CAN REGIONAL ORGANIC AGRICULTURE FEED THE REGIONAL COMMUNITY?

A Case Study for Hamburg and North Germany

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Any remaining errors are the responsibility of the author — who appreciates feedback and invites the readership to indicate possible mistakes.

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Abstract

The current global industrialized food system has developed into a highly complex structure, lacking transparency and separating the spheres of production and consumption. Centralization and concentration of food production and retailing is prevalent, and in many cases, the system fails to recognize the significant negative impacts on our environment, human and animal health and social equity. One potential solution towards a more sustainable food system is an increased emphasis and attention towards organic and locally produced foods. The study focuses on the area of Hamburg and Northern Germany, illustrating the potential for maximizing regional, organic agriculture to feed the regional community. The individual agricultural land footprint for food production for one person is outlined for different diet scenarios based on various diet compositions. The findings indicate that there is potential to feed the regional community solely on regionally, organically grown foods, but this result is dependent on two main factors: (1) the total agricultural area available in the defined "region" in comparison to the amount of persons to be fed; (2) the consumption quantities of various food groups in the human diet— specifically, how much meat the average person consumes. Diets comparatively lower in meat consumption require less agricultural land for production. In addition to diet choices, organic regional agriculture can be promoted through bottom up approaches such as Alternative Food Networks (AFNs), which may – through their transparency and connection to identifiable regional producers – increase consumers' willingness to pay more for organically produced food products.

Key Terms: food system, organic agriculture, regional agriculture

Table of Contents

List of Figures

List of Tables

List of Abbreviations

AFNs	Alternative Food Networks
CAP	Common Agricultural Policy
CSA	Community Supported Agriculture
CAFOs	Concentrated Animal Feeding Operations
DGE	Deutsche Gesellschaft für Ernährung/German Nutrition Society
DVT	Deutscher Verband Tiernahrung/German Association of Feed
EU	European Union
BMEL	Bundesministerium für Ernährung und Landwirtschaft/Federal Ministry of Food and Agriculture
FAO	Food and Agriculture Organization of the United Nations
GHG	Green House Gas
GM	Genetically Modified
GMO	Genetically Modified Organism
NGO	Non-Governmental Organization
ÖLG	Organic Farming Act
OECD	Organization for Economic Co-operation and Development
UBA	Umweltbundesamt/Federal Environment Agency
UN	United Nations
WFP	World Food Program
WHO	World Health Organization

Introduction

Motivation

The world's food system is out of balance. Fruits, vegetables, grains, fish and meat travel around the globe. The Amazon Rain Forest is cut down for soy production to feed pigs in Germany that are exported as pork to China. It has become so expanded and complicated, with such a lack of transparency, that many of us have no idea who produced our food, where or how it was produced, and how it got from the farm to our fork. While the industrialized food system has theoretically accomplished its main goal— to maximize crop yields at minimal financial costs— in many cases it neglects to recognize the significant negative effects on our environment, human and animal health and social equity.

Non-governmental organizations (NGOs) such as *Bund Ökologische Lebensmittelwirtschaft* (BÖLW, an Association of Ecological Farmers, Trade and Retail Enterprises), claim that a growing number of voices are calling for a turn back (BÖWL, 2015). In January 2016, 23.000 people marched through the streets of Berlin in to participate in the sixth annual *"Wir Haben Es Satt"* ("We Are Fed Up") march to say no to the broken industrialized international food system, and yes to an alternative, more sustainable solution (BUND, 2016). The term *"Agrarwende"*, fashioned after the term *"Energiewende"* (Energy Transition) is official latest since fall 2014 when the Green party resolved to adopt this as a policy goal (Deutsche Presse-Agentur GmbH, 2014).

On a personal level, I, the author of this thesis, wish to have greater access to fresh, healthy, nutritious foods for myself and future generations to come. At the 2015 UN Conference on Climate Change in Paris, a study revealed that nearly 33% of the world's arable land has been lost to erosion or pollution in the past 40 years (Grantham Centre, 2015). Continued use of intensive industrial agriculture will only increase this figure. We have a responsibility to try to improve this situation and establish more sustainable ways to feed ourselves, and the ever-increasing global population.


Image source: (Sydney Zentz, 2016)

Research Question

While numerous studies and organizations have identified the need for change, (FAO, 2012), (BMEL, 2015), redesigning the food system is a highly complex task, dependent on numerous factors, i.e. socioeconomic situation, geographic location, available technologies, and one solution will not be applicable to each situation. In the end, we must discover a way to feed the world's ever-increasing population while simultaneously minimizing global environmental impacts (Seufert, Ramankutty, & Foley, 2012). Increasing demand for products that are produced in a sustainable manner and providing healthy, fresh food to consumers is one method towards this goal.

To begin at a local level, this thesis will focus on the case of Northern Germany. Hamburg, Germany, a modern and diverse city with the ills of modern civilizations but also a large community of vibrant and engaged citizens, will be the center point. Sections of the bordering Bundeslander (federal states) of Mecklenburg-Vorpommern, Niedersachsen and Schleswig-Holstein are also examined, as parts are included in the "regions" identified in this thesis.

It will seek to explore three questions:

1. To what extent can a population in an industrialized region with agricultural resources feed itself by regionally and organically grown agricultural products?
2. How can regional organic food production be promoted and expanded by the individual consumer's consumption choices?
3. What characteristics do alternative food networks posses to promote these choices?

I am addressing these questions by exploring (in quantitative terms):

1. The individual consumer's agricultural land footprint for food production according to various diet scenarios with different compositions of specific food groups.
2. The maximum number of persons that can be fed according to identified diet scenarios within the selected regions, taking into account land use breakdown of agricultural land.
3. The effect of more sustainable individual German diet consumption choices on the overall land footprint for food production, and thus the potential to feed the regional community with regional organic agriculture.

The method to attempt to answer the research question is as follows:

1. Conduct research of background information of the current situation of the food system, current situation of organic food production and consumption at a European, German and regional level, relevant government policies and current alternative food network initiatives.
2. Interview local farmers, organic food associations, cooperatives and other experts in the field of regional and organic agriculture in Northern Germany.
3. Assess the potential to feed the local community through regionally produced organic foods based upon the current individual consumer agricultural land footprint for food production and the available agricultural area available within the defined regions.
4. Identify potential shifts in the single German consumer's diet towards a decrease in the individual agricultural land footprint for food production and illustrate the effects on the maximum number of persons that can be fed within defined regions when these modifications are applied.
5. Identify models of alternative food networks that could assist in increasing the levels of production of local, organic products in Northern Germany and assess characteristics that could help to overcome the price barrier commonly associated with organic products.
6. Develop conclusions and summary of results.

Structure of the Thesis

The structure of the thesis is as follows:

- **Chapter 1:** Introduction including motivation, the research questions to be answered, methods to answer said questions and an outline of the structure of the thesis.
- **Chapter 2:** Explore the current situation of the global food system. Identify the effect of changing human diets on increased resource usage; the environmental, health and social challenges posed by the current food system; and potential solutions towards a more sustainable global food system.
- **Chapter 3:** Determine the role and importance of organic agriculture to improve the current food system. Examine the current situation of production and consumption of organic products in Europe and Germany; identify barriers towards increased production and consumption; and relevant government policies.
- **Chapter 4:** Explore quantities of the number of maximum persons that can be fed in three identified regions based on eight different individual diet scenarios. Quantify the required agricultural land to produce food for one German person; define three selected regions to be assessed; and illustrate the effect of consumption choices on the land footprint for food production.
- **Chapter 5:** Identify alternative food network initiatives already in place in the regions of Hamburg and North Germany and their potential to increase consumers willingness to pay a price premium for organic products.
- **Chapter 6:** Discussion of results.
- **Chapter 7:** Conclusions and outlook.

Image source: (Markus Spiske, 2016)

Food System: Current Situation

The current industrialized countries' food system is largely based on three central themes: centralization, specialization and globalization. Crops and livestock produced, processed and supplied in huge quantities through a centralized system is the norm. A multitude of regional farms, each with a range of products, has given way to few producers that specialize in one or a few species of plants and animals, and by the time food has reached the consumer it reguarly has traveled across the globe or includes ingredients from a multitude of countries.

The development of these themes is two-fold: 1) a result of technological advances that greatly increased the productivity of land and agricultural labor, i.e., made it possible to produce a higher yield per hectare with reduced labor input; and 2) policies put into place by government bodies which promote ever decreasing (internal) costs of food production. These were first established in response to food security concerns in the early to mid twentieth century but have since become a mainstay of the agricultural sector.

In many ways, these advances have provided a significant positive impact on society as a whole. While the world's population has increased from roughly less than one billion people in 1800 to six billion in the year 2000, global agricultural production has increased substantially faster— at least tenfold in the same period (Federico, 2005). In Germany, for example, harvest yield for one hectare of wheat increased by 67% between 1950 and 2013 and for potatoes the increase was 38% during the same period. For common animal products such as milk the yield increase per cow was 66% and for eggs, 59% (BMEL(d), 2014).

The growth in agricultural productivity implied that fewer people were required for farming, freeing up a large part of the labor force to turn to other sectors. This allowed society to develop in other areas: for one, it created new sectors of knowledge and economic activity, leading to technical progress in fields like medicine and engineering, which in turn allowed for sustained

Image source: (Viktor Hanacek, 2016)

population growth. This also fostered an increasing amount of people moving to urban areas. In the past century, 75% of the workforce was employed in the agricultural sector (Federico, 2005); today, agricultural workers account for approximately 31% of the worldwide workforce. This figure reflects the average, however. In developing countries, as much as 65% of employment is in the agricultural sector (FAO(e), 2015), while it makes up as little as 1% of employment in more advanced countries, such as Germany (World Bank(b), 2016).

The development of the food system, especially since the second half of the 20th century, however, has created a highly complex system, lacking transparency and separating the spheres of production and consumption. Centralization of food production and retailing is prevalent throughout the world. For example, in Germany, five food retailers accounted for 70% of the revenue from food retail products in 2014, in which they exert market power upstream and can dictate price.

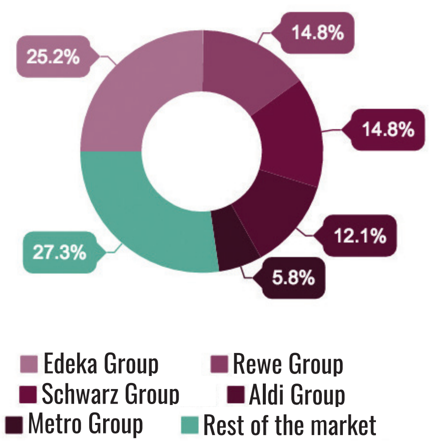


Figure 1. Market share of revenue of the leading companies in food retail in Germany in 2014. Adapted from (Statista, 2014)

Globalization of the food system began with improvements in transportation and an increase in transatlantic migration, expanding trade of known varieties of plants and animals. Beginning in the 17th century, European colonists, for example, attempted to reproduce the familiar plant and animal products of their homelands, although in many cases the natural conditions were not comparable and the approach did not succeed (Federico, 2005). Therefore, the settlers resorted to long-range imports, ushering in the era of demand for "exotic" foods.

Lastly, government policies and technological advances, to be discussed in the next section, particularly fostered an environment where specialization in production was more economically attractive than traditional bio-diverse, holistic farms.

Tractor from the Kattendorfer Hof. (Joseph, 2016)

From Local to Global: Technologies and Policies that Revolutionized Agriculture to Shape Our Current Food System

While environmental factors still play a major role in the agricultural process today, the invention of new technologies has had a great influence, allowing for manipulation of the natural environment that weren't thought possible even fifty years ago. Today, the ideal habitat for growing— including soil, temperature, and water usage— the methods for restoring nutrients to the soil and seasonality of production, can be altered through artificial fertilizers, herbicides, pesticides, genetic engineering, etc. Nutrient cycling, as it was practiced by pre-industrial agricultural societies, was replaced by mass deposition of artificial fertilizer, boosting yields, but also accompanied by environmental problems described below. Additionally, even when the natural elements cannot be significantly manipulated by technical measures as these, the effects of production fluctuations are relatively smaller today due to global consumption trade, as well as policies for insurance and relief for farmers (Federico, 2005).

Machinery

Before the 19th century, agricultural tasks, i.e. sowing, tillage, and harvesting, were done through hand-powered and livestock-driven tools, although pre-mechanical changes and improvements were constantly developing (Federico, 2005). Fueled by the Industrial Revolution, the gas-powered tractor is one of the most important agricultural innovations that led to our current food system. This allowed for larger farms and fewer farmers, which became a cornerstone of a thriving metropolitan population (Ellis, 2000), while machines continued to replace hand- and livestock-powered tools for most tasks. The result, still seen today, is a much more efficient system that has significantly reduced the amount of labor required, for both farmers and animals, and has allowed the process of production to move much more quickly, on a much larger scale (Hesterman, 2011).

Due to the invention of agricultural machinery, in addition to certain government policies, specialization became an even more relevant topic. Because different crops required different expensive machines, a more homogeneous crop portfolio required less machinery; therefore, it became economically attractive to specialize in particular crops or livestock that could be tended with the same machine.

Agricultural Chemicals

The agricultural industry's dependence on the environment distinguishes it from other sectors. The replacement of natural nutrient cycling (crop rotations and land-bound feedstock raising whose manure was used as fertilizer) with synthetic fertilizers accompanied by the introduction of synthetic herbicides and pesticides— coined as the „Green Revolution"— increased yields and lowered production cost, though at a high environmental price. The majority of these chemicals were, and still are, produced in factories. By the 1950s, inexpensive synthetic fertilizers were easily accessible to farmers, allowing them greater control of crop security and increased production, as well as the ability to do without crop rotation and to specialize in the cultivation of one crop on the same area of land for many seasons without compromising yield (Federico, 2005).

Herbicides to kill weeds and pesticides to kill insects were also extremely effective by the mid 20th century (Ellis, 2000). The use of certain pesticides and herbicides is a controversial topic, however. The pesticide DDT (dichloro-diphenyl-trichloroethane) was introduced in the 1940s to help control the effects of mosquitos and other insects, but later banned in many regions including the U.S. and Northern Europe, for animal and human health concerns (US EPA, 2015). One example of this effect was on predatory birds in North America. As DDT was carried through surface runoff into waterways, the process of *bioaccummulation* ("the intake of a chemical and its concentration in the organism" (Alexander, 1999)) occurred, followed by *biomagnification* ("when the chemical is passed up the food chain to higher trophic levels" (Alexander, 1999)). As these bird species ate the prey from affected waterways the bioaccumulation of DDT altered the bird's calcium metabolism, causing the eggshells to be abnormally thin. This resulted in the adult birds breaking the shells of their unhatched offspring at higher than normal rates and the population of these species plummeted. Since the ban of DDT in 1972, populations of these birds have significantly increased or returned to pre-DDT levels (Ehrlich, et al., 1988).

Crop Genetics

Biotechnological advances also greatly influenced the development of our current food system. The use of hybrid seeds, resulting from the cross-pollination of plants from the same family, is a low-tech example that has been used since ancient times. When successful, this strategy could produce a crop with a higher yield and a greater resistance to pests, although these results were unpredictable and not based in scientific research (Federico, 2005).

The breakthrough of a science-based approach to biological innovations can be seen in the hybrid corn of the 1930s. Yields increased by 20%, spurring increased research and development in this area (Federico, 2005). The development of genetically modified (GM) seeds began in the late 1980s. Scientists moved the genes of one organism— which could be a plant, an animal or a bacterium— to a plant, creating a new GM seed with higher crop yield and reduced need for pesticides (Ellis, 2000).

Genetically modified organisms (GMO) are also a highly controversial technology, however, in which the production of seeds is moving faster than our ability to assess the long-term risks. To date, eleven out of sixteen German federal states, including Hamburg, signed the Charta of Florence, joining the network of European GMO-Free regions (GMO-Free Europe, 2015). Furthermore, since 2012, there has been no commercial cultivation of GMOs in Germany, and no deliberate release since 2013 (GMO-Free Europe, 2015).

Government Policies

The agricultural sector plays a crucial role in the economic, political, and environmental arena of nations. Aside from providing the most obvious value in the supply of food for persons and animals, it creates livelihood for citizens, revenue for the national income, a basis for economic development in industries, promotion of international trade, protection (and destruction) of the natural environment, supplies of energy and raw materials, and influence in the development of settlements and the transport sector. Germany, for example, has a strong agricultural sector, with about half of the land being farmed, despite high population density. There are approximately one million people working in roughly 285,000 agricultural enterprises, producing more than fifty billion Euros worth of goods per year (BMEL, 2014).

Government policies, in turn, have great influence over the development of the agricultural sector, and in many ways, the shaping of our global food system. Following the Second World War, most OECD countries developed emergency support for agriculture, especially with an eye toward maximizing yields and providing inexpensive food for citizens (Federico, 2005). Aims were a combination of protection of staple crops, such as cereals, and a guarantee of minimum pricing for farmers (Federico, 2005).

In 1949-1950, the agricultural output returned to prewar levels in Western Europe, but policies did not change. Rather, Germany even extended the scope of support, providing subsidies for farmers and provision of credit support for research and development (Federico, 2005). With the implementation and continued use of these policies, many OECD countries have been faced with a surplus of production since the 1950s. Today, European agricultural production is funded by the Common Agricultural Policy (CAP), which supports farmers by providing a variety of prices guarantees including direct payments and other instruments such as quotas and tariffs on imported produce (ECPA, 2016).

Changing Diets, Growing Resource Use

The human diet significantly changed in the past one hundred years, which was facilitated by the increased productivity described above. In Germany, the most influential change began after World War II. Income and wealth rose dramatically, and food production turned into a mass production business. In 1920, the average German family was spending about 60% of their household budget on food and beverages (Deelstra H., 1991); in 2013, in Germany, this figure dropped to approximately 14% (Destatis(a), 2013). Again, these figures are an average, with some citizens spending a much higher percentage, and some much lower.

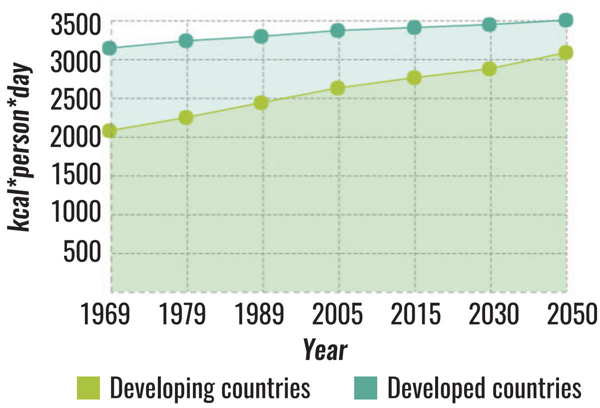


Figure 2. Global increase in per capita food consumption. Adapted from (FAO(a), 2012).

As more disposable income was available, choice and quantity of food consumed increased. On average, worldwide per capita daily intake in 1969 was 2,372 kcal per person, per day. In 2005 however, the intake was 2,772 kcal/capita/day (FAO(a), 2012). This figure is an average; in the developed world, the average person was eating more calories per day, and in the developing world, fewer (FAO(a), 2012). This is illustrated in Figure 2.

Internationalization of the food system began to gain momentum after 1950. Fruit consumption increased and sugar became more readily available, due to a rise in imports in Germany (Deelstra H., 1991). Consumption of potatoes decreased from roughly 190 kilograms per person, per year in 1950 to 70 kg today (WWF(a), 2011). As well, the consumption of processed and "ready-made" foods increased during this time period (WWF(a), 2011).

Between 1950 and 2011, the average annual German meat consumption doubled. Since 1850, it has more than quadrupled. Meanwhile, other sources of protein have been nearly forgotten (WWF(a), 2011)**.**

Globally, the biggest change in diet— and the most significant in terms of a growing resource use— is the substantial increase in meat intake. In the past twenty years, the consumption of meat has increased in all regions globally, except Africa. The production of meat has more than quadrupled since 1961, when just over 70 million tonnes (Mt) were produced (FAOSTAT(a), 2016), to roughly 315 Mt in 2014 (FAO(g), 2015). The average world meat consumption increased from 24.2 kg/capita/year in 1964/1966, to 41.3 kg/capita/year in 2015 (FAO(f), 2015).

Between 1950 and 2011, the average annual German meat consumption per capita doubled. Since 1850, it has more than quadrupled, illustrated in Figure 3. Meat has been part of the human diet since the beginning of humanity; it was, and still is, an important source of protein and other nutrients. However, to meet the body's protein requirement, meat consumption is not necessary. In the past, in many regions, including mainland Europe, meat was never the only source of protein. As meat consumption increased, however, other sources of protein have been nearly forgotten. The average German person in 1950 ate 20 kg of pulses such as beans, peas and lentils each year. Today, the average consumer eats only 0.5 kg annually (WWF(a), 2011). Furthermore, the resource use for meat production competes with production of food for direct human consumption.

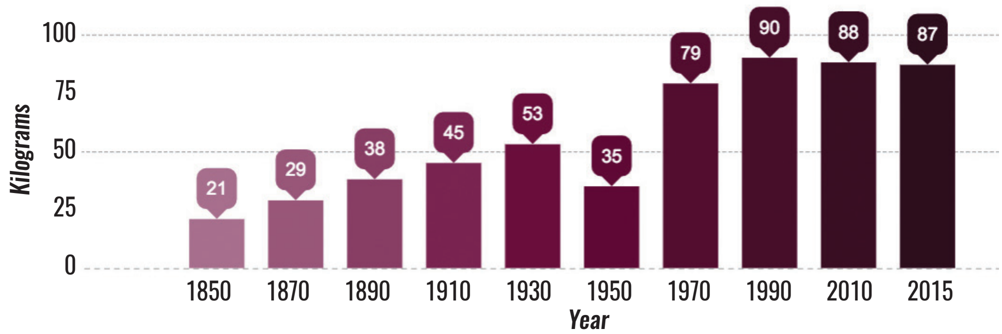


Figure 3. German meat consumption per capita by year. Adapted from (von Alvensleben, 1999) and (BMELV, 2011).

Land Use

Land use for food production is increasing steadily on a global scale (FAOSTAT(b), 2014). According to the World Bank, nearly 40% of the earth's ice-free land surface is used for agriculture (World Bank(a), 2013). This is measured as the share of land that is arable, under permanent crops, or under permanent pastures (World Bank, 2013). There is almost no arable land available for expansion in Southern and Western Asia and Northern Africa (FAO(e), 2015). Furthermore, the Food and Agriculture Organization of the United Nations (FAO) has projected that cropland and pasture-based food production will need to increase significantly by 2050 (FAO(f), 2015).

According to studies by (Herrero, et al., 2013) and (WWF(a), 2011), land use for livestock, including feedstuffs such as cereals and oilseeds, amounts to approximately 33% of the earth's land surface. When compared to the statistics from the World Bank, this illustrates that animal-based products take up a significant share of the agricultural land throughout the world. For feedstuffs, (WWF(a), 2011) cites the Deutscher Verband Tiernahrung (DTV) (2011), stating that, in German agriculture (food produced only in Germany), 60% of all cereals and 70% of all oilseeds are used to feed livestock, although this figure varies by specific crop. This increasingly high demand for animal feed is also echoed on the global scale. For example, between 1960 and 2013, soybean production increased globally nearly tenfold (FAOSTAT, 2014), and approximately 80% of soy produced is used to feed livestock today (WWF(a), 2011).

To satisfy the European Union's (EU) demand for meat consumption, there is a large-scale "virtual importation of land." The EU cannot domestically produce sufficient food for the livestock it raises and, therefore, must utilize land outside of its territory, specifically in Brazil and Argentina (WWF(a), 2011). If diets continue to trend toward increased meat consumption and increased food demand overall, as is expected in the medium-term future (Bajželj, et al., 2014), there will be a further increase in agricultural land needed for production.

Energy Use

Agriculture is an energy-intensive sector, both in terms of direct and indirect energy use. Energy is used directly in land preparation, cultivation, irrigation, harvesting, post-harvest, processing, food production, storage, and transport of agricultural inputs and outputs (FAO(b), n.d.). Indirect energy use is, for a large part, the production of synthetic mineral fertilizer, and, in particular, the production of ammonia. Additionally, it is used to produce pesticides and herbicides, as well as farm machinery and buildings (Eurostat(a), 2015).

Globalization of our diet, the increased use of synthetic mineral fertilizers and other agrochemicals (50% of total energy usage), and increased meat consumption have had the biggest impact on energy usage in agriculture (AgrEE, 2012). The larger share of meat in the average human diet implies a greater energy usage on several accounts. Not only is it required to raise livestock, i.e. heat for housing, etc., energy is also required to grow crops for feed. Intensive feeding of livestock, or concentrated animal feeding operations (CAFOs), are more energy intensive than farms whose animals forage or graze on fields.

Furthermore, feed-use efficiency of farm animals (the conversion of dry unit mass of feed into mass unit of meat output) varies greatly between species, and is largely influenced by diet composition and quality of feed (Herrero, et al., 2013). A UNESCO study (Mekonnen & Hoekstra, 2010) concluded that ruminants (cattle, sheep, goats) are less efficient than non-ruminants (pigs, chickens), as illustrated in Table 1.

Animal category	Feed conversion efficiency (kg dry mass feed/kg output)			
	Grazing	*Mixed*	*Industrial*	**Overall**
Beef cattle	70.1	51.8	19.2	**46.9**
Dairy cattle	3.5	1.6	1.1	**1.9**
Broiler chicken	9.0	4.9	2.8	**4.2**
Layer chicken	9.3	4.4	2.3	**3.1**
Pig	11.3	6.5	3.9	**5.8**
Sheep and goat	49.6	25.8	13.3	**30.2**

Table 1: Global average feed conversion efficiency per animal category and production system. Adapted from (Mekonnen & Hoekstra, 2010).

Water Use

According to the United Nations World Water Development Report 3 (UN Water, 2009), global water withdrawals increased threefold in the last half century. This is largely due to a growing population, but also to a changing food preference to more water-intensive crops and livestock and a rapid increase in irrigation since the 1970s (UN Water(a), 2009). Furthermore, the most recent report states that the growth rates of agricultural demands on the world's fresh water resources are unsustainable, with inefficient water usage for crop production depleting aquifers, reducing river flows, and degrading wildlife habitats (UN Water(b), 2015).

Water usage is measured as the green-blue water footprint (sum of rain and irrigation water consumption) and the gray water footprint (volume of polluted water) (Mekonnen & Hoekstra, 2010). Currently, 70% of the accessible surface and groundwater used globally is for agriculture, with as much as 90% used in the developing world (WWF(d), 2014). Of this portion of water used by agriculture, the WWF study *The Imported Risk: Germany's Water Risks in Times of Globalisation* estimates that between 15-35% is unsustainable, and agriculture wastes 60% of the water it uses each year (WWF(d), 2014). Conclusions about the water footprints of selected food products from crop and animal origins (Mekonnen & Hoekstra, 2010) are illustrated in Figure 4. This reflects how individual consumption choices can affect overall water requirements.

Although Germany is a relatively water-rich country with low water risk, globalization of the food consumption has also had a significant impact on water usage, especially in terms of irrigation. A growing demand for sugarcane and coffee are examples of this. The same WWF study indicates that twenty-three percent of Germany's sugarcane is imported from India, where irrigation is required for 90% of production (WWF(d), 2014). Similarly, 22.5% of coffee is imported to Germany from Vietnam, where irrigation is required for 87% of production (WWF(d), 2014).

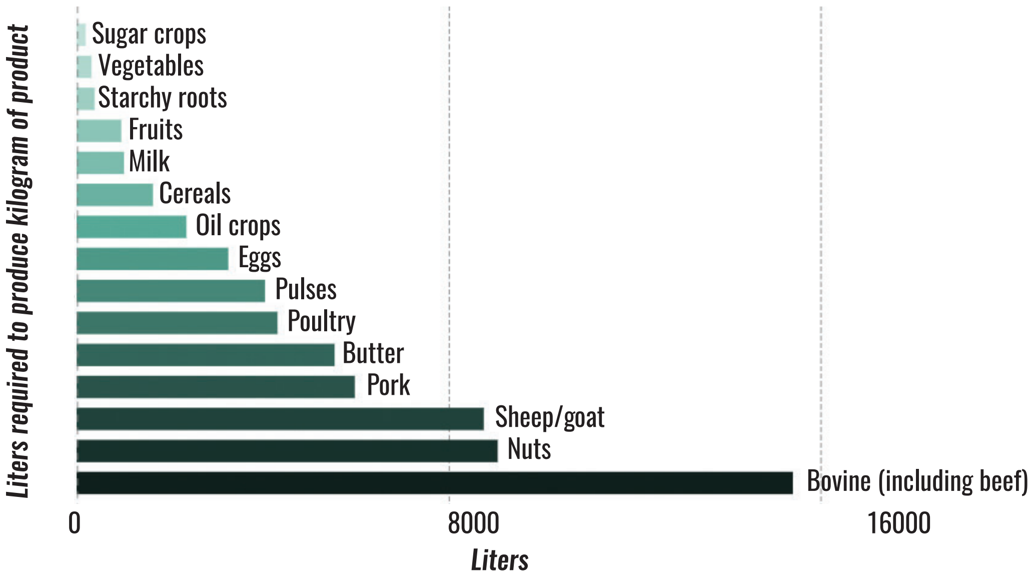


Figure 4. Water requirement to produce one kilogram of product. Adapted from (Mekonnen & Hoekstra, 2010).

Lastly, if we consider water usage along the supply chain, it is also clear that our changing preferences to more processed foods have affected water usage. Although agricultural production requires more than half of the water consumption along the chain, processing and packaging of raw materials also contributes to 40% of consumption (WWF(d), 2014).

The Costs of Food Production and Consumption: Environment, Health, and Social Equality

The consequences of our current industrialized system were largely not foreseen when the technological and policy developments of the 20th century were implemented. Natural resources were abundant and the rapid increase in production was providing more food security than ever before, a huge achievement for society. The situation has changed, however, and the food system today is greatly contributing to adverse effects on our environment, health, and social equity.

Environment

Soil Erosion, Salinization and Degradation

According to a study by the Grantham Centre for Sustainable Futures (Cameron, et al., 2015) presented at the COP21 Climate Conference in Paris, nearly 33% of the world's arable land has been lost to erosion or pollution in the last 40 years. The rate at which erosion occurs from ploughed fields is 10-100 times greater than natural rates of formation, and it takes roughly 500 years to form 2.5 cm of topsoil under normal agricultural conditions (Cameron, et al., 2015).

Nearly 33% of the world's arable land has been lost to soil erosion or pollution in the last 40 years. The rate at which erosion occurs from ploughed fields is 10-100 times greater than natural rates of formation (Cameron, et al., 2015).

Unsustainable farming and forestry operations encourage erosion, especially when sloping land is plowed, grass is removed from semi-arid land for dry land farming, and when cattle, sheep, or goats are allowed to overgraze. Furthermore, according to the most recent UN Water Report (UN Water(b), 2015) current agricultural practices have caused salinization of 20% of the global irrigated area. Salinization refers to the build up of salts in soil. Although this is also a natural process, it has been exacerbated by the industrialized agricultural practices, and can lead to salt levels in soil toxic to plants.

Water Pollution

According to the *Agriculture and Water Quality Interactions: A Global Overview by the FAO* (Mateo-Sagasta & Burke, 2011), the three most important water pollution challenges related to agriculture are: the "(i) excess nutrients accumulating in surface and coastal waters that cause eutrophication, hypoxia and algal blooms; (ii) accumulation of nitrates in groundwater; and (iii) pesticides accumulated in groundwater and surface water bodies. Water pollution caused by nutrients (particularly nitrate) and pesticides has increased as intensive farming methods have proliferated, such as increased use of chemical fertilizers and higher concentrations."

Developed countries, such as Germany, are facing significant water pollution challenges. According to (Bouraoui & Grizzetti, 2013), large-scale water quality degradation due to agriculture is responsible for approximately 55% of nitrogen entering European Seas. For example, in the Baltic Sea, an area that is sometimes as large as Germany itself is being covered in polluting algae blooms, due in large part to nitrogen and phosphorus run-off from industrial farming in the surrounding areas (WWF(c), 2015). Additionally, in November 2016, the EU announced it will officially take Germany to court due to high nitrate levels detected in its waters, especially due to manure spreading and agricultural fertilizer (EurActiv with AFP, 2016).

Contributions to Climate Change

While agriculture is highly affected by climate change, it is also a substantial contributor. According to the IPCC (Intergovernmental Panel on Climate Change), the agriculture, forestry and other land uses (AFOLU) sector was responsible for 24% of 2010 green house gas (GHG) emissions, with the majority of these coming from deforestation, agricultural emissions from livestock and soil and nutrient management (IPCC, 2014).

Within the agricultural sector, significant amounts of carbon dioxide (CO_2), methane (CO_4) and nitrous oxide (N_2O) are released into the atmosphere. This is further broken down between indirect and direct GHG emissions:

Direct green house gas (GHG) emissions			*Indirect GHG emissions*
Carbon dioxide emissions resulting from energy use for the production of agricultural inputs, from agricultural production itself, and from the packaging, storage, transport, preparation and disposal of food.	***Nitrous oxide emissions*** resulting from inorganic and organic nitrogen fertilizer use.	***Methane emissions*** resulting from (ruminant) digestion as well as organic fertilizer use in rice paddy farming.	***Carbon dioxide emissions*** resulting from (indirect) land use change, i.e. the conversion of natural areas into farmland or the conversion of grassland into cropland.

Figure 5. Types of emissions from the agricultural sector. Adapted from (WWF(b), 2012).

In the EU, agricultural production accounted for 10.35% of GHG emissions in 2012, with main sources linked to the management of agricultural soils, livestock, rice production, and biomass burning (Eurostat(b), 2015). It should be noted, however, that in the EU-28[1], in the period of 1990-2012, a decline of almost one quarter (23.8%) of GHG emissions from agriculture was reported. This reduction may, in part, be credited to more efficient farming practices, reduction of nitrogen-based fertilizers, and better forms of manure management (Eurostat(b), 2015).

1 EU 28: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden and United Kingdom

Using data from studies by Eberle (2008), Fritsche & Eberle (2007), Meier & Christen (2011, 2012), Nieberg (2009), Reinhardt et al. (2009) and Wiegmann & Schmidt (2007), the WWF report *Climate Change on Your Plate* (WWF(b), 2012) concluded that, in Germany, nearly 70% of all GHG emissions resulting from food consumption can be attributed to livestock-based foods (meat, meat products, fish, fish products, eggs, egg products, milk, dairy products), while plant-based foods account for just under a third (vegetable oils and fats, cereal, cereal products, potatoes, potato products, vegetables, vegetable products, fruit, fruit products, sugar, sweets and other foods).

As well, the globalized system and loss of the local market also creates increasing "food miles," the transportation of goods between farmers, industry and consumers. In many cases, food products can be shipped around the globe before they reach the consumer's plate, which may result in increased GHG emissions (Reisch, et al., 2013).

Decrease in Biodiversity

Biodiversity of crops and livestock helps to create resilience to disease and pests. Intensive farming, however, encourages specialization of crops and livestock, leading to a decrease in biodiversity. This, in turn, increases vulnerability and requires inputs of more artificial protections such as pesticides, herbicides, antibiotics, and synthetic fertilizers. Intense crop specialization and concentration can also lead to monocultures, where only one crop or livestock species is produced on a very large scale. In this case, if a pest discovers how to attack this species, the entire yield could be wiped out, or even more herbicides and pesticides will be required.

Pesticides may not only kill parasites harmful to crops, but also beneficial insects vital to the food chain. A recent study by the *Umweltbundesamt* (UBA) concluded that Germany's intensive farming poses a risk for certain birds and mammals to lose food resources, risking disappearance (Sagener, 2015).

In addition, intensive breeding of livestock often seeks to maximize production, especially through genetic manipulation of animals for rapid growth, efficient feed conversion, and high yields (Heinrich Böll Foundation, 2014). The breeds then become highly dependent on high-protein feeds, expensive pharmaceuticals, such as antibiotics, and climate-controlled housing for survival (Heinrich Böll Foundation, 2014).

Furthermore, when specialization of livestock production occurs, as with CAFOs, the natural nutrient cycle of the farm system is eliminated. If animals and crops are raised on the same farm, waste from one part of the system— the animals— becomes a valuable resource for another part of the system, as fertilizer for crops. Agricultural manure in liquid form, known as slurry, is produced by more intensive livestock rearing systems where concrete or slats are used, instead of straw bedding. The slurry builds up and becomes a source of pollution, posing risks to the environment and human health. In the case of a crop-only farm, the nutrients otherwise provided by animal manure (animal excreta in solid form, mixed with straw or similar materials) need to be replaced by artificial fertilizers.

Deforestation

According to the Global Canopy Program, "*The production and trade of the key forest risk commodities— palm oil, soya, beef and timber, pulp and paper— are the largest global direct drivers of tropical deforestation and degradation*" (Rautner, et al., 2013). While not all are directly related to agriculture, such as paper and pulp, they can still be used in packaging or as paper napkins. As well, approximately 50% of processed foods found in typical supermarkets contain one or more of the identified key forest risk commodities (Rautner, et al., 2013).

By 2008, 47% of the Cerrado had already been lost. In the Amazon Rain Forest, 62.2% of deforested land is used for pasture cattle— essentially meaning the world's biggest rain forest is being destroyed to produce beef & cattle. (WWF(a), 2011), (Heinrich Böll Foundation, 2014).

Farmers and large agribusiness companies clear sizable sections of forest areas to plant profitable crops, such as palm oil, rice, sugar cane, or bananas. Pasture for cattle and cultivation for livestock feeds, such as soya, are destroying huge portions of South American forests each year. According to a WWF study *Das Grosse Fressen* (WWF(g), 2015), more than 30% of the food and feed imported to Germany is connected to deforestation (Sarmadi, 2015).

