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Degree of Master of Science

Closing the nutrient loop? Challenges and opportunities for up-scaling of recycling principles within the conventional and organic farming sector Case study: Poland

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Author's declaration

No portion of the work referred to in this thesis has been submitted in support of an application for another degree or qualification of this or any other university or other institute of learning.

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The current trends in the Polish agricultural sector concern farm enlargement and specialization in either crops or livestock, which are usually accompanied by intensive farming practices that involve reliance on synthetic fertilizers and concentrate feeds, the latter one being produced to feed increasingly concentrated livestock populations. The heavy nutrient loadings associated therewith tip the ecological balance and have far-reaching implications manifested in soil depletion, water pollution, biodiversity loss and limited adaptability to unpredictable economic climate and weather conditions. However, by re-introducing 'recycling principles', i.e. recouple crops and livestock, diversify crops with leguminous plants, and balance livestock units to acreage ratio, it would be possible to restore nutrient balance. Therefore, the purpose of this thesis is to explore limitations and opportunities for up-scaling of such 'recycling principles' within the Polish conventional and organic farming sector, whereby the latter one is likewise becoming greatly rationalized. By adopting the multi-level perspective theory, which frames findings from review of literature, interviews and group discussions; this thesis explores how wider historical, socio-environmental, institutional and technological setting of the Polish agriculture, combined with values and beliefs of interviewed stakeholders, can influence scaling of recycling principles on the farm or territorial level. It concludes that while the spatial segregation of farms and globalization constitute the key challenges; by recognizing recycling principles at EU level and engaging stakeholders across the food production chain in policy-making, it would be possible to rethink nutrient management in a cooperative way, and potentially create a window of opportunity for up-scaling of recycling principles.

Keywords: recycling principles, nutrient cycle, Poland, Common Agricultural Policy, multi-level framework, (up) scaling of agroecological innovations, mixed crops-livestock systems, globalization, agroecology

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'The growth of soil, reflects the growth of soul' (from pamphlet found in Järna)

TABLE OF CONTENTS

List of Tables

List of Figures

List of Abbreviations

ARC 2020	Agricultural and Rural Convention 2020
BERAS	Baltic Ecological Recycling Agriculture and Society
BSAP	Baltic Sea Action Plan
BSAP	Common Agricultural Policy
COPA-COGECA	Committee of Professional Agricultural Organisations – General Committee for Agricultural Cooperation in the European Union
EC	European Commission
EU	European Union
ERA	Ecological Recycling/Regenerative Agriculture
FAO	Food and Agriculture Organization
HELCOM	Baltic Marine Environment Protection Commission
IFOAM	The International Federation of Organic Agriculture Movements
IAFE-NRI	Instytut Ekonomiki Rolnictwa i Gospodarki Żywnościowej [Institute of Agricultural and Food Economics]
IJHAR-S	Wojewódzki Inspektorat Jakości Handlowej Artykułów Rolno-Spożywczych [Agricultural and Food Quality Agency]
IRWiR PAN	Instytut Rozwoju Wsi i Rolnictwa PAN [National Institute of rural and agricultural development]
IUNG	Instytut Uprawy Nawożenia i Gleboznawstwa [National Institute of Soil Science and Plant Cultivation]
MINROL	Ministerstwo Rolnictwa i Rozwoju Wsi [Ministry of Agriculture and Rural Development]
MLP	Multi-Level Perspective framework
MR	Ministerstwo Rozwoju [Ministry of Development]
PROW	Program Rozwoju Obszarow Wiejskich [Rural Development Programme
UN	United Nations
WWF	World Wildlife Fund

1 INTRODUCTION

Following the discovery of chemical fixation of nitrogen by Haber and Bosch and mineralizing properties of phosphates for soils in the first half of the 20^{st} century, the amount of mineral nutrients circulating in the economy has experienced a dramatic growth and does not seem to decrease in the near future. While nitrogen synthesis, which is fossil fuel-intensive, is reported to already exceed the planetary boundary by factor of four, the demand for the mined phosphate rock to manufacture phosphorus is forecasted to increase by 50-100% by 2050, and finitely deplete global phosphorus reserves within the next 50-100 years (Rockstorm *et al.* 2009; EC 2016a; Cordell *et al.* 2009). The main reason behind such high demand for synthetic fertilizers is the fact that we are living in times when the rising global population, which is estimated to reach nearly 9.7 billion humans by 2015 (UN 2015), creates extra demand for food supply that can be relatively quickly met through the use of inorganic commercial fertilizers. The growing food exigency and a common desire to produce food cost-effectively and without intensive knowledge inputs in such an increasingly globalized economy where food quantity tends to be valued over food quality, is also greatly reflected in the dramatic rise of livestock density per hectare during the past few years, and which further results in hazardous nutrient surpluses. In order to highlight the scale of the problem related to high demand for meat products, it is worth mentioning that the global meat production is forecasted to double by 2050 when compared to production in 1999/2001, especially in developing countries with a transition economy (FAO 2016). Moreover, such increased production of livestock involves expansion of cultivated cereals for fodder, which only fosters deforestation in neotropical countries, and causes increase in the prices of cereals for people (Herrero *et al.* 2010). Overall, the above trends clearly imply unsustainable intensification of agricultural production whereby soils – farmers' most precious assets, suffer from nutrient imbalances that inevitably lead to their degradation. Since soil formation is a very slow and lengthy process, and in some extreme cases soil fertility loss is irreversible, soil can be classified as a non-renewable natural resource that needs to be taken care of in order to sustain the planet.

In the light of above trends, it can be argued that there is a large room for improvement in agricultural practices around the world with regards to creation of channel mechanisms that facilitate soil nutrient recycling and increase resilience to extreme climatic events. Even though it is impossible to ensure that 100% of nutrients can be recycled (and possibly even undesirable since the absence of nutrient leakage can disrupt the ecosystems, which are organized around nutrient flows), by employing certain recycling principles as part of farming practices, it is possible to significantly reduce nutrient losses from the soil that would otherwise end up in water reservoirs or atmosphere, and subsequently resulting in increased eutrophication and greenhouse gas emissions, respectively. Such recycling principles, which are the core subject of investigation in this thesis and currently experience a renewed interest from various scientists, might include mixed crop-livestock system at the farm/territorial level, crop rotations (incl. leguminous plants) and low animal concentrations – all of which help to significantly improve fertilizer and feed concentrates autonomy. However, the process of scaling (diffusing) such principles is currently being challenged by the process of specialization in either crops or livestock, which, in most cases, further reflects unsustainable intensification of agricultural production that is associated with nutrient surplus via over-fertilization of fields with synthetic fertilizers or manure (especially in case animals are raised indoor), respectively. Such trend toward specialization, which is usually paired with the phenomenon of increasing land size, is highly notable in many European countries, which have experienced a significant decline in the mixed crops-livestock farms (that were commonly practiced in the 1950s) during the past 40 years (Ryschawy *et al.* 2013). One of the major historical events, which accelerated the trends toward specialization and subsequently increasing land size, was accession of many European countries to the European Union (EU), which has a 'common market' and quickly become the major producer of food globally. The

