

Master thesis

The impact of livestock raising on China's water

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Abstract

China is currently facing difficult environmental challenges, one of which is water problems. With both water scarcity and the majority of the waterways heavily polluted, the Chinese government has begun to take measures to solve these problems in recent years. While China like the rest of the world recognises livestock's major impact on greenhouse gas emissions, its role in causing water scarcity and pollution in China has not yet been studied. Although insufficient statistical data is available to precisely determine livestock's impact on China's water problems, this paper examines how developments in livestock raising in China in the last century have changed livestock's impact on water and the environment more generally. The paper discusses the different ways in which livestock influences the quantity of water as well as water quality and how developments in the livestock sector have had an impact on this. In addition, the paper assesses possible options to improve the water quality and availability, based on what we know about the ways livestock negatively impacts China's water resources.

Introduction

Today China is facing numerous pressing environmental challenges. The problems vary from air and water pollution to climate change, ozone depletion, desertification and a loss of biodiversity.¹ China's environmental problems not only affect China, but also the rest of the world, as climate change has an impact on everyone and pollution does not stop at country borders. Therefore, the problems that face China today and how it decides to work towards solving them is relevant for everyone.² Although observers from outside China have sometimes stated that China is not taking action to stop environmental degradation, the Chinese government has been working on environmental protection since the introduction of the Environmental Protection Law in 1979. Since then China has created various environmental protection agencies and created additional environmental laws and programs.³ However, these laws and measures have not been able to stop China's environmental problems as of yet.

One of China's environmental challenges is dealing with its water problems. As a sufficient supply of clean water is vital for both human life, other species and the environment,

¹ Shapiro, Judith (2013): 18.

² Shapiro, Judith (2013): 18.

³ Ma, Xiaoying & Ortolano, Leonard (2000): 2.

it is highly important that all countries including China ensure that this supply of clean water is and will continue to be available. In order to do so, it is necessary to know what processes play a role in threatening the reliable availability of sufficient clean water, also called water security. Works on China's water crisis argue that in the last few decades the intensive water usage by Chinese households, industry and agriculture in combination with deforestation has caused water scarcity and that these three types of water usage also contribute to water pollution.⁴

In works that examine China's water problems agriculture is usually mentioned as playing a role in causing water scarcity and pollution, but its exact impact is not discussed. Animal agriculture does not appear at all or it is only mentioned shortly as a less significant contributor not worthy of a discussion. As studies on a global scale like *Livestock's long shadow*⁵ suggest that livestock raising plays a significant role in water pollution and other water problems, it would seem unlikely that animal agriculture does not play any role in China's water problems. While studies dealing with animal agriculture and its impact on a global scale do usually discuss the sector's impact on water, studies that focus on China do not. While there are studies on animal agriculture and the environment in China, these mostly focus on greenhouse gas emissions and global warming. Because of this, little is known about the impact of livestock raising on the quantity and quality of water in China.

Therefore, in this paper I assess the impact of the livestock sector on China's water resources. I use an environmental systems analysis to evaluate the environmental impact of the livestock sector and the causal relationship between this sector and environmental problems.⁶ I base my analysis predominantly on studies on the influence of the livestock sector on water on a global scale and apply this to the Chinese context along with the few available sources on the Chinese context specifically.

I argue that animal agriculture per se does not have a negative impact on the environment, but that the developments in the last few decades towards an intensive and specialized livestock sector has led to animal agriculture becoming more water-intensive and polluting. The first chapter examines China's problems of water scarcity and water pollution. In the second chapter I discuss the developments in the livestock sector in the last century, followed by a discussion of how animal agriculture is related to the current water problems. Lastly, I examine how these negative effects of livestock raising are not inherent to animal

⁴ Ma, Jun (2004): vii-xi.

⁵ FAO (2006).

⁶ Shimaoka, Takayuki ; Kuba, Takahiro ; Namayama, Hirofumi ; Fujita, Toshiyuki ; Horji, Nobuhiro (2016): 144-146.

agriculture, but a result of a modern and intensive way of raising livestock and offer some suggestions to mitigate livestock's negative impact on water.

1. China's water problems

China has had to deal with water challenges for centuries, with regular floods and droughts as well as attempts to change the course of waterways to improve the situation. However, these challenges have reached a new high in the last few decades. Ecological deterioration has increased and there are still bad floods and droughts. Compared to the past, the situation has worsened as now water scarcity and water pollution are becoming a major problem.⁷ In this chapter I discuss two important aspects of China's water problems: the quantity and the quality of the available water.

1.1 Water quantity

Water is an important resource that humans rely on for survival and therefore it is important that it is used in a sustainable way so that future generations will still have access to sufficient water. Herman E. Daly proposed principles to judge whether a resource is used in a sustainable way. In the case of a renewable resource, such as surface water, sustainable usage would be equal or less than the rate of regeneration. As for non-renewable resources, such as groundwater, sustainable usage cannot exceed the rate at which this resource is refilled by a renewable source.⁸ In the case of water, that would be the rate at which surface water seeps down and becomes groundwater.

China has access to around 2,400 to 2,800 billion square meters of renewable water every year, an enormous amount of water. However, the amount of water per capita that was available in the early 2000s was only 2,100 square meters, only a quarter of the world average. The amount of water per capita even dropped down to 1,856 square meters in 2004.⁹ This is within the boundaries of the Falkenmark Water Stress Indicator, which states that countries with 1700-2000 square meters of water available per capita are in a state of water stress that significantly affects people's lives and economic production.¹⁰ This indicates that water is relatively scarce in China. The amount of water that is available per capita is only expected to

⁷ Ma, Jun (2004): vii-xi.

⁸ Daly, Herman E. (1990).

⁹ The World Bank (2006): 5.

¹⁰ Jin, Leshan & Young, Warren (2001): 218.

decrease as the population grows.¹¹ In addition, the water supply in China is not equally divided over the country. While the north of China has 60 percent of all the agricultural land, it has only 16 percent of the water supply. The south of China, on the other hand, has only 40 percent of the agricultural land while having 84 percent of China's water.¹² However, even though the north is more arid and the south more humid, both have water shortages.¹³

Most big cities in China have trouble providing their citizens with enough water and in order to supply more water, groundwater aquifers are being used in many places to get more water. As people dig deeper to obtain more water, these underground storages of fresh water are quickly being depleted.¹⁴ As this water is not easily renewable and the water table keeps dropping, this is not sustainable according to Herman Daly's principles of sustainable resource usage. This also threatens the water security of big cities like Beijing, as this is not a sustainable long term solution to the water scarcity.¹⁵ Many dams have been built in an attempt to create a stable source of water in areas with water scarcity as well as to reduce the chance of floods. However, even though more than 85,000 dams were built in the last few decades, the water shortage has only become more severe, with more areas where water is becoming scarce and where groundwater aquifers are being depleted to temporarily maintain the water supply.¹⁶

The Chinese government has begun to realise the severity of this problem and has started to take measures. The problem is partly caused by the fact that an excessive amount of water is being used for industrial and agricultural purposes, or by households, while this is slowly depleting unrenovable water resources.¹⁷ Therefore, the government tries to encourage a more sustainable and less wasteful use of water.¹⁸ As the lack of water is not an isolated problem, many other measures to help reduce water shortages are focussed on reducing environmental degradation and restoring natural ecosystems where they have been disrupted by industrial or agricultural activities. Deforestation, desertification and soil erosion play a significant role in the creation of water shortages as they lead to sedimentation that restricts the river's flow, thereby reducing the amount of water that reaches places further downstream.

