and other highly infectious diseases*, *disease control in neighbouring countries*, *standards for poultry products set by import partners*, and *the contamination of meat and eggs with zoonotic microorganisms* were considered as highly concerning issues for Thailand, while *the role of food retailers* was considered very concerning in Germany. The German and Thai experts had different opinions on the *killing of male layer chicks*. This issue was considered very concerning in Germany due to ongoing ethical discussions, while none of the Thai experts expressed concern over the issue of killing day-old cocks, since male layer chicks are used for meat production rather than being killed.

Chapter 7 provided an overview of the role of NGOs, animal welfare groups and leading integrated poultry companies in the sustainability of poultry production.

In Germany, the leading integrated poultry companies face pressure from NGOs and animal welfare groups, as well as consumer preferences for sustainable production. Therefore, their strategies can be considered reactive in response to the pressure exerted by these groups. Efforts to improve the sustainability of poultry production have been actively made by the poultry companies. However, there are still limitations to solving some concerning issues, such as *the killing of day-old male layer chicks, de-beaking, the use of antibiotics in poultry production, the role of food retailers* and *outbreaks of avian influenza* due to trade-offs between economic efficiency and societal preference, the current availability of technology

and innovation, and the lack of public information on the actual state of modern poultry production and the industry's efforts to improve the sustainability of poultry production.

In Thailand, there is no pressure exerted by NGOs and animal welfare groups on the poultry industry. Thus, the leading integrated poultry companies have proactively worked on their production strategies to gain societal acceptance and increase confidence among importing countries. However, there are limitations to solving some concerning issues, such as *outbreaks of avian influenza, disease control in neighbouring countries, the use of antibiotic in poultry production, the contamination of meat and eggs with zoonotic microorganisms,* and *standards for poultry products set by import partners*, mainly due to the current level of availability of technology and innovation, the role of social media, and external factors, such as problems in poultry production in neighbouring countries.

Chapter 8 discussed the research findings of this study and highlighted its implications for improving the sustainability of poultry production. Recommendations were made based on the Delphi study on sustainability concerns in poultry production and improving sustainability. The recommendations for the poultry industry are as follows:

- *Improve fertilisation management in feed production, manure management, and energy and feed efficiency;*
- *Promote research strategies on animal feed supply;*
- *Continue reducing the use of antibiotics in poultry production;*
- *Improve consumer perceptions of the poultry industry;*
- *Improve preventive strategies for avian influenza;*
- *Promote research on disease-resistant poultry breeds;*
- *Support the compartmentalisation during avian influenza or Newcastle disease outbreaks and/or promote the geographic dispersion of genetic stock;*
- *Improve production management in areas of intensive farming;*
- *Improve collaboration on the prevention and control of contagious diseases in border regions;*
- *Enforce one law for all federal states;*
- *Shorten the European authorisation procedure for GM imports and its animal feed policy;*
- *Improve existing technologies and practices along with developing new technologies and innovation.*

In summary, the sustainability issues that currently concern the poultry industry, and were identified and ranked in this study, provide crucial information for the poultry industry in Germany and Thailand. In order to address these issues and problems, all stakeholders engaged in poultry production should use these research findings as a basis for further developing and improving poultry production systems in line with principles of sustainability.

9.2 Conclusions

The final conclusions derived from this study are:

- The high quality and animal welfare standards set by importing countries (EU) are a potentially large incentive for improvements in production standards in exporting countries (Thailand).
- The increasing consumer awareness of animal welfare advocated by NGOs and animal welfare groups forces the German government to set guidelines on improving poultry welfare, such as providing more space for poultry, and banning beak trimming and the killing of male layer chicks in laying hens.
- The demand for antibiotic-free chickens is growing in society.
- NGOs and animal welfare groups have no impact on the Thai poultry industry.
- Outbreaks of avian influenza continue to be a global concerning issue.
- Food retailers play a central role in the German poultry industry.
- Animal welfare issues are an important part of the sustainability of poultry production.
- Animal welfare issues are of more concern in Germany than in Thailand.
- Raising animal welfare standards contributes to an increasing cost of production and consequently a higher price for premium poultry products.
- Beak trimming and the killing of male layer chicks will no longer be allowed in the German poultry industry in the near future.
- The regional concentration of production is a site-specific issue.
- A proactive approach is a powerful tool for gaining consumer trust and acceptance.
- The Thai poultry industry has gained a positive image through their proactive strategies.
- There is no single solution for improving sustainability in poultry production due to the vast diversity of agro-ecological and socio-economic characteristics of different regions or countries.

- The decision-making process for improving the sustainability of poultry production requires public dialogues and needs to be based on scientific knowledge.

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Appendix 1: Estimated Gini coefficient for the geographical concentration of broiler production in Germany (2013)

State	Number of broiler places	Cumulative share of states	% of broiler places	Cumulative share of broiler places	Area under the Lorenz curve
Rhineland-Palatinate	36,000	0.1111	0.0004	0.0004	0.00002
Thuringia	273,000	0.2222	0.0032	0.0036	0.00022
Baden-Württemberg	950,000	0.3333	0.0111	0.0147	0.00102
Schleswig-Holstein	1,541,000	0.4444	0.0180	0.0328	0.00264
Saxony-Anhalt	2903000	0.5556	0.0340	0.0667	0.00552
Mecklenburg-Western Pomerania	4,552,000	0.6667	0.0533	0.1200	0.01036
North Rhine-Westphalia	5,186,000	0.7778	0.0607	0.1807	0.01669
Bavaria	5,658,000	0.8889	0.0662	0.2469	0.02373
Lower Saxony	64,358,000	1	0.7531	1	0.06920
Total	85,457,000		1		0.12941
Area A = 0.3706					
Gini coefficient = 0.7412					

Appendix 2: Estimated Gini coefficient for the geographical concentration of turkey production in Germany (2013)

State	Number of turkey places	Cumulative share of states	% of turkey places	Cumulative share of turkeys places	Area under the Lorenz curve
Saarland	0	0.0833	0.0000	0.0000	0.0000
Schleswig-Holstein	57,000	0.1667	0.0043	0.0043	0.0002
Hesse	106,000	0.2500	0.0080	0.0123	0.0007
Thuringia	163,000	0.3333	0.0123	0.0246	0.0015
Saxony	196,000	0.4167	0.0148	0.0394	0.0027
Mecklenburg-Western Pomerania	590,000	0.5000	0.0446	0.0840	0.0051
Bavaria	812,000	0.5833	0.0614	0.1454	0.0095
Saxony-Anhalt	963,000	0.6667	0.0728	0.2182	0.0151
Baden-Württemberg	1,002,000	0.7500	0.0757	0.2939	0.0213
Brandenburg	1,383,000	0.8333	0.1045	0.3984	0.0287
North Rhine-Westphalia	1,537,000	0.9167	0.1161	0.5145	0.0379
Lower Saxony	6,424,000	1	0.4855	1	0.0629
Total	13,233,000		1		0.1855
Area A = 0.3145					
Gini coefficient = 0.6290					

Appendix 3: Estimated Gini coefficient for the geographical concentration of laying hen husbandry in Germany (2013)

State	Number of laying hen places	Cumulative share of states	% of laying hen places	Cumulative share of laying hens places	Area under the Lorenz curve
Saarland	125,000	0.0769	0.0026	0.0026	0.0001
Rhineland-Palatinate	901,000	0.1538	0.0188	0.0214	0.0009
Hesse	983,000	0.2308	0.0205	0.0419	0.0024
Schleswig-Holstein	1536,000	0.3077	0.0320	0.0739	0.0045
Thuringia	1,974,000	0.3846	0.0411	0.1150	0.0073
Baden-Württemberg	2,538,000	0.4615	0.0529	0.1679	0.0109
Mecklenburg-Western Pomerania	2,599,000	0.5385	0.0542	0.2221	0.0150
Brandenburg	3,495,000	0.6154	0.0728	0.2949	0.0199
North Rhine-Westphalia	3,598,000	0.6923	0.0750	0.3699	0.0256
Saxony	3,830,000	0.7692	0.0798	0.4498	0.0316
Bavaria	3,837,000	0.8462	0.0800	0.5297	0.0377
Saxony-Anhalt	3,974,000	0.9231	0.0828	0.6126	0.0440
Lower Saxony	18,589,000	1	0.3874	1	0.0621
Total	47,979,000		1		0.2619
Area A = 0.2381					
Gini coefficient = 0.4761					

Appendix 4: Estimated Gini coefficient for the geographical concentration of broiler production in Thailand (2013)

Province	Number of broiler places	Cumulative share of provinces	% of broiler places	Cumulative share of broiler places	Area under the Lorenz curve
Bueng Kan	0	0.0130	0	0	0
Mae Hong Son	3,454	0.0260	0.00002	0.00002	0.0000001
Samut Songkhram	20,857	0.0390	0.00014	0.00016	0.0000012
Kalasin	31,984	0.0519	0.00021	0.00038	0.0000035
Samut Sakhon	32,779	0.0649	0.00022	0.00059	0.0000063
Nan	45,811	0.0779	0.00031	0.00090	0.0000097
Tak	48,717	0.0909	0.00032	0.00122	0.0000138
Mukdahan	50,863	0.1039	0.00034	0.00156	0.0000181
Nong Bua Lamphu	61,050	0.1169	0.00041	0.00197	0.0000230
Nonthaburi	63,855	0.1299	0.00043	0.00240	0.0000284
Samut Prakan	71,276	0.1429	0.00048	0.00287	0.0000343
Phrae	71,894	0.1558	0.00048	0.00335	0.0000405
Satun	76,074	0.1688	0.00051	0.00386	0.0000469
Yala	79,480	0.1818	0.00053	0.00439	0.0000536
Loei	80,106	0.1948	0.00053	0.00492	0.0000605
Nakhon Phanom	108,405	0.2078	0.00072	0.00565	0.0000687
Sukhothai	109,507	0.2208	0.00073	0.00638	0.0000782
Bangkok	115,300	0.2338	0.00077	0.00715	0.0000879
Surin	116,386	0.2468	0.00078	0.00792	0.0000980
Amnat Charoen	164,342	0.2597	0.00110	0.00902	0.0001101
Phayao	167,495	0.2727	0.00112	0.01014	0.0001245
Narathiwat	184,920	0.2857	0.00123	0.01137	0.0001398
Lampang	199,310	0.2987	0.00133	0.01270	0.0001565
Nong Khai	207,813	0.3117	0.00139	0.01409	0.0001741
Phuket	218,410	0.3247	0.00146	0.01554	0.0001926
Ranong	223,498	0.3377	0.00149	0.01704	0.0002118
Sakon Nakhon	230,605	0.3506	0.00154	0.01857	0.0002315
Maha Sarakham	275,114	0.3636	0.00184	0.02041	0.0002534
Si Sa Ket	311,061	0.3766	0.00208	0.02248	0.0002788
Trat	323,270	0.3896	0.00216	0.02464	0.0003063
Phichit	352,505	0.4026	0.00235	0.02699	0.0003356
Kamphaeng Phet	416,602	0.4156	0.00278	0.02977	0.0003690
Sing Buri	449,969	0.4286	0.00300	0.03277	0.0004065
Sa Kaeo	451,275	0.4416	0.00301	0.03578	0.0004456
Chai Nat	453,475	0.4545	0.00303	0.03881	0.0004849
Phangnga	488,908	0.4675	0.00326	0.04207	0.0005257
Roi Et	491,584	0.4805	0.00328	0.04535	0.0005682
Krabi	493,540	0.4935	0.00329	0.04864	0.0006109
Udon Thani	493,560	0.5065	0.00329	0.05193	0.0006538
Trang	495,804	0.5195	0.00331	0.05524	0.0006967

Appendix 4: Estimated Gini coefficient for the geographical concentration of broiler production in Thailand (2013) (Continued)

Province	Number of broiler places	Cumulative share of provinces	% of broiler places	Cumulative share of broiler places	Area under the Lorenz curve
Ang Thong	529,401	0.5325	0.00353	0.05877	0.0007411
Surat Thani	540,010	0.5455	0.00360	0.06238	0.0007875
Pattani	548,029	0.5584	0.00366	0.06603	0.0008347
Uthai Thani	556,525	0.5714	0.00371	0.06975	0.0008826
Prachuap Khiri Khan	592,181	0.5844	0.00395	0.07370	0.0009324
Pathum Thani	656,187	0.5974	0.00438	0.07807	0.0009865
Lamphun	676,277	0.6104	0.00451	0.08258	0.0010443
Yasothon	697,180	0.6234	0.00465	0.08724	0.0011038
Chiang Rai	757,708	0.6364	0.00505	0.09229	0.0011669
Phitsanulok	940,744	0.6494	0.00628	0.09857	0.0012406
Kanchanaburi	940,799	0.6623	0.00628	0.10484	0.0013222
Phetchaburi	966,646	0.6753	0.00645	0.11129	0.0014049
Uttaradit	1,058,647	0.6883	0.00706	0.11835	0.0014927
Khon Kaen	1,195,401	0.7013	0.00797	0.12633	0.0015904
Phatthalung	1,245,975	0.7143	0.00831	0.13464	0.0016963
Nakhon Si Thammarat	1,248,945	0.7273	0.00833	0.14297	0.0018045
Chumphon	1,540,862	0.7403	0.01028	0.15325	0.0019254
Nakhon Sawan	1,590,153	0.7532	0.01061	0.16386	0.0020612
Phra Nakhon Si Ayutthaya	1,619,481	0.7662	0.01080	0.17466	0.0022004
Nakhon Pathom	1,970,868	0.7792	0.01315	0.18781	0.0023561
Buri Ram	2,139,176	0.7922	0.01427	0.20208	0.0025343
Phetchabun	2,288,330	0.8052	0.01527	0.21735	0.0027263
Songkhla	2,746,005	0.8182	0.01832	0.23567	0.0029446
Suphan Buri	2,832,505	0.8312	0.01890	0.25456	0.0031865
Ratchaburi	3,130,507	0.8442	0.02088	0.27545	0.0034451
Chanthaburi	3,188,247	0.8571	0.02127	0.29671	0.0037190
Saraburi	4,010,254	0.8701	0.02675	0.32347	0.0040312
Chiang Mai	4,559,894	0.8831	0.03042	0.35389	0.0044028
Chaiyaphum	5,726,257	0.8961	0.03820	0.39209	0.0048488
Ubon Ratchathani	7,077,044	0.9091	0.04721	0.43930	0.0054040
Nakhon Ratchasima	7,858,613	0.9221	0.05243	0.49173	0.0060517
Lop Buri	7,970,827	0.9351	0.05317	0.54490	0.0067381
Nakhon Nayok	8,785,831	0.9481	0.05861	0.60351	0.0074647
Prachin Buri	10,047,518	0.9610	0.06703	0.67054	0.0082813
Chachoengsao	10,760,502	0.9740	0.07178	0.74232	0.0091836
Rayong	10,789,571	0.9870	0.07198	0.81430	0.0101181
Chon Buri	27,836,302	1	0.18570	1	0.0117930
Total	149,900,260		1		0.1323962
Area A = 0.3676					
Gini coefficient = 0.7352					

Appendix 5: Estimated Gini coefficient for the geographical concentration of laying hen husbandry in Thailand (2013)

Province	Number of laying hen places	Cumulative share of provinces	% of laying hen places	Cumulative share of laying hen places	Area under the Lorenz curve
Bueng Kan	7,520	0.0130	0.0002	0.0002	0.000001
Nonthaburi	9,100	0.0260	0.0002	0.0004	0.000004
Yasothon	10,842	0.0390	0.0002	0.0006	0.000006
Phichit	11,795	0.0519	0.0003	0.0009	0.000010
Tak	12,193	0.0649	0.0003	0.0012	0.000013
Mae Hong Son	13,023	0.0779	0.0003	0.0015	0.000017
Nong Bua Lamphu	21,545	0.0909	0.0005	0.0019	0.000022
Kamphaeng Phet	28,533	0.1039	0.0006	0.0026	0.000029
Mukdahan	30,655	0.1169	0.0007	0.0033	0.000038
Chaiyaphum	31,670	0.1299	0.0007	0.0040	0.000047
Amnat Charoen	35,449	0.1429	0.0008	0.0048	0.000057
Phitsanulok	38,655	0.1558	0.0009	0.0057	0.000068
Surin	39,382	0.1688	0.0009	0.0066	0.000079
Sing Buri	40,065	0.1818	0.0009	0.0075	0.000091
Uthai Thani	42,445	0.1948	0.0010	0.0084	0.000103
Trat	42,828	0.2078	0.0010	0.0094	0.000116
Maha Sarakham	44,961	0.2208	0.0010	0.0104	0.000129
Samut Prakan	56,232	0.2338	0.0013	0.0117	0.000143
Narathiwat	58,591	0.2468	0.0013	0.0130	0.000160
Chai Nat	65,173	0.2597	0.0015	0.0145	0.000178
Kalasin	66,322	0.2727	0.0015	0.0160	0.000198
Sukhothai	68,181	0.2857	0.0015	0.0175	0.000217
Samut Songkhram	79,913	0.2987	0.0018	0.0193	0.000239
Si Sa Ket	80,027	0.3117	0.0018	0.0211	0.000263
Samut Sakhon	82,247	0.3247	0.0019	0.0230	0.000286
Nan	82,959	0.3377	0.0019	0.0248	0.000311
Yala	83,046	0.3506	0.0019	0.0267	0.000335
Bangkok	87,996	0.3636	0.0020	0.0287	0.000360
Pattani	97,900	0.3766	0.0022	0.0309	0.000387
Phrae	126,824	0.3896	0.0029	0.0338	0.000420
Krabi	127,363	0.4026	0.0029	0.0366	0.000458
Pathum Thani	130,436	0.4156	0.0029	0.0396	0.000496
Kanchanaburi	145,673	0.4286	0.0033	0.0429	0.000536
Loei	157,768	0.4416	0.0036	0.0464	0.000581
Phayao	160,620	0.4545	0.0036	0.0501	0.000627
Satun	162,719	0.4675	0.0037	0.0537	0.000675
Ratchaburi	180,606	0.4805	0.0041	0.0578	0.000725
Phuket	183,866	0.4935	0.0042	0.0620	0.000779
Nakhon Sawan	184,245	0.5065	0.0042	0.0661	0.000833

Appendix 5: Estimated Gini coefficient for the geographical concentration of laying hen production in Thailand (2013) (Continued)

Province	Number of laying hen places	Cumulative share of provinces	% of laying hen places	Cumulative share of laying hen places	Area under the Lorenz curve
Trang	212,911	0.5195	0.0048	0.0709	0.000891
Sa Kaeo	223,554	0.5325	0.0050	0.0760	0.000955
Phangnga	234,140	0.5455	0.0053	0.0813	0.001022
Roi Et	247,511	0.5584	0.0056	0.0868	0.001093
Udon Thani	251,958	0.5714	0.0057	0.0925	0.001166
Phatthalung	256,887	0.5844	0.0058	0.0983	0.001241
Chanthaburi	264,536	0.5974	0.0060	0.1043	0.001317
Buri Ram	283,892	0.6104	0.0064	0.1107	0.001398
Lamphun	285,355	0.6234	0.0064	0.1172	0.001481
Sakon Nakhon	286,564	0.6364	0.0065	0.1236	0.001565
Lampang	291,683	0.6494	0.0066	0.1302	0.001650
Chumphon	302,124	0.6623	0.0068	0.1370	0.001737
Prachuap Khiri Khan	305,801	0.6753	0.0069	0.1439	0.001826
Ranong	316,045	0.6883	0.0071	0.1511	0.001917
Lop Buri	387,005	0.7013	0.0087	0.1598	0.002021
Nakhon Phanom	510,669	0.7143	0.0115	0.1713	0.002152
Prachin Buri	580,413	0.7273	0.0131	0.1844	0.002312
Nakhon Ratchasima	620,189	0.7403	0.0140	0.1984	0.002489
Phetchabun	627,939	0.7532	0.0142	0.2126	0.002672
Rayong	660,307	0.7662	0.0149	0.2275	0.002861
Ang Thong	665,425	0.7792	0.0150	0.2425	0.003055
Surat Thani	669,220	0.7922	0.0151	0.2576	0.003251
Nakhon Si Thammarat	811,530	0.8052	0.0183	0.2760	0.003468
Uttaradit	878,420	0.8182	0.0198	0.2958	0.003716
Chiang Rai	1,046,644	0.8312	0.0236	0.3194	0.003999
Phetchaburi	1,291,450	0.8442	0.0292	0.3486	0.004342
Songkhla	1,411,726	0.8571	0.0319	0.3804	0.004738
Khon Kaen	1,444,561	0.8701	0.0326	0.4130	0.005158
Nong Khai	1,786,166	0.8831	0.0403	0.4534	0.005632
Nakhon Pathom	1,816,424	0.8961	0.0410	0.4944	0.006160
Saraburi	1,918,426	0.9091	0.0433	0.5377	0.006708
Ubon Ratchathani	1,980,505	0.9221	0.0447	0.5824	0.007280
Chiang Mai	2,413,643	0.9351	0.0545	0.6369	0.007925
Suphan Buri	2,542,405	0.9481	0.0574	0.6942	0.008652
Chon Buri	2,620,495	0.9610	0.0592	0.7534	0.009410
Phra Nakhon Si Ayutthaya	3,197,588	0.9740	0.0722	0.8256	0.010263
Nakhon Nayok	3,279,133	0.9870	0.0740	0.8996	0.011214
Chachoengsao	4,448,191	1	0.1004	1	0.012347
Total	44,300,803		1		0.161122
Area A = 0.3389					
Gini coefficient = 0.6778					

Appendix 6: Estimated Gini coefficient for the geographical concentration of native chicken production in Thailand (2013)