Common Agricultural Policy – the key legislative framework reshaping '*production, sale and processing of agricultural products*' (ARC2020 2015a) in the EU together with the phenomena of globalization – a worldwide movement intending to create a more economically interdependent and interconnected world via WTO agreements, have created a mood for modernization, which has opened a pathway for unsustainable agricultural intensification, specialization and mechanization. The new, weaker EU member states such as Poland were also propelled to undergo dramatic changes in farm structures as a result of large transformations within the political and economic landscape upon entering EU and global market. Consequently, the European agricultural sector in its entire sense is widely known for its contribution to anoxic events in lakes and Baltic Sea, biodiversity loss, deterioration of water quality; or disturbances in nitrogen and carbon cycle, among others (Ohlund *et al.* 2015; Larsson and Granstedt 2010). Interestingly, the agricultural production in Poland, which is the study area of this research thesis and where agriculture constitutes the fourth largest sector of the national economy, is still characterized by relatively extensive production and the majority of farms in the country with the total land surface of 10-50ha still have both multiple enterprise (crop and livestock) and apply crop rotations. However, many of those mixed crops-livestock farms are managed unsustainably (i.e. they heavily rely on fossil-fuel dependent off-farm inputs and do not properly manage manure), and the number of farms, which decide to enlarge their land holdings and specialize in either crops or livestock, is on the rise (Igras *et al.* 2014).

Given that some of the regions in Poland are more suitable for certain types of animal husbandry (e.g. cattle, which requires only fodder and grasslands) and some regions are more favorable for the cultivation of certain crops than others (e.g. root crops have higher soil requirements), this thesis investigates the potential to integrate recycling practices into Polish agro-food systems (at farm level and between farms) by taking into account a wide array of exogenous and endogenous aspects, ranging from geographical and agronomic conditions to available policies and farmers' opinions. It argues why the maintenance and scaling of such multiple enterprises in Poland, which integrate crop production with livestock production in a sustainable manner, is a challenging yet an important task as there are sound environmental and economic reasons for it. It also depicts globalization and ongoing modernization of agricultural sector upon entering EU as the main driving forces responsible for the current trends in the Polish agricultural sector, which are negative from an ecological point of view. Moreover, the potential to scale recycling principles within **organic farming** sector, which, contrary to the conventional farming prohibits the use of synthetic fertilizers, GM fodder and pesticides under EC No 834/2007, is investigated in the context of the Polish agriculture on behalf of the BERAS project (Baltic Ecological Recycling Agriculture and Society)[1], whose core objective is to reduce eutrophication of the Baltic Sea through the diffusion of recycling principles on a much bigger scale and across Baltic states. However, given that the conventional farming sector, which is increasingly becoming more dependent on mineral fertilizers, occupies nearly 96% of total agricultural land in Poland and certified organic farms constitute only 4.3% of the total agricultural land (0.1% of the total agricultural land is also constituted by the certified integrated production) (GUS 2016); it leaves no doubt that the conventional farming sector is likely to remain largely conventional for many years to come, and thereby requires significant improvement of farming practices to decrease, at least partially, the reliance on off-farm inputs, right away. Consequently, the thesis investigates the challenges and opportunities for scaling of recycling principles not only within the organic farming sector but also within the conventional farming sector, thus goes beyond the scope of the BERAS project, which is primarily[2] concerned with the promotion of recycling principles within the context of EU regulations on organic farming (EC No 834/2007). However, it is important to mention that the recycling

[1] A background information on the BERAS project is available in Appendix A

[2] The 'BERAS International project' also focuses on the promotion of recycling principles beyond the EU regulations on organic farming (EC No 834/2007) in non-EU countries such as India, Cuba or Norway

principles under this study can be truly effective and beneficial for the soil once no herbicides, pesticides and imported GMOs are present at the farm level.

The research adds to the relatively limited literature on the interplay of more 'endogenous' aspects of farmers' innovation adoption decision making (e.g. farmers' individual characteristics) with 'exogenous' factors such as policies or subsidies, which can either support or limit the adoption of certain agricultural practices/ agro-environmental schemes, especially those which are oriented at building synergies between farming components at farm or territorial level. By exploring Polish farmers' individual histories related to their farm management and opinions on recycling principles as well as by analyzing the broader economic and political linkages in the context of the current and emerging policies, this thesis adds to the growing yet still under-investigated body of research on recycling principles. However, it also shows that the investigated recycling principles such as mixed crops-livestock systems in particular, remain 'suppressed' during the policy-making process due to the dominance of conventional, and often very unsustainable, agricultural paradigm, especially in the context of Poland. The analysis of the interplay of various factors helps to 'typologise' farmers in order to determine which farmers' groups require special attention from policy-makers when introducing/up-scaling an agroecological innovation (that can constitute an agro-environmental scheme) whose aim is to improve nutrient cycle within the ecosystem.

1.2 Research aim

To investigate challenges and opportunities for up-scaling of recycling principles (mixed crops-livestock system, crop rotations incl. leguminous plants, and balanced animal concentrations to land acreage) in order to improve the state of environment in the Polish agricultural sector (both conventional and organic) and subsequently enhance human well-being. In other words, it investigates what are the challenges and opportunities to decrease reliance on off-farm inputs, enhance nutrient management and increase resilience to climate change.

1.3 Research question(s)

Q1: What histories (and how) paved the way toward the current agricultural paradigm?

Q2: What are the limitations and opportunities to up-scale 'recycling principles' within the Polish conventional and organic agricultural sector?

1.4 Scope

This thesis is concerned with the diffusion of recycling principles in the Polish organic and conventional farming sector. While it is important to apply a life-cycle thinking in order to improve nutrient management: from farm to fork, this thesis is mainly concerned with nutrient recycling at farm level (internal agricultural loop) and 'to-farm level' (in terms of transport of agricultural inputs to the farm as part of the external agricultural loop); and only partially addresses food processing and consumer dynamics (wider external agricultural loop) due to its limited scope. Moreover, given that the EU agricultural policy is a very broad topic, this study focuses only on its specific parts, which are deemed relevant to the research topic. Similarly, this thesis does not provide a detailed analysis of policies falling under the 'Environmental protection regime' as it lies beyond the scope of the thesis. However, some policy analysis can be found in relevant Appendices. Besides, the research does not depict in a very detailed way the cross-regional diversity in Poland, which is reflected in different potentials for up-scaling of recycling principles in different regions within the country. Lastly, since the adopted multi-level framework can help to generate scenarios for the future and all of the interviewed stakeholders were asked about their visions of the future of the agricultural sector, which can help to better determine the potential for scaling of recycling principles, the scope of this thesis did not enable to include a detailed scenario analysis. The possible future trajectories are only briefly touched upon in the context of relevant challenges and opportunities for up-scaling of recycling principles in the Discussion Chapter

1.5 AUDIENCE

The content of thesis is useful for farmers and scholars interested in agroecological farming practices as well as policy makers who could benefit both people and environment by implementing policies promoting the diffusion of alternative, recycling farming methods.

1.6 DISPOSITION

This thesis is organized into seven main chapters. Following this introductory Chapter 1; the Chapter 2 (Literature Review) provides conceptual and contextual background related to nutrient cycling in the agricultural sector, and a brief overview of the Polish agricultural sector, including. its historical setting. The next chapter presents selected theories, which co-create the analytical framework to guide analysis and discussion of research findings. Then, Chapter 4 presents employed methods of data collection. The subsequent Chapter 5 analyses the research findings through the lens of the multi-level framework, which are ultimately subject to Discussion in the context of the Literature Review in the Chapter 6. Lastly, the Chapter 7 contains key conclusions and provides recommendations directed to the principal audience (including possible policy pathways and areas for future research).

