CAN REGIONAL, ORGANIC AGRICULTURE FEED THE REGIONAL COMMUNITY?

A Case Study for Hamburg and North Germany

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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 to 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 to the regional community. The individual agricultural land footprint for food production for one person, for one year 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 provide the right balance of factors to increase consumers' willingness-to-pay (WTP) more for organic products.

Key Terms: food system, organic agriculture, regional agriculture

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List of Abbreviations

GAKG	Act on a Joint Task for the Improvement of Agricultural Structure and Coastal Protection
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
EAFRD	European Agricultural Fund for Rural Development
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
ÖLG	Organic Farming Act
OECD	Organization for Economic Co-operation and Development
RDPs	Rural Development Programs
UBA	Umweltbundesamt/Federal Environment Agency
UN	United Nations
UNECE	United Nations Economic Commission for Europe
WTP	Willingness-to-Pay
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 contribution to negative effects on our environment, human and animal health and social equity.

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).

On a personal level, I, the author of this thesis, wish to have greater access to fresh, healthy, nutritious foods for myself and for 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: hdwyn.com

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, etc., 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 two questions:

1. How can regional, organic food production be promoted and expanded by the individual consumer's consumption choices?
2. 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 land footprint for food production according to various diet scenarios.
2. The maximum persons fed according to identified diet scenarios within the selected regions.
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 individual consumer land footprint for food production and the available agricultural area available within the defined regions.
4. Identify potential shifts in the individual German diet towards an individual and overall decreased land footprint for food production and illustrate the effects on the maximum persons fed within defined regions.
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 motivations, the research question to be answered, methods to aim to answer said question 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 maximum persons fed in three identified regions based on eight different individual diet scenarios. Quantify the required agricultural land to produce food for one German person, for one year; 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 the price premium for organic products.
- **Chapter 6:** Discussion of results.
- **Chapter 7:** Conclusion and outlook.

Image source: (Joseph, 2016)

Introduction
Food system: Current Situation
Organic Agriculture
Case Study: Hamburg
Case Study: AFNs in Hamburg
Discussion of Results
Conclusions and Outlook

2

Food System: Current Situation

The current industrialized countries' food system is largely based on three central themes: centralization, specialization and globalization. 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 higher yields on an equal area of agricultural land 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 put in place 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).

Furthermore, technical advances in food production also allowed farmers to produce a higher yield on an equal area of land. For example, in Germany, 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

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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).

However, the development of the food system, especially since the second half of the 20th century, has created a highly complex system, lacking transparency and separating the spheres of production and consumption. Centralization and concentration 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.

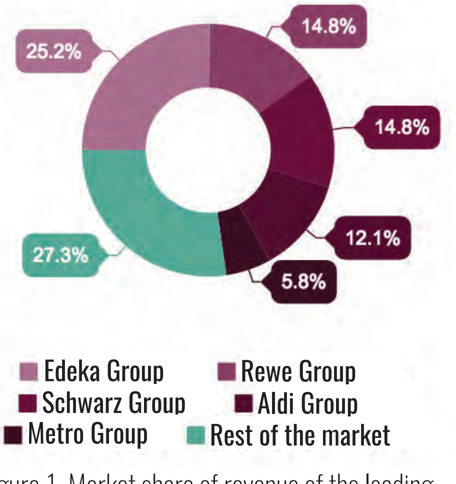


Figure 1. Market share of revenue of the leading companies in food retail in Germany in 2014 Adapted from (Statista, 2014)

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 further down 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).

As mentioned earlier, 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 ability to artificially replace nutrients through inputs such as chemical fertilizers and to provide some level of protection for crops and crop yields through herbicides and pesticides was introduced in the mid 1900s. This was the basis of the so-called "Green Revolution" of the second half of the 20th century. The majority of these chemicals were, and still are, produced in laboratories and are petroleum based, allowing farmers greater control of crop security and increased production.

By the 1950s, inexpensive artificial fertilizers were easily accessible to farmers, allowing them to provide nutrients, such as nitrogen, phosphorus, potassium, and other elements required for plant growth, and to replace nutrients lost in the soil during the production process (Ellis, 2000). This gave farmers greater flexibility to reintegrate natural fertility without the use of complex rotations, allowing for specialization in cultivation of the same crop on the same area of land for many consecutive seasons without effects on 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. For example, DDT (dichloro-diphenyl-trichloroethane) was introduced in the 1940s but later banned in many regions, including the U.S. and Northern Europe, for human health concerns (US EPA, 2015).

Crop Genetics

Biotechnological advances also greatly influenced the development of our current 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.

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.

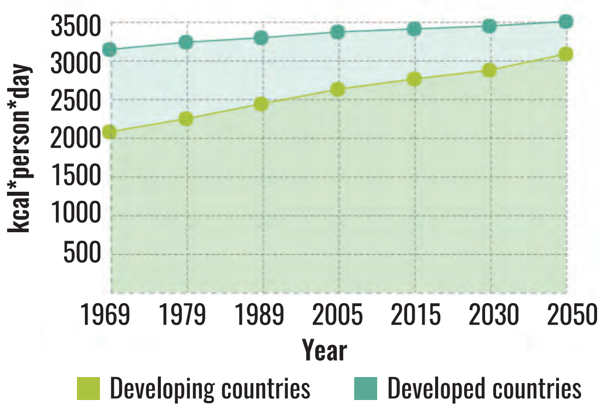


Figure 2. Global increase in per capita food consumption. Adapted from (FAO(a), 2012).

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 tripled. 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 tripled. Meanwhile, other sources of protein have been nearly forgotten. This is illustrated in figure 3. The average person in 1950 would have eaten 20 kg of pulses such as beans,

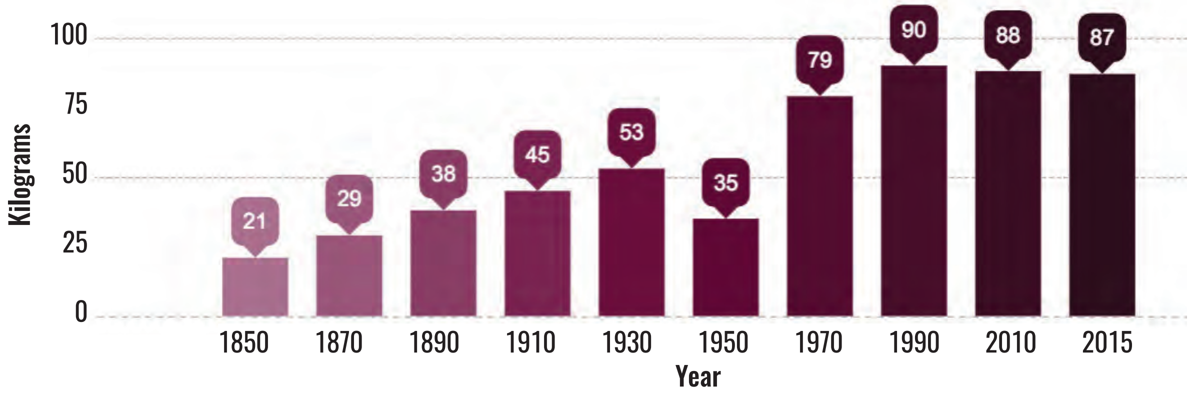


Figure 3. Increase in German meat consumption per capita by year. Adapted from von Alvensleben (1999) and (BMELV, 2011).

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.

Land Use

Land use for food production is increasing steadily on a global scale (FAOSTAT(b), 2014). Approximately 38% 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 increase by 60% by 2050, calculated by tonnages weighted and crop prices (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 one third of the earth's land surface. This is a significant portion of overall agricultural land use. For feedstuffs, (WWF(a), 2011) cites the Deutscher Verband Tiernahrung (DTV) (2011), stating that, in German agriculture, 60% of all cereals and 70% of all oilseeds are used to feed livestock, although this figure varies by specific crop. 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 (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 soy to feed its livestock 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

Energy in the agricultural sector is measured in two ways: directly and indirectly. Direct use refers to the energy required for land preparation, cultivation, irrigation, harvesting, post-harvest processing, food production, storage, and transport of agricultural inputs and outputs (FAO(b), n.d.). Indirect energy usage refers to the production of agrochemicals. The majority of indirect energy usage is related to natural gas for producing artificial fertilizers. 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 artificial 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 has a multifactor effect on energy use. Not only it is required to raise livestock, i.e. heat for housing, etc., energy is also required to grow crops for feed. Feeding operations, or feedlots, particularly common for poultry in Germany (BMEL, 2014), require a higher energy input than farms whose animals forage or graze on fields.

Furthermore, feed-use efficiency of farm animals 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, it is estimated 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. 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 through Vietnam, where irrigation is required for 87% of production (WWF(d), 2014).

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).

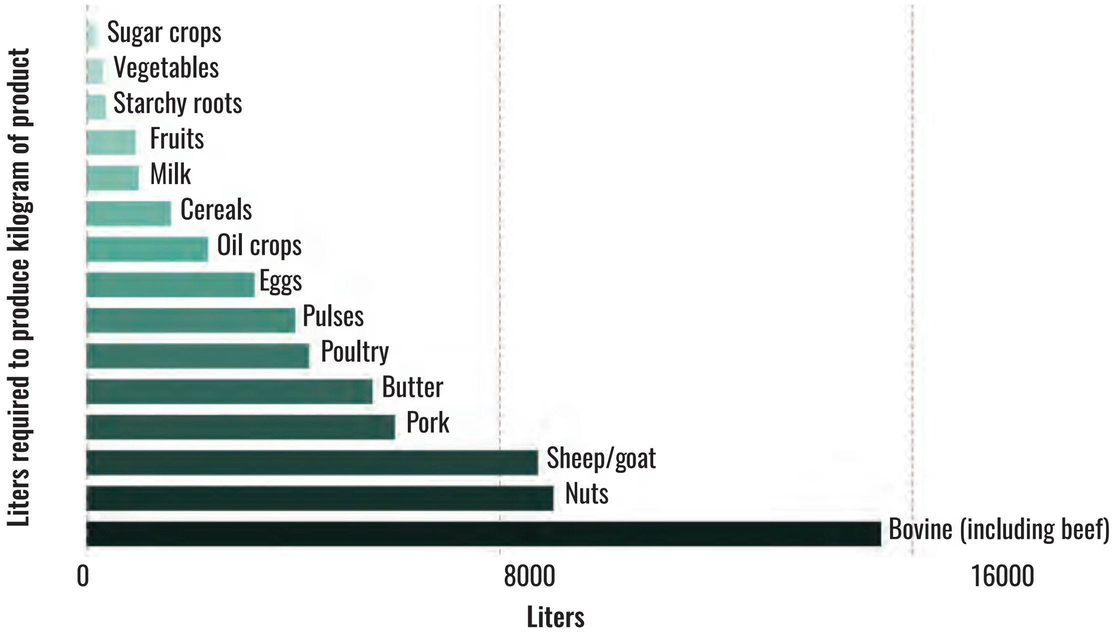


Figure 4. Water requirement to produce one kilogram of product.. Adapted from (Mekonnen & Hoekstra, 2010).

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

The consequences of our current industrialized system could not have been predicted 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, Osborne, Horton, & Sinclair, 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, Osborne, Horton, & Sinclair, 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, Osborne, Horton, & Sinclair, 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.

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).

Contributions to Climate Change

While agriculture is highly affected by climate change, it is also a substantial contributor. According to a recent study by the *Consultative Group on International Agricultural Research* (CGIAR), the global food system process in its entirety is responsible for up to one-third of all human-caused greenhouse gas emissions (Gilbert, 2012). This includes the primary steps of fertilizer manufacture; the production of raw materials that require high energy amounts, causing direct green house gas (GHG) emissions; and the transportation, processing, packaging and storing of goods.

Emissions can be broken down into two types: indirect GHG emissions, 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, 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 more efficient farming practices, reduction of nitrogen-based fertilizers, and better forms of manure management (Eurostat(b), 2015).

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 *Cli-*

mate 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 consumers plate, which may result in increased GHG emissions (Reisch, Eberle, & Lorek, 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 *Umwelt Bundesamt* (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, corporate breeding of livestock and other farm animals 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 concentrated animal feeding operations (CAFOs), the holistic balance of the farm system is abolished. 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. In the case of CAFOs, animal manure 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 once provided by animal manure need to be replaced by artificial fertilizers.

Deforestation

One of the largest contributors to deforestation worldwide is agriculture. 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 soy, 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).

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. This essentially means that the world's biggest rain forest is being destroyed to produce cattle.
(WWF(a), 2011), (Heinrich Böll Foundation, 2014).

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. By 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 complicated, 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). 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 citizens.

> **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)

Fewer Farmers and Decreased Prospects

As illustrated in earlier sections, new technologies in agriculture allowed higher yields on an equal area of space, requiring lower labor input and, thus, fewer farmers. At the same time, the development of the market toward commercialization shifted the traditional view of the farmer from being mainly self-sufficient to being profit-driven, where the majority of the farm's output is sold (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, Eberle, & Lorek, 2013).

The result is a combination of factors. Farmers are receiving a lower percentage of the profits, as well as companies want farmers to produce maximum yields at minimum costs, while consumers want to pay low prices. This price squeeze, coupled with high land and capital investment prices, makes it prohibitive 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).

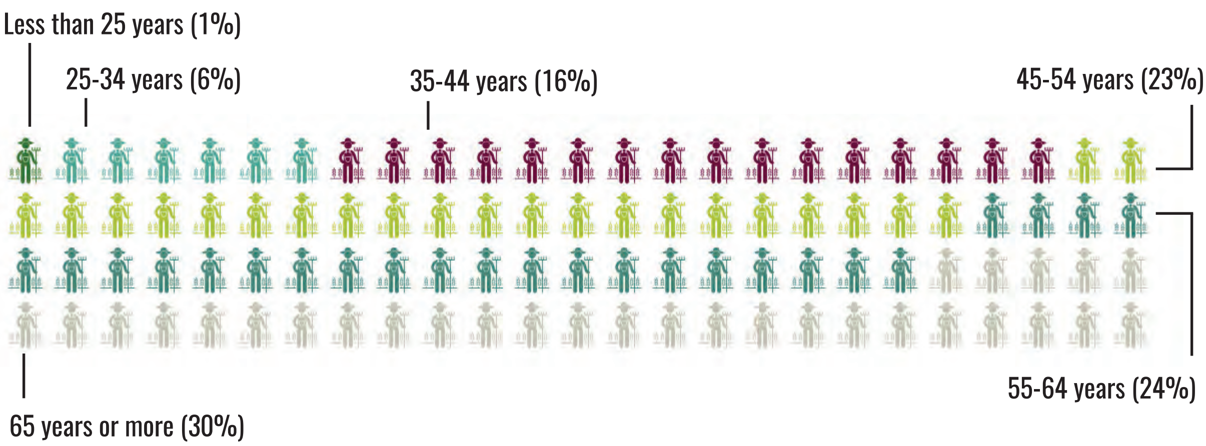


Figure 6. Ages of farmers in Germany. Source: (Eurostat(c), 2014).

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 (CAFOs). When livestock is raised in CAFOs, there are not only environmental concerns, such as pollution to nearby areas from large amounts of manure, or risk of exposure to antibiotic resistant bacteria for consumers, but also significant risk to animal welfare.

Worker Exploitation

Globally, large farms and concentrated processing facilities require an enormous labor force. In many cases, especially in developing nations, workers are exploited and subjected to unfair or unsafe conditions. Child labor, unfair practices, 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, in all settings. It should respect the natural systems and promote diversity, resiliency, and sustainability in production. It should be grown in a holistic manner that recycles waste from one component and uses it in another.

The system must integrate three main goals: environmental health, economic profitability, and social and economic equity (UC Davis, 2015). We must learn to fulfill the needs of this generation, without sacrificing the security of the next (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, such as private-public partnerships and 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 methods to protect these natural resources— and, when possible, substitute renewable ones— 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.** -Ulrich Von Bonin, Arpshof Farmer

Ecological or organic farming methods 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). Large-scale industrial producers, however, make it difficult for farmers to produce from an ecological point of view. 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 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 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. Ecological crop diversity methods, such as 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 meat 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. A system that affects everyone should be designed by everyone, not by a few enormous agro-companies that seek to maximize profits at the cost of the environment, human health, and social equity.

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 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 health and environment. While attention paid to organic, local, and more environmentally-friendly food choices is increasing globally, it is still relatively a niche market (BÖWL, 2015). 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).

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, Rijk, & van Ittersum, 2012). Furthermore, faced with the question of how will we being 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)

While the practice is sometimes criticized as an inefficient approach to food production and security, 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 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).

Principles of Organic Agriculture

Organic farming is a broad term used to describe an agricultural system aimed at producing foods with minimal harm to ecosystems, animals, or humans (Seufert, Ramankutty, & Foley, 2012), where the farm is understood to be a complete organism comprised of man, flora, fauna, and soil (BMEL(b), 2015). These systems can range from strict closed-cycle ones, such as biodynamic agriculture, to less strict, more standard organic certifications. The base level certification of products as "organic" varies between country, region, and system.