Province	Number of native chicken places	Cumulative share of provinces	% of native chicken places	Cumulative share of native chicken places	Area under the Lorenz curve
Samut Songkhram	12,049	0.0130	0.0000000002	0.0000000002	0.000000000001
Samut Prakan	18,507	0.0260	0.0002845437	0.0002845439	0.000001849537
Pathum Thani	18,863	0.0390	0.0002900172	0.0005745611	0.000005584182
Bangkok	22,742	0.0519	0.0003496565	0.0009242176	0.000009742061
Nonthaburi	31,286	0.0649	0.0004810198	0.0014052374	0.000015141457
Samut Sakhon	36,616	0.0779	0.0005629682	0.0019682056	0.000021927380
Ang Thong	73,927	0.0909	0.0011366219	0.0031048275	0.000032974715
Phuket	77,250	0.1039	0.0011877128	0.0042925403	0.000048082891
Trat	101,969	0.1169	0.0015677655	0.0058603059	0.000065993500
Phra Nakhon Si Ayutthaya	111,031	0.1299	0.0017070931	0.0075673989	0.000087280081
Sing Buri	128,914	0.1429	0.0019820428	0.0095494418	0.000111259465
Chanthaburi	130,415	0.1558	0.0020051206	0.0115545624	0.000137176027
Nakhon Pathom	173,083	0.1688	0.0026611378	0.0142157002	0.000167506706
Narathiwat	174,739	0.1818	0.0026865987	0.0169022988	0.000202266993
Rayong	179,569	0.1948	0.0027608596	0.0196631584	0.000237675472
Ranong	188,393	0.2078	0.0028965279	0.0225596863	0.000274448490
Nakhon Nayok	197,053	0.2208	0.0030296747	0.0255893610	0.000312968807
Chon Buri	207,017	0.2338	0.0031828704	0.0287722314	0.000353350351
Lop Buri	266,648	0.2468	0.0040996925	0.0328719239	0.000400687010
Amnat Charoen	272,237	0.2597	0.0041856229	0.0370575468	0.000454541560
Mae Hong Son	314,272	0.2727	0.0048319078	0.0418894546	0.000513155509
Yala	320,794	0.2857	0.0049321831	0.0468216377	0.000576622100
Chai Nat	336,650	0.2987	0.0051759678	0.0519976055	0.000642325081
Phangnga	339,279	0.3117	0.0052163885	0.0572139940	0.000709875397
Suphan Buri	345,748	0.3247	0.0053158489	0.0625298429	0.000778334940
Pattani	348,614	0.3377	0.0053599134	0.0678897563	0.000847727395
Ratchaburi	351,085	0.3506	0.0053979049	0.0732876612	0.000917653214
Chumphon	359,900	0.3636	0.0055334348	0.0788210960	0.000988706922
Nakhon Sawan	374,001	0.3766	0.0057502366	0.0845713326	0.001062050786
Prachin Buri	378,133	0.3896	0.0058137658	0.0903850984	0.001137216801
Prachuap Khiri Khan	408,486	0.4026	0.0062804408	0.0966655392	0.001215829144
Satun	415,179	0.4156	0.0063833452	0.1030488843	0.001298143753
Chachoengsao	422,532	0.4286	0.0064963970	0.1095452813	0.001381862077
Krabi	473,729	0.4416	0.0072835469	0.1168288282	0.001471431712
Uthai Thani	479,566	0.4545	0.0073732903	0.1242021186	0.001566701154
Phetchaburi	493,019	0.4675	0.0075801292	0.1317822477	0.001663898381
Bueng Kan	497,811	0.4805	0.0076538058	0.1394360536	0.001762918958
Saraburi	508,655	0.4935	0.0078205315	0.1472565850	0.001863502151
Phitsanulok	560,215	0.5065	0.0086132625	0.1558698475	0.001970321812

Appendix 6: Estimated Gini coefficient for the geographical concentration of native chicken production in Thailand (2013) (Continued)

Province	Number of native chicken places	Cumulative share of provinces	% of native chicken places	Cumulative share of native chicken places	Area under the Lorenz curve
Tak	602,623	0.5195	0.0092652822	0.1651351298	0.002086532353
Phichit	675,864	0.5325	0.0103913570	0.1755264868	0.002214300508
Kamphaeng Phet	695,324	0.5455	0.0106905530	0.1862170397	0.002351332922
Trang	703,517	0.5584	0.0108165197	0.1970335595	0.002491128895
Nong Khai	705,966	0.5714	0.0108541729	0.2078877324	0.002631988397
Kanchanaburi	718,720	0.5844	0.0110502647	0.2189379971	0.002774367241
Sa Kaeo	722,066	0.5974	0.0111017092	0.2300397062	0.002918355072
Lamphun	728,038	0.6104	0.0111935282	0.2412332345	0.003063274115
Uttaradit	769,130	0.6234	0.0118253146	0.2530585490	0.003212896593
Nakhon Phanom	774,576	0.6364	0.0119090464	0.2649675954	0.003367169939
Nong Bua Lamphu	775,832	0.6494	0.0119283573	0.2768959527	0.003522113063
Mukdahan	785,433	0.6623	0.0120759719	0.2889719246	0.003678141202
Sukhothai	789,512	0.6753	0.0121386862	0.3011106108	0.003835536480
Loei	799,147	0.6883	0.0122868236	0.3133974345	0.003994302294
Surat Thani	806,793	0.7013	0.0124043803	0.3258018147	0.004154795120
Phetchabun	812,273	0.7143	0.0124886349	0.3382904496	0.004316599718
Phatthalung	883,275	0.7273	0.0135802851	0.3518707347	0.004486047698
Kalasin	963,093	0.7403	0.0148074807	0.3666782155	0.004670568176
Lampang	987,747	0.7532	0.0151865341	0.3818647496	0.004865529273
Phrae	996,590	0.7662	0.0153224945	0.3971872441	0.005063837959
Nan	1,040,210	0.7792	0.0159931487	0.4131803928	0.005267389640
Sakon Nakhon	1,091,281	0.7922	0.0167783614	0.4299587542	0.005480404456
Udon Thani	1,107,125	0.8052	0.0170219617	0.4469807159	0.005700106555
Yasothon	1,141,269	0.8182	0.0175469230	0.4645276389	0.005924804306
Roi Et	1,215,091	0.8312	0.0186819306	0.4832095695	0.006160291855
Songkhla	1,277,836	0.8442	0.0196466301	0.5028561997	0.006409427500
Chaiyaphum	1,703,325	0.8571	0.0261884908	0.5290446904	0.006707355786
Phayao	1,718,056	0.8701	0.0264149788	0.5554596692	0.007049278338
Chiang Mai	1,753,581	0.8831	0.0269611729	0.5824208421	0.007396223323
Maha Sarakham	1,863,684	0.8961	0.0286539981	0.6110748402	0.007757721935
Surin	2,355,306	0.9091	0.0362126485	0.6472874886	0.008179355137
Si Sa Ket	2,467,742	0.9221	0.0379413433	0.6852288319	0.008661356084
Buri Ram	2,840,813	0.9351	0.0436772812	0.7289061132	0.009191877143
Chiang Rai	2,894,902	0.9481	0.0445088954	0.7734150086	0.009765087292
Khon Kaen	3,030,513	0.9610	0.0465939041	0.8200089127	0.010357255489
Nakhon Si Thammarat	3,341,117	0.9740	0.0513694167	0.8713783295	0.010994017074
Ubon Ratchathani	3,563,684	0.9870	0.0547913672	0.9261696967	0.011684062170
Nakhon Ratchasima	4,789,946	1	0.0736450511	1	0.012520103028
Total	65,040,976		1		0.240213668101
Area A = 0.2598					
Gini coefficient = 0.5196					

Appendix 7: Estimated Gini coefficient for the geographical concentration of meat duck production in Thailand (2013)

Province	Number of meat duck places	Cumulative share of provinces	% of meat duck places	Cumulative share of meat duck places	Area under the Lorenz curve
Samut Songkhram	532	0.0130	0.0001	0.0001	0.0000004
Samut Prakan	1,455	0.0260	0.0002	0.0002	0.0000017
Tak	2,924	0.0390	0.0003	0.0005	0.0000047
Ranong	3,309	0.0519	0.0003	0.0009	0.0000089
Sukhothai	3,914	0.0649	0.0004	0.0013	0.0000137
Trat	4,824	0.0779	0.0005	0.0018	0.0000196
Chumphon	5,507	0.0909	0.0006	0.0023	0.0000266
Pathum Thani	5,819	0.1039	0.0006	0.0029	0.0000343
Prachuap Khiri Khan	5,857	0.1169	0.0006	0.0035	0.0000421
Phichit	5,889	0.1299	0.0006	0.0042	0.0000501
Samut Sakhon	7,038	0.1429	0.0007	0.0049	0.0000588
Uthai Thani	7,501	0.1558	0.0008	0.0057	0.0000686
Phetchaburi	7,520	0.1688	0.0008	0.0064	0.0000787
Nakhon Sawan	8,056	0.1818	0.0008	0.0073	0.0000892
Trang	9,058	0.1948	0.0009	0.0082	0.0001008
Sing Buri	9,169	0.2078	0.0010	0.0092	0.0001131
Chanthaburi	9,500	0.2208	0.0010	0.0102	0.0001257
Kamphaeng Phet	9,695	0.2338	0.0010	0.0112	0.0001387
Mae Hong Son	10,873	0.2468	0.0011	0.0123	0.0001525
Phuket	10,996	0.2597	0.0011	0.0134	0.0001673
Lamphun	11,154	0.2727	0.0012	0.0146	0.0001822
Phitsanulok	11,613	0.2857	0.0012	0.0158	0.0001976
Phangnga	11,798	0.2987	0.0012	0.0170	0.0002134
Phra Nakhon Si Ayutthaya	12,016	0.3117	0.0012	0.0183	0.0002295
Krabi	12,257	0.3247	0.0013	0.0195	0.0002459
Chai Nat	15,700	0.3377	0.0016	0.0212	0.0002647
Phetchabun	20,081	0.3506	0.0021	0.0233	0.0002889
Nan	20,151	0.3636	0.0021	0.0254	0.0003160
Phrae	24,584	0.3766	0.0026	0.0279	0.0003462
Lampang	24,895	0.3896	0.0026	0.0305	0.0003796
Ang Thong	25,918	0.4026	0.0027	0.0332	0.0004139
Nonthaburi	29,213	0.4156	0.0030	0.0362	0.0004511
Songkhla	32,296	0.4286	0.0034	0.0396	0.0004926
Lop Buri	32,596	0.4416	0.0034	0.0430	0.0005364
Satun	39,258	0.4545	0.0041	0.0470	0.0005849
Nakhon Si Thammarat	42,147	0.4675	0.0044	0.0514	0.0006399
Surat Thani	47,361	0.4805	0.0049	0.0563	0.0007003
Phatthalung	48,220	0.4935	0.0050	0.0613	0.0007648
Narathiwat	53,590	0.5065	0.0056	0.0669	0.0008335

Appendix 7: Estimated Gini coefficient for the geographical concentration of meat duck production in Thailand (2013) (Continued)

Province	Number of meat duck places	Cumulative share of provinces	% of meat duck places	Cumulative share of meat duck places	Area under the Lorenz curve
Loei	58,905	0.5195	0.0061	0.0730	0.0009094
Phayao	61,035	0.5325	0.0063	0.0793	0.0009904
Bueng Kan	61,622	0.5455	0.0064	0.0857	0.0010731
Mukdahan	64,504	0.5584	0.0067	0.0924	0.0011583
Uttaradit	78,457	0.5714	0.0081	0.1006	0.0012547
Suphan Buri	79,112	0.5844	0.0082	0.1088	0.0013611
Bangkok	79,254	0.5974	0.0082	0.1170	0.0014680
Amnat Charoen	85,860	0.6104	0.0089	0.1260	0.0015794
Yala	92,578	0.6234	0.0096	0.1356	0.0016998
Chiang Mai	95,959	0.6364	0.0100	0.1455	0.0018271
Saraburi	95,981	0.6494	0.0100	0.1555	0.0019566
Yasothon	97,225	0.6623	0.0101	0.1656	0.0020870
Nong Bua Lamphu	104,828	0.6753	0.0109	0.1765	0.0022234
Chiang Rai	106,722	0.6883	0.0111	0.1876	0.0023662
Nong Khai	111,971	0.7013	0.0116	0.1992	0.0025137
Nakhon Pathom	116,398	0.7143	0.0121	0.2113	0.0026679
Pattani	119,008	0.7273	0.0124	0.2236	0.0028267
Nakhon Phanom	123,981	0.7403	0.0129	0.2365	0.0029907
Sakon Nakhon	145,961	0.7532	0.0152	0.2516	0.0031729
Kanchanaburi	172,168	0.7662	0.0179	0.2695	0.0033876
Udon Thani	175,884	0.7792	0.0183	0.2878	0.0036225
Ratchaburi	186,386	0.7922	0.0194	0.3071	0.0038670
Chaiyaphum	243,932	0.8052	0.0253	0.3325	0.0041574
Rayong	245,900	0.8182	0.0255	0.3580	0.0044880
Buri Ram	283,184	0.8312	0.0294	0.3874	0.0048451
Ubon Ratchathani	312,692	0.8442	0.0325	0.4199	0.0052473
Surin	326,347	0.8571	0.0339	0.4538	0.0056786
Nakhon Nayok	330,617	0.8701	0.0343	0.4881	0.0061219
Roi Et	344,181	0.8831	0.0357	0.5238	0.0065774
Maha Sarakham	372,804	0.8961	0.0387	0.5625	0.0070613
Kalasin	429,454	0.9091	0.0446	0.6071	0.0076027
Sa Kaeo	441,950	0.9221	0.0459	0.6530	0.0081908
Chachoengsao	510,650	0.9351	0.0530	0.7060	0.0088337
Si Sa Ket	520,146	0.9481	0.0540	0.7600	0.0095294
Chon Buri	548,013	0.9610	0.0569	0.8169	0.0102503
Nakhon Ratchasima	567,193	0.9740	0.0589	0.8758	0.0110030
Prachin Buri	570,860	0.9870	0.0593	0.9351	0.0117710
Khon Kaen	625,052	1	0.0649	1	0.0125782
Total	9,631,058		1		0.1803166
Area A = 0.3197					
Gini coefficient = 0.6394					

Appendix 8: Estimated Gini coefficient for the geographical concentration of laying duck husbandry in Thailand (2013)

Province	Number of laying duck places	Cumulative share of provinces	% of laying duck places	Cumulative share of laying duck places	Area under the Lorenz curve
Yala	593	0.0130	0.0001	0.0001	0.000001
Narathiwat	720	0.0260	0.0001	0.0002	0.000002
Mae Hong Son	767	0.0390	0.0001	0.0004	0.000004
Loei	986	0.0519	0.0002	0.0005	0.000006
Tak	1,185	0.0649	0.0002	0.0008	0.000008
Satun	1,354	0.0779	0.0002	0.0010	0.000011
Nakhon Phanom	1,508	0.0909	0.0003	0.0013	0.000015
Sakon Nakhon	1,536	0.1039	0.0003	0.0015	0.000018
Phrae	1,897	0.1169	0.0003	0.0019	0.000022
Nong Bua Lamphu	2,008	0.1299	0.0004	0.0022	0.000027
Trang	2,235	0.1429	0.0004	0.0026	0.000032
Phuket	2,367	0.1558	0.0004	0.0030	0.000037
Samut Sakhon	2,591	0.1688	0.0005	0.0035	0.000043
Bangkok	2,765	0.1818	0.0005	0.0040	0.000049
Pattani	2,843	0.1948	0.0005	0.0045	0.000055
Amnat Charoen	2,929	0.2078	0.0005	0.0050	0.000062
Yasothon	3,102	0.2208	0.0006	0.0056	0.000069
Samut Songkhram	3,253	0.2338	0.0006	0.0062	0.000076
Mukdahan	4,293	0.2468	0.0008	0.0069	0.000085
Krabi	4,927	0.2597	0.0009	0.0078	0.000096
Lamphun	4,928	0.2727	0.0009	0.0087	0.000107
Bueng Kan	4,936	0.2857	0.0009	0.0095	0.000118
Chanthaburi	5,479	0.2987	0.0010	0.0105	0.000130
Sa Kaeo	5,608	0.3117	0.0010	0.0115	0.000143
Ranong	5,966	0.3247	0.0011	0.0126	0.000157
Lampang	6,422	0.3377	0.0011	0.0137	0.000171
Nan	6,592	0.3506	0.0012	0.0149	0.000186
Kalasin	6,728	0.3636	0.0012	0.0161	0.000201
Maha Sarakham	7,022	0.3766	0.0012	0.0173	0.000217
Prachin Buri	7,909	0.3896	0.0014	0.0187	0.000235
Nong Khai	8,273	0.4026	0.0015	0.0202	0.000253
Roi Et	8,769	0.4156	0.0016	0.0218	0.000273
Udon Thani	8,922	0.4286	0.0016	0.0234	0.000293
Trat	9,025	0.4416	0.0016	0.0250	0.000314
Samut Prakan	9,054	0.4545	0.0016	0.0266	0.000335
Rayong	10,249	0.4675	0.0018	0.0284	0.000357
Nakhon Nayok	12,735	0.4805	0.0023	0.0307	0.000384
Chiang Mai	15,156	0.4935	0.0027	0.0333	0.000416
Phetchabun	16,507	0.5065	0.0029	0.0363	0.000453

Appendix 8: Estimated Gini coefficient for the geographical concentration of laying duck husbandry in Thailand (2013) (Continued)

Province	Number of laying duck places	Cumulative share of provinces	% of laying duck places	Cumulative share of laying duck places	Area under the Lorenz curve
Nonthaburi	17,475	0.5195	0.0031	0.0394	0.000492
Phatthalung	18,590	0.5325	0.0033	0.0427	0.000534
Chumphon	19,441	0.5455	0.0035	0.0461	0.000577
Phangnga	25,456	0.5584	0.0045	0.0507	0.000629
Khon Kaen	26,322	0.5714	0.0047	0.0554	0.000689
Chaiyaphum	26,383	0.5844	0.0047	0.0600	0.000750
Saraburi	29,831	0.5974	0.0053	0.0653	0.000815
Ubon Ratchathani	29,926	0.6104	0.0053	0.0707	0.000884
Phayao	31,882	0.6234	0.0057	0.0763	0.000955
Pathum Thani	32,059	0.6364	0.0057	0.0820	0.001029
Songkhla	35,632	0.6494	0.0063	0.0884	0.001107
Prachuap Khiri Khan	37,923	0.6623	0.0067	0.0951	0.001192
Sing Buri	40,900	0.6753	0.0073	0.1024	0.001284
Kanchanaburi	46,852	0.6883	0.0083	0.1107	0.001385
Ang Thong	47,905	0.7013	0.0085	0.1192	0.001494
Phra Nakhon Si Ayutthaya	59,120	0.7143	0.0105	0.1297	0.001618
Chiang Rai	59,698	0.7273	0.0106	0.1403	0.001755
Si Sa Ket	62,257	0.7403	0.0111	0.1514	0.001896
Lop Buri	69,664	0.7532	0.0124	0.1638	0.002049
Surin	74,925	0.7662	0.0133	0.1771	0.002216
Surat Thani	76,237	0.7792	0.0135	0.1906	0.002390
Buri Ram	79,675	0.7922	0.0142	0.2048	0.002570
Nakhon Ratchasima	80,203	0.8052	0.0143	0.2191	0.002755
Nakhon Si Thammarat	85,000	0.8182	0.0151	0.2342	0.002946
Sukhothai	90,916	0.8312	0.0162	0.2503	0.003149
Phetchaburi	91,969	0.8442	0.0163	0.2667	0.003360
Uthai Thani	102,502	0.8571	0.0182	0.2849	0.003585
Chachoengsao	106,639	0.8701	0.0190	0.3038	0.003827
Chai Nat	117,814	0.8831	0.0209	0.3248	0.004086
Uttaradit	126,028	0.8961	0.0224	0.3472	0.004368
Suphan Buri	133,252	0.9091	0.0237	0.3709	0.004667
Ratchaburi	189,401	0.9221	0.0337	0.4045	0.005040
Chon Buri	252,242	0.9351	0.0448	0.4494	0.005550
Nakhon Sawan	412,399	0.9481	0.0733	0.5227	0.006318
Nakhon Pathom	499,626	0.9610	0.0888	0.6115	0.007372
Phitsanulok	623,897	0.9740	0.1109	0.7223	0.008670
Phichit	772,565	0.9870	0.1373	0.8597	0.010283
Kamphaeng Phet	789,613	1	0.1403	1	0.012088
Total	5,626,358		1		0.121838
Area A = 0.3782					
Gini coefficient = 0.7563					

Appendix 9: Invitation letter (Germany)

Universität Vechta
University of Vechta

wing
Wissenschafts- und Informationszentrum
Nachhaltige Geflügelwirtschaft

Universität Vechta · Postfach 1553 · D-49364 Vechta

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Invitation to participate in a Delphi study on sustainability concerns in poultry production

Dear…….,

The research project "Nachhaltige Geflügelwirtschaft – Sustainable Poultry Production" is run by the Science and Information Centre for Sustainable Poultry Production (Wissenschafts- und Informationszentrum Nachhaltige Geflügelwirtschaft – WING), University of Vechta. The project aims to highlight opportunities to increase the sustainability of poultry production in Germany. I am a Ph.D. candidate at the University of Vechta and this study is part of my doctoral thesis under the supervision of Prof. Dr. Hans-Wilhelm Windhorst.

The survey focuses on identifying the main sustainability concerns society has raised regarding the sustainability of poultry production. This study will ultimately develop guidelines for improving the sustainability of poultry production.

Your experience in poultry production/industry is very valuable to this research. This survey will involve approximately 35 experts in Germany.

A Delphi study is a research method that allows a group of experts to participate jointly, yet also anonymously, in defining and analysing a complex problem or issue. This Delphi study will consist of two rounds of questionnaires distributed electronically. Members of the panel therefore do not meet up in person at any time during the process. In each round, a questionnaire is sent to you and you will be asked to email it back within 10 days. The timeframe for each round is approximately 15 minutes. Please find the timetable below.

In return for your cooperation, the final report of this survey will be provided to you.

If you would like to join the expert panel, please confirm your participation **BEFORE 11 April**. Please also inform me if you would like to decline this invitation to participate or would like to suggest another expert with experience in and perspectives on the poultry industry. If you have any questions please do not hesitate to contact me using the contact details provided below.

I look forward to your participation and thank you kindly for your time.