2 LITERATURE REVIEW

The main purpose of this chapter is to provide an exploratory and explanatory overview of key conceptual approaches related to the research topic. This chapter constitutes a reference for the type of selected research design presented in the following Methodology and Theoretical Framework chapters, and 'sets the stage' for the Results and Analysis and as well as Discussion chapters by providing a brief overview of the agricultural sector in Poland.

2.1 CONCEPT OF RATIONALIZATION OF AGRICULTURE VERSUS NUTRIENT IMBALANCE

Agriculture constitutes the basis for food security and is often a source of livelihood for many families worldwide. However, while in some countries agriculture can be viewed as a way of life, in many parts of the world agriculture is increasingly being viewed as a business operating within a productivist industrial paradigm, which can be referred to as a 'corporate food regime'. Following Holt-Giménez and Shattuck (2011), the 'corporate food regime' is characterized by *'unprecedented market power and profits of monopoly agro-food corporations, globalized animal protein chains, growing links between food and fuel economies, a 'supermarket revolution', liberalized global trade in food, increasingly concentrated land ownership, a shrinking natural resource base, and growing opposition from food movements worldwide*'. In such a modern, increasingly dominant and conventional type of agriculture the productive processes and production structures can be 'rationalized', whereby the dependence on workforce and knowledge is greatly suppressed due to the availability of modern, labor-saving machinery; the small-scale farmers are marginalized as big farm sizes are valued; and food production is exposed to the process of specialization, which refers to the pursuance of a single dominant activity (either crop cultivation or livestock raising) that provides '*at least two thirds of farm income or the business size of agricultural holding*' (Eurostat 2016; Drengson 1995). Even though specialization is often paired with large scale and intensive agricultural practices, this process has a negative impact on the natural environment even when it occurs in small scale enterprises, be it organic or conventional (Allard *et al.* 2000). The main reason for the above statement is the fact that in such a specialized agricultural system the flow of nutrients, water and energy is greatly linearized in time and space, unless the specialized farm is exchanging on-farm produced inputs with another specialized farm in proximity. Overall, in the absence of natural cyclic flows of nutrients and feedback loops, the agroecosystems cannot function without the support of human ingenuity (Altieri 1995). However, the presence of various environmental and socio-economic issues, which are associated with unhealthy intensification and specialization of agricultural land holdings, clearly indicates that it is very difficult to maintain agroecosystems healthy by applying solely artificial, man-made measures, which often tend to cause more harm than good (Ohlund *et al.* 2015). Some of these key environmental challenges, which are attributable to agricultural food production that is untenable for the future, include:

Soil nutrient mining: humus loss

The presence of soil nutrients, which constitute a pre-condition for soil fertility, is determined by various inherent factors such as soil geomorphologic characteristics (e.g. aeration), climatic conditions and vegetation type. However, the soil fertility is also affected by land use and unsustainable, intensive farming practices (i.e. the use of synthetic fertilizers or maintenance of highly concentrated livestock populations on small acreages, which poses extra challenges for manure management) can severely deteriorate the structure of humus, which takes a lot of time to build up. Without humus, the soil's capacity to store nutrients, retain water to increase resilience to erosion, provide ground for root plants, and buffer against fluctuations in pH is significantly reduced. Since the withdrawal amount of nutrients is proportional to the size of the yields, the higher the yields and the more input-based agricultural practices are, the more severe soil depletion is likely to be (Kotschi 2013). While mineral fertilizers help to boost the formation of nutrient-rich biomass, create favorable conditions for carbon sequestration and reduce soil erosion, the benefits related to the use thereof are only short-term, especially in case they dosed injudiciously (Donovan 2004).

Soil acidification

Synthetic nitrogen fertilizers are greatly comprised of ammonia (e.g. ammonium nitrate or ammonium phosphate), which contribute to soil acidification. Therefore, the application of high nitrogen inputs disrupts the balance in the ratios of nitrogen, phosphorus, calcium and potassium, with the two latter ones being significantly reduced due to higher soil acidity. Soil acidification in turn prevents crops from absorbing phosphate from the soil and increases the content of toxic ions to eventually inhibit ability of soil to stimulate plants' growth. Consequently, nutrient surplus, which can be also associated with high concentrations of livestock, is another aspect that needs to be addressed as it leads to soil nutrient imbalance (Kotschi 2013).

Soil bleeding: water pollution

According to the previous paragraph, the lack of nutrient equilibrium in the soil, which is caused by the heavy loadings of external inputs (and inappropriate management thereof), increases the soil's vulnerability to runoff of micro- and macro elements (NPK) into groundwater, lakes, rivers and seas. The accumulation of these micro- and macro elements in water reservoirs contributes to the process of eutrophication, which implies a depletion of dissolved oxygen (in the water body) that kills aquatic animals and plants through explosive growth of phytoplankton, the latter one consuming oxygen from the water during the decomposition of algae, fish, and other organisms. More importantly, the excess riverine nutrient discharge that leads to eutrophication of water systems is determined by a variety of both biotic and abiotic factors ranging from population dynamics, sewage management or changes in precipitation patterns. However, one of the main anthropogenic causes of eutrophication refers to high discharge of nitrates and phosphates from increasingly industrialized farming systems (Pastuszak *et al.* 2014). It can be also added that eutrophication can promote climate change. For example, toxic cyanobacterial blooms in the sea have the ability to retain heat generated by greenhouse gases in the atmosphere (Moss *et al.* 2011; Svanback and McCrackin 2016). Overall, eutrophication process, be it marine or environmental, triggers high environmental costs, which are very expensive to deal with and affect not only biodiversity but also human health.

Air pollution

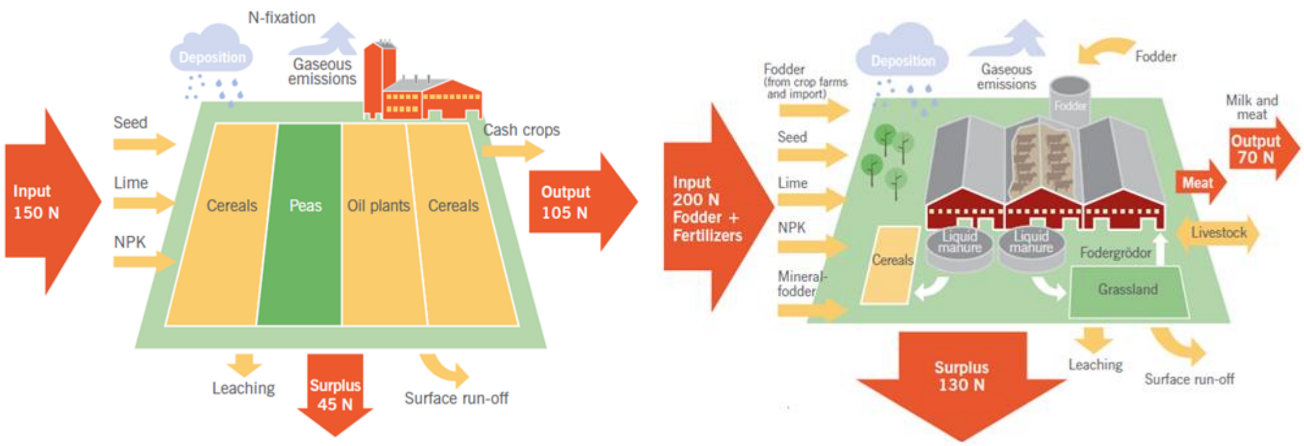
Given that nitrogen (e.g. from manure) has the ability to escape into the atmosphere in the form of greenhouse gas (nitrous oxide), which is capable of breaking down stratospheric ozone, air pollution is another aspect of unsustainable agricultural practices (Granstedt 2012). Therefore, fertilizing fields with this mineral contributes to climate change that can negatively affect food production (Svanback and McCrackin 2016; Khan *et al.* 2007). Consequently, it is very important to ensure that the manure is properly handled and livestock production is balanced.

