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Policy Brief

Key messages

- Given the interdependence of the agricultural sector and climate change, it is important to reduce GHG emissions caused by livestock production.
- Best practice case examples in Germany and China show that efficient nitrogen use in combined livestock and crop production is feasible.
- Enhancement of nitrogen use efficiency and a reduction in emissions can be achieved through improved livestock feeding, housing as well as storage, processing and application of manure.
- The production of biogas from manure converts excess manure into energy and improves the plant availability of the fertiliser.
- The combined production of meat and grains on one farm at a large scale can be combined with additional areas of operation, such as the processing of agricultural raw materials (added value).

Livestock Production and Climate Change

By Gerhard Rappold

Introduction

Agricultural production, like many other human activities, emits greenhouse gases (GHG) and therefore contributes to climate change. At the same time, the agricultural sector suffers from the adverse effects of climate change in various ways.

In Germany, 7.3% and in China 6.8% of the annual emissions are attributable to the agricultural sector. Livestock production in Germany (including farm manure) accounts for a large share of these emissions at around 35% (UBA, 2019).

GHGs emitted by livestock husbandry include:

- Methane (CH_4): is produced during fermentation processes in the stomach of ruminants, predominantly cattle, but also sheep and goats.
- Methane and nitrous oxide (N_2O): are caused by the manure of animals - this is not limited to cattle, but also occurs in the manure of pigs or chickens.
- Ammonia (NH_3) and nitrate (NO_3): are emitted in livestock husbandry (mainly cattle) and react with atmospheric components to form nitrous oxide.

Due to their long persistence in the atmosphere, nitrous oxide and methane are powerful GHGs, which is expressed by their Global Warming Potential (or carbon dioxide equivalent).

Table 1. Greenhouse gas emissions and their carbon dioxide equivalent (CO_2-eq). Source: own, 2020.

Gas	**Formula**	**CO_2-eq**
Carbon dioxide	CO_2	1
Methane	CH_4	28
Nitrous oxide	N_2O	298

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In addition to these direct emissions from livestock production, there are other emissions associated with it. Today's intensive livestock production relies on protein-rich feed. Soya is the most protein-rich fodder plant (legume) and is therefore cultivated on a large scale to feed the world's livestock. The main production of soybeans takes place in the United States and Latin America, while livestock is mainly produced in Europe and Asia. This is especially true of pork production, which has quintupled in less than 50 years (Müller, 2020). Thus, the economic interests of the livestock industry lead to the deforestation of the tropical rainforest in soybean-producing countries. Since rainforests are CO_2 sinks, this deforestation process even accelerates climate change.

Additionally, climate change has direct negative impacts on livestock farming. One example is the heat sensitivity of dairy cattle. Hot spells are a common phenomenon of climate change, while the ideal conditions for cattle are below 20°C. A temperature rise above 25°C reduces milk yield by up to 20% (which is irreversible until the next calving (Amon, 2019), resulting in a fundamental decline in milk production.

Approach

While adaptation to climate change is a necessity from a local perspective, the reduction of greenhouse gas emissions is imperative from a global perspective. Ultimately, the most effective form of adaptation is mitigation. The key question is therefore how to produce in a climate-friendly way, i.e. with the lowest possible GHG emissions. In order to assess the status quo and best practices in China and Germany, an interdisciplinary team of experts undertook two study tours during which expert interviews, scientific discussions and farm visits were conducted. Best practice examples from these visits are presented in the following section.

Best practice cases

Agrarunternehmen Barnstädt e. G. – Elaborated circular material flow management

The Agricultural Cooperative Barnstädt is a large farm with about 5,500 ha of arable land and an annual pork production of 100,000 pigs. The entire agricultural production is optimised to minimise external inputs and at the same time achieve a good profit. Almost all the feed is produced on-farm. The manure from the pigs is primarily used as fertiliser for crop and fodder production using the direct injection method, which results in very low GHG emissions. In addition, the manure is used to produce biogas (by a contractor). The annual material flow balance is decisive for the farm management. It is mandatory to determine the nitrogen balance and thus calculate the fertiliser requirement of the soil, which must be reported to the regional State Office for Agriculture and Horticulture.

The mandatory nitrogen balance can be seen as a best practice instrument for a circular economy in the agricultural sector. This is of particular importance for Germany. The country has been exceeding the EU limits for nitrate pollution for years and faces sanctions. In order to avoid this, a new law, the *Fertiliser Ordinance 2020* (DüV-20), was passed. Farms with intensive animal production today lack the agricultural land for environmentally sensitive fertilisation and thus manure is transported over long distances to find suitable 'sinks'.