Yours sincerely,

Sakson Soisontes
Reseacher/PhD candidate

Prof. Dr. Hans-Wilhelm Windhorst
Supervisor

Contact details:

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Timetable Delphi study

11.04.2014	Deadline registration expert panel
14.04.2014	Start Round 1
25.04.2014	Deadline Round 1
05.05.2014	Start Round 2
16.05.2014	Deadline Round 2
June 2014	Final report

Appendix 10: List of participating experts in the Delphi study in Germany

Name	Organisation
1. Prof. Dr. Michael Grashorn	Fakultät Agrarwissenschaften, Universität Hohenheim, Stuttgart
2. Prof. Dr. Hafez Mohamed Hafez	Fachbereich Veterinärmedizin, Freie Universität Berlin, Berlin
3. Prof. Dr. Robby Andersson	Fakultät Agrarwissenschaften und Landschaftsarchitektur, Hochschule Osnabrück, Osnabrück
4. Prof. Dr. Thomas Blaha	Außenstelle für Epidemiologie, Stiftung Tierärztliche Hochschule Hannover, Bakum
5. Dr. Thomas Janning	ZDG-Zentralverband der Deutschen Geflügelwirtschaft e.V., Berlin
6. Dieter Oltmann	NGW-Niedersächsische Geflügelwirtschaft, Landesverband e.V., Oldenburg
7. Dr. Lars Schrader	Institut für Tierschutz und Tierhaltung, Friedrich-Loeffler-Institut, Celle
8. Dr. Gisela Hahn	Institut für Sicherheit und Qualität bei Fleisch, Max Rubner-Institut, Bundesforschungsinstitut für Ernährung und Lebensmittel, Kulmbach
9. Dr. Klaus Damme	Bayerische Landesanstalt für Landwirtschaft (LfL) Lehr-, Versuchs- und Fachzentrum für Geflügel- und Kleintierhaltung Kitzingen, Kitzingen
10. Silvia Bender	Referentin für Umwelt und Landwirtschaft, Vertretung des Landes Rheinland-Pfalz, Berlin
11. Bernd Adleff	Landesverband der Bayerischen Geflügelwirtschaft e.V., Olching
12. Dr. Josef Efken	Institut für Marktanalyse, Thünen-Institut, Braunschweig
13. Dr. Dieter Schulze	Tierärztliche Praxis Am Bergweg, Lohne
14. Dr. Matthias Link	Tierarztpraxis Dr. Matthias Link, Varrel
15. Christian Woltering	Heidemark Mästerkreis GmbH & Co. KG, Ahlhorn
16. Dr. Stephan Gramzow	Geflügelhof Möckern, ZN der Lohmann & Co. AG, Möckern
17. Wilfried Fleming	Rothkötter Mischfutterwerk GmbH, Meppen-Versen
18. Dr. Josef Bachmeier	Brüterei Süd, ZN der BWE-Brüterei, Weser-Ems GmbH & Co. KG, Regenstauf
19. Prof. Dr. Rudolf Preisinger	Lohmann Tierzucht GmbH, Cuxhaven
20. Dr. Michael Lüke	Lohmann Tierzucht GmbH, Cuxhaven
21. Dr. Matthias Schmutz	Lohmann Tierzucht GmbH, Cuxhaven

Appendix 10: List of participating experts in the Delphi study in Germany (Continued)

Name	Organisation
22. Dr. Egbert Strobel	Deutsche Vilomix Tierernährung GmbH, Neuenkirchen-Vörden
23. Hanspeter Christ	Gebrueder Christ OHG, Frankfurt
24. Nina Flechtker	REWE-Zentral AG, Köln
25. Julia Dollinger	Büro Friedrich Ostendorff, MdB, Bundestagsfraktion Bündnis 90/Die Grünen, Berlin
26. Dr. Christel Happach-Kasan	Dr. Christel Happach-Kasan, Bäk
27. Stephanie Töwe-Rimkeit	Greenpeace, Hamburg
28. Janet Strahl	PROVIEH, Kiel
29. Prof. Dr. Sievert Lorenzen	PROVIEH, Kiel

Appendix 11: Delphi study on sustainability concerns in poultry production in Germany

The first round of questionnaires

Description

1. The goal of this questionnaire is to identify the major sustainability concerns in poultry production in **Germany** based on your professional experience.
2. **"Sustainability"** of poultry production is defined in this study as "the production system that optimises the overall sustainability aspects, including environmental, economic, social, political and animal welfare issues".
3. **26 initial major sustainability concerns/issues (A1-A26)** in poultry production, including environmental, economic, social, political and animal welfare aspects, are identified in this first questionnaire.
4. An explanation of all the issues is given on page 4 – 6.
5. Please send your completed questionnaire (**page 2 and 3**) back to ssoisontes@wing.uni-vechta.de **BEFORE 25 April 2014**.

Your Task

1. Based on your personal professional experience, please rate each issue (A1-A26) by entering a number in the table on **page 2** using a 5-point Likert scale rating system (see example below). You can rate it from 1 (considered not at all concerning issue) to 5 (considered very concerning issue), depending on how important you consider that issue. The higher you rated an issue, the more concerning it is.

2. **If** you have any comments on the 26 initial major sustainability concerns, please feel free to add your opinions. For this purpose, you can answer either in **English** or in **German**.

3. **If** a concern/issue is **not** included in the list, please feel free to add, describe and score it. For this purpose, you can answer either in **English** or in **German**.

Example

A **5-point Likert scale rating system for sustainability concerns in poultry production**

1 – Not at all concerning issue
2 – Slightly concerning issue
3 – Somewhat concerning issue
4 – Fairly concerning issue
5 – Very concerning issue

Major sustainability concerns/issues in intensive poultry production	**Level of concern**				
	Not at all concerned (1)	Slightly concerned (2)	Somewhat concerned (3)	Fairly concerned (4)	Very concerned (5)
Environmental aspects					
A1. Acidification, eutrophication and global warming potential			4		
A2. Manure management			2		
A3. Use of pesticides in poultry feed production			5		

please rate the issue in this column

1. Please rate each issue (A1-A26) by typing a number in the table below using a 5-point Likert scale rating system as described above.

Major sustainability concerns/issues in poultry production	Level of concern				
	Not at all concerned (1)	Slightly concerned (2)	Somewhat concerned (3)	Fairly concerned (4)	Very concerned (5)
A1. Acidification, eutrophication and global warming potential					
A2. Manure management					
A3. Use of pesticides in poultry feed production					
A4. Resource use					
A5. Biodiversity					
A6. Labour wages					
A7. Industry competitiveness/farm income					
A8. Feed supply					
A9. Consumer demand					
A10. Role of food retailers					
A11. Breeding					
A12. Efficiency of feed conversion					
A13. Pressure on/from urban centres					
A14. Workers in slaughter houses					
A15. Contamination of meat and eggs with zoonotic microorganisms					
A16. Use of antibiotics in poultry production					
A17. Outbreak of avian influenza and other highly infectious diseases					
A18. Negative image of the poultry industry portrayed by the media					
A19. Communication between producers and consumers					
A20. Food labelling					
A21. Introduction of new laws and regulations/legal framework					
A22. Transportation					
A23. Slaughter (procedure/process)					
A24. De-beaking					
A25. Killing of male layer chicks					
A26. Housing system					

2. If you have any comments on the 26 initial major sustainability concerns, please feel free to add your opinions. For this purpose, you can answer either in **English** or in **German**.

3. If a concern/issue is **not** included in the list, please feel free to add, describe and score it. For this purpose, you can answer either in **English** or in **German**.

New issue	Description	Level of concern				
		Not at all concerned (1)	Slightly concerned (2)	Somewhat concerned (3)	Fairly concerned (4)	Very concerned (5)
1.						
2.						
3.						
4.						
5.						

Description of sustainability issues in poultry production cited in the scientific literature and reports

Issue	Description
A1. Acidification, eutrophication and global warming potential	Ammonia emissions and nutrient leaching from poultry production sites contribute to acidification, eutrophication and global warming
A2. Manure management	Manure produced at poultry production sites is an environmental concern due to the emission of greenhouse gases, leaching of sewage, and runoff
A3. Use of pesticides in poultry feed production	The use of pesticides in poultry feed production, such as in soybean production areas, affects the health of humans, insects and microorganisms in the soil
A4. Resource use	Producing meat and eggs requires energy, water and land, which can contribute to resource depletion if not managed carefully
A5. Biodiversity	Monocultures planted for poultry feed production reduce the number of plant, insect and microorganism species in the farming area
A6. Labour wages	The requirement to increase the minimum wage for labourers working in poultry production units has a large impact on the poultry industry
A7. Industry competitiveness/ Farm income	The increasing costs of production, trade prices and the ability to access markets challenge the competitiveness of farms in the poultry industry
A8. Feed supply	The dependence on feed imports from other countries, especially non-genetically modified soybeans, poses a challenge to the future of the poultry industry: In February egg & meat producers already announced to no longer demand GMO-free soybeans
A9. Consumer demand	Consumer preferences for poultry products, including products prioritising animal welfare and/or using less antibiotics during the production stage

Description of sustainability issues in poultry production cited in the scientific literature and reports (continued)

Issue	Description
A10. Role of food retailers	Food retailers provide different products based on consumer preferences. They determine the type of products sourced from producers and directly impact on consumers' choices
A11. Breeding	More robust breeds should be encouraged to develop and use in poultry production
A12. Efficiency of feed conversion	The feed conversion rate of chickens has a direct impact on the cost of production and emission of ammonia and greenhouse gases
A13. Pressure on/from urban centres	Poultry farm intensification around urban areas has a direct impact on land-use management in expanding metropolitan centres, and vice versa
A14. Workers in slaughter houses	The introduction of cheap labour to poultry slaughter houses from other countries is highly criticised, as workers live in close quarters on-site and are highly controlled. This includes concerns over labour regulations and workers' welfare
A15. Contamination of meat and eggs with zoonotic microorganisms	Contamination of poultry products with zoonotic microorganisms, such as *Campylobacter* (causing campylobacteriosis) and *Salmonella* (causing salmonellosis) contributes to human health problems
A16. Use of antibiotics in poultry production	Using antibiotics in poultry production is believed to increase the risk of multi-drug resistant bacteria and could impact on disease treatment, such as Methicillin-Resistant *Staphylococcus aureus* (MRSA) and Extended Spectrum b-Lactamase (ESBL) Enterobacteria
A17. Outbreak of avian influenza and other highly infectious diseases	Highly infectious diseases, such as the highly pathogenic avian influenza (HPAI), have been fatal to humans in many countries and reduce consumers' confidence in poultry products
A18. Negative image of the poultry industry portrayed by the media	Some media reports and documentaries on select production practices in poultry and slaughter houses can make consumers think negatively about the poultry sector as a whole
A19. Communication between producers and consumers	Consumers rarely have the chance to communicate directly with producers. This can lead to misunderstandings regarding the reality of poultry production systems

Description of sustainability issues in poultry production cited in the scientific literature and reports (continued)

Issue	Description
A20. Food labelling	Labelling provides consumer information on the poultry product. However, such labels have been highly criticised for their transparency and control systems
A21. Introduction of new laws and regulations/legal framework	The introduction of laws and regulations, including a total ban on conventional cage systems, prohibiting de-beaking and restrictions on the use of antibiotics in poultry production, has a direct impact on producers. In order to comply with the legal framework, production systems need to be changed and management plans need to be developed in order to stay competitive in the global market
A22. Transportation	Transportation, including transportation methods, transportation density and transportation of poultry to (and from) slaughter houses
A23. Slaughter (procedure/process)	Distress prior to slaughter, conditions in slaughter houses and methods of slaughter
A24. De-beaking	De-beaking is a method used to prevent cannibalism and feather pecking in laying hens and turkeys. However, this practice raises concerns over animal welfare
A25. Killing of male layer chicks	This practice is used as male chicks are of no use to laying facilities and their feed conversion rates are too low to produce meat. However, there is increasing concern over ethical issues
A26. Housing system	Housing systems, including ventilation, access to the outside/food/water/light

The second round of questionnaires

Description

1. The goal of this questionnaire is to identify the major sustainability concerns in poultry production in **Germany** based on your professional experience.
2. **"Sustainability"** of poultry production is defined in this study as "the production system that optimises the overall sustainability aspects, including environmental, economic, social, political and animal welfare issues".
3. **15 new concerns/issues (A27-A41)** proposed by the expert panel during the first round of questionnaires have been added to the **26 initial major sustainability concerns/issues (A1-A26).** All 41 issues are to be ranked based on your level of concern in this second round of questionnaires.
4. An explanation of the **15 new concerns/issues** and the 26 initial concerns/issues is given on pages 4 – 8.
5. Please send your completed questionnaire (**page 2 and 3**) back to

ssoisontes@wing.uni-vechta.de **BEFORE 28 May 2014**.

Your Task

In the second round of questionnaires, you have the chance to **revise the answers** you provided in the first round of questionnaires and make recommendations on how to solve the major concerns and issues in order to enable a shift towards sustainable poultry production.

1. The results of the first round of questionnaires are presented in Table 1.

2. In the second questionnaire you have the chance to revise the rating you provided in the first round. Please rate each issue again as you did in the first questionnaire in the "New Rating" column in Table 1.

3. Based on the results of the first round of questionnaires, **15 more new concerns/issues** were proposed by the expert panellists. Based on your personal professional experience, please rate each issue (A27-A41) by entering a number in the "New Rating" column in **Table 2** using the 5-point Likert scale rating system as you did in the first questionnaire, depending on how concerned you are about that issue. The higher you rate an issue, the more concerning it is.

4. If a concern/issue is still **not** included in the initial and revised lists, please feel free to add, describe and score further concerns/issues. You can add them either in **English** or in **German**. If you do not have any issues to add, please skip this step and continue with Question 5.

5. In response to the most pressing sustainability concerns in poultry production, as identified in the first round of questionnaires, please propose solutions or make recommendations for improving the sustainability of poultry production **based on your area of expertise**. You can answer either in **English** or in **German** (Voluntary).

……..

***A **5-point** Likert scale rating system for sustainability concerns in poultry production **

1 – Not at all concerning issue
2 – Slightly concerning issue
3 – Somewhat concerning issue
4 – Fairly concerning issue
5 – Very concerning issue

1. The results of the first round of questionnaire are presented in Table 1.
2. You have chance to revise your rating provided in the first questionnaire, please rate each issue again in the "New Rating" column in the Table 1.

Table 1

Major sustainability concerns/issues in poultry production	*Level of concern (N=29)						
	Not at all concerned (1) (% Rating)	Slightly concerned (2) (% Rating)	Somewhat concerned (3) (% Rating)	Fairly concerned (4) (% Rating)	Very concerned (5) (% Rating)	Mean Rank	New Rating
A1. Acidification, eutrophication and global warming potential	3.4	24.1	**34.5**	27.6	10.3	3.17	
A2. Manure management	6.9	17.2	24.1	**41.4**	10.3	3.31	
A3. Use of pesticides in poultry feed production	13.8	24.1	**27.6**	17.2	17.2	3.00	
A4. Resource use	3.4	17.2	24.1	**34.5**	20.7	3.52	
A5. Biodiversity	10.3	13.8	**41.4**	24.1	10.3	3.10	
A6. Labour wages	13.8	24.1	**37.9**	20.7	3.4	2.76	
A7. Industry competitiveness/Farm income	3.4	6.9	27.6	**34.5**	27.6	3.76	
A8. Feed supply	6.9	3.4	34.5	**44.8**	10.3	3.48	
A9. Consumer demand	3.4	27.6	13.8	**34.5**	20.7	3.41	
A10. Role of food retailers	6.9	6.9	27.6	27.6	**31.0**	3.67	
A11. Breeding	3.4	6.9	24.1	**37.9**	27.6	3.79	
A12. Efficiency of feed conversion	17.2	13.8	13.8	**27.6**	**27.6**	3.35	
A13. Pressure on/from urban centres	6.9	13.8	**51.7**	20.7	6.9	3.07	
A14. Workers in slaughter houses	10.3	17.2	**31.0**	**31.0**	10.3	3.14	
A15. Contamination of meat and eggs with zoonotic microorganisms	10.3	24.1	17.2	20.7	**27.6**	3.31	
A16. Use of antibiotics in poultry production	3.4	3.4	24.1	6.9	**62.1**	4.21	
A17. Outbreak of avian influenza and other highly infectious diseases	3.4	10.3	27.6	**34.5**	24.1	3.66	
A18. Negative image of the poultry industry portrayed by the media	6.9	6.9	24.1	**31.0**	**31.0**	3.72	
A19. Communication between producers and consumers	0	20.7	24.1	**34.5**	20.7	3.55	
A20. Food labelling	6.9	**34.5**	**34.5**	10.3	13.8	2.90	
A21. Laws and regulations/legal framework	3.4	3.4	20.7	34.5	**37.9**	4.00	
A22. Transportation	3.4	17.2	**34.5**	**34.5**	10.3	3.31	
A23. Slaughter (procedure/process)	3.4	17.2	**44.8**	20.7	13.8	3.24	
A24. De-beaking	0	13.8	17.2	27.6	**41.4**	3.97	
A25. Killing of male layer chicks	10.3	6.9	3.4	34.5	**44.8**	3.97	
A26. Housing system	0	17.2	13.8	**34.5**	**34.5**	3.86	

*N = Number of experts

3. Based on the results of the first questionnaire, 15 more new concerning issues were proposed by the expert panellists. Descriptions of these new issues are given on the next page of this questionnaire. Based on your personal professional experience, please rate each issue (A27-A41) by entering a number in the "New Rating" column in Table 2 below using a 5-point Likert scale rating system as you did in the first questionnaire.

Table 2

Major sustainability concerns/issues in poultry production	Level of concern (1 - 5)						
	Not at all concerned (1) (% Rating)	Slightly concerned (2) (% Rating)	Somewhat concerned (3) (% Rating)	Fairly concerned (4) (% Rating)	Very concerned (5) (% Rating)	Mean Rank	New Rating
A27. Regional concentration of production/Mass production (n=3)	0	0	0	0	**100**	5	
A28. Space per animal/Stocking density (n=1)	0	0	0	0	**100**	5	
A29. Consumer responsibility (n=1)	0	0	0	0	**100**	5	
A30. Societal acceptance (n=1)	0	0	0	0	**100**	5	
A31. The role of NGOs and activist groups (n=1)	0	0	0	**100**	0	4	
A32. Lacking efforts to prevent avoidable deficiencies within the industry (n=1)	0	0	0	0	**100**	5	
A33. Excess of national production (n=1)	0	0	0	**100**	0	4	
A34. Custom growing (fattening) (n=1)	0	0	**100**	0	0	3	
A35. Poultry mortality rate (n=1)	0	0	0	0	**100**	5	
A36. Growth rate of poultry (n=2)	0	0	0	**50**	**50**	4.5	
A37. Environmental laws and regulations (n=1)	0	0	0	0	**100**	5	
A38. Rating value of foods (n=1)	0	0	0	**100**	0	4	
A39. Genetic diversity of native poultry (n=1)	0	0	0	**100**	0	4	
A40. International trade of poultry products (n=1)	0	0	0	**100**	0	4	
A41. Efficiency of using poultry by-products (n=1)	0	0	0	**100**	0	4	

*n = number of expert

4. If a concern/issue is still **not** included in the initial and revised lists, please feel free to add, describe and score the issue. You can answer either in **English** or in **German**. If you do not have any issues to add, please skip this step and continue with question 5.

New issue	Description	Level of concern				
		Not at all concerned (1)	Slightly concerned (2)	Somewhat concerned (3)	Fairly concerned (4)	Very concerned (5)
1. 2.						

5. In response to the most pressing sustainability concerns in poultry production, as identified in the first round of questionnaires, please propose solutions or make recommendations for improving the sustainability of poultry production based on your area of expertise. For this task, you can answer either in English or in German (Voluntary).

Description of the new sustainability issues in poultry production proposed by the expert panel in the first round of questionnaires

Issue	Description
A27. Regional concentration of production/Mass production	The regional concentration and increasing farm size of poultry production are also perpetuating environmental and human health risks such as changes in landscape, increased transportation, and an increasing spread of poultry diseases
A28. Space per animal/stocking density	Space in the poultry-raising facility is an important key indicator of animal welfare
A29. Consumer responsibility	Consumers prefer poultry meat and eggs from a high standard of production. Levelling the standard of production is adding the cost to producers. Thus, the product prices are increased. However, consumers still demand a lower price for poultry products. Not all consumers accept the higher price
A30. Societal acceptance	The intensive poultry industry is seen as the worst form of "factory farming"
A31. The role of NGOs and activist groups	Some NGOs and activist groups are seen as providing the media with selective "negative" reports and pictures
A32. Lacking efforts to prevent avoidable deficiencies within the industry	For example, the rate of foot lesions and cannibalism can be minimised through good management practices – a select few producers who mismanage their facilities determine the general image of the industry
A33. Excess of national poultry meat production	The excess of national poultry meat production within the country forces producers to export the remaining products to African countries
A34. Custom growing (fattening)	Farmers grow broilers or turkey for a vertically integrated company on a contract basis, which limits their decision-making capacity for the entire production facility
A35. Poultry mortality rate	The vitality of poultry during production is the most important goal for producers. Thus, the loss rate of poultry has a direct impact on their income

Description of the new sustainability issues in poultry production proposed by the expert panel in the first round of questionnaires (Continued)

Issue	Description
A36. Growth rate of poultry	Intensive rearing of fast growing breeds leads to health issues, mainly noted in an increase of leg problems
A37. Current status of environmental laws and regulations	The current legal framework of environmental laws and regulations for the poultry industry is still not strict enough
A38. Rating value of foods	People are presently rating the value of foods quite low compared to cars, clothes and holidays. Thus, it is difficult to initiate a transition towards sustainability. Convincing people to increase their spending on food is a major challenge for sustainable food production
A39. Genetic diversity of native poultry	The current poultry species bred for commercial purposes are contributing to the loss of genetic diversity amongst native poultry species
A40. International trade in poultry products	Fair trade and quality assurance are key issues related to the international trade in poultry. Equal competition conditions and differing quality standards between countries are still important issues for the poultry industry
A41. Efficiency of using poultry by-products	The use and management of poultry by-products are still not efficient enough to reduce its impact

Appendix 12: Ratings of concerning issues in the Delphi round 1 in Germany

Sustainability concerns/issues in poultry production	N	Level of concern				
		Not at all concerned (1)	Slightly concerned (2)	Somewhat concerned (3)	Fairly concerned (4)	Very concerned (5)
A1. Acidification, eutrophication and global warming potential	29	1	7	10	8	3
A2. Manure management	29	2	5	7	12	3
A3. Use of pesticides in poultry feed production	29	4	7	8	5	5
A4. Resource use	29	1	5	7	10	6
A5. Biodiversity	29	3	4	12	7	3
A6. Labour wages	29	4	7	11	6	1
A7. Industry competitiveness/Farm income	29	1	2	8	10	8
A8. Feed supply	29	2	1	10	13	3
A9. Consumer demand	29	1	8	4	10	6
A10. Role of food retailers	29	2	2	8	8	9
A11. Breeding	29	1	2	7	11	8
A12. Efficiency of feed conversion	29	5	4	4	8	3
A13. Pressure on/from urban centres	29	2	4	15	6	2
A14. Workers in slaughter houses	29	3	5	9	9	3
A15. Contamination of meat and eggs with zoonotic microorganisms	29	3	7	5	6	8
A16. Use of antibiotics in poultry production	29	1	1	7	2	18
A17. Outbreak of avian influenza and other highly infectious diseases	29	1	3	8	10	7
A18. Negative image of the poultry industry portrayed by the media	29	2	2	7	9	9
A19. Communication between producers and consumers	29	0	6	7	10	6
A20. Food labelling	29	2	10	10	3	4
A21. Introduction of new laws and regulations/legal framework	29	1	1	6	10	11
A22. Transportation	29	1	5	10	10	3
A23. Slaughter (procedure/process)	29	1	5	13	6	4
A24. De-beaking	29	0	4	5	8	12
A25. Killing of male layer chicks	29	3	2	1	10	13
A26. Housing system	29	0	5	4	10	10
A27. Regional concentration of production/Mass production	3	.	.	.	.	3
A28. Space per animal/Stocking density	1	.	.	.	.	1
A29. Consumer responsibility	1	.	.	.	.	1
A30. Societal acceptance	1	.	.	.	.	1
A31. The role of NGOs and activist groups	1	.	.	.	1	.
A32. Lacking efforts to prevent avoidable deficiencies within the industry	1	.	.	.	.	1
A33. Excess of national poultry meat production	1	.	.	.	1	.
A34. Custom growing (fattening)	1	.	.	1	.	.
A35. Poultry mortality rate	1	.	.	.	.	1
A36. Growth rate of poultry	2	.	.	.	1	1
A37. Current status of environmental laws and regulations	1	.	.	.	.	1
A38. Rating value of foods	1	.	.	.	1	.
A39. Genetic diversity of native poultry	1	.	.	.	1	.
A40. International trade in poultry products	1	.	.	.	1	.
A41. Efficiency of using poultry by-products	1	.	.	.	1	.