Biodiversity loss

The disrupted nutrient cycle caused by external inputs of nitrogen can have negative impact on the lives of soil microbes, which are used to feast on organic matter of low in nitrogen soils. Since the lack of nutrient balance in soils can also inhibit the growth of plants, which constitute source of food for various animal species, the existence of these animals is also exposed to danger. In addition, many plants and animal species suffer from intoxication by pesticides (e.g. nitrogen fixation, which is required for the growth of higher plants, is hindered by pesticides in soil) (Kotschi 2013; Potera 2007).

All of the above environmental challenges are associated with **nutrient imbalances** in unsustainably managed farms, especially those specialized in either crops or livestock, and can alter global biogeochemical cycles (Granstedt 2012). In order to illustrate such nutrient imbalances on average specialized crop or livestock farm, the following two figures, which are based on the Swedish agricultural data, are provided in the next page.

Figure 2.1: Specialized crop[3] (left) and livestock[4] (right) farm: input, output and surplus of Nitrogen kg/ha and year



Source: Granstedt 2012 (data basd on Swedish board of agriculture report 2008:25)

The figure to the left illustrates that the nitrogen inputs in a crop-specialist farm comprise fertilizers, seeds and acid deposition. In case the total sum of added inputs equals 150 kg of nitrogen per hectare and year, 105kg of it is removed from the system in the form of cash crops (cereals) and 45kg of nitrogen surplus is leached to the ground water or is lost in the atmosphere. Approximately 80% of agricultural outputs (crop yields) is being sold to livestock-specialist farms via the feed trade (Granstedt 2012).

By referring to the figure on the right, the nitrogen inputs in livestock-specialist farm are usually derived from the crop-specialist farm in the form of fodder (e.g. straw); imported feed (especially genetically modified soybean seeds from neotropical countries such as Brazil or Argentina); and acid deposition stemming from nitrogen-fixation on farms due to the presence of manure on the field,

[3] Average 563 farms in the period between 2001-2006
[4] Average 701 dairy farms in the period between 2000-2006

especially when cattle is grazed on grasslands and/or manure is inappropriately stored outside the farm facilities. In case the total sum of added inputs equals 200 kg of nitrogen per hectare and year, 70 kg of nitrogen per hectare and year is removed in the form of milk and meat for processing, and 130kg of nitrogen surplus is leached to the ground water or is lost in the atmosphere. Likewise, the phosphorus surplus is usually leached to the ground (Granstedt 2012).

Apart from environmental challenges, it is also worth highlighting several **socio-economic challenges**, which are attributable to unsustainably managed agricultural food production systems presented above, namely:

Fossil fuel dependency

The manufacturing of nitrogen and phosphorus fertilizers is energy intensive and involves heavy reliance on fossil fuels such as oil. According to the International Fertilizer Industry Association (IFA) (2009), in 2007, the fertilizer production industry contributed to the global greenhouse gas emissions (GHG) by 0.93% by releasing 465 million tons of CO2 emissions. In addition, long-distance transport of off-farm inputs such as fertilizers, animal concentrates or GM soy beans for fodder further indicates strong reliance of agricultural sector on fossil fuels, which have the total negative impact on the ecosystem, especially when GHG emissions are considered. Another important aspect is the irreplaceable nature of phosphorus, which has been already severely depleted in the past 20 years. The EU alone imports approximately 6 million tons of phosphates per year (EC 2016b).

Technological and production treadmill

Intensification and specialization of food production can also be reflected in the concept of technological treadmill ('never ending cycle'), which illustrates farmers' heavy reliance on technology (fertilizers, pesticides, modern machinery) to maximize crop yields; as well as the concept of production treadmill, which refers to farmers' reliance on subsidies to compensate low prices of food products (Duram 2005; Weis 2007; Levins and Cochrane 1996). Both types of technological treadmill are interconnected and encompass the process of increasing farm ownership and land consolidation, whereby the former one fosters intensification of production methods as a way to compete with other 'wealth-holders', and the latter one referring to enlargement of farm holdings (Levins and Cochrane 1996). However, once farms grow in size, farmers are again forced to rely on the system of loans and subsidies to afford modern technological 'solutions' (e.g. fertilizers) and 'better' manage bigger fields. The technological treadmill can also imply erosion of traditional knowledge as farmers, being increasingly specialized and modernized, tend to focus only on key animals or cash crops and are less capable and willing to apply traditional techniques to combat various pest/weed problems (Weis 2007). Overall, one of the outcomes of being 'entrapped' in such a technological and production treadmill is the national support for technological innovations and subsidies as one of the key measures to promote 'national/agricultural development' and provide 'social security' through the expanded system of wages and jobs. Finally, another major outcome of such 'entrapment' is disorganization at the ecosystem level in terms of hazardous depletion of natural resource base that only further propels socioeconomic disorganization at the institutional level.

Circle of poison

Heavy loadings of synthetic fertilizers, pesticides and herbicides pose serious health threats to farmers who are exposed to volatile substances during the application process thereof. Since pesticides and herbicides tend to accumulate in plants throughout their vegetation process, it is widely acknowledged that they also pose harm to consumers. Similarly, the residues of cadmium in phosphate fertilizers tend to bio-accumulate in soils, and thereby consumers (Granstedt 2012). Regardless the common perception that the highly contested GMOs decrease pesticide use, the farmers who grow genetically modified soybeans for export and production of livestock fodder are often forced to apply higher amounts of toxic pesticides, which destroy precious soil microbes (GMWatch 2016). Moreover, the soils, which are depleted of nutrient resources via improper soil management techniques, render less nutritious, and thereby less healthy crops (Lyne and Barak 2000). In addition, high concentrations of conventionally raised livestock not only further contribute to water pollution, which has serious consequences for human health, but also creates favorable conditions for the development of various diseases afflicting animals and workers in such industrialized livestock facilities. What is worse, since these diseases are usually tackled with antibiotics, the residues thereof are contained within animals' excrements and urine that can be relatively easily transferred into waterways and end up in food chain in case plants are fertilized with manure contaminated with antibiotic remnants (Herrero *et al.* 2010).