Image source: (Joseph, 2015)

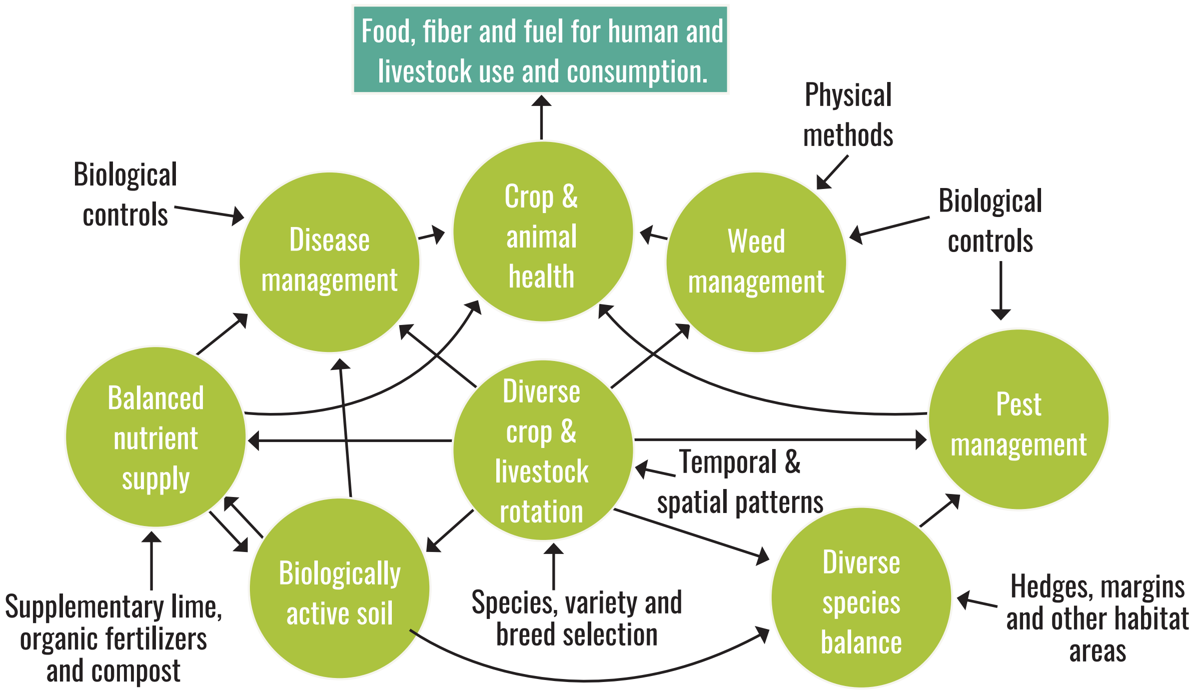


Figure 7. Organic management practices. Structural factors (circles) are the foundation of organic management. Tactical management decisions (black text) are used to supplement structural factors. Adapted from (Reganold & Wachter, 2016)

In general, organic agriculture management practices commonly focus on: (1) promoting soil quality and fertility, prohibiting the use of artificial fertilizers in favor of manure or slurry, or practicing crop rotations and regularly planting crops such as beans, peas or clover that improve the nutrient content of the soil. (2) Maintaining plant and animal diversity, as well as attempting to maintain a closed-cycle approach to the farm system as much as 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 seven.

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*. Demeter follows a biodynamic approach to agriculture in which there is greater emphasis on maintaining a complete closed cycle on the farm than there is in basic organic agriculture. Other farming associations in Germany include *Naturland, Biokreis, Bundesverband Ökologischer Weinbau* (Federation for Organic Viticulture, ECOVIN), *Gäa, Ecoland*, *Biopark* and the *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, Ramankutty, & Foley, 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, Rijk, & van Ittersum, 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%.

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, Ramankutty, & Foley, 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 nu-

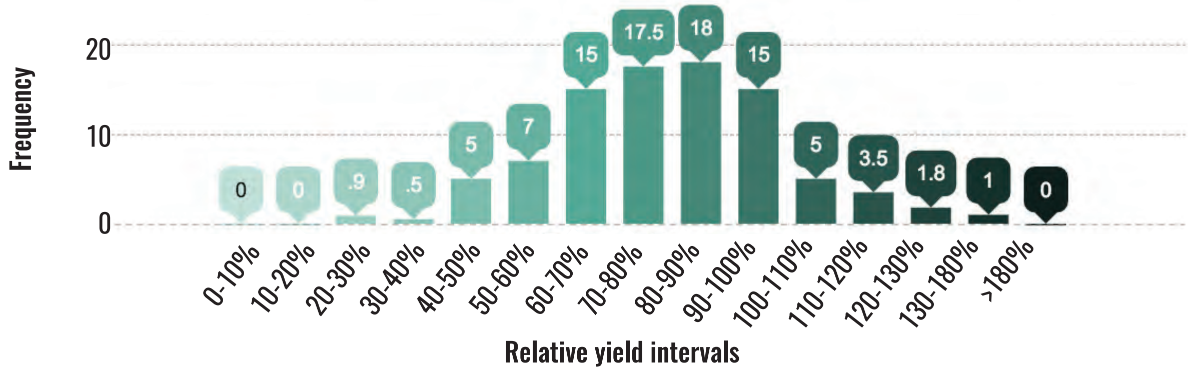


Figure 8. Frequency of occurrence of relative yields of organic vs. conventional agriculture, grouped in 10% intervals. Adapted from (de Ponti, Rijk, & van Ittersum, 2012).

tritional 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 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 allowed in one space, 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

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).

Economic competitiveness also depends on the extent to which the consumer price reflects costs of externalities associated with production, such as the environmental, health, or social challenges presented in the previous section, as well as the policy environment providing support for organic agriculture (de Ponti, Rijk, & van Ittersum, 2012).

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

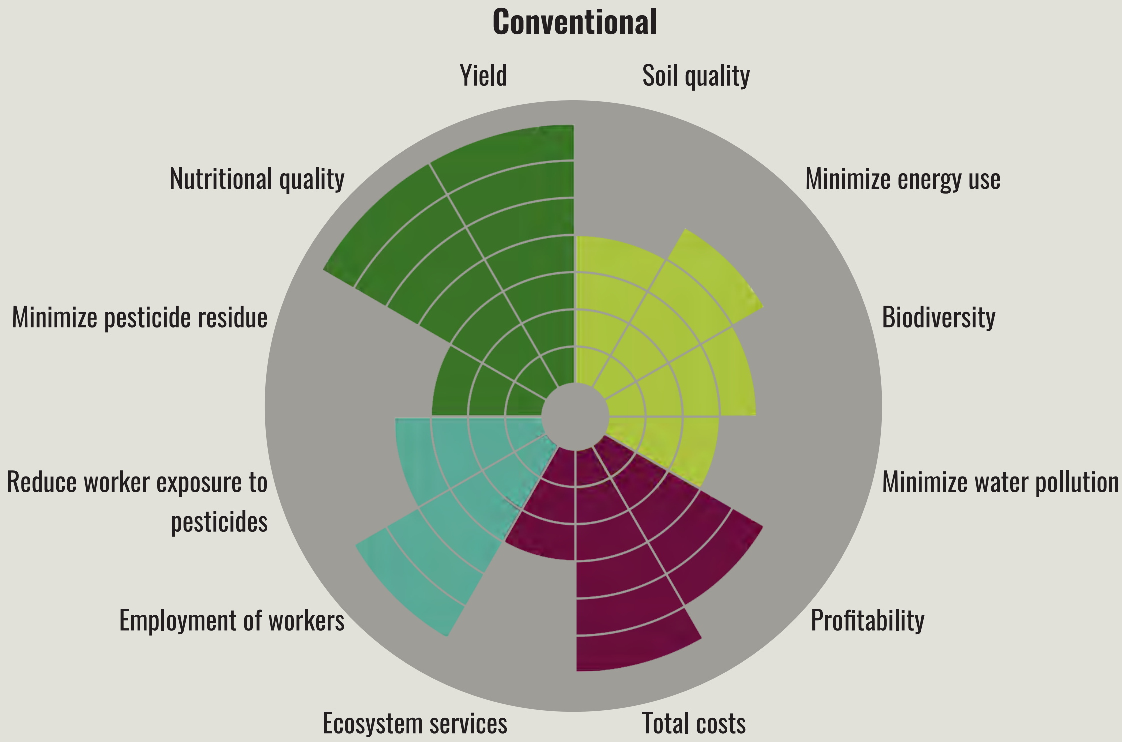


Figure 9. Assessment of organic farming relative to conventional farming in the four major areas of sustainability. Length of sustainability metrics. Dark green represents productivity, light green: environmental sustainability, red: economic sustainability system balance of organic farmer versus conventional.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

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.

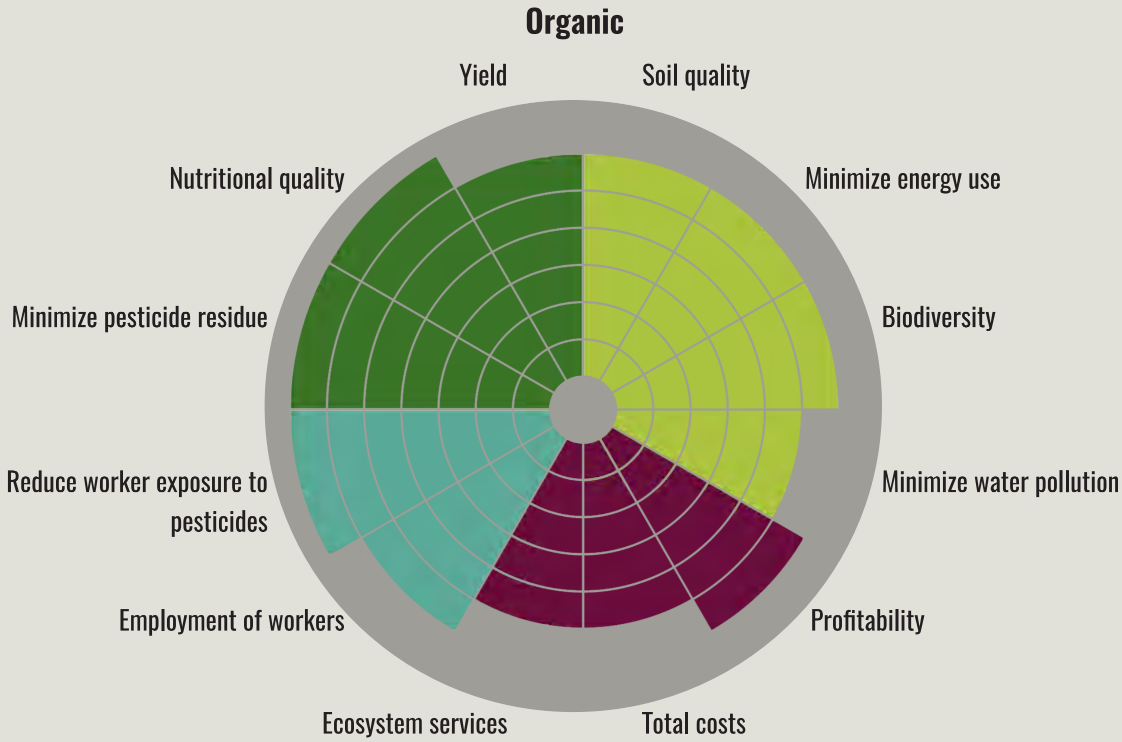
Status of Organic Agriculture in Europe

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[1] in 2014 was 5.9%, 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]), 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).

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



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

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. 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,

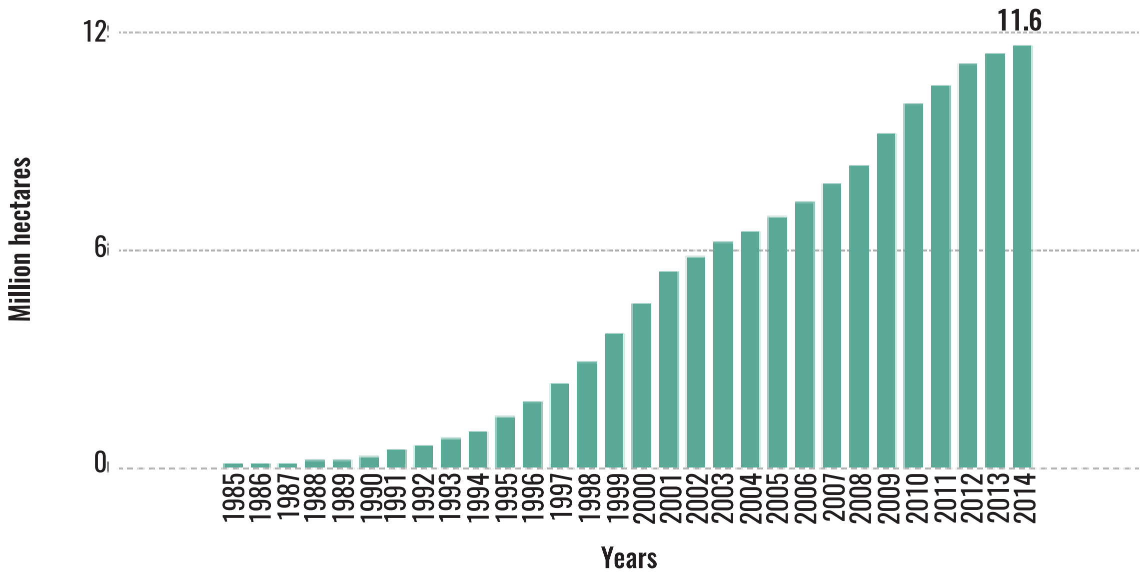


Figure 10. Development of organic agricultural land in Europe (1985-2014). Adapted from (Willer & Lernoud, 2016).

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.

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 per capita consumption worldwide, with the largest organic food market share highest 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. 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).

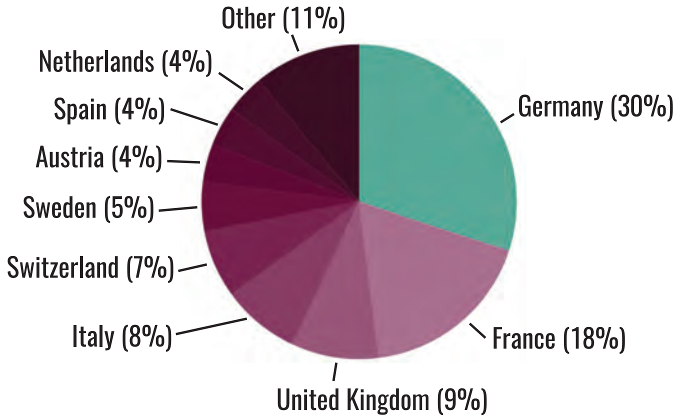


Figure 11. Distribution of retail organic food sales in Europe (2014). Adapted from (Willer & Lernoud, 2016).

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 there were more spaces converted back to conventional farmland

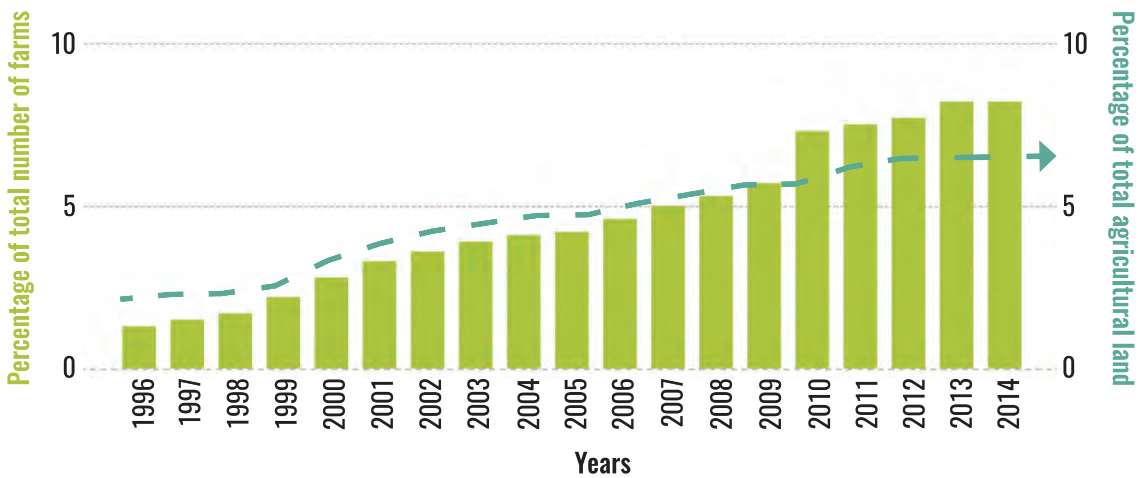


Figure 12. Organic farming in Germany (1996-2014) Adapted from (BMEL(b), 2015).

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

than vice-versa in 2010 (Rossbach, 2013). In 2015, however, there was a slightly positive trend, despite uncertainty in EU regulations. According to estimates, the domestic organic area grew by 2.9% and increasing potential for German organic agricultural production (BÖLW(b), 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 organic land is used by organic associations (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 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, then composted, and the composting methane is burned to produce electricity. This not only creates environmental challenges, such as monocultures, but it also reduces the amount of land available for 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 energy, 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 are 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 smaller or sole-proprietorship shops, this creates a price challenge.