Appendix 13: Ratings of concerning issues in the Delphi round 2 in Germany

Sustainability concerns/issues in poultry production	Level of concern (N=26)				
	Not at all concerned (1)	Slightly concerned (2)	Somewhat concerned (3)	Fairly concerned (4)	Very concerned (5)
A1. Acidification, eutrophication and global warming potential	0	7	10	6	3
A2. Manure management	1	6	3	12	4
A3. Use of pesticides in poultry feed production	1	9	6	5	5
A4. Resource use	0	1	6	11	8
A5. Biodiversity	0	2	12	8	4
A6. Labour wages	1	5	11	8	1
A7. Industry competitiveness/Farm income	0	3	10	9	4
A8. Feed supply	1	3	6	16	0
A9. Consumer demand	1	7	4	9	5
A10. Role of food retailers	0	1	4	8	13
A11. Breeding	1	1	8	9	7
A12. Efficiency of feed conversion	4	3	5	10	4
A13. Pressure on/from urban centres	3	6	11	4	2
A14. Workers in slaughter houses	1	2	7	14	2
A15. Contamination of meat and eggs with zoonotic microorganisms	3	2	9	4	8
A16. Use of antibiotics in poultry production	1	0	3	3	19
A17. Outbreak of avian influenza and other highly infectious diseases	0	2	5	15	4
A18. Negative image of the poultry industry portrayed by the media	2	3	3	8	10
A19. Communication between producers and consumers	0	3	6	12	5
A20. Food labelling	2	11	6	4	3
A21. Introduction of new laws and regulations/legal framework	1	4	3	7	11
A22. Transportation	0	3	13	9	1
A23. Slaughter (procedure/process)	0	3	15	5	3
A24. De-beaking	1	1	5	7	12
A25. Killing of male layer chicks	1	0	0	8	17
A26. Housing system	0	4	2	13	7
A27. Regional concentration of production/Mass production	0	3	5	6	12
A28. Space per animal/Stocking density	0	2	8	6	10
A29. Consumer responsibility	0	2	10	7	7
A30. Societal acceptance	1	1	5	11	8
A31. The role of NGOs and activist groups	4	1	5	8	8
A32. Lacking efforts to prevent avoidable deficiencies within the industry	1	4	6	10	5
A33. Excess of national poultry meat production	3	6	6	8	3
A34. Custom growing (fattening)	5	9	7	4	1
A35. Poultry mortality rate	1	3	11	5	6
A36. Growth rate of poultry	0	5	7	6	8
A37. Current status of environmental laws and regulations	3	3	7	5	8
A38. Rating value of foods	0	1	9	10	6
A39. Genetic diversity of native poultry	4	4	6	7	5
A40. International trade in poultry products	0	6	6	10	4
A41. Efficiency of using poultry by-products	1	6	7	9	3

Appendix 14: Results of the Delphi round 2 identified by researchers in Germany

Sustainability concerns/issues in poultry production	N = 6	
	Mean	Standard deviation
Killing of male layer chicks	5.00	0.00
Use of antibiotics in poultry production	4.67	0.52
Housing system	4.50	0.55
Role of food retailers	4.50	0.55
Communication between producers and consumers	4.33	0.82
Rating value of foods	4.17	0.75
Poultry mortality rate	4.17	0.98
Lacking efforts to prevent avoidable deficiencies within the industry	4.00	1.10
Societal acceptance	4.00	1.55
Space per animal/Stocking density	4.00	0.89
Regional concentration of production/Mass production	4.00	1.10
Contamination of meat and eggs with zoonotic microorganisms	4.00	1.26
Workers in slaughter houses	4.00	0.00
Manure management	4.00	1.10
De-beaking	3.83	1.60
International trade in poultry products	3.83	0.75
Outbreak of avian influenza and other highly infectious diseases	3.83	0.41
Efficiency of feed conversion	3.83	0.98
Consumer responsibility	3.67	0.82
Food labelling	3.67	1.37
Negative image of the poultry industry portrayed by the media	3.67	1.51
Resource use	3.67	1.03
Efficiency of using poultry by-products	3.50	1.05
The role of NGOs and activist groups	3.50	1.38
Transportation	3.50	0.55
Breeding	3.50	0.84
Consumer demand	3.50	1.64
Biodiversity	3.50	0.55
Use of pesticides in poultry feed production	3.50	1.22
Environmental laws and regulations	3.33	1.21
Growth rate of poultry	3.33	0.82
Slaughter (procedure/process)	3.33	0.52
Industry competitiveness/Farm income	3.33	0.82
Labour wages	3.17	1.17
Excess of national poultry meat production	3.17	1.47
Genetic diversity of native poultry	3.00	1.41
Laws and regulations/legal framework	3.00	1.55
Feed supply	3.00	1.26
Acidification, eutrophication and global warming potential	3.00	0.89
Pressure on/from urban centres	2.83	1.33
Custom growing (fattening)	2.00	0.89
Kendall's coefficient of concordance (W)	0.281	

Appendix 15: Results of the Delphi round 2 identified by the private sector in Germany

Sustainability concerns/issues in poultry production	N = 9	
	Mean	Standard deviation
Negative image of the poultry industry portrayed by the media	4.44	0.73
Use of antibiotics in poultry production	4.44	0.88
Laws and regulations/legal framework	4.33	0.87
Role of food retailers	4.33	0.71
Environmental laws and regulations	4.11	0.93
The role of NGOs and activist groups	4.11	0.93
Societal acceptance	4.11	0.60
Killing of male layer chicks	4.00	1.22
Communication between producers and consumers	3.78	0.83
Resource use	3.78	0.67
Efficiency of feed conversion	3.78	1.20
Consumer responsibility	3.67	1.12
De-beaking	3.67	1.00
Breeding	3.67	1.32
Industry competitiveness/Farm income	3.67	0.71
Space per animal/Stocking density	3.56	1.01
Regional concentration of production/Mass production	3.56	1.01
Outbreak of avian influenza and other highly infectious diseases	3.56	0.88
Rating value of foods	3.44	0.88
Feed supply	3.44	0.73
Biodiversity	3.44	1.01
Growth rate of poultry	3.33	1.32
Workers in slaughter houses	3.22	0.83
Pressure on/from urban centres	3.22	0.83
Consumer demand	3.22	1.20
Transportation	3.11	0.60
Housing system	3.11	1.17
Lacking efforts to prevent avoidable deficiencies within the industry	3.00	1.00
Genetic diversity of native poultry	3.00	1.12
Slaughter (procedure/process)	3.00	0.71
Contamination of meat and eggs with zoonotic microorganisms	3.00	1.50
Manure management	3.00	0.87
Efficiency of using poultry by-products	2.89	0.93
Labour wages	2.89	0.60
Acidification, eutrophication and global warming potential	2.89	0.60
Poultry mortality rate	2.78	0.97
Use of pesticides in poultry feed production	2.78	1.09
Excess of national poultry meat production	2.67	1.00
International trade in poultry products	2.67	0.71
Custom growing (fattening)	2.33	1.00
Food labelling	2.33	0.87
Kendall's coefficient of concordance (W)	0.338	

Appendix 16: Results of the Delphi round 2 identified by government officials in Germany

Sustainability concerns/issues in poultry production	N = 7	
	Mean	Standard deviation
Killing of male layer chicks	4.71	0.49
De-beaking	4.43	0.79
Laws and regulations/legal framework	4.29	0.76
Housing system	4.29	0.76
Regional concentration of production/Mass production	4.14	1.21
Use of antibiotics in poultry production	4.14	1.57
Industry competitiveness/Farm income	4.14	0.90
Resource use	4.14	0.90
Role of food retailers	4.00	1.00
Space per animal/Stocking density	3.86	1.21
Outbreak of avian influenza and other highly infectious diseases	3.86	1.07
Breeding	3.71	0.76
Rating value of foods	3.71	0.76
Societal acceptance	3.71	1.11
Consumer responsibility	3.71	1.11
Negative image of the poultry industry portrayed by the media	3.71	1.38
Feed supply	3.71	0.49
International trade in poultry products	3.57	1.13
Growth rate of poultry	3.57	0.98
Communication between producers and consumers	3.57	0.98
The role of NGOs and activist groups	3.57	1.62
Lacking efforts to prevent avoidable deficiencies within the industry	3.43	1.13
Workers in slaughter houses	3.29	1.25
Consumer demand	3.29	0.95
Slaughter (procedure/process)	3.14	0.90
Contamination of meat and eggs with zoonotic microorganisms	3.14	1.21
Efficiency of using poultry by-products	3.14	1.35
Poultry mortality rate	3.14	0.69
Labour wages	3.14	1.21
Manure management	3.14	1.46
Transportation	3.00	0.82
Biodiversity	3.00	0.00
Acidification, eutrophication and global warming potential	3.00	1.15
Environmental laws and regulations	2.86	1.46
Genetic diversity of native poultry	2.71	1.50
Excess of national poultry meat production	2.71	1.11
Use of pesticides in poultry feed production	2.71	1.25
Efficiency of feed conversion	2.57	1.51
Food labelling	2.43	0.53
Custom growing (fattening)	2.29	0.95
Pressure on/from urban centres	2.29	0.95
Kendall's coefficient of concordance (W)	0.308	

Appendix 17: Invitation letter (Thailand)

Universität Vechta
University of Vechta

wing
Wissenschafts- und Informationszentrum
Nachhaltige Geflügelwirtschaft

Universität Vechta · Postfach 1553 · D-49364 Vechta

Sakson Soisontes
Wissenschafts- und Informationszentrum
Nachhaltige Geflügelwirtschaft – WING
Universität Vechta
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Telefon +49.(0).4441.15 171
Fax +49.(0).4441.15 67 168
E-Mail: ssoisontes@wing.uni-vechta.de

Invitation to participate in a Delphi study on sustainability concerns in poultry production

Dear…….,

The research project "Nachhaltige Geflügelwirtschaft – Sustainable Poultry Production" is run by the Science and Information Centre for Sustainable Poultry Production (Wissenschafts- und Informationszentrum Nachhaltige Geflügelwirtschaft – WING), University of Vechta. The project aims to highlight opportunities to increase the sustainability of poultry production in Thailand. I am a Ph.D. candidate at the University of Vechta and this study is part of my doctoral thesis under the supervision of Prof. Dr. Hans-Wilhelm Windhorst.

The survey focuses on identifying the main sustainability concerns society has raised regarding the sustainability of poultry production. This study will ultimately develop guidelines for improving the sustainability of poultry production.

Your experience in poultry production/industry is very valuable to this research. This survey will involve approximately 40 experts in Thailand.

A Delphi study is a research method that allows a group of experts to participate jointly, yet also anonymously, in defining and analysing a complex problem or issue. This Delphi study will consist of two rounds of questionnaires distributed electronically. Members of the panel therefore do not meet up in person at any time during the process. In each round, a questionnaire is sent to you and you will be asked to email it back within 10 days. The timeframe for each round is approximately 15 minutes. Please find the timetable below.

In return for your cooperation, the final report of this survey will be provided to you.

If you would like to join the expert panel, please confirm your participation **BEFORE 18 August 2014**. Please also inform me if you would like to decline this invitation to participate or would like to suggest another expert with experience in and perspectives on the poultry industry. If you have any questions please do not hesitate to contact me using the contact details provided below.

I look forward to your participation and thank you kindly for your time.

Yours sincerely,

Sakson Soisontes
Reseacher/PhD candidate

Prof. Dr. Hans-Wilhelm Windhorst
Supervisor

Contact details:

Sakson Soisontes
Wissenschafts- und Informationszentrum Nachhaltige Geflügelwirtschaft – WING
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E-Mail: ssoisontes@wing.uni-vechta.de

Timetable Delphi study

18.08.2014	Deadline registration expert panel
19.08.2014	Start Round 1
09.09.2014	Deadline Round 1
15.09.2014	Start Round 2
25.10.2014	Deadline Round 2
November 2014	Final report

Appendix 18: List of participating experts in the Delphi study in Thailand

Name	Organisation
1. Assoc. Prof. Dr. Supaporn Isariyodom	Faculty of Agriculture, Kasetsart University, Bangkok, Thailand
2. Assoc. Prof. Dr.Voravit Siripholvat	Faculty of Innovative Agricultural Management, Panyapiwat Institute of Management, Nonthaburi, Thailand
3. Asst. Prof. Dr. Ornprapun Songserm	Faculty of Agriculture at Kamphaengsaen, Kasetsart University, Kamphaengsaen Campus, Nakhon Pathom, Thailand
4. Assoc. Prof. Dr. Suphachai Nuanualsuwan	Faculty of Veterinary Science, Chulalongkorn University, Bangkok, Thailand
5. Asst. Prof. Suwicha Kasemsuwan	Faculty of Veterinary Medicine, Kasetsart University, Kamphaengsaen Campus, Nakhon Pathom, Thailand
6. Assoc. Prof. Dr. Kan Suksupath	Faculty of Agricultural Technology , King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand
7. Assoc. Prof. Dr. Monticha Putsakum	School of Agricultural Extension and Cooperatives, Sukhothai Thammathirat Open University, Nonthaburi, Thailand
8. Asst. Prof. Orawan Chinrasri	Faculty of Technology, Mahasarakham University, Mahasarakham, Thailand
9. Asst. Prof. Dr. Surawat Chalorsantisakul	Faculty of Animal Science and Agricultural Technology, Silpakorn University, Phetchaburi IT Campus, Phetchaburi, Thailand
10. Asst. Prof. Dr. Charunee Kasonpikul	Faculty of Animal Science and Agricultural Technology, Silpakorn University, Phetchaburi IT Campus, Phetchaburi, Thailand
11. Assoc. Prof. Dr. Sukit Khantaprab	Faculty of Animal science and Technology, Meajo University, Chiangmai, Thailand
12. Asst. Prof. Dr. Kamlang Chumpolbanchorn	Faculty of Veterinary Science, Mahidol University, Salaya Campus, Nakhon Pathom, Thailand
13. Asst. Prof. Dr. Banchorn Likitdecharote	Institute of Agricultural Technology, Suranaree University of Technology, Nakhon Ratchasima, Thailand
14. Assoc. Prof. Terdsak Khammeng	Faculty of Agriculture, Khon Kaen University, Khon Kaen, Thailand
15. Asst. Prof. Dr. Yupin Phasuk	Faculty of Agriculture, Khon Kaen University, Khon Kaen, Thailand
16. Asst. Prof. Dr. Wuttigrai Boonkum	Faculty of Agriculture, Khon Kaen University, Khon Kaen, Thailand
17. Dr. Sawitree Wongtangtintharn	Faculty of Agriculture, Khon Kaen University, Khon Kaen, Thailand
18. Asst. Prof. Sajee Kunharing	Faculty of Agriculture, Khon Kaen University, Khon Kaen, Thailand

Appendix 18: List of participating experts in the Delphi study in Thailand (Continued)

Name	Organisation
19. Asst. Prof. Dr. Niwat Muangkeow	School of Agricultural Technology, Walailak University, Nakhon Si Thammarat, Thailand
20. Dr. Thanakrid Luupanyalerd	Elanco Animal Health, Nonthaburi, Thailand
21. Suchai Charoenpongsuk	Thai Foods Group Company Limited, Bangkok, Thailand
22. Sirada Luewattananon	Thai Foods Group Company Limited, Bangkok, Thailand
23. Vimonrat Premsiri	Thai Broiler Processing Exporters Association, Bangkok, Thailand
24. Seree Bhobhakdee	Betagro-Group, Bangkok, Thailand
25. Pramote Rutavepol	Charoen Pokphand Foods Public Company Limited (CPF), Bangkok, Thailand
26. Weerapong Thanapongtharm	Bureau of Disease Control and Veterinary Services, Department of Livestock Development, Ministry of Agriculture and Cooperatives, Bangkok, Thailand
27. Amnuay Leotaragul	Chiangmai Animal Husbandry and Research Centre, Department of Livestock Development, Ministry of Agriculture and Cooperatives, Chiangmai, Thailand
28. Dr. Pennapa Matayompong	Bureau of Livestock Standards and Certification, Department of Livestock Development, Ministry of Agriculture and Cooperatives, Bangkok, Thailand
29. Dr. Nutcharnart Tipmongkolsilp	Bureau of Livestock Standards and Certification, Department of Livestock Development, Ministry of Agriculture and Cooperatives, Bangkok, Thailand
30. Dr. Philaiphon Chetiyawan	Veterinary Research and Development Centre (Western Region), Department of Livestock Development, Ministry of Agriculture and Cooperatives, Ratchaburi, Thailand
31. Dr. Chaivat Vitoorakool	Veterinary Research and Development Centre (Upper Northern Region), Department of Livestock Development, Ministry of Agriculture and Cooperatives, Lampang, Thailand
32. Darunee Sopa	Poultry Research and Development Section, Bureau of Animal Husbandry and Genetic Improvement, Department of Livestock Development, Ministry of Agriculture and Cooperatives, Bangkok, Thailand
33. Dr. Arux Chaiyakul	Department of Livestock Development, Ministry of Agriculture and Cooperatives, Bangkok, Thailand

Appendix 19: Delphi study on sustainability concerns in poultry production in Thailand

The first round of questionnaires

การศึกษาความยั่งยืนของอุตสาหกรรมการผลิตสัตว์ปีกในประเทศไทยโดยวิธี Delphi
Delphi study on sustainability concerns in poultry production in Thailand

แบบสอบถามรอบแรก

คำชี้แจง

1. วัตถุประสงค์หลักของการศึกษาครั้งนี้คือการวิเคราะห์ประเด็นสำคัญต่างๆ ที่เกี่ยวข้องกับการผลิตสัตว์ปีกอย่างยืน ว่ามีประเด็นใดบ้างที่ยังเป็นที่วิตกกังวลต่ออุตสาหกรรมการผลิตสัตว์ปีกในประเทศไทย
2. คำจำกัดความ ความยั่งยืน (sustainability) ในงานวิจัยชุดนี้คือ ระบบการผลิตสัตว์ปีกที่คำนึงถึงประเด็นต่างๆ ห้าประเด็นที่เกี่ยวข้องกับความยั่งยืน ได้แก่ ด้านสิ่งแวดล้อม (environment) เศรษฐกิจ (economics) สังคม (society) การเมือง (politics) และสวัสดิภาพสัตว์ (animal welfare)
3. แบบสอบถามชุดแรกนี้ ประกอบด้วย **41 ประเด็นหลัก** (A1-A41) ที่เกี่ยวข้องกับการผลิตสัตว์ปีกอย่างยั่งยืน ครอบคลุมด้านสิ่งแวดล้อม (environment) เศรษฐกิจ (economics) สังคม (society) การเมือง (politics) และสวัสดิภาพสัตว์ (animal welfare)
4. คำอธิบายในแต่ละประเด็น (A1-A41) อยู่ในไฟล์ข้อมูลอีกฉบับที่แนบมากับอีเมลนี้
5. หลังจากกรอกคำตอบ (**หน้า 2-4**) ในแบบสอบถามชุดนี้เสร็จแล้ว กรุณาบันทึกข้อมูลแล้วส่งไฟล์ชุดนี้กลับมายัง ssoisontes@wing.uni-vechta.de ภายในวันที่ **9 กันยายน พ.ศ. 2557**

ชุดคำถาม

1. จากประสบการณ์ของท่าน จงให้น้ำหนักคะแนนในแต่ละประเด็น A1-A41 โดยการพิมพ์ตัวเลขลงไปในตารางในหน้าที่ 2 ของแบบสอบถามชุดนี้ โดยใช้ระบบคะแนน จาก 1 ถึง 5 ซึ่งท่านสามารถให้คะแนนจากระดับ 1 หากประเด็นนั้นไม่เป็นที่กังวลสำหรับอุตสาหกรรมการผลิตสัตว์ปีกในเทศไทย ถึงระดับ 5 หากประเด็นนั้นเป็นที่กังวลสำหรับอุตสาหกรรมการผลิตสัตว์ปีกในประเทศไทยเป็นอย่างมาก ขึ้นอยู่กับว่าท่านพิจารณาแต่ละประเด็นอย่างไร ประเด็นที่เป็นที่กังวลมากกว่าก็จะได้รับคะแนนมากกว่า
2. ถ้าหากท่านมีคำชี้แนะเพิ่มเติมเกี่ยวกับ 41 ประเด็นหลัก ที่เกี่ยวข้องกับการผลิตสัตว์ปีกอย่างยั่งยืน กรุณาแสดงความคิดเห็นในข้อนี้ แต่ถ้าหากท่านไม่มี ขอให้ข้ามคำถามข้อนี้ไป
3. ถ้าประเด็นที่เกี่ยวข้องกับการผลิตสัตว์ปีกในประเทศไทยไม่ได้รวมอยู่ใน 41 ประเด็นที่ส่งให้ ท่านสามารถเสนอเพิ่มเติมได้ พร้อมคำอธิบายสั้นๆ และให้น้ำหนักคะแนนระดับความกังวลสำหรับประเด็นที่เสนอมาด้วย ถ้าหากไม่มี ขอให้ข้ามคำถามข้อนี้ไป

……

ตัวอย่างการตอบคำถามสำหรับข้อ 1

ความหมายของระดับความกังวลในระบบเสกล 1 – 5

1 – ประเด็นนี้ไม่เป็นที่กังวล (not at all concerning issue)
2 – ประเด็นนี้เป็นที่กังวลเล็กน้อย (slightly concerning issue)
3 – ประเด็นนี้เป็นที่กังวลปานกลาง (somewhat concerning issue)
4 – ประเด็นนี้ค่อนข้างเป็นที่กังวลมาก (fairly concerning issue)
5 – ประเด็นนี้เป็นที่กังวลอย่างมาก (very concerning issue)

ประเด็นหลักที่เกี่ยวข้องกับอุตสาหกรรมการผลิตสัตว์ปีก	ระดับความกังวล (1-5)
A1. ก่อให้เกิดสภาวะกรด (Acidification) การเจริญเติบโตที่รวดเร็วของพืชและสาหร่าย (eutrophication) และสภาวะโลกร้อน (global warming)	3
A2. การจัดการมูลไก่ (manure management)	4

โปรดให้คะแนนระดับความกังวลของแต่ละประเด็นในช่องนี้

1. จงให้น้ำหนักคะแนนในแต่ละประเด็น A1-A41 โดยการพิมพ์ตัวเลขลงไปในช่อง**ระดับความกังวล**ในตารางที่ 1 ด้านล่าง โดยใช้ระบบคะแนนระบุระดับความกังวล จาก 1 ถึง 5 ตามคำอธิบายในตัวอย่างบนหน้าแรก ท่านสามารถให้คะแนนจากระดับ **1** หากประเด็นนั้นไม่เป็นที่กังวลสำหรับอุตสาหกรรมการผลิตสัตว์ปีกในประเทศไทย ถึงระดับ **5** หากประเด็นนั้นเป็นที่กังวลสำหรับอุตสาหกรรมการผลิตสัตว์ปีกในประเทศไทยเป็นอย่างมาก ขึ้นอยู่กับว่าท่านพิจารณาแต่ละประเด็นอย่างไร ประเด็นที่เป็นที่กังวลมากกว่าก็จะได้รับคะแนนมากกว่า