The Cerrado, the Brazilian Savannah, is one of the most biodiverse regions on earth. However, it is being destroyed rapidly each year, as a result of expanding grazing lands and soybean production. According to the WWF study *Meat Eats Land,* in 2008, 47% of the Cerrado had already been lost (WWF(a), 2011). In the Amazon Rain Forest, 62.2% of deforested land is used as pasture for cattle, 21% is not used at all and is covered by growth, and only 4.9% is cultivated. This essentially means that the world's biggest rain forest is being destroyed to produce cattle (Heinrich Böll Foundation, 2014). Government efforts are being made to control deforestation, but at the moment it still remains a significant consequence of the agricultural industry (Heinrich Böll Foundation, 2014).

Health

Food safety

Intense concentration of the food system creates a risk to food safety. As the system is immense and highly complex, bacteria or disease in one sector of the supply chain can spread very quickly, and on a massive scale. In these cases, it may take weeks, or even months, before the source can be identified. In addition to bacteria or disease outbreaks, agrochemicals can pose an increased risk to human health. The world's best-selling chemical herbicide, glyphosate, is used for production of glyphosate-resistant soybeans, which are widely grown in South and North America for export to China and the EU to feed poultry, pigs, and cattle in concentrated animal feeding operations.

Although the production of GM crops is restricted in the EU, meat, dairy and eggs produced with GM animal feed to be sold without a GM label (Heinrich Böll Foundation, 2014). Glyphosate cannot be broken down by cooking or removed by washing, and residue remains constant in food and feed for a year or more (Heinrich Böll Foundation, 2014). Most of us are exposed to it on a daily basis, despite the fact that, in 2015, the World Health Organization (WHO) released a study concluding that the herbicide glyphosate, as well as the insecticides malathion and diazinon, were classified as "probably carcinogenic to humans" (WHO(a), 2015; WHO(b), 2015).

Antibiotics

Globally, antibiotics are widely used to accelerate growth and prevent disease in cattle, poultry, and pigs, primarily in CAFOs. According to the FAO report *Antibiotics in Farm Animal Production: Public Health and Animal Welfare*, "drug resistant bacteria ('superbugs') created in farm animals by antibiotic use can be transferred to people, leading to antibiotic resistance, food-borne infections in humans that are more likely to be severe and longer lasting, more likely to lead to infections in the bloodstream and to hospitalization and more likely to lead to death" (FAO(h), 2011). Antibiotics to promote growth were prohibited in the EU in 2006; however, their use did not decrease significantly, with Germany being the largest consumer overall (Heinrich Böll Foundation, 2014).

These can be passed to humans in a few ways (Heinrich Böll Foundation, 2014):

1. The food chain.
2. Bacteria can be blown several hundred meters by the exhaust fans of livestock houses.
3. Bacteria are abundant in manure and can be washed into waterways.

Social Challenges

Food Shortages and Hunger and Obesity

For many citizens of advanced countries in the economic middle class or above, with easy access to grocery stores, farmers' markets, and more food than could possibly be consumed in a day, the food system may not appear to be broken. Globally, however, while progress is being made, 795 million people do not have enough food to live a healthy, active life (FAO(i), 2016). This is approximately equal to one in nine people on the planet, or about 12.9% of the entire population (WFP, 2016). According to the *World Food Program* (WFP) two-thirds of the total population is categorized as "hungry" in Asia, and one in four Africans are undernourished. On the other side, according to the WHO, there are roughly 600 million adults globally who were considered obese in 2014 (with a body mass index, or BMI, of 30 or higher) (WHO(b), 2015).

While we may be producing enough food to feed the world, distribution is so skewed that there are roughly three-quarters as many obese citizens of the world as there are undernourished citizens.
(FAO(i), 2016), (WHO(b), 2015)

These figures indicate the incredible social imbalance of our food system. While we may be producing enough food to feed the world, distribution is so skewed that there are roughly three-quarters as many obese citizens of the world as there are undernourished persons.

Fewer Farmers and Decreased Prospects

As illustrated in earlier sections, new technologies in agriculture allowed higher yields, requiring lower labor input and, thus, fewer farm workers. At the same time, the commercialization of agricultural production implied that farmers who used to work mainly for self-sufficiency now increasingly worked for profit (Federico, 2005). Historically, if farmers would sell their output, it would go to a local market, while today however, most are likely to sell to a large, complex supply chain in which the single farmer plays only a minuscule role. The result is that today, on average, only one fourth of the retail price of food goes to the farmers, compared to approximately 50% a half-century ago (Reisch, et al., 2013).

Not only do farmers receive a lower percentage of the profits from food production and sales. In addition, there is market concentration in food production and retailing. The companies that farmers sell their output to can squeeze them on price. At the same time, consumers are used to low food prices. This price squeeze, coupled with high land and capital investment prices, makes it very hard for the next generation to farm professionally, unless they inherit land and equipment or are brought up in farming from a young age.

In the EU, thirty percent of farmers are over the age of 65 (Eurostat(c), 2014), and succession is a major social challenge for family farmers (Davidova & Thomson, 2014). In Germany, approximately 70% of sole-proprietorship farms had no or unclear farm succession, according to the 2010 Census of Agriculture (Destatis(b), 2010).

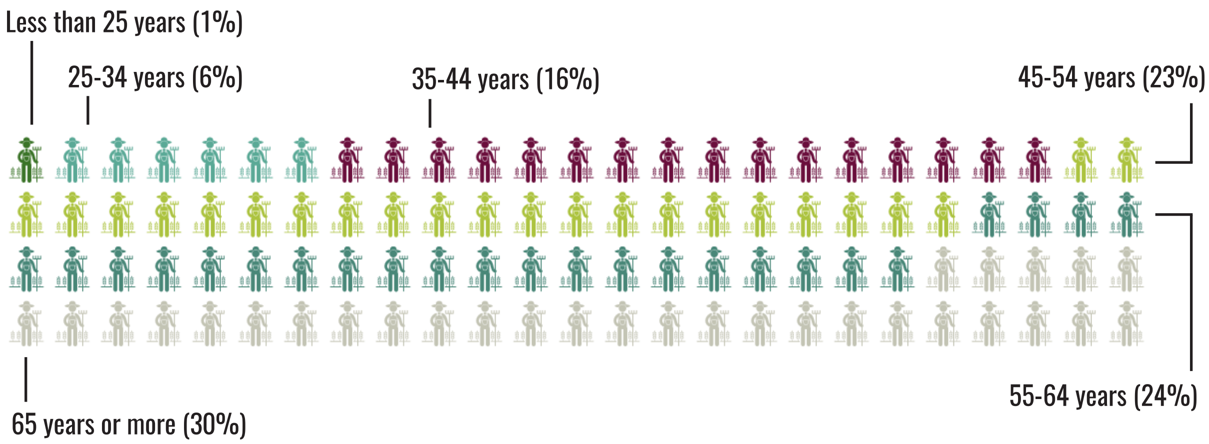


Figure 6. Ages of farmers in Germany. Source: (Eurostat(c), 2014).

Concentrated Animal Feeding Operations and Animal Welfare

In the past fifty years, there has been a shift from raising livestock in decentralized, small family farms to a more concentrated, industrialized system, where a large number of animals live in small, confined spaces, known as "concentrated animal feeding operations" (CAFOs). When livestock is raised in CAFOs, there are not only environmental concerns, such as pollution to nearby areas from large amounts of slurry, or risk of exposure to antibiotic resistant bacteria for consumers, but also significant risk to animal welfare. In many cases, animals are kept in tightly confined conditions prohibiting their ability to exercise, fully extend limbs or participate in natural behaviors respective to each species (Compassion in World Farming, n.d.). As a result, these animals can suffer from prolonged physical and psychological effects (Compassion in World Farming, n.d.).

Worker Exploitation

Large farms and concentrated processing facilities require little skilled work. Many farm and slaughterhouse employees today are unskilled workers that are easily exploited, and unfair and unsafe working conditions prevail in much of agricultural production. Child labor, poverty, slavery, and hunger are all directly related to agricultural production (Simons, 2015). According to the FAO, there are still approximately 100 million children aged 5-17 who are in engaged in child labor in agriculture (FAO(j), 2015).

Resolutions for Sustainable Improvement of the Food System

The environmental, health, and social equity consequences currently emerging in our global food system will only be exacerbated by increased population growth, scarcity of precious natural resources, and the continuation of unsustainable practices in the entire food production and consumption chain. A new food system should provide access to healthy, nutritious, and safe food for everyone. It should promote diversity, resiliency, and sustainability in production. It should be grown in a manner that closes the natural nutrient cycle locally, or regionally.

The system must integrate three main goals: environmental health, economic profitability, and social and economic equity (UC Davis, 2015). Efforts in transformation must be on all levels—government, industry and consumer— on both the supply and demand sides. Different levels of cooperation, i.e. private-public partnerships or community involvement, must also be integrated.

Stewardship of Natural and Human Resources

Sustainability requires that we protect our current resources for future generations rather than exploit them. Natural resources, such as water, soil, and energy, are severely compromised under the current food system, as described in earlier sections. Research and Development to protect these natural resources will be key in developing a sustainable food system. Socially, ensuring fair trade practices for all workers along the food chain and prioritizing human health in production methods are essential first steps.

> **"One of the most important points that many people forget is that this soil we are working worldwide is not for just one generation, and it didn't come one generation before us. It has to stay for thousands of years. We have to work to maintain and enhance the soil. We have a big responsibility.**
> -Demeter-certified farmer in Northern Germany

Organic farming methods (the term will be defined further down) are one way to protect our natural resources and provide a healthy, sustainable system for future generations. This not only produces nutritious food, but also keeps the soil alive, keeps the water and air clean, keeps GHG emissions lower, and promotes biodiversity (Heinrich Böll Foundation, 2014). The industrialized food system with large-scale monopolistically organized food producers and retailers make it hard for farmers to follow organic production practices. These large-scale producers are able to sell products at very low prices to consumers because they externalize costs, such as damage to the environment, harm to animals, and risks to human health (Heinrich Böll Foundation, 2014).

Develop a Holistic Perspective

Looking at our food system through a holistic lens will give us a better understanding of how each element affects the next, and help us learn to maximize these connections. At the farm level, for instance, creating a strong connection between plants and livestock allows the waste of one to be the resource of another, building a holistic, closed system in which resource efficiency is maximized. At the community level, organizations or collaborations such as Community Supported Agriculture (CSA) to promote local and/or organic products can create a dynamic system in which the consumer, the farmer, and the environment all benefit. Furthermore, emphasis placed on the system as a whole will encourage decision makers to consider the effects or consequences of certain farming practices with a long-term perspective.

Encourage Diversity and Resilience

While monocultures may be more efficient (in purely quantitative input-output terms, neglecting external cost) and easier to manage, they can make crops increasingly susceptible to pests and diseases. If there is loss of the crop in any one season, the effects can dramatically disrupt the viability of the entire farm. Promoting biodiversity, on the other hand, allows farmers to spread their portfolio, providing economic safety and protection from market fluctuations. Increasing crop diversity, through crop rotations or cover crops, can improve the crops' resilience to weeds, pests, and diseases, and improve soil. This also reduces the need for inputs, such as pesticides and herbicides, which can have a negative impact on our environment and human health.

Promote Research, Development and Knowledge Sharing

A huge barrier in the sustainable food market, specifically for organic products, is that the consumer is not well informed. The price of a product is tangible; the consumer can feel it in real time and make decisions based on short-term outcomes. The idea of sustainability, however, is long-term. When consumers' purchasing decisions are dependent on their willingness to buy into an "idea"— in this case, sustainability— it is necessary that they know why they should choose an organic product, for example, over one produced conventionally.

Knowledge-sharing platforms, such as cooperatives and workshops, or even the simple purchase of products from small shops where owners can take time to inform consumers about the stories behind their goods, are small steps in the right direction. According to a *Global Greendex Survey* by the National Geographic Society, when consumers are better informed, they are more likely to pay attention to ingredients in food, believe that industrialized meat production is bad for the environment, and be more willing to pay more for organic and local foods (Stone, 2014). Research and Development efforts have to come from an interdisciplinary perspective, requiring the input of researchers, as well as farmers, workers, consumers, and policy makers.

Support Local Farmers (And Buy In Season)

Buying local, seasonal products is becoming an increasingly important topic for consumers and retailers (BÖWL, 2015). Not only does purchasing local products allow customers to build a better connection with their food and the farmers who grew it, but it also provides a plethora of benefits to the community. Although most food purchases in Germany are made at chain grocery markets (Statista, 2014), farmers' markets, food co-ops, delivery boxes, CSA programs, and farm stands are direct point-of-sale locations, which can ensure support to local farmers.

Government policies should encourage the production of local goods, and retailers should favor having local products on their shelves. Buying locally-produced products means that GHG emissions from distribution are decreased, jobs are provided for the local economy, and the community is given access to fresh, healthy, nutritious foods. Buying in-season can also reduce the amount of GHG emissions, because the produce does not need to be imported and does not require energy for storage. However, the reduction is highly contextual, based on a variety of factors.

Changes in Consumption Choices

As presented in earlier sections, our changing diets over the past century have had a dramatic impact on our environment. Changes in consumption choices, even at the individual level, have the potential to make a significant impact. The production of meat is the leader in consuming natural resources and producing GHG emissions. To move toward a more sustainable food system, it is of utmost importance to substitute some of the share currently occupied by meat in the human diet for other protein-rich sources, such as legumes.

A WWF study, *Meat Eats Land* concluded that if Germans refrained from eating meat just one day per week, 595,000 hectares of land could be available for other uses (WWF(a), 2011). Furthermore, when consumers do purchase meat, there should be more attention paid to animal welfare. Meat produced in CAFOs will likely have a greater environmental impact than that which is raised organically. Moreover, certain regulations for organically-raised livestock, such as sufficient space for movement and access to outdoor areas, ensure fair treatment (WWF(b), 2012).

3

Role and Importance of Organic Agriculture

Organic agriculture remains a relatively niche production system, comprising approximately 1% of global agricultural land (Willer & Lernoud, 2016). This may be, from the consumer's perspective, due to price premiums at which organic food is marketed and from the producer's prospective, the potential for lower and more variable yields, limited demand for organic products and challenges of converting to organic production (de Ponti, et al., 2012). Furthermore, faced with the question of how we will be able to feed the world's increasing population, the practice of organic agriculture is many times criticized as an inefficient approach to food production and security (Reganold & Wachter, 2016)

Despite the current situation of organic farming on a world scale, the number of organic farms, extent of organically farmed land, amount of research funding devoted to organic farming and the market for organic products has been steadily increasing globally (Reganold & Wachter, 2016). Additionally, organic agriculture is increasingly recognized as an innovating farming system that can balance multiple sustainability goals and will play a growing role in future global food and ecosystem security (Reganold & Wachter, 2016).

Principles of Organic Agriculture

Organic farming is a broad term used to describe an agricultural practice aimed at producing food with minimal harm to ecosystems, animals, or humans (Seufert, at al., 2012), where the farm is understood to be a complete organism comprised of man, flora, fauna, and soil (BMEL(b), 2015). Organic farms can range from strict closed-nutrient-cycle systems, such as biodynamically managed farms, to more open systems. Countries differ in their certification systems for organic agriculture and organic produce.

Harvesting Celeriac at the Kattendorfer Hof. Image source: (Joseph, 2015)

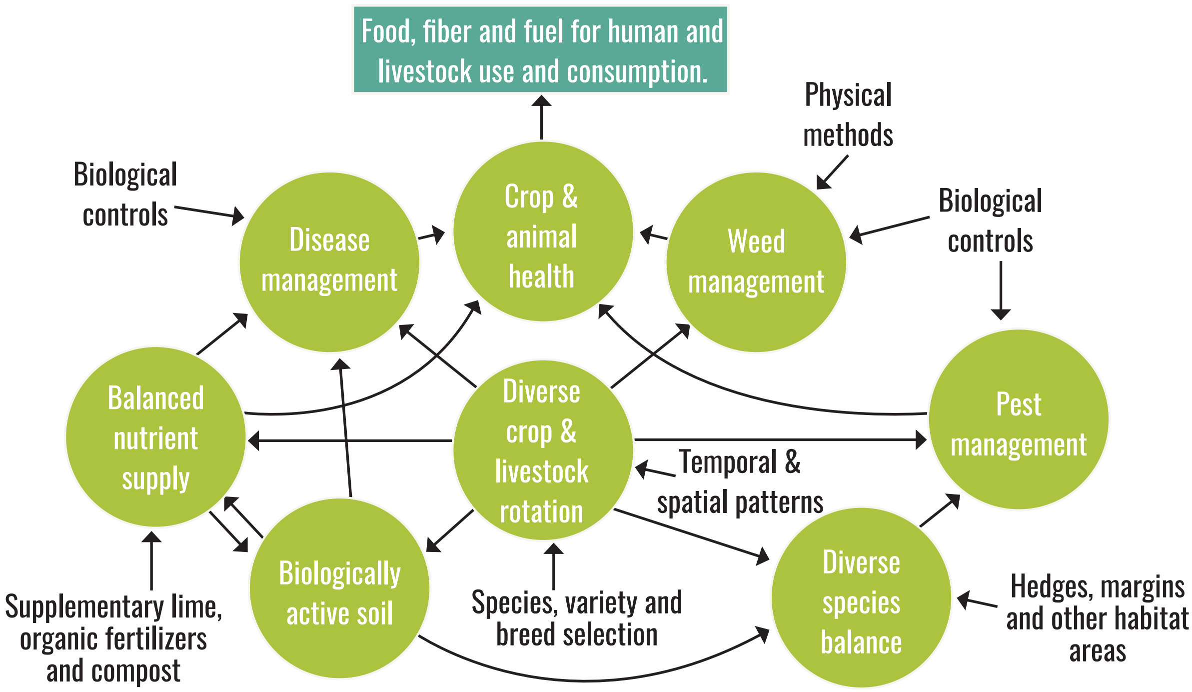


Figure 7. Organic management practices. Structural factors (circles) are the foundation of organic management. Tactical management decisions (black text) are used to supplement structural factors. Adapted from (Reganold & Wachter, 2016)

In general, organic agriculture management practices commonly focus on: (1) promoting soil quality and fertility, prohibiting the use of synthetic mineral fertilizer in favor of manure, or practicing crop rotations and regularly planting legume crops that enrich the soil with nitrogen. (2) Maintaining plant and animal diversity, as well as closing the nutrient cycle to the largest extent possible, including feeding animals with fodder grown mainly, and in some cases exclusively, on the farm. (3) Utilizing natural processes, such as shrubbery or bees, to keep plants healthy, rather than chemical herbicide or pesticide inputs. (4) Raising livestock in a manner that is as appropriate to the respective species as possible, including access to open-air exercise and opportunities to engage in normal types of behavior. Further, the use of antibiotics and genetic engineering is not allowed (BMEL(d), 2014). The complex relationship of management practices is illustrated in Figure 7.

Certification of Organic Products

For a product to be labeled organic in the EU and in Germany, it must have an organic percentage of at least 95%, with a maximum of up to 5% of non-organically produced ingredients for the entire product (BMEL(b), 2015). The label for organic products in Germany is referred to as "Bio-Siegel," used to mark any unprocessed agricultural product or any agricultural product for human consumption that is subject to EU legislation governing organic farming (BMEL(b), 2015).

Within the organic sector, there are also more ambitious certifications that use the legal "organic label" as a base and then build from there. Please see Appendix IV for complete comparison. In Germany, more than half of organic farms join "farming associations," which have higher quality and production standards than the Bio-Siegel (BMEL(b), 2015). Two of the oldest and largest of these associations are *Bioland* and *Demeter*. Others include: *Naturland, Biokreis, Gäa, Ecoland, Biopark* and *Verband Ökohöfe* (BMEL(b), 2015).

Sustainability of Organic Farming vs. Conventional Farming

To be recognized as a sustainable alternative to conventional farming, organic farming must illustrate that it can produce sufficient amounts of high-quality food, enhance the natural resources and environment, be financially realistic, and contribute to well-being of farmers and the community (Reganold & Wachter, 2016).

Yield Comparison Organic vs. Conventional Agriculture

Yield-limiting factors, specifically nutrient limitations and pests and diseases, play a more central role in organic agriculture. Numerous studies have been conducted regarding crop yield of organic production vs. conventional production. For example, (Seufert, et al., 2012) found that overall, organic yields are typically lower, ranging from five to 34% less than conventional yields depending on the crop, but an average yield of 25% lower overall. Another study by (Reganold & Wachter, 2016) synthesized data from several meta-analyses or reviews, finding that yield averages are eight to 25% lower in organic systems. Furthermore, a study by (de Ponti, et al., 2012) compiled and analyzed a meta-dataset of 362 published organic–conventional comparative crop yields and determined that, on average, organic yields are 20% lower than those obtained under conventional conditions, with a standard deviation of 21%.

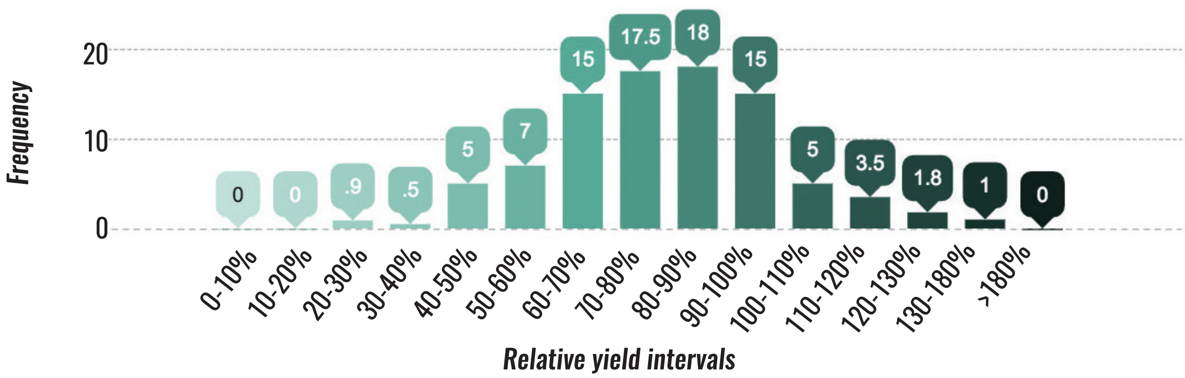


Figure 8. Frequency of occurrence of relative yields of organic vs. conventional agriculture, grouped in 10% intervals. Adapted from (de Ponti, et al., 2012).

With all studies, yield differences were highly contextual, depending on the system, site characteristics, crops, growing conditions, and management practices. In the case of drought and excessive rainfall conditions, as may be expected in many regions with increasing climate change, organic production tends to surpass conventional production, due to the high water-holding ability of organic soils (Reganold & Wachter, 2016) (Seufert, et al., 2012).

Nutritional Quality

While the assessment of nutritional quality of organic versus conventional foods is still in its infancy, in chemical-analytical terms, organic produce frequently demonstrates higher quality features than conventional produce (BMEL(b), 2015). This is further confirmed by (Reganold & Wachter, 2016), who referenced fifteen reviews or meta-analyses of scientific literature comparing nutritional values of organic and conventional foods. Twelve studies found evidence of organic food being more nutritious, such as having higher concentrations of vitamin c, more total antioxidants, more total omega-3 fatty acids, and higher omega-3 to -6 ratios (Reganold & Wachter, 2016). One of three studies that found no significant difference (Smith-Spangler, et al., 2012). However, it did find that conventional chicken and pork had a 33% higher risk of contamination with antibiotic-resistant bacteria compared to organic alternatives.

Environmental Enhancement and Sustainability

Compared to conventional farming, organic farming is generally considered more environmentally friendly, with greater protection of natural resources— particularly greater soil carbon levels, better soil quality, and less erosion (Reganold & Wachter, 2016). Soil conservation is achieved through the promotion of humus formation and soil biota via natural fertilizers and compost. Measures that can increase risks of soil erosion are avoided, and, instead, organic farming focuses on methods such as crop rotation or cover crops (BMEL(b), 2015).

Furthermore, organic farms tend to have greater biodiversity of flora and fauna, encouraged by the prohibition of agrochemicals that can upset the balance of the natural ecosystem (BMEL(b), 2015). Nutrient surpluses created by purchased fodder and synthetic mineral fertilizers can be avoided, reducing potential for runoff and pollution of water bodies and groundwater (UBA(a), 2014). As organic agriculture restricts the amount of livestock per hectare farmland, there is generally no build-up of manure and slurry that can cause pollution. Instead, the manure can be used as fertilizer for plants (BMEL(b), 2015).

Profitability and Price Competition

Profitability of organic agriculture compared to conventional production can be determined by crop yields, labor and total costs, price premiums for organic products, potential for reduced income during the organic transition period of typically three years, and potential cost savings from reduced reliance on non-renewable resources and purchased inputs (Reganold & Wachter, 2016). One meta-analysis study by (Crowdera & Reganold, 2015) examined the financial performance of organic and conventional agriculture from forty years of studies, covering fifty-five crops grown on five continents. It was concluded that when price premiums— the higher prices awarded to organic foods— were applied, organic agriculture was significantly more profitable (22 to 35%) (Crowdera & Reganold, 2015).

From the consumer's point of view, the competitiveness of conventional vs. organic products in terms of price will also depend on the extent in which the price to be paid by the consumer reflects the costs of externalities associated with production (de Ponti, et al., 2012). If the external costs (i.e. to the environment, human health) were internalized for conventionally-produced food today, the price would be higher, and thus it can be expected that organic foods will be more competitive at price point for consumers.

Social Well-Being

In terms of community and farmer wellbeing, it is unclear if there is an advantage to organic over conventional production. However, in some cases, organic farming methods have been proven to demonstrate certain sociocultural strengths, such as community economic developments, increased social interaction between farmer and consumer, and reduced exposure to chemicals for farmers and workers (Reganold & Wachter, 2016). Additionally, organic certifications require that animals be raised in a humane way, aligned to natural behaviors and needs.

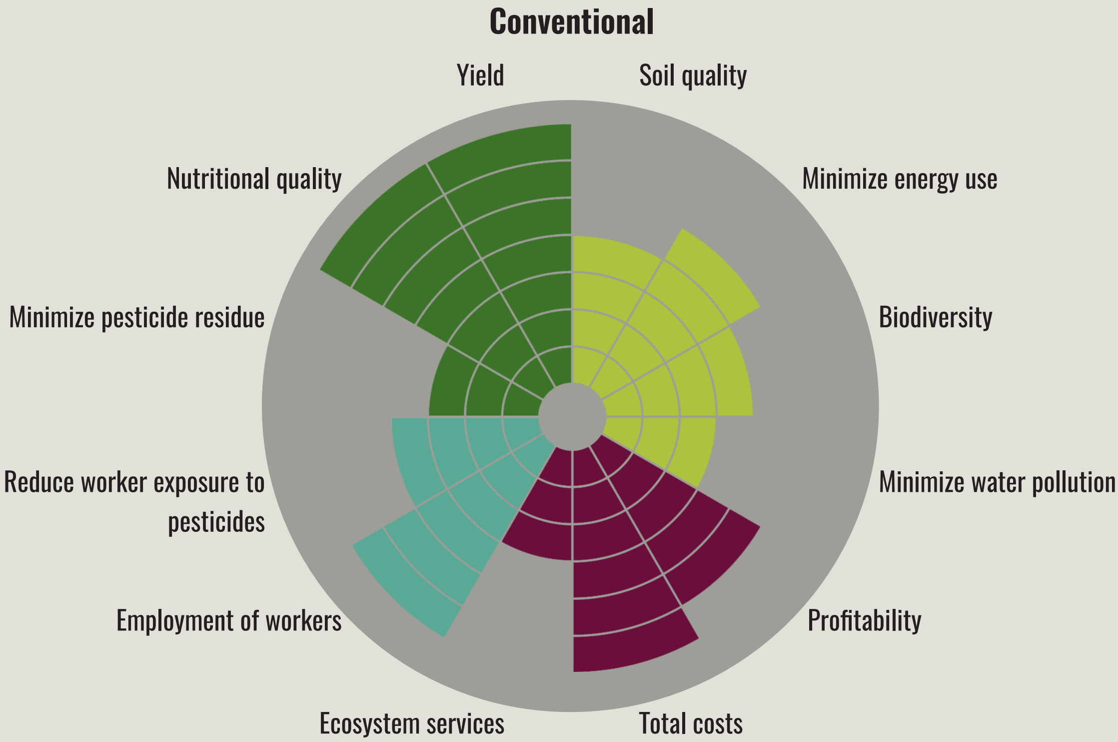


Figure 9. Assessment of organic farming relative to conventional farming in the four major areas of sustainability. Length of sustainability metrics. Dark green represents productivity, light green: environmental sustainability, red: economic sustainability system balance of organic farmer versus conventional. Adapted from (Reganold & Wachter, 2016).

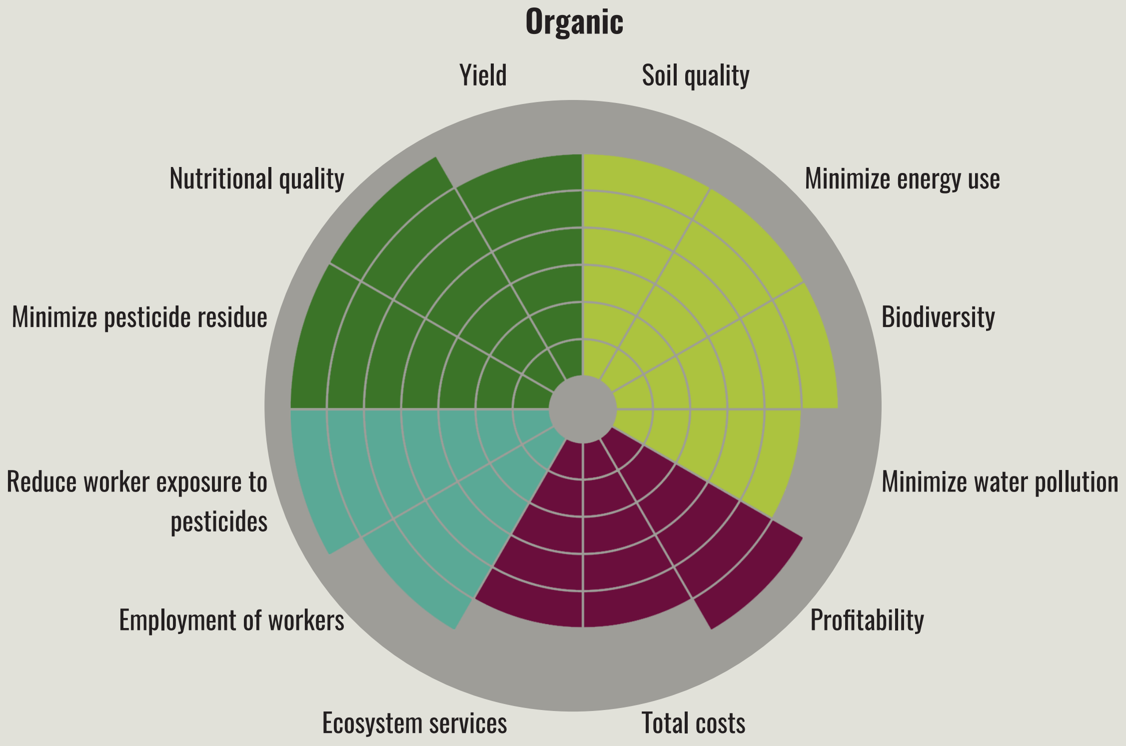
Status of Organic Agriculture in Europe

According to the most recent reports— *The World of Organic Agriculture 2016* published by the *Research Institute of Organic Agriculture* (FIBL) and the *International Federation of Organic Agriculture Movements* (IFOAM)— the organic sector of Europe is well-developed in relation to the global context, with steady growth in area and number of operators, increasing annual market demand, and a relatively high share of agricultural land (Willer & Lernoud, 2016). Total organic area in the EU-28 in 2014 was 5.9% of all agricultural area, increasing in area by 2.3% between 2013 and 2014, while the world average is just 1% (Eurostat(d), 2015). The production in this sector, however, is still relatively niche, and in many countries the demand for organic products cannot be met by domestic production (Willer & Lernoud, 2016).

Organic Production in Europe

Growth has continued in the area of total organic land, number of organic farmers, and the organic market through 2014, as illustrated in Figure 10. The current agricultural area under organic management in Europe is 11.6 million hectares (10.3 million in the EU-28), 1.6 million of which are under conversion. This represents 2.4% of the total agricultural land in Europe (5.7% in the EU), a 2% increase since 2013. Currently, 27.6% of the world's total organic farmland is located in Europe (Willer & Lernoud, 2016).

Denmark is the largest exporter of organic products, especially to Germany, Sweden, France, and the Netherlands. The countries with the largest areas of organic land are Spain, Italy, France and Germany. The number of producers has increased by 57% in the EU since 2004, and currently 15% of the world's organic farmers are in Europe (Willer & Lernoud, 2016). Arable land is the largest portion of organic land in Europe, followed by permanent grassland, then permanent crops.



spoke qualitatively based upon study by (Reganold & Wachter, 2016) and indicate levels of performance of specific sustainability and blue: social well-being of workers. The comparison between the two diagrams illustrates the better

The largest permanent grassland or grazing areas are in Spain and Germany, and cereals are the largest crop group. (Willer & Lernoud, 2016).The countries with the largest arable crops are Italy, France, and Germany, with the largest proportion of arable crop groups being green fodder (Willer & Lernoud, 2016). Fodder crops are typically used for animal feed, further illustrating the share of land required for livestock.

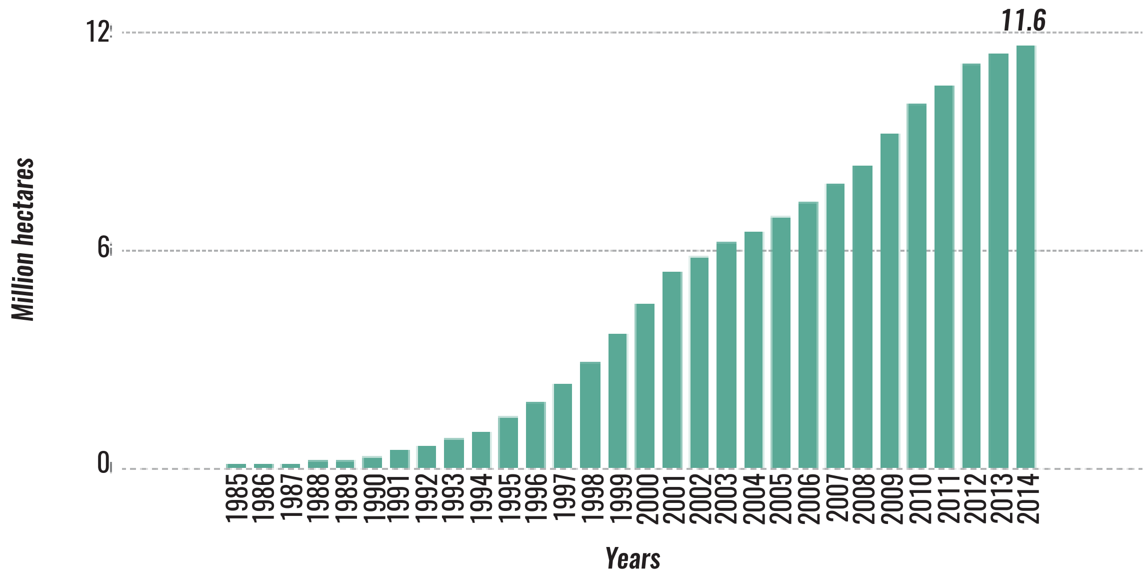


Figure 10. Development of organic agricultural land in Europe (1985-2014). Adapted from (Willer & Lernoud, 2016).

Organic Consumption in Europe

The EU is the second-largest global single organic market, after the United States, with a growth of 8% in 2014. Furthermore, European countries have the highest average per capita consumption of organic products worldwide and highest organic food market share, with the largest in Denmark, Switzerland, and Austria (Willer & Lernoud, 2016).

Germany has the largest market in Europe (7.9 billion Euros), and is the second largest organic market in the world, behind the United States (roughly 29.3 billion Euros according to average 2014 exchange rate). Denmark continues to have the highest organic market share globally, with 7.6% of the Danish food market classified as organic. It should also be noted that, while numbers reflect an average of organic product consumption, there is a much higher potential for certain products to reach higher market shares; for instance, in Germany, organic baby food is over 40% and organic meat substitutes are over 60% (Willer & Lernoud, 2016).

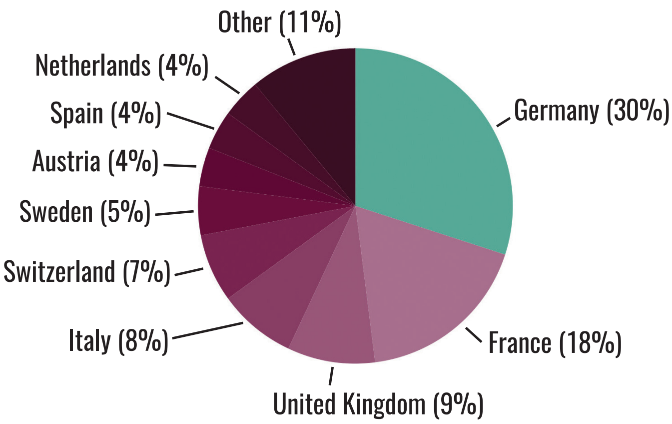


Figure 11. Distribution of retail organic food sales in Europe (2014). Adapted from (Willer & Lernoud, 2016).

Status of Organic Agriculture in Germany

Organic Production in Germany

Currently, the organic sector is still relatively niche in Germany (BÖLW(a), 2015). At the end of 2014, organic farms that met the EU standard regarding organic farming accounted for 8.2% of all holdings and approximately 6.3% of the total utilized agricultural area (BMEL(b), 2015). Germany represents the third largest amount of organic area of the EU member states with approximately 1 million ha (BMEL(b), 2015).