Competition from Inexpensive Imports

Food produced in areas such 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 at a price point, 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 Ideology

Consumer ideology 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 spends approximately 14% of his or her income on food (Destatis(a), 2013). This illustrates that disposable income is, in fact, available to spend on organic, local 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 requires greater labor intensity and a higher level of management, with potentially lower yields, which can, therefore, make production more expensive (BMEL(b), 2015). Although, as mentioned previously, there is potential for organic products to be more economically profitable than conventional ones if organic price premiums are applied, this was not the case in Germany during this time.

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 and drink 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 retailers (roughly 30%), like *Al Natura* or *Dens*; and other channels (roughly 20%), such as delivery boxes, farmers' markets, 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).

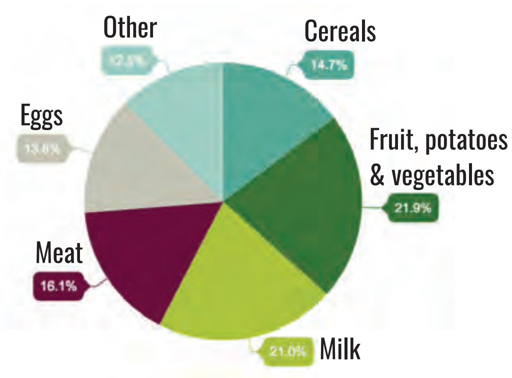


Figure 13. Share of sales in organic farming (2014). Adapted from (BÖLW(c), 2015).

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 health food stores. 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 (Willer & Lernoud, 2016). Some of these could also be produced locally. 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.

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). Goals should focus on recognizing the increase in consumer demand, enacting measures that seek to meet this production domestically, and further promoting methods of agricultural production that protect the environment, natural resources, human health, and animal welfare.

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 Euro, 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).

Potential For Maximizing Regional Organic Production

To illustrate the potential for maximizing regional organic food production in Hamburg and the surrounding areas, this thesis will conduct a two-step analysis. The first section of the analysis will attempt to determine the proportion of consumption demand that can be supplied by organically and regionally produced goods, imagining that all agricultural land will convert to at least organic production standards, if not even stricter standards, such as Demeter. To this end, the primary step is to quantify the amount of agricultural area, in square meters, that is required to meet food consumption demand for one person, for one year. Four scenarios of consumption quantities, production methods, and total land footprint for food production per person will be examined.

Next, three different regions will be defined to determine the amount of total agricultural land available for food production. It will be assumed that all agricultural land will be converted to organic production methods. The populations of each identified "region" will be measured. This will serve as the comparison point to determine the percentage of population that can be fed solely by regional and organic agriculture. Upper, lower, and middle bounds of agricultural area to be used exclusively for food production will be identified.

The second section will assess the effect of consumer consumption choices on the overall land footprint for food production. It is assumed that, as the land footprint for individual consumption decreases, a greater number of people can be fed with organic and regional food production.

The next section will give a brief summary of the current conventional and organic agricultural production in the city-state of Hamburg and the bordering *Bundesländer* (federal states)

Image source: (Joseph, 2015)

of Mecklenburg-Vorpommern, Niedersachsen, and Schleswig-Holstein—here, also referred to as the region of "Northern Germany." This also serves to provide a general impression of a diet comprised solely of regionally produced.

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

Overall, Germany has a strong agricultural sector, representing the fourth largest producer in the EU (BMEL(d), 2014). Domestic production equates to more than four-fifths of the demand for food, corresponding to a theoretical self-sufficiency rate of approximately 85%. This figure, however, does not reflect the realistic situation, which is highly influenced by the globalized economy and consumer demand for diverse products (BMEL(d), 2014). The identified states of Hamburg, Mecklenburg-Vorpommern, and Schleswig-Holstein all contribute to the overall domestic agricultural production, albeit to varying degrees.

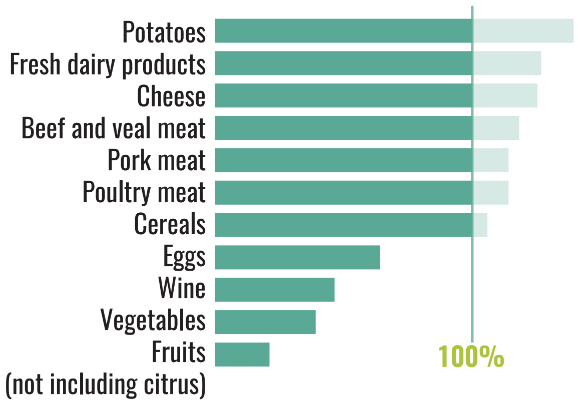


Figure 14. Average rate of self-sufficiency in Germany for selected products from 2010-2012. Adapted from (BMEL(d), 2014).

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 sections also have a larger percentage of farming area than others. This is illustrated in figure 15.

Furthermore, in the cases 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.).

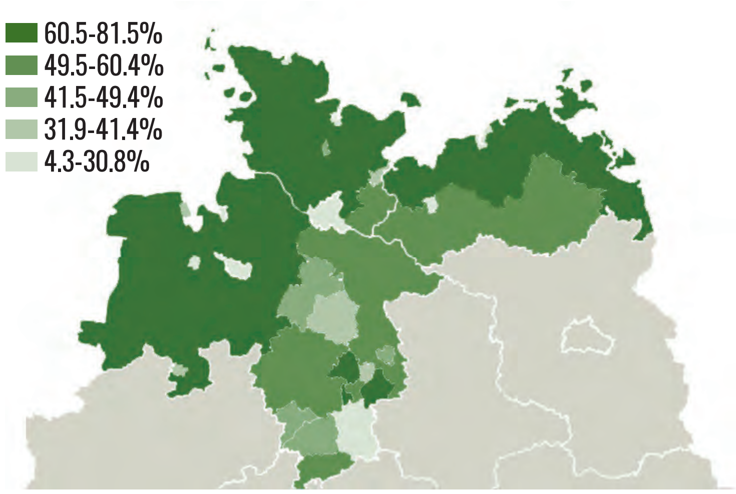


Figure 15. Percentage of total farming area compared to total area within Northern German Federal States. Source: (Destatis(d), 2014).

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 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). Due to limited data availability, the specific organic crop and livestock production for individual federal states will not be presented in this chapter. It can be assumed that the data analyzed will include both conventionally and organically produced products and will indicate organic production when possible.

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). In comparison to the entire production value in Euros of agriculture of Germany in 2013, Schleswig-Holstein comprised 6.3%, Niedersachsen 17.1%, and Mecklenburg-Vorpommern 6.8% of total crop production value, while Hamburg contributed to less than 1% (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).

Figure 16. Indication (dark green area) of which animal products predominate in which areas of Germany. Top left: cattle, top right: pigs, bottom left laying hens, bottom right sheep. Source: (Destatis(d), 2014).

Animal Products

Animal husbandry 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.

Of the four states analyzed in this section, 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 minor, 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: Breakdown of production percentage by specific livestock and federal states compared to overall German yield. Own table based on data from 2014 (percentage of German total) (Statistische Ämter des Bundes und der Länder(b), 2015) and (Destatis(e), 2015)

Vegetables and Fruit

In total, the domestic farming sector provides approximately one-third of Germany's demand for vegetables and one-fifth of its demand for fruit. The main exception is production of potatoes, which exceeds consumption, with part of the harvest destined for export (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. Main vegetables crops include carrots, cabbage, lettuce, pickling cucumbers and onions. Main fruits include apples, strawberries and other berries (BMEL(d), 2014).

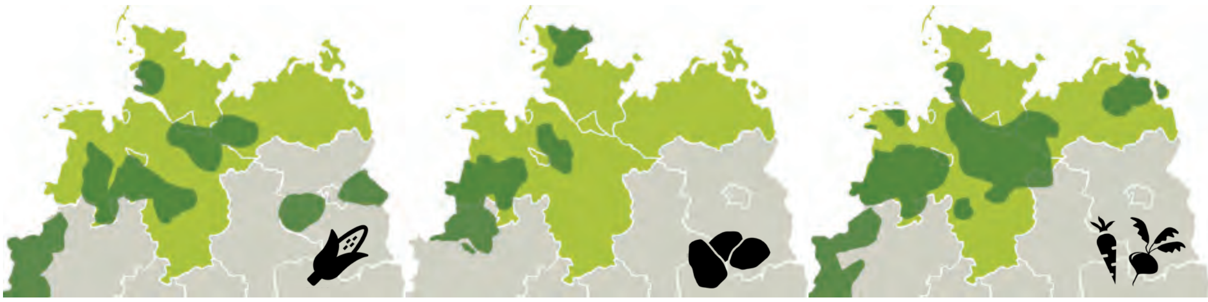


Figure 17. Indication (dark green area) of which plant products predominate in which areas of Germany. From left to right: field vegetables, maize and potatoes. Source: (Destatis(d), 2014).

Niedersachsen, especially the Lüneburger Heath, produces nearly half (43.5%) of the overall potato production in Germany, as well as roughly one-fourth of rye, winter wheat, and sugar beets (Niedersachsen, 2016). Schleswig-Holstein, on the other hand, produced nearly half (42%) of the German white cabbage harvest in 2014 (Table 5 figure 27.8% represents all types of cabbage), almost exclusively in the growing area of Dithmarschen (Schleswig-Holstein, n.d.). Of the entire German harvest for vegetables in 2014, the share of organically produced products ranged from 3.7% to 13.5%.

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: Breakdown of production percentage by specific crops and federal states compared to overall German yield. Own table based on data from 2014 (percentage of German total) (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 in 2014 (BMEL(d), 2014). Strawberries, plums, pears, cherries, and other types of berries are also produced, but on a smaller scale. Fruit production is also concentrated in areas that can provide ideal growing conditions. For example, 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 yield, respectively.

Figure 18. Indication (dark green area) of predominate apple production in areas of 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: Breakdown of production percentage by specific crops and federal states. Own table based on data from 2014 (percentage of German total) (Statistische Ämter des Bundes und der Länder(b), 2015) and (Destatis(e), 2015)

Figure 19. Indication (dark green area) of predominate cereals production in areas of Germany. Source: (Destatis(d), 2014).

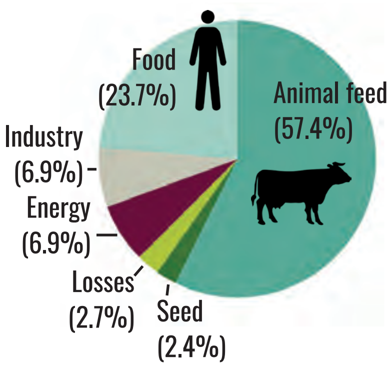


Figure 20. Cereal consumption breakdown 2011-13. Adapted from (BMEL(d), 2014).

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 (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).

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 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 Individual German Consumer's Diet Footprint

Individual diet choices, foot habits, and preferences are shaped by a variety of factors: cultural traditions, habits, fashion, psychological needs, personal food experiences, and accessibility and availability of consumption choices (Reisch, Eberle, & Lorek, 2013). These preferences, combined with lifestyle factors such as financial or family situations and work patterns, greatly influence food consumption choices, and thus, the individual consumer land footprint for food production (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

In some cases, the data was altered to make the diet more nutrient-complete or to make diets more comparable to each other in terms of consumption quantities. 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 organic standards, and in some cases, meet the stricter level of "Demeter" standards.

For certain food groups in the third diet, produced solely organically, some data was not available for consumption quantity or specific production yield efficiency (agricultural area required to produce one kilogram of product). In these cases, a consumption value for that specific food group was estimated based on recommendations from the German Nutrition Society, *Deutsche Gesellschaft für Ernährung* (DGE).

The quantity of agricultural land required for organic food production of each food group was calculated by multiplying the conventional production yield efficiency by an average yield comparison factor of conventional versus organic production for that specific food group, as determined by relevant research. 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 of 74% was imagined. 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 1: Potato Diet

To set a "lowest bound" scenario, an annual diet comprised solely of conventionally produced potatoes is imagined. Potatoes are one of the most land-efficient crops, with an average production efficiency of 0.3 m^2 required to produce one kilogram of potatoes conventionally, and 0.7 m^2 required to produce the same amount organically. Yield efficiency between conventional and organic production methods is highly contextual, however, and therefore may vary by up to 30%, according to identified studies. It was determined that the land footprint for food production to feed one person for one year on a diet comprised solely of potatoes is 189.1 m^2. 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.

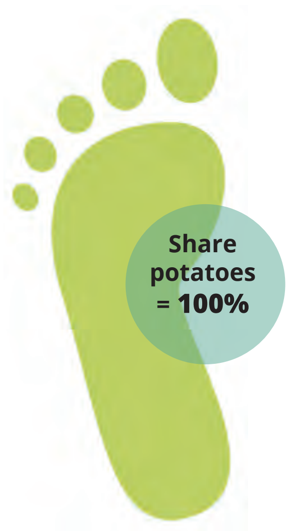


Figure 21. Composition of Diet Scenario One.

Food group	Quantity (kg/L) * cap *year	Land footprint (m^2*year)	% Of total land footprint	Calories per capita (kcal*yr)
Potatoes & potato products	1095.0	189.1	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.

Diet 2: Status Quo, Conventionally Produced Diet

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). The individual consumer footprint for food production was identified as 2,397m^2 per person, per year. This was also compared to similar studies by the Umweltbundesamt (UBA) and Meier et al., who determined the footprint for German food production was 2,460 m^2per year and 2,365 m^2 per year, respectively.

This figure was calculated by determining the overall agricultural area required for consumption: 21,659 million hectares, both in Germany (16,135 million hectares) and abroad (5,524 million hectares) (WWF(h), 2015). The area not used to produce food products, i.e., land for energy crops or agricultural commodities, was subtracted, leaving a total of 19,369 million hectares required in Germany and abroad for food and fodder production. This was divided by the quantity of the total German population, roughly 80.8 million people, which equals 2,397m^2 per person, per year.

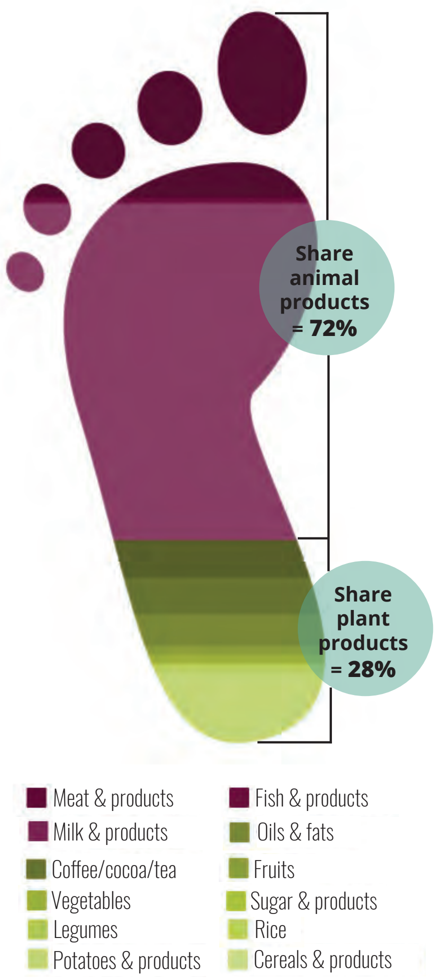


Figure 22. Composition of total land footprint for food production: Diet Scenario Two.

Breakdown of food groups, given this figure, was calculated by dividing the agricultural area under cultivation per food group by the total population. The land footprint for food production per food group, per person was then identified. This was then compared to the consumption data from the Federal Ministry of Food and Agriculture (BMEL) to illustrate the amount of land required to produce the supply that will fulfill consumption demand.

For the analysis of this thesis, this figure was slightly altered. When the land footprint for production of each food group was broken down, the sum did not equal 2,397 m^2, but rather 2,395 m^2. The source of this discrepancy was unable to be identified, and therefore it was decided to use the sum of the total land required for all food groups (2,395 m^2 per person, per year) in order to make the figure as transparent as possible.

Secondly, the production efficiency for legumes in the WWF study is identified as 10.0 m^2 to produce one kilogram of legumes. This was not consistent with data from the *Statistisches Jahrbuch 2015* from the German Federal Statistics Office (Destatis) (Destatis(e), 2015), which determined the average yield for legumes in Germany was 1.16 m^2/kg in 2014, or the Online database of Destatis, which indicated that the average yield was 1.21 m^2/kg in 2015. Therefore, the average of the two figures— 1.18 m^2 to produce one kilogram of legumes— was used.

The resultant 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.

Main characteristics of the current average German diet 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.

Food group	Quantity (kg or L) per capita, per year	Land footprint (m² per year)	% Of total land footprint	Calories per capita, per year (kcal)
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***	***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.

Diet 3: Ecological, Organically Produced Diet

Diet Scenario Three is based on actual results obtained from Kattendorfer Hof, a local, Demeter-certified farm in the north of Hamburg. As described in an earlier section, Demeter has stricter production standards than the base level German and EU organic certification. Please see Appendix I for a complete comparison.