¹¹ The World Bank (2006): 5.

¹² Shapiro, Judith (2013): 22.

¹³ Ma, Jun (2004): ix.

¹⁴ Shapiro, Judith (2013): 22.

¹⁵ Shapiro, Judith (2013): 22, 45.

¹⁶ Ma, Jun (2004): ix.

¹⁷ Ma, Jun (2004): 36, 111.

¹⁸ Ma, Jun (2004): x.

Therefore the government encourages the restoration of forests and natural waterways to improve the situation.¹⁹

1.2 Water quality

While the shortage of water is a big problem, another issue is that the available water often is not of good quality.²⁰ This reduction in quality is mainly because of pollution, which Ahluwalia defines as “an undesirable change in the physical, chemical or biological characteristics of the environmental components, namely, air, water, and soil, which adversely affects the life support system of the biosphere.”²¹ In the case of water this usually means any decrease in the quality of water.²² There are two types of pollutants. The first type are biodegradable pollutants, such as fertilizer, paper or sewage that can be broken down by bacteria and can therefore eventually be neutralized by the environment. The second type are non-degradable pollutants that stay in the environment unchanging like pesticides, plastic and heavy metals.²³ Pollutants can also be divided in point source, where the pollution happens at a specific place like the end of a pipe or sewer, and non-point source pollution, where pollution happens over a wide area and is harder to measure and study, like chemicals from fields ending up in water.²⁴

75 percent of rivers and lakes in China are heavily polluted.²⁵ 90 percent of urban groundwater is heavily polluted and 28 percent of this water has even been ranked in the fifth category of water pollution, the worst of the five categories used by the Chinese state to indicate the level of pollution.²⁶ Water ranked in category five can not only be found in urban groundwater, but also in some rivers, such as the Huai and Hai, of which more than half of the surface water has been ranked category five.²⁷ This water is so badly polluted that it is deemed unsuitable even for agricultural usage.²⁸ In addition, many lakes and coastal areas have eutrophication problems, severally deteriorating the water quality.²⁹

¹⁹ Ma, Jun (2004): x, 15-31, 66-67, 130.

²⁰ Ma, Xiaoying & Ortolano, Leonard (2000): 2.

²¹ Ahluwalia, V.K. (2013): 95.

²² Ahluwalia, V.K. (2013): 121.

²³ Ahluwalia, V.K. (2013): 95.

²⁴ Ahluwalia, V.K. (2013): 124.

²⁵ Shapiro, Judith (2013): 22.

²⁶ Shapiro, Judith (2013): 22.

²⁷ Ma, Xiaoying & Ortolano, Leonard (2000): 2.

²⁸ Shapiro, Judith (2013): 22.

²⁹ The World Bank (2001): 58.

There are numerous sources causing the heavy water pollution in China. One of these is industrial waste, which is often dumped untreated.³⁰ Most of the efforts made by the government to reduce water pollution have focussed on this type of pollution. These policies have led to more wastewater being treated before being released into rivers through the creation of maximum standards for certain pollutants and fines for the violation of these standards.³¹ Other sources of water pollution are the discharge of mostly untreated wastewater from cities into rivers and chemical fertilizer and pesticides from agriculture of which a large part ends up in waterways.³² This water that is contaminated by a variety of wastewaters and toxic chemicals is used as drinking water by hundreds of millions of Chinese people.³³

Pollution itself is not necessarily problematic, depending on the rate of emission. Pollution is sustainable if it happens at a rate that is equal to or less than the rate at which the environment can recycle the pollutant in question or make it harmless, in the case of biodegradable pollutants.³⁴ However, as the amount of pollutants in China's waterways seems to continually rise, it is clear that pollution is happening at a higher rate than what would be sustainable and in addition there are also many non-degradable pollutants being emitted.

1.3 Animal agriculture and environmental problems

In recent years it has become known that animal agriculture plays a considerable role in the creation of environmental problems. The 2006 Food and Agriculture Organisation of the United Nations (FAO) report *Livestock's long shadow: environmental issues and options* explained the different ways in which the livestock sector influences the environment and assessed how it contributes to certain environmental problems.³⁵ The report concludes that:

“The livestock sector emerges as one of the top two or three most significant contributors to the most serious environmental problems, at every scale from local to global. The findings of this report suggest that it should be a major policy focus when dealing with problems of land degradation, climate change and air pollution, water shortage and water pollution and loss of biodiversity.”³⁶

³⁰ Ma, Jun (2004): 35, 121-140.

³¹ Ma, Xiaoying & Ortolano, Leonard (2000): 3, 21.

³² Ma, Jun (2004): 79-82, 123-140, 162-163.

³³ Shapiro, Judith (2013): 22.

³⁴ Daly, Herman E. (1990).

³⁵ FAO (2006).

³⁶ FAO (2006): xx.

The fact that animal agriculture is a significant contributor to environmental problems has not remained unnoticed by the Chinese government. However, both in China and abroad most attention has focussed on livestock's contribution to global warming and carbon dioxide emissions. Not just global studies show the link between the livestock sector and greenhouse gasses, but studies focussing specifically on China demonstrate that the developments in animal agriculture have resulted in an exponential growth in greenhouse gas emissions.³⁷ In 2016 the Chinese government began a campaign to encourage people to consume less meat in order to reduce greenhouse gas emissions. This campaign included information adverts, such as one starring the famous Hollywood star Arnold Schwarzenegger who said "Less meat, less heat".³⁸ Around the same time the Chinese government released new dietary guidelines advising a relatively low consumption of meat.³⁹ The goal of this campaign was to reduce carbon dioxide emissions and if the guidelines are followed it is expected that by 2030 China's emissions will be half of what it would have been without the new guidelines.⁴⁰ While the Chinese government does encourage its citizens to consume less meat, it also encourages the growth of animal agriculture, which I will discuss in the next chapter. This seems to be rather contradictory, but while the government wants to reduce environmental pollution, it may not want to give up economic growth from the livestock sector.

2. Livestock in China

The number of livestock raised in China has been continuously growing for about a century now. In order to understand how this has affected the environment and more specifically, the quality and quantity of China's water, it is important to first understand how farming has changed over the years. These changes do not only consist of a rise in the number of animals being bred and raised, but also changes in farm size and livestock raising methods. Therefore, this chapter discusses the developments in livestock raising in China.

³⁷ Zhou, Jiang, & Chen (2007): 3766 ; Luo, Ting; Yue, Qiang; Yan, Ming; Cheng, Kun & Pan, Genxing (2015) ; Department of Climate Change (2012).

³⁸ Milman, Oliver & Leavenworth, Stuart (2016).

³⁹ The Chinese Dietary Guidelines 中国居民膳食指南 (2016).