Between 1996 and 2014, there was a notable increase in both the amount of area farmed organically and the number of organic holdings. Between 2010 and 2014, in the regions of Lower Saxony and Schleswig-Holstein, however, there were more hectares converted back to conventional farmland than vice-versa in 2010 (Rossbach, 2013). In 2015, there was a slightly positive trend, despite uncertainty in EU regulations. According to estimates, the domestic organic area grew by 2.9%, increasing potential for German organic agricultural production (BÖLW(b), 2016).

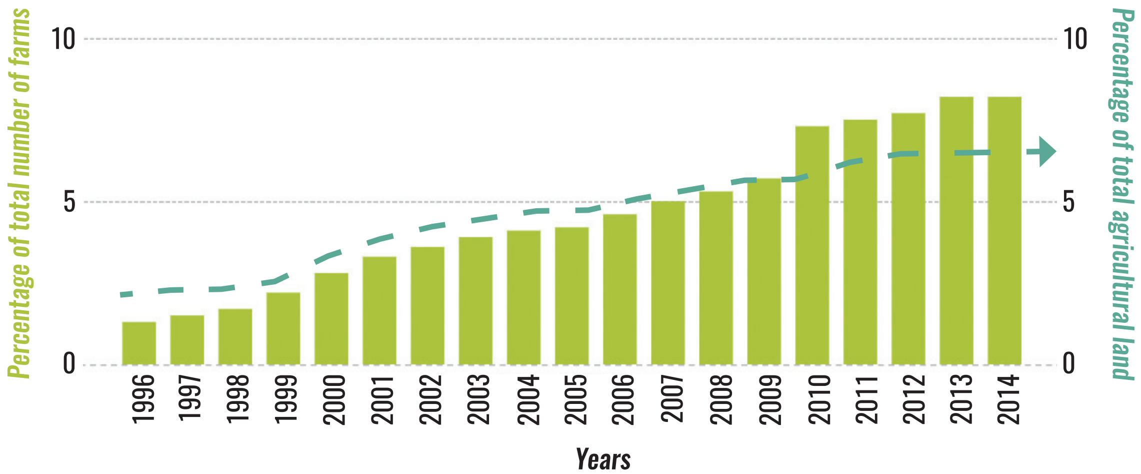


Figure 12. Organic farming in Germany (1996-2014). Adapted from (BMEL(b), 2015).

Images from Demeter-certified Kattendorfer Hof source: (Joseph, 2016)

Furthermore, as stated earlier, more than half or organic farms in Germany belong to a farming association or farming union (BÖLW(b), 2016), and two thirds of the organically farmed land belongs to some organic farming association within Germany (BÖLW(c), 2015). Between 2015 and 2016, there was an increase in the number of farms participating in the majority of associations, with the exception being the most ambitious and strictest association: Demeter (BÖLW(b), 2016). This may be due to stricter policy requirements, which can deter farmers from joining this association. Trends in 2015 include an increase in organic fruit, wine, and poultry production, as well as slight increases in legumes and vegetables, especially in green houses (BÖLW(b), 2016).

Farming Association	Number of farms	Area (Hectares)
Biokreis	1,000	39,095
Bioland	6,325	304,929
Biopark	579	120,496
Demeter	1,468	73,327
Ecoland	41	2,537
Ecovin	235	2,097
Gäa	357	30,561
Naturland	2,638	150,837

Table 2: Farming associations in Germany in 2016. Adapted from (BÖLW(b), 2016).

Furthermore, there is a distinct variation in area of cultivated organic land across regions, illustrated in Table 3. For example, in 2014, Saarland, Hesse, and Brandenburg had the highest percentage of regional land farmed organically, while Lower Saxony and Scheswig-Holstein had the lowest (BMEL(e), 2014).

One reason for this variation is the difference in regional governments. The subsidy system allows the federal states to choose how much they allocate for organic farmers, and then the EU matches this. If there is no federal state money allocated or if the funds are decreased, the EU funds follow suit (BMEL(b), 2015.

Federal state (Länder)	Organically farmed land (ha)	Share of organic area in total German farmed area (%)	Share of organic farms to the total farms in the state (%)
Baden-Württemberg	124,534	11.9%	16.3%
Bavaria	214,040	20.4%	7.3%
Brandenburg	134,763	12.9%	14.2%
Hesse	85,885	8.2%	10.3%
Mecklenburg-Vorpommern	119,076	11.4%	16.7%
Lower Saxony	71,296	6.8%	3.5%
North Rhine-Westphalia	70,069	6.7%	5.2%
Rhineland-Palatinate	53,988	5.2%	6.6%
Saarland	9,251	0.9%	14.0%
Saxony	36,663	3.5%	8.3%
Saxony-Anhalt	55,604	5.3%	9.0%
Schleswig-Holstein	37,085	3.5%	3.7%
Thuringia	32,901	3.1%	8.5%
City-states in total	2,478	0.2%	9.0%

Table 3: Breakdown of organic land in Germany by Federal States. Adapted from (BMEL(e), 2014).

Barriers to Organic Production in Germany

Biogas Promotion and Rising Land Prices

Beginning in 2004, there was an increased emphasis on renewable energy production, including a subsidy program for the promotion of biogas plants. Maize is grown and fermented, yielding "biogas" (mainly methane with trace components of sulfur and other substances) which is burnt in cogeneration facilities, to produce electricity and heat. This not only creates environmental challenges, such as monocultures, but it also reduces the amount of land available for food crop and livestock production. In 2011, some regions of Germany cultivated maize on more than 50% of arable land (BMEL(c), 2011). In total, roughly 5.4% and 4.5% of farmland in Germany is used for maize for biogas and rapeseed for biodiesel, respectively (BMEL(d), 2014).

Biogas promotion also has an impact on rising land prices. Biogas operators maintain high and secure 20-year government funding for electricity production, and are able to pay much higher land prices than organic farmers (UBA(b), 2015). Furthermore, the production profits from maize cultivation for biogas is not achievable through other agricultural practices, such as livestock or dairy farming (BMEL(c), 2011). This makes it even more attractive to produce single crops rather than a holistic farm approach that includes livestock and crops.

Large Retailers Keep Prices Low

Large retailers control the majority of the market (Statista, 2014), and therefore exert market power upstream. In many cases, these retailers also have their own organic labels, although they just meet the minimum requirements for organic certification. For certified *Naturkostläden* (natrual food shops) that carry more ambitious labels, this constitutes a price challenge.

Competition from Inexpensive Imports

Food produced as far away as Eastern Europe, South America, India, and China is generally less expensive than that produced in Germany. This is largely due to the lower wages and, in some cases, exploitation of farm laborers. This makes it difficult for regional or domestically produced products to compete on price, placing an added price pressure on domestic producers. The higher prices can then deter customers from purchasing these goods, reducing the demand for local, organic products and, consequently, the potential for an increase in production.

Consumer Attitudes

Consumer attitudes presents a significant barrier to the increase of production of locally produced organic products. Many consumers make their purchase choices based on the cost of the good. This is a tangible decision that produces short-term benefits, where consumers are not willing to pay more for organic products, as they are essentially paying for the “idea” of sustainability.

In Germany, the average consumer spent approximately 14% of his or her income on food, beverages (including alcoholic) and tobacco in 2014 (Destatis(a), 2014). Costs for housing, energy, furnishing, equipment and maintenance of the dwelling was on average 42%., health-related costs, 4%, transport, 14%, clothing and footwear, 4.5% and postal communication and telecommunication, 2.5%, respectively (Destatis(a), 2014). In total, these expenses equal roughly 80% of total monthly expenditure. The average net monthly income per household in Germany in 2014 was €3,147 (Destatis(g), 2016). Considering these statistics, and imagining that the situation has not drastically changed since 2014, the average German citizen has roughly €630 of disposable income per month. This illustrates that disposable income is, in fact, available to spend on organic products for at least a portion of the population, yet purchasing is not carried out.

Lower Financial Prospects Compared to Conventional Farming

According to calculations from the year 2013-2014, the average income of organic farms was approximately 10% lower than that of conventional farms in Germany (BMEL(b), 2015). Organic production is more labor intensive and requires a higher level of management, with potentially lower yields, which can, therefore, make production more expensive (BMEL(b), 2015).

Organic Consumption in Germany

As mentioned previously, Germany has the largest organic food market in Europe and the second largest worldwide (Willer & Lernoud, 2016). In 2014, the total retail sales of organic food in Germany increased by 4.8%, from 7.55 to 7.91 billion Euros (Willer & Lernoud, 2016). The most prevalent market channels include large general retailers (roughly 50%), such as *Rewe* or *Edeka*; organic chain retailers (roughly 30%), like *Al Natura* or *Dens*; and other channels (roughly 20%), such as delivery boxes, farmers’ markets, *Naturkostläden*, etc. (UBA(a), 2014). Top selling products include vegetables and potatoes, bread and bakery products, fruit (UBA(a), 2014), milk, and meat (BÖLW(b), 2016). Trends in 2015 also showed an increase in organic milk, egg, wine, and cereal consumption (BÖLW(b), 2016).

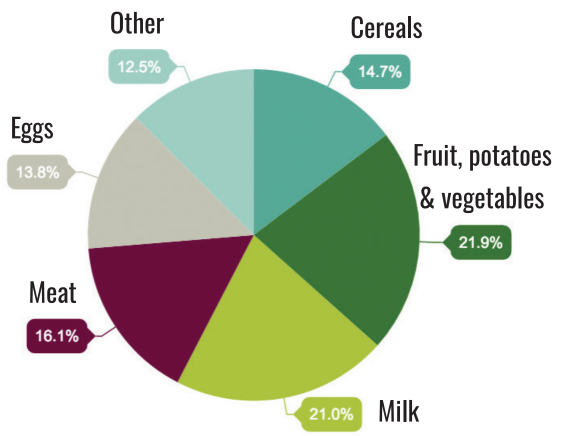


Figure 13. Share of sales in organic farming (2014). Adapted from (BÖLW(c), 2015).

In 2014, sales from general retailers remained relatively stagnant while the highest growth was in specialized trade distribution channels, such as bakeries, butcher shops, farmers’ markets, delivery boxes, and *Naturkostläden*. These grew by 9% (Willer & Lernoud, 2016). Furthermore, in the first three quarters of 2015, expenditure of private households on fresh, organic products and organically processed products increased 10%, compared to the same period in 2014 (Willer & Lernoud, 2016). Discount retailers also showed growth, due to the increase in new products that are organically certified (Willer & Lernoud, 2016). In 2015, German households accounted for 8.62 billion Euros of organic food and drink purchases from all retailers, a rise of 11% from the previous year. In 2014, German households spent, on average, 4.8% more money on organic food than they did in 2013 (BÖLW(c), 2015).

While growth in consumption demonstrates a positive trend toward an increasing interest in organic products, the inability of domestic production alone to meet increasing demand persists. It is estimated that 30-50% of organic products must be imported to Germany to fulfill demand, depending on the type of product, including ones which could be produce locally (Willer & Lernoud, 2016). According to a study by the University of Bonn, out of every two organic apples— a main domestic product— sold in Germany, one is an import (Baig, 2013).

Policy Environment

European Policies and Regulations Relating to Organic Agriculture

Income for farmers is also dependent on financial support from government bodies, as well as other sources of income (BMEL(d), 2014). In the case of organic agriculture, this may be even more crucial; especially in the early stages, production requires a high capital and labor input, while the products cannot be sold as organic for at least three years.

The policy and regulatory framework is anticipated to have a significant impact on the development of the EU organic sector in the next decade (Willer & Lernoud, 2016). Currently, a new legislative proposal launched in 2014 is under negotiation with the *European Commission*, *European Agriculture Council*, and *European Parliament*. A final agreement on the basic legislation is foreseen in 2016, with action expected to come in force in 2018 (Willer & Lernoud, 2016).

Under the new *Common Agricultural Policy* (CAP) 2014-2020, organic farming is supported under Pillar 1 (direct payments) and Pillar 2 (Rural Development Programs) (RDPs). Percentage is expressed as portion of total funds.

Pillar 1:

- Basic Payment Scheme (mandatory, up to 70%): a basic payment per hectare, the level of which is to be harmonized according to national or regional economic or administrative criteria and subject to a convergence process.
- "Greening" component (mandatory, 30%): As additional support to offset the cost of providing environmental public goods not remunerated by the market. 3 main groups: "crop diversification", "maintaining permanent grassland", "maintaining ecological focus area of at least 5%".
- Young farmers (mandatory, up to 2%): additional payment for a period of five years for young farmers (under 40 years). Only 14% of EU farmers are under 40.
- Redistribution payment (up to 30%): farmers may be granted additional support for the first hectares of farmland.
- To provide more targeted support for small and medium-sized farms by simplifying the support scheme, facilitating access to direct payments and reducing administrative burden.
- Specific national constraints (up to 5%): areas under specific national constraints.
- Coupled support (up to 15%): granted in respect of certain areas or types of farming for economic/social reasons, i.e. payments links to certain products.
- Small farmers scheme (up to 1,250 Euros, not more than 10% with some exceptions): simplified scheme based on annual payment.

Pillar 2:

- Specific aid programs for sustainable and environmentally sound farming and development.
- Includes agri-environment/climate payments, organic farming and Natura 2000. (European Commission (c), 2014).

Organic farmers automatically qualify for the new "greening" payment (Willer & Lernoud, 2016), equal to approximately 30% of the CAP direct payments. However, this does not dedicate any specific amounts solely to organic agriculture development and support (European Commission (c), 2014). The first three sections of Pillar 1 are mandatory, with allocation at the discretion of each individual member state (Willer & Lernoud, 2016).

Under implementation of the new policy in 2015, there is support for conversion to organic agriculture, calculated to compensate for the loss of income, costs resulting from this conversion, and the maintenance of organic agriculture (European Commission (c), 2014). It is also possible that support can be granted to organic farmers who want to set up producer groups (under measure:

"setting up of producer groups"). For support of organic agriculture, the relevant sub-program for content and financing is "climate change mitigation and adaptation and biodiversity" (European Commission (c), 2014). Also, another thematic sub-program for "small farms and short supply chains" could be relevant for organic farming (European Commission (c), 2014). It is expected that organic area payments will account for 6.4% of total spending of EU public expenditures for RDPs through 2020 (Willer & Lernoud, 2016).

German Policies and Regulations Relating to Organic Agriculture

The promotion of organic farming through public funds was first introduced in Germany in 1989 (BMEL(b), 2015). Since 1994, the introduction and maintenance of organic farming was supported under the *Länder* (federal state) programs for rural development (RDPs), based on EU regulation (EU) No 1305/2013 of the European Parliament and of the Council of 17 December 2013 on support for rural development by the *European Agricultural Fund for Rural Development* (EAFRD) (Art. 29 of Regulation (EU) No 1305/2013) as amended (BMEL(b), 2015).

By law, EU subsidies must be co-financed by federal states, giving individual regions more flexibility on how the organic farming production develops. The payment structure is allocated through the *Act on a Joint Task for the Improvement of Agricultural Structure and Coastal Protection* (GAK Act – GAKG). The structure is as follows:

- National funds are co-financed with the *Länder* at a rate of 60:40, respectively. Maximum EU contribution in most cases is 75% of eligible public expenditure.
- Payments are made to compensate farmers for the additional costs and income lost due to special management requirements.
- The *Länder*, within the scope of the implementation of GAK measures, considering the political priority setting and available public funds, sets premiums.
- The *Länder* may increase or decrease amounts by up to 30%.
- From 2015, the support rates increase 19% for the introduction of organic agricultural practices and 24% for the maintenance compared to 2013. (BMEL(b), 2015)

Currently, CAP support in Germany is equal to 6.3 billion Euros of annual funding from 2014 to 2020, divided across Pillar 1 and Pillar 2 (BMEL(a), 2015). Of this funding, direct payments to farmers are granted on a per hectare basis under the first pillar and make up on average 40% of the farmer's total income (BMEL(a), 2015). The second pillar comprises aid programs for sustainable and environmentally friendly farming and rural development, for which Germany has allocated 1.3 billion Euros available per year (BMEL(a), 2015).

A focus will also be placed on strengthening support for small and medium sized farms. Since 2014, a supplement for the first few hectares is granted, where farms receive 50 Euros for the first 30 hectares, and an additional 30 Euros for a further 16 hectares (BMEL(a), 2015). Furthermore, very small farms will be exempt from fulfilling certain requirements (BMEL(a), 2015).

Certification of organic products falls under the *Organic Farming Act* (ÖLG), which includes the requirements for organic certification, inspection protocol, and, when necessary, disciplinary measures. The ÖLG also has stricter requirements than the EU legislation on organic farming (BMELV (b), 2013). For example, under EU regulation, a holding may convert partially to organic farming under certain circumstances, while support with public funds in Germany requires an entire conversion as a prerequisite (BMELV (b), 2013).

There are, furthermore, other regulations that indirectly promote or hinder the conversion to organic agriculture, for example the European Nitrates Directive which requires EU member countries to implement measures for reducing nitrate pollution of water bodies. As described above, agriculture and Concentrated Animal Feeding Operations are the main culprits of nitrates pollution. Should the German government adopt policies to penalize conventional farmers for causing nitrates pollution, this could be one incentive to switch to organic production.

4

Feeding the Regional Community with Regional (Organic) Agriculture: Case Study

To illustrate the potential for maximizing regional organic food production in a specific locality, this thesis looks at three regions in North Germany— the city state of Hamburg, and two larger regions centered around Hamburg, with a radius of 50 and 100 km, respectively— and investigates to what extent the people living within these regions can be fed by organic food products grown in these regions.

The case study proceeds in the following steps:

1. **The first step** consists of determining the "land footprint" of the food consumption of an individual person for four average "current consumption" diet scenarios, including determining the "organic yield comparison factor".
2. **The second step** identifies the agricultural land area available for food production in the case study regions.
3. **The third step** assesses the share of regional population that can be fed by the available agricultural land in each region for the first four diet scenarios.
4. **The fourth step** determines the "land footprint" of the food consumption of an individual person for four more diet scenarios illustrating shifts towards more sustainable diets in terms of the land footprint for food production for both conventionally and organically produced foods.
5. **The fifth step** assesses the share of regional population that can be fed by the available agricultural land in each region for the last four diet scenarios.

Image source: (Peter Hershey, 2016)

Regarding the first step:

"Footprint" is a measure that attempts to represent the resources needed to produce a product, both directly and indirectly. The term was pioneered by Wackernagel and Rees (1996) and has been applied to different resources, whereby the exact definitions of various "footprint" measures and methods to compute them differ. Hoekstra and Chapagain (2007), for example, calculated the water footprint of different products— all the water input needed to produce, for example, a kilogram of rice, or a car. Not only is the direct water use in the production of car parts assessed with this measure, but also the indirect inputs— those needed in the production of intermediate goods; i.e. mining and processing of bauxite that forms aluminum which is used in a car.

The concept has also been applied to the resource "land"— in particular in assessments of the resource use of food production (for example, World Wildlife Fund (WWF) 2015, which plays an important role in this case study). Land footprint in this context is the agricultural area required to produce the crops and animal products that are consumed both directly and indirectly by humans. Direct consumption refers to the food that is eaten in unprocessed form, such as whole fruits and vegetables. Indirect consumption refers to the crops that are grown to feed livestock that will eventually be consumed as meat. Also included in the land footprint for food consumption are products that are used as part of other food groups, i.e., ready-made frozen pizzas or canned soups.

This step also included determining the "organic yield comparison factor"— the figure to be used to calculate the yield produced organically on the same size area of agricultural land compared to conventional methods. This is in part directly observed from the Kattendorfer Hof, in part determined from the literature and the Destatis statistical database about actual German yields in 2014/2015. When not available from Kattendorfer Hof, an organic production yield adaptation factor was applied to the data for the yield of conventionally grown crops.

Image source: (Unsplash, 2015)

Regarding the second step:

For each region, comprised of Hamburg and surrounding *Landkreise* (rural districts), the amount of agricultural land is identified from the German Statistical Office. In view of the fact that not all agricultural land is used to grow food crops, but some is used to grow energy crops (maize that is fermented to produce biogas, and rapeseed for ethanol production that is mixed with gasoline), calculations are made with three assumptions: 100% of the agricultural land in the region is used to grow food (the upper bound), 75% (the middle bound) and 50% (the lower bound). On the other hand, vegetables can be grown on land that is not classified officially as "agricultural land". Private gardens, adjacent to residential buildings or in garden colonies, are not counted as "agricultural land" but nevertheless can serve to grow food. This area is not included in the analysis of this thesis.

Regarding the third step:

First, for each region and diet scenario, the land areas needed to feed the regional population are computed. Then, the share of available land (with the upper, middle and lower bound) in total land needed to grow the food for feeding the population is computed. This corresponds, by definition of the land footprint, to the share of regional population that can be fed from regional agriculture.

Regarding the fourth step:

The individual land footprint for four more diet scenarios are outlined here, each representing a shift in consumption quantities towards less land-intensive foods, i.e. a substituting meat for plant products. Both conventional and organic production methods are outlined here.

Regarding the fifth step:

The same process as step three is followed here, with a share of 75% of agricultural land utilized for food production. This corresponds, by definition of the land footprint, to the share of regional population that can be fed from regional agriculture.

The eight diet scenarios are described in detail below. In summary, they are:

1. **Diet One:** A potatoes-only diet (as potatoes provide a high nutrition value per area unit needed to grow it), produced by conventional agriculture.
2. **Diet Two**: The current average German diet, produced by conventional agriculture (taken from a study by (WWF, 2015).
3. **Diet Three:** The "Kattendorfer Hof" diet, produced by organic agriculture at the certified Demeter standard. Kattendorfer Hof is a community-supported farm in the North of Hamburg that produces a wide range of products with the aim to feed, to the largest extent possible, the community that supports it financially. It provides almost the entire range of food products that can be produced under the local climatic conditions, including livestock whose manure is used to provide nutrients for the soil.

Products that cannot be produced on the farm, such as coffee, tea or citrus fruits are consumed by supporting members, but purchased through other means (this will be discussed in detail later). The idea is that they solely consume foods produced at the Kattendorfer Hof as much as they are willing to tailor their consumption around foods adapted to the local climate and grown on the farm. The author of the thesis visited Kattendorfer Hof and obtained data on production mix and yields for a range of crops.

4. **Diet Four**: Equal consumption quantities as Diet Two (i.e. the current average German diet, taken from a study by World Wildlife Fund (WWF) (2015), except for the assumption that it is produced organically according to EU basic organic production standards (which are not as ambitious as, for example, the Demeter label).
5. **Diet Five:** Diet according to recommendations by the German Society for Nutrition (*Deutsche Gesellschaft für Ernährung, DGE*) with some adjustments.
6. **Diet Six:** Equal consumption quantities as Diet Two, except for a 30% reduction in meat consumption, corresponding to two meat-free days a week, compensated by a corresponding increase in the consumption of legumes.
7. **Diet Seven:** Equal consumption quantities as Diet Two, except for a 60% reduction in meat consumption, corresponding to four meat-free days a week, compensated by a corresponding increase in the consumption of legumes.
8. **Diet Eight:** Vegetarian Diet, meat being compensated by a corresponding increase in the consumption of eggs and legumes.

The next section presents, prior to the analysis for the case study, a brief summary of the current conventional and organic agricultural production in the city-state of Hamburg and the bordering *Bundesländer* (federal states) of Mecklenburg-Vorpommern, Niedersachsen, and Schleswig-Holstein— here, also referred to as the region of "Northern Germany." This helps the reader appreciate the nature of the agricultural sector in North Germany.

Current Crop and Livestock Production in Northern Germany: Conventional and Organic

Overall, Germany has a strong agricultural sector. Germany is the fourth largest producer of agricultural products in the EU (BMEL(d), 2014). According to the German Federal Ministry of Agriculture (BMEL), domestic production equalled more than four-fifths of domestic demand for food, corresponding to a theoretical self-sufficiency rate of approximately 85% in 2014. This figure, however, is misleading. Not all that is produced domestically is consumed domestically; rather, there is considerable trade in food products across Germany's borders (BMEL(d), 2014). That is why it is called the "theoretical" self-sufficiency here. Figure 14 illustrates the average rate of theoretical German self-sufficiency (the rate of domestic production to domestic demand) from the years 2010-2012 for most commonly produced crops. In these years, domestic production of potatoes, dairy products, cheese, beef and veal, pork, poultry and cereals theoretically met domestic demand.

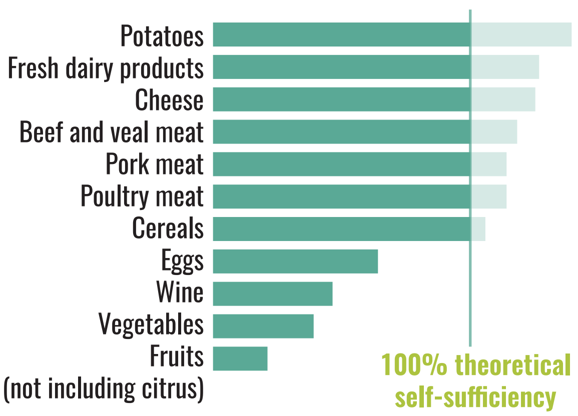


Figure 14. Average rate of theoretical self-sufficiency in Germany for products from 2010-2012. Adapted from (BMEL(d), 2014).

The Northern German states of Hamburg, Mecklenburg-Vorpommern, Niedersachsen and Schleswig-Holstein all contribute to the overall domestic agricultural production, albeit to varying degrees. The total utilized agricultural area (UAA) in Germany is equal to 16.7 million hectares (Destatis(e), 2015). Hamburg contributes less than 1% of this total UAA, Mecklenburg-Vorpommern 8% (Destatis(d), 2014), Niedersachsen 16% (Niedersachsen, 2016), and

Schleswig-Holstein 6% (Schleswig-Holstein, n.d.). Within the federal states, some *Landkreise* (rural districts) also have a larger percentage of farming area than others. This is illustrated in Figure 15.

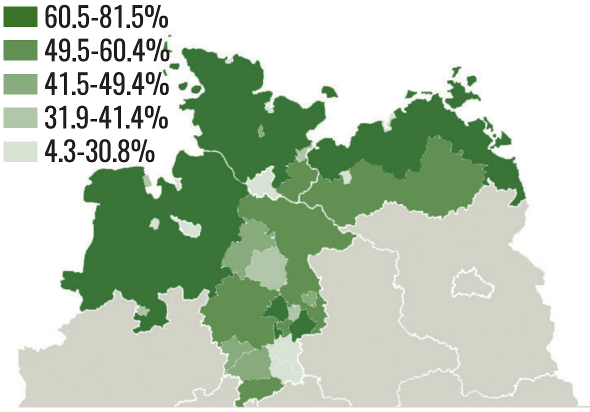


Figure 15. Percentage of total farming area within *Landkreise* (i.e. rural districts) in Northern Germany. Source: (Destatis(d), 2014).

Furthermore, in the case of Schleswig-Holstein, Niedersachsen, and Mecklenburg-Vorpommern, the average farm size is much larger than the German average of 59.2 hectares in 2013 (Schleswig-Holstein, n.d.). The average in Mecklenburg-Vorpommern was 291.5 hectares, Niedersachsen 66.9 hectares and Schleswig-Holstein 74.5 hectares (Schleswig-Holstein, n.d.).

In terms of utilized agricultural area devoted to organic farming, Schleswig-Holstein and Niedersachsen are below the German average of roughly 6.3% of total agricultural area with 3.7% and 2.8% in 2014, respectively (BMEL(e), 2014). Mecklenberg-Vorpommern is above the average, with roughly 8.9% of the agricultural area under organic cultivation (BMEL(e), 2014). In Hamburg, 7.6% of total agricultural area was under organic cultivation in 2014 (Bürgerschaft der Freien und Hansestadt Hamburg, 2017). The statistics on individual crop and livestock production in the federal states that are reported in the following section do not differentiate between organic and non-organic production, due to data limitations.

What is produced?

Main crops include cereals, potatoes, sugar beets, fruits, and vegetables; while beef, pigs, and poultry dominate the livestock sector (BMEL(d), 2014). Schleswig-Holstein contributed 6,3%, Niedersachsen 17.1%, Mecklenburg-Vorpommern 4.2% and Hamburg less than 1% to the total value of crop production in Germany (Statistische Ämter des Bundes und der Länder(a), 2013). In the case of animal products— including cattle, pigs, sheep, goats, poultry, eggs, milk and others— Schleswig-Holstein contributed to 7.6%, Niedersachsen 26.6%, Mecklenburg-Vorpommern 4.2%, and Hamburg less than 1% of total animal production value (Statistische Ämter des Bundes und der Länder(a), 2013).

Animal Products

Livestock production represents a significant part of the farming sector in Germany, which is the largest producer of pork and milk in Europe (BMEL(d), 2014). Dominant products in particular areas of Germany according to the Federal Ministry of Food and Agriculture (BMEL) are represented in Figure 16. It can be seen that western Niedersachsen in particular produces a significant amount of cattle, which includes dairy cows and fattening cows, pigs, and hens. Schleswig-Holstein is also identified as a main cattle and sheep producing area.

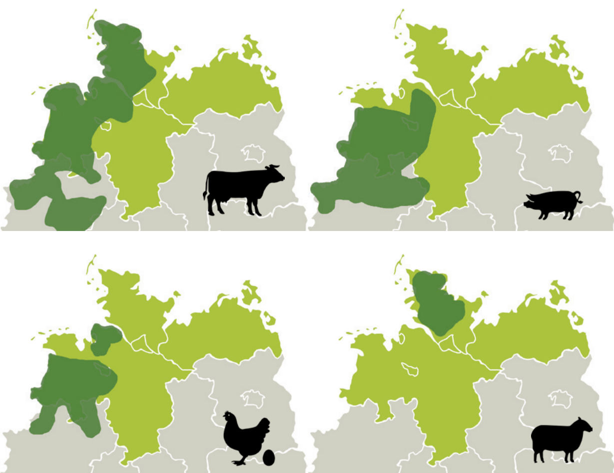


Figure 16. Indication (dark green area) of main growing areas in Northern Germany of different livestock species. Top left: cattle, top right: pigs, bottom left laying hens, bottom right sheep. Source: (Destatis(d), 2014).

Niedersachsen is the largest overall producer of animal products in Germany, producing roughly 15% of all beef, 32% of all pork, nearly 60% of all poultry meat, and nearly 40% of all eggs in 2014. For comparison, please see Table 4. The total share of organically produced animal products for all of Germany is still relatively small, with the exception of sheep. In 2013, organically produced beef accounted for 5.1%, pork 0.9%, and sheep 15.1% of the total number of animals (Destatis(e), 2015).

Federal State	Cattle	Pigs	Sheep	Poultry	Eggs
Hamburg	*0.02%*	*0.002%*	*No data*	*0%*	*0%*
Mecklenburg-Vorpommern	*3.9%*	*0.7%*	*No data*	*No data*	*5.5%*
Niedersachsen	*15.3%*	*32.3%*	*5.0%*	*59.1%*	*37.3%*
Schleswig-Holstein	*8.8%*	*0.9%*	*15.0%*	*0.1%*	*3.0%*

Table 4: Livestock production in the four states as percentage of total German production (number of animals). Own table based on data from 2014 (Statistische Ämter des Bundes und der Länder(b), 2015) and (Destatis(e), 2015)

Vegetables and Fruit

In total, the German farming sector provides approximately one-third of Germany's demand for vegetables (by weight) and one fifth of its demand for fruit (by weight). As explained above, these shares are not equal to the degree of self-sufficiency in the production of these food categories, as most agricultural products, including fruits and vegetables, are traded across national borders. The vegetable crop that stands out is potatoes. The German potato production even exceeds German consumption (BMEL(d), 2014). Main vegetable crops include carrots, cabbage, lettuce, pickling cucumbers and onions. Main fruits include apples, strawberries and other berries (BMEL(d), 2014). Crops can be grown outdoors or in greenhouses, which can extend the growing season and protect plants from extreme weather and pests.

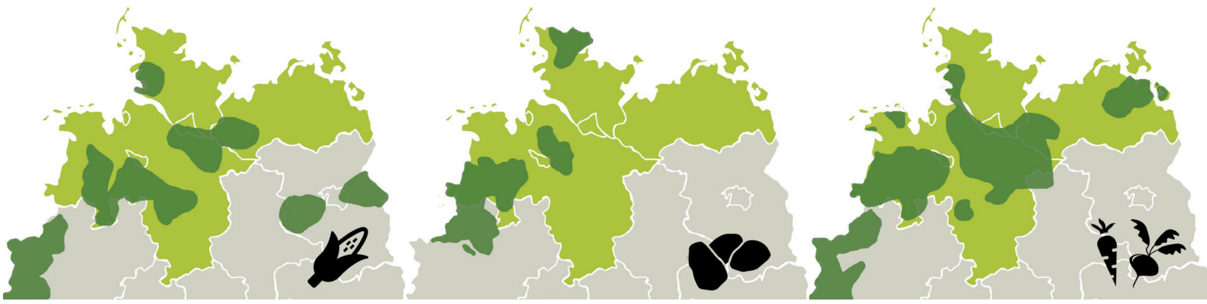


Figure 17. Indication (dark green area) of main growing areas in Northern Germany for different crops. From left to right: field vegetables, maize and potatoes. Source: (Destatis(d), 2014).

Niedersachsen, especially the Lüneburger Heath, accounts for nearly half (43.5%) of the overall potato production in Germany, as well as roughly one-fourth of rye, winter wheat, and sugar beets in terms of quantity in kilograms produced (Niedersachsen, 2016). Schleswig-Holstein, on the other hand, produced nearly half (42%) of the German white cabbage harvest in 2014 in terms of quantity in kilograms produced, (the Table 5 figure 27.8% represents all types of cabbage), almost exclusively in the growing area of Dithmarschen (Schleswig-Holstein, n.d.).

Federal State	Potatoes	Sugarbeats	Cabbage	Leafy vegetables	Stem vegetables	Root & tuber vegetables	Legumes
Mecklenburg-Vorpommern	*4.1%*	*6.5%*	*1.0%*	*2.0%*	*1.0%*	*1.1%*	*0.0%*
Niedersachsen	*43.5%*	*28.4%*	*7.7%*	*16.3%*	*14.2%*	*16.9%*	*10.9%*
Schleswig-Holstein	*2.0%*	*2.4%*	*27.8%*	*0.0%*	*0.7%*	*4.1%*	*1.6%*

Table 5: Share of Northern German states' production in overall German production of specific vegetable crops by weight. Own table based on data from 2014 (percentage of German total in weight) (Statistische Ämter des Bundes und der Länder(b), 2015) and (Destatis(e), 2015)

German fruit production is dominated by apples, which represented roughly 72% of the overall fruit harvest by weight in 2014 (BMEL(d), 2014). Strawberries, plums, pears, cherries, and other types of berries are also produced, but on a smaller scale. The *Altes Land*, a section of Niedersachen, produced approximately 31% of all German apples in 2014 (Destatis(e), 2015). Also, in 2014, 32% of the entire German berry harvest—which excludes strawberries, but includes red, white, and black currants, raspberries, blueberries, elderberries, elderflower, seabuckthorn, gooseberries, blackberries, and aronia berries— was produced in Niedersachsen (Destatis(e), 2015). The share of organically domestically produced strawberries and bush berries was approximately 2.2% and 10.5% of total production, respectively.

Figure 18. Indication (dark green area) of main apple growing areas in Northern Germany. Source: (Destatis(d), 2014).

Federal State	Apple	Strawberry	Pear	Cherry	Plum
Mecklenburg-Vorpommern	*3.3%*	*4.6%*	*0.3%*	*0.5%*	*0.0%*
Niedersachsen	*30.7%*	*25.6%*	*15.7%*	*12.3%*	*7.2%*
Schleswig-Holstein	*1.1%*	*7.4%*	*0.8%*	*1.0%*	*0.0%*

Table 6: Share of Northern German states' production in overall German production of specific fruit and berry crops by weight. Own table based on data from 2014 (percentage of German total by weight) (Statistische Ämter des Bundes und der Länder(b), 2015) and (Destatis(e), 2015).

Cereals

Cereals, particularly wheat, represent the most important plant product of the German farming sector (BMEL(d), 2014). Grown on over a third of agriculture land, cereals provide food to humans, animals and, to a lesser degree, a renewable raw material (BMEL(d), 2014). Wheat is the most common cereal grown, followed by barley, used mainly for animal feed and to brew beer, then by rye, commonly used for bread production (BMEL(d), 2014). Nearly two-thirds of cereals are used for animal feed and less than one-fourth is grown for human consumption (BMEL(d), 2014). Cereals are typically harvested from July, but come as two types: winter varieties, which are sown in late autumn and summer varieties, sown from March onwards (BMEL(d), 2014). Winter varieties are considered to be more important as they produce a higher yield (BMEL(d), 2014). In the northern regions, Schleswig-Holstein produced 5.4%, Niedersachsen 14.3%, and Mecklenburg-Vorpommern 9.1% of total German grain output in 2014 (Statistische Ämter des Bundes und der Länder(b), 2015).

Figure 19. Indication (dark green area) of main cereal growing areas in Northern Germany Source: (Destatis(d), 2014).

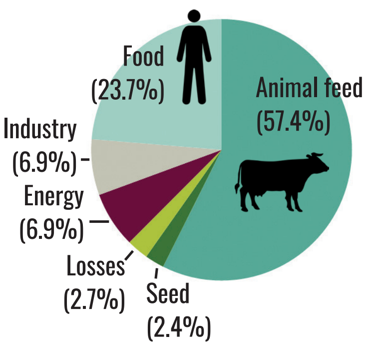


Figure 20. Cereal consumption breakdown 2011-13. Adapted from (BMEL(d), 2014).

Forage crops

Nearly two-thirds of agricultural land, which includes meadows, pastures, and arable land, is dedicated to growing feed for animals to produce meat, milk, and eggs (BMEL(d), 2014). Even with this extensive amount of agricultural land devoted to forage crops, German domestic production cannot meet domestic demand; therefore feed, particularly soy and other high-protein feed, must be imported, as was discussed in Chapter Two. The two types of forage crops include: (1) arable forage production, such as maize and cereals and (2) grassland husbandry, which includes meadows mown for feed and pastures where animals graze (BMEL(d), 2014).