The figures for the food groups of cereals, potatoes, sugar (in the form of honey), meat, eggs, and milk products were not altered. Figures for legumes, oils and fats, vegetables, fruits, and coffee/tea/cocoa were imagined or adjusted. Reasons for this are: (1) the farm is not able to produce a sufficient amount for a complete diet, in the case of legumes, oils and fats, fruit, and coffee/tea/cocoa, or (2) in the case of vegetables, enough was produced to feed one person, but in the interest of making the various diets as comparable as possible in terms of total quantities, more vegetables were added. 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 ecological Kattendorfer Hof diet is 37 kilograms of beef, pork, poultry, and goat per person, per year. This is roughly 60% lower than the current meat consumption average in Germany. To supplement a lower meat intake, a higher consumption quantity of legumes compared to Diet Scenario Two is imagined. 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).

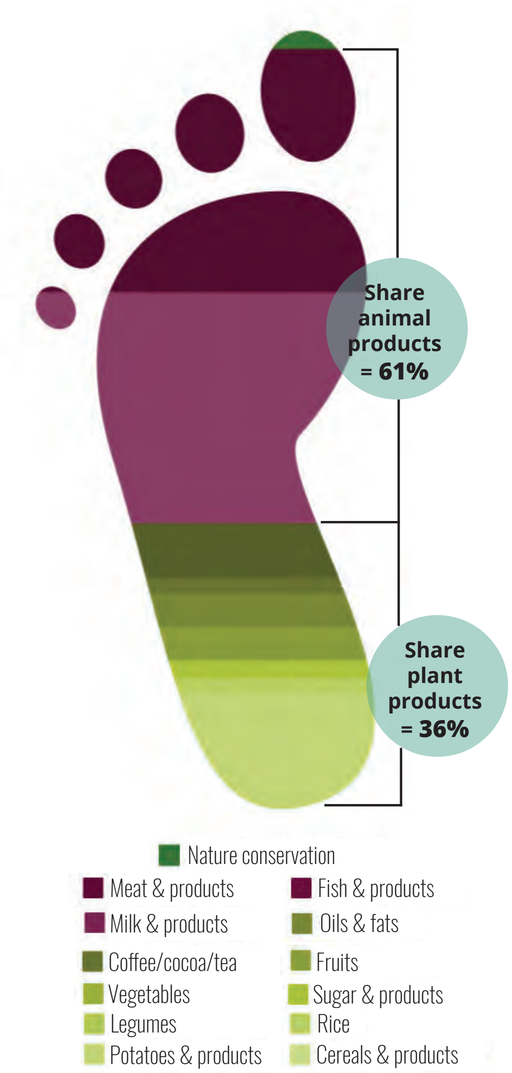


Figure 23. Composition of total land footprint for food production: Diet Scenario Three.

A consumption quantity of 40 kilograms of legumes per person, per year was imagined. To quantify the agricultural production space required to meet consumption demand, the production efficiency factor of 1.18 m^2 to produce one kilogram of legumes conventionally was multiplied by the yield efficiency comparison of conventional versus organic legumes. Based on studies by (de Ponti, Rijk, & van Ittersum, 2012), (Seufert, Ramankutty, & Foley, 2012) and data from Destatis (Destatis(e), 2015), organic legume yield is, on average, 82% of conventional legume yield on an equal amount of space. When the conventional yield efficiency factor of 1.18 m^2 was multiplied by 82%, a production efficiency factor of 1.4 m^2 to produce one kilogram of legumes organically per person, per year was identified.

Sugar is produced on the farm in the form of honey from bees. Although the quantity was approximately 90% lower than the average sugar consumption from 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, will be 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 therefore not included.

Vegetable consumption quantities were imagined according to the DGE recommendations of at least 300-600 grams per person, per day of vegetables. The average of 450 grams was used in calculations, amounting to 165 kilograms of vegetables per person, per year. This was multiplied by the production efficiency factor of 0.6 m^2 to produce one kilogram of vegetables, according to actual farm data.

Fruit consumption was also imagined according to DGE recommendations of at least 250 grams per day. As with legumes, an organic production efficiency value was calculated by multiplying the conventional fruit production efficiency value of 0.9 m^2 per kilogram of fruit by a yield comparison factor, calculated by comparing studies from (de Ponti, Rijk, & van Ittersum, 2012), (Seufert, Ramankutty, & Foley, 2012) and Destatis, of 77% of conventional yields. This equaled an organic fruit production efficiency factor of 1.1 m^2 to produce one kilogram 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— which includes beef, pork, poultry, goat, as well as 150 eggs per person— per year, 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, according to an average by the *United Nations Economic Commission for Europe (*UNECE) standard for edible hen eggs (UN, 2010), with a result of 9.0 kilograms. This illustrated an average overall production efficiency factor for meat and eggs of 15.2 m^2 to produce one kilogram of product.

Coffee/tea/cocoa were not produced on the farm, but were in 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; however, the land footprint of 127 m^2 for conventional coffee/tea/cocoa production was multiplied by the overall average organic yield comparison factor of 74% of conventional yields. The result was 160.2 m^2 per person, per year is required to fulfill consumption demand.

The last figure included in this diet scenario is 50 m^2 per person, per year 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 resultant 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.

Food group	Quantity (kg or L) per capita, per year	Land footprint (m^2 per year)	% Of total land footprint	Calories per capita, per year (kcal)
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 or L) per capita, per year	Land footprint (m^2 per year)	% Of total land footprint	Calories per capita, per year (kcal)
Beef				39,220
Pork	37.0	700.0	30%	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	160.2	7%	-
Nature conservation	0.0	50.0	2%	-
Total	***642***	***2,346***	***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.

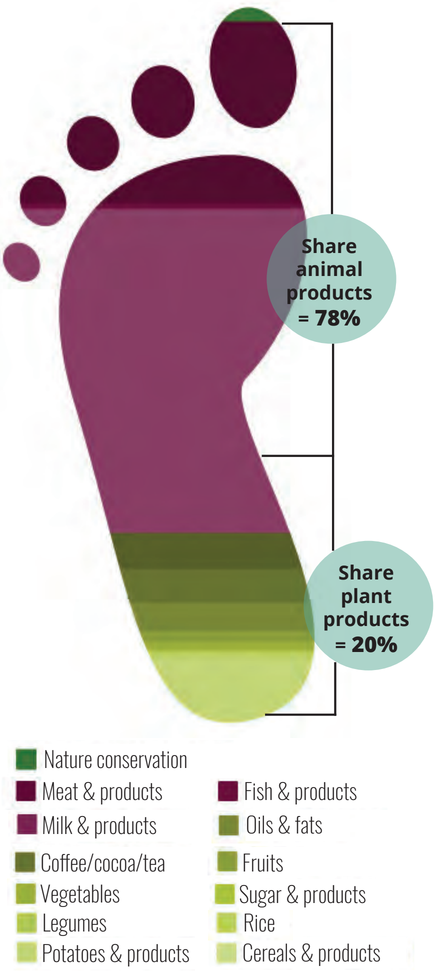


Figure 24. Composition of total land footprint for food production: Diet Scenario Four.

Diet 4: Status Quo, Organically Produced Diet

Diet Scenario Four represents the land footprint for food production per person if current eating habits are maintained, but the food is only produced organically. Consumption quantities were taken exactly from diet scenario two.

To determine land footprint for food production per food group, the first step was to calculate an average organic comparison factor based on results from the Kattendorfer Hof, studies by (de Ponti, Rijk, & van Ittersum, 2012) and (Seufert, Ramankutty, & Foley, 2012), as well as results from Destatis. See Appendix II for calculations.

The next step was to multiply the space required for each food group conventionally produced in diet scenario two by the calculated efficiency comparison of organic versus conventional yields. 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. While in the case of diet scenario three, the consumption quantity of 46 kilogram per year of meat and eggs requires 700 m^2 of land per year. This equates to a production efficiency of 15.2 m^2 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 m^2 per person, per year, with an aggregated yield efficiency of 11.0 m^2 per year for production of specified animal products. Compared to the production 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. The resultant land footprint for the current average per capita consumption quantity of organically produced foods is 3,102 m^2, per year.

Food group	Quantity (kg or L) per capita, per year	Land footprint (m^2 per year)	% Of total land footprint	Calories per capita, per year (kcal)
Cereals & cereal products	95.6	279.5	9%	272,460
Potatoes & potato products	70.7	30.2	1%	48,076
Rice	5.3	11.7	0%	19,981
Legumes	0.4	0.6	0%	1,392
Sugar products	48.0	37.8	1%	170,400
Vegetables	95.4	40.2	1%	24,804
Fruits	110.5	121.8	4%	60,775
Oils & fats	19.9	149.9	5%	68,655
Beef	13.0	449.3	14%	13,780
Pork	52.6	599.0	19%	88,894
Poultry	18.5	192.0	6%	24,420
Sheep/goat	0.9	30.7	1%	2,187
Eggs	13.3	107.5	3%	18,620
Other meat	2.0	29.4	1%	2,320
Fish & fish products	14.1	23.0	1%	14,523
Milk & milk products	118.8	788.6	25%	57,024
Coffee/cocoa/tea	0.0	160.2	5%	-
Nature conservation	0.0	50.0	2%	-
Total	***679***	***3,102***	***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.

Scenarios of Maximum Amount of Persons Fed From Regional Organic Agriculture

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

The first step to calculate the maximum amount of persons fed from regional organic agricultural production is to define the "region." In this thesis, three separate "regions" will be defined.

Using Hamburg as the center point, the first region is comprised solely of the city-state of Hamburg. The second region encompasses the city-state of Hamburg and all the surrounding "Landkreise" (counties) within a 50-kilometer radius. The third region comprises the city-state of Hamburg and all counties within a 100-kilometer radius. If more than half of the county was within the radius, it was included.

To simplify this analysis, the thesis will assume the closest source will deliver to the closest consumer. For example, producers from Schleswig-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 incredibly complex. Instead, it will always be assumed that the producers will first fulfill needs of the closest consumers.

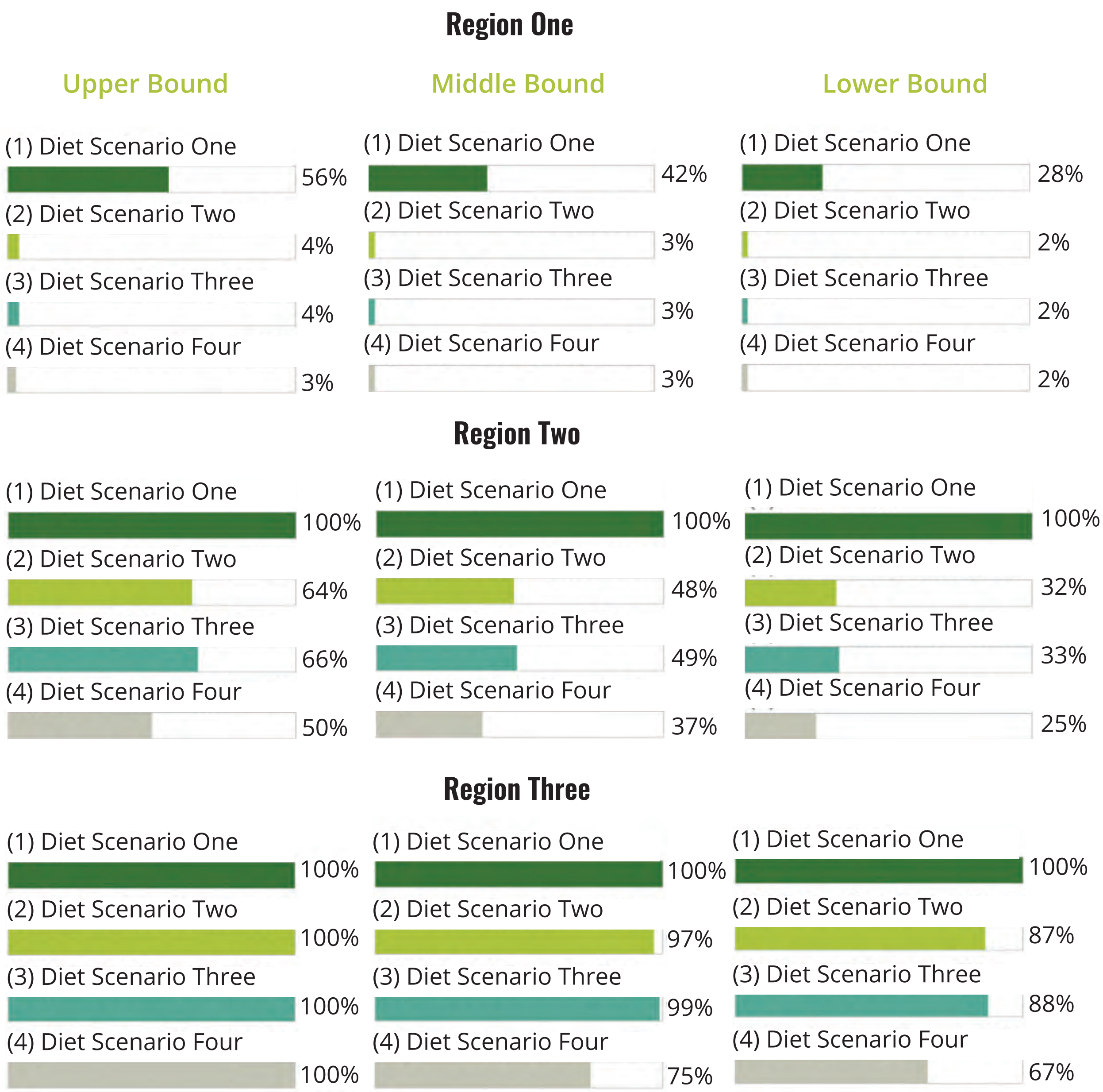
The next step is determining the amount of people who live within the selected regions and will be fed with the regionally produced food. The population of region one is 1,762,791 people; region two, 2,198,693 people; and region three, 6,177,700 people (Destatis(f), 2015). To give an indication of the potential to feed citizens within the region, the ratio of persons to be fed with one square kilometer of agricultural land per region was defined. This was done by dividing the population by total agricultural land available within each region. Results are indicated on each map (as people to agricultural land).

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

Furthermore, the breakdown of agricultural land is also an important indicator of land-use. 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 federal states analyzed in this thesis are as follows (Destatis(e), 2015):

The breakdowns of agricultural land use in the federal states analyzed in this thesis are as follows, information for Hamburg was not available (Destatis(e), 2015):

- Mecklenburg-Vorpommern is comprised of roughly 80% arable land, 20% permanent grassland and 0.2% permanent crops.
- Niedersachsen is comprised of roughly 72% arable land, 28% permanent grassland and 0.07% permanent crops.
- Schleswig-Holstein is comprised of roughly 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 imagined.

The results are as follows:

Region 1

The results for the first region are a good indicator of population density in the city-state of Hamburg, which has more than five times the population of the next most inhabited county, *Pinneberg*, and has the fourth smallest agricultural area behind *Kiel, Lübeck*, and *Neumünster.* 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.

Region 2

Results from the second region indicate that, even when only 50% of the agricultural land is being 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 37% 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, nearly all of the people can be fed with Diet Scenarios Two and Three, and three-quarters with Diet Scenario Four. If only half of agricultural land is used for food production, nearly 90% can be fed with Diet Scenarios Two and Three, and nearly 70% 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 resultant overall land footprint for food production, three more diet scenarios will be examined. Diet scenario Five is following consumption data per capita according to the German Nutrition Society (DGE) recommendations. Diet Scenario Six is based on average current consumption data per capita for Germans, except with a 30% reduction in meat intake, equal to eating “meat-free” two days per week. Diet Scenario Seven is based on average current consumption data per capita for Germans, except with a 60% reduction in meat intake, equal to eating “meat-free” four days per week. Diet Scenario 8 represents a completely vegetarian diet, with no meat or fish intake, but with an increased egg and legume intake to recoup protein that would have come from meat. Each potential diet represents a shift of varying degree toward a more ecological diet, compared to the current Diet Scenario Two, in terms of land footprint for food production.

To assess the affects of consumer diet choices on the potential for feeding citizens with regionally produced foods, maximum persons fed for Regions One, Two and Three (as described in the previous section) will also be illustrated 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, per year of each diet will be calculated using production 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 purposes.

Diet 5: DGE Recommendations

The first scenario will analyze the land footprint for food production if citizens ate according to recommendations by the DGE, as illustrated in table 11:

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)

Diet Scenario Five is based on recommendations from the DGE. All figures follow exact guidelines as outlined in table 11, except there has been an increase in vegetable and fruit 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 due to the desire 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.

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

Although not discussed in detail in this thesis, current consumption patterns (diet scenario two) are not in line with the DGE recommendations. 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 potato 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

The resultant land footprint for the current consumption quantity of organically and conventionally produced foods according to DGE consumption quantities is 1542.1 m^2, per person, per year for conventional production and 2054.1 m^2, per person, per year for organic production.

Main characteristics of the this diet are:

1. A significant decrease in meat intake of roughly 72% compared to diet scenarios two and four. This indicates that Germany's average meat consumption is not only land-intensive, but also may be harmful to health.
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.