⁴⁰ The Chinese Dietary Guidelines 中国居民膳食指南 (2016).

2.1 Livestock raising in the past

In the past, Chinese farmers were known to often have kept a variety of draft animals as well as animals for meat or other products, such as eggs or wool. Some often-kept animals were horses, oxen, sheep, pigs, dogs and fowls.⁴¹ Not much is known about the development of agriculture and livestock in premodern China and there are no statistics about the exact number of animals that were kept. Nevertheless, a number of scholars has tried to discover as much as possible about agriculture in China's past.

We know that the population of China steadily increased from the fourteenth century until the fall of the Qing empire. During these centuries, meat production and consumption seems to have been quite low and the per capita number of animals that were kept appears to have been relatively stable throughout this period.⁴² At this time not every farmer owned or was able to rent a draft animal.⁴³

However, in the 20th century, the number of livestock that were kept and consumed started to increase. Dwight Perkins suggests that a rise in demand for meat, especially in urban areas, may have played a role in the rise in pig and poultry raising.⁴⁴ Between 1914-1918 and 1957, the number of pigs in China more than doubled, the number of sheep and goats increased almost fourfold and the number of oxen and water buffaloes increased threefold.⁴⁵

According to John Lossing Buck, three-fourths of the animals kept in China in the period 1929-1933 were used as draft animals, while a mere one-fourth was kept to produce goods, such as meat, hides, eggs and suchlike.⁴⁶ While 10 percent of the farmers at this time did not own any animals, the density of the animal population was not too low. This was important to keep up the fertility of the land, although individual farms usually had only a handful of animals because most farms were quite small.⁴⁷ In his study, he also confirms that the consumption of meat was not high, stating that: "The sources of this food energy are largely vegetarian, nearly 98 percent being from plant origin and only 2.3 percent from animal products."⁴⁸

⁴¹ Perkins, Dwight (1969): 49.

⁴² Perkins, Dwight (1969): 13-15.

⁴³ Perkins, Dwight (1969): 57.

⁴⁴ Perkins, Dwight (1969): 129.

⁴⁵ Perkins, Dwight (1969): 287.

⁴⁶ Buck, John Lossing (1937): 11.

⁴⁷ Buck, John Lossing (1937): 12, 245.

⁴⁸ Buck, John Lossing (1937): 16-17.

In the 50s and 60s the government tried to reorganise the countryside in collectives and implemented new agricultural policies. These new policies led to a government monopoly on grain and farmers lost control over their own harvests.⁴⁹ However, while the number of livestock being raised had already started to grow, Dwight Perkins points out that farm technology during this time was still quite similar to that used in previous periods. Only in the early 60s did the government begin to press for a move towards more capital intensive and modern farming techniques, such as the use of chemical fertilizers and mechanical power.⁵⁰ This would be the beginning of a development that would change animal agriculture significantly. From this time until the 1980s the state had a monopoly on the distribution and marketing of animal products and therefore the raising and selling of animals was not regulated by the market. The state bought set quotas of live animals from both collectives and individual household farms and sold the meat in state food stores, mostly in urban areas. This government regulated market in meat did not make it very profitable for farmers to raise a lot of livestock so there was not much incentive to do so. In rural areas farmers would sometimes consume their own animals, but in both rural and urban areas animal products were often in short supply and infrequently available.⁵¹

2.2 Modern animal agriculture

In his 1937 book, John Lossing Buck wrote:

Considering the dense population of China, it is doubtful if the animal industry can be increased to any great extent for such purposes as milk, meat or egg supply, except in the frontier regions where land is primarily adapted to the animal industry or in limited areas where some land might now be better used for pasture than for fuel, or even for crops.⁵²

Today, we know that Buck was wrong in thinking that the animal industry could not increase to any great extent. Since the 1980s rapid changes have occurred in China, as the country has opened up to the rest of the world and began to focus more on economic development. The

⁴⁹ Dikötter, Frank (2011): 127-128.

⁵⁰ Perkins, Dwight (1969): 8, 55.

⁵¹ The World Bank (1987): 16.

⁵² Buck, John Lossing (1937): 266.

resulting economic growth has led to an increasing demand for animal products.⁵³ When compared to Perkins' 1957 estimate of the livestock population, we can see that the number of livestock had greatly increased by 1990, with the number of animals of most species being about 1.5 to 2 times as high as in 1957.⁵⁴ According to the FAO, in the period 2000-2011 the meat production in China increased by about 3.2 percent, eggs by 2.3 percent and milk by a staggering 11.9 percent.⁵⁵ As mentioned earlier, while the number of livestock was relatively stable during previous decades, it is clear from the table below that the number of livestock being held in China has greatly increased in the last century.

Table 1: Number of livestock and egg production (x1000 heads/eggs)

| Year | Pigs | Cattle | Dairy cattle | Poultry | Egg production | Sheep/goats | Other large animals |
|-------------------------|---------|---------|--------------|-----------|----------------|-------------|---------------------|
| 1914-1918 ⁵⁶ | 63,500 | 23,000 | n.a. | n.a. | n.a. | 26,400 | 10,000 |
| 1931-1937 ⁵⁷ | 68,358 | 37,900 | n.a. | n.a. | n.a. | 48,100 | 21,090 |
| 1933 ⁵⁸ | 70,000 | 40,000 | n.a. | n.a. | n.a. | 72,000 | 21,500 |
| 1955 ⁵⁹ | 87,920 | 65,951 | n.a. | n.a. | n.a. | 84,218 | 21,437 |
| 1957 ⁶⁰ | 145,900 | 63,612 | n.a. | n.a. | n.a. | 98,580 | 19,845 |
| 1987 ⁶¹ | 306,792 | 80,792 | 1,336 | n.a. | 4,316 | 158,400 | 26,261 |
| 1990 ⁶² | 360,594 | 76,965 | 2,645 | 1,984,363 | n.a. | 211,821 | 32,195 |
| 2000 ⁶³ | 416,336 | 123,532 | n.a. | n.a. | 21,820 | 279,482 | 22,849 |
| 2005 ⁶⁴ | 433,191 | 109,908 | n.a. | n.a. | 24,381 | 297,927 | 19,042 |

⁵³ Simpson, J.R.; Xu, Cheng & Miyazaki, Akira (1994): xv.

⁵⁴ Perkins, Dwight (1969): 287; Simpson, J.R.; Xu, Cheng & Miyazaki, Akira (1994): 7.

⁵⁵ Food and Agriculture Organization of the United Nations (2014): 132.

⁵⁶ *NSTCP* estimates taken from the averages of the years 1914-1915 and 1917-1918 in: Perkins, Dwight (1969): 287.

⁵⁷ Based on estimates from *China Handbook, 1937-1943* and *Manchurian Yearbook, 1932-1933* in Perkins, Dwight (1969): 287.

⁵⁸ Liu-Yeh estimates for 1933 (1965, p. 340) cited in: Perkins, Dwight (1969): 287.

⁵⁹ Chen, Nai-Ruenn (1967): 340.

⁶⁰ Chen, Nai-Ruenn (1967): 340.