ตารางที่ 1

ประเด็นหลักที่เกี่ยวข้องกับอุตสาหกรรมการผลิตสัตว์ปีก	ระดับความกังวล (1-5)
A1. ก่อให้เกิดสภาวะกรด (acidification) การเจริญเติบโตที่รวดเร็วของพืชและสาหร่าย (eutrophication) และสภาวะโลกร้อน (global warming)	
A2. การจัดการมูลไก่ (manure management)	
A3. การใช้สารกำจัดศัตรูพืชในการผลิตพืชอาหารสัตว์ (use of pesticides in poultry feed production)	
A4. การใช้ทรัพยากรณ์เพื่อการผลิตสัตว์ปีก เช่น น้ำ ไฟฟ้า ที่ดิน เป็นต้น (resource use)	
A5. ความหลากหลายทางชีวภาพในพื้นที่ที่ปลูกพืชเชิงเดี่ยวเพื่อเป็นอาหารสัตว์ (biodiversity)	
A6. ค่าจ้างแรงงาน (labour wages)	
A7. ความสามารถในการแข่งขันของอุตสาหกรรมสัตว์ปีกและ/หรือ รายได้ของฟาร์มผู้ผลิต (industry competitiveness/farm income)	
A8. อุปทานหรือปริมาณอาหารสัตว์ที่มี เพื่อสนองความต้องการในภาคการผลิต (feed supply)	
A9. อุปสงค์หรือความต้องการของผู้บริโภค (consumer demand)	
A10. บทบาทของห้างผู้ค้าปลีก (role of food retailers)	
A11. การปรับปรุงพันธุ์ไก่ (breeding)	
A12. ประสิทธิภาพการใช้อาหารสัตว์ของไก่ (efficiency of feed conversion)	
A13. สร้างความกดดันต่อบริเวณชุมชนที่อยู่อาศัย (pressure on/from urban centres)	
A14. สวัสดิภาพของแรงงานในโรงเชือดหรือโรงฆ่า (worker's welfare in slaughter houses)	
A15. การปนเปื้อนของเชื้อโรคที่สามารถติดต่อจากสัตว์สู่คนในเนื้อสัตว์ปีก และไข่ (contamination of meat and eggs with zoonotic microorganisms)	
A16. การใช้ยาปฏิชีวนะในการผลิตไก่ (use of antibiotics in poultry production)	
A17. การระบาดของเชื้อไข้หวัดนก และโรคติดต่อร้ายแรงชนิดอื่นในสัตว์ปีก (outbreak of avian influenza and other highly infectious diseases)	
A18. การเสนอข่าวในเชิงลบต่ออุตสาหกรรมสัตว์ปีก ของสื่อต่างๆ (negative image of the poultry industry portrayed by the media)	
A19. การสื่อสารระหว่างผู้ผลิตและผู้บริโภค (communication between producers and consumers)	
A20. ฉลากที่ระบุข้อมูลผลิตภัณฑ์สัตว์ปีก (food labelling)	
A21. การออกกฎหมายและข้อปฏิบัติใหม่ๆ เพื่อควบคุมการผลิตสัตว์ปีก (introduction of new laws and regulations/legal framework)	
A22. สวัสดิภาพของไก่เนื้อในระหว่างการขนส่งจากฟาร์มไปยังโรงฆ่า (transportation)	
A23. วิธีการชำแหละ หรือกระบวนการที่ใช้ในการชำแหละไก่เนื้อ (slaughter procedure/process)	
A24. การตัดจงอยปากซึ่งส่งผลต่อสวัสดิภาพของไก่ไข่ (de-beaking)	

โปรดให้คะแนนระดับความกังวลของแต่ละประเด็นในช่องนี้

ตารางที่ 1 (ต่อ)

ประเด็นหลักที่เกี่ยวข้องกับอุตสาหกรรมการผลิตสัตว์ปีก	ระดับความกังวล (1-5)
A25. การฆ่าลูกไก่เพศผู้ในไก่ไข่ ซึ่งเกี่ยวข้องกับปัญหาทางด้านจริยธรรม (killing of male layer chicks)	
A26. ระบบโรงเรือนที่ใช้เลี้ยงไก่ (housing system)	
A27. การกระจุกตัวอย่างหนาแน่นของฟาร์มเลี้ยงไก่ในบริเวณใดบริเวณหนึ่ง (regional concentration of production/mass production)	
A28. พื้นที่ในโรงเรือนต่อไก่หนึ่งตัว หรือความหนาแน่นของประชากรไก่ต่อฟาร์ม (space per animal/stocking density)	
A29. การมีความรับผิดชอบของผู้บริโภค (consumer responsibility)	
A30. การยอมรับจากสังคมที่มีต่ออุตสาหกรรมการผลิตไก่ (societal acceptance)	
A31. บทบาทขององค์กรอิสระและกลุ่มส่งเสริมสวิสดิภาพสัตว์ (the role of NGOs and activist groups)	
A32. ขาดความพยายามหาทางป้องกันปัญหาที่สามารถหลีกเลี่ยงได้ภายในอุตสาหกรรมการผลิตสัตว์ปีก (lacking efforts to prevent avoidable deficiencies within the industry)	
A33. ปริมาณการผลิตที่มากเกินไปภายในประเทศ (excess of national production)	
A34. การผลิตไก่เนื้อและไก่ไข่ของเกษตรกร ภายใต้สัญญาที่ทำกับบริษัทแม่ (custom growing)	
A35. อัตราการตายของไก่ในระหว่างการเลี้ยง (poultry mortality rate)	
A36. การเร่งการเจริญเติบโตของไก่ที่เร็วเกินไป (growth rate of poultry)	
A37. สถานะของกฎหมายและข้อปฏิบัติด้านสิ่งแวดล้อมที่เกี่ยวข้องกับการเลี้ยงไก่ในปัจจุบัน (current status of environmental laws and regulations)	
A38. การประเมินค่าอาหารที่ยังต่ำเมื่อเปรียบเทียบกับรถยนต์หรือการท่องเที่ยว (rating value of foods)	
A39. ความหลายหลายของพันธุ์ไก่พื้นเมืองในปัจจุบัน (genetic diversity of native poultry)	
A40. ความเป็นธรรมของการค้าระหว่างประเทศของผลิตภัณฑ์สัตว์ปีก (international trade in poultry products)	
A41. ประสิทธิภาพการใช้ประโยชน์จากของเสียที่เหลือจากซากไก่ (efficiency of using poultry by-products)	

โปรดให้คะแนนระดับความกังวลของแต่ละประเด็นในช่องนี้

2. ถ้าหากท่านมีคำชี้แนะเพิ่มเติมเกี่ยวกับ 41 ประเด็นหลัก ที่เกี่ยวข้องกับการผลิตสัตว์ปีกอย่างยั่งยืน กรุณาแสดงความคิดเห็นในข้อนี้ แต่ถ้าหากท่านไม่มี ขอให้ข้ามคำถามข้อนี้ไป

3. ถ้าประเด็นที่เกี่ยวข้องกับการผลิตสัตว์ปีกในประเทศไทยไม่ได้รวมอยู่ใน 41 ประเด็นที่ส่งให้ ท่านสามารถเสนอเพิ่มเติมได้ พร้อมคำอธิบายสั้นๆ และให้น้ำหนักคะแนนระดับความกังวลสำหรับประเด็นที่เสนอมาด้วย ถ้าหากไม่มี ขอให้ข้ามคำถามข้อนี้ไป

ประเด็นใหม่	คำอธิบาย	ระดับความกังวล (1-5)
1.		
2.		
3.		

Description of sustainability issues in poultry production cited in the scientific literature and reports (Thai)

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ประเด็น	คำอธิบาย
A1. ก่อให้เกิดสภาวะกรด (acidification) การเจริญเติบโตที่รวดเร็วของพืชและสาหร่าย (eutrophication) และสภาวะโลกร้อน (global warming)	การระเหยของแก๊สแอมโมเนียและการชะล้างของแร่ธาตุจากบริเวณฟาร์มเลี้ยงไก่ก่อให้เกิดสภาวะกรด (acidification) การเจริญเติบโตที่รวดเร็วของพืชและสาหร่าย (eutrophication) และสภาวะโลกร้อน (global warming) ซึ่งการระเหยของแก๊สแอมโมเนียนั้นยังส่งผลต่อการผุกร่อนของโครงหลังคาเหล็ก และหลังคาสังกะสีของโรงเรือน ทำให้อายุการใช้งานของโรงเรือนสั้นลง
A2. การจัดการมูลไก่ (manure management)	ถึงแม้มูลไก่เนื้อที่เกิดจากการเลี้ยงไก่สามารถนำไปเป็นปุ๋ยต้นไม้ และมูลไก่ไข่เป็นอาหารปลาได้ แต่ถ้าหากการจัดการยังไม่มีประสิทธิภาพจะเป็นการสร้างมลภาวะต่อสิ่งแวดล้อมเนื่องจากการระเหยของแก๊สเรือนกระจก และการชะล้างของแร่ธาตุจากฟาร์มไปสู่แหล่งน้ำต่างๆ ตามธรรมชาติ
A3. การใช้สารกำจัดศัตรูพืชในการผลิตพืชอาหารสัตว์ (use of pesticides in poultry feed production)	การใช้สารกำจัดศัตรูพืชในการผลิตพืชอาหารสัตว์ เช่น ในการผลิตถั่วเหลือง ส่งผลกระทบต่อสุขภาพของเกษตรกรหรือผู้อยู่อาศัยบริเวณใกล้เคียง แมลง และสิ่งมีชีวิตในดิน เป็นต้น
A4. การใช้ทรัพยากรณ์เพื่อการผลิตสัตว์ปีก เช่น น้ำ ไฟฟ้า ที่ดิน เป็นต้น (resource use)	การผลิตเนื้อไก่และไข่นั้น ต้องมีการใช้พลังงาน น้ำ และพื้นที่สำหรับเลี้ยง ซึ่งอาจก่อให้เกิดการสิ้นเปลืองทรัพยากรณ์ ถ้าหากการจัดการไม่ดีพอ
A5. ความหลากหลายทางชีวภาพในพื้นที่ที่ปลูกพืชเชิงเดี่ยวเพื่อเป็นอาหารสัตว์ (biodiversity)	การผลิตพืชอาหารสัตว์เชิงเดี่ยวนั้นส่งผลต่อการลดจำนวนของแมลงที่เป็นประโยชน์ลง และสิ่งมีชีวิตในดินในบริเวณนั้น
A6. ค่าจ้างแรงงาน (labour wages)	ความต้องการเพิ่มค่าแรงขั้นต่ำของแรงงานในภาคอุตสาหกรรมการผลิตไก่นั้นส่งผลกระทบโดยตรงต่ออุตสาหกรรมสัตว์ปีก
A7. ความสามารถในการแข่งขันของอุตสาหกรรมสัตว์ปีกและ/หรือ รายได้ของฟาร์มผู้ผลิต (industry competitiveness/farm income)	ต้นทุนที่สูงขึ้นในการผลิต ราคาของผลิตภัณฑ์ในตลาด และความสามารถในการเจาะตลาดต่างๆ นั้นเป็นความท้าทายของอุตสาหกรรมสัตว์ปีก
A8. อุปทานหรือปริมาณอาหารสัตว์ที่มี เพื่อสนองความต้องการในภาคการผลิต (feed supply)	การที่ต้องพึ่งพาการนำเข้าอาหารสัตว์ในปริมาณมากจากต่างประเทศ นั้นเป็นปัจจัยสำคัญปัจจัยหนึ่งที่ส่งผลกระทบโดยตรงต่อการพัฒนาอุตสาหกรรมสัตว์ปีกในประเทศไทย เช่น ต้นทุนการผลิต เป็นต้น
A9. อุปสงค์หรือความต้องการของผู้บริโภค (consumer demand)	คือความต้องการของผู้บริโภคที่มีต่อผลิตภัณฑ์เนื้อไก่และไข่ เช่นผลิตภัณฑ์ที่คำนึงถึงสวัสดิภาพสัตว์ และหรือที่ใช้ยาปฏิชีวนะในการผลิตน้อยหรือไม่ใช้เลย

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ประเด็น	คำอธิบาย
A10. บทบาทของห้างผู้ค้าปลีก (role of food retailers)	ห้างผู้ค้าปลีกจัดจำหน่ายผลิตภัณฑ์ตามความต้องการของผู้บริโภคเป็นหลัก ซึ่งห้างผู้ค้าปลีกนั้นเป็นผู้กำหนดชนิดและประเภทของผลิตภัณฑ์เนื้อไก่และไข่และกระทบโดยตรงต่อจำนวนทางเลือกของผู้บริโภค
A11. การปรับปรุงพันธุ์ไก่ (breeding)	เนื่องจากประเทศไทยยังไม่มีการผลิตสายพันธุ์ไก่เนื้อและไก่ไข่ขึ้นเอง จึงต้องพึ่งพาการนำเข้าจากต่างประเทศ หากมีปัญหาจะส่งผลกระทบต่ออุตสาหกรรมการผลิตไก่เนื้อและไข่ของไทย ดังนั้นจึงควรสนับสนุนให้มีการวิจัยและพัฒนาสายพันธุ์ที่เหมาะสมสำหรับภูมิอากาศในประเทศไทย
A12. ประสิทธิภาพการใช้อาหารสัตว์ของไก่ (efficiency of feed conversion)	อัตราการใช้อาหารเพื่อเปลี่ยนไปเป็นเนื้อของไก่นั้น ส่งผลกระทบโดยตรงต่อต้นทุนการผลิตและปริมาณการปลดปล่อยแก๊สแอมโมเนียจากฟาร์มไก่
A13. สร้างความกดดันต่อบริเวณชุมชนที่อยู่อาศัย (pressure on/from urban centres)	ความหนาแน่นของฟาร์มไก่รอบๆ บริเวณชุมชนที่อยู่อาศัย มีผลกระทบโดยตรงต่อการใช้ที่ดินและการขยายหรือลดขนาดของชุมชน
A14. สวัสดิภาพของแรงงานในโรงเชือดหรือโรงฆ่า (worker's welfare in slaughter houses)	การนำเข้าแรงงานราคาถูกจากประเทศเพื่อนบ้านเพื่อมาทำงานในภาคการผลิตสัตว์ปีก นั้นเป็นประเด็นที่ถกเถียงเกี่ยวกับสวัสดิภาพความเป็นอยู่ของแรงงานเหล่านั้น
A15. การปนเปื้อนของเชื้อโรคที่สามารถติดต่อจากสัตว์สู่คนในเนื้อสัตว์ปีก และไข่ (contamination of meat and eggs with zoonotic microorganisms)	การปนเปื้อนของเชื้อโรคในผลิตภัณฑ์เนื้อสัตว์ปีก และไข่ เช่น *Campylobacter* และ *Salmonella* ส่งผลต่อสุขภาพของผู้บริโภค
A16. การใช้ยาปฏิชีวนะในการผลิตไก่ (use of antibiotics in poultry production)	การใช้ยาปฏิชีวนะในการผลิตไก่นั้นเชื่อว่าเป็นการกระตุ้นให้เกิดการดื้อยาของจุลินทรีย์ และทำให้การรักษาโรคนั้นยุ่งยากขึ้น เช่น จุลินทรีย์กลุ่ม Methicillin-Resistant *Staphylococcus aureus* (MRSA) และ Extended Spectrum b-Lactamase (ESBL) Enterobacteria
A17. การระบาดของเชื้อไข้หวัดนก และโรคติดต่อร้ายแรงชนิดอื่นในสัตว์ปีก (outbreak of avian influenza and other highly infectious diseases)	โรคติดต่อร้ายแรง เช่น ไข้หวัดนก นั้นสร้างความหายเสียหายต่อชีวิตมนุษย์และส่งผลต่อความเชื่อมั่นของผู้บริโภคต่อผลิตภัณฑ์เนื้อไก่ และไข่
A18. การเสนอข่าวในเชิงลบต่ออุตสาหกรรมสัตว์ปีก ของสื่อต่างๆ (negative image of the poultry industry portrayed by the media)	สื่อบางกลุ่มเลือกนำเสนอเฉพาะส่วนที่ไม่ดีของอุตสาหกรรมสัตว์ปีกเกินจริง ซึ่งส่งผลโดยตรงต่อภาพลักษ์ของอุตสาหกรรม
A19. การสื่อสารระหว่างผู้ผลิตและผู้บริโภค (communication between producers and consumers)	ผู้บริโภคมีโอกาสสื่อสารโดยตรงกับผู้ผลิตค่อนข้างน้อย นำมาซึ่งความเข้าใจที่ผิดเกี่ยวกับความจริงของระบบการผลิต

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ประเด็น	คำอธิบาย
A20. ฉลากที่ระบุข้อมูลผลิตภัณฑ์สัตว์ปีก (food labelling)	ฉลากอาหารนำเสนอข้อมูลต่างๆ เกี่ยวกับผลิตภัณฑ์ อย่างไรก็ตามประเด็นนี้ยังเป็นที่ถกเถียงในเรื่องของความโปร่งใสและการบวนการควบคุม
A21. การออกกฎหมายและข้อปฏิบัติใหม่ๆ เพื่อควบคุมการผลิตสัตว์ปีก (introduction of new laws and regulations/legal framework)	การออกกฎหมายใหม่ๆ เช่น การห้ามการตัดจงอยปากในไก่ไข่ หรือการควบคุมการใช้ยาปฏิชีวนะในกระบวนการผลิตนั้นส่งผลโดยตรงต่อผู้ผลิต ซึ่งจะต้องปฏิบัติตามและเปลี่ยนรูปแบบการจัดการฟาร์มเพื่อพัฒนากลยุทธ์ในการแข่งขันในตลาดโลกให้ได้
A22. สวัสดิภาพของไก่เนื้อในระหว่างการขนส่งจากฟาร์มไปยังโรงฆ่า (transportation)	วิธีการและกระบวนการ การขนส่งไก่เนื้อจากฟาร์มไปยังโรงฆ่านั้นต้องคำนึงถึงสวัสดิภาพสัตว์ด้วย
A23. วิธีการชำแหละ หรือกระบวนการที่ใช้ในการชำแหละไก่เนื้อ (slaughter procedure/process)	วิธีการหรือกระบวนการชำแหละไก่เนื้อ รวมทั้งองค์ประกอบภายในโรงเชือด ต้องคำนึงถึงหลักสวัสดิภาพสัตว์ด้วย
A24. การตัดจงอยปากซึ่งส่งผลต่อสวัสดิภาพของไก่ไข่ (de-beaking)	การตัดจงอยปากในไก่ไข่นั้นเป็นวิธีการป้องกันการจิกหรือทำร้ายกันเองของไก่ไข่ในโรงเรือน อย่างไรก็ตามกระบวนการนี้ยังเป็นที่ถกเถียงเกี่ยวกับหลักสวิสดิภาพสัตว์
A25. การฆ่าลูกไก่เพศผู้ในไก่ไข่ ซึ่งเกี่ยวข้องกับปัญหาทางด้านจริยธรรม (killing of male layer chicks)	การฆ่าลูกไก่เพศผู้ในไก่ไข่นั้นเนื่องมาจากการที่ไม่สามารถให้ไข่ได้และประสิทธิภาพการใช้อาหารของลูกไก่ไข่ตัวผู้นั้นค่อนข้างต่ำ อย่างไรก็ตามประเด็นนี้ยังเป็นที่ถกเถียงเกี่ยวกับปัญหาทางจริยธรรม
A26. ระบบโรงเรือนที่ใช้เลี้ยงไก่ (housing system)	ระบบโรงเรือน ประกอบด้วยระบบปรับอากาศเพื่อถ่ายเทความร้อน พื้นที่สำหรับไก่ในการแสดงพฤติกรรมทางธรรมชาติ และการเข้าถึงอาหาร แสง และน้ำ เป็นต้น
A27. การกระจุกตัวอย่างหนาแน่นของฟาร์มเลี้ยงไก่ในบริเวณใดบริเวณหนึ่ง (regional concentration of production/mass production)	การขยายตัวและการกระจุกตัวอย่างหนาแน่นของฟาร์มในพื้นที่ใดพื้นที่หนึ่งนั้นอาจส่งผลกระทบต่อทิวทัศน์และสิ่งแวดล้อมบริเวณนั้น รวมทั้งเพิ่มความเสี่ยงต่อการแพร่ระบาดของโรคสัตว์ปีก และสุขภาพของผู้อยู่อาศัยบริเวณนั้น ด้วยเหตุนี้ทางกรมปศุสัตว์จึงได้จัดทำโซนการเลี้ยงสัตว์ โดยพิจารณาจากพื้นที่ที่เหมาะสมต่อการเลี้ยงสัตว์แต่ละชนิด มีแหล่งอาหารสัตว์เพียงพอ มีส่วนประกอบอื่นในห่วงโซ่การผลิต เช่น โรงฆ่าสัตว์ โรงงานแปรรูปเนื้อสัตว์ มีการค้าขายได้สะดวกทั้งภายในประเทศและส่งออก ทั้งนี้เพื่อการระดมทรัพยากรณ์ที่จำเป็นเพื่อการเลี้ยงสัตว์ในโซนนั้นๆ รวมถึงการควบคุมโรคสัตว์ ด้วย ดังนั้นจึงเป็นการลดความเสี่ยงของประเด็นนี้ได้เป็นอย่างดี
A28. พื้นที่ในโรงเรือนต่อไก่หนึ่งตัว หรือความหนาแน่นของประชากรไก่ต่อฟาร์ม (space per animal/stocking density)	พื้นที่ในโรงเรือนต่อจำนวนประชากรไก่นั้นเป็นตัวบ่งชี้ที่สำคัญเกี่ยวกับพื้นฐานของสวัสดิภาพสัตว์

คำอธิบายประเด็นต่างๆ ทั้ง 41 ประเด็นที่เกี่ยวข้องกับการผลิตสัตว์ปีกอย่างยั่งยืนในประเทศไทย (ต่อ)