<table>
<tr><th>Food group</th><th>Quantity (kg/L) *cap*year</th><th>Land footprint produced conventionally (m²*year)</th><th>Land footprint produced organically (m²*year)</th><th>Calories per capita (kcal*yr)</th></tr>
<tr><td>Cereals & cereal products</td><td>91.3</td><td>220.5</td><td>266.8</td><td>260,062.5</td></tr>
<tr><td>Potatoes & potato products</td><td>82.1</td><td>24.4</td><td>35.1</td><td>55,845.0</td></tr>
<tr><td>Rice</td><td>0.0</td><td>0.0</td><td>0.0</td><td>-</td></tr>
<tr><td>Legumes</td><td>40.0</td><td>47.0</td><td>56.0</td><td>139,200.0</td></tr>
<tr><td>Sugar products</td><td>14.4</td><td>9.0</td><td>11.3</td><td>-</td></tr>
<tr><td>Vegetables</td><td>182.5</td><td>57.4</td><td>76.9</td><td>47,450.0</td></tr>
<tr><td>Fruits</td><td>109.5</td><td>98.1</td><td>120.7</td><td>60,225.0</td></tr>
<tr><td>Oils & fats</td><td>12.8</td><td>76.4</td><td>96.3</td><td>44,073.8</td></tr>
<tr><td>Beef</td><td rowspan="6">32.1</td><td rowspan="6">353.1</td><td rowspan="6">487.9</td><td rowspan="6">52,162.5</td></tr>
<tr><td>Pork</td></tr>
<tr><td>Poultry</td></tr>
<tr><td>Sheep/goat</td></tr>
<tr><td>Eggs</td></tr>
<tr><td>Other meat</td></tr>
<tr><td>Fish & fish products</td><td>8.9</td><td>11.3</td><td>14.5</td><td>9,146.4</td></tr>
<tr><td>Milk & milk products</td><td>102.2</td><td>517.9</td><td>678.4</td><td>49,056.0</td></tr>
<tr><td>Coffee/cocoa/tea</td><td>n.a.</td><td>127.0</td><td>160.2</td><td>-</td></tr>
<tr><td>Nature conservation</td><td>n.a.</td><td>0.0</td><td>50.0</td><td>-</td></tr>
<tr><td>Total</td><td>675.73</td><td>1542.1</td><td>2054.1</td><td>717,221.2</td></tr>
</table>

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.

Diet 6: Current consumption + two "meat free" days per week

Diet scenario six is comprised of the exact quantities of current average consumption data, but with a 30% reduction in meat intake. This corresponds to going "meat-free" just two days per week. To compensate for the reduce in meat intake from roughly 100 kilograms to 70 kilograms, a 29.5 kilogram increase in legume intake is imagined.

The resultant land footprint for the current consumption quantities of organically and conventionally produced foods, based off of current consumption quantities with a reduction in meat intake and an increase in legumes, equals 2095.5 m^2, per person, per year for conventional production, and 2802 m^2, per person, per year for organic production.

Main characteristics of the this diet are:

1. A decrease in meat intake by 30%.
2. Including eggs, milk, and milk products; meat and meat products; and fish, roughly 68%

Food group	Quantity (kg/L) *cap*year	Land footprint produced conventionally (m^2*year)	Land footprint produced organically (m^2*year)	Calories per capita (kcal*yr)
Cereals & cereal products	95.6	231.0	279.5	272,460
Potatoes & potato products	70.7	21.0	30.2	48,076
Rice	5.3	11.0	11.7	19,981
Legumes	30	35.3	42.0	104,400
Sugar products	48.0	30.0	37.8	170,400
Vegetables	95.4	30.0	40.2	24,804
Fruits	110.5	99.0	121.8	60,775
Oils & fats	19.9	119.0	149.9	68,655
Beef	70.2	772.2	1067.0	74,412
Pork				
Poultry				
Sheep/goat				
Eggs				
Other meat				
Fish & fish products	14.1	18.0	23.0	14,523
Milk & milk products	118.8	602.0	788.6	57,024
Coffee/cocoa/tea	n.a.	127.0	160.2	-
Nature conservation	n.a.	0.0	50.0	-
Total	***679***	***2,095.5***	***2,802.0***	***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.

of the total land footprint for food production, conventional and organic, is dedicated to producing animal products.

Diet scenario 7: Current consumption + four "meat free" days per week

Diet scenario seven is comprised of the exact quantities of current average consumption data, 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 reduce in meat intake from roughly 100 kilograms to 40 kilograms, a 59.5 kilogram increase in legume intake is imagined.

The resultant land footprint for the current consumption quantities of organically and conventionally produced foods, based off of current consumption quantities with a reduction in meat intake and an increase in legumes, equals 1799.8 m^2, per person, per year for conventional production and 2366.6 m^2, per person, per year for organic production.

Main characteristics of the this diet are:

1. A decrease in meat intake by 60%.

Food group	Quantity (kg/L) * cap *year	Land footprint produced conventionally (m^2*year)	Land footprint produced organically (m^2*year)	Calories per capita (kcal*yr)
Cereals & cereal products	95.6	231.0	279.5	272,460
Potatoes & potato products	70.7	21.0	30.2	48,076
Rice	5.3	11.0	11.7	19,981
Legumes	30	35.3	42.0	104,400
Sugar products	48.0	30.0	37.8	170,400
Vegetables	95.4	30.0	40.2	24,804
Fruits	110.5	99.0	121.8	60,775
Oils & fats	19.9	119.0	149.9	68,655
Beef Pork Poultry Sheep/goat Eggs Other meat	40.1	441.3	609.8	42,527
Fish & fish products	14.1	18.0	23.0	14,523
Milk & milk products	118.8	602.0	788.6	57,024
Coffee/cocoa/tea	n.a.	127.0	160.2	-
Nature conservation	n.a.	0.0	50.0	-
Total	***678***	***1,799.8***	***2,366.6***	***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.

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.

Diet scenario 8: Vegetarian + increase in egg and legume intake

Diet scenario seven 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 results will indicate that it 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 resultant land footprint for the current consumption quantities of organically and conventionally produced foods, based off of current consumption quantities with no meat intake and an increase in legumes and eggs, equals 1484.3 m^2, per person, per year for conventional production, and 1938.7 m^2, per person, per year for organic production.

Main characteristics of the this diet are:

Food group	Quantity (kg/L) * cap *year	Land footprint produced conventionally (m^2*year)	Land footprint produced organically (m^2*year)	Calories per capita (kcal*yr)
Cereals & cereal products	95.6	231.0	279.5	272,460
Potatoes & potato products	70.7	21.0	30.2	48,076
Rice	5.3	11.0	11.7	19,981
Legumes	30	35.3	42.0	104,400
Sugar products	48.0	30.0	37.8	170,400
Vegetables	95.4	30.0	40.2	24,804
Fruits	110.5	99.0	121.8	60,775
Oils & fats	19.9	119.0	149.9	68,655
Beef	-	-	-	-
Pork	-	-	-	-
Poultry	-	-	-	-
Sheep/goat	-	-	-	-
Eggs	15	132.0	182.4	16,800
Other meat	-	-	-	-
Fish & fish products	14.1	18.0	23.0	14,523
Milk & milk products	118.8	602.0	788.6	57,024
Coffee/cocoa/tea	n.a.	127.0	160.2	-
Nature conservation	n.a.	0.0	50.0	-
Total	***681***	***1,484.25***	***1,938.7***	***982,575***

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.

Top: Vegetables at the Warenwirtschaft. Right: Feldsalat growing at the Kattendorfer Hof Image sources: (Joseph, 2016)

1. No meat or fish intake.
2. An increase of sixty times legume consumption and a 12% increase in egg consumption compared to current, average per capita quantities.

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, maximum persons fed for Regions One, Two and Three (as described in the previous section) will also be illustrated for Diet Scenarios Five through Eight. The Middle Bound of 75% of agricultural land to be used for food production will be utilized. This was considered to be the closest to the most plausible scenario, bearing in mind the other potential production uses for agricultural land such as to produce energy plants or other agricultural commodities.

Furthermore, as this thesis is focusing on organic agricultural as a potential alternative that can mitigate some of the environmental challenges posed by our current, globalized, conventional food system in Chapter Two, organic production methods have been analyzed. The following figures will 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 Scenario Five through Eight, results are still limited within Region One, with potential to only feed at most 4% of the population. Results for Region Two, however, indicate that the Diet Scenario Eight, a vegetarian diet, has the most potential to feed citizens, with 100% able to be fed within Region Two, with 75% of agricultural land used for food production. Diet Scenario Five is a close second, with 94% able to be fed within this region. Diet Scenarios Six and Seven still produce limited results, where just less than three-quarters of

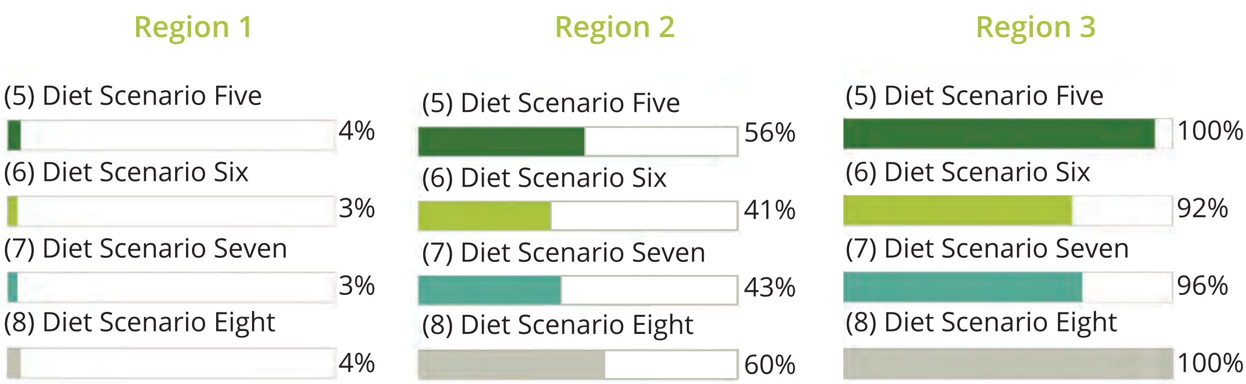


Figure 26. Percentage of regional population fed in Region One, Two and Three with Diet Scenarios 5-8.

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, Eberle, & Lorek, 2013), (Hughner, McDonagh, Prothero, Shultz II, & Stanton, 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, Eberle, & Lorek, 2013). Further, other obstacles— 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.

Image source: (Joseph, 2016)

The question then remains: ***how can organic and regional agriculture be promoted if consumers are not willing, or able, to pay more for these products?***

One option relies on governments and policy-makers to promote sustainable food consumption and production through not only information-based, but also market-based and regulatory, instruments. Although there is not yet a commonly agreed upon definition of “sustainable food consumption,” it generally refers to foods that (Reisch, Eberle, & Lorek, 2013):

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

To date, however, government efforts are largely focused on food security and maintenance of overall agricultural production without significant concentration toward an integrated policy of sustainable development that covers all actors in the food system (Reisch, Eberle, & Lorek, 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 also be noted that organically produced food has become part of the globalization process, where foods must increasingly be imported because domestic production cannot meet demand. Local food, on the other hand, represents an opposite trend, encouraging more proximity of food production (Hempel & Hamm, 2016).

Right: Field salad at the Kattendorfer Hof. Top: Plow at the Kattendorfer Hof. Image sources: (Joseph, 2016)

Perhaps a more plausible opportunity for making significant progress toward promoting organic and regionally produced foods is a bottom-up approach. The rise of new or adapted alternative food networks (AFNs) 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, Eberle, & Lorek, 2013).

The following section will focus on defining AFNs, giving examples of three efforts in the regions of Hamburg and Northern Germany, and identifying qualities that models of AFNs posses to help overcome the higher price premium of organic products. The examples of the networks will then be assessed based on the perceived relativity to the qualities that can affect consumers purchasing choices to illustrate which model may have the most potential to promote increased production and consumption of organic and regionally produced foods.

Characteristics of Alternative Food Networks

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

- Shortening distances between producers and consumers
- Smaller farm sizes and scale, usually organic or closed-cycle compared to agribusiness-oriented
- 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).










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 *Solidarischer 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 provide labor on the farm, while 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 in 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 (Solidarischer 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 their 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 resultant 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 holistic balance of the farm is 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
Christ Hof
Moorrüben


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


Tomaten


Herk.: d Zert.: bioland
Zwiebeln rot
5 kg
AUEHOF
Reese

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 who they serve (UN Social, 2016). This structure ensures that decisions made balance the need for profits 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 shop runs on the model of a cooperative, where 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 consumers 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 losses when food is stolen or has gone rotten. Price reductions differ greatly between products. For example, while members typically pay 40-50% less for fresh fruits and vegetables, they pay only 5% lower prices for milk compared to non-members (Frötscher, 2016).

Membership has also increased significantly since the co-op began nearly eight years ago with thirty original members. 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 suitable amount of work for the owners, as well as to maintain a comfortable, familiar environment for members without the possibility of scarcity of products (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 place a preference on 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 or brought by land if necessary. 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
Dithmarschen
Rendsburg-Eckernförde
Kiel
Plön
Ostholstein
Neumünster
Steinburg
Segeberg
Lübeck
Nordwest-mecklenburg
Stormarn
Cuxhaven
Pinneberg
Herzogtum Lauenburg
Stade
Hamburg
Ludwigslust
Harburg
Rotenburg (Wümme)
Lüneburg
Lüchow-Dannenberg
Heidekreis
Uelzen


eigene


BREITENWEGERHOF
demeter

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

3. A Holistic 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 results are limited.

The model's foundation is the building of 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. Investments include a mix of private and public contributions; 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* or the environmental foundation *Greenpeace*, with a total of 945,000 euros of capital (Schönheim, 2016).

One of the major goals 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). At the same time, there are many educated young farmers who do not have access to land due to high investment costs. Regionalwert AG seeks to connect want-to-be farmers with farmers who don't have successors and then provide financial support if needed.

Also, another focus is to reduce the burden on farmers who switch to organic production methods. This not only supports the individual farmers, but supports growth in the number of regional, organic farms. 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 stating they are obliged 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. 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 pigs at a local farm.

Characteristics of AFNs that Affect Consumers' Willingness-to-Pay (WTP)

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 (WTP) refers to the largest sum a consumer is willing to pay for a product or service. It is assumed that, in general, local products are not more expensive than non-local, conventionally produced products (Hempel & Hamm, 2016). In the case of organic products, ample studies have been conducted to attempt to identify factors that may affect consumers' WTP 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 organic consumers 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 individual financial considerations. 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, as well (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 WTP 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 welfare (dark green); convenience and diversity (maroon); and social and knowledge sharing (light blue).

Seven different distribution channels will also be identified, and their relation to the factors will be analyzed. Each of the distribution channels will be rated on a scale of one to three in terms of their relatively of factors that may influence consumers' WTP, illustrated in a wheel diagram. One color block indicates low perceived relevance; 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 sixth 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,"* an EU 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 conventional supermarket or discount retailer is considered to be the least expensive option for consumers to purchase products. The food co-op example of Warenwirtschaft is considered to be less expensive than the other five organic distribution channels, as members pay a reduced price for food, assuming they purchase enough to exceed the monthly membership fee. Prices for organic products from the CSA, regional network, delivery box, Online marketplace, and organic shop are considered to be the highest, and low prices would not be a relevant factor for consumers who choose to purchase products from these channels.

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

A study by (Padilla Bravo, Cordts, Schulze, & Spiller, 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, McDonagh, Prothero, Shultz II, & Stanton, 2008) and (Reisch, Eberle, & Lorek, 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, McDonagh, Prothero, Shultz II, & Stanton, 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, McDonagh, Prothero, Shultz II, & Stanton, 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 first six organic and/or regional distribution channels were assessed to provide a high relevance 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, McDonagh, Prothero, Shultz II, & Stanton, 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 CSA program and the delivery box were considered 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 and support of the local economy.

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, Cordts, Schulze, & Spiller, 2013), German consumers are particularly interested in animal welfare and are more willing to pay for products that provide evidence of this attribute. Additionally, consumers perceive chemicals 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, McDonagh, Prothero, Shultz II, & Stanton, 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, saves 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).

CSA, regional network and delivery box were considered to have the closest connected with 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, McDonagh, Prothero, Shultz II, & Stanton, 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 first six organic and/or regional distribution channels were considered 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 CSA, delivery box, and regional network were assessed to 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

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

distribution channels were also expected to have a high relevance in terms of diversity because products can come from a variety of sources, as well as be imported.

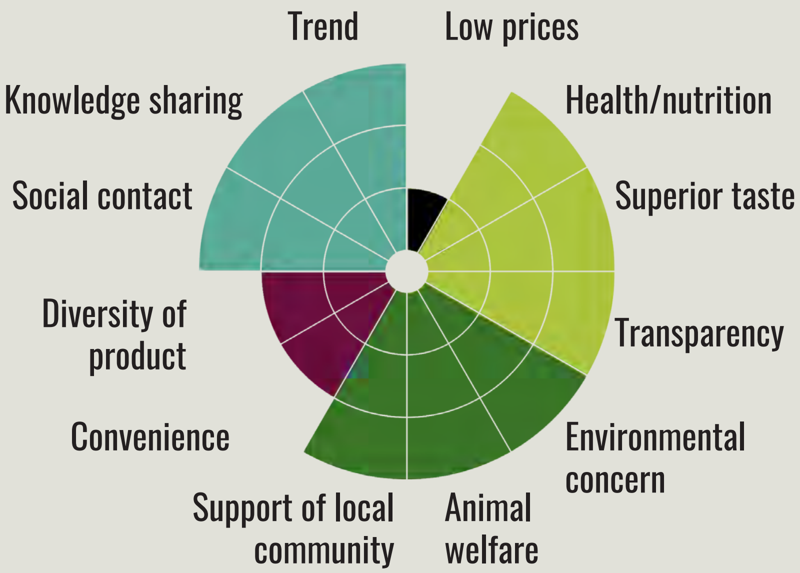
Social contact, knowledge sharing and trend (light blue)

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).