⁶¹ The World Bank (1987): 149

⁶² Data from FAO, *Production Yearbook* 1991 in Simpson, J.R.; Xu, Cheng & Miyazaki, Akira (1994): 7.

⁶³ National Bureau of Statistics of China (2016).

| | | | | | | | |
|--------------------|---------|---------|------|------|--------|---------|--------|
| 2010 ⁶⁵ | 464,600 | 106,264 | n.a. | n.a. | 27,627 | 280,879 | 16,121 |
| 2015 ⁶⁶ | 708,250 | 108,173 | n.a. | n.a. | 29,992 | 310,994 | 13,785 |

Not only did the demand for animal products increase, but the production and marketing of animal products also changed. In 1978 the Household Responsibility System was established, which gave farmers more freedom to choose which crops to grow and allowed them to keep the surplus of what they produced.⁶⁷ Starting in 1985 reforms were implemented to expand the role of the market. Policies were put in place to slowly reduce the role of the government in deciding what could be sold for what price. Farmers now had the choice to raise any animal they wanted and to sell it wherever they would fetch the best price. The sale of animals and meat was no longer regulated by the government, but instead by the market through supply and demand. This resulted in an animal industry that had to take into consideration profitmaking and work with market prices instead of prices determined by the state.⁶⁸ This led to a great increase in the number of livestock being raised, as raising livestock became a profitable business, which led to the incentive to up-scale and expand production.

Not only the number of animals has increased, but the way they are raised has also changed a lot. For example, during the Qing dynasty pigs were mostly fed garbage or parts of plants that humans do not eat, such as the husks of rice or pulverized stalks. Sometimes they were also fed cheap varieties of grain or other inexpensive food. For a long time, the number of pigs depended on the availability of this excess food and therefore on the grain production and population size. According to Dwight Perkins, the price of pork was quite low and therefore it was not profitable to raise pigs for pork alone. Only by raising pigs for fertilizer was it profitable to keep pigs, as fertilizer was important for farmers to maintain their production of crops.⁶⁹ While farmers would still occasionally eat their pigs, especially in times of scarcity, they could not afford to raise many pigs and eat them as soon as they had grown big.

In recent years, an increasing number of pigs are being raised and this usually happens in quite a different way. Many pigs are no longer fed garbage. In China, pig feed in 2006 usually consists of more than 50 percent maize and also small amounts of wheat, soymeal and

⁶⁴ National Bureau of Statistics of China (2016).

⁶⁵ National Bureau of Statistics of China (2016).

⁶⁶ National Bureau of Statistics of China (2016).

⁶⁷ Zhang, Qian Forrest & Donaldson, John A. (2008): 26-28.

⁶⁸ The World Bank (1987): iv.

⁶⁹ Perkins, Dwight (1969): 71-73.

fishmeal which are supposed to help the pigs gain weight fast. Most pigs are specifically kept to create meat for the market and are raised on large factory farms.⁷⁰ This change in feed and the way animals are raised was important in order to provide enough animal products for a growing urban population. A World Bank report from 1987 observed that in order to keep up with demand, it was necessary to have farms that would be specialized in raising animals and do this on a large scale rather than on small family farms, as the number of animals that could be raised on family farms would be too limited. The report also argues that in order to make production more efficient it would be necessary to advance the usage of foreign technology.⁷¹ Examples of foreign assistance would be help with improving the quality of animal feed for optimal results, importing genetic material from abroad to improve breeding results and help with disease-prevention programs like vaccinations.⁷²

2.3 Recent developments

As described above, in the 1980s there was a development towards farms that were completely specialized in raising livestock on a large scale. This development towards upscaling and specialization in animal agriculture is still ongoing today and the number of livestock is still growing. Part of this development is market-led as the increased demand for animal products makes the sector attractive for private investment.⁷³ However, the Chinese livestock sector is also greatly influenced by government policies and subsidies. The state not only sets up rules for the animal industry, but also supports it financially which makes it more attractive for private investors. A good example is the pig farming industry, which has now become a multi-billion yuan industry.⁷⁴ Most commercial firms that raise pigs receive state-support, such as subsidies, tax exemptions and loans, as it is in the state's interest to create a domestic agriculture sector that can compete on a global scale.⁷⁵ These include exemption or reduction of export tax, value added tax and other types of tax, easy access to loans for agribusinesses and producers of export products and special subsidies for developing new products or for building facilities, such as sewage or freezer storage.⁷⁶

⁷⁰ Food and Agriculture Organization of the United Nations (2006): 34-45.

⁷¹ The World Bank (1987): 1.

⁷² The World Bank (1987): 35-48, 64.

⁷³ Cao et al. (2013).

⁷⁴ Schneider, Mindi (2015): 2.

⁷⁵ Schneider, Mindi (2015): 2.

⁷⁶ Zhang, H.; Fan, S. & Qian, K. (2005): 4.

Many of the commercial firms raising livestock consist of Concentrated Animal Feeding Operations, or CAFOs that are meant to turn animals into meat as efficiently and fast as possible. In the case of pigs, these farms can contain 500 to 50,000 pigs per year and sometimes up to a 100,000 pigs.⁷⁷ There are even plans to clone animals to increase their numbers faster, with the company Boyalife currently working on a plant in Tianjin that should eventually be able to clone 1 million farm animals every year.⁷⁸ The development towards large scale farms is not only generated by the demand for animal products, but it is also encouraged by the government through loans, subsidies and tax exemptions as mentioned earlier. In addition, it is government policy to promote “larger, more standardized and vertically integrated production systems”⁷⁹ by for example handing out grants for operation enlargements.⁸⁰ According to a Rabobank report, “There are many kinds of subsidies, including tax exemptions for farming projects, VAT tax exemptions for feed production, income tax rebates for slaughtering, subsidy for the treatment of waste water from slaughtering, and a subsidy for fertile sow insurance.”⁸¹ The government does not only give subsidies and other privileges to farms, but stimulates all stages of the production process by also subsidising animal feed production and slaughterhouses.

The consumption of animal products varies in different places and depending on income. Urban consumers consume considerably more animal products than rural consumers. Consumers with a higher income (defined as the 20 percent of the population with the highest income) consume about twice as much meat as people with a low income (20 percent with the lowest income).⁸² In addition, there are also regional differences, with more beef and mutton being consumed in the north, while pork is more popular in the south and dairy is mostly consumed by minority groups and high income consumers. While these differences are important, the overall demand for animal products is growing in all areas of China and among both urban and rural, high and low income consumers.⁸³ Therefore, it is not surprising that agribusiness companies continue to invest in animal agriculture which has grown in scale and become more intensive and specialized than it used to be. As the Chinese state encourages animal agriculture through its policies, it also contributes to the growth of this sector as this makes it even more lucrative for companies to invest in animal agriculture. Therefore, as the

⁷⁷ Schneider, Mindi (2015): 3-5.

⁷⁸ Boyalife website.

⁷⁹ Wei, Xinjie ; Lin, Wanlong ; Hennessy, David A. (2015): 52.

⁸⁰ Wei, Xinjie ; Lin, Wanlong ; Hennessy, David A. (2015): 53.

