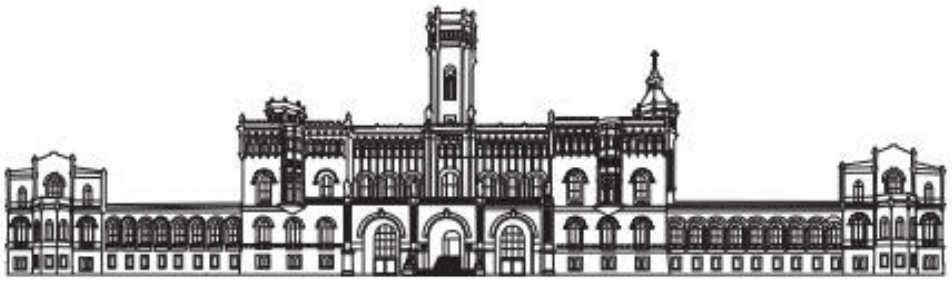

LEIBNIZ UNIVERSITÄT HANNOVER
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Towards Green Meat: A Decision Support System for Sustainable Livestock Production

Masterarbeit

zur Erlangung des akademischen Grades „Master of Science (M. Sc.)“ im Studiengang Wirtschaftswissenschaft der Wirtschaftswissenschaftlichen Fakultät der Leibniz Universität Hannover

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Introduction

1.1 Motivation and Relevance

Meat is a valuable source of essential nutrients such as zinc and iron. Despite the fact that a variety of vital nutrients can be acquired from various other food sources, the consumption of meat steadily increases. According to several studies conducted by the Food and Agricultural Organization (FAO), especially high-income continents such as North America, Europe and Australia have high consumption patterns of meat. Alone in Germany meat consumption rose from 63.85 kg in 1961 to 87.78 kg per person in 2017 [2].

The production of meat emits a great number of emissions per unit of energy that can be derived from it. As a major emitter of several greenhouse gases (GHG) leading to environmental degradation processes, the agricultural sector, in particular livestock husbandry plays a crucial role in climate change. Anthropogenic GHGs are emitted across the supply chain starting from land-use changes and feed production up until packaging and retail [3]. Up to date it remains a key challenge for academic researchers to determine emissions from the livestock sector. As claimed by the FAO, the livestock sector is accountable for 18 percent of anthropogenic GHG emissions [4]. However, estimations regarding livestock's contribution to anthropogenic GHG emissions vary between 7 and 18 percent [5] depending on the GHG accounting frameworks applied livestock species, production system, exogenous factors such as climate and land conditions. Land use changes such as deforestation, mostly brought by extension measures for arable land for feed crop production and pasture land release great amounts of carbon dioxide (CO_2). Next to CO_2, other gases such as methane coming from enteric fermentation processes or manure management, for instance storage and housing, and nitrous oxide (N_2O) released by fertilizing methods have a great impact on global warming. In addition, GHG are considerably responsible for acidification and eutrophication processes and livestock production contributes significantly to water depletion and degradation.

In 2015, the United Nations (UN) established 17 goals to combine economic growth with sustainable development. This "Agenda 2030" centers on climate change and addresses issues ranging from clean and affordable energy supply to responsible consumption patterns as well as quality education to achieve their goals by 2030 [6]. Applying these goals are unneglectable in order to design livestock production systems more sustainable. Specifically, unused resources in the context of meat production such as liquid and solid manure as well as straw used for litter can be recycled for energy production via an installed biogas plant or as fertilizer. Usually, farms have a great potential for applying renewable energy infrastructure due to the space available. While photovoltaic and solar thermal systems can be arranged on stable roofs, wind turbines are largely used on pasture and arable land.

As a result, livestock production systems offer various resources for several renewable energy production.

1.2 Research Question and Structure

Facing the immanent threat of climate change, the challenge to provide food to the world in a sustainable way remains. The objective of this thesis is to examine, how energy systems installed on farm grounds can help to produce meat in a more sustainable manner. As a focal point this thesis uses the Nano Energy System Simulation software, in short NESSI, initially developed as a decision support system (DSS) for in-depth analyses of building energy systems (BES). For the purpose of this thesis the existing software is extended and remodeled for the livestock sector. The following research question is further investigated throughout the course of this thesis:

RQ: "How can a DSS aid livestock stakeholders to anticipate and visualize the potential of renewable energy systems on farm grounds in order to produce meat in a sustainable manner?"

The research conducted in this thesis uses the three cycle design science research by Hevner (2007), displayed in Figure 1 [7].