To sum up, all of the above problems imply that sustaining soil fertility by maintaining and (re-)creating soil nutrient balance – closing **nutrient loop**, is as important as for us, humans, is the necessity to have a good access to clean air, food and water in order to maintain healthy bodies. It is also important to highlight that all of the described issues, except those which are related to the use of manure, which comes from animals that were fed with genetically modified soybean/corn-based fodder, can be attributed to **organic farming** sector (especially the one which is specialized in crop production) that is likewise trapped in the vicious cycle of technological and production treadmill. For example, even though organic farming prohibits the use of GMOs, synthetic fertilizers and pesticides, the organic farmers are generally not prohibited from using manure from non-organic (non-industrialized) farms, which usually use fodder grown with the use of synthetic nitrogen fertilizer that remains chemically fixed after being processed through livestock. In result, the final product retains the same source of nitrogen (McGuire 2012).

2.3 CONCEPT OF SUSTAINABLE AGRICULTURE TO CLOSE THE NUTRIENT LOOP

In response to the above discussed negative externalities, the concept of sustainable agriculture has emerged and received a substantial body of literature. Despite difficulties associated with defining and interpreting the concept of agricultural sustainability, this concept is useful as it encompasses not only technical but also social, cultural, economic and political dimensions of agriculture, all of which coevolve with natural systems (Stirling 2009; Altieri 1995). One of the definitions of sustainable agriculture is as follows: '*Agriculture contributes significantly to the society of the future. Sustainable agriculture is the production of high quality food and other agricultural products/services in the long run with consideration taken to economy and social structure, in such a way that the resource base of non-renewable and renewable resources is maintained*', whereby one of its sub-goals is: '*Farmers should practice production methods which do not threaten human or animal health or degrade the environment, including biodiversity, and at the same time minimise our environmental problems for which future generations must assume responsibility*' (*Agenda 21 for the Baltic Sea Region - Batic 21 in:* UN n.d). Therefore, it can be argued in the line with Ohlund *et al.* (2015) that the concept of sustainability helps to depict agricultural systems as multifunctional, nested socio-ecological systems. More importantly, the concept of sustainable agriculture constitutes an umbrella term for various alternative agricultural practices, which benefit both natural environment and humans in multiple ways. These practices are usually aimed at reducing or completely eliminating mineral fertilizers and pesticides and ensuring the balanced nutrient cycling within the farming system in order to restore and maintain soil fertility for future plant growth. The most popular ones, which had been commonly practiced in the past prior to being slowly replaced by modern intensive farming methods, usually revolve around the following **recycling principles**:

- **Crop rotations:**

Temporal diversity of crops in order to enrich soils with beneficial nutrients, increase soil cover, minimize risk of erosion and reinforce soil immunity to fight off natural enemies such as pests, weeds and prevent re-occurrence thereof (Sumner 1982; Stein-Bachinger et al. 2013).

- **Leguminous plants:**

The presence of legumes such as alfalfa, soy, clover or beans naturally boosts soil organic matter as these plants help to convert nitrogen into ammonia (NH3) and other usable inorganic compounds to support plants' growth; once they form a grassland they acts as a carbon sink (Kotschi 2013).

- **Balance between livestock units and land acreage:**

The imbalance of livestock with land area causes problems associated with excess manure.

- **Integrated mixed crop-livestock farming systems:**

Once livestock and crops are tightly integrated into a holistic system on a farm or territory level the benefits stemming from the above three recycling principles can have better impact on the natural environment as under such circumstances farmers can become more **self-sufficient** in resources such as fodder and manure, which can be produced at the farm level (FAO 2017; Ryschawy *et al.* 2013). In such a traditional type of the integrated mixed crops-livestock farming system (ICLS)[5], catch crops help to prevent nutrient leaching and cropping enables to preserve and restore soil health, which in turn helps plants to activate their natural defense system against pests and diseases such as fungal infections. Moreover, cropping can provide animals with fodder in the form of leys, nitrogen-fixing legumes, weeds and crop residues that would otherwise be loaded on to the natural resource base.

[5] ICLS is one of many ways of defining integrated crop-livestock systems; and ICLS term is widely used in American research circles (Hendrickson *et al.* 2008)

Animals in turn provide crops with manure, which is a natural fertilizer (Hendrickson *et al*. 2008). In case there is manure surplus, it can serve as a biomass to generate biogas for domestic electricity supply. However, in a well-managed and knowledge-intensive integrated farming system it is possible to prevent the production of excess manure by balancing livestock and land use.

For example, when beef and pork are combined, pigs can consume undigested grains from the beef manure. Similarly, in case cows and sheep are grazed together, the use of biomass is greatly maximized and disease outbreaks are less common (FAO 2001). Moreover, as in any other system, crop failures cannot be avoided (e.g. due to unpredictable climatic events) and the failures to harvest cereals as grains as well as obtain low in protein silage yields cannot be excluded. However, such failed grain harvest and poor silage yields can serve as feed for beef-breed and poultry animals that have lesser requirements than for example milk cattle. Interestingly, poultry are also good eaters of slaughter waste, various spilled seeds, cattle manure and even household waste. Either way, it is also very important to make reserves of fodder e.g. by storing surplus of fodder from the good season for worse times, or saving precious leftovers of cereals derived from the milling process (Granstedt and Seuri 2013; Johansson 2013).

Moreover, even though growing certain types of legumes, especially in combination with other crops, might render lower yields in the short-term, multi-purpose crop combinations can significantly improve the soil structure in the long run. In the same way, if farmers reject cereal varieties, which are expected to give high crop yields, yet they do not provide a sufficient quantity and quality of straw for fodder, they could maximize their total agricultural outputs. Such tradeoffs stemming from multi-agent combinations are defined through the concept of 'communal ideotype' according to which, it is important to cultivate crops and/or raise animals that maximize total yields and/or benefits when they are combined together, rather than when they are cultivated/raised separately for single-purpose (e.g.

for commercial commodity or fodder for one type of livestock) (FAO 2001). In addition, such synergistic links between crops and animals can be also understood by means of metabolic approach according to which a farm is a unit where the steady and regular, yet naturally cyclic flows of materials (incl. waste) help to ensure a healthy functioning of the ecosystem (Erb 2012). The flow of materials and interactions within the system that vary in time and space were further described by Moraine *et al.* (2014) who distinguished two types of interactions (overlaps) between crops, grasslands and animals: direct interactions, which refer to spatial dimension whereby two different units (crops/animals) interact at the same time (e.g. livestock grazing/feeding on grasslands) or in several time periods (e.g. using catch crops as part of crop rotations); and indirect interactions where materials such as manure flow across the farm unit(s). While technical efficiency is usually interpreted in terms of ability to effectively convert inputs into outputs, the integrated mixed crops-livestock systems can be evaluated in terms of '*the efficiency of use of purchased inputs and also the use of natural resource inputs (e.g. soil and water)*' (Watson *et al.* 2015). Further according to Watson *et al.* (2015), in such mixed crops-livestock systems the efficiency is reflected in the 'degree of synergy between components', which is in turn determined by the organizational structures at farm level (or between farms in case cooperation is considered). The possible levels of synergies or dis-synergies are illustrated in the Figures below.