⁸¹ Rabobank (2012): 14.

⁸² Cao et al. (2013): 17.

⁸³ Cao et al. (2013): 16-17.

demand for animal products continues to make animal agriculture a profitable sector, this growth is not likely to end soon.

3. The impact of animal agriculture on China's water

China's water problems are a considerable challenge that requires a solution in order for people to be able to live healthily. As mentioned in the first chapter, the Chinese government has adopted laws and taken measures in an attempt to improve the water quantity and quality. These measures focus on industrial and municipal sectors, with only very few measures concentrating on agriculture or livestock raising.⁸⁴

In order to further improve the water quantity and quality, it is necessary to have a clear understanding of all the different factors that play a role in causing the problems in the first place. Since animal agriculture is responsible for more than 8 percent of human water use worldwide,⁸⁵ it seems likely this sector influences the water situation in China. While many scholars mention that agriculture plays a role, most scholars do not mention how big they think the contribution of the agricultural or livestock sector is in causing water pollution. Based on data on the amount of manure produced by the livestock sector in China, Mindi Schneider concludes that this sector is “*the* main source of water pollution in China today.”⁸⁶ However, she does not use much data to compare manure to other forms of pollution. At the same time, as the livestock sector is one among many causes of water problems, it is hard to measure the exact impact of this sector.⁸⁷ Nevertheless, this chapter assesses the sector's impact on water as I analyse the different ways in which animal agriculture contributes to water shortages and water pollution.

3.1 Animal feed

As mentioned in chapter 2, Chinese farmers in the past used to feed their animals mostly leftovers and parts of crops that were not edible for humans. Today, however, with a grown and specialized livestock sector, an increasing number of animals are fed food specifically grown for this purpose. Farmers also no longer rely on local food sources, but buy animal feed that has been grown elsewhere in the country or is sometimes even imported from

⁸⁴ The World Bank (2006): 15.

⁸⁵ FAO (2006): XXII.

⁸⁶ Schneider, Mindi (2015): 8.

⁸⁷ FAO & ILRI (2013): 7.

abroad.⁸⁸ In the late 90s it was estimated that 29% of grains grown in China were used for animal agriculture.⁸⁹

According to calculations from the FAO, pig feed in China consists of almost 60 percent of maize. In addition, soy meal, wheat and fish meal are also important components of pig feed.⁹⁰ Chicken feed is made up of more than 60 percent maize and also contains soy meal and other types of oil seed meal.⁹¹ Most of this maize is grown in the north east of China while soybeans for animal consumption are grown all over eastern China.⁹² The growing of these crops for animal feed requires a lot of land and water and is a source of pollution as pesticides are often used.

Therefore, the first way in which the animal agriculture sector influences the water quantity and quality is through the production of this animal feed. While the growing of crops is necessary to feed humans, the main problem here is that by feeding so many crops to livestock, much more land and water is necessary to produce animal products than would be necessary when feeding crops to humans directly. When it comes to using animals as food, feed conversion rates are important. Using plants to feed animals and then eating the animal is not the most efficient way of using energy. It differs per species how efficiently animal feed is used to create meat, with monogastric species, such as pig and poultry, being more efficient than ruminants.⁹³ Other factors play a role as well, such as the exact composition of the animal feed and how it has been grown. However, while these factors cause differences in the amount of water necessary to sustain an animal and thus create an animal product, this always costs considerably more water than non-animal products.

A study on the water footprint of the entire supply chain of a 150 gram soy burger found that the production required around 158 litre of water compared to an average of 2350 litre for a 150 gram beef burger. Similarly, the same study found that the production of a litre of soy milk required 297 litre of fresh water, while a litre of cow's milk required 1050 litre of water to produce it.⁹⁴ They conclude that plant-based alternatives on average only require 28 percent and 7 percent for milk and burgers respectively, of the water use of the animal-based equivalents.⁹⁵ Consequently, because of the animal industry, more land and water is necessary

⁸⁸ FAO (2006): 12.

⁸⁹ Yi, Liu (2005): 73.

⁹⁰ FAO (2006): 42.

⁹¹ FAO (2006): 41.

⁹² FAO (2006): 329.

⁹³ FAO (2006): 12-14.

⁹⁴ Ercin, A Ertug ; Aldaya, Maite M. & Hoekstra, Arjen Y. (2012): 393-400.

⁹⁵ Ercin, A Ertug ; Aldaya, Maite M. & Hoekstra, Arjen Y. (2012): 401.

to feed the population than if the crops were not fed to animals, but used for human consumption. Therefore, while the impact on water caused by agriculture described below is caused by both the production of crops for human consumption as well as animal feed, it is important to keep in mind that by feeding a considerable part of crops to animals much more agricultural land and water is being used than if we would not raise huge numbers of livestock.

Animal feed and water availability

The growing of crops first of all requires land. In the last few decades this often meant cutting down forests to create this land. Where the natural vegetation has been removed to make space for agriculture, this often lead to soil erosion. Because of this, a lot of sand ends up in the river, silting it up and reducing the flow of the river.⁹⁶ An FAO report explains that: “Forests play an important role in managing the natural water cycle. The canopy softens the fall of raindrops, leaf litter improves soil infiltration capacity and enhances groundwater recharge.”⁹⁷ Therefore, keeping forests instead of using the land for agricultural purposes helps retain water in an area instead of it flowing away. In an attempt to improve the situation, the Chinese government has encouraged farmers working near certain rivers to stop farming close to the river in exchange for financial compensation, grain and saplings. Gradually some of these areas have returned to their natural state, ending the soil erosion.⁹⁸

In addition to land, growing crops also requires water. Especially in areas where there is a lot of agriculture, this can take away a lot of the scarce water, which leaves less water for other uses, such as direct human consumption.⁹⁹ Although a large part of the water used by plants and for irrigation does eventually get back into the water cycle, it does mean less water is available for other purposes. Especially in arid areas the growing of crops can be responsible for water shortages.¹⁰⁰ The FAO estimates that worldwide around 15 percent of irrigation water is used to grow crops for animal feed,¹⁰¹ which can make a considerable difference in areas with water shortages.

Another problem with water use is that in China irrigation water is very cheap. Users of irrigation water only need to pay for the pumping, meaning they do not pay anything for

⁹⁶ Ma, Jun (2004): 41, 98, 111-112.

⁹⁷ FAO (2006): 165.

⁹⁸ Ma, Jun (2004): 41-42

⁹⁹ Ma, Jun (2004): 93-98.

¹⁰⁰ FAO (2006): 133-134.

¹⁰¹ FAO (2006): 135.

the water itself and often only pay around 28 percent of the supply costs.¹⁰² In addition, grain producers can pay even lower prices as part of a government incentive to encourage more grain production. However, these low prices also encourage the overuse and waste of water.¹⁰³ In addition, this has resulted in more than 70 percent of the irrigation in China not having any water-saving measures, even though these could reduce the amount of water that would be necessary by more than half.¹⁰⁴ With more than 40 percent of China's arable land under irrigation,¹⁰⁵ whether this irrigation is efficient or not can make a huge difference for the amount of water that is being used.