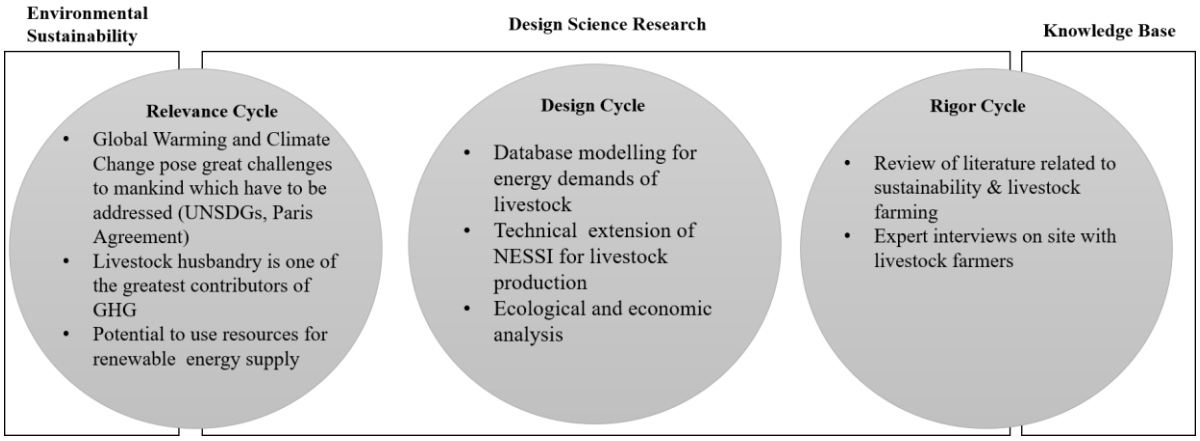

Figure 1 Design Science Research considered in this thesis, own compilation based on Hevner (2007) [7]

The relevance of this thesis can be drawn from chapter 1.1. To begin with, the concept of sustainability, livestock husbandry methods, GHG emissions and energy components are further examined. For this purpose, the concept of sustainability, specifically in an agricultural context is outlined and animal husbandry methods for cattle and pig production are reviewed. In a next step, expert interviews have been conducted. Here, a total of four experts in cattle and pig farming were interviewed and two farms visited. The transcribed interviews and the underlying interview guide can be found in the Appendix A.2. Afterwards, GHG emissions of livestock are considered. In order to model hourly demands for livestock, load profiles retrieved from the Bavarian regional office, are edited and analyzed. Next, newly implemented or modified energy components incorporated in the NESSI Livestock simulation are described. Based on the conducted research the NESSI software is extended and remodeled for livestock

operations accounting for GHG emissions in pork and beef. Next, analyses are conducted considering GHG emissions reduction potential of meat through the incorporation of a CO_2 credit. Lastly, limitations and recommendations for further research possibilities are examined.

7. Conclusion

The livestock production sector is one of the greatest emitters of GHG emissions globally. However, with growing populations, demand for energy and nutritional supply increases. Since agricultural land offers a great potential for the implementation of sustainable energy, renewable energy systems can be implemented supplying cleaner energy to nearby communities. This research aimed to identify economical and ecological implementation strategies for renewable energy systems for livestock stakeholders making production processes of meat sustainable. For the purpose of this thesis, the existing DSS, namely NESSI, is extended and remodeled for livestock production systems. With reference to the research question, a CO_2 credit is implemented, in order to feed-in excess energy and reduce respective emissions incorporated in each kg of meat.

To begin with, chapter 2 gives theoretical background information considering the concept of sustainability and animal husbandry. Further, experts in livestock production are interviewed and farms were visited. In chapter 3, the load profiles forming the necessary basis for the NESSI simulation software, are further examined. Data for dairy cattle, piglet production, piglet rearing and fattening pig processes were retrieved from the Bavarian regional office. The available data was analysed and edited in order to implement the load profiles within the NESSI Livestock application. In addition, new energy components including a biogas plant and a heating canon as well as modifications of the CHP plant are considered. Besides, agricultural machinery is implemented accounting for daily on farm operations and released emissions.

Chapter 4 incorporates a detailed explanation of modifaications made to the existing NESSI versions. First, the restructure of the GUI is considered. Second, modifications and adjustments made to existing energy components are elucidated and displayed. Here, several possible uses for the unused slurry and manure of the existing animals is accounted for, if no biogas plant is available.

Subsequently, the newly implemented consumers and energy components are applied in several analyses in chapter 5.

Comparing pig and cattle simulations, this thesis shows that unused manure accounts for a major part of emissions incorporated in meat. Excluding the implementation of the CO_2 credit the wind turbine is the most economical efficient option for cattle production. In pig production processes the incorporation of the local heating network and a combination of a wind turbine and a PV system are economically viable. Considering the inclusion of the CO_2 credit, both analyses show a high saving potential in terms of costs and GHG emissions reduction through the implementation of a biogas plant fed with additional substrates.

Chapter 6 outlines limitations of the NESSI Livestock simulation and considers further research options and possibilities.

This research clearly illustrates a concept for a decision support system -NESSI Livestock- that helps livestock stakeholders to anticipate and visualize the potential of renewable energy

systems on farm grounds for a sustainable meat production. Due to the complexity of factors influencing livestock production and resulting GHG emissions incorporated in meat, further studies are recommended. To better understand the implications of the results of this thesis, future studies should address data scarcity, especially in fattening cattle processes.