Figure 2.2: Traditional mixed crops-livestock system (strong synergies between components)

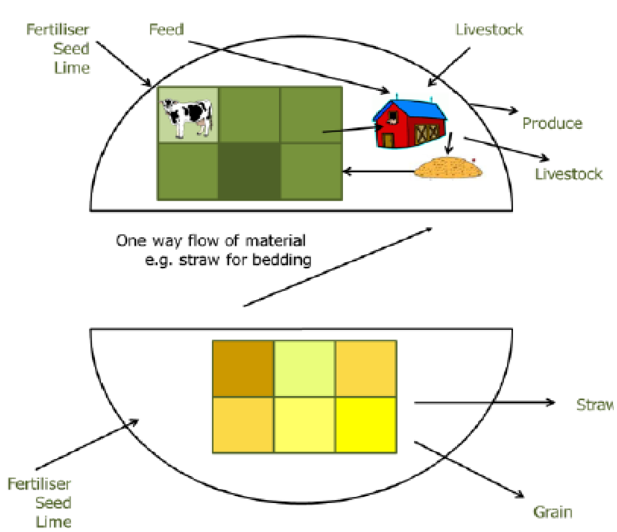


Figure 2.3: Semi-integrated crop and livestock production (low synergy)

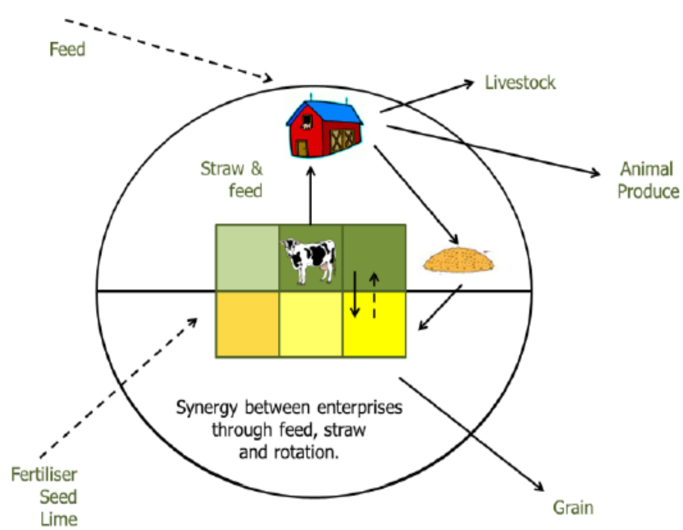
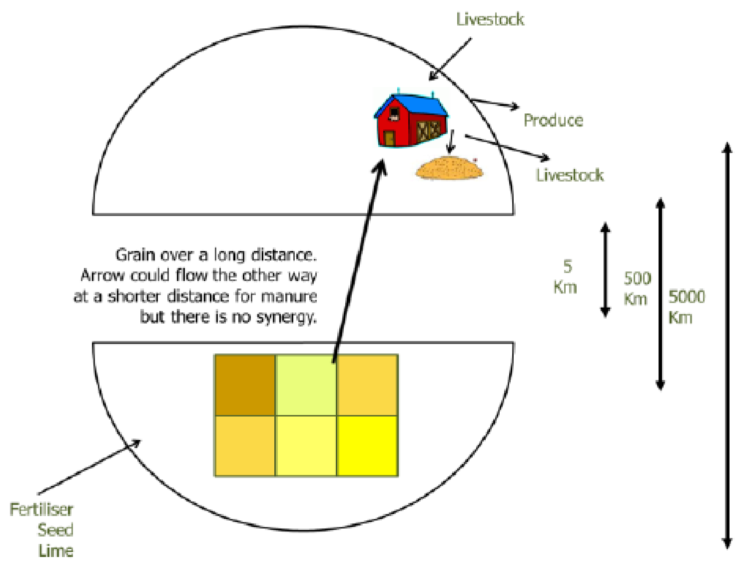


Figure 2.4: Non-integrated crop and livestock production (dis-synergy)[6]



Source: Watson *et al.* 2015

Apart from **environmental benefits**, such an integrated production system has an inherent economic value as the costs associated with imports of fodder (incl. concentrated feeds), herbicides, pesticides and/or synthetic fertilizers, or even liming (which neutralizes soil pH level in case of nutrient imbalance), are removed or suppressed (not to mention the costs associated with dealing with environmental externalities in case unsustainable farming methods prevail), thus in favor of pursuing economies of scale (Wilkins 2008**)**. Moreover, diversification of production, which employs crop rotations, can help farmers to become more resilient to market fluctuations in a global economy market (Russelle *et al.* 2007). In addition, by balancing livestock with land and using crops with different characteristics (including nitrogen-fixing leguminous plants), agriculture is diversified and local biodiversity improved (FAO 2017; Herrero *et al.* 2010). However, some of the key challenges such integrated farm model faces can relate to its **knowledge-intensive** character (e.g. it is important to know how to effectively fertilize fields and feed livestock, and how to collectively and effectively

[6] Dis-synergy might be greatly induced by short or long distance

organize cooperation between the farms), its relatively **labor-intensive** nature (yet such system can be supported by some external technology, e.g. software that could facilitate cropping) and globalization, which favors multinational food chains (**economies of scale**) rather than local food markets (economies of scope) (Ryschawy *et al.* 2013; Hendrickson *et al.* 2008). Despite these limitations, such integrated system is especially recognized among environmentalists and wider academic research circles due to its largely closed character, landscape beautification, and the fact that the crops and animals not only coexist, but are also physically complementary, be it at farm or district level (FAO 2011; Grandstedt *et al.* 2008; Havet *et al.* 2014; Lemaire *et al.* 2015; Ryschawy *et al.* 2013; Schiere and Kater 2001).

Overall, the above described core elements of recycling practices also lie in accordance with the concept of **agroecology**, which can be defined as '*a scientific discipline, a set of practices and a social movement*' (FAO 2017; Wezel *et al.* 2009). The main aim of agroecological approach, which can concern any type of farming system, be it conventional, organic or integrated, is to challenge the dominant productivist paradigm by adopting low-input management methods and creating positive synergistic relations between different components of the agroecosystem (Altieri 1995). By taking an agroecological approach to manage farmland, it is possible to go beyond viewing farming as a linear system where inputs such as mineral fertilizers or animas impact only outputs such as crop yields or meat produce, respectively. Since agroecology enables to manage farmland as a whole, it helps to fortify the flow and cycling of nutrients by returning them back to the soil for reutilization. Such cyclical system helps to sustain and restore soil fertility via proper management of above-ground biomass, and boosts both biogeochemical cycles and microbial activity within below-ground biomass. It also helps to promote and maintain crop diversity in order to make the agricultural system more resilient in the face of climate-related shocks (FAO 2017; Bellon *et al.* 2011). It can be also argued that some of the recycling principles constitute part of the concept of '**conservation agriculture'**, whose main aim is to improve soil biological processes by applying diversified crop rotations and permanent soil cover among other measures (Derpsch *et al*. 2010).

From farm to fork

Apart from optimizing biological efficiency, which can be reflected in reduced use of external resources and increased use of internal resources, the agroecological/conservation approach also promotes local interactions between producers and consumers. It views farmland as part of the larger food production system (food value chain), which includes food distribution and consumption (the latter one being highly influenced by processing and marketing of food products).