The German Consumer's Diet Footprint

Individual diet choices are shaped by a variety of factors: cultural traditions, experiences and psychology, preferences and habits. In addition to these factors, which one may call "soft factors", there are "hard" factors such as accessibility to food sources (both geographical and financial) and time budget available for purchase and preparation (Reisch, Eberle, & Lorek, 2013).

The individual consumer land footprint for food production is comprised of the land required to produce the crops and the animal products that are consumed both directly and indirectly by humans. Direct consumption refers to the food that is eaten in unprocessed form, such as whole fruits and vegetables. Indirect consumption refers to the crops that are grown to feed livestock that will eventually be consumed as meat. Also included in the land footprint for food consumption are products that are used as part of other food groups, i.e., ready-made frozen pizzas or canned soups.

Notes on calculations

A crucial figure for calculating land footprints of diet scenarios is the yield of the specific food product— the kilograms produced per square meter of land. The inverse of this figure, m^2 per kg, is called "yield efficiency" in the following. For this thesis, yield efficiencies were taken from different sources. The most important is the WWF (2015) study mentioned previously, the National German Statistical Office, the scientific literature and the production figures from the Kattendorfer Hof.

The first two diets are comprised of food produced solely conventionally, with the second diet representing the status quo, or the average German diet of today. In the third and fourth diets, production methods meet at least the EU base organic standard. The base of Diet Three is from the Kattendorfer Hof which produces according to the ambitious Demeter production standard. In some cases where data was assumed, the base EU certification production standard was used. This will be further explained in the section describing Diet Three in more detail. In Diet Four, some crops are produced according to the base EU organic standard, while others by the ambitious Demeter production standard. This will be described further in detail in the Diet Four section.

For certain food groups in the third diet, data was not available for consumption quantity or specific yield efficiency (agricultural area required to produce one kilogram of product). In these cases, a consumption value for that specific food group was based on recommendations from the German Nutrition Society, *Deutsche Gesellschaft für Ernährung* (DGE). The corresponding agricultural land required for food production was calculated according to the stricter Demeter standard when possible. If this was not available, the EU organic standard was used.

The quantity of agricultural land required for organic food production of each food group was calculated by multiplying the conventional yield efficiency by an average organic yield comparison factor of conventional versus organic production for that specific food group, as found in the literature. In the case that there was no average yield comparison of organic versus conventional yields for a specific food group available, an overall yield comparison factor of 74% (organic yield as share of conventional yield) was assumed. This figure represents an average of all the available yield comparisons for the separate food groups. Please see Appendix II for a more detailed breakdown of the calculations.

Diet One: Potatoes Only

To set a scenario with minimum land requirement to feed one person, a diet comprised solely of conventionally grown potatoes is assumed. Potatoes provide good nourishment (kcal and vitamins) per gram and they need little land for growing, with an average yield efficiency of 0.3 m² required to produce one kilogram of potatoes conventionally, and 0.7 m² required to produce the same amount organically. Yield efficiency between conventional and organic production methods is highly contextual, however, and may vary by up to 30%, as found in the literature. According to the calculations, the land footprint for food production to feed one person on a diet comprised solely of potatoes is 328.5 m² annually. Although the consumption quantity— approximately 3 kilos of potatoes per day— is very high and perhaps unrealistic, it was determined that it was necessary to fulfill calorie requirements, as recommended by the DGE. Please see Appendix I for breakdown of calculations. See Table 7.

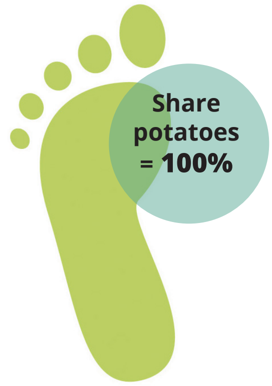


Figure 21. Composition of Diet Scenario One.

Food group	Quantity (kg / (cap*yr))	Land footprint of conventional production (m²)	% of total land footprint	Calories per capita and year (kcal / (cap * yr)
Potatoes & potato products	*1095.0*	*328.5*	*100%*	*744,600*

Table 7: Breakdown of Diet Scenario One by food group. Includes: quantity consumed, individual land footprint for food production, percentage of specific food group of overall footprint, calories consumed.

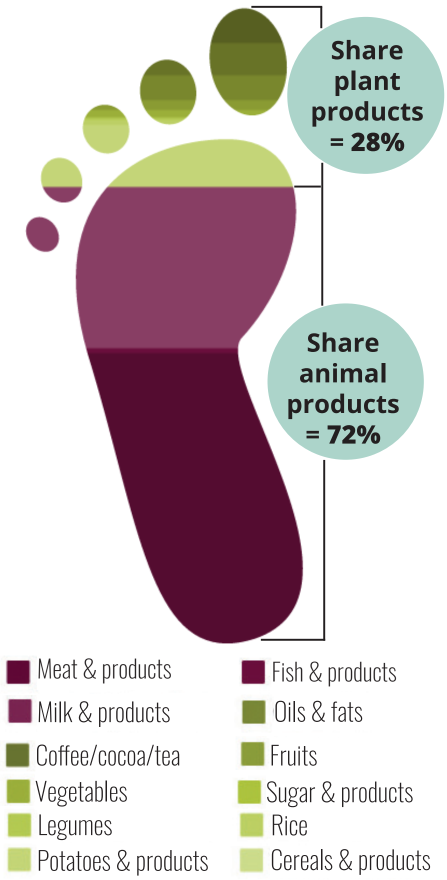


Figure 22. Composition of total land footprint for food production: Diet Scenario Two.

Diet Two: Status Quo Conventionally Produced (as in WWF 2015)

Diet Scenario Two is based on the consumption quantities for the average German citizen in 2012, as identified by a WWF Germany study, *Nahrungsmittelverbrauch und Fußabdrücke des Konsums in Deutschland* (WWF(h), 2015). Using international trade data, the WWF study authors calculated land footprint of German food consumption by determining the overall agricultural area required for producing this food: 14,122 million hectares in Germany and 5,247 abroad. This adds to 19,369 million hectares land requirement for the entire food consumption of Germany, or 2,397 m² per capita.

The WWF study authors report that their figures are comparable to those of similar studies: Umweltbundesamt (2014) and Meier et al. (2014): 2,460 and 2,365 m² per capita, respectively. The authors allocated the 2,397 m² per person to different food groups by a combination of methods with data from different sources.

For the analysis in this thesis, the meat footprint was broken down in types of meat, using figures reported in the WWF study. For legumes production footprint, another source was used. The WWF study reports 10 m² per kg, but the *Statistisches Jahrbuch 2015* (Destatis) reports 1.16 m²/kg, and the Destatis online database reports 1.21 m²/kg. In this thesis, the average of these two figures is used. See Table 8. The resulting land footprint for the current per capita consumption quantity of conventionally produced foods for the average German citizen is 2,388 m² per person, per year.

Image source: (Alfonso Cenname, 2016)

Main characteristics of the current average German diet (Diet Scenario Two) are:

1. A high meat intake of 87 kilograms per person, per year. This is roughly 10% higher than the EU average and 45% higher than the world average (FAO(f), 2015).
2. A low legume intake of just 0.5 kilograms per year. Legumes are a protein rich alternative to meat, and in the early- to mid-19th century, roughly the same amount of legumes and meat were consumed (WWF(a), 2011).
3. Including eggs, milk, and milk products; fish and fish products; and meat and meat products, roughly 72% of the total land footprint for food production is dedicated to producing animal products. See Table 8.

Food group	Quantity (kg / (cap* yr))	Land footprint of conventional production (m²)	% of total land footprint	Calories per capita and year (kcal / (cap * yr))
Cereals & cereal products	*95.6*	*231.0*	*10%*	*272,460*
Potatoes & potato products	*70.7*	*21.0*	*1%*	*48,076*
Rice	*5.3*	*11.0*	*0%*	*19,981*
Legumes	*0.4*	*0.5*	*0%*	*1,392*
Sugar products	*48.0*	*30.0*	*1%*	*170,400*
Vegetables	*95.4*	*30.0*	*1%*	*24,804*
Fruits	*110.5*	*99.0*	*4%*	*60,775*
Oils & fats	*19.9*	*119.0*	*5%*	*68,655*
Beef	*13.0*	*351.0*	*15%*	*13,780*
Pork	*52.6*	*468.0*	*20%*	*88,894*
Poultry	*18.5*	*150.0*	*6%*	*24,420*
Sheep/goat	*0.9*	*24.0*	*1%*	*2,187*
Eggs	*13.3*	*84.0*	*4%*	*18,620*
Other meat	*2.0*	*23.0*	*1%*	*2,320*
Fish & fish products	*14.1*	*18.0*	*1%*	*14,523*
Milk & milk products	*118.8*	*602.0*	*25%*	*57,024*
Coffee/cocoa/tea	*0.0*	*127.0*	*5%*	-
Nature conservation	*0.0*	*0.0*	*0%*	-
Total	**679**	**2,388.5**	**100%**	**888,311**

Table 8: Breakdown of Diet Scenario Two by food group. Includes: quantity consumed, individual land footprint for food production, percentage of specific food group of overall footprint, calories consumed. Source: WWF, 2015, with alterations.

Diet Three: Kattendorfer Hof Production (Community Supported Demeter Certified Farm)

Diet Scenario Three is based on figures for yield and production mix obtained from Kattendorfer Hof, a local Demeter-certified farm in the north of Hamburg. As described earlier, Demeter has stricter production standards than the base level German and EU organic certification. Please see Appendix I for a complete comparison. Kattendorfer Hof functions as a community-supported farm. This will be further discussed in detail in Chapter Five, but in summary, this means that a group of "shareholders" financially support the farm by paying a monthly fee per person. In turn, the shareholders receive a weekly basket of harvested fruits and vegetables as well as meat and dairy products such as cheese, milk, yogurt and butter. Kattendorfer Hof is able to provide data about the amount of agricultural land required to produce different crops and animal products per person because they have both specific figures for the number of people consuming their products (the shareholders) and the exact land area used to produce these products.

The figures for the food groups of cereals, potatoes, sugar (in the form of honey), meat, eggs, and milk products were taken directly from actual farm production quantities. Figures for legumes, oils and fats, vegetables, fruits, and coffee/tea/cocoa were assumed or adjusted. There are two reasons for this. Either the farm is not able to produce a sufficient amount for a complete diet— in the case of oils and fats, fruit, and coffee/tea/cocoa. Or, in the case of vegetables and legumes, to make the various diets as comparable as possible in terms of total kilograms, kcal and nutrients, assumed consumption quantities were increased. Rice was not included, as it is not produced on the farm and potatoes or another cereal product can be substituted to fulfill nutrient requirements

Meat consumption for the Kattendorfer Hof diet is 37 kg of beef, pork, poultry, and goat per person, per year. This is roughly 60% lower than the current meat consumption average in Germany (Diet Scenario Two). To supplement a lower meat intake, a higher legumes consumption than in Diet Scenario Two is assumed. Legumes are rich in plant protein, and similar to meat in nutrients, but with lower iron levels and no animal fats. This makes them an option in the place of meat and dairy products when combined properly (U.S. National Library of Medicine, 2016).

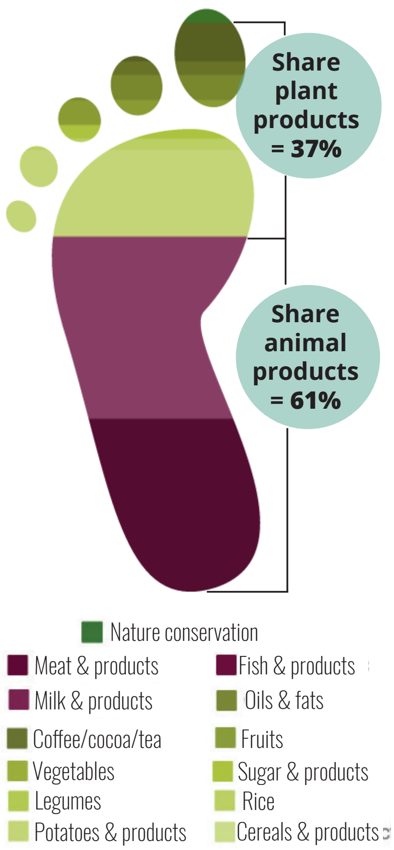


Figure 23. Composition of total land footprint for food production: Diet Scenario Three.

Sugar is produced on the farm in the form of honey from bees. Although the quantity is approximately 90% lower than the average sugar consumption in Diet Scenario Two, according to the DGE, sugar intake should be only occasional and is not considered a necessity. Therefore, no additional sugar intake, beyond what is produced on the farm, is included. The hives footprint was 10 m^2 in total. When broken down among the amount of people it serves the figure was less than 1 m^2 and not included.

Vegetable consumption quantities are assumed according to the DGE recommendations of at least 300-600 grams per person, per day. The average of 450 grams was used in calculations, equal to 165 kg of vegetables per person annually This was multiplied by the organic yield efficiency factor of 0.6 m^2 to produce one kilogram of vegetables, based on actual farm data.

A consumption quantity of 40 kilograms of legumes per person, per year was assumed to compensate for the 40 kilogram reduction in meat consumption compared to Diet Scenario Two. The farm does produce legumes, but these are predominantly used as cover crops or to feed livestock, and not included in the weekly delivery to shareholders. The organic yield efficiency was calculated from farm data to equal 1.4 m^2 of agricultural land per kilogram of legumes grown organically per person, and this was simply multiplied by the entire amount of legumes attributed in the diet scenario.

Fruit consumption was also assumed according to DGE recommendations of at least 250 grams per day. Fruits are produced on the farm, but this figure was very limited and there was no data available. Therefore, an organic yield efficiency was identified by an organic production yield factor calculated by studies from (de Ponti, et al., 2012), (Seufert, et al., 2012) and Destatis. Thus, while conventional fruit production requirement (as in Diet Scenario Two) is 0.9 m^2 per kg of fruit, the organic fruit production requirement is 1.1 m^2 per kg of fruit.

Quantities for meat consumption and required agricultural area for production were provided by the farm as an aggregated figure. To produce 37 kilograms of meat and animal products—which includes beef, pork, poultry, goat, as well as 150 eggs per person annually— 700 m^2 of agricultural land is required. To convert the value of 150 eggs to kilograms, the average single egg weight of 0.06 kg was used (this is according to an average by the *United Nations Economic Commission for Europe (*UNECE) standard for edible hen eggs) (UN, 2010). The result is that 150 eggs equals 9.0 kilograms. This illustrated an average overall yield efficiency factor for meat and eggs of 15.2 m^2 to produce one kilogram of product. Compared to the yield efficiency factor of conventional meat and eggs, the organic yield will be 72%, according to this calculation, which is aligned with the reference 74% yield factor identified previously.

Coffee/tea/cocoa were not produced on the farm, but were included in this diet to make it as realistic and comparable as possible to Diet Scenario Two. Additionally, these products are consumed by people on the farm and those who participate in the CSA program, but they are purchased from outside sources. Consumption data was not available from the farm; however, it was accessible for the average German diet (see Diet Scenario Two). The overall average organic yield comparison factor of 74% of conventional yields was applied to the land footprint equal to 127 m^2 for conventional coffee/tea/cocoa production. The result was 160.2 m^2 per person, per year required to fulfill consumption demand of organically produced coffee/tea/cocoa.

The last figure included in this diet scenario is 50 m^2 per person for nature conservation. This takes the form of hedges, woods, flowers, etc. that are necessary to promote and maintain biodiversity on the farm. This also enables better management of pest control and is considered an integral part of agricultural land required for production.

The resulting land footprint for the current per capita consumption quantity of organically produced foods from the Kattendorfer Hof is 2,346 m^2, per year.

Main characteristics of Diet Scenario Three are:

1. A meat intake of 37 kilograms per year, 60% lower than the average German person.
2. A legume intake of 40 kilograms per year, which serves as a nutrient substitute to supplement lower meat demand. Legumes are much more land-efficient than meat in terms of production, as illustrated by comparing diets two and three.
3. Including eggs, milk, and milk products and meat and meat products, roughly 61% of the total land footprint for food production is dedicated to producing animal products. See Table 9.

Food group	Quantity (kg / (cap* yr))	Land footprint of organic production (m^2)	% of total land footprint	Calories per capita and year (kcal / (cap * yr))
Cereals & cereal products	*120.0*	*350.0*	*15%*	*342,000*
Potatoes & potato products	*70.0*	*50.0*	*2%*	*47,600*
Rice	*0.0*	*0.0*	*0%*	-
Legumes	*40.0*	*56.0*	*2%*	*139,200*
Sugar products	*5.0*	*0.0*	*0%*	*17,750*
Vegetables	*165.0*	*99.0*	*4%*	*42,900*
Fruits	*91.3*	*100.4*	*4%*	*50,215*
Oils & fats	*5.0*	*50.0*	*2%*	*17,250*

Food group	Quantity (kg / (cap* yr))	Land footprint of organic production (m²)	% of total land footprint	Calories per capita and year (kcal / (cap * yr))
Beef	37.0	700.0	30%	39,220
Pork				62,530
Poultry				48,840
Sheep/goat				89,910
Eggs	9.0			12,600
Other meat	0.0	0.0	0%	-
Fish & fish products	0.0	0.0	0%	-
Milk & milk products	99.4	730.0	31%	47,712
Coffee/cocoa/tea	0.0	160.7	7%	-
Nature conservation	0.0	50.0	2%	-
Total	**642**	**2,346.1**	**100%**	**957,727**

Table 9: Breakdown of Diet Scenario Three by food group. Includes: quantity consumed, individual land footprint for food production, percentage of specific food group of overall footprint, calories consumed. Source: Kattendorfer Hof (2016) (de Ponti, et al., 2012), (Seufert, et al., 2012), Destatis (2014) with alterations.

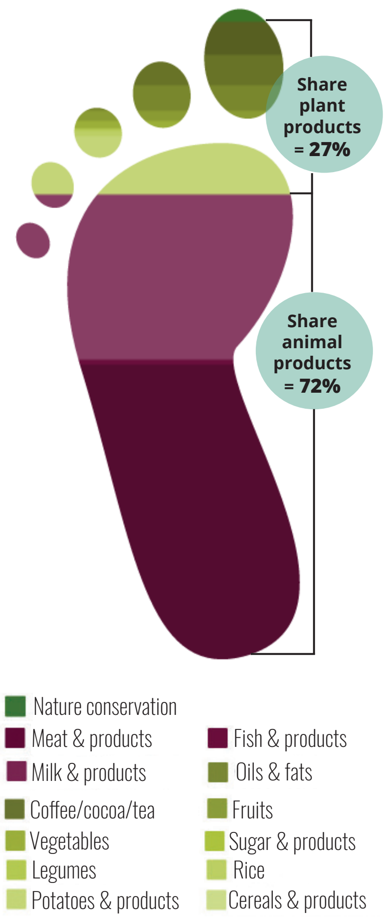


Figure 24. Composition of total land footprint for food production: Diet Scenario Four.

Diet Four: Status Quo (from WWF 2015), Organically Produced

Diet Scenario Four represents the land footprint for food production per person if current eating habits are maintained, but the food is produced organically, according to the base level EU organic standard. Consumption quantities are the same as in Diet Scenario Two.

To determine the land footprint for food production per food group, the first step was to calculate the organic yield comparison factor based on results from the Kattendorfer Hof, studies by (de Ponti, et al., 2012) and (Seufert, et al., 2012), as well as results from Destatis. See Appendix II for calculations.

The next step was to multiply the land area required for each food group conventionally produced in Diet Scenario Two by the calculated organic yield comparison factor. In cases where this figure was not available for a specific food group, as in fish and coffee/tea/cocoa, the average organic comparison yield of 74% of the total conventional yield was applied.

In the case of meat, the data from the conventional diet scenario had to be aggregated to be comparable for calculation. In the case of Diet Scenario Three, the consumption quantity of 46 kilogram per year of meat and eggs requires 700 m² of land per year. This equates to a yield efficiency of 15.2 m² for one kilogram of product, as previously mentioned. For the conventional Diet Scenario Two, all meat products, including beef, pork, poultry, goat/sheep, and other meat, as well as eggs, were summed to equal a consumption total of 98.3 kilograms per person, per year. The land footprint for production of these products equals 1077 m² per person, per year, with an aggregated yield efficiency of 11.0 m² per year for production of animal products. Compared to the yield efficiency of conventional meat and eggs, the organic yield will be 72%, according to this calculation, which is aligned with the reference 74% yield factor identified previously. The resulting land footprint for the current average per capita consumption quantity of organically produced foods is 3,353.6 m² per year. See Table 10.

Food group	Quantity (kg / (cap* yr))	Land footprint of organic production (m²)	% of total land footprint	Calories per capita and year (kcal / (cap * yr))
Cereals & cereal products	*95.6*	*293.8*	*9%*	*272,460*
Potatoes & potato products	*70.7*	*37.6*	*1%*	*48,076*
Rice	*5.3*	*11.7*	*0%*	*19,981*
Legumes	*0.4*	*0.6*	*0%*	*1,392*
Sugar products	*48.0*	*40.5*	*1%*	*170,400*
Vegetables	*95.4*	*44.1*	*1%*	*24,804*
Fruits	*110.5*	*129.1*	*4%*	*60,775*
Oils & fats	*19.9*	*160.2*	*5%*	*68,655*
Beef	*13.0*	*487.5*	*14%*	*13,780*
Pork	*52.6*	*650.0*	*19%*	*88,894*
Poultry	*18.5*	*208.3*	*6%*	*24,420*
Sheep/goat	*0.9*	*33.3*	*1%*	*2,187*
Eggs	*13.3*	*116.7*	*3%*	*18,620*
Other meat	*2.0*	*31.9*	*1%*	*2,320*
Fish & fish products	*14.1*	*25.0*	*1%*	*14,523*
Milk & milk products	*118.8*	*872.5*	*25%*	*57,024*
Coffee/cocoa/tea	*0.0*	*160.7*	*5%*	-
Nature conservation	*0.0*	*50.0*	*2%*	-
Total	**679**	**3,353.6**	**100%**	**888,311**

Table 10: Breakdown of Diet Scenario Four by food group. Includes: quantity consumed, individual land footprint for food production, percentage of specific food group of overall footprint, calories consumed. Source: WWF (2015, Kattendorfer Hof (2016) (de Ponti, et al., 2012), (Seufert, et al., 2012), Destatis (2014) with alterations.


Image source: (Anda Ambrosini, 2016)

Scenarios of Numbers of Persons That Can Be Fed From Regional Organic Agriculture

Figure 25. Identification of Regions One, Two and Three.

The three regions for which this thesis explores the potential to feed their populations are defined as follows:

The first region is comprised solely of the city-state of Hamburg. The second region encompasses the city-state of Hamburg in the center and all the surrounding *Landkreise* (rural districts) within a 50-kilometer radius. The third region comprises the city-state of Hamburg in the center and all the surrounding *Landkreise* within a 100-kilometer radius. If more than half of the *Landkreis* was within the radius, it was included.

To simplify the analysis, this thesis assumes that the producers within the concentric circles around Hamburg deliver all their production to Hamburg and not, for example, to Hanover or Bremen, which lie closer to the southern edge of Region Three than Hamburg. This is of course an unrealistic assumption. Furthermore, producers from Schelswig-Holstein may deliver to other regions or other large cities besides Hamburg, such as Bremen or Berlin. However, to calculate these distribution channels would make the analysis too complex for the scope of this thesis.

The next step is determining the amount of people who live within the selected regions and will be fed with the regionally produced food. The population of Region One is 1,762,791 people; Region Two, 3,802,253 people; and Region Three, 6,289,073 people (Destatis(f), 2015). To give an indication of the potential to feed citizens within the region, the ratio of persons to be fed per sq. kilometer of agriculcultural land in the region was calculated. Results are indicated on each map in Figure 25.

It must also be noted that in reality, not all of the agricultural land is used solely for food production. Currently, approximately 10% of agricultural land is used for the production of energy crops (BMEL(d), 2014), for example.

Furthermore, not all agricultural land is available for producing any type of food product. Permanent grassland, for example, is not suitable for growing crops. It can be zoned for nature conservation purposes, to provide buffers or coastal protection, or for other dedications. It can also be used, however, for animal grazing and can be a valuable source of food for ruminants. Areas designated for permanent crops are also not suitable for growing many other plants except, for example, fruit trees.

The breakdowns of agricultural land use in the *Bundesländer* (federal states) analyzed in this thesis are as follows (Bürgerschaft der Freien und Hansestadt Hamburg, 2017), (Destatis(e), 2015):

- Hamburg: 38% arable land, 47% permanent grassland and 15% permanent cropland.
- Mecklenburg-Vorpommern: 80% arable land, 20% permanent grassland and 0.2% permanent crops.
- Niedersachsen: 72% arable land, 28% permanent grassland and 0.07% permanent crops.
- Schleswig-Holstein: 67% arable land 32% permanent grassland and 1% permanent crops.

Using this data, estimated bounds were established. A highest bound of 100% of agricultural land used for food production, a middle bound of 75% of agricultural land used for food production, and a lower bound of 50% of agricultural land used for food production were assumed.

The results are as follows:

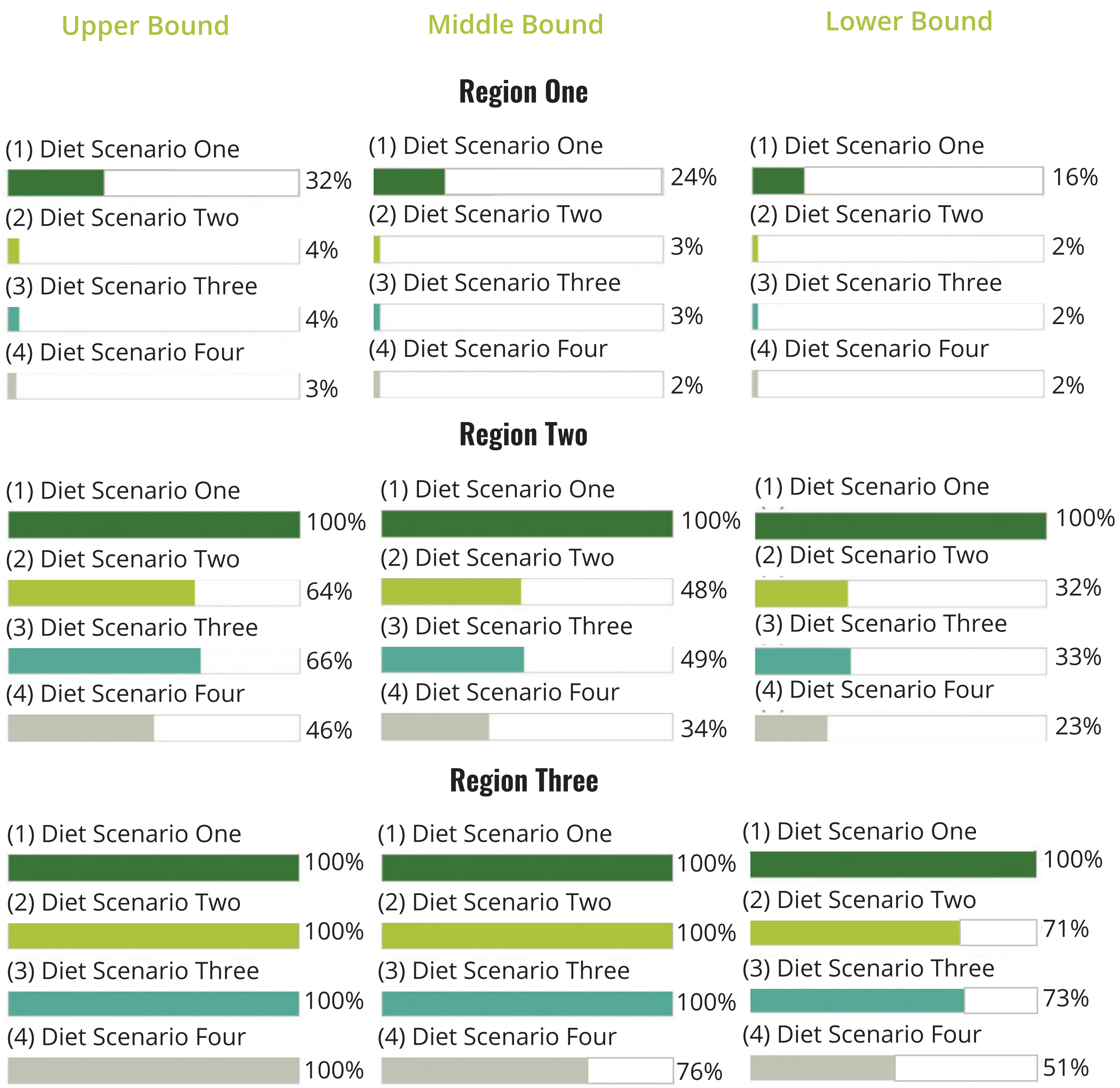


Figure 26. Percentage of regional population fed in Region One, Two and Three at upper bound (100% agricultural land used), middle bound (75% agricultural land used) and lower bound (50% agricultural land used) with Diet Scenarios One to Four.

Region 1

The results for the first region— the city state of Hamburg— reflect its high population density, which is more than five times of the next most inhabited *Landkreis*, Pinneberg. Only 56% of the population of the city-state of Hamburg can be fed eating only potatoes in Diet Scenario One produced within the region if all agricultural land is used. Further reducing the area for agricultural production, if 75% of the agricultural area is used, less than half of the citizens can be fed; if half the land is used, only a little more than one-quarter of the citizens can be fed. Diet Scenarios Two, Three and Four represent more realistic options, with results indicating that less than 5% of the population could be fed on these diets, even using the maximum amount of agricultural land available. This indicates that there is very limited potential for the city-state of Hamburg alone to be able to meet the consumption demand of citizens. It should be noted, though, that this calculation is based on the area that is classified as "agricultural land". Private and urban gardens where people grown their own vegetables are not included in this calculation.

Region 2

Results from the second region indicate that, even when only 50% of the agricultural land is used for food production, 100% of the population can be fed within the confines of Diet Scenario One, eating only potatoes. However, even if all agricultural land is utilized, 64% of citizens could be fed with Diet Scenario Two, 66% with Diet Scenario Three, and only half with Diet Scenario Four. If 75% of agricultural land is dedicated to food production, roughly half of the population can be fed with Diet Scenarios Two and Three, and only 34% with Diet Scenario Four. Finally, if only half of agricultural land is utilized, roughly one-third of citizens can be fed with Diet Scenarios Two and Three, and just one-quarter with Diet Scenario Four. These results also illustrate the significant change in ratio of agricultural land to population between Hamburg and the surrounding counties.

Region 3

This region represents the most potential for all four diets, with 100% of people able to be fed on all four diets if all agricultural land is used for food production. If 75% of land is used for food production, all of the people can be fed with Diet Scenarios Two and Three, and just over half of citizens with Diet Scenario Four. If only half of agricultural land is used for food production, nearly 75% can be fed with Diet Scenarios Two and Three, and just half with Diet Scenario Four.

The Effect of Consumer Diet Choices on Individual and Overall Food Production Land Footprints

In an attempt to illustrate the effects of individual diet choices and the resulting land footprint for food production, four more diet scenarios will be examined (Diets Five to Eight). Diet Scenario Five follows the recommendations for daily food intake of the German Nutrition Society (*Deutsche Gesellschaft für Ernährung, DGE*). Diet Scenario Six is based on average current consumption data per capita, except with a 30% reduction in meat intake, equal to two meat free days per week. Diet Scenario Seven is based on average current consumption data per capita, except with a 60% reduction in meat intake, equal to four meat free days per week. Diet Scenario Eight follows current consumption quantities, but represents a completely vegetarian diet, with no meat or fish intake. Increased egg and legume intake was included to substitute for protein that would have come from meat. Each of these diets represent a shift of varying degree toward a less land-consuming diet, compared to the current Diet Scenario Two, in terms of land footprint for food production.

To assess the effects of consumer diet choices on the potential for feeding citizens with regionally produced foods, maximum number of persons fed for Regions One, Two and Three (as described in the previous section) will be calculated for each diet. An average amount of 75% of agricultural land used for food production purposes was utilized. This is considered to be closest to the most plausible scenario, bearing in mind, zoning of agricultural land and that at least agricultural land is also used to produce energy plants and other agricultural commodities.

Furthermore, the land footprint per person of each diet will be calculated using yield efficiencies for both conventional and organic production methods. Although organic production is one of the primary focuses of this thesis, conventional figures are provided for comparison.

Image source: (Keenan Loo, 2016)

Diet Five: DGE Recommendations

This scenario will analyze the land footprint for food production if citizens ate according to recommendations by the DGE, as illustrated in Table 11.

All figures follow exact guidelines as outlined in Table 11, except there has been an increase in vegetable and fruit intake to make the diets more comparable in terms of kilograms and nutrient intake. This increase is still aligned with recommendations, specifically the recommendation of "400 grams or more" of vegetables and "250 grams or more" of fruits. Legumes are considered a class of vegetable, and were also increased. The increase was assumed to make the diets as even as possible in terms of kilograms consumed annually, as well as to fulfill the energy requirements recommended by the DGE. With this diet, vegetable consumption is equal to roughly 500 g per day and legumes equal to 100 g per day.

Furthermore, rice and pasta products, which are included in the potato group, were not included to simplify the calculations.

While not dealt with in depth in this thesis, it is obvious that current consumption patterns (Diet Scenario Two) are not in line with the DGE recommendations.

Food group	Quantity per day
Cereals, cereal products, potatoes	• Bread: 200-300 g (4-6 slices) or bread 150-250 g (3-5 slices) plus 50-60 g cereal flakes • Potatoes: 200-250 g or pasta 200-250 g (cooked) or rice 150-180 g (cooked)
Vegetables	• Total of 400 g or more
Fruit	• Total of 250 g or more
Milk & dairy products	• Milk: 20-250 g • Cheese: 50-60 g
Meat, fish eggs (per week)	• Meat and sausage: Max. 300-600 g total • Fish: Marine whitefish 80-150 g, plus marine oily fish 70 g • Eggs: up to three eggs, including eggs in dishes
Fats & oils	• Butter and margarine: 15-30 g • Oil: 10-15 g
Beverages	• 1.5 liters, preferably energy free, low calorie drinks

Table 11: DGE diet recommendations. Source: (DGE, 2016)

Comparing current consumption data with DGE recommendations, the following shifts would be necessary to align with nutrition recommendations:

- 4% less cereals and cereal products
- 16% more potatoes and products
- **70% less sugar and sugar products**
- **73% more vegetables**
- 1% less fruit
- 4% less milk and dairy products
- **73% less meat and sausages**
- 37% less fish
- 35% less eggs
- 36% less fats and oils

Image source: (Couleur, 2016)

The land footprints for consumption according to DGE recommendations (slightly altered as described above) are 1,545.7 m² if produced conventionally, and 2,144.2 m² if produced organically.

Main characteristics of Diet Scenario Five are:

1. A significant decrease in meat intake (roughly 72%) compared to Diets Two and Four.
2. Including eggs, milk, and milk products; meat and meat products; and fish, roughly 57% of the total land footprint for food production, conventional and organic, is dedicated to producing animal products. See Table 12.

Food group	Quantity (kg / (cap* yr))	Land footprint of conventional production (m²)	Land footprint of organic production (m²)	Calories per capita and year (kcal / (cap * yr))
Cereals & cereal products	91.3	220.5	280.5	260,062.5
Potatoes & potato products	82.1	24.4	43.7	55,845.0
Rice	0.0	0.0	0.0	-
Legumes	40.0	47.0	57.2	139,200.0
Sugar products	14.4	9.0	12.2	-
Vegetables	182.5	57.4	84.3	47,450.0
Fruits	109.5	98.1	128.0	60,225.0
Oils & fats	12.8	76.4	102.9	44,073.8
Beef				
Pork				
Poultry	32.1	356.7	458.6	52,162.5
Sheep/goat				
Eggs				
Other meat				
Fish & fish products	8.9	11.3	15.7	9,146.4
Milk & milk products	102.2	517.9	750.6	49,056.0
Coffee/cocoa/tea	n.a.	127.0	160.7	-
Nature conservation	n.a.	0.0	50.0	-
Total	**675**	**1,545.7**	**2,144.2**	**717,221**

Table 12: Breakdown of Diet Scenario Five by food group. Includes: quantity consumed, individual land footprint for food production, both organic and conventional and calories consumed. Source: WWF (2015, Kattendorfer Hof (2016) (de Ponti, et al., 2012), (Seufert, et al., 2012), Destatis (2014) and DGE (2016) with alterations.

Diet Six: Current Consumption (as in Diet Two) except for two meat-free days per week

Diet Scenario Six is comprised of the quantities of current average consumption, but with a 30% reduction in meat intake. This corresponds to going “meat-free” just two days per week. To compensate for the reduction in meat intake from roughly 100 kilograms to 70 kilograms, a 29.5 kilogram increase in legume intake is assumed (0.5 kilograms is already eaten).

The resulting land footprint for personal food consumption in Scenario Six is 2,103.3 m^2 if produced conventionally, and 2,871.0 m^2 if produced organically. Compare this to 2,388.5 m^2 of Diet Scenario Two (i.e. without the meat reduction, produced conventionally) and 3,353.6 m^2 of Diet Scenario Four (i.e. without the meat reduction, produced organically).

Main characteristics of Diet Scenario Six are:

1. A decrease in meat intake by 30% compared to Diet Scenarios Two and Four.
2. Including eggs, milk, and milk products; meat and meat products; and fish, roughly 68% of the total land footprint for food production, conventional and organic, is dedicated to producing animal products. See Table 13.