Zhongyu Company Ltd. – Pilot engineering of circular agriculture, non-point pollution control and livestock manure management

The Zhongyu Company is an agricultural enterprise with a total of 100,000 ha of land and an annual production of 100,000 pigs, including a complete food processing chain for wheat products such as noodles, bread or distilled alcohol. According to the company management, vegetables are produced in greenhouses without the use of synthetic fertilisers. The company optimised its production through large-scale material and energy flows and increased product improvement by producing wheat products (pasta, bread, gluten, alcohol) and frozen meat products.

Pig manure and human faeces are collected from nearby households. Together with straw residues (which until recently were burned in the fields) they form the fuel for the biogas plant to produce energy needed for food processing. Furthermore, the biogas effluent and residues are processed into liquid fertiliser for the greenhouses and solid fertiliser for the fields. Wheat (for food production) and maize (for fodder production) are grown in rotation on the fields. Cucumbers, tomatoes, eggplants and other vegetables are grown in the greenhouses. The use of pesticides in the greenhouses is avoided as far as possible. In a four-week fallow period of May/June each year, the greenhouses are heated up to 70°C to eliminate pests.

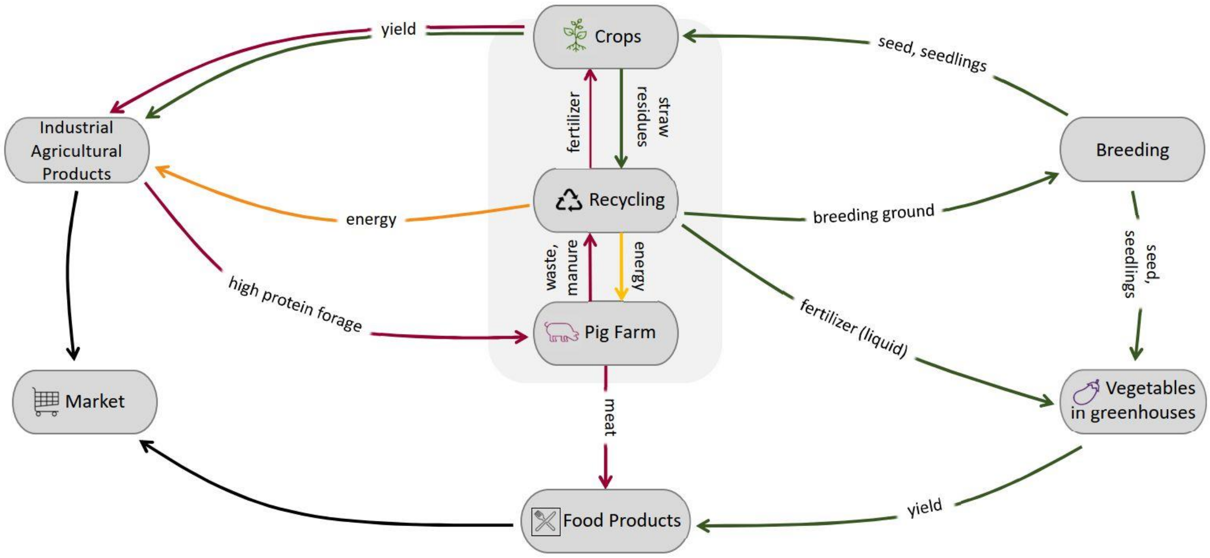

Figure 1. Circular agro-industrial production chain of the Zhongyu Company. Source: Adapted from Zhongyu Company 2020.

On the basis of manure from pig production, an ecological vegetable and environmentally friendly wheat production was established. The wheat is processed into quality products using the energy from biogas. The greater depth of production at farm level creates synergies that save resources. In addition, the selling prices are better than for raw products. This best practice shows the positive economies of scale: emissions and environmental impacts are minimised while production is optimised.

Reduction of nitrogen emissions: Concepts for best practices in dealing with environmental needs

For almost a century, mankind has caused unprecedented changes in the nitrogen cycle by more than doubling the conversion of non-reactive atmospheric nitrogen (N_2) into reactive forms of nitrogen (N_r), which spread in cascades through the environment. For the European Union (E27), the total health costs associated with nitrogen losses (from agriculture) are estimated at 320 billion EUR annually (Sutton et al., 2011). In view of continuous global population growth, agricultural practices will have to change fundamentally in order to radically reduce nitrogen emissions.