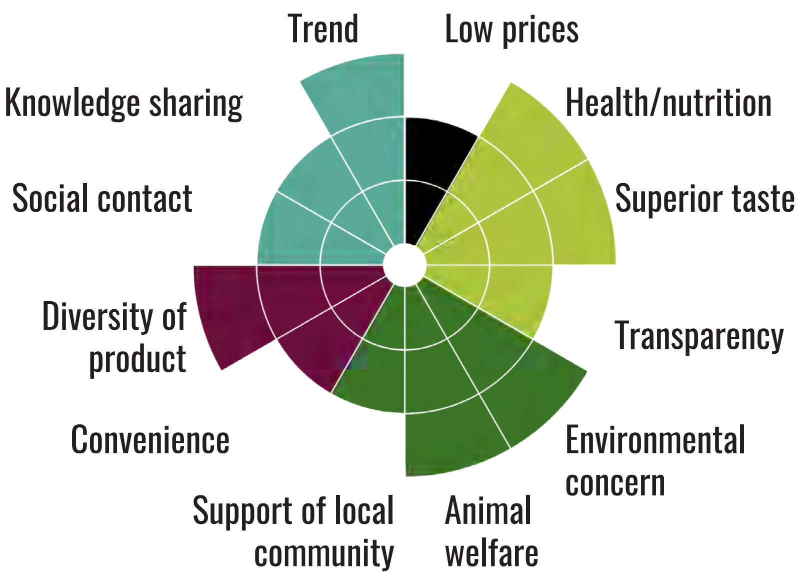
The CSA and regional network were considered to be the most relevant to knowledge sharing and social contact between members, as these are fundamental principles of their models. The food co-op, delivery box, Online marketplace, and Online shop were considered to have medium relevancy, as members are 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, McDonagh, Prothero, Shultz II, & Stanton, 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, Eberle, & Lorek, 2013).

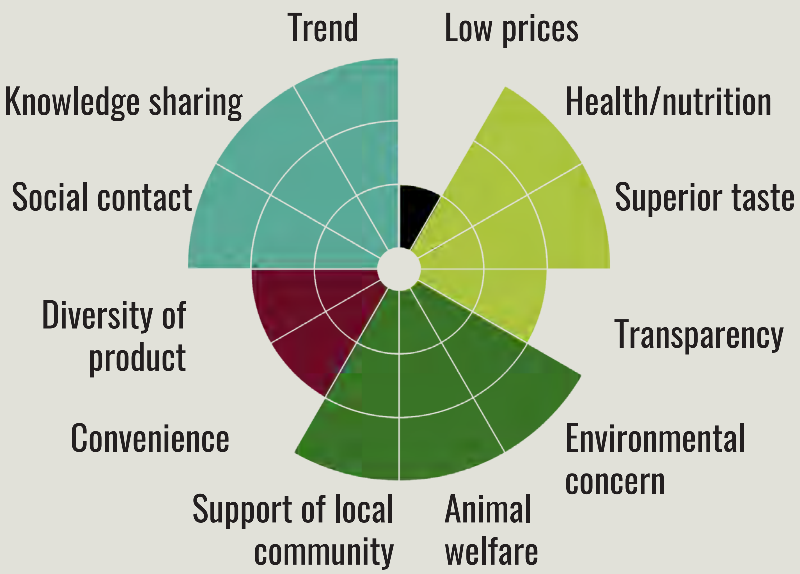
The first six distribution channels— CSA, food co-op, regional network, delivery box, Online marketplace, and organic shop— are all highly relevant to this the concept of organic and regionally produced food as "trendy." Conventional supermarkets, on the other hand, have a low relevance to this factor.



1. Community Supported Agriculture

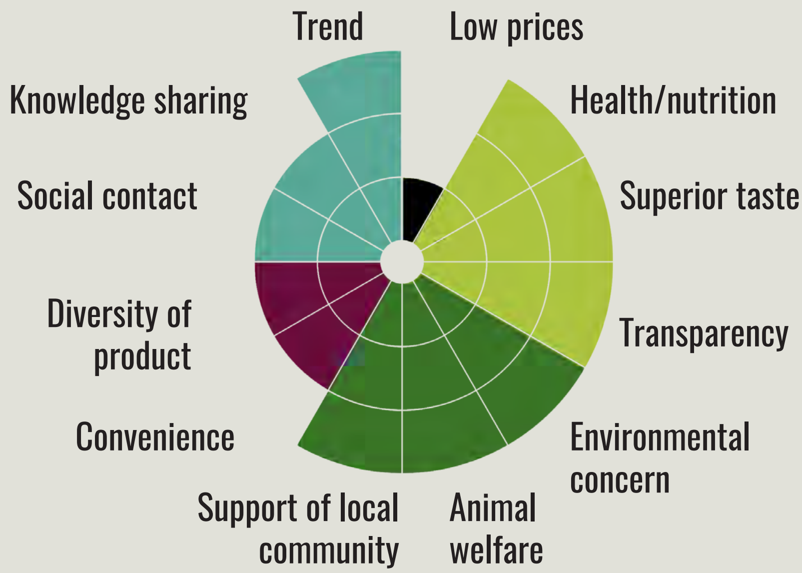


2. Food Co-op



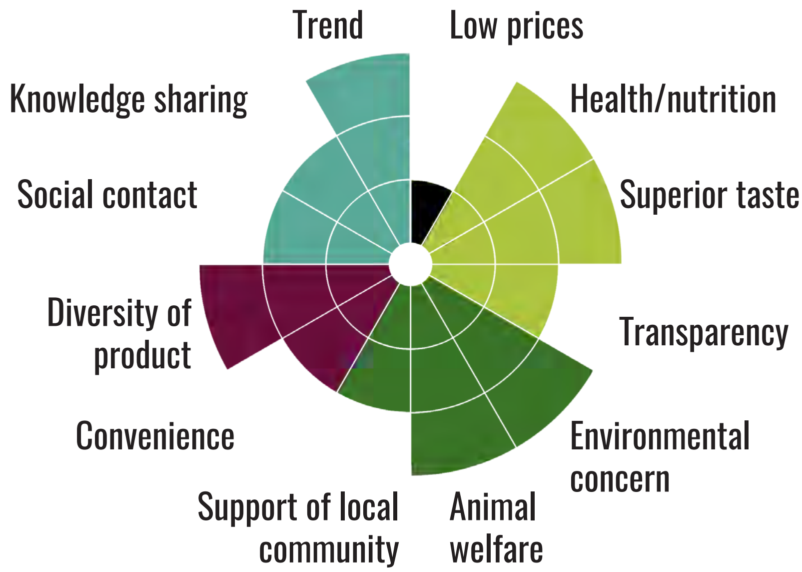
3. Regionalwert

4. Delivery Box



5. Online Marketplace

6. Small Organic Shop



7. Large Retail Chain

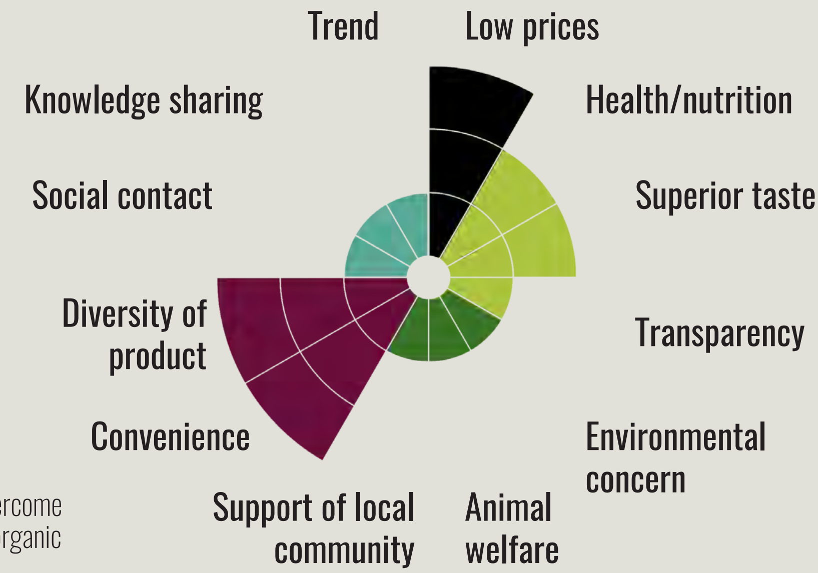


Figure 27. Assessment of factors to overcome willingness-to-pay price premiums for organic products by distribution channel

Discussion of Results

Comparison of Land Footprint for Diet Scenarios

The results of the comparison of the diet scenarios presented indicate that individual consumption choices have a significant impact on the individual consumer land footprint for food production and, in sum, the overall land footprint to supply the entire population. Meat consumption quantities, in particular, play the largest role in determining the required agricultural land for food production. This point is further echoed by a study conducted by Jungbluth, N. et al. (2012), which concluded that an environmentally friendly, health conscious and vegetarian diets had the highest potential to reduce the impact of the food system on the environment and climate change (UBA(c), 2014).

It should be noted that while milk and dairy products do also contribute to a large percentage of the overall land footprint for food production, the production 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/sheep. For this reason, as well as the fact that current average per capita German milk consumption values are approximately aligned to DGE recommendations as identified in Chapter 4, reduction of milk and dairy products was not focused on in this thesis.

The first indicator to support this theory is revealed 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 option, higher in vegetables and legumes and lower in meat consumption, produced according to at least basic-level German organic standards. It may be assumed 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: (Flickr, 2016)

Although more land is required to produce organic plant products as compared to Diet Scenario Two, the nearly 60% reduction in meat intake for Diet Scenario Three plays a huge role in the land footprint for food production. Meat and egg consumption quantities for Diet Scenario Three is 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 land production efficiency of organically produced legumes, roughly 1.4 m^2 to produce one kilogram of legumes, is much greater than the land production 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.

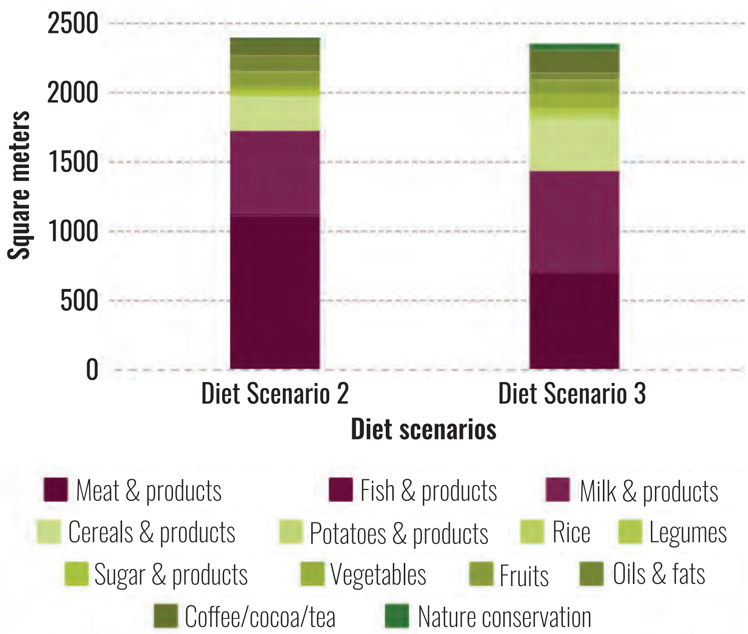


Figure 28. Comparison of Diet Scenarios 2 and 3.

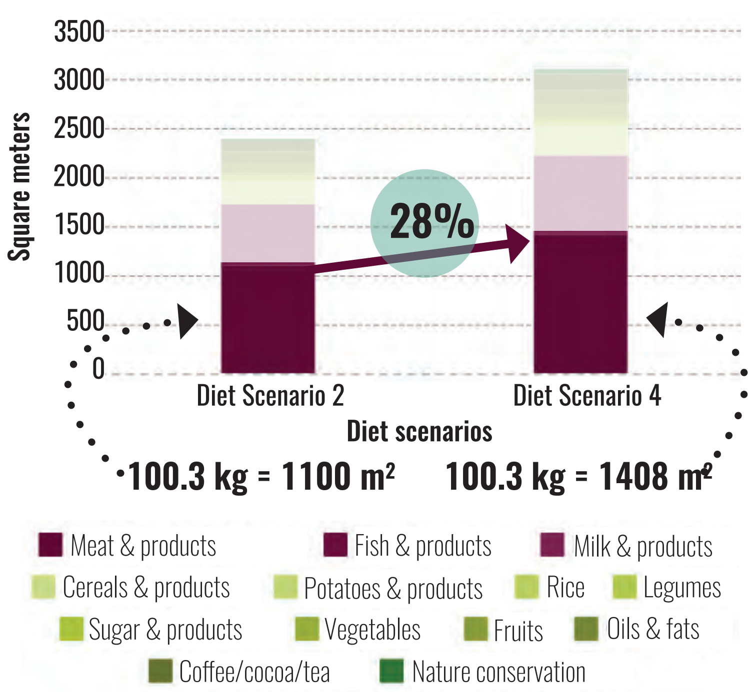


Figure 29. Comparison of Diet Scenarios 2 and 4.

When comparing Diet Scenarios Two and Three, it can be concluded that a reduction in meat intake of at least 60% will compensate 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 imagined that the population maintains current consumption quantities, but food is produced according to organic standards. This is illustrated in figure 29.

Land requirement to produce 100.3 kilograms of meat and eggs equaled 1100 m^2 conventionally and 1408 m^2 organically, corresponding to an increase of 28% (figure 29). For plant products, the agricultural land requirement increased from 689 m^2 by conventional standards to 832 m^2 by organic standards, equaling an increase of 24%. 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 143 m^2 more per person, per year compared to conventional products, organic animal products required 308 m^2 more per person, per year. Therefore, it can be concluded that producing animal products organically has a larger effect on land footprint for food production than a switch from conventionally to organically produced plant products. This point is further corroborated when Diet Scenarios Six and Seven are compared to Diet Scenario Four, as illustrated in figure 30.

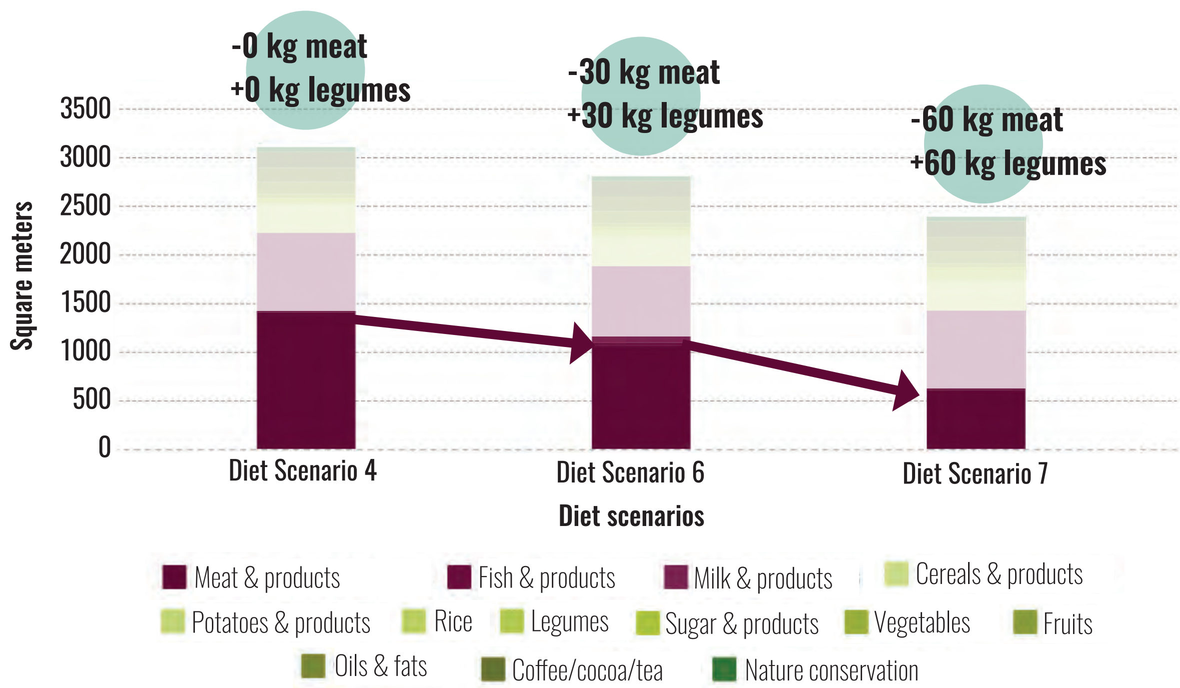


Figure 30. Comparison of Diet Scenarios 4 ,6 and 7.