Food group	Quantity (kg / (cap* yr))	Land footprint of conventional production (m^2)	Land footprint of organic production (m^2)	Calories per capita and year (kcal / (cap * yr))
Cereals & cereal products	*95.6*	*231.0*	*293.8*	*272,460*
Potatoes & potato products	*70.7*	*21.0*	*37.6*	*48,076*
Rice	*5.3*	*11.0*	*11.7*	*19,981*
Legumes	*30*	*35.3*	*42.9*	*104,400*
Sugar products	*48.0*	*30.0*	*40.5*	*170,400*
Vegetables	*95.4*	*30.0*	*44.1*	*24,804*
Fruits	*110.5*	*99.0*	*129.1*	*60,775*
Oils & fats	*19.9*	*119.0*	*160.2*	*68,655*
Beef	*70.2*	*780.0*	*1002.9*	*74,412*
Pork				
Poultry				
Sheep/goat				
Eggs				
Other meat				
Fish & fish products	*14.1*	*18.0*	*25.0*	*14,523*
Milk & milk products	*118.8*	*602.0*	*872.5*	*57,024*
Coffee/cocoa/tea	*n.a.*	*127.0*	*160.7*	*-*
Nature conservation	*n.a.*	*0.0*	*50.0*	*-*
Total	**679**	**2,103.3**	**2,871.0**	**915,510**

Table 13: Breakdown of Diet Scenario Six by food group. Includes: quantity consumed, individual land footprint for food production, both organic and conventional and calories consumed. Source: WWF (2015, Kattendorfer Hof (2016) (de Ponti, et al., 2012), (Seufert, et al., 2012), Destatis (2014) and DGE (2016) with alterations.

Diet Seven: Current Consumption (as in Diet Two) except for four meat-free days per week

Diet Scenario Seven is comprised of the quantities of current average consumption as in Diet Scenario Two, but with a 60% reduction in meat intake, corresponding to a consumption of 40.1 kilograms of meat per person, per year, or going “meat free” four days per week. To compensate for the reduction in meat intake from roughly 100 kilograms to 40 kilograms, a 59.5 kilogram increase in legume intake is assumed.

The resulting land footprint for personal food consumption in Scenario Seven is 1,804.1 m^2 if produced conventionally, and 2,483.9 m^2 if produced organically. Compare this to 2,103.3 m^2 of Diet Scenario Six (i.e. where meat reduction is only 30% less than current consumption), conventionally produced, and 2,871.0 m^2 of Diet Scenario Six, organically produced.

Main characteristics of Diet Scenario Seven are:

1. A decrease in meat intake by 60% compared to Diet Scenarios Two and Four.
2. Including eggs, milk and milk products and meat and meat products, and fish, roughly 58% of the total land footprint for food production, conventionally and organically, is dedicated to producing animal products. See Table 14.

Food group	Quantity (kg / (cap* yr))	Land footprint of conventional production (m^2)	Land footprint of organic production (m^2)	Calories per capita and year (kcal / (cap * yr))
Cereals & cereal products	*95.6*	*231.0*	*293.8*	*272,460*
Potatoes & potato products	*70.7*	*21.0*	*37.6*	*48,076*
Rice	*5.3*	*11.0*	*11.7*	*19,981*
Legumes	*60*	*70.5*	*85.7*	*104,400*
Sugar products	*48.0*	*30.0*	*40.5*	*170,400*
Vegetables	*95.4*	*30.0*	*44.1*	*24,804*
Fruits	*110.5*	*99.0*	*129.1*	*60,775*
Oils & fats	*19.9*	*119.0*	*160.2*	*68,655*
Beef	*40.1*	*445.6*	*572.9*	*42,527*
Pork				
Poultry				
Sheep/goat				
Eggs				
Other meat				
Fish & fish products	*14.1*	*18.0*	*25.0*	*14,523*
Milk & milk products	*118.8*	*602.0*	*872.5*	*57,024*
Coffee/cocoa/tea	*n.a.*	*127.0*	*160.7*	*-*
Nature conservation	*n.a.*	*0.0*	*50.0*	*-*
Total	**678**	**1,804.1**	**2,483.9**	**988,025**

Table 14: Breakdown of Diet Scenario Seven by food group. Includes: quantity consumed, individual land footprint for food production, both organic and conventional and calories consumed. Source: WWF (2015, Kattendorfer Hof (2016) (de Ponti, et al., 2012), (Seufert, et al., 2012), Destatis (2014) and DGE (2016) with alterations.

Diet Eight: Vegetarian, plus increase in egg and legume intake

Diet Scenario Eight illustrates the effect on land footprint for food production if citizens ate according to the current consumption averages, but stopped eating meat entirely. This scenario is considered to be extreme, yet has the smallest land footprint. In order to replace proteins lost by lack of meat intake, consumption quantities of legumes and eggs were increased.

The resulting land footprint for personal food consumption in Diet Scenario Eight is 1,518.9 m^2 if produced conventionally, and 2,114.6 m^2 if produced organically. Compare this to 2,388.5 m^2 of Diet Scenario Two produced conventionally, and 3,353.6 m^2 of Diet Scenario Four (Diet Scenario Two, produced organically).

Main characteristics of Diet Scenario Eight are:

1. No meat or fish intake.
2. A sixty-fold increase in legume consumption, from 0.5 kg per capita and year to 30 kg per capita and year, and a 12% increase in egg consumption compared to current, average per capita quantities. See Table 15.

Food group	Quantity (kg / (cap* yr))	Land footprint of conventional production (m^2)	Land footprint of organic production (m^2)	Calories per capita and year (kcal / (cap * yr))
Cereals & cereal products	*95.6*	*231.0*	*293.8*	*272,460*
Potatoes & potato products	*70.7*	*21.0*	*37.6*	*48,076*
Rice	*5.3*	*11.0*	*11.7*	*19,981*
Legumes	*70.0*	*82.3*	*100.0*	*104,400*
Sugar products	*48.0*	*30.0*	*40.5*	*170,400*
Vegetables	*95.4*	*30.0*	*44.1*	*24,804*
Fruits	*110.5*	*99.0*	*129.1*	*60,775*
Oils & fats	*19.9*	*119.0*	*160.2*	*68,655*
Beef	-	-	-	-
Pork	-	-	-	-
Poultry	-	-	-	-
Sheep/goat	-	-	-	-
Eggs	*15*	*166.7*	*214.3*	*16,800*
Other meat	-	-	-	-
Fish & fish products	-	-	-	*14,523*
Milk & milk products	*118.8*	*602.0*	*872.5*	*57,024*
Coffee/cocoa/tea	*n.a.*	*127.0*	*160.27*	-
Nature conservation	*n.a.*	*0.0*	*50.0*	-
Total	**649**	**1,518.9**	**2,114.6**	**986,775**

Table 15: Breakdown of Diet Scenario Eight by food group. Includes: quantity consumed, individual land footprint for food production, both organic and conventional and calories consumed. Source: WWF (2015, Kattendorfer Hof (2016) (de Ponti, et al., 2012), (Seufert, et al., 2012), Destatis (2014) and DGE (2016) with alterations.

Effect of Diet Shifts on Regional Self-Sufficiency

Results of the potential for self-sufficiency for Diet Scenarios One to Four have been indicated in the previous section. To assess the effect of consumer diet choices on the potential for feeding citizens with regionally organically produced foods, the number of persons that can be fed in Regions One, Two and Three (as described earlier) is also illustrated for Diet Scenarios Five to Eight. The Middle Bound of 75% of agricultural land for food production will be utilized. This was considered to be the most plausible, bearing in mind the other potential production uses for agricultural land such as energy plants or other agricultural commodities.

Furthermore, as this thesis focuses on organic as an alternative that can mitigate some of the environmental and health challenges posed by our current, globalized, conventional food system as described in Chapter Two, organic production methods have been analyzed. The following figures illustrate the potential shift towards increased regional self-sufficiency when consumers alter diet choices towards foods which are more land efficient in production terms, as well as eat foods produced only organically.

If the average citizen ate according to Diet Scenarios Five to Eight, Region One could still only feed at most 4% of its population. Region Two could feed around 40% to 55% of its population, and Region Three could feed 90 to 100% of its population.

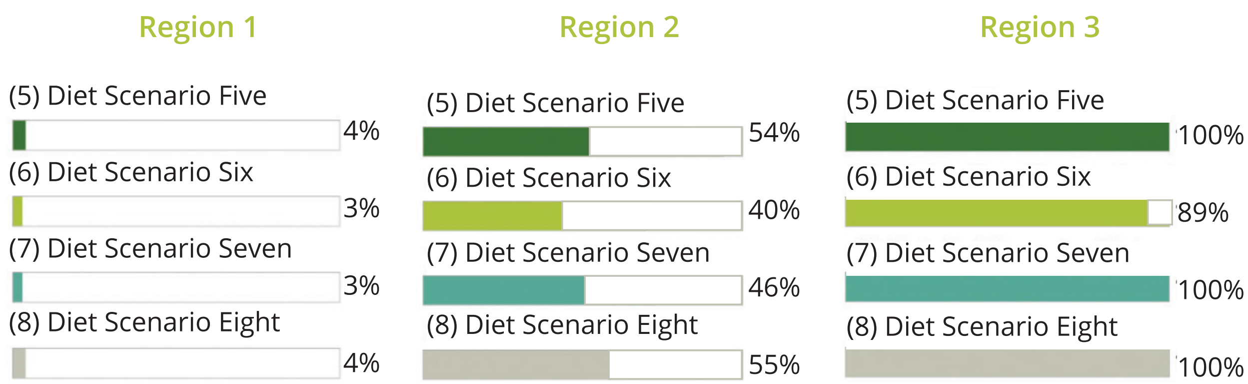


Figure 27. Percentage of regional population fed in Region One, Two and Three with Diet Scenarios Five to Eight.

Image source: (Joseph, 2016)

“Alternative Food Network” Models to Promote the Transition to Regional Organic Agriculture

Despite increasing interest and growth in the regional and organic food market, both in Germany and abroad, the sector is still relatively niche, as mentioned previously. Many studies indicate that the price premium for organic products compared to those that are conventionally produced is the main barrier for consumers at purchase point (Hempel & Hamm, 2016), (Reisch, et al., 2013), (Hughner, et al., 2008).

In Germany, for example, organically produced food is, on average, 17% more expensive than its conventionally produced counterparts according to a study by (Reisch, et al., 2013). Further, other factors— such as accessibility, skepticism about certifications and organic labels, insufficient marketing and knowledge sharing, and satisfaction with the current food source— also contribute to impeded growth of the organic and/or regional food sector. Given the significant external costs of the current food production system, the textbook solution would be for the policy maker to devise policy instruments for steering production into a more sustainable direction. That is happening, but very slowly.

Image source: (Agence Producteurs Locaux Damien Kühn, 2016)

In the meantime, the question remains: How can organic regional agriculture be promoted in the face of consumers' lack of interest in its products? Be it due to is price premium, or due to mistrust in labels, or lack of knowledge?

According to Reisch, et al., 2013 sustainable food consumption generally refers to foods that:

- Are safe, healthy and nutritious for consumers and meet needs of the less financially secure on a global scale.
- Provide a livelihood for farmers, processors and retailers where employees have a safe and hygienic working environment.
- Respect the natural limits, improves the environment and reduces energy consumption.
- Respect the highest standards of animal health and welfare.
- Provide affordable food for all sectors of society.
- Support rural economies and diversity of rural culture.
- Emphasize local products that reduce food miles.

Plow at the Kattendorfer Hof. (Joseph, 2016)

To date, however, government efforts are largely focused on food security and maintenance of overall agricultural production without significant concentration on an integrated policy of sustainable development that covers all actors in the food system (Reisch, et al., 2013). Although efforts to reduce food waste or decrease GHG emissions have been introduced, support and promotion of regional and organic food production is still lacking.

Also, it should be noted that organically produced food has become part of the globalization process, where foods are increasingly imported. Local food, on the other hand, represents an opposite trend, encouraging more proximity of food production to consumption (Hempel & Hamm, 2016).

Perhaps a more promising strategy for making significant progress toward promoting organic and regionally produced foods is a bottom-up approach. The rise of new or adapted so-called "alternative food networks" (AFNs)— "alternative" in reference to the current industrial agriculture system— provides an example of an approach that challenges the current industrialized, global food system by reevaluating and redesigning the chain of production and consumption. While the current system is focused on globalized, centralized and specialized methods, concepts derived from AFNs are commonly based on models that focus on local, more sustainable systems and put the power in the hands of the individual consumers or communities. The growth of AFNs can also assist policy-makers to facilitate the availability, affordability, and accessibility of the sustainable food supply (Reisch, et al., 2013).

The following section will focus on defining AFNs, giving examples of three efforts in the regions of Hamburg and Northern Germany, and identify qualities that models of AFNs possess to help overcome the higher price premium of organic products. Once these qualities have been identified, the author will then assess seven different models of AFNs (three from the regions of Hamburg and Northern Germany that will be highlighted in the next section and four more that are currently active in Germany and/or globally) to examine to what extent they posses said qualities.

Characteristics of Alternative Food Networks

Key characteristics of AFNs include (Sage & Goldberger, 2012):

- Shortening distances between producers and consumers.
- Smaller farm size and scale, often organic or and closing the nutrient cycle (or coming close to it).
- Reliance on alternative food purchasing venues.
- Commitment to social, economic and environmental considerations of food production.

In many cases, AFNs are built on long-standing concepts, redeveloped with the input of new technologies and social structures, such as an Online marketplace revamping the traditional farmer's market, allowing consumers to purchase all of their organic groceries at the click of a button. Other examples, such as Community Supported Agriculture (CSA) or food co-ops, are not new, but are instead increasing in number of schemes and participants each year (Botsman & Rogers, 2011).

Field salad at the Kattendorfer Hof. (Joseph, 2016)










Images from the Kattendorfer Hof. Image sources: (Joseph, 2016)

Models of AFNs in the Region of Hamburg and North Germany

1. Community Supported Agriculture: Kattendorfor Hof

Community Supported Agriculture (CSA), referred to as *Solidarische Landwirtschaft*, or *Solawi*, in Germany, began in North America in the 1980s through a collaboration of several biodynamic farmers (Biodynamic Association, 2016). The model is based on collaboration between consumers and farmers. Consumers share the costs of supporting the farm and the risk of variable harvests, and in some cases, they help the farmers work the land.

Members of the program are typically referred to as "shareholders," who subscribe to or finance the harvest for the entire season in advance (Biodynamic Association, 2016). Length of season, crops grown, level of social activities, and price of shares vary depending on the individual farm and geographic location.

Participation in a CSA scheme effectively removes consumers and producers from the globalized "market" and high dependence on subsidies and market prices on which the individual farmer or consumer has no control. Consumers agree to an annual contract for which they are delivered a regular box of foodstuff. They know exactly how and where it was produced. Additionally, farmers are not subject to market pressures, but instead, participate in a needs-based economy in which they produce what is required for their members (Solidarische Landwirtschaft, 2016).

One example of a growing CSA program is the Kattendorfer Hof, located in the town of Kattendorf in the north of Hamburg. The farm is roughly 240 acres and produces a variety of crops and livestock based on Demeter certifications. Currently, there are approximately 400 shareholders who participate in its CSA scheme, representing an increase from 200 shareholders just four years ago. Within the next two years, the owners of the farm plan to purchase 150 additional hectares, due to increased interest in the CSA program, to meet the need for more land to produce food for members (Dungworth, 2015). As well, when more members join, the farm needs to balance the purchase of animals and plants so that the nutrient balance of the farm can be maintained.

As of 2016, members pay 178 Euros per share, per month for the normal harvest share, with the potential to buy a half-share or a vegetarian option. The vegetarian option costs 145 Euros per share, per month and includes the same quantities of products as the normal share but does not include meat. Included weekly with the purchase of a full share, which has approximately the amount of food required by an adult, are:

- 1.5 to 3 kilograms of vegetables depending on the season
- Additional herbs and salad (both depending on the season)
- 1 kilogram of potatoes
- Approximately 0.7 kilograms of meat and sausages, typically pork and beef
- Milk and dairy products equal to 8.75 liters of milk (roughly 1 liter of milk, 0.5 kilograms of yogurt, 0.25 kilograms of curd, 0.6 kilograms of cheese)


MOORMÖHREN
MITGLIEDERPREIS 1,90 /kg
NORMALPREIS 2,90
D Bioland
Christiansen's Hof


mitglieder-
bioladen
und café
kaffee
kuchen
suppe
fladenbrote
-auch zum mitnehmen-
warenwirtschaft


TOMATEN


warenwirtschaft


bioland
AUEHOF
Reese
Zwiebeln rot
5 kg

Images from the Warenwirtschaft. Image sources: (Joseph, 2016)

2. Food Cooperatives: Warenwirtschaft

Food cooperatives, or food co-ops, are business enterprises that are owned and controlled by the members whom they serve (UN Social, 2016). This structure ensures that decisions made balance the need for revenues with the requirements and interests of the members and community (UN Social, 2016). Similar to CSA programs, food co-ops are an enduring idea that has been the focus of increased attention as an alternative to our current food system in recent years. The United Nations, for example, declared 2012 the “International Year of Cooperatives”.

An example of a food co-op in Hamburg is Warenwirtschaft, a collectively owned organic food shop and café that is controlled by eight founding members located in the city neighborhood of Altona. The eight founding members make decisions together, as well as purchase their products at the shop.

Additionally, they offer membership to their shop, which entitles co-op members to a lower price on products. Currently, membership fees are 22 Euros per adult in the household, per month, and an additional 3 Euros for all children in the household. Members pay the price that is paid to the wholesaler for each product, plus taxes and a 12% fee for extra costs to the shop, such as rent, utilities and losses through food spoilage and theft. Members pay a lower price than non-members. Price differences range from 5% for milk to 40% to 50% for fresh fruits and vegetables (Frötscher, 2016).

Membership has also increased significantly since the co-op began nearly eight years ago. Today, there are 650 adult members, as well as 200 child members. Two years ago, a cap was placed on membership and, as of February 2016, there were roughly 150 people on the waiting list to be members. The cap was introduced to retain a manageable amount of work for the owners, as well as to maintain a comfortable, familiar environment for members and reducing the risk that products would sell out too fast (Frötscher, 2016).

The three most important qualities of the products sold at the shop are a mixture of organic standard, regional production, and the quality of the product itself. The owners prioritize the highest quality organic standard— Demeter or Bioland— as well as products being in season. Additionally, they do not sell any products that have been flown in, only products that have been shipped by land or sea. Currently, approximately twenty sources deliver products directly to the shop, with the main contributor being *Naturkostnord,* a wholesaler in Northern Germany (Frötscher, 2016).


Regionalwert AG
NETZWERK-PRODUKT


Regionalwert AG


Flensburg
Schleswig-Flensburg
Nordfriesland
Rendsburg-Eckernförde
Kiel
Plön
Dithmarschen
Ostholstein
Neumünster
Steinburg
Segeberg
Lübeck
Nordwest-mecklenburg
Stormarn
Cuxhaven
Pinneberg
Herzogtum Lauenburg
Stade
Hamburg
Ludwigslust
Harburg
Rotenburg (Wümme)
Lüneburg
Lüchow-Dannenberg
Heidekreis
Uelzen


eigene
Eier


BREITENWEGERHOF
demeter

Images from the Regionalwert AG. Image sources: (Regionalwert Ag, 2016)

3. Network Along the Food Chain: Regionalwert AG

Regionalwert AG is an example of an innovative, new approach to promote a more sustainable food system. Based on a successful model in the Southwest German region of Freiburg, the Hamburg-based company is still in its infancy, and therefore there is not much experience yet with this business model.

The model of the company is to build a network that encompasses all members of the food supply and consumption chain— the farmers, processors, wholesalers, retailers, and consumers— and provides support in both financial capital and knowledge sharing. Each share costs 500 Euros and is used to support regional, organic farms and ensure their existence. As of March 2016, Regionalwert AG had 230 shareholders, including large retailers in Hamburg such as *Budnikowsky*, with a total of 945,000 Euros of capital (Schönheim, 2016).

A major goal of the company is to connect farmers with successors. In the case of Schleswig-Holstein and Hamburg, approximately 70% of farmers have not secured a successor (Schönheim, 2016) (Destatis(b), 2010). At the same time, there are many educated young farmers who would like to buy farm land but have no access to capital. Regionalwert AG seeks to connect want-to-be farmers with farmers who don't have successors and provide financial support if needed.

Also, another focus of Regionalwert AG is to help farmers switch to organic production methods. During the conversion process, farmers cannot sell their products as organic for at least three years. The company assists these farmers by providing financial support during the transition as well as knowledge from other experienced organic farmers within the network. To fulfill the investment qualifications, the farms must be organic by the end of a four-year period (Schönheim, 2016).

Investments also go toward processing companies, such as dairy processors, breweries, bakeries, or butcheries, as well as wholesalers, restaurants, or cafes within the network. When accepting investment, the companies sign a contract committing themselves to follow certain social and ecological criteria (Schönheim, 2016).

At the end of the supply chain, the investors also become the consumers. "Regionalwert products," those produced or processed by the members of the network, are to be sold at various shops throughout the region— that is the plan. The consumers benefit from transparency along the supply chain, as they know exactly to what standards their product was produced.

Furthermore, by connecting all of the actors of the regional and organic food supply chain, the network can serve as a tool to solve one problem of intense specialization and utilize the waste of one member as the resource of another. For example, the waste of a milk processing plant can be utilized to feed at a in the network farm.

Characteristics of AFNs that Affect Consumers' Willingness to Pay

As stated previously, price premiums of organic products are one, if not the most, significant deterrent for consumers at purchase point. At the same time, organic agriculture is increasingly being recognized as an innovating farming system that can balance multiple sustainability goals and will be increasingly important in future global food and ecosystem security (Reganold & Wachter, 2016). Large-scale conventional producers are able sell products at low prices because the external costs— damage to the environment, harm to animals and human health— are not reflected in the price that the individual consumer pays at the point of sale (Heinrich Böll Foundation, 2014).

It can be assumed that prices of organic products will not be reduced significantly without notable government action; therefore, to fill the gap between realizing sustainability goals and the resistance to purchasing more expensive organic and local products, research must focus on what factors can affect consumers' willingness to pay for more expensive products.

The term "willingness to pay" refers to the largest sum a consumer is willing to pay for a product or service. In the case of organic products, ample studies have been conducted to attempt to identify factors that may affect consumers' willingness to pay price premiums for these products, as well as to classify what type of consumer is more likely to purchase organic and/or regional products.

Thus far, the majority of research on consumers of organic food products has found weak relations between socio-demographic data and organic food consumption (Hempel & Hamm, 2016). The only recognized tendency is the relation between gender, age, income, and education, partly due to the positive relationship found between age and income, as well as education and income (Hempel & Hamm, 2016). A study by (Aschemann-Witzel & Aagaard, 2014) found that consumers weigh quality considerations— mostly referring to taste and freshness— and moral beliefs, like environmental or animal welfare concerns, against price. This is especially true for young consumers with lower incomes (Aschemann-Witzel & Aagaard, 2014).

Research has found that female consumers tend to be more in favor of alternative and healthy foods, preferring organic products more than male consumers (Hempel & Hamm, 2016). From this, it can be surmised that, in general, organic and/or local food consumers are very diverse, with a tendency to exemplify one or more of the following characteristics: female, older, higher income, or higher education.

For consumers who are price-sensitive, identifying factors that affect their willingness to pay more for organic products is key to understanding the motivations, perceptions, and attitudes consumers hold regarding organic foods. Twelve factors will be presented in the following table, each representing a potential influence on the purchase decision for consumers. The factors are grouped into four categories: health and taste (light green); environment and animal welfare (dark green); convenience and diversity (maroon); and social and knowledge sharing (light blue).

Seven different distribution channels will also be identified, which includes the three previously discussed and four more AFNs that are active in Germany and/or globally. The author will assess (based on research and interviews with experts) to what extent each of these distribution channels possess the qualities that may help to overcome the higher prices of organic products. This will be represented in a wheel diagram at the end of this chapter. According to the author's assessment, one color block indicates low perceived relevance to overcome the higher prices of organic products, two; medium perceived relevance and three; high relevance.

The first three distribution channels, CSA programs, food co-ops, and a regional network, such as Regionalwert AG, have been presented in the previous section. The fourth channel, "delivery box" or *Biokiste*, as it is referred to in Germany, is a box of fruits, vegetables, and in some cases meat, dairy products, or breads that is delivered to consumers on a regular basis. Ideally, the products are in season and have been produced on the farm, but in some cases, especially with changing diets, delivery companies work with wholesalers and also include imported or exotic products.

The fifth channel refers to the "Online marketplace," which combines the traditional ideas of the farmer's market with the delivery box scheme. Consumers can visit one website and create their own “basket” of food to be delivered to their home. Usually, the boxes are not regular deliveries, but instead are one-time purchases that will be repeated by the consumer if desired, similar to visiting a grocery store or market. One example of this system is *“OrganicNet,”* a project that is currently developing to connect organic producers with consumers in the local area, as well as farther away. Through the marketplace, producers and consumers can build trust and connections, and there is a “rate and review” feature to build individual reputations.

The sixth channel refers to the small, sole-proprietorship organic shops or farm shops known as *Bioladen* or *Naturkostladen* in Germany. This is a traditional shop model that sells only organic products. The last distribution channel is the conventional or discount supermarket, such as *Rewe*, *Edeka* or *Aldi* in Germany. Although these brands also sell their own organic products, for comparison purposes the products analyzed from this distribution channel should be considered conventionally produced, with no emphasis on localness.

Lower prices (black)

As a reference point, “lower prices” was included in the comparison of the different distribution channels. The evidence of the author is that the conventional supermarket or discount retailer is the least expensive. The food co-op example of Warenwirtschaft is more expensive, but not the most expensive because members pay a reduced price for food, assuming they purchase enough to exceed the monthly membership fee. The CSA, regional network, delivery box, Online marketplace, and organic shop are the most expensive. This coincides with the judgment by interview partners.

Health and nutrition, superior taste and transparency (light green)

A study by (Padilla Bravo, et al., 2013) examined a sample of 13,074 Germany consumers surveyed in the German National Nutrition Survey II (NVS II) and concluded that health-related, nutritional, and quality aspects were the main psychographic determinants of organic food purchase in Germany. This is echoed by other studies by (Hughner, et al., 2008) and (Reisch, et al. 2013). Consumers prefer to avoid chemicals and GMOs used in conventional food production, perceived to be associated with long-term or unknown effects on health (Hughner, et al., 2008).

Furthermore, some studies indicate that organic food may be more nutritious than conventional food, as mentioned in Chapter Three; however, there is not yet conclusive evidence of that fact. Freshness of products refers to products that are produced locally and purchased in season.

Several studies have concluded that consumers perceive the “superior taste” of organic products as important criteria for purchasing (Hughner, et al., 2008). A study by (Krömker & Matthies, 2014) surveyed 571 participants directly after purchasing at the supermarket and concluded that consumers who purchased organic foods regularly were more likely to indicate that the taste and nutrient content of organic products are superior to those of conventional foods, compared to consumers who only purchased organic products occasionally. Consumers may also perceive a product to be of higher quality and therefore having superior taste and standards if it has relatively higher prices, although this may vary depending on product type (Van Doorn & Verhoef, 2015).

The author identifies that in general the first six organic and/or regional distribution channels possess the highest relevancy in terms of health, nutrition, freshness and taste compared to the conventional supermarket or discount retailer. As all products are organic, they do possess the qualities that many consumers have found to be associated with identified factors as described above.

Studies suggest that consumers have a favorable attitude toward purchasing organically and locally produced products (Hughner, et al., 2008). A study by (Hempel & Hamm, 2016) surveyed 641 participants outside of rural and urban supermarkets in Germany, finding that both consumers who purchased organic foods regularly and those who did not felt that purchasing local foods was an important aspect of their decision-making process. In fact, 92% of respondents favored local food over organically produced food from farther away, and 72% favored a combination of local and organically produced food (Hempel & Hamm, 2016).

Localness of production is often associated with transparency and food security. According to (Hempel & Hamm, 2016), consumers had the most trust in products produced in Germany, followed by Austria, Denmark, France, and the Netherlands. On the other hand, consumers had the lowest trust in products produced in the USA, Egypt, Dominican Republic, Kazakhstan and China, with China engendering the least trust. As the food system is so globalized and complex, it is becoming increasingly important for consumers to be aware of who produced their food, and how and where it is produced.

The author considers the CSA program and the delivery box to be the most relevant for consumers who value transparency in production, as products typically come directly from the farm. The food co-op, regional network, Online marketplace, and organic shop were considered to have medium relevancy, as food comes from a variety of sources, but organic qualities and regionalism of products are still considered important factors for these retailers. The conventional supermarket is estimated to have the lowest levels of transparency.

Environmental and animal welfare concerns and support of the local community (dark green)

Empirical evidence suggests that altruistic reasons, such as concern for the environment and animal welfare, play a role in consumer purchasing decisions. According to (Padilla Bravo, et al., 2013), German consumers are particularly interested in animal welfare and willing to pay more for products that provide evidence of this attribute. Additionally, consumers perceive the agricultural chemicals such as synthetic fertilizers, pesticides and herbicides used in conventional production to be potentially harmful to their health and to the environment, while organic products are perceived to be environmentally friendly (Hughner, et al., 2008) (Krömker & Matthies, 2014).

As environmental and animal welfare concerns are embedded in the production methods of organic agriculture, the first six distribution channels were assessed as having a high relevance to these factors. The large retail chain was determined to have a low relevance as conventional agriculture does not typically emphasize environmental and animal welfare concerns compared to organic production.

By purchasing locally produced products, consumers can help to support the local farmers and community, reduce GHG emissions that would have accumulated from distribution and storage, as well as support jobs in the local economy, This also provides a direct link between consumer and producer. Embeddedness, in the form of social connection, reciprocity and trust is often seen as a key competitive advantage of local food markets (Hinrichs, 2000).

The author assessed that the CSA, regional network and delivery box provided the most support of the local community, as all (or most) products would be produced within a locally defined region. The food co-op, Online marketplace and small organic shop were assessed to have a medium relevancy to local products, as these are typically favored, but it is not a requirement. The large retail chain was determined to have the lowest relevancy to localness.

Convenience and product diversity (maroon)

An early barrier to purchasing organic and local products was lack of convenience, such as difficulty finding distribution channels for organic products and low product diversity (Hughner, et al., 2008). To compete with conventional supermarkets, organic distribution channels must also provide convenience and availability for consumers, as well as the option to choose among a variety of products for a diversified diet.

The author considers the first six organic and/or regional distribution channels to have medium relevancy to convenience, simply based on the fact that there is a fraction of the amount of these channels in comparison to many conventional or discount supermarkets. This is reiterated by the breakdown of market channels for organic foods, where large general retailers control roughly 53% of the market, organic retailers such as *Al Natura* or *Dens* control 33%, and all other channels such as small farm shops, Online shops, delivery boxes, etc., comprise roughly 14% of the market (BÖLW(c), 2015).

In terms of product diversity, the author assessed that the CSA, delivery box, and regional network have the lowest relevance, as products available for consumption should typically only be produced on the farm or in the region, with limited potential for product diversity. The other four distribution channels have a high relevance in terms of diversity because products can come from a variety of sources, as well as be imported.

Image from Warenwirtschaft. Image source: (Joseph, 2016)

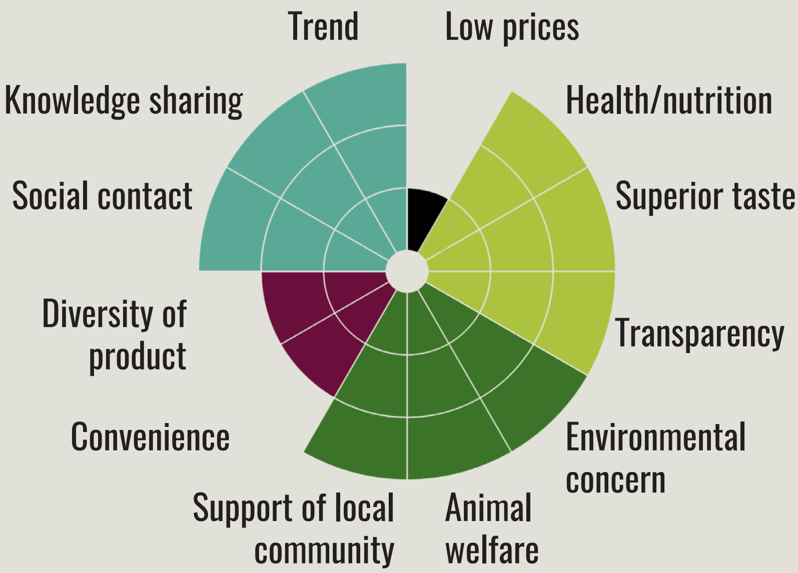
Social contact, knowledge sharing and trend (light blue)

Many AFNs are associated with building communities and sharing knowledge between members. Participants are able to gain access to areas of experience and education and, in some cases, learn about the cultivation and production of foodstuffs and the importance of environmental protection (Solidarischer Landwirtschaft, 2016).

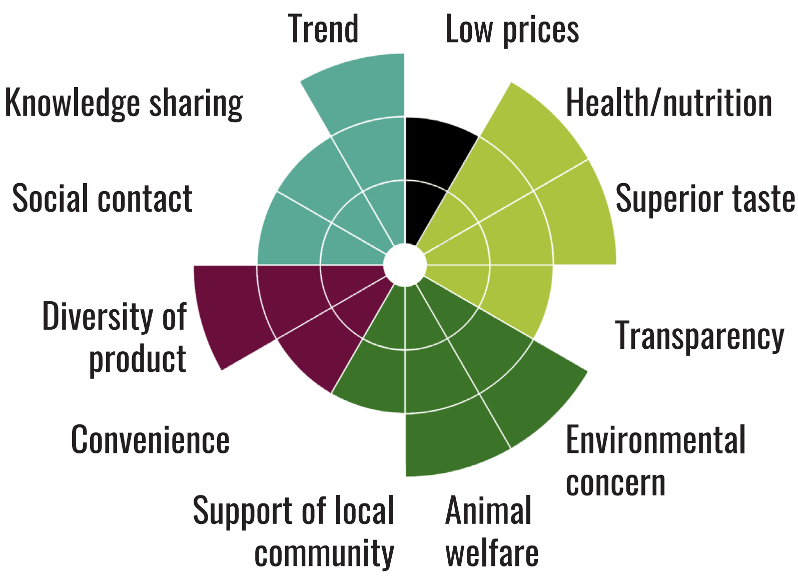
The CSA and regional network were considered to be the most relevant to knowledge sharing and social contact between members, as these are fundamental principles of their models. The food co-op, delivery box, Online marketplace, and Online shop were considered to have medium relevancy, as members are not necessarily directly connected, but, due to the smaller scale of the channel compared to a large retailer, there is more potential for communication between producers and consumers. The large retailer is considered to have the lowest amount of relevance.

Studies suggest that people perceive organic and/or local foods to be fashionable or trendy, due to increased media coverage, promotional campaigns, and the higher prices associated with organic foods (Hughner, et al., 2008). Furthermore, as organic and local foods are being increasingly associated with health benefits, the social and economic mega-trends of well-being and a healthy lifestyle are becoming even more relevant to the sector (Reisch, et al., 2013).

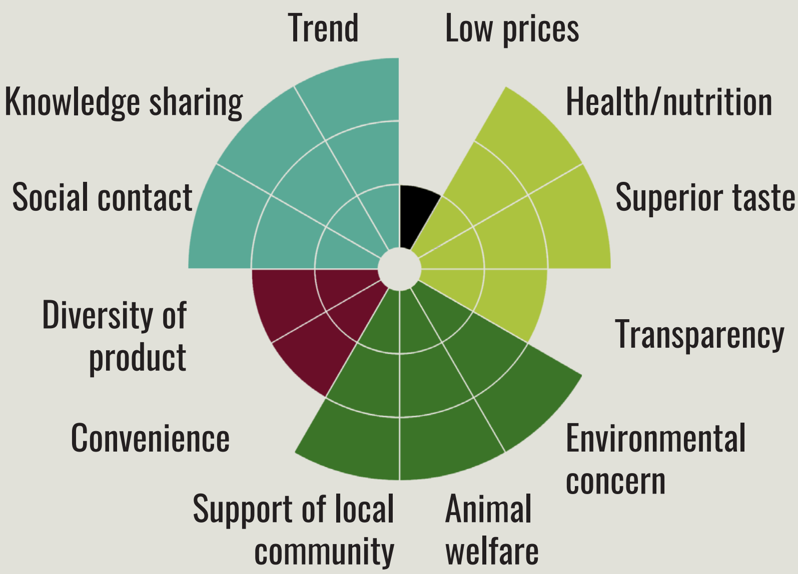
The first six distribution channels— CSA, food co-op, regional network, delivery box, Online marketplace, and organic shop— are all highly relevant to this the concept of organic and regionally produced food as "trendy." Conventional supermarkets, on the other hand, have a low relevance to this factor.