Animal feed and water pollution

As described earlier, by consuming animal products instead of directly using crops, we need significantly more water and land. As agriculture contributes to water pollution, the growing of crops for animal feed does so as well. While the pollution from agriculture is much harder to measure than that from cities and industrial sources, what we do know is that agriculture is a major cause of water pollution.¹⁰⁶ This water pollution from agriculture is mostly caused by the use of chemical fertilizer and pesticides.¹⁰⁷

Until a few decades ago fertilizer often consisted of animal manure, human excrement, ashes or left-over organic matter.¹⁰⁸ As mentioned in chapter 2, the use of chemical fertilizer began in the 60s and has increased since. Especially around the Yangtze river the pollution from chemical fertilizer is high because a lot of fertilizer is applied to the surrounding fields at the beginning of the rainy season, which is then carried away to waterways when the rain begins.¹⁰⁹ Whereas many developed countries have started to decrease the use of chemical fertilizers since the 90s to limit the amount of harmful nutrients that end up in water, China has not done so yet.¹¹⁰ According to some scholars there is already clear evidence that fertilizer nutrients are overused through the overuse of both chemical fertilizer and manure, causing severe environmental problems.¹¹¹

¹⁰² Jin, Leshan & Young, Warren (2001): 224.

¹⁰³ FAO (2006): 243-245.

¹⁰⁴ Jin, Leshan & Young, Warren (2001): 222-224.

¹⁰⁵ Jin, Leshan & Young, Warren (2001): 216.

¹⁰⁶ Ma, Xiaoying & Ortolano, Leonard (2000): 2.

¹⁰⁷ Ma, Jun (2004): 79-83, 123, 140, 170.

¹⁰⁸ Buck, John Lossing (1937): 191.

¹⁰⁹ Ma, Jun (2004): 83.

¹¹⁰ FAO (2006): 26.

¹¹¹ Chadwick, David ; Wei, Jia ; Yan'an, Tong ; Guanghui, Yu ; Qirong, Shen & Qing, Chen (2015): 35.

An important component of chemical fertilizer is nitrogen. It is estimated that between 40 and 60 percent of nitrogen from fertilizer is not actually absorbed by plants. This nitrogen will therefore either remain in the soil or end up in waterways through leaching, contaminating the water.¹¹² According to the FAO, 16 percent of China's nitrogen fertilizer use comes from the livestock sector. It is estimated that in 2001 alone this led to about 750,000 tonnes of nitrogen ending up in water.¹¹³ Another harmful component of chemical fertilizer is phosphorus, of which 13 percent of its usage is due to the livestock sector. This resulted in 124,000 tons of phosphorus getting into water in 2001.¹¹⁴ In order to obtain access to clean water people in many regions of China have resorted to using groundwater from aquifers. However, as these sources are getting depleted, this is not a long term solution.¹¹⁵

Another source of pollution from growing animal feed is pesticide usage. The use of pesticides has been increasing since the 90s and by 2012 an estimated 3,549 million tons of pesticides were used in China.¹¹⁶ While not all these pesticides were used on animal feed, the growing of animal feed does contribute to pesticide usage. In addition, not all pesticides are equally toxic, but many of them are harmful and even pesticides that have been banned because of their toxicity seem to still be used. A study that checked both animal feed and animal manure in China found residues of highly toxic pesticides (some of which have been banned for decades) in most of the samples.¹¹⁷ With the use of pesticides being so prevalent, it is no wonder that a considerable amount of it ends up in the rivers because irrigation or rain water takes some pesticides away.¹¹⁸

3.2 Animal waste

Animal waste has long been used by farmers as fertilizer. Animal waste in itself is not necessarily a problem. While there is a good balance between the number of livestock and the fields that require fertilizer, animal waste can be quite valuable. However, in areas with a high number of animals, the waste can no longer all be absorbed by the surrounding fields and this leads to environmental damage, with manure often ending up in the water or even directly

¹¹² FAO (2006): 72.

¹¹³ FAO (2006): 155-156.

¹¹⁴ FAO (2006): 155-156.

¹¹⁵ Ma, Xiaoying & Ortolano, Leonard (2000): 6.

¹¹⁶ Hou, Changqing (2013): 14.

¹¹⁷ Zhao, Ling; Dong, Yuanhua & Wang, Hui (2013): 348-349.

¹¹⁸ Ma, Xiaoying & Ortolano, Leonard (2000): 3.

being dumped into waterways.¹¹⁹ While small-scale family farms usually reuse about 90 percent of their manure, Concentrated Animal Feeding Operations (CAFOs) dump almost half of their manure in rivers.¹²⁰ In addition, an estimated 20 percent of manure is left unmanaged, which often results in part of this ending up in waterways through rain.¹²¹ As CAFOs usually have hundreds of thousands of animals and no farm land, they have no way of efficiently disposing of their manure. Therefore, an important problem in dealing with animal waste is the rise of large scale CAFOs. Small family farms often use manure on their own or neighbouring fields, but it is much harder for large scale farms to find a way to responsibly dispose of animal waste. In the early 2000s more than 80 percent of CAFOs did not have an infrastructure to dispose of manure in an environmentally-friendly way and 70 percent of them did not have the equipment to separate solid waste from wastewater.¹²²

There are a variety of harmful substances in animal waste that can contaminate water, such as nutrients like phosphorus and nitrogen, drug residues, pathogens and heavy metals.¹²³ Heavy metals are fed to animals to promote their health or growth, but as only 5 to 15 percent of them are absorbed by the body, the majority is excreted again.¹²⁴ Antibiotics use on livestock is common and about 40 to 90 percent of antibiotics are excreted again. This has led to livestock becoming the most important source of antibiotics pollution in rivers and an important contributor to the increasing prevalence of antibiotic resistant bacteria in China.¹²⁵

Nutrients like nitrogen and phosphorus are in animal feed, but most of it is not absorbed by the body. A high concentration of these nutrients can end up in waterways and has devastating consequences for aquatic ecosystems, as it causes algal bloom and excessive growth of certain aquatic plants.¹²⁶ This can lead to oxygen depletion of the water, a weird water smell and taste and an increase in bacterial growth.¹²⁷ Especially phosphorus is often thought to be the key nutrient in aquatic ecosystems and crucial for the water quality.¹²⁸ In his dissertation on phosphorus flows in China, Liu Yi notes that livestock manure plays an important role in phosphorus pollution as the phosphorus in manure now often exceeds the

¹¹⁹ FAO (2006): 31.

¹²⁰ Chadwick, David ; Wei, Jia ; Yan'an, Tong ; Guanghui, Yu ; Qirong, Shen & Qing, Chen (2015): 38.

¹²¹ Chadwick, David ; Wei, Jia ; Yan'an, Tong ; Guanghui, Yu ; Qirong, Shen & Qing, Chen (2015): 38.

¹²² Yi, Liu (2005): 94-96.

¹²³ FAO (2006): 136.

¹²⁴ FAO (2006): 143.

¹²⁵ Zhang, Xuelian; Li, Yanxia; Liu, Bei; Wang, Jing; Feng, Chenghong; Gao, Min & Wang, Lina (2014): 1-2.