Diet Scenario Four represents the agricultural land footprint for current consumption quantities produced to organic standards, with meat consumption equaling 100.3 kilograms per person, per year. Scenario Six represents a reduction in meat consumption quantities 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. 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 resultant reduction of the agricultural land footprint for meat and egg production compared to Diet Scenario Four is 341 m^2 in Diet Scenario Six, and 798 m^2 in Diet Scenario Seven. This corresponds to an overall reduction of total land footprint of roughly 11% and 26%, respectively.

Legume intake for Diet Scenario Three equaled 0.5 kilograms per person, per year, 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.

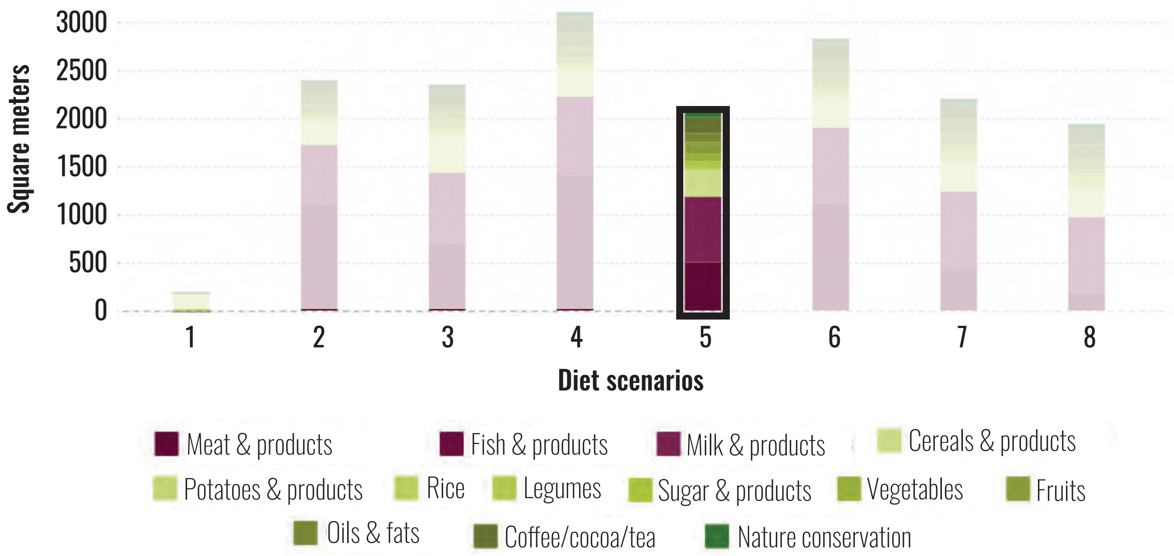


Figure 31. Comparison of all Diet Scenarios 1-8.

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 31.

While the vegetarian diet may appear to represent the most ecological choice in terms of land footprint, it may present sustainability challenges when considering the holistic 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; 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 31). 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 organically, 300 m^2 of agricultural land per person, per year could be freed up to produce other food items. This corresponds to a total of 24,186 km^2 of available land if all German citizens implemented these changes, nearly equivalent to the total agricultural area (21,475 km^2) of Region Three, discussed in the previous chapter. If all citizens with Region Three, roughly 6.8 million people, ate according to this diet, an additional 918,559 people could be fed according to consumption quantities of Diet Scenario Six.

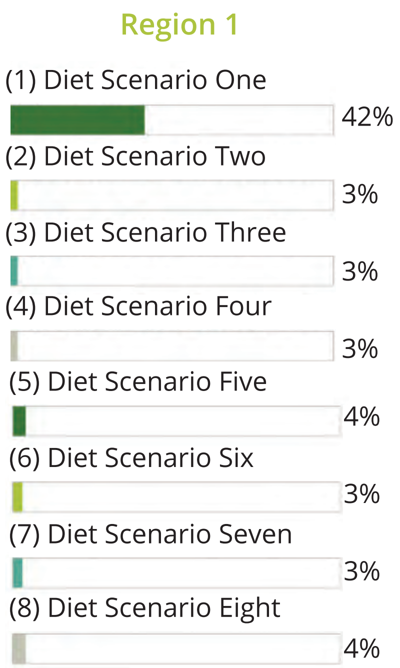


Figure 32. Percentage of regional population fed in Region One with Diet Scenarios 1-8.

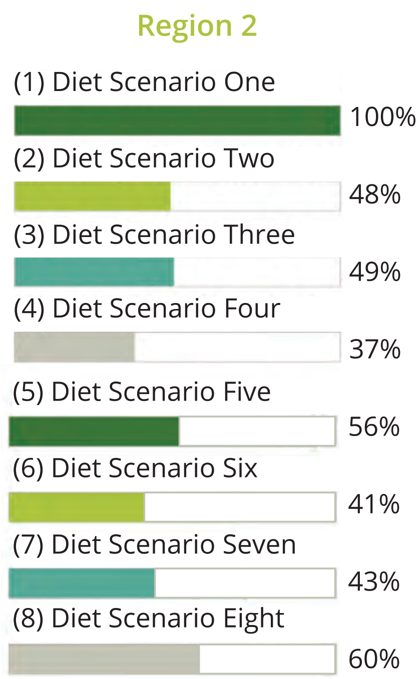


Figure 33. Percentage of regional population fed in Region Two with Diet Scenarios 1-8.

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 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 56% 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. 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 60% of the population able to be fed. 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. First, the yield comparison of conventional versus organic agriculture is illustrated by the fact that even when meat consumption is decreased by 60% compared to Diet Scenarios Two and Four, in Diet Scenario Seven, there is still less potential to feed all citizens with organically produced food than conventional at full meat intake. Secondly, compar-

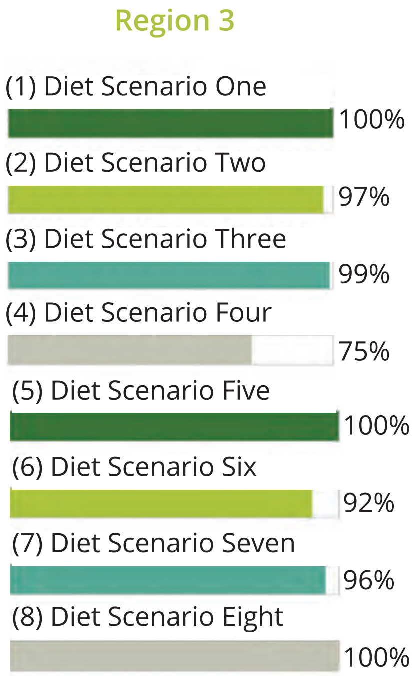


Figure 34. Percentage of regional population fed in Region Three with Diet Scenarios 1-8.

ing Diet Scenarios Four, Six and Seven, it is clear that as meat intake is decreased, more citizens can be fed on a strictly regionally produced diet.

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 persons fed on a diversified diet.

Region Three produces the best results, with the potential to feed most amounts of people with regionally produced food. Three out of ten diet scenarios, One, Five and Eight can feed 100% of the population. Nearly all of the population can be fed with Diet Scenarios Two, Three, Six and Seven. Diet Scenario Four has the lowest potential to feed all citizens, with just 75% of the community able to be fed with this diet. Comparing Diet Scenarios Four, Six and Seven it becomes further apparent of the effect of the reduction of meat intake. Nearly all citizens could be fed with regional organic foods if meat consumption as reduced just 30%.

With all results for regional self-sufficiency, it should also be noted that Hamburg is the only large city (more than 300,000 residents) within the radius of all three regions. Therefore, there is no significant competition for food supply. We can assume that if another comparable city would be included, the potential to feed citizens would decrease. From these results the conclusion can be drawn, however, that as the region is expanded, considering a large city such as Hamburg as the center point, potential to feed more people will increase. As well, diet options become more diversified as the region becomes larger.

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

Chapter Five presented factors associated with AFNs that can affect the consumers' WTP the price premium associated with organic products. As it is difficult to quantify these results, the relevancy of these factors to the corresponding distribution channel was based on the perceived judgment of the author of this thesis from research conducted throughout the process, interviews with members of these food networks as well as studies associated with these topics.

The CSA program was determined to have the highest relevancy in terms of possessing characteristics to increase consumers' WTP more for organically produced products compared to the other distribution channels. The regional network was identified as possessing the second highest potential of promoting organic regional agriculture, especially due to the health, nutrition and transparency factors as well as the environmental and animal welfare concerns and support of the local community and social and knowledge sharing. As the model is still in its infancy, however, it is yet difficult to assess how successful it will be in gaining participation. In general all of the first five distribution channels gives an indication that they all possess qualities that could help to overcome the price barrier, but to varying degrees.

The large retail chain was identified as having the lowest relevancy, indicating that it 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.

7 Conclusions and Outlook

While the industrialized food system has theoretically accomplished its main goal— to produce enough food to feed the global population and maximize crop yields at minimal financial costs— in many cases it has failed to recognize the significant negative impacts on our environment, human and animal health and social equity. The system has become so skewed in terms of distribution that food regularly travels around the globe, and while many developed countries face the challenge of surpluses or excess food, there are nearly as many obese people in the world as there are starving.

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 to this, a changing shift in the human diet on a global scale towards increased consumption of more resource intensive foods, especially meat and animal products, is stressing precious natural resources such as land, water, energy and soil.

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, contributions 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.

Image source: pixabay.com

A growing number of voices are calling for a turn back, however, on both a local scale— such as the *"Wir Haben Es Satt"* march in Berlin— and a global one, where numerous studies and organizations such as the FAO and BMEL have identified a need for change. Redesigning 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 situation. In the end, we must uncover a way to feed the world's ever increasing 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 promote 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 friends foods, such as increased plant product consumption, substituting animal products.

One alternative to contribute to a more sustainable food system 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 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 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).

Image source: pixabay.com

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).

To begin at a local level, this thesis examined the potential to feed the regional community of Hamburg 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 provided the best results, with potential to feed the most citizens, especially in the case of diets with the lowest per capita land footprint for annual food production.

From the results, it can be concluded that the largest factor in determining amount of persons that could be feed 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 determining how much land is required for food production, especially when considering a large proportion of cereals, legumes, etc. go towards animal feed, competing with direct 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 options, 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. If all citizens with Region Three, roughly 6.8 million people, ate according to this diet, an additional 918,559 people could be fed according to consumption quantities of Diet Scenario Six. 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 CSA, food co-ops, regional networks, delivery boxes and online marketplaces, which may provide the right balance of factors to increase consumers' WTP 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 organicproducts: young Danish consumers and in-store food choice. International Journal of Consumer Studies , 550-558.

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 (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.

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

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.

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

Destatis. (2013). Consumption expenditure - Germany. Retrieved January 28, 2016, from Destatis: https://www.destatis.de/EN/FactsFigures/SocietyState/IncomeConsumptionLivingConditions/ConsumptionExpenditure/Tables/Territory.html

Destatis(a). (2013). Consumption expenditure - Germany. Retrieved January 28, 2016, from Destatis: https://www.destatis.de/EN/FactsFigures/SocietyState/IncomeConsumptionLivingConditions/ConsumptionExpenditure/Tables/Territory.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(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(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

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

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].

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.

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

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

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/

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.

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 .

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.

Krömker, D., & Matthies, E. (2014). Differences between Occasional Organic and Regular Organic Food Consumers in. Food and Nutrition Sciences , 1914-1925.

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

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

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.

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.

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.

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

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

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

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/

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(a). (2011). Meat Eats Land. Retrieved January 28, 2016, from 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(l)/cap/yr)	Land Footprint (m^2/yr)	% of Land Footprint	Calories Per Capita (kcal/yr)	Quantity (kg(l)/cap/yr)	Land Footprint (m^2/yr)	% of Land Footprint	Calories Per Capita (kcal/yr)
Cereal & products	0	0	0%	0	95.6	231.0	10%	272,460
Potato & products	1095.0	189.1	100%	744,600	70.7	21.0	1%	48,076
Rice	0	0	0%	0	5.3	11.0	0%	19,981
Legumes	0	0	0%	0	0.4	0.5	0%	1,392
Sugar products (including honey)	0	0	0%	0	48.0	30.0	1%	170,400
Vegetables	0	0	0%	0	95.4	30.0	1%	24,804
Fruits	0	0	0%	0	110.5	99.0	4%	60,775
Oils & fats	0	0	0%	0	19.9	119.0	5%	68,655
Beef	0	0	0%	0	13.0	351.0	15%	13,780
Pork	0	0	0%	0	52.6	468.0	20%	88,894
Poultry	0	0	0%	0	18.5	150.0	6%	24,420
Sheep/goat	0	0	0%	0	0.9	24.0	1%	2,187
Eggs	0	0	0%	0	13.3	84.0	4%	18,620
Other Meat	0	0	0%	0	2.0	23.0	1%	2,320
Fish & products	0	0	0%	0	14.1	18.0	1%	14,523
Milk & products	0	0	0%	0	118.8	602.0	25%	57,024
Coffee/cocoa/tea	0	0	0%	0	0.0	127.0	5%	-
Nature conservation	0	0	0%	0	0.0	0.0	0%	-
Total:	**1095.0**	**189.10**	**100%**	**744,600**	**679**	**2,388**	**100%**	**888,311**

Source: (WWF(h), 2015)

Diet Scenario 5 / Diet Scenario 6

	(5) DGE Food Guide Plan				(6) Status Quo + Reducing Meat & Egg intake by 30% (two "meat free" days per week)			
Food Group	Quantity (kg(l)/cap/yr)	Land Footprint produced conventionally (m2)	Land Footprint produced by Demeter standards (m2)	Calories Per Capita (kcal/yr)	Quantity (kg(l)/cap/yr)	Land Footprint produced conventionally (m2)	Land Footprint produced by Demeter standards (m2)	Calories Per Capita (kcal/yr)
Cereal & products	91.3	220.5	266.8	260,062.5	95.6	231.0	279.5	272,460
Potato & products	82.1	24.4	35.1	55,845.0	70.7	21.0	30.2	48,076
Rice	0.0	0.0	0.0	-	5.3	11.0	11.7	19,981
Legumes	40.0	47.0	56.0	139,200.0	30	35.3	42.0	104,400
Sugar products (including honey)	14.4	9.0	11.3	-	48.0	30.0	37.8	170,400
Vegetables	182.5	57.4	76.9	47,450.0	95.4	30.0	40.2	24,804
Fruits	109.5	98.1	120.7	60,225.0	110.5	99.0	121.8	60,775
Oils & fats	12.8	76.4	96.3	44,073.8	19.9	119.0	149.9	68,655
Meat & products (including eggs)	32.1	353.1	487.9	52,162.5	70.2	772.2	1067.0	74,412
Fish & products	8.9	11.3	14.5	9,146.4	14.1	18.0	23.0	14,523
Milk & products	102.2	517.9	678.4	49,056.0	118.8	602.0	788.6	57,024
Coffee/cocoa/tea	n.a.	127.0	160.2	-	n.a.	127.0	160.2	-
Nature conservation	n.a.	0.0	50.0	-	n.a.	0.0	50.0	-
Total:	**675.73**	**1542.1**	**2054.1**	**717,221.2**	**679**	**2,095.5**	**2,802.0**	**915,510**

Source: (DGE, 2016).