2.3.1 Ecological recycling agriculture

According to the EU regulation on Organic Farming (EC No 834/2007), organic farming provides a set of requirements for food production, certification, labelling and processing. In addition, IFOAM has distinguished four main principles of organic agriculture, namely: health, ecology, fairness and care (IFOAM 2008). The main difference between conventional and organic farming is the fact that the former type of agriculture is concerned with biological and mechanical processes and prohibits the use of chemical, off-farm inputs such as artificial fertilizers and pesticides. In other words, organic farming practices are concerned with integrated nutrient management by using compost, organic manure, nitrogen-fixing crops and advanced crop rotations. Consequently, organic farming can be considered as the prototype of a farm system that is concerned with closing nutrient cycles (Nowak *et al*. 2015). However, even though the concept of organic farming encompasses recycling principles such as crop rotations or composting, organic farms do not necessarily adopt a holistic approach; do not always have diversified system of crop rotations; and do not always integrate livestock production with crop production in a sustainable way (if at all) (Pastuszak *et al*. 2014). Consequently, the unfavorable trends toward agricultural specialization in either livestock or crops are currently observable not only in the context of conventional but also organic farming sector. In addition, apart from specialization, this sector is also reported to be undergoing concentration and mechanization – two processes, which can have overall negative impacts on the ecosystems in the long run (Pastuszak *et al.* 2014). These negative trends prompted scientists to measure environmental benefits stemming from implementing mixed organic farming systems. According to studies, low-input mixed organic farming systems render much higher yields and significantly can reduce nutrient leaching, when compared to all-arable crop rotations (Loges *et al.* 2006). Moreover, such integrated system was also proven to achieve the best score in the environmental index (Muller-Lindenlauf *et al.* 2010). Likewise, Granstedt *et al.* (2008), a precursor of the BERAS project (Baltic Ecological Recycling Agriculture and Society), revealed that it is possible to significantly improve soil fertility, achieve higher yields when compared to other types of organic farming, and even reduce nitrogen and phosphorus emissions by half under his concept of the 'Ecological Recycling/Regenerative Agriculture' (ERA), which is built upon EU Organic farming regulations (EC No 834/2007) and comprises the following set of interrelated recycling principles with corresponding parameters:

- **Integrated crop-livestock production**;
- **Crop rotation** *(30%-60% of crops is required to be constituted by* ***legumes***[7]*, which have the ability to fix nitrogen);*
- **Balanced livestock units to land ratio** *(0.5-1.0 animal livestock unit per ha - 1 livestock unit is approximately equivalent to the energy need of a cow who weighs 550 kg and milks 6000 kg milk/year)*

  (Granstedt *et al.* 2012; Grandstedt and Souri 2013).

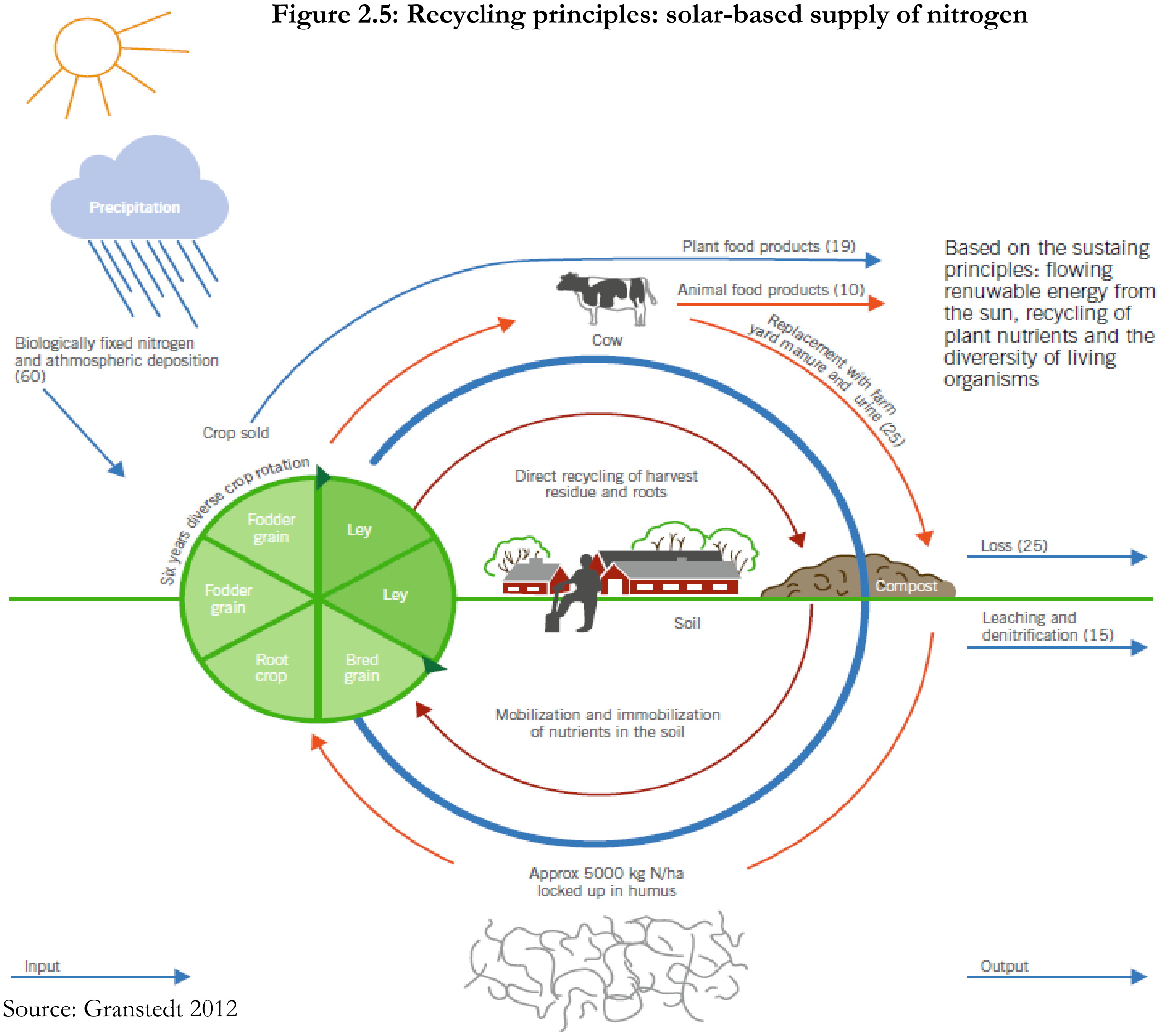
In the line with the previous sub-section, the application of these principles helps to achieve the nutrient balance in soils and enables to substitute imported mineral fertilizers and fodder with on-farm/between farms produced manure and fodder. It is believed that by applying the above