¹²⁶ The World Bank (2001): 58.

¹²⁷ FAO (2006): 137-138.

¹²⁸ FAO (2006): 137-138.

amount that farmlands need.¹²⁹ Excessive phosphorus can lead to the consequences mentioned above, such as algal bloom and therefore reduces the water quality.¹³⁰ He states that one of the reasons so much phosphorus from animal manure ends up in waterways is because the majority of this waste is dumped in the water without any treatment, causing 53 percent of the phosphorus flow in water in China.¹³¹

Waste from livestock does not only pollute China's rivers but also the South China Sea. An FAO report notes that waste from pig and poultry farms in coastal areas of China, Vietnam and Thailand are playing a major role in the pollution of the South China Sea. The pollution is causing algal bloom and threatening fragile ecosystems like mangroves and coral reefs.¹³²

Unfortunately, for a long time none of China's environmental protection or water protection laws mentioned animal waste as a source for pollution or were there any regulations related to handling animal waste.¹³³ Part of the reason for that could be that it was not until 1998 that the administrative jurisdiction for environmental regulation related to livestock had been fixed, meaning that no government agency was officially responsible for this before 1998.¹³⁴ In 2010 in a government report on water pollution, agriculture as well as the livestock sector were mentioned as contributors to water pollution.¹³⁵ In 2014 China made the "Intensive Livestock Farming Pollution Prevention Regulations" that encourage the treatment of manure along with some other environmental regulations that have been enacted to reduce pollution from animal agriculture.¹³⁶ As of 2015 the Chinese government made an amendment to the environmental protection law, providing more severe penalties for polluters and now also adding CAFOs as a target.¹³⁷ However, as mentioned above, many CAFOs still dump considerable amounts of manure and do not have the facilities to dispose of manure in an environmentally friendly way.

¹²⁹ Yi, Liu (2005): 4-5.

¹³⁰ Yi, Liu (2005): 6.

¹³¹ Yi, Liu (2005): 44-45.

¹³² FAO (2006): 71.

¹³³ Yi, Liu (2005): 98-99.

¹³⁴ Yi, Liu (2005): 99.

¹³⁵ Ministry of Environmental Protection of the People's Republic of China 中华人民共和国环境保护部 (2010): 9-11.

¹³⁶ Pan, D.; Zhou, Gz.; Zhang, N. & Zhang, Lg. (2016): 574.

¹³⁷ Schneider, Mindi (2015): 3.

3.3 Livestock facilities

Also on farms and CAFOs itself a lot of water is used. In China, the majority of farm animals are held in the eastern part of the country. In this area, most farms work with landless production.¹³⁸ On these farms, whether they are small family farms or big farm factories, water plays an important role. First of all, water is needed for the animals to drink. Another, usually bigger water need is service water needed to keep the farm running. This includes water for cleaning both production units and the animals themselves and keeping facilities and animals cool. In the case of milk production, water is also used to keep the milk cool. In addition, water is used to dispose of waste. Especially on pig farms this can take up much more water than the drinking water.¹³⁹ The exact amount of water used also depends a lot on the type of farm. On farms where animals are left to graze the animals require more drinking water compared to farms where animals do not move much. In addition, more industrial, large scale production systems often require more water for cooling and cleaning.¹⁴⁰ While the majority of drinking and servicing water does eventually return to the environment, it is often polluted.¹⁴¹

3.4 Processing animal products

The last way in which livestock raising affects water is during the processing of an animal into products. Most animals will eventually end up in a slaughterhouse. There, water is used to wash carcasses and for cleaning the facilities. In addition, water is also used to keep the meat cool. Certain animals need additional water at the slaughterhouse, such as poultry. Hot water is used to scald birds to make them easier to defeather and additional water is used to transport the feathers, heads, feet and viscera.¹⁴² Moreover, more water is used in further processing meat into value-added products or in processing hides for leather.¹⁴³

A slaughterhouse can cause local water pollution if it does not have waste treatment facilities. The wastewater often contains organic compounds like blood, fat, hair and waste from the stomach and intestines of the animals, with blood being the most important pollutant. Because of the high concentration of pollutants, wastewater from slaughterhouses can be

¹³⁸ FAO (2006): 337, 440-441.

¹³⁹ FAO (2006): 128-129.

¹⁴⁰ FAO (2006): 128-129.

¹⁴¹ FAO (2006): 136.

¹⁴² FAO (2006): 130-132.

¹⁴³ FAO (2006): 130-132.

dangerous, even in relatively small amounts.¹⁴⁴ In addition, tanneries can also be a source of water pollution as during the tanning process water comes into contact with a variety of organic and chemical pollutants. This poses a big threat to the water quality when the wastewater is returned to waterways untreated.¹⁴⁵

3.5 Water problems in relation to developments in livestock raising

Although Chinese farmers have kept livestock for centuries, it seems that livestock's negative impact on water is a more recent problem. While having livestock has of course always lead to water use and forms of pollution, this seems to long have been on a scale that was sustainable for the environment. Today a lot of the problems caused by animal agriculture have to do with the developments in the livestock sector in the last century. First of all, the huge rise in livestock raising naturally leads to more resources being used during all stages of the production of animal products and more pollution. In addition, the development towards more specialized large-scale animal agriculture has created problems that do not occur in small-scale farming. As mentioned earlier, small farms would use mostly leftovers or parts of plants that are not edible for humans to feed their animals, meaning that it was not necessary to use additional land purely to grow animal feed. With today's large-scale livestock operations, the only way to provide feed for all these animals is to grow food specifically for this purpose, leading to additional land and water use. Furthermore, family farms are a closed system, not just providing animal feed for itself, but in turn also using manure on the farm's own or nearby fields. As mentioned in the previous chapter, a lot of big feedlot operations do not have any use for manure and therefore just dump it in rivers, leading to water pollution. In addition, as farms and slaughterhouses used to be much smaller, much less water was being used there as well. Therefore, a lot of the ways animal agriculture has a negative impact on China's water is caused by modern animal agriculture.

4. Options for improvement

As the negative impact of livestock raising on China's water supply is related to recent developments in livestock raising, this can also help reduce this negative impact. The concept of sustainable development was created by the United Nations and defined as a "development

¹⁴⁴ FAO (2006): 150.

¹⁴⁵ FAO (2006): 150.

that meets the needs of the present without compromising the ability of future generations to meet their own needs.”¹⁴⁶ When it comes to water usage in China today, it seems that China’s development is not sustainable as it uses and pollutes much more water than can be renewed and cleaned by the environment. As such, China’s water problems require measures to solve this problem and while the livestock sector is not the only cause of this problem, reducing water usage and pollution from animal agriculture would contribute to solving China’s water crisis. This will require weighing the importance and benefits of economic pursuits, whether from animal agriculture or other sectors, not just in monetary value but also in ecological terms.