1. Community Supported Agriculture

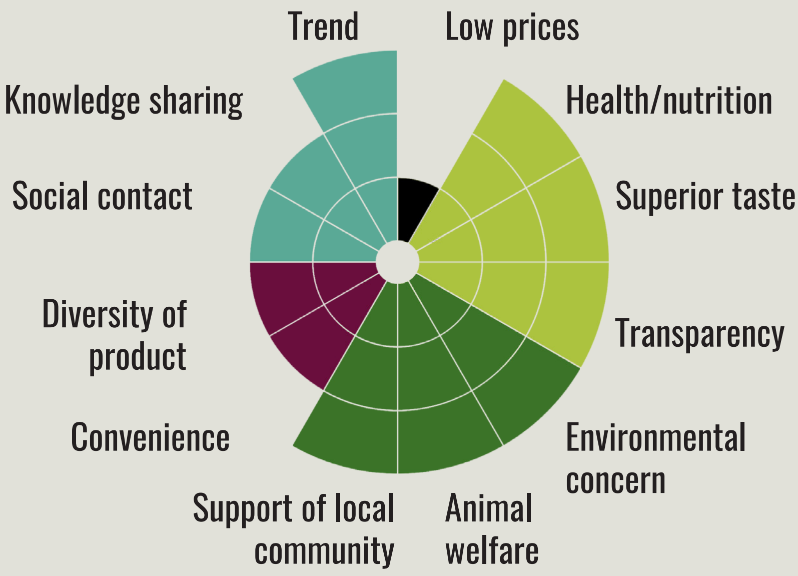


2. Food Co-op



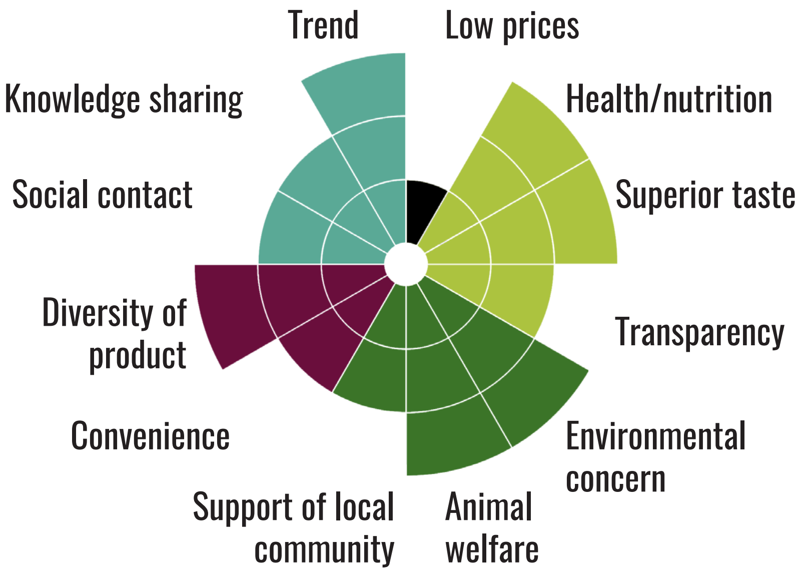
3. Regionalwert

4. Delivery Box



5. Online Marketplace

6. Small Organic Shop



7. Large Retail Chain

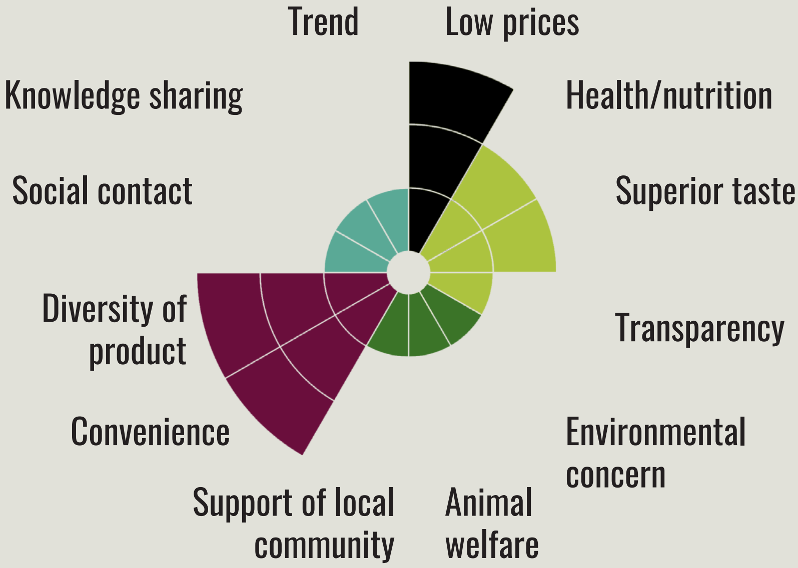


Figure 28. Assessment of factors to increase willingness to pay price premiums for organic products by distribution channel

Discussion of Results

Comparison of Land Footprint for Diet Scenarios

The comparison of the diet scenarios indicate that consumption choices have a significant impact on the land footprint for food production. Meat consumption, in particular, plays the largest role in determining the required agricultural land for food production. This point is echoed by a study conducted by (Jungbluth, et al., 2012), which concluded that a health conscious and vegetarian diet had the highest potential to reduce the impact of the food system on the environment and climate change.

It should be noted that while milk and dairy products also contribute to a large share— the kg yield per square meter of farmland— of the overall land footprint for food production, the yield efficiency for these products is much greater compared to meat— approximately 1.5 times more efficient than pork and poultry and more than five times more efficient than beef, goat or sheep. For this reason, as well as the fact that current average per capita German milk consumption is approximately aligned to DGE recommendations as identified in Chapter Four, reduction of milk and dairy products was not focused on in this thesis.

The impact of meat consumption on the overall land footprint for food production becomes most clear when comparing when comparing Diet Scenarios Two and Three. Diet Scenario Two represents the current average German eating habits with conventionally produced food, while Diet Scenario Three represents a more ecological diet, higher in vegetables and legumes and lower in meat consumption, produced according to at least base level EU organic standards. It may be seem at first glance that the organically produced diet will have a higher land requirement for production because organically produced foods typically produce lower yields than their conventional counterparts.


Image source: (Veeterzy, 2016)

Although more land is required to produce organic plant products, Diet Scenario Three has a reduced land footprint, due to its nearly 60% reduction in meat intake, compared to Diet Scenario Two. The combined meat and egg consumption quantities for Diet Scenario Two are 100.3 kilograms, corresponding to a land requirement of 1100 m^2 per person, per year. For Diet Scenario Three, the consumption quantity is 46 kilograms per year, corresponding to a land requirement of 700 m^2 per person, per year.

Furthermore, even though legume intake is much higher for Diet Scenario Three (40 kg compared to 0.5 kg for Diet Scenario Two), the yield efficiency of organically produced legumes, roughly 1.4 m^2 to produce one kilogram of legumes, is much greater than the yield efficiency to produce organic meat and products, roughly 15.2 m^2. According to these estimates, organic legumes are nearly eleven times more land-efficient than organic meat and meat products. Therefore, it can be concluded that when organically produced legumes are substituted for organically produced meat and/or eggs, the land footprint for production will decrease by a corresponding factor of eleven times the quantity of substitution. The substitution described here is in terms of kg, not kcal. Thus, the more ecological diet is also lower in kcal. This does correspond to the recommendations of the *Deutsche Gesellschaft für Ernährung* (DGE).

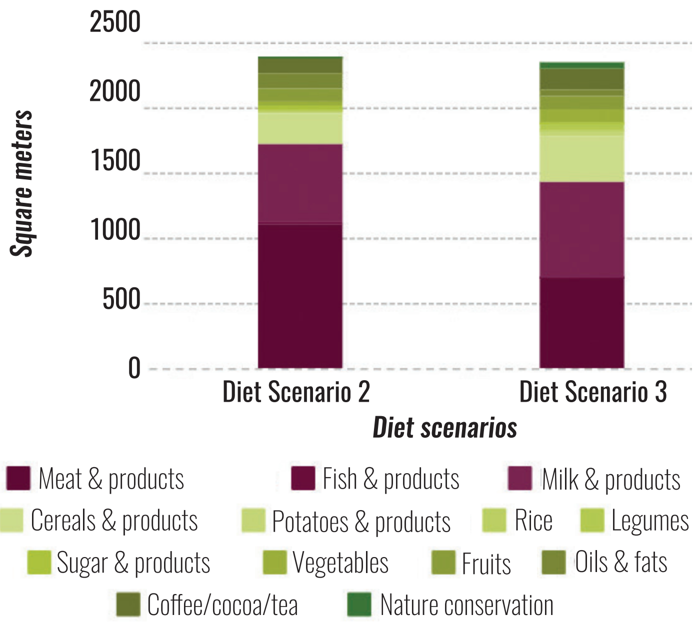


Figure 29. Comparison of Diet Scenarios Two and Three.

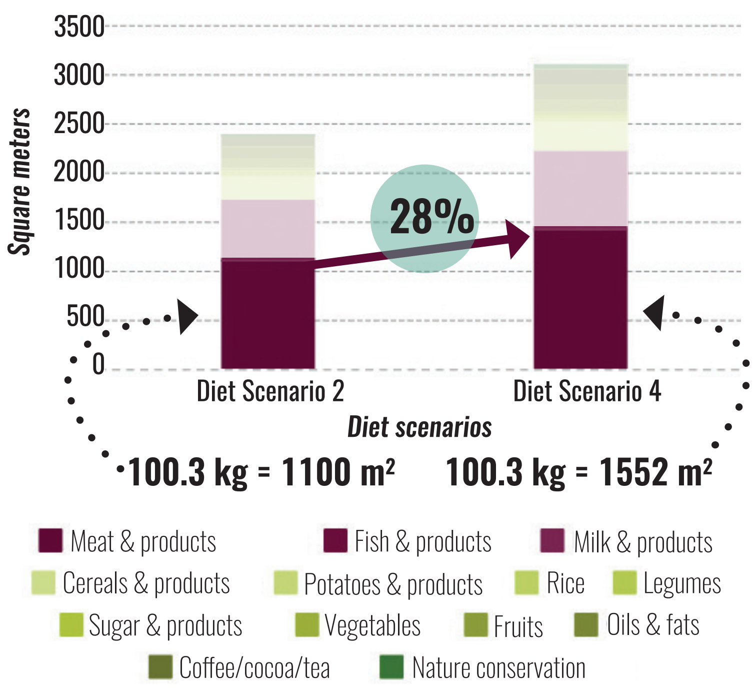


Figure 30. Comparison of Diet Scenarios Two and Four.

When comparing Diet Scenarios Two and Three, it can be concluded that a reduction in meat intake of at least 60% compensated for the crop yield gap between organic and conventional agriculture. Hence, less agricultural land will be required to produce an organic diet following the outlined consumption quantities in Diet Scenario Three versus Diet Scenario Two.

The situation changes, however, when it is assumed that the population maintains current consumption patterns, but food is produced according to organic standards. This is illustrated in Figure 30.

Land requirement to produce 100.3 kilograms of meat and eggs equaled 1100 m² conventionally and 1552 m² organically, corresponding to an increase of 28% of agricultural land for food production (Figure 30). For plant products, the agricultural land requirement increased from 689 m² by conventional standards to 928 m² by organic standards, equaling an increase of 26%. Although the percentage of increase is roughly comparable for plant and animal products, the increase in actual land required to produce animal products is more than double the increase for plant products. While organic plant products required 239 m² more per person, per year compared to conventional products, organic animal products required 452 m² more per person, per year. In other words, producing animal products organically has a larger effect on land footprint for food production than a switch from conventionally to organically produced plant products, also illustrated when Diet Scenarios Six and Seven are compared to Diet Scenario Four, as illustrated in Figure 31.

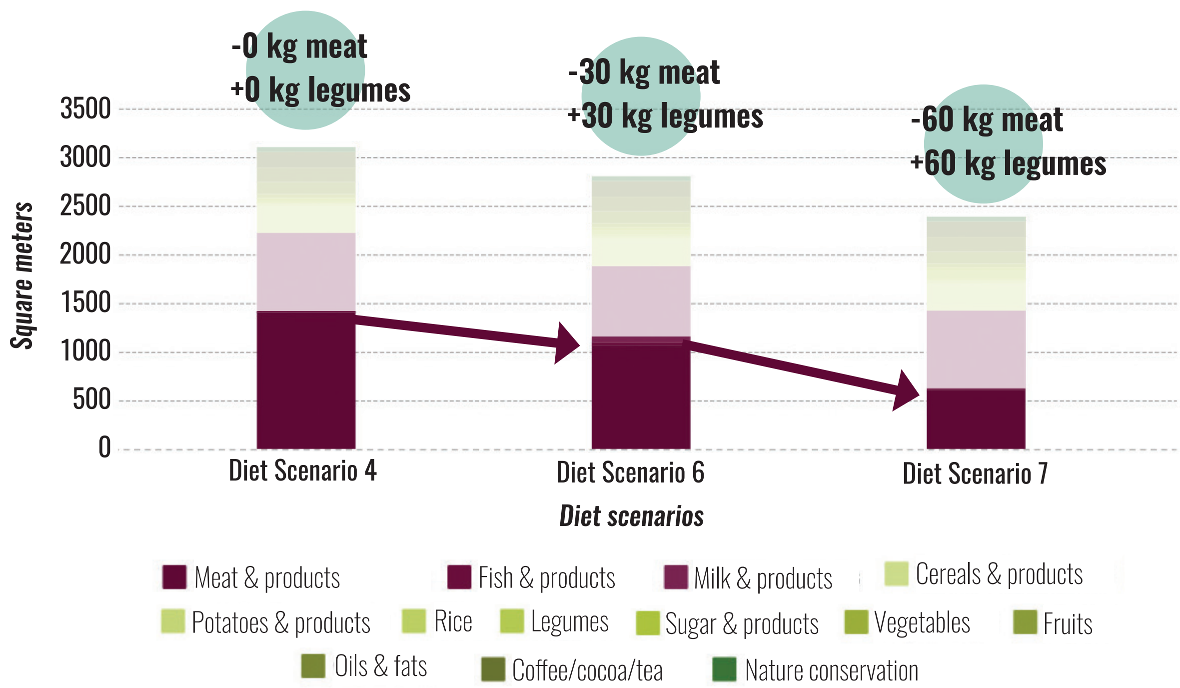


Figure 31. Comparison of Diet Scenarios Four, Six and Seven.

Diet Scenario Four represents the agricultural land footprint for current consumption quantities produced according to EU organic standards, with meat consumption equaling 100.3 kilograms per person, per year. Diet Scenario Six represents a reduction in meat consumption by 30%, equal to a consumption quantity of 70.2 kilograms per person, pear year, with the addition of 30 kilograms of legumes per person, per year as a meat substitute. Diet Scenario Seven represents a reduction in meat consumption quantities by 60%, equal to a consumption quantity of 40.1 kilograms per person, pear year, with an additional 60 kilograms of legumes per person, per year as a meat substitute. The resulting reduction of the agricultural land footprint for meat and egg production compared to Diet Scenario Four is 524 m^2 in Diet Scenario Six, and 954 m^2 in Diet Scenario Seven.

Legume intake for Diet Scenario Four equaled 0.5 kilograms per person, corresponding to an agricultural land requirement of 0.6 m^2. An increase to 30 kilograms per person, per year, illustrated in Scenario Six corresponds to 42 m^2 per person, per year and an increase to 60 kilograms for Diet Scenario Seven required 84 m^2. This corresponds to an overall increase of total land footprint of roughly 2.4% and 3.8%, respectively.

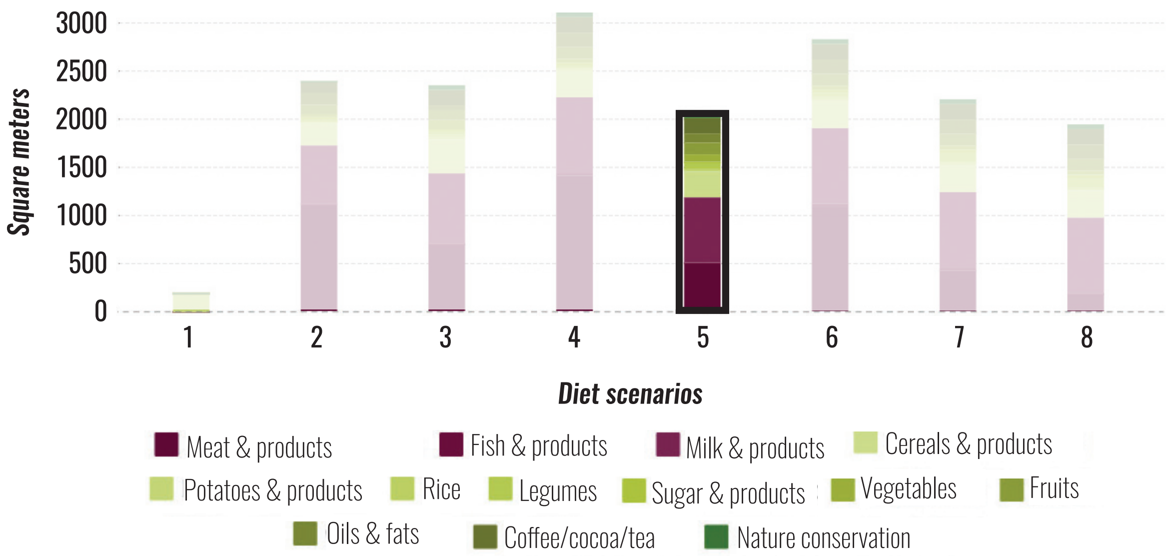


Figure 32. Comparison of all Diet Scenarios One-Eight. The most favorable diet, in terms of footprint and fitness for human health according to the DGE, is Diet Scenario Five.

A complete removal of meat from the human diet, represented by diet scenario eight, results in the lowest overall land footprint for food production of all diets analyzed, with the exception of the potato diet as represented in Figure 32.

While the vegetarian diet may appear to represent the most ecological choice in terms of land footprint, it presents sustainability challenges when considering the nutrient cycle of the farm. As mentioned in Chapter Two, a significant challenge of the current food system is the separation of crops and livestock. The waste of one group can no longer be used as a resource for the other, causing challenges of pollution in the case of CAFOs and the artificial fertilizers required to replace nutrients for crops. In this scenario, eggs and dairy products are still considered to be part of the vegetarian diet, which would allow for the creation of some fertilizer from dairy cows (waste); however, the question of what to do with the animal that is no longer producing eggs or milk arises.

According to the results, the “best choice” option of the diets presented may be Diet Scenario Five (highlighted in Figure 32). This scenario represents not only the lowest land footprint for food production next to the vegetarian and potato diet, but also is aligned with nutrition recommendations according to the DGE. This diet, however, would require a significant change in consumption patterns, as indicated in the previous section. Meat and sugar intake would have to decrease by 70%, while vegetable consumption, which includes legumes, should nearly double.

Perhaps the most realistic scenario would be Diet Scenario Six, which reduces meat intake by just 30%, corresponding to two "meat-free" days per week. If all citizens followed this diet, and food was produced according to organic standards, the total agricultural land footprint for food production of one person, for one year would equal 2,871.0 m^2. If we assume that citizens maintain current consumption quantities, but food is produced according to organic standards (represented in Diet Scenario Four, equal to 3,353.6 m^2), a shift to Diet Scenario Six would free up 524 m^2 of agricultural land per person, per year to produce other food items. If all citizens within Region Three, roughly 6.3 million people, ate according to this diet, an additional roughly one million more people could be fed according to Diet Scenario Six if we assume that citizens had maintained current consumption quantities, but production method are switched to organic.

If we assume that citizens maintain current consumption quantities, but do not switch to organic cultivation methods (essentially the "status quo" as outlined in Diet Scenario Two) a shift to Diet Scenario Six, representing a 30% reduction in meat, but produced by organic standards would require more agricultural land to produce food. However, if all citizens reduced meat intake by 60% but switched to organic methods, as illustrated in Diet Scenario Seven, the land footprint would be nearly equal to Diet Scenario Two, 2,483.9 m^2compared to 2,388.5 m^2, respectively. This indicates that the reduction of 60% meat intake, equal to four "meat free" days per week can overcome the organic yield comparison between these two diets.

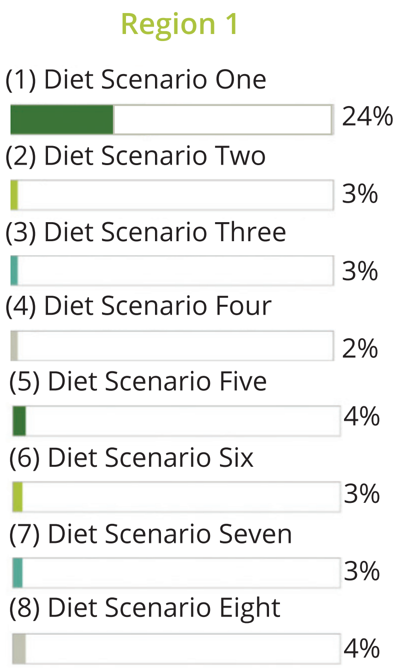


Figure 33. Percentage of regional population fed in Region One with Diet Scenarios One to Eight.

Regional Self-Sufficiency with 75% of Agricultural Land Use

Results from the analysis of the potential for regional self-sufficiency illustrate several deductions. As mentioned previously, the middle bound of 75% of agricultural land used for food production will be utilized as it was considered the most realistic situation.

Region One (Figure 33) has the lowest potential for self-sufficiency, with at most 4% of the population able to be fed with Diet Scenarios Two through Eight for all cases. We can assume here that it is not realistic that all citizens would switch to Diet Scenario One, consisting only of potatoes, unless there was a serious break in the food supply chain such as a natural disaster or national crisis. However, even if all citizens did eat potatoes, at most 24% of the population could be fed with this diet if all land was used.

Therefore, we cannot consider the city-state of Hamburg to have the potential for regional self-sufficiency even when a lowest bound diet scenario is imagined (Diet Scenario One). These results are a reflection of Hamburg's high population density compared to the other counties within the region. Of all the regions, Region One reflects the highest ratio of population to agricultural area available: roughly 9,500 people to every one square kilometer of agricultural area. For comparison purposes, the ratio of Region Two is roughly 650 people to one square kilometer of agricultural area and Region Three; roughly 293 people to one square kilometer of agricultural area.

Region Two produces better results in terms of potential for regional self sufficiency than Region One. In the case of a break in the food supply chain, 100% of citizens could be fed on Diet Scenario One, consisting solely of potatoes. Diet Scenario Eight, consisting of a purely vegetarian diet with an above average egg and legume consumption compared to the other diet scenarios produces the second best result, with 55% of the population able to be fed. Diet Scenario Five has the third best potential behind Diet Scenarios One and Eight, with just over half of the population able to be fed. This diet also represents the highest diversity of the top three diets, further confirming an earlier conclusion that this diet scenario may produce the "best results" in terms of number of persons fed on a diversified diet.

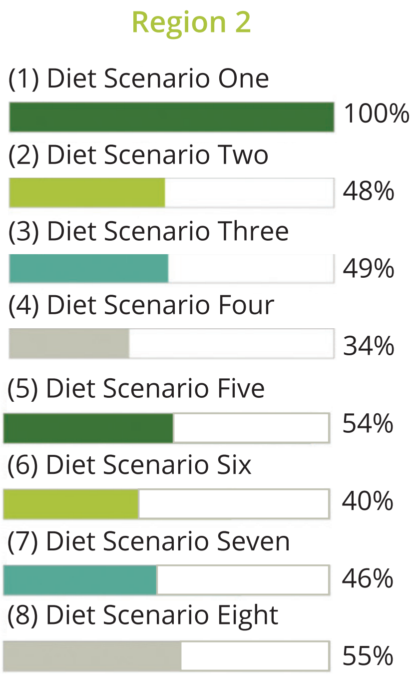


Figure 34. Percentage of regional population fed in Region Two with Diet Scenarios One to Eight.

When comparing the current consumption quantities of Diet Scenarios Two and Four as well as Scenarios Six and Seven, with reduced meat intake, a few conclusions can be drawn for Region Two (Figure 34). First, the balance of decreased meat intake and the yield comparison of conventional versus organic agriculture can be found when meat consumption is decreased by 60%, if all other food group quantities stay the same as illustrated when comparing Scenarios Two and Seven. Secondly, comparing Diet Scenarios Four, Six and Seven, it is clear that as meat intake is decreased, more citizens can be fed on a strictly regionally and organically produced diet.

Region Three (Figure 35) produces the best results, with the potential to feed most amounts of people with regionally produced food. Eight out of ten diet scenarios can feed 100% of the population. Nearly all of the population can be fed with Diet Scenarios Six, while Diet Scenario Four has the lowest potential to feed all citizens, with 76% of the community able to be fed with this diet. Comparing Diet Scenarios Four, Six and Seven the effect of the reduction of meat intake becomes further apparent. Nearly all citizens could be fed with regional organic foods if meat consumption as reduced just 30%.

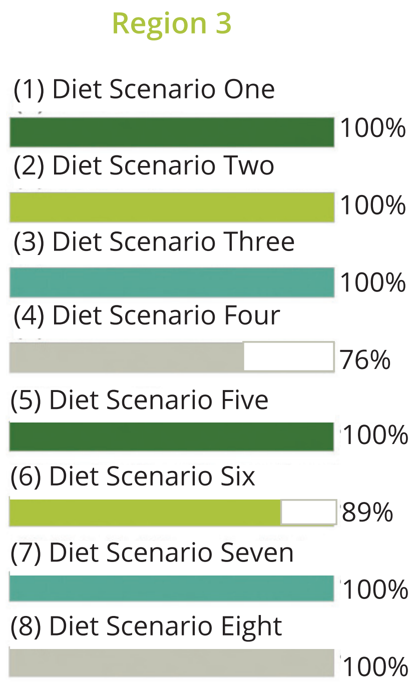


Figure 35. Percentage of regional population fed in Region Three with Diet Scenarios One to Eight.

AFNs Potential to Increase Consumers' Willingness to Pay for Organic and Regionally Produced Food

Chapter Five presented factors associated with AFNs that can affect the consumers' willingness to pay the price premium associated with organic products. As they are difficult to quantify, the author assigned relevance scores to them, based on her research (reading of the literature and on interviews with stakeholders).

The CSA program and regional network were assessed to have the highest relevance in terms of possessing characteristics to increase consumers' willingness to pay more for organically produced products compared to the other distribution channels. This was especially due to the health, nutrition and transparency factors, attention to environmental and animal welfare concerns, support of the local community and social and knowledge sharing. In general all of the first five distribution channels possess qualities that could help to overcome the price barrier, but to varying degrees.

The large retail chain has the least amount of qualities that would overcome high price points for products. However, this is more to illustrate the effect of price on consumer purchasing decisions. Although this option represents the lowest relevancy to health, nutrition, transparency, environment concern, animal welfare concern, social capita building, knowledge sharing and trend compared to the other channels, the low prices make it the continued point of sale for most consumers.

Assumptions and Limitations of the Analysis

This thesis examines the potential to feed the regional community solely with organically and regionally produced food. While the calculations deal with real data in terms of square meters required for food production, total agricultural area within each region, total population of each region, organic yield comparison and average German citizen consumption quantities, the results are highly contextual and based on a number of assumptions.

Assumptions in Diet Scenarios

Firstly, when calculating the agricultural land required to meet consumption demand the yields for both conventional and organic agriculture are highly contextual. Especially, as far as organic production is concerned, yield is dependent on a variety of factors including production method, site characteristics, soil and growing conditions, management practices, and crop type. To calculate the agricultural land footprint for feeding one person for one year, the yield efficiency ratio— how many kilograms of product that can be produced on one square meter of farmland— utilized the yield information based on the scientific literature, and real site conditions of an organic farm near Hamburg.

Secondly, each diet scenario analyzed assumes that every citizen in the region will follow it exactly in his or her food consumption. In reality, however, it is much more likely that there will be a small portion of the population that will make a shift towards more sustainable diet choices and consumption quantities will not be homogeneous among the entire group.

Assumptions to Assess Regional Self-Sufficiency

As the food system is highly complex, even at a local level, it is beyond the scope of a Master thesis to explore quantitatively whether regional self-sufficiency is possible in a completely realistic situation, especially pertaining to distribution and logistics of food.

At the moment, not all available agricultural land is available for food production. As presented in Chapter Three, cultivation of maize for biogas plants takes up a considerable share of farmland in Germany. Agricultural land can also be used for other purposes such as textiles. Additionally, land use is further broken down within utilized agricultural area into three sections: arable, permanent crops and permanent grassland. Only arable land is suitable for growing most crops while permanent grassland can be used for various purposes such as grazing for ruminants. This is not dealt with extensively in the analysis. To attempt to make the situation realistic in terms of land use, three bounds were utilized, as presented in Chapter Four.

In terms of food distribution and logistics, the calculations assume that the closest producer will deliver to the closest consumer, when in reality producers are typically part of a complex network including wholesalers and retailers in which food is distributed not only within the region, but also throughout Germany and abroad.

On the same note, the only large city (with more than 300,000 inhabitants) included in the analysis is Hamburg. The results would

Figure 36. 100 km concentric circles around Bremen, Hanover and Hamburg.

change if Berlin or Bremen, for example, were included. The potential to feed the regional community may decrease as the competition for food increases with another included metropolitan area. However, it may also expand as more farmland was available. The key factor here is the total agricultural area available for food production compared to the amount of people within the region that need to be fed. As the ratio of farmland to citizens grows larger, the potential to feed more people with regionally produced food follows. Region Three— the 100 km radius around Hamburg— does not include Hanover and Bremen. Figure 36 illustrates the overlap areas if we assume a 100 km radius around Hamburg, Hanover and Bremen, and thus the areas which would be necessary to produce food for two or more large cities.

Expanding further, if we look at Germany as a whole, the conclusion drawn from this thesis (there is potential to feed the regional community, but this is dependent on diet choices and number of persons to be fed compared to total agricultural area available) are further echoed. In total, Germany has roughly 82.2 million inhabitants and 167,000 km^2 of agricultural area. This equals 492 persons to be fed per square kilometer of agricultural land or roughly 1.7 times the density compared to Region Three (with 293 people per square kilometer of agricultural land). See Figure 37, illustrating the maximum percentage of persons fed if 100% of German agricultural land is used.

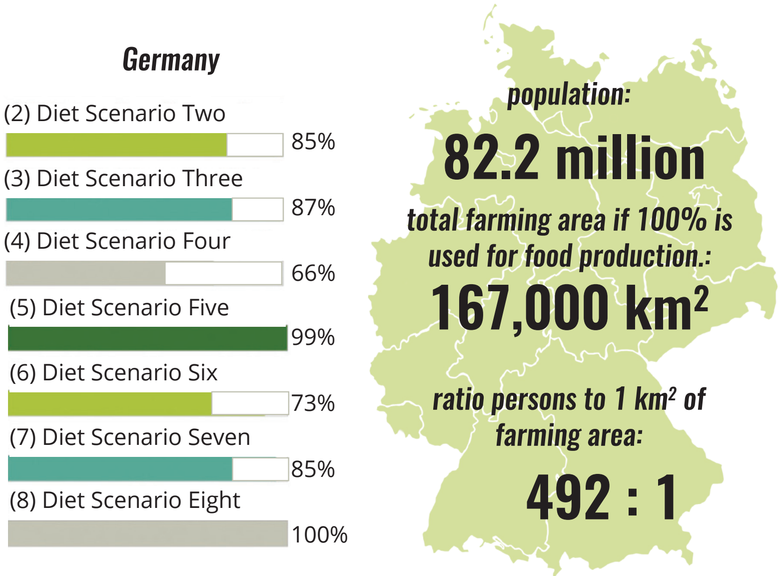


Figure 37. Percentage of German population fed with Diet Scenarios Two to Eight if 100% of agricultural area is used for food production.

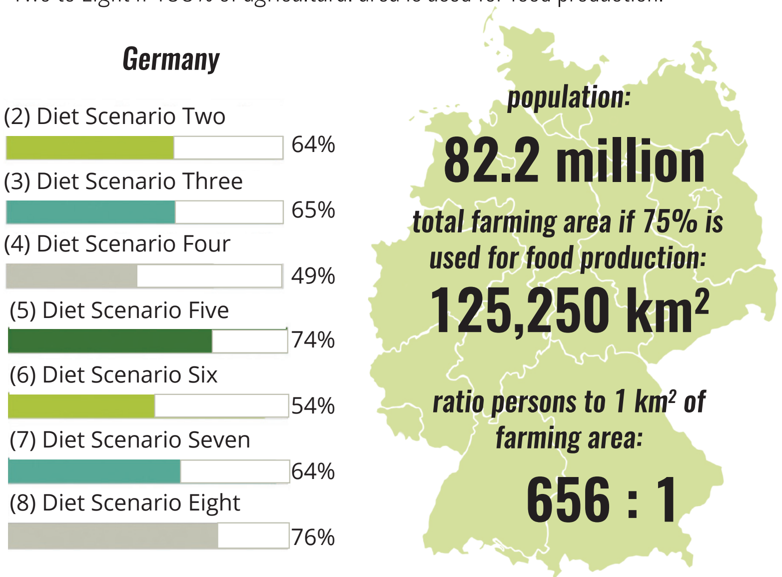


Figure 38. Percentage of German population fed with Diet Scenarios Two to Eight if 75% of agricultural area is used for food production.

If we assume that only 75% of the agricultural area will be used for food production, there will be 125,250 km^2. This equals a density of 656 persons to be fed with one square kilometer of agricultural land. This is roughly equal to the density of Region Two, with 650 persons per square kilometer of agricultural land. The resulting maximum number of persons that could be fed within the region if 75% of agricultural area is used is illustrated in Figure 38.

From these results, we see that there is potential to feed a significant percentage of the German population with nearly all diet scenarios under at least EU organic agricultural methods. Ninety-nine percent of the German population can be fed, for example, by domestically and organically produced foods if all citizens ate according to the recommendations of the DGE and all agricultural area is used for food production, and roughly three quarters if 75% is used.

While perhaps in a more realistic case, if citizens ate according to current consumption quantities but reduced meat intake by 30% (Diet Scenario Six) just under three quarters could be fed with 100% agricultural land used to produce food and just over half with 75% used.

7 Conclusions and Outlook

While the industrialized food system has theoretically accomplished its main goal— to produce enough food to feed the global population— it will not be able to do so in the future. For one, vital resources are getting scarce— water and soil nutrients, above all, phosphorus. Moreover, the system fails on several accounts: It causes severe environmental impacts, like the destruction of the rain forest and the pollution of groundwater bodies with nutrient excesses, foremost, nitrates. It fails to distribute its output evenly. There are nearly as many obese people in the world as there are starving. Animals are raised in dismal conditions.

Technologies and policy developments of the 20th century have shaped the global food system into one that is highly complex, lacking transparency and separating the spheres of production and consumption. Globalization, specialization and concentration of the chain of production and consumption are common themes. In addition, there is an unsustainable shift in the human diet on a global scale towards increased consumption of more resource-intensive foods, especially meat and animal products.

In the past 40 years, 33% of the world's arable land, necessary for growing crops, has been lost to erosion or pollution (Grantham Centre, 2015). Soil erosion, water pollution, contribution to climate change, decrease in biodiversity, deforestation, food scares, intense antibiotic use in CAFOs, food shortages and obesity, lack of financial security for farmers, worker exploitation and animal welfare are just some of the main challenges attributed to our current global food system.

A growing number of voices are calling for a turn back, both at the local scale— such as the *"Wir Haben Es Satt"* march in Berlin— and the global scale, like the FAO and numerous NGOs that have identified the need for change in many studies. Refashioning the food system is an incredibly complex task, however, dependent on numerous factors, i.e. socioeconomic situation, geographic location, available technologies, etc., and one solution will not be applicable for each

Image source: (Elaine Casap, 2016)

situation. In the end, we must uncover a way to feed the world's population while simultaneously minimizing global environmental impacts, ensuring food safety and security and safeguarding fair conditions for workers and animals.

Potential solutions towards a more sustainable food system could include: stewardship of natural and human resources, including internalizing the costs— to the environment, human and animal health and social equity— that are many times externalized by conventional, industrial systems; view the entire food system as a holistic, closed-cycle structure in which we also pay closer attention to the long-term consequences of our actions; reduce incentives for monocultures and instead encourage biodiversity and resilience; promote research, development and knowledge sharing for producers, consumers and all actors of the supply chain; support local communities and farmers, increasing transparency and fostering a deeper connection between the consumer and producer; and, on the consumer level, shift our diets towards more environmentally-friendly foods, such as a change towards a plant-based diet, substituting animal products. As well, it may also be possible in the future that conventional production methods move towards organic through a shift away from the industrialized system and an increased emphasis on sustainability.

One alternative to contribute to a more sustainable food system today is to put an increased emphasis and attention towards the development of organic agriculture on a global scale. While organic agriculture remains a relatively niche production system— comprising approximately 1% of total global agricultural land— the number of organic farms, extent of organically farmed land, amount of research funding devoted to organic farming and the market for organic products has been steadily increasing globally (Reganold & Wachter, 2016). Also, it is steadily being recognized as an innovative farming system that can balance multiple sustainability goals and will be increasingly important in future global food and ecosystem security (Reganold & Wachter, 2016).

At the same time, the system of organic farming is many times criticized as being an inefficient approach to food production and food security. To be recognized as a sustainable alternative to conventional farming, organic farming must illustrate that it can produce sufficient amounts of high-quality food, enhance the natural resources and environment, be financially realistic, and contribute to well-being of farmers and the community (Reganold & Wachter, 2016).

Image source: (Surajith S, 2016)

Image source: (Kate Remmer, 2016)

To begin at a local level, this thesis examined the potential to feed the regional community of Hamburg and sections of the bordering federal states of Mecklenburg-Vorpommern, Niedersachsen and Schleswig-Holstein with organically produced, regional food. Results indicated that the city-state of Hamburg alone (Region One) had very limited potential to feed the citizens within. While Region Two, encompassing a fifty kilometer radius around Hamburg provided better results, still roughly half of citizens could be fed with the presented diets, if we imagine a scenario where 75% of agricultural land is used solely for food production. Region Three, comprising a 100-kilometer radius surrounding the city of Hamburg turned out to have the largest potential for feeding its inhabitants from within, especially in the case of diets with the lowest per capita land footprint for annual food production.

It can be concluded that the largest factor in determining the amount of persons that could be fed with regionally, organically produced food is the consumption quantities of the human diet— specifically, how much meat the average person consumes. Meat and animal products have the largest impact on how much land is required for food production, especially when considering a large proportion of cereals, legumes, etc., go towards animal feed, competing directly with human consumption.

In terms of a complete diet scenario, Diet Scenario Five, according to DGE recommendations, a reduction in meat consumption by 70%, may be the best option in terms of diversity of food selection, including animal and plant products, nutrition and reduced agricultural land use for food production and the consequential quantity of persons fed within the selected regions. On the other hand, perhaps the most realistic diet scenario, which would still have an impact on the reduction of agricultural land use for food production is Diet Scenario Six, which represents a reduction of individual average meat consumption of just 30%— equal to going "meat free" two days per week. Also, consumption of regionally produced foods supports the local community, gives access to fresh, seasonal foods and increases transparency in the production.