ประเด็น	คำอธิบาย
A29. การมีความรับผิดชอบของผู้บริโภค (consumer responsibility)	ผู้บริโภคมีความต้องการผลิตภัณฑ์เนื้อไก่และไข่จากกระบวนการผลิตที่ได้มาตรฐานสูง ซึ่งการยกระดับมาตรฐานในการผลิตของผู้ผลิตนั้นต้องมีการเพิ่มเงินลงทุนที่สูงขึ้นตามไปด้วย ทำให้ราคาผลิตภัณฑ์สูงขึ้น ในขณะที่ผู้บริโภคต้องการสินค้าในราคาถูก และไม่ทุกคนยอมรับในราคาที่เพิ่มขึ้น ซึ่งเป็นความต้องการที่สวนทางกันเองของผู้บริโภค
A30. การยอมรับจากสังคมที่มีต่ออุตสาหกรรมการผลิตไก่ (societal acceptance)	อุตสาหกรรมสัตว์ปีกแบบเข้มข้นถูกมองว่าเป็นรูปแบบที่แย่ที่สุดของอุตสาหกรรมการผลิตสัตว์
A31. บทบาทขององค์กรอิสระและกลุ่มส่งเสริมสวิสดิภาพสัตว์ (the role of NGOs and activist groups)	กลุ่มองค์กรอิสระและพิทักษ์สวัสดิภาพสัตว์บางกลุ่มถูกมองว่าเป็นผู้จัดหาข้อมูลด้านลบของอุตสาหกรรม ให้กับสื่อต่างๆ
A32. ขาดความพยายามหาทางป้องกันปัญหาที่สามารถหลีกเลี่ยงได้ภายในอุตสาหกรรมการผลิตสัตว์ปีก (lacking efforts to prevent avoidable deficiencies within the industry)	ตัวอย่างเช่น ปัญหาการบาดเจ็บเท้าหรือการทำร้ายกันเองของไก่ในโรงเรือน ซึ่งสามารถลดปัญหาดังกล่าวได้โดยการจัดการฟาร์มที่ดี ซึ่งเกษตรกรบางกลุ่มละเลยปัญหานี้ และสื่อนำข้อมูลในส่วนนี้มานำเสนอ ซึ่งส่งผลกระทบต่อภาพลักษ์โดยรวมต่ออุตสาหกรรมสัตว์ปีก
A33. ปริมาณการผลิตที่มากเกินไปภายในประเทศ (excess of national production)	การผลิตที่มากเกินไปทำให้ราคาสินค้าในท้องตลาดลดลง ในทางตรงกันข้ามก็เป็นผลดีต่อภาคการส่งออกของประเทศ
A34. การผลิตไก่เนื้อและไก่ไข่ของเกษตรกรภายใต้สัญญาที่ทำกับบริษัทแม่ (custom growing)	เกษตรกรเลี้ยงไก่ภายใต้สัญญาที่ได้ทำกับบริษัทแม่ ซึ่งจำกัดอิสระในการตัดสินใจของเกษตรกร ซึ่งจะต้องปฏิบัติตามเงื่อนไขของสัญญาอย่างเคร่งครัด
A35. อัตราการตายของไก่ในระหว่างการเลี้ยง (poultry mortality rate)	การเลี้ยงไก่ให้มีชีวิตอยู่ได้จนสามารถส่งถึงผู้บริโภคนั้นเป็นเป็นเป้าหมายหลักของผู้ผลิต ซึ่งอัตราการสูญเสียไก่ในระหว่างการเลี้ยงส่งผลกระทบโดยตรงต่อรายได้ในภาคการผลิต
A36. การเร่งการเจริญเติบโตของไก่ที่เร็วเกินไป (Growth rate of poultry)	การเลี้ยงไก่ในปัจจุบันเป็นพันธุ์ที่ได้รับการปรับปรุงให้มีการเจริญเติบโตอย่างรวดเร็ว ซึ่งการเจริญเติบโตที่เร็วเกินไปทำให้ไก่มีปัญหาที่ขา และลำบากในการเดิน
A37. สถานะของกฎหมายและข้อปฏิบัติด้านสิ่งแวดล้อมที่เกี่ยวข้องกับการเลี้ยงไก่ในปัจจุบัน (current status of environmental laws and regulations)	สถานะกฎหมายและการนำมาปฏิบัติทางด้านสิ่งแวดล้อมที่เกี่ยวข้องกับอุตสาหกรรมการเลี้ยงสัตว์ในประเทศไทย ยังไม่มีความเข้มข้นเพียงพอที่จะรักษาคุณภาพสิ่งแวดล้อมให้อยู่ในระดับที่ดีได้

คำอธิบายประเด็นต่างๆ ทั้ง 41 ประเด็นที่เกี่ยวข้องกับการผลิตสัตว์ปีกอย่างยั่งยืนในประเทศไทย (ต่อ)

ประเด็น	คำอธิบาย
A38. การประเมินค่าอาหารที่ยังต่ำเมื่อเปรียบเทียบกับรถยนต์หรือการท่องเที่ยว (rating value of foods)	มนุษย์ประเมินค่าของอาหารในปัจจุบันอยู่ในระดับต่ำเมื่อเปรียบเทียบกับคุณค่าของรถยนต์ เสื้อผ้า หรือการพักผ่อน ดังนั้นจึงเป็นเรื่องยากที่จะเปลี่ยนระบบการผลิตจากปัจจุบันให้มีความยั่งยืนมากขึ้น การสร้างความตระหนักให้ผู้บริโภคเห็นความสำคัญของอาหารมากขึ้น เป็นความท้าทายของการผลิตอาหารอย่างยั่งยืน
A39. ความหลายหลายของพันธุ์ไก่พื้นเมืองในปัจจุบัน (genetic diversity of native poultry)	การปรับปรุงพันธุ์ไก่เพื่อการค้าในปัจจุบัน มีส่วนกระทบต่อความหลากหลายของพันธุ์ไก่พื้นเมือง
A40. ความเป็นธรรมของการค้าระหว่างประเทศของผลิตภัณฑ์สัตว์ปีก (international trade in poultry products)	ความเป็นธรรมทางการค้าและความเชื่อมั่นในคุณภาพของสินค้า เป็นประเด็นหลักที่เกี่ยวข้องกับการค้าระหว่างประเทศ ซึ่งรูปแบบการแข่งขันที่เท่าเทียมกัน และความแตกต่างของคุณภาพของสินค้าในแต่ละประเทศ ยังเป็นประเด็นที่นำมาซึ่งการกีดกันทางการค้าอยู่
A41. ประสิทธิภาพการใช้ประโยชน์จากของเสียที่เหลือจากซากไก่ (efficiency of using poultry by-products)	การใช้และการจัดการของเสียจากซากไก่ยังไม่มีประสิทธิภาพพอที่จะลดผลกระทบต่อสิ่งแวดล้อมและสุขภาพมนุษย์

Description of sustainability issues in poultry production cited in the scientific literature and reports (English)

Issue	Description
A1. Acidification, eutrophication and global warming potential	Ammonia emissions and nutrient leaching from poultry production sites contribute to acidification, eutrophication and global warming. Additionally, ammonia emissions damage the metal structure of the roofs of poultry houses, shortening its lifespan
A2. Manure management	Poultry waste at production sites can be used as manure or fish feed. However, if it is not managed effectively, the waste can be an environmental concern due to the emission of greenhouse gases, runoff, and leaching of sewage
A3. Use of pesticides in poultry feed production	The use of pesticides in poultry feed production, such as in soybean production areas, affects the health of humans, insects and microorganisms in the soil
A4. Resource use	Producing meat and eggs requires energy, water and land, which can contribute to resource depletion if not managed carefully
A5. Biodiversity	Monocultures planted for poultry feed production reduce the number of plant, insect and microorganism species in the farming area
A6. Labour wages	The requirement to increase the minimum wage for labourers working in poultry production units has a large impact on the poultry industry
A7. Industry competitiveness/ Farm income	The increasing costs of production, trade prices and the ability to access markets challenge the competitiveness of farms in the poultry industry
A8. Feed supply	The dependence on feed imports from other countries, poses a challenge to the future of the poultry industry in Thailand, especially the cost of production
A9. Consumer demand	Consumer preferences for poultry products, including products prioritising animal welfare and/or using less antibiotics during the production stage
A10. Role of food retailers	Food retailers provide different products based on consumer preferences. They determine the type of products sourced from producers and directly impact on consumers' choices

Description of sustainability issues in poultry production cited in the scientific literature and reports (continued)

Issue	Description
A11. Breeding	The dependence on parent stock imports from other countries can effect the broiler and egg industry in Thailand if there are problems in export countries. More robust breeds should be developed and used in poultry production
A12. Efficiency of feed conversion	The feed conversion rate of chickens has a direct impact on the cost of production and emission of ammonia and greenhouse gases
A13. Pressure on/from urban centres	Poultry farm intensification around urban areas has a direct impact on land-use management in expanding metropolitan centres, and vice versa
A14. Workers in slaughter houses	The introduction of cheap labour to poultry slaughter houses from other countries is highly criticised, as workers live in close quarters on-site and are highly controlled. This includes concerns over labour regulations and workers' welfare
A15. Contamination of meat and eggs with zoonotic microorganisms	Contamination of poultry products with zoonotic microorganisms, such as *Campylobacter* (causing campylobacteriosis) and *Salmonella* (causing salmonellosis) contributes to human health problems
A16. Use of antibiotics in poultry production	Using antibiotics in poultry production is believed to increase the risk of multi-drug resistant bacteria and could impact on disease treatment, such as Methicillin-Resistant *Staphylococcus aureus* (MRSA) and Extended Spectrum b-Lactamase (ESBL) Enterobacteria
A17. Outbreak of avian influenza and other highly infectious diseases	Highly infectious diseases, such as the highly pathogenic avian influenza (HPAI), have been fatal to humans in many countries and reduce consumers' confidence in poultry products
A18. Negative image of the poultry industry portrayed by the media	Some media reports and documentaries on select production practices in poultry and slaughter houses can make consumers think negatively about the poultry sector as a whole
A19. Communication between producers and consumers	Consumers rarely have the chance to communicate directly with producers. This can lead to misunderstandings regarding the reality of poultry production systems

Description of sustainability issues in poultry production cited in the scientific literature and reports (continued)

Issue	Description
A20. Food labelling	Labelling provides consumer information on the poultry product. However, such labels have been highly criticised for their transparency and control systems
A21. Introduction of new laws and regulations/legal framework	The introduction of laws and regulations, including a total ban on conventional cage systems, prohibiting de-beaking and restrictions on the use of antibiotics in poultry production, has a direct impact on producers. In order to comply with the legal framework, production systems need to be changed and management plans need to be developed in order to stay competitive in the global market
A22. Transportation	Transportation, including transportation methods, transportation density and transportation of poultry to (and from) slaughter houses
A23. Slaughter (procedure/process)	Distress prior to slaughter, conditions in slaughter houses and methods of slaughter
A24. De-beaking	De-beaking is a method used to prevent cannibalism and feather pecking in laying hens and turkeys. However, this practice raises concerns over animal welfare
A25. Killing of male layer chicks	This practice is used as male chicks are of no use to laying facilities and their feed conversion rates are too low to produce meat. However, there is increasing concern over ethical issues
A26. Housing system	Housing systems, including ventilation, access to the outside/food/water/light
A27. Regional concentration of production/Mass production	The regional concentration and increasing farm size of poultry production are also perpetuating environmental and human health risks such as changes in landscape, increased transportation, and an increasing spread of poultry diseases
A28. Space per animal/stocking density	Space in the poultry-raising facility is an important key indicator of animal welfare
A29. Consumer responsibility	Consumers prefer poultry meat and eggs from a high standard of production. Levelling the standard of production is adding the cost to producers. Thus, the product prices are increased. However, consumers still demand a lower price for poultry products. Not all consumers accept the higher price

Description of sustainability issues in poultry production cited in the scientific literature and reports (continued)

Issue	Description
A30. Societal acceptance	The intensive poultry industry is seen as the worst form of "factory farming"
A31. The role of NGOs and activist groups	Some NGOs and activist groups are seen as providing the media with selective "negative" reports and pictures
A32. Lacking efforts to prevent avoidable deficiencies within the industry	For example, the rate of foot lesions and cannibalism can be minimised through good management practices – a select few producers who mismanage their facilities determine the general image of the industry
A33. Excess of national poultry meat production	The over-abundance of national poultry meat production facilities within the country affects the product prices on the domestic market. However, it contributes to increasing the capacity to export to other countries
A34. Custom growing (fattening)	Farmers grow broilers or turkey for a vertically integrated company on a contract basis, which limits their decision-making capacity for the entire production facility
A35. Poultry mortality rate	The vitality of poultry during production is the most important goal for producers. Thus, the loss rate of poultry has a direct impact on their income
A36. Growth rate of poultry	Intensive rearing of fast growing breeds leads to health issues, mainly noted in an increase of leg problems
A37. Current status of environmental laws and regulations	The current legal framework of environmental laws and regulations for the poultry industry is still not strict enough
A38. Rating value of foods	People are presently rating the value of foods quite low compared to cars, clothes and holidays. Thus, it is difficult to initiate a transition towards sustainability. Convincing people to increase their spending on food is a major challenge for sustainable food production

Description of sustainability issues in poultry production cited in the scientific literature and reports (continued)

Issue	Description
A39. Genetic diversity of native poultry	The current poultry species bred for commercial purposes are contributing to the loss of genetic diversity amongst native poultry species
A40. International trade in poultry products	Fair trade and quality assurance are key issues related to the international trade in poultry. Equal competition conditions and differing quality standards between countries are still important issues for the poultry industry
A41. Efficiency of using poultry by-products	The use and management of poultry by-products are still not efficient enough to reduce its impact

The second round of questionnaires

การศึกษาความยั่งยืนของอุตสาหกรรมการผลิตสัตว์ปีกในประเทศไทยโดยวิธี Delphi
Delphi study on sustainability concerns in poultry production in Thailand

แบบสอบถามรอบที่ 2

คำชี้แจง

1. วัตถุประสงค์หลักของการศึกษาครั้งนี้คือการวิเคราะห์ประเด็นสำคัญต่างๆ ที่เกี่ยวข้องกับการผลิตสัตว์ปีกอย่างยืน ว่ามีประเด็นใดบ้างที่ยังเป็นที่วิตกกังวลต่ออุตสาหกรรมการผลิตไก่เนื้อและไข่ไก่ในประเทศไทย
2. คำจำกัดความ ความยั่งยืน (sustainability) ในงานวิจัยชุดนี้คือ ระบบการผลิตสัตว์ปีกที่คำนึงถึงประเด็นต่างๆ ห้าประเด็นที่เกี่ยวข้องกับความยั่งยืน ได้แก่ ด้านสิ่งแวดล้อม (environment) เศรษฐกิจ (economics) สังคม (society) การเมือง (politics) และสวัสดิภาพสัตว์ (animal welfare)
3. แบบสอบถามรอบที่สองนี้ ประกอบด้วย **41 ประเด็นหลัก (A1-A41)** เหมือนกับในรอบแรก และเพิ่มเติมอีก **14 ประเด็นใหม่ (A42-A55)** จากคณะผู้ร่วมตอบแบบสอบถามที่นำเสนอจากการศึกษารอบแรก ซึ่งเกี่ยวข้องกับการผลิตไก่เนื้อและไข่ไก่อย่างยั่งยืน ครอบคลุม ด้านสิ่งแวดล้อม (environment) เศรษฐกิจ (economics) สังคม (society) การเมือง (politics) และสวัสดิภาพสัตว์ (animal welfare) รวมทั้งหมด **55 ประเด็น**ที่ท่านจะต้องให้น้ำหนักคะแนนระดับความกังวลอีกครั้งในรอบนี้
4. คำอธิบายในแต่ละประเด็น (A1-A55) อยู่ในไฟล์ข้อมูลอีกฉบับที่แนบมากับอีเมลนี้ ซึ่งมีการปรับปรุงข้อมูลจากคำแนะนำจากคณะผู้ร่วมตอบแบบสอบถามในรอบแรก ให้ถูกต้องมากยิ่งขึ้น
5. หลังจากกรอกคำตอบ (**หน้า 2-4**) ในแบบสอบถามชุดนี้เสร็จแล้ว กรุณาบันทึกข้อมูลแล้วส่งไฟล์ชุดนี้กลับมายัง ssoisontes@wing.uni-vechta.de ภายในวันที่ **25 ตุลาคม พ.ศ. 2557** ซึ่งจะมีการแจ้งเตือนหนึ่งสัปดาห์ก่อนวันครบกำหนดส่งคำตอบ

ชุดคำถามรอบที่สอง

ในการตอบแบบสอบถามรอบที่สองนี้ ท่านมีโอกาศพิจารณาทบทวนการให้น้ำหนักคะแนนระดับความกังวลแต่ละประเด็นอีกครั้งโดยอิงจากผลการศึกษาของกลุ่มผู้ตอบแบบสอบถามในรอบแรก และสามารถแสดงความคิดเห็นเกี่ยวกับทางออกหรือการแก้ปัญหาต่างๆ ที่มีอยู่สำหรับอุตสาหกรรมการผลิตไก่เนื้อและไข่ไก่ในประเทศไทย เพื่อเป็นแนวทางในการพัฒนาการผลิตให้ยั่งยืนมากยิ่งขึ้น

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ตัวอย่างการตอบคำถาม

ความหมายของระดับความกังวลในระบบเสกล 1 – 5

1 – ประเด็นนี้ไม่เป็นที่กังวล (not at all concerning issue)
2 – ประเด็นนี้เป็นที่กังวลเล็กน้อย (slightly concerning issue)
3 – ประเด็นนี้เป็นที่กังวลปานกลาง (somewhat concerning issue)
4 – ประเด็นนี้ค่อนข้างเป็นที่กังวลมาก (fairly concerning issue)
5 – ประเด็นนี้เป็นที่กังวลอย่างมาก (very concerning issue)

ประเด็นหลักที่เกี่ยวข้องกับอุตสาหกรรมการผลิตสัตว์ปีก	เปอร์เซ็นการให้คะแนนระดับความกังวลในรอบแรก (N = 32)					ระดับความกังวลครั้งที่สอง (1 - 5)
	ระดับ 1 %	ระดับ2 %	ระดับ 3 %	ระดับ 4 %	ระดับ 5 %	
A1. ก่อให้เกิดสภาวะกรด การเจริญเติบโตที่รวดเร็วของพืชและสาหร่าย และสภาวะโลกร้อน	12.5	31.3	43.8	9.4	3.1	3
A2. การจัดการมูลไก่	12.5	28.1	31.3	21.9	6.3	3
A3. การใช้สารกำจัดศัตรูพืชในการผลิตพืชอาหารสัตว์	9.4	12.5	28.1	28.1	21.9	4

โปรดให้คะแนนระดับความกังวลของแต่ละประเด็นในช่องนี้

1. ผลการศึกษาในรอบแรกแสดงในตารางที่ 1

2.ในการตอบแบบสอบถามรอบที่สองนี้ ท่านสามารถพิจารณาทบทวนการให้น้ำหนักคะแนนระดับความกังวลในแต่ละประเด็นอีกครั้ง โดยพิจารณาผลการศึกษาในรอบแรกของกลุ่มผู้ร่วมตอบแบบสอบถามประกอบ ซึ่งแสดงเป็นเปอร์เซ็นในตารางด้านล่าง เปอร์เซ็นที่เน้นสีแดง เป็นระดับความกังวลที่ผู้ร่วมตอบแบบสอบถามส่วนใหญ่พิจารณา

3. จงให้คะแนนระดับความกังวลในแต่ละประเด็นอีกครั้งโดยพิมพ์คำตอบลงในช่อง **„ระดับความกังวลรอบที่สอง (1-5)“** ในช่องขวามือสุดของตารางที่ 1 ซึ่งหลักเกณฑ์การให้น้ำหนักคะแนนจาก 1 ถึง 5 เหมือนกับในรอบแรก ดังตัวอย่างที่แสดงด้านบน

ตารางที่ 1

ประเด็นหลักที่เกี่ยวข้องกับอุตสาหกรรมการผลิตสัตว์ปีก	เปอร์เซ็นการให้คะแนนระดับความกังวลในรอบแรก (N = 33)					ระดับความกังวลรอบที่สอง (1 - 5)
	ระดับ1 %	ระดับ2 %	ระดับ3 %	ระดับ4 %	ระดับ5 %	
A1. ก่อให้เกิดสภาวะกรด การเจริญเติบโตที่รวดเร็วของพืชและสาหร่าย และสภาวะโลกร้อน	12.1	33.3	**42.4**	9.1	3.0	
A2. การจัดการมูลไก่	12.1	**30.3**	**30.3**	21.2	6.1	
A3. การใช้สารกำจัดศัตรูพืชในการผลิตพืชอาหารสัตว์	9.1	12.1	27.3	**30.3**	21.2	
A4. การใช้ทรัพยากรณ์เพื่อการผลิตสัตว์ปีก เช่น น้ำ ไฟฟ้า ที่ดิน	6.1	18.2	**39.4**	27.3	9.1	
A5. ความหลากหลายทางชีวภาพในพื้นที่ที่ปลูกพืชเชิงเดี่ยวเพื่อเป็นอาหารสัตว์	18.2	**33.3**	30.3	15.6	3.1	
A6. ค่าจ้างแรงงาน	0	3.0	**39.4**	33.3	24.2	
A7. ความสามารถในการแข่งขันของอุตสาหกรรมสัตว์ปีกและ/หรือ รายได้ของฟาร์มผู้ผลิต	9.1	12.1	**33.3**	**33.3**	12.1	
A8. อุปทานหรือปริมาณอาหารสัตว์ที่มี เพื่อสนองความต้องการในภาคการผลิต	3.0	18.2	**39.4**	24.2	15.2	
A9. อุปสงค์หรือความต้องการของผู้บริโภค	9.1	24.2	**42.4**	21.2	3.0	
A10. บทบาทของห้างผู้ค้าปลีก	6.1	27.3	**42.4**	21.2	3.0	
A11. การปรับปรุงพันธุ์ไก่	15.2	12.1	**24.2**	**24.2**	**24.2**	
A12. ประสิทธิภาพการใช้อาหารสัตว์ของไก่	24.2	9.1	**33.3**	30.3	3.0	
A13. สร้างความกดดันต่อบริเวณชุมชนที่อยู่อาศัย	3.0	21.2	15.2	**39.4**	21.2	
A14. สวัสดิภาพของแรงงานในโรงเชือดหรือโรงฆ่า	0	30.3	**36.4**	24.2	9.1	
A15. การปนเปื้อนของเชื้อโรคที่สามารถติดต่อจากสัตว์สู่คนในเนื้อสัตว์ปีก และไข่	6.1	21.2	18.2	**27.3**	**27.3**	
A16. การใช้ยาปฏิชีวนะในการผลิตไก่	3.0	18.2	24.2	**27.3**	**27.3**	
A17. การระบาดของเชื้อไข้หวัดนก และโรคติดต่อร้ายแรงชนิดอื่นในสัตว์ปีก	3.0	12.1	15.2	18.2	**51.5**	
A18. การเสนอข่าวในเชิงลบต่ออุตสาหกรรมสัตว์ปีกของสื่อต่างๆ	6.1	12.1	18.2	**36.4**	27.3	

*N = จำนวนผู้ตอบแบบสอบถามทั้งหมด (33 คน)

โปรดให้คะแนนระดับความกังวลของแต่ละประเด็นในช่องนี้

ตารางที่ 1 (ต่อ)