As the growth and intensification of animal agriculture played an important role in increasing water problems, this also helps to find suggestions to make livestock raising more sustainable. For example, there are many ways in which the livestock sector’s water use can be reduced. As agriculture is the most important water user, using over 60 percent of the water consumption, reducing the amount of water used for animal feed related agricultural purposes could make a significant difference.¹⁴⁷ An often mentioned approach in environmental studies is the more efficient usage of resources so that production can continue as normal without it being as environmentally damaging.¹⁴⁸ More efficient irrigation systems and more realistic water pricing could save water when growing crops for both human consumption and crops meant as animal feed. Governmental regulations limiting the scale and expansion of the livestock sector could also help save water.¹⁴⁹ As a lot of the problems are caused by large scale intensive farming, a move towards more small scale farms would already help reduce the negative impact of animal agriculture.

However, as mentioned in chapter two, the Chinese government is encouraging the expansion of animal agriculture so it is not very likely they will stop doing this soon. Nevertheless, government support is crucial for implementing new regulations and ending damaging subsidies that do not encourage environmentally friendly farming, such as the already mentioned low water prices and subsidies for animal agriculture.¹⁵⁰

Another way to save water would be to stop growing animal feed and instead import it from abroad. As China is already struggling to provide enough food for its growing population, it is already importing food for both humans and animals. It is importing soybeans

¹⁴⁶ United Nations (1987).

¹⁴⁷ The World Bank (2006): 6.

¹⁴⁸ Shimaoka, Takayuki ; Kuba, Takahiro ; Namayama, Hirofumi ; Fujita, Toshiyuki ; Horji, Nobuhiro (2016): 142.

¹⁴⁹ FAO (2006): XXII.

¹⁵⁰ FAO (2006): XXIV.

from Brazil for animal feed and this amount is only expected to increase.¹⁵¹ In 2015 China was importing 66 percent of the global soy trade.¹⁵² In addition, China also imports fishmeal and other animal feed components.¹⁵³ However, while this would be helpful for China, it merely moves the problems of water use and water pollution to another country.

In order to mitigate livestock's polluting effects, a reduction in the number of livestock would of course be helpful. As this is not likely to happen, other measures might be more helpful in reducing pollution. For example, pollutants can be treated, both at the source or at the end of the production process, called end-of-pipe measures.¹⁵⁴ In his dissertation of phosphorus, Liu Yi notes that less intensive livestock rearing would be an important way to reduce phosphorus levels in waterways. He states that this will both reduce the phosphorus used in producing animal feed as well as the phosphorus output from animal manure.¹⁵⁵ On small-scale farms manure can be reused, meaning it will not be dumped in waterways and no chemical fertilizer is needed so this type of farming would be much more environmentally friendly. This same strategy of decentralizing livestock production is also suggested by the FAO as a way of reducing soil and water pollution.¹⁵⁶ In addition, improved waste and manure management and diets with better nutrient absorption would also help mitigate water contamination.¹⁵⁷ Finally, better monitoring of the water quality and the sources of water pollution would help create a clearer image of the extent of China's water problems.¹⁵⁸ A survey has shown that 80 percent of pig farmers were willing to actively reduce livestock pollution, most of them choosing biogas subsidies, technical support and pollution fees as preferred methods to achieve this.¹⁵⁹ With farmers being open to environmental measures and government assistance, there is a lot of potential for improvement.

Conclusion

Currently China faces severe water-related problems that could threaten China's water security if these problems are not solved. Water scarcity has already reached the Falkenmark

¹⁵¹ Neves, Marcos Fava (2014): 55-57.

¹⁵² Schneider, Mindi (2015): 2.

¹⁵³ Yang, H. (2013): 249.

¹⁵⁴ Shimaoka, Takayuki ; Kuba, Takahiro ; Namayama, Hirofumi ; Fujita, Toshiyuki ; Horji, Nobuhiro (2016): 143.

¹⁵⁵ Yi, Liu (2005): 134.

¹⁵⁶ FAO (2006): XXII.

¹⁵⁷ FAO (2006): XXII.

¹⁵⁸ The World Bank (2006): 41.

¹⁵⁹ Pan, D.; Zhou, Gz.; Zhang, N. & Zhang, Lg. (2016): 578-582.

water stress level and is only expected to get worse as the population continues to grow. While the use of groundwater temporarily helps to obtain sufficient water, this is only a temporary solution. In addition, water pollution is reducing the quality of the scarce water that is available and poses a risk to human health as well as the sustainability of ecosystems. While both water scarcity and water pollution are caused by a variety of causes, including the use of water by households and for industrial and agricultural purposes, especially about the effects of the last one not much is known. An even less studied topic is the impact of livestock raising on China's water resources. This paper argues that animal agriculture does have a significant impact on China's water resources and adds to the water scarcity and water pollution. However, this impact is not inherent to animal agriculture, but mainly caused by industrial large scale factory farming.

While Chinese people have been raising livestock for centuries, the last century has seen big changes. Whereas before small family farms had a few animals that were fed leftovers and whose manure was used to fertilize the fields, today most farms are large CAFOs. With population growth and an increasing number of people who are able to afford a considerable amount of meat, the livestock sector has developed into more specialized large-scale farms. These farms rely on specially grown feed to feed their animals, therefore needing additional resources. Moreover, as these farms produce huge amounts of manure while not having any destination for it, the manure often gets dumped in waterways. In addition to new farming practices, the number of livestock being raised has also greatly increased with the rise of industrial farms.

It is not surprising that these changes in the livestock sector have influenced the environment and the water supply. The growing of animal feed has led to additional water use and in areas near rivers it often results in soil erosion. In addition, much water is used during other stages in the livestock raising process, for example water for animals to drink, to clean them and the facilities and to keep them cool, as well as additional water during slaughtering and the processing of animal products. Growing crops specifically for animals also causes a lot of fertilizer and pesticides to get into waterways through rain. The excessive amounts of manure being dumped causes additional water pollution. High concentrations of phosphorus get into lakes and waterways through both fertilizer and manure, making the livestock sector a considerable contributor to eutrophication.

Knowing how developments in animal agriculture have impacted China's water resources can help to reduce its negative impact. For example, water saving measures can help reduce the amount of water used for animal agriculture and waste treatment and less

chemical fertilizer and pesticides could reduce water pollution. While there is a lot of potential for improvement, it remains to be seen whether the Chinese government will take action in reducing the negative impact of the livestock sector on water. While the government has tried to encourage people to eat less meat in order to reduce greenhouse gas emissions, at the same time it also supports the livestock sector through loans, subsidies and tax exemptions. An important step towards limiting the negative impact of livestock raising on water would be for the government to limit the sector's scale and encourage measures towards a more environmentally friendly and sustainable animal agriculture.

It is also very important that more research will be done to learn more about the causes of water scarcity and pollution in China and the exact role of animal agriculture in this. While we have a relatively clear idea of the different ways in which the livestock sector influences the water quality and availability in China, we do not yet know exactly on what scale this happens and how much this contributes to the overall problem. Monitoring waterways and more research is necessary to find out the exact extent of the water scarcity and water pollution and to what extent this can be attributed to animal agriculture and other sectors. This would also make it easier for the Chinese government to create policies and regulations to try to improve China's water situation. Meanwhile, it is clear that the livestock sector does play a significant role in both China's water scarcity and pollution. Therefore more research and measures to make livestock raising less damaging should be encouraged.

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