In addition to diet choices, organic, regional agriculture can be promoted through bottom up approaches such as Community Supported Agriculture (CSA), food co-ops, regional networks, delivery boxes and Online marketplaces, which may provide the right balance of factors to increase consumers' willingness to pay more for organic products.

In the end, each of us can make a difference. Collective small changes at the individual scale, such as eating "meat free" just one or two days per week, would have big effects on a community, regional, national and international scale. Increased demand for products produced in a sustainable manner can contribute to providing healthy, fresh food to consumers, minimize global sustainability challenges and nurture the environment that has been here for thousands of years before us and must remain for thousands of years to come.

References

AgrEE. (2012). State of the Art on Energy Efficiency in Agriculture. Retrieved January 29, 2016, from Agriculture and Energy Efficiency (Agree): http://www.agree.aua.gr/files/agree_state.pdf

Aschemann-Witzel, J., & Aagaard, E. M. (2014). Elaborating on the attitude–behaviour gap regarding organic products: young Danish consumers and in-store food choice. International Journal of Consumer Studies , 550-558. https://www.researchgate.net/publication/264243254_Elaborating_on_the_Attitude-behaviour_Gap_Regarding_Organic_Products_Young_Danish_Consumers_and_In-store_Food_Choice

BÖLW(a). (2015, February 02). Organic sales growth - and thus the opportunities for organic farming and organic production. Retrieved December 09, 2015, from Bund Ökologische Lebensmittelwirtschaft e.V. (BÖLW): http://www.boelw.de/pm+M5e0beb895d5.html

BÖLW(b). (2016, February 10). Zahlen, Daten, Fakten Die Bio-Branche 2016. Retrieved February 15, 2016, from Bund Ökologische Lebensmittelwirtschaft e. V. (BÖLW): http://www.boelw.de/fileadmin/Veranstaltungen/BIOFACH/ZDF/BOELW_ZDF_2016_web.pdf

BÖLW(c). (2015). Zahlen, Daten, Fakten Die Bio-Branche 2015. Retrieved 16 2016, March, from Bund Ökologische Lebensmittelwirtschaft e. V. (BÖLW): http://www.boelw.de/uploads/media/BOELW_ZDF_2015_web.pdf

BÖWL. (2015, February 02). Organic sales growth - and thus the opportunities for organic farming and organic production. Retrieved December 09, 2015, from Bund Ökologische Lebensmittelwirtschaft e.V.: http://www.boelw.de/pm+M5e0beb895d5.html

Baig, R. (2013, May 14). German farmers can't keep up with organic boom. Retrieved December 09, 2015, from Deutsche Welle: http://www.dw.com/en/german-farmers-cant-keep-up-with-organic-boom/a-16811400

Bajželj, B., Richards, K. S., Allwood, J. M., Smith, P., Dennis, J. S., Curmi, E., et al. (2014, October). Importance of food-demand management for climate mitigation. Retrieved March 14, 2016, from Nature Climate Change: http://www.nature.com/doifinder/10.1038/nclimate2353

Biodynamic Association. (2016). Community Supported Agriculture: An Introduction to CSA. Retrieved March 29, 2016, from Biodynamic Association: https://www.biodynamics.com/content/community-supported-agriculture-introduction-csa#howworks

BMEL(a). (2015, February 24). FAQs on the agricultural reform and national implementation. Retrieved from Federal Ministry of Food and Agriculture (BMEL): http://www.bmel.de/EN/Agriculture/EU-AgriculturalPolicy/_Texte/GAP-FAQs.html

BMEL(b). (2015, July). Organic Farming in Germany. Retrieved September 7, 2015, from Federal Ministry of Food and Agriculture (BMEL): http://www.bmelv.de/SharedDocs/Downloads/EN/Agriculture/OrganicFarming/Organic-Farming-in-Germany.pdf?__blob=publicationFile

BMEL(c). (2011, April). Promotion of Biogas Production. Retrieved February 7, 2016, from Federal Ministry of Food and Agriculture (BMEL): http://www.bmel.de/SharedDocs/Downloads/EN/Ministry/Biogas-EEG.pdf?__blob=publicationFile

BMEL(d). (2014, November). Understanding Farming. Retrieved March 2, 2016, from Federal Ministry of Food and Agriculture (BMEL): http://www.bmel.de/SharedDocs/Downloads/EN/Publications/UnderstandingFarming.pdf?__blob=publicationFile

BMEL(e). (2014). Organic Agriculture in Germany in 2014. Retrieved March 16, 2016, from Federal Ministry of Food and Agriculture (BMEL): https://www.bmel.de/EN/Agriculture/SustainableLandUse/_Texte/OrganicFarmingTable1.html

BMELV (Bundesministerium für Ernährung, Landwirtschaft und Forsten) (2011): Statistisches-Jahrbuch über Ernährung, Landwirtschaft und Forsten 2010. Bremerhaven: Wirtschaftsverlag.

BMELV (b). (2013, January 8). Organic Farming in Germany. Retrieved September 7, 2015, from Federal Ministry of Food and Agriculture: http://www.bmelv.de/SharedDocs/Downloads/EN/Agriculture/OrganicFarming/Organic-Farming-in-Germany.pdf?__blob=publicationFile

Botsman, R., & Rogers, R. (2011). What's Mine is Yours: How Collaborative Consumption is Changing the Way We Live. London, UK: Collins.

Bouraoui, F., & Grizzetti, B. (2013). Modelling mitigation options to reduce diffuse nitrogen water pollution from agriculture. Science of the Total Environment , 468-469, 1267-1277.https://www.ncbi.nlm.nih.gov/pubmed/23998504

Brown, L. R. (2006). Plan B 2.0: Rescuing a Planet Under Stress and a Civilization in Trouble. Retrieved February 2, 2016, from Earth Policy Institute: http://www.earth-policy.org/books/pb2/pb2ch9_ss4

Bürgerschaft der Freien und Hansestadt Hamburg. (2017). Hamburgs Landwirtschaft stärken – Hamburger Öko-Aktionsplan 2020.

Cameron, D., Osborne, C., Horton, P., & Sinclair, M. (2015, December). A sustainable model for intensive agriculture. Retrieved March 14, 2016, from Grantham Centre for Sustainable Futures: http://grantham.sheffield.ac.uk/wp-content/uploads/2015/12/A4-sustainable-model-intensive-agriculture-spread.pdf

CDC. (2015, September 21). Adult Obesity Facts. Retrieved February 4, 2016, from Center for Disease Control (CDC): http://www.cdc.gov/obesity/data/adult.html

Collaborative Lab. (n.d.). The Sharing Economy Lacks Shared Definitions: Give Meaning to the Terms. Retrieved February 10, 2016, from Collaborative Lab: http://www.slideshare.net/collablab

Crowdera, D. W., & Reganold, J. P. (2015, May 1). Financial competitiveness of organic agriculture on a global scale. Retrieved March 15, 2016, from Proceedings of the National Academy of Sciences in the United States of America (PNAS): http://www.pnas.org/content/112/24/7611.full

Davidova, S., & Thomson, K. (2014). Family Farming in Europe: Challenges and Prospects. Retrieved March 15, 2016, from European Parliament: http://www.europarl.europa.eu/RegData/etudes/note/join/2014/529047/IPOL-AGRI_NT(2014)529047_EN.pdf

de Ponti, T., Rijk, B., & van Ittersum, M. K. (2012). The crop yield gap between organic and conventional agriculture. Agricultural Systems , 108, 1-9. https://www.researchgate.net/publication/254406610_The_crop_yield_gap_between_organic_an_conventional_agriculture

Deelstra H., F. M. (1991). Food Policy Trends in Europe: Nutrition, Technology, Analysis and Safety. Elsevier.

Destatis(a). (2014). Consumption expenditure - Germany. Retrieved January 3, 2017, from Destatis: https://www.destatis.de/EN/FactsFigures/SocietyState/IncomeConsumptionLivingConditions/ConsumptionExpenditure/Tables/PrivateConsumption_D_LWR.html

Destatis(b). (2010). Continuing the holding, "farm succession" 2010 in sole proprietorships. Retrieved March 15, 2016, from Destatis: https://www.destatis.de/EN/FactsFigures/EconomicSectors/AgricultureForestryFisheries/CensusAgriculture/Tables/6_2ContinuingHoldingFarmSuccession2010SoleProprietorshipsCensusAgriculture2010FinalResults.html

Destatis(c). (2013). Agricultural holdings. Retrieved March 21, 2016, from Destatis: https://www.destatis.de/EN/FactsFigures/EconomicSectors/AgricultureForestryFisheries/AgriculturalHoldings/Tables/4_1AgriculturalHoldingsTotalHoldingsOrganicFarming2013s.html

Destatis(d). (2014). Farming Area in Total. Retrieved March 21, 2016, from Destatis: https://www-genesis.destatis.de/gis/genView?GenMLURL=https://www-genesis.destatis.de/regatlas/AI001.xml&CONTEXT=REGATLAS01

Destatis(f). (2015, December 17). Kreisfreie Städte und Landkreise nach Fläche, Bevölkerung und Bevölkerungsdichte am 31.12.2014. Retrieved March 27, 2016, from Destatis: https://www.destatis.de/DE/ZahlenFakten/LaenderRegionen/Regionales/Gemeindeverzeichnis/Administrativ/Aktuell/04Kreise.html

Destatis(e). (2015, August 1). Statistisches Bundesamt, Statistisches Jahrbuch 2015. Retrieved March 21, 2016, from Destatis: https://www.destatis.de/DE/Publikationen/StatistischesJahrbuch/StatistischesJahrbuch2015.pdf?__blob=publicationFile

Destatis(g). (2015, December 17). Kreisfreie Städte und Landkreise nach Fläche, Bevölkerung und Bevölkerungsdichte am 31.12.2014. Retrieved March 27, 2016, from Destatis: https://www.destatis.de/DE/ZahlenFakten/LaenderRegionen/Regionales/Gemeindeverzeichnis/Administrativ/Aktuell/04Kreise.html

DGE. (2016). Food guide circle. Retrieved April 6, 2016, from Deutsche Gesellschaft für Ernährung (DGE): https://www.dge.de/ernaehrungspraxis/vollwertige-ernaehrung/ernaehrung-skreis/

DVT (Deutscher Verband Tiernahrung) (2011): Futtermittel-Tabellarium: Ausgabe 2011. Bonn: DVT

Dungworth, L. (2015, November 16). Kattendorfer Hof. (S. Joseph, Interviewer)

ECPA. (2016). What is the Common Agricultural Policy (CAP)? Retrieved April 9, 2016, from European Crop Protection Association (ECPA): http://www.ecpa.eu/information-page/agriculture-today/common-agricultural-policy-cap

Ellis, L. (Writer), & Hill, B. (Director). (2000). Modern Marvels: Farming Technology [Motion Picture].

Eberle, U. (2008): Die Klimaauswirkungen unserer Ernährung. Vortrag auf dem Verbraucherpolitischen Forum „Essen eine Klimasünde? Wie Ernährung und Klima zusammenhängen". Berlin: Verbraucherzentrale Bundesverband.

European Commission (c). (2014). Organic Farming. A guide on support opportunities for organic producers in Europe. Retrieved September 7, 2015, from EU Agriculture and Rural Development: http://ec.europa.eu/agriculture/organic/documents/eu-policy/european-action-plan/support-opportunities-guide_en.pdf

Eurostat(a). (2015, November 11). Agri-environmental indicator - energy use. Retrieved January 29, 2016, from Eurostat: http://ec.europa.eu/eurostat/statistics-explained/index.php/Agri-environmental_indicator_-_energy_use

Eurostat(b). (2015, July). Agriculture - greenhouse gas emission statistics. Retrieved March 15, 2016, from Eurostat: http://ec.europa.eu/eurostat/statistics-explained/index.php/Agriculture_-_greenhouse_gas_emission_statistics

Eurostat(c). (2014, December). Agriculture statistics - family farming in the EU. Retrieved March 15, 2016, from Eurostat: http://ec.europa.eu/eurostat/statistics-explained/index.php/Archive:Agriculture_statistics_-_family_farming_in_the_EU

Eurostat(d). (2015, October). Organic farming statistics. Retrieved March 16, 2016, from Eurostat: http://ec.europa.eu/eurostat/statistics-explained/index.php/Organic_farming_statistics#-Total_organic_area

FAO(a). (2012, June). World agriculture towards 2030/2050: the 2012 revision. Retrieved January 29, 2015, from Food and Agriculture Organization of the United Nations (FAO): http://www.fao.org/docrep/016/ap106e/ap106e.pdf

FAO(b). (n.d.). Chapter 2: Energy for Agriculture. Retrieved January 29, 2016, from Food and Agriculture Organization of the United Nations (FAO): http://www.fao.org/docrep/003/x8054e/x8054e05.htm

FAO(d). (2014, December). Aquastat: Water withdrawal and pressure on water resources. Retrieved February 2, 2016, from Food and Agriculture Organization of the United Nations (FAO): http://www.fao.org/nr/water/aquastat/didyouknow/index2.stm

FAO(e). (2015). Statistical Pocketbook World Food and Agriculture 2015. Retrieved March 14, 2016, from Food and Agriculture Organization of the United Nations (FAO): http://www.fao.org/3/a-i4691e.pdf

FAO(f). (2015). World Agriculture: Towards 2015/2030. An FAO Perspective: Livestock Commodities. Retrieved March 14, 2016, from Food and Agriculture Organization of the United Nations (FAO): http://www.fao.org/docrep/005/y4252e/y4252e05b.htm

FAO(g). (2015, October). Food Outlook: Biannual Report on Global Food Markets. Retrieved March 14, 2016, from Food and Agriculture Organization of the United Nations (FAO): http://www.globalagriculture.org/fileadmin/files/weltagrarbericht/GlobalAgriculture/02Hunger/Oktober2015.pdf

FAO(h). (2011, November). Antibiotics in Farm Animal Production: Public Health and Animal Welfare. Retrieved March 15, 2016, from Food and Agriculture Organization of the United Nations (FAO): http://www.fao.org/fileadmin/user_upload/animalwelfare/antibiotics_in_animal_farming.pdf

FAO(i). (2016). The State of Food Insecurity in the World 2015. Retrieved February 4, 2016, from Food and Agriculture Organization of the United Nations (FAO): http://www.fao.org/hunger/en/

FAO(j). (2015, June 10). Whittling down instances of child labour in agriculture. Retrieved March 15, 2016, from Food and Agriculture Organization of the United Nations (FAO): http://www.fao.org/zhc/detail-events/en/c/293318/

FAOSTAT. (2014). FAOSTAT. Retrieved March 14, 2016, from FAOSTAT: Food and Agriculture Organization of the United Nations: http://faostat.fao.org/

FAOSTAT(a). (2016). Primary Livestock Production. Retrieved March 14, 2016, from FAOSTAT: Food and Agriculture Organization of the United Nations (FAO): http://faostat.fao.org/site/569/DesktopDefault.aspx?PageID=569#ancor

FAOSTAT(b). (2014, April). Agricultural area. Retrieved March 14, 2016, from FAOSTAT: Food and Agriculture Organization of the United Nations (FAO): http://faostat.fao.org/site/377/Desktop-Default.aspx?PageID=377#ancor

Federico, G. (2005). Feeding the World: An Economic History of Agriculture, 1800-2000. Princeton, New Jersey, United States of America: Princeton University Press.

Friedrich, B. (2013, March 16). The Cruelest of All Factory Farm Products: Eggs From Caged Hens. Retrieved January 4, 2016, from Huffington Post: http://www.huffingtonpost.com/bruce-friedrich/eggs-from-caged-hens_b_2458525.html

Fritsche, U.R.; Eberle, U. (2007): Treibhausgasemissionen durch Erzeugung und Verarbeitung von Lebensmitteln. Darmstadt: Öko-Institut e.V

Frost, D. (2014, December 16). Organic food – can we reduce the price barrier? Retrieved February 11, 2016, from Organic Centre Wales: http://organicfoodandfarming.org.uk/organic-food-can-we-reduce-the-price-barrier/

Frötscher, F. (2016, February 8). Warenwirtschaft. (S. Joseph, Interviewer)

Gilbert, N. (2012, October 31). One-third of our greenhouse gas emissions come from agriculture. Retrieved March 15, 2016, from Nature News: http://www.nature.com/news/one-third-of-our-greenhouse-gas-emissions-come-from-agriculture-1.11708

Global Agriculture. (n.d.). Industrial Agriculture and Small-scale Farming. Retrieved January 26, 2016, from Global Agriculture: http://www.globalagriculture.org/report-topics/industrial-agriculture-and-small-scale-farming/industrial-agriculture-and-small-scale-farming.html

GMO-Free Europe. (2015). Germany. Retrieved January 28, 2016, from GMO-Free Europe: http://www.gmo-free-regions.org/gmo-free-regions/germany.html

Harvard. (n.d.). Adult Obesity. Retrieved February 4, 2016, from Harvard T.C. Chan School of Public Health: http://www.hsph.harvard.edu/obesity-prevention-source/obesity-trends/obesity-rates-worldwide/

Heinrich Böll Foundation. (2014, January). Meat Atlas. Retrieved January 28, 2016, from Friends of Earth Europe: https://www.foeeurope.org/sites/default/files/publications/foee_hbf_meatatlas_jan2014.pdf

Hempel, C., & Hamm, U. (2016). How important is local food to organic-minded consumers? Appetite , 96, 309-318.

Herrero, M., Havlík, P., Valin, H., Notenbaert, A., Rufino, M. C., Thorntond, P. K., et al. (2013, October 15). Biomass use, production, feed efficiencies, and greenhouse gas emissions from global livestock systems. Retrieved March 14, 2016, from Proceedings of the National Academy of Sciences of the United States of America (PNAS): http://www.pnas.org/content/110/52/20888.full#content-block

Hesterman, O. B. (2011). Fair Food: Growing a Healthy, Sustainable Food System for All. New York: BBS Publications.

Hinrichs, C. (2000). Embeddedness and local food systems: notes on two types of direct agricultural market. Journal of Rural Studies, 16 (3), 295-303. http://www.academia.edu/3439200/Embeddedness_and_local_food_systems_notes_on_two_types_of_direct_agricultural_market

Hoekstra, A.Y., Chapagain, A.K. (2007). Water footprints of nations: Water use by people as a function of their consumption pattern. Water Resource Management, 21-35. https://link.springer.com/article/10.1007%2Fs11269-006-9039-x

Hughner, R. S., McDonagh, P., Prothero, A., Shultz II, C. J., & Stanton, J. (2008). Who are organic food consumers? A compilation and review of why people purchase organic food. Journal of Consumer Behaviour. http://www.academia.edu/516926/Who_are_organic_food_consumers_A_compilation_and_review_of_why_people_purchase_organic_food

IAASTD. (2009). Agriculture at a Crossroads: Global Report. Retrieved March 15, 2016, from International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD): http://www.unep.org/dewa/agassessment/reports/IAASTD/EN/Agriculture%20at%20a%20Crossroads_Global%20Report%20(English).pdf

Jörck, T. (2015, September 24). Owner of BioInsel Organic Shop. (S. Joseph, Interviewer) Hamburg, Germany.

Jungbluth, N, Itten, René & Schori, S. (2014). Environmental impacts of food consumption and its reduction potentials. 8th International Conference on LCA in the Agri-Food Sector, Rennes, France, 2-4 October 2012

Krömker, D., & Matthies, E. (2014). Differences between Occasional Organic and Regular Organic Food Consumers. Food and Nutrition Sciences , 1914-1925. http://file.scirp.org/pdf/FNS_2014101416433070.pdf

Ladner, P. (2011). The Urban Food Revolution: Changing the Way We Feed Cities. Gabriola Island, BC, Canada: New Society Publishers.

Little, J. B. (2009, March 1). The Ogallala Aquifer: Saving a Vital U.S. Water Source. Retrieved February 2, 2016, from Scientific American: http://www.scientificamerican.com/article/the-ogallala-aquifer/

Mateo-Sagasta, J., & Burke, J. (2011). Agriculture and water quality interactions: a global overview. Retrieved March 15, 2016, from Food and Agriculture Organization of the United Nations (FAO): http://www.fao.org/fileadmin/templates/solaw/files/thematic_reports/TR_08.pdf

Mecklenburg-Vorpommern Statistiches Amt. (n.d.). Agriculture, forestry and fishing. Retrieved March 21, 2016, from Mecklenburg-Vorpommern Statistiches Amt: http://sisonline.statistik.m-v.de/sachgebiete/suche/41

Mekonnen, M., & Hoekstra, A. (2010, December). The Green, Blue and Grey Water Footprint of Farm Animals and Animal Products: Volume 1: Main Report. Retrieved March 14, 2016, from Water Footprint: http://waterfootprint.org/media/downloads/Report-48-WaterFootprint-AnimalProducts-Vol1_1.pdf

Meier, T.; Christen, O. (2011): Umweltwirkungen der Ernährung: Ökobilanzierung des Nahrungsmittelverbrauchs tierischer Produkte nach Gesellschaftsgruppen in Deutschland. Beitrag zur Jahrestagung der Gesellschaft für Wirtschaftsund Sozialwissenschaften des Landbaus (GEWISOLA). Halle (Saale).

Meier, T.; Christen, O.; Semler, E.; Jahreis, G.; Voget-Kleschin, L.; Schrode, A.; Artmann, M. (2014): Balancing virtual land imports by a shift in the diet. Using a land balance approach to assess the sustainability of food consumption. Germany as an example. In: Appetite 75, p. 20–34.

Morgen, J. (2014, October 16). Why The Collaborative Economy Is Changing Everything. Retrieved February 10, 2016, from Forbes Leadership: http://www.forbes.com/sites/jacobmorgan/2014/10/16/why-the-collaborative-economy-is-changing-everything/#3594b9de4fc1

Muhammad, F. (2014, December 11). Saudi Arabia to stop wheat production by 2016. Retrieved February 2, 2016, from AL Arabiya English: http://english.alarabiya.net/en/business/economy/2014/12/11/KSA-to-stop-wheat-production-by-2016.html

Nieberg, H. (2009): Auf den Nahrungskonsum zurückzuführende THG-Emissionen. In: Osterburg, B.; Nieberg, H.; Rüter, S.; Isermeyer, V.; Haenel, H.D.; Hahne, J.; Krentler, J.G.; Paulsen, H.M.; Schuchardt, F.; Schweinle, J.; Weiland, P. (Hrsg.): Erfassung, Bewertung und Minderung von Treibhausgasemissionen des deutschen Agrar- und Ernährungssektors. Arbeitsberichte aus der vTI-Agrarökonomie 03/2009. Braunschweig: vTI.

Niedersachsen. (2016, February). Ergänzungen zur Broschüre: Die niedersächsische Landwirtschaft in Zahlen 2014 (Stand 03.02.2016) . Retrieved March 21, 2016, from Niedersachsen: http://www.ml.niedersachsen.de/portal/live.php?navigation_id=1364&article_id=121348&_psmand=7

Non-GMO Project. (2016). WHAT IS GMO? Agricultural Crops That Have a Risk of Being GMO. Retrieved January 26, 2016, from Non-GMO Project: http://www.nongmoproject.org/learn-more/what-is-gmo/

Organic Net. (2015, November 2). It's Time You Meet Our Startup: OrganicNet. (S. S. Novoselac, Editor) Retrieved February 11, 2016, from Eton Digital: http://www.etondigital.com/its-time-you-meet-our-startup-organicnet/

Owen, J. (2005, December 9). Farming Claims Almost Half Earth's Land, New Maps Show. Retrieved January 29, 2016, from National Geographic: http://news.nationalgeographic.com/news/2005/12/1209_051209_crops_map.html

Padilla Bravo, C., Cordts, A., Schulze, B., & Spiller, A. (2013). Assessing determinants of organic food consumption using data from the German National Nutrition Survey II. Food Quality and Preference , 28 (1), 60-70.

Perren, R., & Grauerholz, L. (2015). Collaborative Consumption. Retrieved March 16, 2016, from International Encyclopedia of the Social & Behavioral Sciences: http://dx.doi.org/10.1016/B978-0-08-097086-8.64143-0

Pimentel, D., & Pimentel, M. (2003). Sustainability of meat-based and plant-based diets and the environment. Retrieved February 2, 2016, from American Journal of Clinical Nutrition: http://ajcn.nutrition.org/content/78/3/660S.full.pdf+html

Rankin, B. (2009). World Cropland. Retrieved January 29, 2016, from Radical Cartology: http://www.radicalcartography.net/index.html?worldcrops

Reganold, J. P., & Wachter, J. M. (2016). Organic agriculture in the twenty-first century. Nature Plants , 2.

Reinhardt, G.; Gärtner, S.; Münch, J.; Häfele, S. (2009): Ökologische Optimierung regional erzeugter Lebensmittel: Energie- und Klimabilanzen. Heidelberg: IFEU.

Reisch, L., Eberle, U., & Lorek, S. (2013). Sustainable food consumption : an overview of contemporary issues and policies. Sustainability: Science, Practice, & Policy , 9 (2), 7-25. https://sspp.proquest.com/sustainable-food-consumption-an-overview-of-contemporary-issues-and-policies-fa0273bf5ea1#.e4a2132lk

Rexroth. (2012, July). Rexroth: Bosch Group. Retrieved January 26, 2016, from History: The mechanization of agriculture: http://www.boschrexroth.com/de/de/trends-und-themen/directions/agricultural-technology-in-the-21stcentury-2#

Rossbach, H. (2013, May 7). Die Biolebensmittel reichen nicht. Retrieved February 7, 2016, from Frankfurter Allgemeine: http://www.faz.net/aktuell/wirtschaft/wirtschaftspolitik/lebensmittel/immer-mehr-importe-die-biolebensmittel-reichen-nicht-12174744.html

Sage, J. L., & Goldberger, J. R. (2012). Decisions to direct market: Geographic influences on conventions in organic production. Applied Geography , 34, 57-65.

Sagener, N. (2015, April 13). Agriculture poses immense threat to environment, German study says. Retrieved February 3, 2016, from EurActiv: http://www.euractiv.com/sections/energy/agriculture-poses-immense-threat-environment-german-study-says-313669

Sarmadi, D. (2015, April 17). WWF: Irresponsible food consumption fuels global climate change. Retrieved February 3, 2016, from EurActiv: http://www.euractiv.com/sections/development-policy/wwf-irresponsible-food-consumption-fuels-global-climate-change-313483

Schönheim, U. (2016, January 26). Board Member Regionalwert-Hamburg. (S. Joseph, Interviewer)

Schleswig-Holstein. (n.d.). Agrarstatistik. Retrieved March 21, 2016, from Ministry of Energy Transition, Agriculture, Environment and Rural Areas Schleswig-Holstein: http://www.schleswig-holstein.de/DE/Schwerpunkte/Agrarstatistik/agrarstatistik_node.html

Sedghi, A. (2013, January 10). How much water is needed to produce food and how much do we waste? Retrieved February 2, 2016, from The Guardian: http://www.theguardian.com/news/datablog/2013/jan/10/how-much-water-food-production-waste#data

Seufert, V., Ramankutty, N., & Foley, J. a. (2012). Comparing the yields of organic and conventional agriculture. Nature , 485 (7397), 229-232.bhttps://www.researchgate.net/publication/224846705_Comparing_the_yields_of_organic_and_conventional_agriculture

Simons, L. (2015). Changing the Food Game. Sheffield, UK: Greenleaf Publishing.

Smith-Spangler, C., Brandeau, M., Hunter, G., Bavinger, J., Pearson, M., Eschbach, P., et al. (2012, September 4). Are organic foods safer or healthier than conventional alternatives?: a systematic review. Annals of Internal Medicine , 348-366.

Solidarischer Landwirtschaft. (2016). Die Idee. Retrieved March 29, 2016, from Solidarischer Landwirtschaft: http://www.solidarische-landwirtschaft.org/de/was-ist-solawi/die-idee/

Statista. (2014). Market share of the leading companies in food retail in Germany in 2014. Retrieved March 15, 2016, from Statista: http://www.statista.com/statistics/505129/leading-companies-in-food-retail-germany/

Statistikamt Nord. (n.d.). Landwirtschaft. Retrieved March 21, 2016, from Statistisches Amt für Hamburg und Schleswig-Holstein (Statistikamt Nord): http://www.statistik-nord.de/daten/landwirtschaft/

Statistische Ämter des Bundes und der Länder(a). (2013). Regionale Landwirtschaftliche Gesamtrechnung. Retrieved March 21, 2016, from Statistische Ämter des Bundes und der Länder: http://www.statistik-portal.de/LGR/DE_home.asp

Statistische Ämter des Bundes und der Länder(b). (2015). Agriculture. Retrieved March 21, 2016, from Statistische Ämter des Bundes und der Länder: http://www.statistikportal.de/Statistik-Portal/en/en_inhalt11.asp

Stone, A. (2014, September 29). Global Survey Says We're Eating Better, But Our Diet Is Still Unsustainable. Retrieved February 5, 2016, from National Geographic: http://news.nationalgeographic.com/news/2014/09/140929-greendex-survey-environmental-attitudes-ngfood/

Sustainable America. (2015, June 23). Introducing the New Shared Earth. Retrieved February 14, 2016, from Sustainable America: http://www.sustainableamerica.org/blog/introducing-the-new-shared-earth/

The Economist. (2013, December 31). Meat and greens. Retrieved January 29, 2016, from The Economist: http://www.economist.com/blogs/feastandfamine/2013/12/livestock

Thornton, P. Recalibrating Food Production in the Developing World: Global Warming Will Change More Than Just the Climate. CCAFS Policy Brief no. 6. (CGIAR Research Program on Climate Change, Agriculture and Food Security, 2012).

U.S. National Library of Medicine. (2016, April 5). Healthy food trends -- beans and legumes. Retrieved April 10, 2016, from U.S. National Library of Medicine: https://www.nlm.nih.gov/medlineplus/ency/patientinstructions/000726.htm

UBA(a). (2014, February 18). Organic Farming. Retrieved March 15, 2016, from Umweltbundesamt (UBA): http://www.umweltbundesamt.de/en/print/topics/soil-agriculture/toward-ecofriendly-farming/organic-farming 1/4

UBA(b). (2015, July 10). Organic farming. Retrieved March 21, 2016, from Umweltbundesamt (UBA): https://www.umweltbundesamt.de/daten/land-forstwirtschaft/landwirtschaft/oekologischer-landbau

UBA(c). (Umweltbundesamt) (2014): Nachhaltiger Konsum: Entwicklung eines deutschen Indikatorensatzes als Beitrag zu einer thematischen Erweiterung der deutschen Nachhaltigkeitsstrategie. Dessau-Roßlau: UBA.

UC Davis. (2015, September 18). What is sustainable agriculture? Retrieved February 5, 2016, from Sustainable Agriculture Research and Education Program: http://asi.ucdavis.edu/programs/sarep/about/what-is-sustainable-agriculture

Umweltbundesamt (b). (2014, February 18). Organic Farming. Retrieved September 8, 2015, from Umwelt Bundesamt: http://www.umweltbundesamt.de/en/print/topics/soil-agriculture/toward-ecofriendly-farming/organic-farming 1/4

Umweltbundesamt (c). (2014). Green Products in Germany. Retrieved April 12, 2016, from Umwelt Bundesamt: www.uba.de/publikationen/ green-products-in-germany-2014

UN Social. (2016). About Cooperatives. Retrieved March 29, 2016, from United Nations Social : http://social.un.org/coopsyear/cooperatives-are.html

UN. (2010). Unece Standard Egg. Retrieved March 27, 2016, from United Nations (UN): http://www.unece.org/fileadmin/DAM/trade/agr/standard/eggs/Standards/EGG01_EggsInShell_2010E.pdf

UN Water. (2009). The United Nations World Water Development Report 3. Retrieved February 2, 2016, from UNESCO: http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/SC/pdf/WWDR3_Facts_and_Figures.pdf

UN Water(a). (2009). The United Nations World Water Development Report 3. Retrieved February 2, 2016, from UNESCO: http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/SC/pdf/WWDR3_Facts_and_Figures.pdf

UN Water(b). (2015). The United Nations World Water Development Report 2015. Retrieved March 14, 2016, from UNESCO: http://unesdoc.unesco.org/images/0023/002318/231823E.pdf

Urgenci. (2013). Solidarische Landwirtschaft. Retrieved February 14, 2016, from Urgenci: The International Network for Community Supported Agriculture: http://urgenci.net/germany/

US EPA. (2015, November 5). DDT - A Brief History and Status. Retrieved January 28, 2016, from US EPA: http://www.epa.gov/ingredients-used-pesticide-products/ddt-brief-history-and-status

USDA(a). (2016, January 28). Livestock & Meat Domestic Data. Retrieved February 2, 2016, from United States Department of Agriculture (USDA): http://www.ers.usda.gov/data-products/livestock-meat-domestic-data.aspx

USDA(b). (2015, October 15). Number and Geographical Distribution of Hired Farmworkers. Retrieved February 4, 2016, from United States Department of Agriculture (USDA): http://www.ers.usda.gov/topics/farm-economy/farm-labor/background.aspx

USGS. (2014). High Plains Water-Level Monitoring Study (Groundwater Resources Program). Retrieved February 2, 2016, from USGS: http://ne.water.usgs.gov/ogw/hpwlms/images/HPwlcpd13.jpg

Van Doorn, J., & Verhoef, P. C. (2015). Drivers of and Barriers to Organic Purchase Behavior Drivers of and Barriers to Organic Purchase Behavior. Journal of Retailing.

von Alvensleben, R. (1999): Die Fleischwirtschaft von morgen: Anforderungen von Gesellschaftund Verbrauchern. In: Lohmann Information Januar–März 1999, 1/99.

Von Bonin, U. (2015, November 10). Farmer at Arpshof . (S. Joseph, Interviewer)

Wackernagel, M., & Rees, W. (1996). Our ecological footprint: Reducing human impact on the earth. Oxford, UK: John Carpenter.

WFP. (2016). Hunger Statistics. Retrieved February 4, 2016, from World Food Program (WFP): https://www.wfp.org/hunger/stats

WHO(a). (2015, March 20). IARC Monographs Volume 112: evaluation of five organophosphate insecticides and herbicides. Retrieved March 15, 2016, from World Health Organization (WHO): International Agency for Research on Cancer: https://www.iarc.fr/en/media-centre/iarcnews/pdf/MonographVolume112.pdf

WHO(b). (2015, January). Obesity and overweight. Retrieved March 15, 2016, from World Health Organization (WHO):: http://www.who.int/mediacentre/factsheets/fs311/en/

Wiegmann, K.; Schmidt, K. (2007): Treibhausgasemissionen durch Erzeugung und Verarbeitung von Lebensmitteln. Freiburg: Öko-Institut.