To increase nitrogen use efficiency and reduce direct GHG emissions from livestock production, the following improvements are proposed (Amon, 2020).

Livestock Feeding

The crude protein content and composition in the animal diet is the primary driver of urine excretion, which in turn is the main source of urea. Urea is first broken down to ammonia, which is then converted to nitrous oxide.

Adaptation of crude protein in the diet to the animal's needs is, therefore, the first and most efficient measure to mitigate nitrogen emissions.

Livestock Housing

Emission abatement techniques at the animal housing level should target one or more of the following key factors of the emission processes:

- Rapid drainage of the soil and direct transport of urine to the manure store;
- Minimising the residence time of open urine / manure sources to limit urease activity;
- Prevention and minimisation of open urine / manure sources;
- Regulating the pH and temperature of urine / manure;
- Room air temperature (lower temperature leads to slower reactions);
- Minimising the interaction between air and emitting surfaces;
- Discharge of indoor air.

Storage, processing and application of manure

The optimal use of manure nutrients is essential for sustainable agriculture. Nutrients can be lost through nitrate leaching and gaseous emissions. In addition to nutrient losses, methane emissions into the atmosphere must also be reduced. Therefore, manure should be stored in covered outdoor tanks. The storage capacity depends on the length of the growing season. Manure should be available at all times to meet the nitrogen requirements of the crops. The separation of solid manure from slurry can lead to a useful increase in the content of readily available nitrogen in the manure and reduce the dry matter content. Anaerobic digestion improves the fertilisation value of manure and greatly reduces methane emissions during the storage of manure. The use of advanced application methods such as trailing shoe and injection technology can drastically reduce ammonia and odour emissions, thereby also reducing indirect nitrous oxide emissions.

For more information on manure management methods in China, see also the article *How to Make Use of Livestock Manure? Standard Discharge or Land Application Use* (Wei et al., 2020).

Recommendations

Climate mitigation in livestock production depends very much on local specifications, agricultural practice and empirical optimisation in order to find sound solutions. In the future, *Smart Agriculture* can additionally help to determine the nutrient requirements of livestock or the actual emission values more explicitly by using sensors, thus radically optimising material flows and emissions.

An approach to climate change mitigation and adaption in livestock production that is separated from crop production is limited to scientific research only. In practice, what matters most is the economic unit, i.e. the farm and its interaction with the environment (material flows), and any change or innovation to the system must be tested in practice.

Best practice cases from actual farms are ground-breaking for scaling up resource and energy efficient and industrial farming practices, while scientific approaches provide specific solutions for technical details.

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About the author:

Dr. Gerhard Rappold is an independent consultant with vast experience in international development cooperation since 1997. He was part of the expert team of the subproject *German-Chinese Cooperation on Agriculture and Climate Change* of the DCZ. He studied geography and hydrology at the Albert-Ludwigs-University of Freiburg and additionally meteorology and geology at the Free University of Berlin, where he also received his doctorate.

His main areas of expertise are integrated water resource management (IWRM), climate adaptation and vulnerability analysis as well as the Water-Energy-Food Nexus to address interlinked supply risks. In addition, he moderates workshops and events and advises projects and organisations on project and change management.

About the project:

The Sino-German Agricultural Centre is a joint initiative of the German Federal Ministry of Food and Agriculture (BMEL) and the Ministry of Agriculture and Rural Affairs of the People's Republic of China (MARA). It was established in March 2015 as a central contact and information point and for coordinating bilateral cooperation between Germany and China in the agricultural and food sector. The DCZ brings together stakeholders from the public and private sector and the scientific community. It creates forums in which agricultural issues of common interest are addressed. The spectrum of Sino-German cooperation in the agricultural sector is reflected in the three components of the DCZ: Agricultural Policy Dialogue, Agri-Food Business Dialogue and Scientific Dialogue. Further information can be found on the project website.
https://dcz-china.org/en/the-project.html
The aim of the sub-project on climate change was to bring together renowned experts and scientists to assess the current state of research and best practices in both countries and to identify broader perspectives for cooperation in the field of agriculture and climate change. The Sino-German expert group consisted of scientists and consultants with a focus on environmental policy, mitigation in livestock production, adaptation of crop production, agricultural economics, land use and climate change, who worked together in an interdisciplinary way.