Diet Scenario 3 / Diet Scenario 4

	(3) Kattendorfer Hof Demeter Diet				(4) Status Quo Demeter Diet			
Food Group	**Quantity (kg(l)/cap/yr)**	**Land Footprint (m^2/yr)**	**% of Land Footprint**	**Calories Per Capita (kcal/yr)**	**Quantity (kg(l)/cap/yr)**	**Land Footprint (m^2/yr)**	**% of Land Footprint**	**Calories Per Capita (kcal/yr)**
Cereal & products	120.0	350.0	15%	342,000	95.6	279.5	9%	272,460
Potato & products	70.0	50.0	2%	47,600	70.7	30.2	1%	48,076
Rice	0.0	0.0	0%	-	5.3	11.7	0%	19,981
Legumes	40.0	56.0	2%	139,200	0.4	0.6	0%	1,392
Sugar products (including honey)	5.0	0.0	0%	17,750	48.0	37.8	1%	170,400
Vegetables	165.0	99.0	4%	42,900	95.4	40.2	1%	24,804
Fruits	91.3	100.4	4%	50,215	110.5	121.8	4%	60,775
Oils & fats	5.0	50.0	2%	17,250	19.9	149.9	5%	68,655
Beef	37.0	700.0	30%	39,220	13.0	449.3	14%	13,780
Pork				62,530	52.6	599.0	19%	88,894
Poultry				48,840	18.5	192.0	6%	24,420
Sheep/goat				89,910	0.9	30.7	1%	2,187
Eggs	9.0			12,600	13.3	107.5	3%	18,620
Other Meat	0.0	0.0	0%	-	2.0	29.4	1%	2,320
Fish & products	0.0	0.0	0%	-	14.1	23.0	1%	14,523
Milk & products	99.4	730.0	31%	47,712	118.8	788.6	25%	57,024
Coffee/cocoa/tea	0.0	160.2	7%	-	0.0	160.2	5%	-
Nature conservation	0.0	50.0	2%	-	0.0	50.0	2%	-
Total:	**642**	**2,346**	**100%**	**957,727**	**679**	**3,102**	**100%**	**888,311**

Source: (Dungworth, 2015)

Diet Scenario 7 / Diet Scenario 8

	(7) Status Quo + Reducing Meat & Egg intake by 60% (four "meat free" days per week)				(8) DGE, Except Vegetarian Diet + Increasing Legume and Egg Intake			
Food Group	**Quantity (kg(l)/cap/yr)**	**Land Footprint produced conventionally (m2)**	**Land Footprint produced by Demeter standards (m2)**	**Calories Per Capita (kcal/yr)**	**Quantity (kg(l)/cap/yr)**	**Land Footprint produced conventionally (m2)**	**Land Footprint produced by Demeter standards (m2)**	**Calories Per Capita (kcal/yr)**
Cereal & products	95.6	231.0	279.5	272,460	95.6	231.0	279.5	272,460
Potato & products	70.7	21.0	30.2	48,076	70.7	21.0	30.2	48,076
Rice	5.3	11.0	0.0	19,981	5.3	11.0	0.0	19,981
Legumes	60	70.5	84.0	208,800	70	82.3	98.0	243,600
Sugar products (including honey)	48.0	30.0	37.8	170,400	48.0	30.0	37.8	170,400
Vegetables	95.4	30.0	40.2	24,804	95.4	30.0	40.2	24,804
Fruits	110.5	99.0	121.8	60,775	110.5	99.0	121.8	60,775
Oils & fats	19.9	119.0	149.9	68,655	19.9	119.0	149.9	68,655
Meat & products (including eggs)	40.1	441.3	609.8	42,527	0.0	0.0	0.0	-
					12.0	132.0	182.4	16,800
					0.0	0.0	0.0	-
Fish & products	14.1	18.0	14.5	14,523	0.0	0.0	0.0	-
Milk & products	118.8	602.0	788.6	57,024	118.8	602.0	788.6	57,024
Coffee/cocoa/tea	n.a.	127.0	160.2	-	n.a.	127.0	160.2	-
Nature conservation	n.a.	0.0	50.0	-	n.a.	0.0	50.0	-
Total:	**678**	**1,799.8**	**2,366.6**	**988,025**	**646**	**1484.3**	**1938.7**	**982,575**

Appendix II: Calculation of Efficiencies

Food Group	Case Study: Conventional (2) Yields / Demeter (3) (Ave)	Comparable Studies: Seufert et al., Conv. Yield / Organic Yield (Ave)	Comparable Studies: de Ponti et al., Conv. Yield / Organic Yield (Ave)	Current Data: destatis : Germany 2014/2015 Conv. Yield / Organic Yield (Ave)	Ave. Used: Conv. Yield / Organic Yield (Ave)	(2) Status Quo Conventional Diet: Land Footprint for Consumption (m^2)*(A)*	(2) Status Quo Conventional Diet: Production Efficiency (m^2/kg)	(2) Status Quo Conventional Diet: Annual Consumption (kg)
Cereal & products	83%	74%	79%	n.a.	79%	231.0	2.4	95.6
Potato & products	42%	n.a.	70%	n.a.	56%	21.0	0.3	70.7
Rice	n.a.	n.a.	94%	n.a.	94%	11.0	2.1	5.3
Legumes	n.a.	90%	89%	66%	82%	0.5	1.2	0.4
Sugar products (including honey)	n.a.	n.a.	n.a.	n.a.	74%	30.0	0.6	48.0
Vegetables	52%	67%	80%	73%	68%	30.0	0.3	95.4
Fruits	n.a.	97%	72%	61%	77%	99.0	0.9	110.5
Oils & fats	60%	89%	74%	n.a.	74%	119.0	6.0	19.9
Beef	72%	n.a.	n.a.	n.a.	72%	351.0	27.0	13.0
Pork		n.a.	n.a.	n.a.		468.0	8.9	52.6
Poultry		n.a.	n.a.	n.a.		150.0	8.1	18.5
Sheep/goat		n.a.	n.a.	n.a.		24.0	26.7	0.9
Eggs		n.a.	n.a.	n.a.		84.0	6.3	13.3
Other Meat	n.a.	n.a.	n.a.	n.a.		23.0	11.5	2.0
Fish & products	n.a.	n.a.	n.a.	n.a.		18.0	1.3	14.1
Milk & products	69%	n.a.	n.a.	n.a.	69%	602.0	5.1	118.8
				Average:	**74%**			

Sources : (de Ponti, Rijk, & van Ittersum, 2012)

(Seufert, Ramankutty, & Foley, 2012)

(Destatis(e), 2015)

Percentage of population fed with 75% of agricultural land used for food production:

	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)
Region 1 (Hamburg): Population fed:	90364	67840	67122	50092	70500	52495	93886	71879	
Percentage:	5%	4%	4%	3%	4%	3%	5%	4%	
Region 2 (50 km radius): Population fed:	2846138	2136717	2094552	1566381	2220506	1653411	2937069	2263927	
Percentage:	**75%**	**56%**	**55%**	**41%**	**58%**	**43%**	**134%**	**60%**	
Region 3 (150 km radius): Population fed:	10444367	7841029	7758052	5789744	8148507	6067461	10851446	8307848	
Percentage:	**166%**	**125%**	**123%**	**92%**	**130%**	**96%**	**173%**	**132%**	

Group	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)
	...cts	111.5	0.305479452	305.4794521	871	**2.85**	26.6	**0.09**	3.50	**0.01**
	...ucts	70.7	0.19369863	193.6986301	131	**0.68**	2.9	**0.01**	0.20	**0.00**
	...lent)	3	0.008219178	8.219178082	34	**3.77**	[illegible]	**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

	(3) Kattendorfer Hof Demeter Diet			(4) Status Quo Demeter Diet			Nutrient Efficiencies		
Food Group	**Land Footprint for Consumption (m^2)**	**Production Efficiency (m^2/kg)**	**Annual Consumption (kg)**	**Land Footprint for Consumption (m^2)**	**Production Efficiency (m^2/kg)**	**Annual Consumption (kg)**	**Calorie Efficiency (kcal/kg)** *(B)*	**Protein Efficiency (grams protein/ kg)**	**Fat Efficiency (grams fat/kg)**
Cereal & products	350.0	2.9	120	279.5	2.9	95.6	2850	90.00	10.00
Potato & products	50.0	0.7	70	30.2	0.4	70.7	680	10.00	0.00
Rice	n.a.	n.a.	n.a.	11.7	2.2	5.3	3770	70.00	10.00
Legumes	56.0	1.4	40	0.6	1.4	0.4	3480	310.00	0.00
Sugar products (including honey)	0.0	0.0	5	37.8	0.8	48.0	3550	0.00	0.00
Vegetables	99.0	0.6	165	40.2	0.4	95.4	260	10.00	0.00
Fruits	100.4	1.1	91.3	121.8	1.1	110.5	550	10.00	10.00
Oils & fats	50.0	10.0	5	149.9	7.5	19.9	3450	150.00	270.00
Beef				449.3	34.6	13.0	1060	130.00	60.00
Pork				599.0	11.4	52.6	1690	100.00	140.00
Poultry	700.0	15.2	37	192.0	10.4	18.5	1320	150.00	80.00
Sheep/goat				30.7	34.1	0.9	2430	120.00	200.00
Eggs			9	107.5	8.1	13.3	1400	110.00	100.00
Other Meat	n.a.	n.a.	n.a.	29.4	14.7	2.0	1160	220.00	30.00
Fish & products	n.a.	n.a.	n.a.	23.0	1.6	14.1	1030	120.00	60.00
Milk & products	730.0	7.3	99.4	788.6	6.6	118.8	480	30.00	30.00

Appendix III: Calculations for Maximum Persons Fed Per Region

Region 1: Hamburg
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
	Percentage of Population Fed:							

Maximum persons fed with diet (Upper Bound)			
(1) "Potato Diet"	(2) Status Quo Conventional Diet**	(3) Kat. Hof Demeter Diet*	(4) Status Quo Demeter Diet***
982,569	77,792	79,213	59,906
56%	**4%**	**4%**	**3%**

Maximum persons fed with diet (Middle Bound)			
(1) "Potato Diet"	(2) Status Quo Conventional Diet**	(3) Kat. Hof Demeter Diet*	(4) Status Quo Demeter Diet***
736,927	58,344	59,410	44,930
42%	**3%**	**3%**	**3%**

Maximum persons fed with diet (Lower Bound)			
(1) "Potato Diet"	(2) Status Quo Conventional Diet**	(3) Kat. Hof Demeter Diet*	(4) Status Quo Demeter Diet***
491,285	38,896	39,606	29,953
28%	**2%**	**2%**	**2%**

(A) Data from 2015, Destatis

(B) Data from 2013, Destatis

Region 2: 50 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	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:	**3,263.31**	**9,969.93**		**5,852.04**	**4,389.03**	**2,926.02**	**3,802,253.00**
	Percentage of Population Fed:							

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 Lauenburg	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-Ecklernförde	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
	Nordwestmecklenburg	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**
	Percentage of Population Fed:							

All Regions

Diets 5-8

Percentage of population fed with 75% of agricultural land used for food production:			Diet 5 conventional	Diet 5 organic	Diet 6 conventional	Diet 6 organic
	Region 1 (Hamburg):	Population fed:	90364	67840	67122	50092
		Percentage:	**5%**	**4%**	**4%**	**3%**
	Region 2 (50 km radius):	Population fed:	2846138	2136717	2094552	1566381
		Percentage:	**75%**	**56%**	**55%**	**41%**
	Region 3 (100 km radius):	Population fed:	10444367	7841029	7758052	5789744
		Percentage:	**166%**	**125%**	**123%**	**92%**
			Diet 7 conventional	**Diet 7 organic**	**Diet 8 conventional**	**Diet 8 organic**
	Region 1 (Hamburg):	Population fed:	70500	52495	93886	71879
		Percentage:	**4%**	**3%**	**5%**	**4%**
	Region 2 (50 km radius):	Population fed:	2220506	1653411	2957069	2263927
		Percentage:	**58%**	**43%**	**134%**	**60%**
	Region 3 (100 km radius):	Population fed:	8148507	6067461	10851446	8307848
		Percentage:	**130%**	**96%**	**173%**	**132%**

Maximum persons fed with diet (Upper Bound)				Maximum persons fed with diet (Middle Bound)				Maximum persons fed with diet (Lower Bound)			
(1) "Potato Diet"	(2) Status Quo Conventional Diet**	(3) Kat. Hof Demeter Diet*	(4) Status Quo Demeter Diet***	(1) "Potato Diet"	(2) Status Quo Conventional Diet**	(3) Kat. Hof Demeter Diet*	(4) Status Quo Demeter Diet***	(1) "Potato Diet"	(2) Status Quo Conventional Diet**	(3) Kat. Hof Demeter Diet*	(4) Status Quo Demeter Diet***
982,569	77,792	79,213	59,906	736,927	58,344	59,410	44,930	491,285	38,896	39,606	29,953
3,443,337	272,616	277,595	209,937	2,582,503	204,462	208,196	157,452	1,721,668	136,308	138,797	104,968
3,604,809	285,400	290,613	219,781	2,703,607	214,050	217,959	164,836	1,802,405	142,700	145,306	109,891
4,867,248	385,350	392,388	296,751	3,650,436	289,012	294,291	222,563	2,433,624	192,675	196,194	148,375
3,887,212	307,758	313,379	236,999	2,915,409	230,819	235,034	177,749	1,943,606	153,879	156,690	118,500
368,156	29,148	29,680	22,446	276,117	21,861	22,260	16,835	184,078	14,574	14,840	11,223
159,851	12,656	12,887	9,746	119,888	9,492	9,665	7,309	79,926	6,328	6,443	4,873
2,174,454	172,156	175,300	132,574	1,630,841	129,117	131,475	99,431	1,087,227	86,078	87,650	66,287
4,713,541	373,181	379,996	287,380	3,535,156	279,885	284,997	215,535	2,356,770	186,590	189,998	143,690
4,054,735	321,022	326,885	247,213	3,041,051	240,766	245,163	185,410	2,027,367	160,511	163,442	123,606
2,690,868	213,041	216,932	164,059	2,018,151	159,781	162,699	123,044	1,345,434	106,521	108,466	82,030
30,946,780	**2,450,119**	**2,494,868**	**1,886,792**	**23,210,085**	**1,837,589**	**1,871,151**	**1,415,094**	**15,473,390**	**1,225,060**	**1,247,434**	**943,396**
814%	**64%**	**66%**	**50%**	**610%**	**48%**	**49%**	**37%**	**407%**	**32%**	**33%**	**25%**

Maximum persons fed with diet (Upper Bound)				Maximum persons fed with diet (Middle Bound)				Maximum persons fed with diet (Lower Bound)			
(1) "Potato Diet"	(2) Status Quo Conventional Diet**	(3) Kat. Hof Demeter Diet*	(4) Status Quo Demeter Diet***	(1) "Potato Diet"	(2) Status Quo Conventional Diet**	(3) Kat. Hof Demeter Diet*	(4) Status Quo Demeter Diet***	(1) "Potato Diet"	(2) Status Quo Conventional Diet**	(3) Kat. Hof Demeter Diet*	(4) Status Quo Demeter Diet***
982,569	77,792	79,213	59,906	736,927	58,344	59,410	44,930	491,285	38,896	39,606	29,953
3,170,459	251,012	255,596	193,299	2,377,844	188,259	191,697	144,975	1,585,229	125,506	127,798	96,650
8,270,255	654,773	666,731	504,229	6,202,691	491,080	500,049	378,171	4,135,127	327,386	333,366	252,114
3,443,337	272,616	277,595	209,937	2,582,503	204,462	208,196	157,452	1,721,668	136,308	138,797	104,968
4,151,667	328,696	334,699	253,123	3,113,751	246,522	251,024	189,842	2,075,834	164,348	167,350	126,561
3,356,764	265,762	270,616	204,658	2,517,573	199,321	202,962	153,494	1,678,382	132,881	135,308	102,329
3,604,809	285,400	290,613	219,781	2,703,607	214,050	217,959	164,836	1,802,405	142,700	145,306	109,891
2,350,589	186,101	189,500	143,313	1,762,942	139,576	142,125	107,485	1,175,295	93,050	94,750	71,656
7,729,673	611,974	623,151	471,270	5,797,255	458,980	467,363	353,452	3,864,837	305,987	311,575	235,635
4,867,248	385,350	392,388	296,751	3,650,436	289,012	294,291	222,563	2,433,624	192,675	196,194	148,375
4,083,365	323,288	329,193	248,958	3,062,524	242,466	246,895	186,719	2,041,682	161,644	164,596	124,479
2,866,788	226,969	231,115	174,785	2,150,091	170,227	173,336	131,089	1,433,394	113,485	115,557	87,392
5,769,917	456,816	465,159	351,786	4,327,438	342,612	348,869	263,839	2,884,959	228,408	232,580	175,893
3,887,212	307,758	313,379	236,999	2,915,409	230,819	235,034	177,749	1,943,606	153,879	156,690	118,500
187,606	14,853	15,124	11,438	140,705	11,140	11,343	8,579	93,803	7,427	7,562	5,719
368,156	29,148	29,680	22,446	276,117	21,861	22,260	16,835	184,078	14,574	14,840	11,223
159,851	12,656	12,887	9,746	119,888	9,492	9,665	7,309	79,926	6,328	6,443	4,873
5,316,875	420,948	428,636	324,164	3,987,656	315,711	321,477	243,123	2,658,438	210,474	214,318	162,082
2,174,454	172,156	175,300	132,574	1,630,841	129,117	131,475	99,431	1,087,227	86,078	87,650	66,287
3,917,971	310,194	315,859	238,874	2,938,478	232,645	236,894	179,156	1,958,985	155,097	157,929	119,437
8,335,285	659,921	671,974	508,193	6,251,464	494,941	503,981	381,145	4,167,643	329,961	335,987	254,097
4,713,541	373,181	379,996	287,380	3,535,156	279,885	284,997	215,535	2,356,770	186,590	189,998	143,690
4,054,735	321,022	326,885	247,213	3,041,051	240,766	245,163	185,410	2,027,367	160,511	163,442	123,606
2,690,868	213,041	216,932	164,059	2,018,151	159,781	162,699	123,044	1,345,434	106,521	108,466	82,030
14,978,605	1,185,886	1,207,545	913,229	11,233,954	889,415	905,659	684,922	7,489,303	592,943	603,773	456,615
8,010,231	634,186	645,769	488,375	6,007,673	475,640	484,327	366,281	4,005,115	317,093	322,884	244,188
121,478	9,618	9,793	7,406	91,109	7,213	7,345	5,555	60,739	4,809	4,897	3,703
113,564,308	**8,991,116**	**9,155,327**	**6,923,894**	**85,173,231**	**6,743,337**	**6,866,496**	**5,192,920**	**56,782,154**	**4,495,558**	**4,577,664**	**3,461,947**
1806%	**143%**	**146%**	**110%**	**1230%**	**97%**	**99%**	**75%**	**1093%**	**87%**	**88%**	**67%**

Appendix IV: EU Organic Regulations vs. Farming Associations

	EU/German Organic	Farming Associations Examples:
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)