ประเด็นหลักที่เกี่ยวข้องกับอุตสาหกรรมการผลิตสัตว์ปีก	เปอร์เซ็นการให้คะแนนระดับความกังวลในรอบแรก (N = 33)					ระดับความกังวลรอบที่สอง (1 - 5)
	ระดับ1 %	ระดับ2 %	ระดับ3 %	ระดับ4 %	ระดับ5 %	
A19. การสื่อสารระหว่างผู้ผลิตและผู้บริโภค	0	27.3	**36.4**	30.3	6.1	
A20. ฉลากที่ระบุข้อมูลผลิตภัณฑ์สัตว์ปีก	9.1	**39.4**	21.2	27.3	3.0	
A21. การออกกฎหมายและข้อปฏิบัติใหม่ๆ เพื่อควบคุมการผลิตสัตว์ปีก	6.1	15.2	**42.4**	24.2	12.1	
A22. สวัสดิภาพของไก่เนื้อในระหว่างการขนส่งจากฟาร์มไปยังโรงฆ่า	6.1	24.2	**45.5**	18.2	6.1	
A23. วิธีการชำแหละ หรือกระบวนการที่ใช้ในการชำแหละไก่เนื้อ	15.2	**30.3**	**30.3**	18.2	6.1	
A24. การตัดจงอยปากซึ่งส่งผลต่อสวัสดิภาพของไก่ไข่	12.1	24.2	**42.4**	18.2	3.0	
A25. การฆ่าลูกไก่เพศผู้ในไก่ไข่	**100**	0	0	0	0	
A26. ระบบโรงเรือนที่ใช้เลี้ยงไก่	**24.2**	**24.2**	**24.2**	21.2	6.1	
A27. การกระจุกตัวอย่างหนาแน่นของฟาร์มเลี้ยงไก่ในบริเวณใดบริเวณหนึ่ง	9.1	24.2	18.2	**30.3**	18.2	
A28. พื้นที่ในโรงเรือนต่อไก่หนึ่งตัว หรือความหนาแน่นของประชากรไก่ต่อฟาร์ม	12.1	**33.3**	21.2	27.3	6.1	
A29. การมีความรับผิดชอบของผู้บริโภค	3.0	15.2	30.3	**36.4**	15.2	
A30. การยอมรับจากสังคมที่มีต่ออุตสาหกรรมการผลิตไก่	3.0	**30.3**	27.3	**30.3**	9.1	
A31. บทบาทขององค์กรอิสระและกลุ่มส่งเสริมสวิสดิภาพสัตว์	6.1	**33.3**	24.2	27.3	9.1	
A32. ขาดความพยายามหาทางป้องกันปัญหาที่สามารถหลีกเลี่ยงได้ภายในอุตสาหกรรมการผลิตสัตว์ปีก	12.1	18.2	**39.4**	18.2	12.1	
A33. ปริมาณการผลิตที่มากเกินไปภายในประเทศ	3.0	**42.4**	39.4	9.1	6.1	
A34. การผลิตไก่เนื้อและไก่ไข่ของเกษตรกร ภายใต้สัญญาที่ทำกับบริษัทแม่	9.1	15.2	**39.4**	18.2	18.2	
A35. อัตราการตายของไก่ในระหว่างการเลี้ยง	9.1	27.3	**48.5**	9.1	6.1	
A36. การเร่งการเจริญเติบโตของไก่ที่เร็วเกินไป	15.2	21.2	**39.4**	24.2	0	
A37. สถานะของกฎหมายและข้อปฏิบัติด้านสิ่งแวดล้อมที่เกี่ยวข้องกับการเลี้ยงไก่ในปัจจุบัน	0	18.2	**39.4**	27.3	15.2	
A38. การประเมินค่าอาหารที่ยังต่ำเมื่อเปรียบเทียบกับรถยนต์หรือการท่องเที่ยว	6.1	27.3	27.3	**33.3**	6.1	
A39. ความหลายหลายของพันธุ์ไก่พื้นเมืองในปัจจุบัน	9.1	27.3	**36.4**	21.2	6.1	
A40. ความเป็นธรรมของการค้าระหว่างประเทศของผลิตภัณฑ์สัตว์ปีก	3.0	15.2	**30.3**	**30.3**	21.2	
A41. ประสิทธิภาพการใช้ประโยชน์จากของเสียที่เหลือจากซากไก่	6.1	**36.4**	24.2	24.2	9.1	

*N = จำนวนผู้ตอบแบบสอบถามทั้งหมด (33 คน)

โปรดให้คะแนนระดับความกังวลของแต่ละประเด็นในช่องนี้

4. จากผลการศึกษาในรอบแรก คณะผู้ร่วมตอบแบบสอบถามได้เสนอเพิ่มเติมอีก 14 ประเด็น (A42-A55) ดังแสดงในตารางที่ 2

5. จงให้คะแนนระดับความกังวลในแต่ละประเด็นอีกครั้งโดยพิมพ์คำตอบลงในช่อง **„ระดับความกังวลรอบที่สอง (1-5)“** ในช่องขวามือสุดของตารางที่ 2 ซึ่งหลักเกณฑ์การให้น้ำหนักคะแนนจาก 1 ถึง 5 เหมือนกับในรอบแรก ดังตัวอย่างที่แสดงด้านบน

ตารางที่ 2

ประเด็นหลักที่เกี่ยวข้องกับอุตสาหกรรมการผลิตสัตว์ปีก	N	เปอร์เซ็นการให้คะแนนระดับความกังวลในรอบแรก					ระดับความกังวลรอบที่สอง (1 - 5)
		ระดับ1 %	ระดับ2 %	ระดับ3 %	ระดับ4 %	ระดับ5 %	
A42. การพัฒนาผลิตภัณฑ์จากสัตว์ปีกให้มีมูลค่าหรือคุณค่าทางอาหารเพิ่มขึ้น	1	0	0	**100**	0	0	
A43. นโยบายการส่งเสริมการเลี้ยงไก่โดยภาครัฐ	3	0	0	33.3	**66.7**	0	
A44. สวัสดิภาพของไก่ในระหว่างการเลี้ยง	1	0	**100**	0	0	0	
A45. สวัสดิภาพของไก่ ณ โรงเชือด	2	0	0	**50**	0	**50**	
A46. คุณภาพของเนื้อไก่	2	0	0	**50**	**50**	0	
A47. วัตถุดิบอาหารสัตว์ที่ได้จากการตัดแต่งพันธุกรรม	1	0	0	0	**100**	0	
A48. การเปิดประชาคมเศษฐกิจอาเซียน (AEC)	2	0	0	0	0	**100**	
A49. การควบคุมโรคระบาดจากประเทศเพื่อนบ้าน	1	0	0	0	0	**100**	
A50. ความเข้าใจเกี่ยวกับผลิตภัณฑ์เนื้อไก่	1	0	0	0	**100**	0	
A51. ข้อกำหนดในการเชือดสัตว์ปีกตามข้อกำหนดของกฎหมายและตามหลักการเชือดของศาสนาอิสลาม	1	0	0	0	0	**100**	
A52. การกำหนดมาตรฐานสินค้าจากประเทศนำเข้า	1	0	0	0	**100**	0	
A53. การใช้ประโยชน์จากไก่พื้นเมือง	1	0	0	0	**100**	0	
A54. การทำคอมพาร์ตเมนต์ปลอดโรคไข้หวัดนกในอุตสาหกรรมสัตว์ปีก	1	0	0	**100**	0	0	
A55. บทบาทของเกษตรกรรายย่อย	1	0	0	0	**100**	0	

*N = จำนวนผู้เสนอและตอบแบบสอบถามทั้งหมดในแต่ละประเด็นใหม่

โปรดให้คะแนนระดับความกังวลของแต่ละประเด็นในช่องนี้

6. บนพื้นฐานความรู้และประสบการณ์ในสาขาที่ท่านเชี่ยวชาญ ท่านคิดว่าอะไรที่ยังเป็นปัญหาสำคัญหรืออุปสรรคต่ออุตสาหกรรมการผลิตไก่เนื้อและไข่ไก่ในประเทศไทย และมีคำชี้แนะอย่างไรในการแก้ไขปัญหาดังกล่าว เพื่อเป็นแนวทางในการพัฒนาการผลิตให้ยั่งยืนมากขึ้นในอนาคต **ถ้าท่านไม่มีความเห็น ให้ข้ามคำถามข้อนี้ไป**

Description of the new sustainability issues in poultry production proposed by the expert panel in the first round of questionnaires (Thai)

คำอธิบายประเด็นต่างๆ เพิ่มเติม 15 ประเด็น ที่เกี่ยวข้องกับการผลิตสัตว์ปีกอย่างยั่งยืนในประเทศไทย โดยคณะผู้ตอบแบบสอบถามในรอบแรก

ประเด็น	คำอธิบาย
A42. การพัฒนาผลิตภัณฑ์จากสัตว์ปีกให้มีมูลค่าหรือคุณค่าทางอาหารเพิ่มขึ้น (developement of value added products)	ผู้บริโภคในปัจจุบันให้ความสนใจในการบริโภคผลิตภัณฑ์ที่มีการเสริมคุณค่าทางอาหารเพิ่มขึ้น ดังนั้นจึงควรมีการศึกษาวิจัยด้านนี้เพิ่มขึ้นเพื่อเป็นการเพิ่มมูลค่าทางเศรษฐกิจอีกทางหนึ่ง
A43. นโยบายการส่งเสริมการเลี้ยงไก่โดยภาครัฐ (Public policy of poultry industry)	นโยบายรัฐบาล (กรมปศุสัตว์ กระทรวงเกษตรและสหกรณ์) ต่อการเลี้ยงไก่ยังไม่ประสิทธิภาพเพียงพอ เช่น การนำเข้าไข่ไก่จากต่างประเทศ การกำหนดปริมาณแม่ไก่ไข่ภายในประเทศ และการส่งเสริมการเลี้ยงไก่พื้นเมือง และไก่ชน รวมทั้งการให้ความช่วยเหลือเกษตรกรเมื่อพบปัญหาโรคระบาด ที่รัฐยังให้ความช่วยเหลือน้อยมาก
A44. สวัสดิภาพของไก่ในระหว่างการเลี้ยง (Poultry welfare during growing phase)	การจัดการและวิธีการเลี้ยงไก่ในฟาร์มที่ต้องคำนึงถึงหลักสวัสดิภาพสัตว์ ด้วยหลัก 5 freedoms
A45. สวัสดิภาพของไก่ ณ โรงเชือด (Poultry welfare in slaughter house)	การดูแลกระบวนการชำแหละที่คำนึงถึงสวัสดิภาพสัตว์ ไม่ให้ต้องได้รับความทุกข์ทรมาณเกินความจำเป็น และต้องปฏิบัติตามกฎ EU Regulation 1099/2009
A46. คุณภาพของเนื้อไก่ (Meat quality)	การควบคุมคุณภาพของเนื้อไก่และผลิตภัณฑ์ที่มีความหลากหลาย เช่น เนื้อไก่จากพ่อแม่พันธุ์ เนื้อไก่พื้นเมือง เพื่อสร้างความมั่นใจให้แก่ผู้บริโภค รวมทั้งรสชาติ และความเหนียวนุ่มของเนื้อไก่ก็เป็นสิ่งที่ผู้บริโภคต้องการ
A47. วัตถุดิบอาหารสัตว์ที่ได้จากการตัดแต่งพันธุกรรม (Feed from genetical modified plants)	อาหารสัตว์ที่ได้จากพืชที่ผ่านการตัดแต่งพันธุกรรม นั้นส่งผลต่อความเชื่อมั่นของผู้บริโภค ในเรื่องความปลอดภัยต่อสุขภาพ
A48. การเปิดประชาคมเศษฐกิจอาเซียน (The establishment of the ASEAN Economic Community – AEC)	การเปิดประชาคมเศรษฐกิจอาเซียนในปี 2015 อาจส่งผลต่ออุตสาหกรรมไก่เนื้อและไก่ไข่ของไทย เช่น การแข่งขันทางการผลิต การไหลเข้าและออกของแรงงานต่างชาติ คุณภาพและการจัดการฟาร์มที่ต่ำกว่ามาตรฐานของไทยในประเทศเพื่อนบ้าน และการแพร่ระบาดของโรคจากต่างถิ่น
A49. การควบคุมโรคระบาดจากประเทศเพื่อนบ้าน (Control of disease outbreak from neighbouring countries)	ปัญหาการควบคุมโรคระบาดที่สำคัญ เช่น ไข้หวัดนก นิวคาสเซิล ที่อาจแพร่เข้ามาทางชายแดนที่ติดต่อกับประเทศเพื่อนบ้าน

คำอธิบายประเด็นต่างๆ เพิ่มเติม 15 ประเด็น ที่เกี่ยวข้องกับการผลิตสัตว์ปีกอย่างยั่งยืนในประเทศไทย โดยคณะผู้ตอบแบบสอบถามในรอบแรก (ต่อ)

ประเด็น	คำอธิบาย
A50. ความเข้าใจเกี่ยวกับผลิตภัณฑ์เนื้อไก่ (Perception of poultry meat and products)	ผู้บริโภคส่วนหนึ่งเข้าใจผิดว่าในการเลี้ยงไก่เนื้อมีการใช้ฮอร์โมนเพื่อเร่งการเจริญเติบโต ซึ่งในความเป็นจริงนั้นไม่มีการใช้ เนื่องจากมีการห้ามไม่ให้มีการนำมาใช้ในการเลี้ยงไก่เนื้อ ดังนั้นประเด็นนี้จึงส่งผลต่อภาพลักษณ์ของอุตสาหกรรมไก่เนื้ออีกทางหนึ่งด้วย
A51. ข้อกำหนดในการเชือดสัตว์ปีกตามข้อกำหนดของกฎหมายและตามหลักการเชือดของศาสนาอิสลาม (Regulations of EU and Islam for slaughter process)	กระบวนการชำแหละสัตว์ปีกต้องสอดคล้องกับกฎ EU Reg.1099/2009 และในขณะเดียวกันต้องสอดคล้องตามหลักศาสนาอิสลามด้วย
A52. การกำหนดมาตรฐานสินค้าจากประเทศนำเข้า (Standards of poultry products required from imported countries)	บางประเทศกำหนดมาตรฐานที่ประเทศคู่ค้าไม่สามารถปฏิบัติตามได้ในสภาวะจริง ซึ่งเป็นการกีดกันทางการค้าโดยตรง
A53. การใช้ประโยชน์จากไก่พื้นเมือง (Utilization of native chickens)	ควรมีการนำพันธุกรรมจากไก่พื้นเมือง มาใช้ประโยชน์ทางการค้าให้มากขึ้น โดยเริ่มจากการเพิ่มศักยภาพทางการผลิต เพื่อเพิ่มโอกาสในการแข่งขัน ตามด้วยการสร้างความเข้าใจให้แก่เกษตรกรและผู้บริโภค การพัฒนาเทคโนโลยีการผลิต และถ่ายทอดสู่เกษตรกรในรูปแบบที่เป็นเครือข่ายผู้ผลิตเป็นต้น
A54. การทำคอมพาร์ตเมนต์ปลอดโรคไข้หวัดนกในอุตสาหกรรมสัตว์ปีก (Compartmentalisation of poultry production)	การจัดทำคอมพาร์ตเมนต์ในอุตสาหกรรมสัตว์ปีกตามหลักการขององค์การโรคระบาดสัตว์ระหว่างประเทศ เพื่อป้องกันโรคไข้หวัดนกเข้าสู่ฟาร์มสัตว์ปีก เพื่อให้ประเทศคู่ค้ายอมรับสินค้าแม้ในภาวะที่ประเทศไทยไม่ปลอดโรค อย่างไรก็ตามการเจรจาเรื่องนี้ยังต้องมีการดำเนินการต่อไปเพื่อให้บรรลุวัตถุประสงค์ดังกล่าว
A55. บทบาทของเกษตรกรรายย่อย (Role of small family farmers)	เกษตรกรรายย่อยยังมีบทบาทน้อยมากในอุตสาหกรรมสัตว์ปีก เนื่องจากส่วนใหญ่ยังต้องพึ่งพาบริษัทยักษ์ใหญ่ ทำให้อิสระในการผลิตนั้นยังไม่มากเท่าที่ควร

Description of the new sustainability issues in poultry production proposed by the expert panel in the first round of questionnaires (English)

Issue	Description
A42. Development of value added products	Currently, consumers are interested in value added products, such as nutritional additives or healthy products. Therefore, more research should be conducted on how to add economic value to the industry
A43. Public policy on poultry industry	Government policy is still not effective in supporting the domestic poultry industry, including policy on the import quota for parent stock laying hens and support for farmers during epidemics
A44. Poultry welfare during growing phase	Farm management and husbandry practices during the growing phase should be in line with principles of animal welfare
A45. Poultry welfare in slaughter houses	The treatment of broiler chicken before slaughter needs be in line with principles of animal welfare and EU Regulation 1099/2009
A46. Quality of poultry meat and products	Quality control of poultry meat and poultry products is mandatory in order to increase consumer confidence and acceptance
A47. Fodder from genetically modified plants	Poultry fodder made from genetically modified crops impacts on consumer confidence in poultry meat and products
A48. The establishment of the ASEAN Economic Community – AEC	The Association of South East Asian Nations (ASEAN) will increase cooperation between member countries as a single market and production base in 2015 to increase economic development and competitiveness. However, this could affect the Thai poultry industry due to lower standards in production management and disease control in other member states
A49. Disease control from neighbouring countries	Poultry diseases, such as Avian Influenza and Newcastle, in neighbouring countries could spread to Thailand. Therefore, the control system needs to be more effective

Description of the new sustainability issues in poultry production proposed by the expert panel in the first round of questionnaires (English) (Continued)

Issue	Description
A50. Perception of poultry meat and products	A high number of consumers still misperceive poultry production, such as wrongly believing that growth hormones are used for production
A51. EU and Islamic regulations for slaughter process	Producers have to follow the EU Regulation 1099/2009 and Islamic principles on slaughter processes in order to export their products
A52. Standards for poultry products required from importing countries	Some importing countries set very high standards for poultry products, which are very difficult for exporting countries to implement. This acts as a trade barrier
A53. Use of native chicken species	There should be more variety in the native chicken species used commercially, both for domestic and export markets
A54. Compartmentalisation of poultry production	Plans to compartmentalise poultry production during an epidemic to protect poultry is an alternative strategy that allows production and export of poultry products to continue. However, this process is still not successful in negotiations with importing countries
A55. Role of small-scale family farming	The integrated poultry industry in Thailand has a significant impact on small-scale family farms who rely on big companies

Appendix 20: Ratings of concerning issues in the Delphi round 1 in Thailand

Sustainability concerns/issues in poultry production	N	Level of concerns				
		Not at all concerned (1)	Slightly concerned (2)	Somewhat concerned (3)	Fairly concerned (4)	Very concerned (5)
A1. Acidification, eutrophication and global warming potential	33	4	11	14	3	1
A2. Manure management	33	4	10	10	7	2
A3. Use of pesticides in poultry feed production	33	3	4	9	10	7
A4. Resource use	33	2	6	13	9	3
A5. Biodiversity	33	6	11	10	5	1
A6. Labour wages	33	0	1	13	11	8
A7. Industry competitiveness/Farm income	33	3	4	11	11	4
A8. Feed supply	33	1	6	13	8	5
A9. Consumer demand	33	3	8	14	7	1
A10. Role of food retailers	33	2	9	14	7	1
A11. Breeding	33	5	4	8	8	8
A12. Efficiency of feed conversion	33	8	3	11	10	1
A13. Pressure on/from urban centres	33	1	7	5	13	7
A14. Workers in slaughter houses	33	0	10	12	8	3
A15. Contamination of meat and eggs with zoonotic microorganisms	33	2	7	6	9	9
A16. Use of antibiotics in poultry production	33	1	6	8	9	9
A17. Outbreak of avian influenza and other highly infectious diseases	33	1	4	5	6	17
A18. Negative image of the poultry industry portrayed by the media	33	2	4	6	12	9
A19. Communication between producers and consumers	33	0	9	12	10	2
A20. Food labelling	33	3	13	7	9	1
A21. Introduction of new laws and regulations/legal framework	33	2	5	14	8	4
A22. Transportation	33	2	8	15	6	2
A23. Slaughter (procedure/process)	33	5	10	10	6	2
A24. De-beaking	33	4	8	14	6	1
A25. Killing of male layer chicks	33	33	0	0	0	0
A26. Housing system	33	8	8	8	7	2
A27. Regional concentration of production/Mass production	33	3	8	6	10	6
A28. Space per animal/Stocking density	33	4	11	7	9	2
A29. Consumer responsibility	33	1	5	10	12	5
A30. Societal acceptance	33	1	10	9	10	3
A31. The role of NGOs and activist groups	33	2	11	8	9	3
A32. Lacking efforts to prevent avoidable deficiencies within the industry	33	4	6	13	6	4
A33. Excess of national poultry meat production	33	1	14	13	3	2
A34. Custom growing (fattening)	33	3	5	13	6	6
A35. Poultry mortality rate	33	3	9	16	3	2

Appendix 20: Ratings of concerning issues in the Delphi round 1 in Thailand (Continued)

Sustainability concerns/issues in poultry production	N	Level of concerns				
		Not at all concerned (1)	Slightly concerned (2)	Somewhat concerned (3)	Fairly concerned (4)	Very concerned (5)
A36. Growth rate of poultry	33	5	7	13	8	0
A37. Current status of environmental laws and regulations	33	0	6	13	9	5
A38. Rating value of foods	33	2	9	9	11	2
A39. Genetic diversity of native poultry	33	3	9	12	7	2
A40. International trade in poultry products	33	1	5	10	10	7
A41. Efficiency of using poultry by-products	33	2	12	8	8	3
A42. Development of value added products	1	.	.	1	.	.
A43. Public policy on poultry industry	3	.	.	1	2	.
A44. Poultry welfare during growing phase	1	.	1	.	.	.
A45. Poultry welfare in slaughter houses	2	.	.	1	.	1
A46. Quality of poultry meat and products	2	.	.	1	1	.
A47. Feed from genetically modified plants	1	.	.	1	.	.
A48. The establishment of the ASEAN Economic Community (AEC)	2	.	.	.	.	2
A49. Disease control from neighbouring countries	1	.	.	.	.	1
A50. Perception of poultry meat and products	1	.	.	.	1	.
A51. EU and Islamic regulations for slaughter process	1	.	.	.	.	1
A52. Standards for poultry products required from importing countries	1	.	.	.	1	.
A53. Use of native chicken species	1	.	.	.	1	.
A54. Compartmentalisation of poultry production	1	.	.	1	.	.
A55. Role of small-scale family farming	1	.	.	.	1	.