Willer, H., & Lernoud, J. (. (2016, February 10). The World of Organic Agriculture Statistics and Emerging Trends 2016 . Retrieved February 14, 2016, from Research Institute of Organic Agriculture (FiBL), Frick, and IFOAM – Organics International, Bonn: http://www.organic-world.net/yearbook/yearbook-2016.html

World Bank. (2013). Agricultural land (% of land area). Retrieved January 29, 2016, from World Bank: http://data.worldbank.org/indicator/AG.LND.AGRI.ZS/countries/1W-DE?display=graph

World Bank(a). (2013). Agricultural land (% of land area). Retrieved January 29, 2016, from World Bank: http://data.worldbank.org/indicator/AG.LND.AGRI.ZS/countries/1W-DE?display=-graph

World Bank(b). (2016). Employment in agriculture (% of total employment). Retrieved March 14, 2016, from The World Bank: http://data.worldbank.org/indicator/SL.AGR.EMPL.ZS

World Watch. (2004, July). Is Meat Sustainable? Retrieved January 29, 2016, from World Watch Institute: http://www.worldwatch.org/node/549

WWF(a). (2011). Meat Eats Land. Retrieved January 28, 2016, from World Wide Fund for Nature (WWF): http://www.wwf.de/fileadmin/fm-wwf/Publikationen-PDF/Meat_eats_land.pdf

WWF(b). (2012, October). Climate Change On Your Plate. Retrieved January 29, 2016, from World Wide Fund for Nature (WWF): http://www.wwf.de/fileadmin/fm-wwf/Publikationen-PDF/Climate_change_on_your_plate.pdf

WWF(c). (2015). Threat of eutrophication to the Baltic Sea. Retrieved January 25, 2016, from World Wide Fund for Nature (WWF): http://wwf.panda.org/what_we_do/where_we_work/baltic/threats/eutrophication/

WWF(d). (2014, June). The Imported Risk: Germany's Water Risks in Times of Globalisation. Retrieved February 2, 2016, from World Wide Fund for Nature (WWF): http://www.wwf.de/fileadmin/fm-wwf/Publikationen-PDF/WWF_Study_Waterrisk_Germany.PDF

WWF(e). (2016). Farming: Soil erosion and degradation. Retrieved February 3, 2016, from World Wide Fund for Nature (WWF): http://wwf.panda.org/what_we_do/footprint/agriculture/impacts/soil_erosion/

WWF(f). (2012). Tons for the Trash. Retrieved February 4, 2016, from World Wide Fund for Nature (WWF): http://www.wwf.de/fileadmin/fm-wwf/Publikationen-PDF/Tons_for_the_trash.pdf

WWF(g). (2015, March). Das Grosse Fressen. Retrieved March 15, 2016, from World Wide Fund for Nature (WWF): http://www.wwf.de/fileadmin/fm-wwf/Publikationen-PDF/WWF_Studie_Das_grosse_Fressen_Zusammenfassung.pdf

WWF(h). (2015). Nahrungsmittelverbrauch und Fußabdrücke des Konsums in Deutschland. Retrieved March 24, 2016, from World Wide Fund for Nature (WWF): http://www.wwf.de/fileadmin/fm-wwf/Publikationen-PDF/WWF_Studie_Nahrungsmittelverbrauch_und_Fussabduecke_des_Konsums_in_Deutschland.pdf

Appendix I: Breakdown of land footprint by food group

	Diet Scenario 1			**Diet Scenario 2**		
	(1) Potato Diet			**(2) Status Quo Conventional Diet**		
Food Group	**Quantity (kg / (cap* yr))**	**Land Footprint (m^2/yr)**	**% of Land Footprint**	**Quantity (kg / (cap* yr))**	**Land Footprint (m^2/yr)**	**% of Land Footprint**
Cereal & products	0	0	0%	95.6	231.0	10%
Potato & products	1095.0	328.5	100%	70.7	21.0	1%
Rice	0	0	0%	5.3	11.0	0%
Legumes	0	0	0%	0.4	0.5	0%
Sugar products (including honey)	0	0	0%	48.0	30.0	1%
Vegetables	0	0	0%	95.4	30.0	1%
Fruits	0	0	0%	110.5	99.0	4%
Oils & fats	0	0	0%	19.9	119.0	5%
Beef	0	0	0%	13.0	351.0	15%
Pork	0	0	0%	52.6	468.0	20%
Poultry	0	0	0%	18.5	150.0	6%
Sheep/goat	0	0	0%	0.9	24.0	1%
Eggs	0	0	0%	13.3	84.0	4%
Other Meat	0	0	0%	2.0	23.0	1%
Fish & products	0	0	0%	14.1	18.0	1%
Milk & products	0	0	0%	118.8	602.0	25%
Coffee/cocoa/tea	0	0	0%	n.a.	127.0	5%
Nature conservation	0	0	0%	n.a.	0.0	0%
Total:	**1095.0**	**328.5**	**100%**	**679**	**2,388.5**	**100%**

Source: (WWF(h), 2015)

	Diet Scenario 5			**Diet Scenario 6**		
	DGE Food Guide Plan			**Status Quo + Reducing Meat & Egg intake by 30% (two "meat free" days per week)**		
Food Group	**Annual Consumption (kg)**	**Land Footprint Produced Conventionally (m^2)**	**Land Footprint Produced Organically (m^2)**	**Annual Consumption (kg)**	**Land Footprint Produced Conventionally (m^2)**	**Land Footprint Produced Organically (m^2)**
Cereal & products	91.3	220.5	280.5	95.6	231.0	293.8
Potato & products	82.1	24.4	43.7	70.7	21.0	37.6
Rice	0.0	0.0	0.0	5.3	11.0	11.7
Legumes	40.0	47.0	57.2	30	35.3	42.9
Sugar products	14.4	9.0	12.2	48.0	30.0	40.5
Vegetables	182.5	57.4	84.3	95.4	30.0	44.1
Fruits	109.5	98.1	128.0	110.5	99.0	129.1
Oils & fats	12.8	76.4	102.9	19.9	119.0	160.2
Meat & products (including eggs)	32.1	356.7	458.6	70.2	780.0	1002.9
Fish & products	8.9	11.3	15.7	14.1	18.0	25.0
Milk & products	102.2	517.9	750.6	118.8	602.0	872.5
Coffee/cocoa/tea	n.a.	127.0	160.7	n.a.	127.0	160.7
Nature conservation	n.a.	0.0	50.0	n.a.	0.0	50.0
Total:	**675.73**	**1545.7**	**2144.2**	**679**	**2,103.3**	**2,871.0**

Source: (DGE, 2016).

Diet Scenario 3 / Diet Scenario 4

	(3) Kattendorfer Hof Demeter Diet			(4) Status Quo Demeter Diet		
Food Group	**Quantity (kg / (cap* yr))**	**Land Footprint (m^2/yr)**	**% of Land Footprint**	**Quantity (kg / (cap* yr))**	**Land Footprint (m^2/yr)**	**% of Land Footprint**
Cereal & products	120.0	350.0	15%	95.6	293.8	9%
Potato & products	70.0	50.0	2%	70.7	37.6	1%
Rice	0.0	0.0	0%	5.3	11.7	0%
Legumes	40.0	56.0	2%	0.4	0.6	0%
Sugar products (including honey)	5.0	0.0	0%	48.0	40.5	1%
Vegetables	165.0	99.0	4%	95.4	44.1	1%
Fruits	91.3	100.4	4%	110.5	129.1	4%
Oils & fats	5.0	50.0	2%	19.9	160.2	5%
Beef	37.0	700.0	30%	13.0	487.5	15%
Pork				52.6	650.0	19%
Poultry				18.5	208.3	6%
Sheep/goat				0.9	33.3	1%
Eggs	9.0			13.3	116.7	3%
Other Meat	0.0	0.0	0%	2.0	31.9	1%
Fish & products	0.0	0.0	0%	14.1	25.0	1%
Milk & products	99.4	730.0	31%	118.8	872.5	26%
Coffee/cocoa/tea	n.a.	160.7	7%	n.a.	160.7	5%
Nature conservation	n.a.	50.0	2%	n.a.	50.0	1%
Total:	**642**	**2,346.1**	**100%**	**679**	**3,353.6**	**100%**

Source: (Dungworth, 2015)

Diet Scenario 7 / Diet Scenario 8

	Status Quo + Reducing Meat & Egg intake by 60% (two "meat free" days per week)			Status quo, Except Vegetarian Diet + Increasing Legume and Egg Intake		
Food Group	**Annual Consumption (kg)**	**Land Footprint Produced Conventionally (m^2)**	**Land Footprint Produced Organically (m^2)**	**Annual Consumption (kg)**	**Land Footprint Produced Conventionally (m^2)**	**Land Footprint Produced Organically (m^2)**
Cereal & products	95.6	231.0	293.8	95.6	231.0	293.8
Potato & products	70.7	21.0	37.6	70.7	21.0	37.6
Rice	5.3	11.0	11.7	5.3	11.0	11.7
Legumes	60.0	70.5	85.7	70	82.3	100.0
Sugar products	48.0	30.0	40.5	48.0	30.0	40.5
Vegetables	95.4	30.0	44.1	95.4	30.0	44.1
Fruits	110.5	99.0	129.1	110.5	99.0	129.1
Oils & fats	19.9	119.0	160.2	19.9	119.0	160.2
Meat & products (including eggs)	40.1	445.6	572.9	0.0	0.0	0.0
				15.0	166.7	214.3
				0.0	0.0	0.0
Fish & products	14.1	18.0	25.0	0.0	0.0	0.0
Milk & products	118.8	602.0	872.5	118.8	602.0	872.5
Coffee/cocoa/tea	n.a.	127.0	160.7	n.a.	127.0	160.2
Nature conservation	n.a.	0.0	50.0	n.a.	0.0	50.0
Total:	**678**	**1,804.06**	**2,483.9**	**649**	**1,518.9**	**2114.1**

Appendix II: Calculation of Yield Efficiencies

	Case Study	Comparable Studies		Current Data	Ave. Used
Food Group	Demeter (3) (Ave) / Conventional (2) Yields	Seufert et al., Organic Yield (Ave) / Conv. Yield	de Ponti et al., Organic Yield (Ave) / Conv. Yield	destatis : Organic Yield (Ave) / Germany 2014/2015 Conv. Yield	Organic Yield / Conv. Yield (Ave)
Cereal & products	83%	74%	79%	n.a.	79%
Potato & products	42%	n.a.	70%	n.a.	56%
Rice	n.a.	n.a.	94%	n.a.	94%
Legumes	84%	90%	89%	66%	82%
Sugar products (including honey)	n.a.	n.a.	n.a.	n.a.	74%
Vegetables	52%	67%	80%	73%	68%
Fruits	n.a.	97%	72%	61%	77%
Oils & fats	60%	89%	74%	n.a.	74%
Beef	72%	n.a.	n.a.	n.a.	72%
Pork		n.a.	n.a.	n.a.	
Poultry		n.a.	n.a.	n.a.	
Sheep/goat		n.a.	n.a.	n.a.	
Eggs		n.a.	n.a.	n.a.	
Other Meat	n.a.	n.a.	n.a.	n.a.	
Fish & products	n.a.	n.a.	n.a.	n.a.	
Milk & products	69%	n.a.	n.a.	n.a.	69%
				Average:	74%

Sources : (de Ponti, et al., 2012)

(Seufert, et al., 2012)

(Destatis(e), 2015)

(WWF(h), 2015)

Food Category	Item	Food supply quantity (kg/capita/yr)	Food supply quantity (kg/capita/day)	Food supply quantity (g/capita/day)	Food supply (kcal/capita/day)	Calories of Specific Crops (kcal/g)	Protein Supply Quantity (g/capita/day)	Protein Values of Specific Crops (grams per gram of food)	Fat Supply Quantity (g/capita/day)	Fat Values of Specific Crops (grams per gram of food)
Cereals	Cereals and products	111.5	0.305479452	305.4794521	871	**2.85**	26.6	**0.09**	3.50	**0.01**
Potatoes	Potatoes and products	70.7	0.19369863	193.6986301	131	**0.68**	2.9	**0.01**	0.20	**0.00**
Rice	Rice (Milled Equivalent)	3	0.008219178	8.219178082	31	**3.77**	0.6	**0.07**	0.10	**0.01**
Legumes	Beans	0.1	0.000273973	0.273972603	1	**3.48**	0.1	**0.31**	0.00	**0.00**
	Peas	0.7	0.001917808	1.917808219	6		0.4		0.00	
	Pulses, Other and products	0.2	0.000547945	0.547945205	2		0.2		0.00	
Sugars	Sugar & Sweeteners + (Total)	47.8	0.130958904	130.9589041	464	**3.55**	0.0	**0.00**	0.00	**0.00**
	Sugar (Raw Equivalent)	36.9	0.10109589	101.0958904	358		0.0		0.00	
	Sweeteners, Other	9.9	0.027123288	27.12328767	97		0.0		0.00	
Vegetables	Vegetables	94.3	0.258356164	258.3561644	68	**0.26**	3.2	**0.01**	0.60	**0.00**
Fruits (including nuts)	Fruits	80.4	0.220273973	220.2739726	102	**0.55**	1.1	**0.01**	0.60	**0.01**
	Nuts and products	6.4	0.017534247	17.53424658	46		1.2		4.30	
Oils and fats	Oil crops	3.7	0.010136986	10.1369863	35	**3.45**	1.8	**0.15**	2.70	**0.27**
Meat	Bovine Meat	13.4	0.036712329	36.71232877	39	**1.06**	4.8	**0.13**	2.10	**0.06**
	Pigmeat	53.5	0.146575342	146.5753425	248	**1.69**	14.7	**0.10**	20.50	**0.14**
	Poultry Meat	18	0.049315068	49.31506849	65	**1.32**	7.4	**0.15**	3.80	**0.08**
	Mutton & Goat Meat	0.9	0.002465753	2.465753425	6	**2.43**	0.3	**0.12**	0.50	**0.20**
	Meat, Other	2.2	0.006027397	6.02739726	7	**1.16**	1.3	**0.22**	0.20	**0.03**
Fish	Fish , Seafood	14.2	0.03890411	38.90410959	40	**1.03**	4.5	**0.12**	2.30	**0.06**
Milk	Milk - Excluding Butter	255.4	0.699726027	699.7260274	335	**0.48**	24.1	**0.03**	17.50	**0.03**
Eggs	Eggs	12.8	0.035068493	35.06849315	49	**1.40**	4.0	**0.11**	3.50	**0.10**
Coffee	Coffee and products	6.4	0.017534247	17.53424658	8	**0.46**	1.0	**0.06**	0.00	**0.00**
Cocoa	Cocoa Beans and products	2.1	0.005753425	5.753424658	35	**6.08**	0.5	**0.09**	3.20	**0.56**
Tea	Tea (including mate)	0.5	0.001369863	1.369863014	0	**0.00**	0.1	**0.07**	0.00	**0.00**

Source : FAO balance sheet Germany, 2011

Production Efficiencies		
Food Group	Conventional (kg/m²)	Organic. (kg/m²)
Cereal & products	0.41	0.33
Potato & products	3.37	1.88
Rice	0.48	0.45
Legumes	0.85	0.70
Sugar products	1.60	1.18
Vegetables	3.18	2.17
Fruits	1.12	0.86
Oils & fats	0.17	0.12
Meat & products (including eggs)	0.09	0.07
Fish & products	0.78	0.56
Milk & products	0.20	0.14
Coffee/cocoa/tea	n.a.	n.a.
Nature conservation	n.a.	n.a.
Total:		

Sources : (de Ponti, et al., 2012)
(Seufert, et al., 2012)
(Destatis(e), 2015)
(WWF(h), 2015)

Appendix III: Calculations for Maximum Persons Fed Per Region

Region 1: Hamburg

Bundesland	*(Landkreis)* County	Total Area (km²) *(A)*	Total Area (km²) of Selected Landkreise	Percentage Agricultural Area *(B)*	Total Farming Area (km²) (Upper Bound = 100%)	Total Farming Area (km²) (Middle Bound = 75%)	Total Farming Area (km²) (Lower Bound = 50%)	Population
Hamburg	Hamburg	755.30	755.30	24.6%	185.80	139.35	92.90	1,762,791
	Total:	**755.30**	**755.30**		**185.80**	**139.35**	**92.90**	**1,762,791**

Diets 1-8

	Maximum persons fed with diet (Upper Bound)							
	(1) Potatoes Only Conventional Diet	(2) Status Quo Conventional Diet	(3) Kat. Hof Organic Diet	(4) Status Quo Organic Diet	(5) DGE Organic Diet	(6) Status Quo 30% Reduction Organic Diet	(7) Status Quo 60% Reduction Organic Diet	(8) Vegetarian Organic Diet
	565,613	77,792	79,197	55,404	86,654	64,717	74,803	87,888
	565,613	**77,792**	**79,197**	**55,404**	**86,654.14**	**64,717**	**74,803**	**87,888**
% Population Fed	**32%**	**4%**	**4%**	**3%**	**5%**	**4%**	**4%**	**5%**

Region 2: 50 km radius

Diets 1-8

Bundesland	*(Landkreis)* County	Total Area (km²)	Total Area (km²) of Selected Landkreise	Percentage Agricultural Area	Total Farming Area (km²) (Upper Bound = 100%)	Total Farming Area (km²) (Middle Bound = 75%)	Total Farming Area (km²) (Lower Bound = 50%)	Population
Hamburg	Hamburg	755.30	755.30	24.6%	185.80	139.35	92.90	1,762,791
Niedersachsen	Harburg	1,245.00	3,834.65	52.3%	651.14	488.35	325.57	245,199
	Lüneburg	1,323.63		51.5%	681.67	511.25	340.83	178,122
	Stade	1,266.02		72.7%	920.40	690.30	460.20	197,448
Schleswig-Holstein	Herzogtum Lauenburg	1,263.01	5,379.98	58.2%	735.07	551.30	367.54	190,703
	Lübeck	214.21		32.5%	69.62	52.21	34.81	214,420
	Neumünster	71.63		42.2%	30.23	22.67	15.11	77,588
	Pinneberg	664.28		61.9%	411.19	308.39	205.59	304,087
	Segeberg	1,344.39		66.3%	891.33	668.50	445.67	264,972
	Steinburg	1,056.13		72.6%	766.75	575.06	383.38	130,218
	Stormarn	766.33		66.4%	508.84	381.63	254.42	236,705
	Total:	**9,969.93**	**9,969.93**		**5,852.04**	**4,389.03**	**2,926.02**	**3,802,253**

	Maximum persons fed with diet (Upper Bound)							
	(1) Potatoes Only Conventional Diet	(2) Status Quo Conventional Diet	(3) Kat. Hof Organic Diet	(4) Status Quo Organic Diet	(5) DGE Organic Diet	(6) Status Quo 30% Reduction Organic Diet	(7) Status Quo 60% Reduction Organic Diet	(8) Vegetarian Organic Diet
	565,613	77,792	79,197	55,404	86,654	64,717	74,803	87,888
	1,982,146	272,616	277,539	194,160	303,673	226,797	262,142	307,996
	2,075,097	285,400	290,554	203,265	317,913	237,433	274,435	322,440
	2,801,816	385,350	392,309	274,450	429,249	320,584	370,545	435,361
	2,237,662	307,758	313,316	219,189	342,819	256,033	295,935	347,700
	211,928	29,148	29,674	20,759	32,468	24,249	28,028	32,930
	92,018	12,656	12,884	9,014	14,098	10,529	12,170	14,298
	1,251,718	172,156	175,265	122,611	191,768	143,222	165,542	194,499
	2,713,335	373,181	379,920	265,783	415,694	310,460	358,843	421,612
	2,334,096	321,022	326,819	228,635	357,593	267,067	308,688	362,684
	1,548,990	213,041	216,889	151,730	237,311	177,235	204,857	240,690
	17,814,417	**2,450,119**	**2,494,368**	**1,745,001**	**2,729,239.86**	**2,038,327**	**2,355,987**	**2,768,098**
% Population Fed	**469%**	**64%**	**66%**	**46%**	**72%**	**54%**	**62%**	**73%**

	Maximum persons fed with diet (Middle Bound)							
	(1) Potatoes Only Conventional Diet	(2) Status Quo Conventional Diet	(3) Kat. Hof Organic Diet	(4) Status Quo Organic Diet	(5) DGE Organic Diet	(6) Status Quo 30% Reduction Organic Diet	(7) Status Quo 60% Reduction Organic Diet	(8) Vegetarian Organic Diet
	424,210	58,344	59,398	41,553	64,991	48,538	56,102	65,916
	424,210	**58,344**	**59,398**	**41,553**	**64,990.60**	**48,538**	**56,102**	**65,916**
% Population Fed	**24%**	**3%**	**3%**	**2%**	**4%**	**3%**	**3%**	**4%**

	Maximum persons fed with diet (Lower Bound)							
	(1) Potatoes Only Conventional Diet	(2) Status Quo Conventional Diet	(3) Kat. Hof Organic Diet	(4) Status Quo Organic Diet	(5) DGE Organic Diet	(6) Status Quo 30% Reduction Organic Diet	(7) Status Quo 60% Reduction Organic Diet	(8) Vegetarian Organic Diet
	282,806	38,896	39,598	27,702	43,327	32,359	37,402	43,944
	282,806	**38,896**	**39,598**	**27,702**	**43,327.07**	**32,359**	**37,402**	**43,944**
% Population Fed	**16%**	**2%**	**2%**	**2%**	**2%**	**2%**	**2%**	**2%**

	Maximum persons fed with diet (Middle Bound)							
	(1) Potatoes Only Conventional Diet	(2) Status Quo Conventional Diet	(3) Kat. Hof Organic Diet	(4) Status Quo Organic Diet	(5) DGE Organic Diet	(6) Status Quo 30% Reduction Organic Diet	(7) Status Quo 60% Reduction Organic Diet	(8) Vegetarian Organic Diet
	424,210	58,344	59,398	41,553	64,991	48,538	56,102	65,916
	1,486,610	204,462	208,154	145,620	227,755	170,098	196,607	230,997
	1,556,323	214,050	217,916	152,449	238,435	178,075	205,826	241,830
	2,101,362	289,012	294,232	205,838	321,937	240,438	277,909	326,521
	1,678,246	230,819	234,987	164,392	257,114	192,025	221,951	260,775
	158,946	21,861	22,256	15,569	24,351	18,187	21,021	24,698
	69,013	9,492	9,663	6,760	10,573	7,897	9,127	10,724
	938,788	129,117	131,449	91,958	143,826	107,416	124,156	145,874
	2,035,001	279,885	284,940	199,337	311,770	232,845	269,132	316,209
	1,750,572	240,766	245,114	171,476	268,195	200,301	231,516	272,013
	1,161,742	159,781	162,667	113,798	177,984	132,927	153,642	180,518
	13,360,813	**1,837,589**	**1,870,776**	**1,308,751**	**2,046,929.90**	**1,528,745**	**1,766,990**	**2,076,074**
% Population Fed	**351%**	**48%**	**49%**	**34%**	**54%**	**40%**	**46%**	**55%**

	Maximum persons fed with diet (Lower Bound)							
	(1) Potatoes Only Conventional Diet	(2) Status Quo Conventional Diet	(3) Kat. Hof Organic Diet	(4) Status Quo Organic Diet	(5) DGE Organic Diet	(6) Status Quo 30% Reduction Organic Diet	(7) Status Quo 60% Reduction Organic Diet	(8) Vegetarian Organic Diet
	282,806	38,896	39,598	27,702	43,327	32,359	37,402	43,944
	991,073	136,308	138,770	97,080	151,836	113,399	131,071	153,998
	1,037,549	142,700	145,277	101,632	158,957	118,716	137,218	161,220
	1,400,908	192,675	196,155	137,225	214,625	160,292	185,272	217,680
	1,118,831	153,879	156,658	109,594	171,409	128,017	147,967	173,850
	105,964	14,574	14,837	10,380	16,234	12,124	14,014	16,465
	46,009	6,328	6,442	4,507	7,049	5,264	6,085	7,149
	625,859	86,078	87,633	61,306	95,884	71,611	82,771	97,249
	1,356,668	186,590	189,960	132,892	207,847	155,230	179,422	210,806
	1,167,048	160,511	163,410	114,318	178,796	133,534	154,344	181,342
	774,495	106,521	108,444	75,865	118,656	88,618	102,428	120,345
	8,907,209	**1,225,060**	**1,247,184**	**872,501**	**1,364,619.93**	**1,019,163**	**1,177,994**	**1,384,049**
% Population Fed	**234%**	**32%**	**33%**	**23%**	**36%**	**27%**	**31%**	**36%**

Sources : (de Ponti, et al., 2012)
(Seufert, et al., 2012)
(Destatis(c), 2013)
(Destatis(d), 2014)
(Destatis(f), 2015)
(Destatis(e), 2015)
(Destatis(g), 2015)
(WWF(h), 2015)

Region 3: 100 km radius

Diets 1-4

Bundesland	*(Landkreis)* County	Total Area (km^2)*(A)*	Total Area (km^2) of Selected Landkreise	Percentage Agricultural Area *(B)*	Total Farming Area (km^2) (Upper Bound = 100%)	Total Farming Area (km^2) (Middle Bound = 75%)	Total Farming Area (km^2) (Lower Bound = 50%)	Population
Hamburg	Hamburg	755.30	755.30	24.6%	185.80	139.35	92.90	1,762,791
Niedersachsen	Celle	1,545.19	15,495.30	38.8%	599.53	449.65	299.77	176,157
	Cuxhaven	2,057.77		76.0%	1,563.91	1,172.93	781.95	196,787
	Harburg	1,245.00		52.3%	651.14	488.35	325.57	245,199
	Heidekreis	1,873.70		41.9%	785.08	588.81	392.54	136,200
	Luchow-Dannenberg	1,220.70		52.0%	634.76	476.07	317.38	48,728
	Lüneburg	1,323.63		51.5%	681.67	511.25	340.83	178,122
	Osterholz	650.80		68.3%	444.50	333.37	222.25	111,484
	Rotenburg (Wümme)	2,070.37		70.6%	1,461.68	1,096.26	730.84	161,842
	Stade	1,266.02		72.7%	920.40	690.30	460.20	197,448
	Uelzen	1,454.17		53.1%	772.16	579.12	386.08	92,533
	Verden	787.95		68.8%	542.11	406.58	271.05	133,215
Schleswig-Holstein	Dithmarschen	1,428.13	11,591.65	76.4%	1,091.09	818.32	545.55	132,685
	Herzogtum Lauenbur	1,263.01		58.2%	735.07	551.30	367.54	190,703
	Kiel	118.65		29.9%	35.48	26.61	17.74	243,148
	Lübeck	214.21		32.5%	69.62	52.21	34.81	214,420
	Neumünster	71.63		42.2%	30.23	22.67	15.11	77,588
	Ostholstein	1,392.55		72.2%	1,005.42	754.07	502.71	198,355
	Pinneberg	664.28		61.9%	411.19	308.39	205.59	304,087
	Plön	1,083.17		68.4%	740.89	555.67	370.44	126,865
	Rendsburg-Ecklernför	2,189.17		72.0%	1,576.20	1,182.15	788.10	268,628
	Segeberg	1,344.39		66.3%	891.33	668.50	445.67	264,972
	Steinburg	1,056.13		72.6%	766.75	575.06	383.38	130,218
	Stormarn	766.33		66.4%	508.84	381.63	254.42	236,705
Mecklenburg-Vorpommern	Ludwigslust-Parchim	4,752.44	7,001.47	59.6%	2,832.45	2,124.34	1,416.23	212,631
	Nordwestmecklenbur	2,118.51		71.5%	1,514.73	1,136.05	757.37	155,424
	Schwerin	130.52		17.6%	22.97	17.23	11.49	92,138
	Total:	**34,843.72**	**34,843.72**		**21,475.01**	**16,106.26**	**10,737.51**	**6,289,073**

	Maximum persons fed with diet (Upper Bound)							
	(1) Potatoes Only Conventional Diet	(2) Status Quo Conventional Diet	(3) Kat. Hof Organic Diet	(4) Status Quo Organic Diet	(5) DGE Organic Diet	(6) Status Quo 30% Reduction Organic Diet	(7) Status Quo 60% Reduction Organic Diet	(8) Vegetarian Organic Diet
	565,613	77,792	79,197	55,404	86,654	64,717	74,803	87,888
	1,825,065	251,012	255,545	178,773	279,607	208,824	241,368	283,588
	4,760,746	654,773	666,598	466,336	729,365	544,725	629,617	739,750
	1,982,146	272,616	277,539	194,160	303,673	226,797	262,142	307,996
	2,389,894	328,696	334,632	234,101	366,141	273,452	316,068	371,354
	1,932,311	265,762	270,561	189,278	296,038	221,095	255,551	300,253
	2,075,097	285,400	290,554	203,265	317,913	237,433	274,435	322,440
	1,353,109	186,101	189,462	132,543	207,302	154,823	178,951	210,253
	4,449,562	611,974	623,026	435,854	681,691	509,119	588,462	691,396
	2,801,816	385,350	392,309	274,450	429,249	320,584	370,545	435,361
	2,350,576	323,288	329,127	230,249	360,118	268,953	310,868	365,245
	1,650,258	226,969	231,068	161,650	252,826	188,823	218,249	256,426
	3,321,435	456,816	465,066	325,349	508,857	380,039	439,265	516,102
	2,237,662	307,758	313,316	219,189	342,819	256,033	295,935	347,700
	107,995	14,853	15,121	10,579	16,545	12,357	14,283	16,781
	211,928	29,148	29,674	20,759	32,468	24,249	28,028	32,930
	92,018	12,656	12,884	9,014	14,098	10,529	12,170	14,298
	3,060,643	420,948	428,550	299,804	468,903	350,199	404,775	475,579
	1,251,718	172,156	175,265	122,611	191,768	143,222	165,542	194,499
	2,255,368	310,194	315,796	220,923	345,531	258,059	298,276	350,451
	4,798,181	659,921	671,839	470,003	735,100	549,008	634,568	745,567
	2,713,335	373,181	379,920	265,783	415,694	310,460	358,843	421,612
	2,334,096	321,022	326,819	228,635	357,593	267,067	308,688	362,684
	1,548,990	213,041	216,889	151,730	237,311	177,235	204,857	240,690
	8,622,387	1,185,886	1,207,303	844,601	1,320,984	986,574	1,140,325	1,339,792
	4,611,064	634,186	645,639	451,674	706,433	527,598	609,821	716,491
	69,929	9,618	9,791	6,850	10,713	8,001	9,248	10,866
	65,372,940	**8,991,116**	**9,153,493**	**6,403,570**	**10,015,395.34**	**7,479,976**	**8,645,682**	**10,157,992**
% Population Fed	**1039%**	**143%**	**146%**	**102%**	**159%**	**119%**	**137%**	**162%**

	Maximum persons fed with diet (Middle Bound)							
	(1) Potatoes Only Conventional Diet	(2) Status Quo Conventional Diet	(3) Kat. Hof Organic Diet	(4) Status Quo Organic Diet	(5) DGE Organic Diet	(6) Status Quo 30% Reduction Organic Diet	(7) Status Quo 60% Reduction Organic Diet	(8) Vegetarian Organic Diet
	424,210	58,344	59,398	41,553	64,991	48,538	56,102	65,916
	1,368,798	188,259	191,659	134,080	209,705	156,618	181,026	212,691
	3,570,560	491,080	499,948	349,752	547,024	408,544	472,213	554,812
	1,486,610	204,462	208,154	145,620	227,755	170,098	196,607	230,997
	1,792,421	246,522	250,974	175,576	274,606	205,089	237,051	278,516
	1,449,233	199,321	202,921	141,959	222,028	165,821	191,664	225,189
	1,556,323	214,050	217,916	152,449	238,435	178,075	205,826	241,830
	1,014,832	139,576	142,096	99,407	155,476	116,117	134,213	157,690
	3,337,172	458,980	467,269	326,891	511,268	381,839	441,347	518,547
	2,101,362	289,012	294,232	205,838	321,937	240,438	277,909	326,521
	1,762,932	242,466	246,845	172,687	270,088	201,715	233,151	273,934
	1,237,693	170,227	173,301	121,238	189,620	141,617	163,687	192,319
	2,491,076	342,612	348,799	244,012	381,643	285,029	329,449	387,077
	1,678,246	230,819	234,987	164,392	257,114	192,025	221,951	260,775
	80,996	11,140	11,341	7,934	12,409	9,268	10,712	12,586
	158,946	21,861	22,256	15,569	24,351	18,187	21,021	24,698
	69,013	9,492	9,663	6,760	10,573	7,897	9,127	10,724
	2,295,482	315,711	321,412	224,853	351,677	262,649	303,581	356,684
	938,788	129,117	131,449	91,958	143,826	107,416	124,156	145,874
	1,691,526	232,645	236,847	165,692	259,148	193,544	223,707	262,838
	3,598,636	494,941	503,880	352,502	551,325	411,756	475,926	559,175
	2,035,001	279,885	284,940	199,337	311,770	232,845	269,132	316,209
	1,750,572	240,766	245,114	171,476	268,195	200,301	231,516	272,013
	1,161,742	159,781	162,667	113,798	177,984	132,927	153,642	180,518
	6,466,791	889,415	905,477	633,451	990,738	739,931	855,244	1,004,844
	3,458,298	475,640	484,230	338,756	529,825	395,699	457,366	537,369
	52,446	7,213	7,344	5,137	8,035	6,001	6,936	8,149
	49,029,705	**6,743,337**	**6,865,120**	**4,802,677**	**7,511,546.50**	**5,609,982**	**6,484,262**	**7,618,494**
% Population Fed	**780%**	**107%**	**109%**	**76%**	**119%**	**89%**	**103%**	**121%**

	Maximum persons fed with diet (Lower Bound)							
	(1) Potatoes Only Conventional Diet	(2) Status Quo Conventional Diet	(3) Kat. Hof Organic Diet	(4) Status Quo Organic Diet	(5) DGE Organic Diet	(6) Status Quo 30% Reduction Organic Diet	(7) Status Quo 60% Reduction Organic Diet	(8) Vegetarian Organic Diet
	282,806	38,896	39,598	27,702	43,327	32,359	37,402	43,944
	912,532	125,506	127,772	89,387	139,804	104,412	120,684	141,794
	2,380,373	327,386	333,299	233,168	364,683	272,362	314,808	369,875
	991,073	136,308	138,770	97,080	151,836	113,399	131,071	153,998
	1,194,947	164,348	167,316	117,050	183,071	136,726	158,034	185,677
	966,155	132,881	135,281	94,639	148,019	110,548	127,776	150,126
	1,037,549	142,700	145,277	101,632	158,957	118,716	137,218	161,220
	676,555	93,050	94,731	66,272	103,651	77,411	89,476	105,127
	2,224,781	305,987	311,513	217,927	340,845	254,560	294,231	345,698
	1,400,908	192,675	196,155	137,225	214,625	160,292	185,272	217,680
	1,175,288	161,644	164,563	115,125	180,059	134,477	155,434	182,622
	825,129	113,485	115,534	80,825	126,413	94,411	109,125	128,213
	1,660,717	228,408	232,533	162,675	254,429	190,019	219,633	258,051
	1,118,831	153,879	156,658	109,594	171,409	128,017	147,967	173,850
	53,997	7,427	7,561	5,289	8,273	6,178	7,141	8,390
	105,964	14,574	14,837	10,380	16,234	12,124	14,014	16,465
	46,009	6,328	6,442	4,507	7,049	5,264	6,085	7,149
	1,530,321	210,474	214,275	149,902	234,451	175,099	202,388	237,789
	625,859	86,078	87,633	61,306	95,884	71,611	82,771	97,249
	1,127,684	155,097	157,898	110,462	172,766	129,030	149,138	175,225
	2,399,090	329,961	335,920	235,002	367,550	274,504	317,284	372,783
	1,356,668	186,590	189,960	132,892	207,847	155,230	179,422	210,806
	1,167,048	160,511	163,410	114,318	178,796	133,534	154,344	181,342
	774,495	106,521	108,444	75,865	118,656	88,618	102,428	120,345
	4,311,194	592,943	603,652	422,301	660,492	493,287	570,163	669,896
	2,305,532	317,093	322,820	225,837	353,217	263,799	304,911	358,246
	34,964	4,809	4,896	3,425	5,357	4,001	4,624	5,433
	32,686,470	**4,495,558**	**4,576,747**	**3,201,785**	**5,007,697.67**	**3,739,988**	**4,322,841**	**5,078,996**
% Population Fed	**520%**	**71%**	**73%**	**51%**	**80%**	**59%**	**69%**	**81%**

Sources : (de Ponti, et al., 2012) (Destatis(d), 2014) (Destatis(g), 2015)

(Seufert, et al., 2012) (Destatis(f), 2015) (WWF(h), 2015)

(Destatis(c), 2013) (Destatis(e), 2015)

Appendix IV: EU Organic Regulations vs. Farming Associations

	EU/German Organic	Farming Associations (Examples: biokreis, Bioland, demeter, Naturland, Gäa e.V.)
Management options	Some conversion operation possible, but under strict conditions and reports to the monitoring bodies. In the EU-eco-control and the data must be disclosed on the conventionally managed area.	Conversion of the entire operation to organic farming.
(GMOs) Genetically Modified Organisms	General ban (limit for technically unavoidable and adventitious presence of GMOs defined).	General ban (limit for technically unavoidable and adventitious presence of GMOs defined).
Feed for cows sheep, goats	Exclusively organic feed allowed, with some exceptions: allows 10% of the yearly ration of conventional agriculture.	Exclusively organic feed allowed, with some exceptions: allows 10% of the yearly ration of conventional agriculture.
Feed for pigs and poultry	Organic feed with max 5% conventional feed	Almost exclusively organic feed. depending Association and Species few exceptions
Home-grown fodder	Own feed production is preferred, but is not compulsory	At least 50% of fodder from the farm.
Limited number of animals (calculated on the amount of nitrogen in the manure)	230 hens, 580 chickens or 14 fattening pigs per hectare per year.	140 hens 280 Chicken or 10 fattening pigs per hectare per year.
Transport of animals	Transport of animals to the stress should be kept to a minimum, animals must not be driven with electric shocks and the use of sedatives before and during transport, is prohibited.	Depending on the association, conditions in compliance with transport distances and transport times of max. 4 hours before slaughter.
Fertilization	The use of organic fertilizer nitrogen is limited to 170 kg per hectare per year.	The use of organic nitrogen fertilizers is the farm, depending on the association and limited culture at 40 kg to 112 kg per hectare per year.
Plant protection (copper insert against fungal diseases of plants)	Depending on national pesticide approvals, the permitted amount of copper is limited in the EU Organic Regulation at 6 kg per hectare per year.	Use of copper for crop protection is limited to max. 3 kg (hop 4 kg) per hectare per year.
Purchase manure from conventional	Barn and poultry manure from conventional animal husbandry as fertilizer are allowed, but not from industrial livestock farming. In the summer, nitrogenous fertilizers from organic may not exceed 170 kg per hectare per year.	Poultry manure from conventional animal husbandry is generally not permitted as a fertilizer. Depending on the association, conventional manure up to max. 40 kg nitrogen per hectare per year could be allowed and max. 110 kg total nitrogen per hectare per year.
Origin of raw material	Commodities are subject to EU Organic Regulation. This can be so also frozen vegetables from China or grain from Canada.	Depends on the possible member companies of the respective farming association. Basis of peer resource scarcity recognition between individual organizations is possible.
Food Additives	A positive list regulates the use, divided by plant and animal products.	Severely restricted, for each food groups, only the explicitly authorized additives used.
Natural flavors	Authorized	Demeter prohibits the use of natural flavors in general. It is authorized for Bioland and Naturland for special products.
Nitrite	Limited approved if no alternative is available or special technological characteristics of the product should be maintained. Addition and maximum residue limits are set.	Not allowed with Demeter. Bioland allowed reddening only as spice preparations (MRL 10 ppm). Labeling is mandatory on the product.
Processing Aids	A positive list regulates the use, divided by plant and animal products.	Farming associations insist on the use of - if possible - processing aids according to the EU Organic Regulation.
Enzymes (not to be classified, not on the label recognizable) and preparations of microorganisms	Generally admitted if they are commonly used in food production.	Enzymes are only approved on a product specific basis.
Food processing methods	No provisions for the processing methods that are commonly used in food processing. Only irradiation is generally prohibited in organic.	For some products there are controversial methods such as microwave use prohibited. Demeter also prohibited ESL milk and proofing interruption (frosted, semi-gare dough) with bread and fully baked must not be frozen.
The use of anthropogenic nanoparticles (nanoparticles)	No special scheme, (generally in the food sector of prohibited substances).	It is prohibited to use any form of human activity produced nanoparticles, defined the nano range of approximately 1-300 nm.
Packaging	No specific regulation (general statutory regulations, legal requirements on packaging).	Association recommendations, for example, guide the federal Organic Food Industry eV (BÖLW) "Sustainable packaging of organic foods"

Source: (Echt Bio, 2013)