Appendix 21: Ratings of concerning issues in the Delphi round 2 in Thailand

Sustainability concerns/issues in poultry production	Level of concerns (N = 28)				
	Not at all concerned (1)	Slightly concerned (2)	Somewhat concerned (3)	Fairly concerned (4)	Very concerned (5)
A1. Acidification, eutrophication and global warming potential	2	9	16	1	0
A2. Manure management	0	11	12	3	2
A3. Use of pesticides in poultry feed production	0	3	7	15	3
A4. Resource use	1	2	16	8	1
A5. Biodiversity	4	13	8	3	0
A6. Labour wages	0	0	14	11	3
A7. Industry competitiveness/Farm income	0	3	9	14	2
A8. Feed supply	0	2	17	7	2
A9. Consumer demand	0	3	20	5	0
A10. Role of food retailers	0	6	17	3	2
A11. Breeding	2	1	7	10	8
A12. Efficiency of feed conversion	2	4	11	11	0
A13. Pressure on/from urban centres	0	3	4	17	4
A14. Workers in slaughter houses	0	3	17	8	0
A15. Contamination of meat and eggs with zoonotic microorganisms	0	1	3	10	14
A16. Use of antibiotics in poultry production	0	0	4	10	14
A17. Outbreak of avian influenza and other highly infectious diseases	0	0	2	8	18
A18. Negative image of the poultry industry portrayed by the media	0	0	3	19	6
A19. Communication between producers and consumers	0	3	14	8	3
A20. Food labelling	1	13	8	5	1
A21. Introduction of new laws and regulations/legal framework	0	1	17	7	3
A22. Transportation	0	4	17	5	2
A23. Slaughter (procedure/process)	0	10	11	6	1
A24. De-beaking	2	6	17	2	1
A25. Killing of male layer chicks	28	0	0	0	0
A26. Housing system	5	11	7	4	1
A27. Regional concentration of production/Mass production	0	6	9	9	4
A28. Space per animal/Stocking density	2	12	7	6	1
A29. Consumer responsibility	1	1	10	10	6
A30. Societal acceptance	0	9	9	6	4
A31. The role of NGOs and activist groups	0	13	8	5	2
A32. Lacking efforts to prevent avoidable deficiencies within the industry	2	6	14	5	1
A33. Excess of national poultry meat production	3	11	13	1	0
A34. Custom growing (fattening)	2	2	14	7	3
A35. Poultry mortality rate	2	5	17	3	1

Appendix 21: Ratings of concerning issues in the Delphi round 2 in Thailand (Continued)

Sustainability concerns/issues in poultry production	Level of concerns (N = 28)				
	Not at all concerned (1)	Slightly concerned (2)	Somewhat concerned (3)	Fairly concerned (4)	Very concerned (5)
A36. Growth rate of poultry	2	5	13	7	1
A37. Current status of environmental laws and regulations	0	1	20	4	3
A38. Rating value of foods	0	4	6	18	0
A39. Genetic diversity of native poultry	1	6	11	8	2
A40. International trade in poultry products	0	0	7	15	6
A41. Efficiency of using poultry by-products	2	12	8	5	0
A42. Development of value added products	3	5	14	5	1
A43. Public policy on poultry industry	0	4	7	15	2
A44. Poultry welfare during growing phase	1	10	10	5	2
A45. Poultry welfare in slaughter houses	0	4	14	5	5
A46. Quality of poultry meat and products	2	2	10	12	2
A47. Feed from genetically modified plants	3	4	11	8	2
A48. The establishment of the ASEAN Economic Community (AEC)	1	1	7	9	10
A49. Disease control from neighbouring countries	0	1	3	7	17
A50. Perception of poultry meat and products	0	3	14	9	2
A51. EU and Islamic regulations for slaughter process	0	3	11	5	9
A52. Standards for poultry products required from importing countries	0	1	2	14	11
A53. Use of native chicken species	0	3	13	8	4
A54. Compartmentalisation of poultry production	0	3	15	7	3
A55. Role of small-scale family farming	0	1	9	15	3

Appendix 22: Results of the Delphi round 2 identified by researchers in Thailand

Sustainability concerns/issues in poultry production	N = 14	
	Mean	Standard deviation
Outbreak of avian influenza and other highly infectious diseases	4.50	0.76
Disease control from neighbouring countries	4.43	0.76
Contamination of meat and eggs with zoonotic microorganisms	4.21	0.97
Standards for poultry products required from importing countries	4.14	0.86
Negative image of the poultry industry portrayed by the media	4.14	0.53
Use of antibiotics in poultry production	4.14	0.86
International trade in poultry products	4.07	0.62
Breeding	4.00	1.11
The establishment of the ASEAN Economic Community – AEC	3.86	1.17
Role of small-scale family farming	3.86	0.66
Pressure on/from urban centres	3.79	0.89
Consumer responsibility	3.71	0.91
Industry competitiveness/Farm income	3.64	0.84
Feed supply	3.57	0.85
Labour wages	3.57	0.76
Use of native chicken species	3.50	1.02
Regional concentration of production/Mass production	3.50	1.09
Introduction of new laws and regulations/legal framework	3.50	0.85
Public policy on poultry industry	3.50	0.85
Communication between producers and consumers	3.50	1.09
Use of pesticides in poultry feed production	3.50	0.94
Rating value of foods	3.43	0.85
Genetic diversity of native poultry	3.43	1.02
Current status of environmental laws and regulations	3.36	0.74
Compartmentalisation of poultry production	3.29	0.91
Poultry welfare in slaughter houses	3.29	0.91
Quality of poultry meat and products	3.29	1.14
Transportation	3.21	0.80
Perception of poultry meat and products	3.21	0.89
Role of food retailers	3.21	0.89
Resource use	3.21	0.89
EU and Islamic regulations for slaughter process	3.14	0.95
Custom growing (fattening)	3.14	1.03
Efficiency of feed conversion	3.14	0.95
Workers in slaughter houses	3.07	0.62

Appendix 22: Results of the Delphi round 2 identified by researchers in Thailand (Continued)

Sustainability concerns/issues in poultry production	N = 14	
	Mean	Standard deviation
Consumer demand	3.07	0.62
Societal acceptance	3.07	1.07
Poultry welfare during growing phase	3.00	0.88
Growth rate of poultry	3.00	0.96
De-beaking	3.00	0.96
Manure management	2.93	1.00
Slaughter (procedure/process)	2.86	0.95
Food labelling	2.86	1.03
Feed from genetically modified plants	2.79	1.12
The role of NGOs and activist groups	2.79	0.97
Space per animal/Stocking density	2.79	1.12
Lacking efforts to prevent avoidable deficiencies within the industry	2.71	1.14
Poultry mortality rate	2.71	0.91
Efficiency of using poultry by-products	2.64	1.08
Development of value added products	2.57	1.22
Acidification, eutrophication and global warming potential	2.50	0.85
Biodiversity	2.36	1.01
Housing system	2.29	1.14
Excess of national poultry meat production	2.07	0.73
Killing of male layer chicks	1.00	0.00
Kendall's coefficient of concordance (W)	0.353	

Appendix 23: Results of the Delphi round 2 identified by the private sector in Thailand

Sustainability concerns/issues in poultry production	N = 6	
	Mean	Standard deviation
Outbreak of avian influenza and other highly infectious diseases	4.67	0.52
Use of antibiotics in poultry production	4.50	0.55
Contamination of meat and eggs with zoonotic microorganisms	4.50	0.55
Disease control from neighbouring countries	4.33	0.82
Negative image of the poultry industry portrayed by the media	4.33	0.52
Standards for poultry products required from importing countries	4.17	0.75
EU and Islamic regulations for slaughter process	4.17	0.98
International trade in poultry products	4.17	0.75
Compartmentalisation of poultry production	3.83	0.75
The establishment of the ASEAN Economic Community – AEC	3.83	0.75
Public policy on poultry industry	3.83	0.75
Pressure on/from urban centres	3.83	0.75
Use of pesticides in poultry feed production	3.83	0.98
Quality of poultry meat and products	3.67	1.03
Poultry welfare in slaughter houses	3.67	0.82
Role of small-scale family farming	3.50	0.55
Rating value of foods	3.50	0.84
Consumer responsibility	3.50	1.52
Regional concentration of production/Mass production	3.50	1.05
Communication between producers and consumers	3.50	0.55
Labour wages	3.50	0.55
Perception of poultry meat and products	3.33	0.52
Feed from genetically modified plants	3.33	1.21
Introduction of new laws and regulations/legal framework	3.33	0.82
Breeding	3.33	1.37
Industry competitiveness/Farm income	3.33	0.82
Resource use	3.33	1.03
Development of value added products	3.33	0.52
Current status of environmental laws and regulations	3.33	1.03
Transportation	3.33	1.03
Workers in slaughter houses	3.33	0.52
Poultry welfare during growing phase	3.17	1.33
Consumer demand	3.17	0.41
Poultry mortality rate	3.00	1.10
Excess of national poultry meat production	3.00	0.63

Appendix 23: Results of the Delphi round 2 identified by the private sector in Thailand (Continued)

Sustainability concerns/issues in poultry production	N = 6	
	Mean	Standard deviation
Societal acceptance	3.00	1.26
Slaughter (procedure/process)	3.00	0.89
Efficiency of feed conversion	3.00	1.26
Genetic diversity of native poultry	2.83	0.98
Lacking efforts to prevent avoidable deficiencies within the industry	2.83	0.75
Use of native chicken species	2.83	0.41
Custom growing (fattening)	2.83	0.98
Feed supply	2.83	0.41
Efficiency of using poultry by-products	2.67	1.21
Growth rate of poultry	2.67	1.03
The role of NGOs and activist groups	2.67	0.82
Housing system	2.67	1.37
Role of food retailers	2.67	0.82
Manure management	2.67	0.82
Acidification, eutrophication and global warming potential	2.50	0.55
Space per animal/Stocking density	2.33	1.03
De-beaking	2.33	0.82
Food labelling	2.33	1.03
Biodiversity	2.33	0.82
Killing of male layer chicks	1.00	0.00
Kendall's coefficient of concordance (W)	0.485	

Appendix 24: Results of the Delphi round 2 identified by government officials in Thailand

Sustainability concerns/issues in poultry production	N = 8	
	Mean	Standard deviation
Outbreak of avian influenza and other highly infectious diseases	4.63	0.52
Use of antibiotics in poultry production	4.63	0.52
Standards for poultry products required from importing countries	4.50	0.53
Disease control from neighbouring countries	4.50	1.07
EU and Islamic regulations for slaughter process	4.38	0.74
Contamination of meat and eggs with zoonotic microorganisms	4.38	0.74
The establishment of the ASEAN Economic Community – AEC	4.13	1.13
Use of native chicken species	3.88	0.64
Negative image of the poultry industry portrayed by the media	3.88	0.64
Consumer responsibility	3.75	0.71
Pressure on/from urban centres	3.75	0.89
Labour wages	3.75	0.71
Use of pesticides in poultry feed production	3.75	0.46
Custom growing (fattening)	3.75	0.89
Perception of poultry meat and products	3.63	0.74
International trade in poultry products	3.63	0.74
Rating value of foods	3.63	0.52
Breeding	3.63	1.06
Role of small-scale family farming	3.63	0.92
Societal acceptance	3.50	0.93
Industry competitiveness/Farm income	3.50	0.76
Feed from genetically modified plants	3.38	0.92
Poultry welfare in slaughter houses	3.38	1.19
Public policy on poultry industry	3.38	0.92
Introduction of new laws and regulations/legal framework	3.38	0.52
Quality of poultry meat and products	3.25	0.71
Current status of environmental laws and regulations	3.25	0.46
Lacking efforts to prevent avoidable deficiencies within the industry	3.25	0.46
Growth rate of poultry	3.25	0.89
Workers in slaughter houses	3.25	0.71
Feed supply	3.25	0.46
Compartmentalisation of poultry production	3.13	0.64
Communication between producers and consumers	3.13	0.35
The role of NGOs and activist groups	3.13	1.13
Regional concentration of production/Mass production	3.13	0.83

Appendix 24: Results of the Delphi round 2 identified by government officials in Thailand (Continued)

Sustainability concerns/issues in poultry production	N = 8	
	Mean	Standard deviation
Efficiency of feed conversion	3.13	0.64
Resource use	3.13	0.35
Slaughter (procedure/process)	3.00	0.76
Transportation	3.00	0.53
Development of value added products	3.00	0.53
Poultry mortality rate	3.00	0.53
Role of food retailers	3.00	0.53
Consumer demand	3.00	0.53
Genetic diversity of native poultry	2.88	0.83
Space per animal/Stocking density	2.88	0.83
Manure management	2.88	0.83
Efficiency of using poultry by-products	2.75	0.71
Food labelling	2.75	0.71
Acidification, eutrophication and global warming potential	2.75	0.46
De-beaking	2.75	0.46
Excess of national poultry meat production	2.63	0.52
Housing system	2.63	0.74
Poultry welfare during growing phase	2.50	0.93
Biodiversity	2.38	0.74
Killing of male layer chicks	1.00	0.00
Kendall's coefficient of concordance (W)	0.427	

Appendix 25: Study on action undertaken by NGOs to improve the sustainability of the poultry industry

wing
Wissenschafts- und Informationszentrum
Nachhaltige Geflügelwirtschaft

Universität Vechta
University of Vechta

Questionnaire

Study on action undertaken by NGOs to improve the sustainability of the poultry industry

Background: The ongoing intensification of poultry production is hotly debated in public discussions and the media due to problems caused by the poultry industry, such as issues of animal welfare, the development of resistant bacteria, the use of cheap labour, environmental pollution and meat hygiene scandals. As a result, NGOs have criticised the poultry industry with a view to pushing to improve its production systems and increase the sector's sustainability.

Question: From the perspective of your organisation, what have you been doing or disseminating among the public to change the poultry industry? This can include reports on issues of animal welfare, infectious diseases, labour conditions, environmental problems, or awareness raising campaigns to inform the public.

Answer:

Appendix 26: Study on action undertaken by animal welfare groups to improve the sustainability of the poultry industry

wing
Wissenschafts- und Informationszentrum
Nachhaltige Geflügelwirtschaft

Universität Vechta
University of Vechta

Questionnaire

Study on action undertaken by animal welfare groups to improve the sustainability of the poultry industry

Background: The ongoing intensification of poultry production is hotly debated in public discussions and the media due to problems caused by the poultry industry, such as issues of animal welfare, the development of resistant bacteria, the use of cheap labour, environmental pollution and meat hygiene scandals. As a result, animal welfare groups have criticised the poultry industry with a view to pushing to improve its production systems and increase the sector's sustainability.

Question: From the perspective of your organisation, what have you been doing or disseminating among the public to change the poultry industry? This can include reports on issues of animal welfare, infectious diseases, labour conditions, environmental problems, or awareness raising campaigns to inform the public.

Answer:

Appendix 27: Study on action undertaken by the leading integrated poultry companies to improve their public acceptance

wing
Wissenschafts- und Informationszentrum
Nachhaltige Geflügelwirtschaft

Universität Vechta
University of Vechta

Questionnaire

Study on action undertaken by the leading integrated poultry companies to improve their public acceptance

Background: At present, the intensive poultry industry is portrayed negatively as a form of "Factory Farming"- especially by the media, animal activists and NGOs. Many issues have been criticised, including the practice of de-beaking, killing male chicks, the use of antibiotics in poultry production, outbreaks of avian influenza and other highly contagious diseases, the use of resources, issues of animal welfare and the use of cheap labour from other countries. As a result, the industry has been developing strategies to improve their social acceptance.

Question: From the perspective of your company, what have you done so far to improve the sustainability of the poultry industry in order to increase the level of social acceptance? This can include environment aspects, the use of antibiotics, animal welfare, labour conditions, communication campaigns, etc.

Answer:

Appendix 28: Summarised actions undertaken by NGOs and animal welfare groups on the sustainability of poultry production in Germany

Organisation	Action categorised by sustainability issue	Campaigns against:	Campaigns calling for government and sectoral support:
1. Greenpeace Source: http://www.greenpeace.de/	Use of pesticides in poultry feed production Feed supply Manure management and acidification, eutrophication and global warming potential Resource use Biodiversity Housing system Stocking density Use of antibiotics in poultry production Outbreak of avian influenza Employment of cheap labour from Eastern Europe in slaughterhouses Custom growing	Factory farming Patent on conventionally bred plants and animals Use of antibiotics in poultry production Use of forests and wetlands for poultry feed plantations Use of genetically modified feeds in poultry production	Support organic farming by altering the structure of agricultural subventions Increase transparency and information on egg and poultry meat labelling Use poultry feed from regional production Reduction of chemical fertilisers in feed production Reduction of meat and animal product consumption Increase animal welfare standards Promotion of small herd sizes
2. BUND (Friends of the Earth Germany) Source: http://www.bund.net/	Use of pesticides in poultry feed production Feed supply Manure management and acidification, eutrophication and global warming potential Resource use Biodiversity Housing system Stocking density Use of antibiotics in poultry production De-beaking Growth rate in poultry	Factory farming Use of antibiotics in poultry production Cheap meat De-beaking in laying hens and turkeys Use of genetically modified feeds in poultry production	Support organic farming by altering the structure of agricultural subventions Increase transparency and information on egg and poultry meat labelling Promote free range production systems Use poultry feed from regional production Reduction of chemical fertilisers in feed production Breeding of robust breeds

Appendix 28: Summarised actions undertaken by NGOs and animal welfare groups on the sustainability of poultry production in Germany (Continued)

Organisation	Action categorised by sustainability issue	Campaigns against:	Campaigns calling for government and sectoral support:
2. BUND (Friends of the Earth Germany) Source: http://www.bund.net/			Promotion of small herd sizes Legislation on turkey husbandry Improvement of quality assurance system for poultry meat products Mandatory labelling of poultry meat fed with genetically modified feed
3. Deutscher Tierschutzbund e.V. Source: https://www.tierschutzbund.de/ Interviewees: Dr. Heidrun Betz Renate Seidel	Biodiversity Housing system Stocking density Use of antibiotics in poultry production Custom growing De-beaking Growth rate in poultry Transportation	Factory farming Patent on conventionally bred plants and animals Use of antibiotics in poultry production Cheap meat Construction of large poultry farms and slaughterhouses Muscovy duck husbandry De-beaking in laying hens and turkeys Use of genetically modified feeds in poultry production	Increase transparency and information on egg and poultry meat labelling Promote free range production systems Use poultry feed from regional production Breeding of robust breeds Reduction of meat and animal product consumption Promotion of small herd sizes Increase animal welfare standards Increase quality control of poultry coop designs prior to market release Legislation on turkey husbandry Slaughter in the region of origin

Appendix 28: Summarised actions undertaken by NGOs and animal welfare groups on the sustainability of poultry production in Germany (Continued)

Organisation	Action categorised by sustainability issue	Campaigns against:	Campaigns calling for government and sectoral support:
3. Deutscher Tierschutzbund e.V. Source: https://www.tierschutzbund.de/ Interviewees: Dr. Heidrun Betz Renate Seidel			Limitation of domestic transport times to eight hours from poultry farms to slaughterhouses Mandatory labelling of eggs and products containing eggs
4. Vier Pfoten Germany Source: http://www.vier-pfoten.de/	Housing system Stocking density Growth rate in poultry Killing of day-old male layer chicks	Feeding geese by gavage Use of feathers and down from ducks and geese Killing of day-old male layer chicks	Support organic farming by altering the structure of agricultural subventions Promote free range production systems Breeding of robust breeds Promotion of small herd sizes Increase animal welfare standards Mandatory labelling of eggs and products containing eggs Prohibition of the sale of eggs and products containing eggs laid in cage systems

Appendix 28: Summarised actions undertaken by NGOs and animal welfare groups on the sustainability of poultry production in Germany (Continued)

Organisation	Action categorised by sustainability issue	Campaigns against:	Campaigns calling for government and sectoral support:
5. PROVIEH Source: http://www.provieh.de/ Interviewee: Verena Stampe	Feed supply Manure management and acidification, eutrophication and global warming potential Resource use Biodiversity Housing system Stocking density Use of antibiotics in poultry production Outbreak of avian influenza Excess supply of domestic poultry meat De-beaking Growth rate in poultry Transportation Killing of day-old male layer chicks	Use of antibiotics in poultry production Use of forests and wetlands for poultry feed plantations Import of products from other countries with low animal welfare standards De-beaking in laying hens and turkeys Killing of day-old male layer chicks Use of genetically modified feeds in poultry production	Increase transparency and information on egg and poultry meat labelling Promote free range production systems Breeding of robust breeds Promotion of small herd sizes Increase animal welfare standards Slaughter in the region of origin Limitation of domestic transport times to eight hours from poultry farms to slaughterhouses Elimination of export subsidies for live animals Development of animal welfare laws based on equal consideration for consumers and producers Mandatory labelling of eggs and products containing eggs

Appendix 29: Summarised actions undertaken by leading integrated poultry companies on the sustainability of poultry production in Germany

Company	Production strategy shifts towards sustainability
1. PHW-Group Source: http://www.phw-gruppe.de http://www.wiesenhof-online.de	Modernisation of poultry farms and slaughterhouses Use of modern technology to increase resource efficiency Development of feed additives to reduce nitrogen and phosphorus emissions Use poultry by-products for biogas production Shorten transport routes between poultry farms and slaughterhouses Promotion of scientific research at universities and institutes Promotion of alternative production systems Promotion of animal welfare and non-genetically modified feed Reduction of antibiotics Research on alternative use of day-old male layer chicks Research on laying hen husbandry without de-beaking Traceability and transparency of consumer products Control of poultry feed production Promotion of the use of slow-growing breeds High level of production standards Improved working conditions Support for farmers Promotion of constructive dialogue with NGOs and animal welfare groups
2. Heidemark Source: http://www.heidemark.de/ Heidemark, 2015b. *Heidemark Unternehmens Grundsätze*. Garrel: Heidemark. Interviewee: Cristian Woltering	Modernisation of poultry farms and slaughterhouses Use of modern technology to increase resource efficiency Development of feed additives to reduce nitrogen and phosphorus emissions Shorten transport routes between poultry farms and slaughterhouses Promotion of scientific research at universities and institutes Promotion of animal welfare and non-genetically modified feed Reduction of antibiotics Traceability and transparency of consumer products

Appendix 29: Summarised actions undertaken by leading integrated poultry companies on the sustainability of poultry production in Germany (continued)

Company	Production strategy shifts towards sustainability
2. Heidemark Source: http://www.heidemark.de/ Heidemark, 2015b. *Heidemark Unternehmens Grundsätze*. Garrel: Heidemark. Interviewee: Cristian Woltering	High level of production standards Improved working conditions Support for farmers Promotion of constructive dialogue with NGOs and animal welfare groups

Appendix 30: Summarised actions undertaken by leading integrated poultry companies on the sustainability of poultry production in Thailand

Company	Production strategy shifts towards sustainability
1. Charoen Pokphand Foods Public Company Limited (CPF) Source: http://www.cpfworldwide.com/en/ CPF, 2015b. *Sustainability report 2014*. Bangkok: CPF. Interviewee: Pramote Rutavepol	Development and use of advanced technology and innovation in poultry production Provision of opportunities for business partners and communities to participate in the decision-making process Efficient use of resources Promotion of employee welfare High level of biosecurity standards and product safety Promotion of human rights Improvement of animal welfare standards Labelling of poultry products Collaboration with retailers Promotion of community livelihoods Support for public policy
2. GFPT Public Company Limited Source: http://www.gfpt.co.th/index.php GFPT, 2015b. *GFPT annual report 2014.* Bangkok: GFPT.	Development and use of advanced technology and innovation in poultry production Provision of opportunities for business partners and communities to participate in the decision-making process Efficient use of resources Promotion of employee welfare

Appendix 30: Summarised actions undertaken by leading integrated poultry companies on the sustainability of poultry production in Thailand (continued)

Company	Production strategy shifts towards sustainability
2. GFPT Public Company Limited Source: http://www.gfpt.co.th/index.php GFPT, 2015b. *GFPT annual report 2014.* Bangkok: GFPT	High level of biosecurity standards and product safety Improvement of animal welfare standards Labelling of poultry products Collaboration with retailers Promotion of community livelihoods

Curriculum Vitae

Personal data

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2008 – 2011	M.Sc. in Environmental Management – Management natürlicher Ressourcen, University of Kiel, Germany **Master thesis:** Evaluation of the forest certification systems in Thailand compared to forest certification standards of the forest stewardship council **Supervisors:** Prof. Dr. Hartmut Roweck, Dr. Lutz Fähser
2006 – 2007	Visiting German language course at the Goethe-Institut, Bangkok, Thailand
2002 – 2006	B.Sc. in Agricultural Biotechnology, Kasetsart University, Bangkok, Thailand **Bachelor thesis:** Study on causing agents of mulberry dwarf disease by nested polymerase chain reaction (Nested PCR) technique **Supervisor:** Asst. Prof. Supaporn Klinkong

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