[7] One ton of harvested legume is usually equal to 50kg/ha of nitrogen (Granstedt and Souri 2013)

principles farmers could become **self-sufficient in feed and nutrients by 80%** (Granstedt *et al.* 2008). Overall, by introducing well-designed cropping sequences to grow crops with different characteristics in one area and in sequenced seasons, and by generating natural nitrogen reserves by introducing energy crops - nitrogen-fixing leguminous leys (yet ensuring these forage or protein rich leguminous crops constitute at least 30% of total farm area); it is also possible to create favorable soil conditions for plant roots to absorb beneficial micronutrients. For example, Granstedt (2012) found out that after completing crop rotations in Skilleby Experimental Farm in Järna there was a '*significant increase in humus in the topsoil (0-20 cm), amounting to 400 kg carbon per hectare and year*'. It is also worth highlighting that such crop rotations serve as an important method of pest, weed and disease control. However, pathogens can develop in case they are incorporated into the crop rotation system for too long and it is estimated that legumes should not exceed '20% of the total system of crop rotation **once in every 5 years**, and no more than two types of perennial legumes should take place in the same rotation as ley crops are often affected by the same pathogens' (Granstedt and Souri 2013). By referring to the principle related to balanced livestock and land ratio, the main rationale behind it is the fact that nitrogen levels are highly correlated with the livestock density per hectare and it has been estimated that the excessive amounts of nitrogen can be up to '*50% higher in regions with high animal densities*' (Granstedt 2012). However, yet in reference to the previous sub-section, in order to increase efficiency of fodder (biomass) use, it is important to combine different types of animals. While monogastric animals usually have problems with digesting silage, certain types of livestock such as milk cattle, pig and poultry require higher quality of fodder than others, yet the total amount of proteins provided in a such farm system where there is approx. 30% of leguminous crops might be already too high for them. Therefore, it might be better to integrate such 'demanding' livestock with ruminants that could consume the remaining fodder to avoid any loss (e.g. sheep) (Granstedt and Seuri 2013).

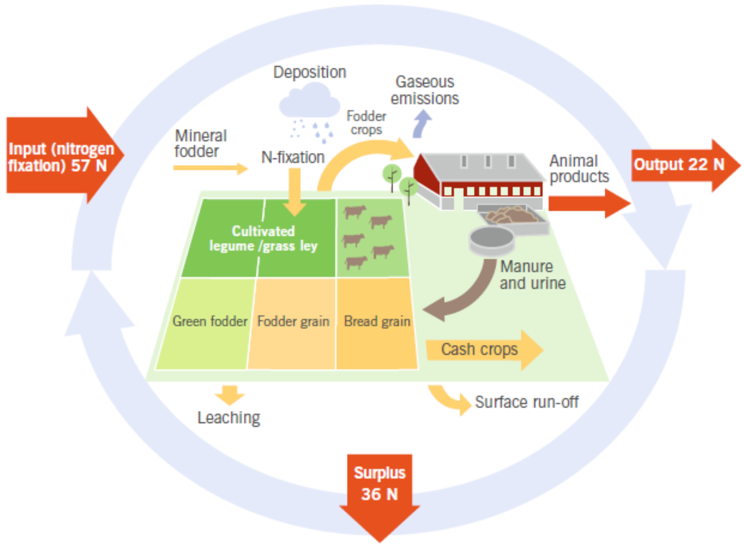
Overall, the main idea behind ERA is to create a closed loop agricultural system, which integrates crop and livestock in order to facilitate nutrient recycling by dispersing manure and urine on the fields instead of accumulating it in specialized farms, and which helps to re-couple nitrogen and carbon cycle. The recycling principles are illustrated in the Figure 2.5 below. The Figure 2.6 additionally presents a simplified farm model based on recycling principles. Following Granstedt's (2012) calculations, it shows that once the farm is self-sufficient by relying on natural resources has significantly lower losses of nitrogen (by 70-75% lower); much lower nitrogen surplus (by 50%); and no phosphorus surplus, when compared to conventional specialized farms presented in the section 2.2.

Figure 2.5: Recycling principles: solar-based supply of nitrogen



Source: Granstedt 2012

Figure 2.6: Simplified ecological recycling farm: input, output and surplus of Nitrogen kg/ha and year[8]



Source: Granstedt 2012

In order to facilitate the adoption of such knowledge-intensive practices, two software tools, which can be defined as 'enabling technologies' that aid diffusion of this type of farm model (e.g. ROTOR tool helps to plan crop rotations) were introduced by the BERAS project (Stein-Bachinger 2013). All in all, the recycling principles of ERA help to develop regenerative farming systems, which offer numerous yet highly interconnected and integrated benefits such as:

- ✓ significant reduction of the land pool of accumulated phosphorus and nitrogen (decreased reliance on fertilizers, and subsequently water pollution[9]);
- ✓ biodiversity protection;
- ✓ increased resilience and adaptability to climate change through sustainable diversification of production (crop rotations);
- ✓ reduced economic and socio-environmental costs associated with fodder import;

[8] Data obtained from the demonstration farm (*Ytterenby – Skilleby)* in Järna, Sweden
[9] The research revealed that one of the farmers, who joined BERAS project and converted his (once conventional and oriented at pig-production) farm into 'Ecological Recycling Farm' model, even managed to clear up the lake, which was bordering his farm fields, and thereby could serve the wider recreational needs in the area (Granstedt and Seuri 2013).

- ✓ potential to improve the well-being of small-scale farmers and consumers by increasing their reliance on local food supply and boosting local and regional rural development, especially in the face of problems related to price volatility (in case there is local market demand for ecologically grown products) (Granstedt *et al*. 2008).

Interestingly, 'ERA' principles are in the line with some of the principles and practices included in the concept of the **biodynamic farming**, which was developed by Rudolf Steiner in the early 1920s. Similarly to 'ERA', biodynamic agriculture applies a holistic approach toward soil management and some of its central features include chemical-free inputs, crop rotations and use of manure within an integrated mixed crop-livestock system in order to enhance farmland's capacity for self-renewal (Steiner 1993).

Nonetheless, as far as economic aspects are concerned, the production costs in such system are generally higher than in case of conventional specialized farming as the former one does internalize environmental costs. For example, the production per cow in Jarna farm in Sweden was lower by 12% due to limited use of fodder (Granstedt *et al*. 2005). Even though by integrating grazing animals (e.g. beef or lamb), the costs associated with harvesting fodder are reduced, the market forces unfortunately propel farmers to intensify their produce in confined facilities (Granstedt and Souri 2013). However, it was argued that such Ecological Recycling Agriculture can also partake in the economies of scale with some of the crops it produces, especially in case it involves cooperation across various farms on a much bigger scale (Grandstedt and Souri 2013).

2.4 AGRICULTURE IN POLAND IN BRIEF

Poland, the case study of this thesis, has the largest agricultural area among the Baltic countries amounting up to 59.8% of the total arable land in 2015, which was equal to 14 500 ha in 2015 (GUS

2016). The country is largely bordered by the Baltic Sea in the north and the Carpathian Mountains in the south. The largest area between north and south refers to central lowlands ('Polish plain'), which occupy the vast territory of the Greater Poland voivodship (91.3% of the total land in Poland is located in lowlands; see Map B1, Appendix B) (Bochenek *et al.* 2015). The hilly and mountainous character of the southern part of the country can partly explain why the vast majority of farms in this part of the country is characterized by relatively small farm size and high fragmentation of the land. For example, the southern Sub-Carpathian voivodship, which is located in the mountainous terrain, has one of the smallest average size of agricultural land in the entire country (4.71ha in 2015). In contrast, the farms located in lowlands are generally larger (e.g. the average size of farms in West Pomerania voivodship, which is located in Szczecin Lowland was 30ha in 2015). However, the average farm size in two southern voivodships, which are located in hilly and mountainous terrain - Lower Silesia and Opole voivodship, is rather high when compared to Lesser Poland and Sub-Carpathian voivodships, and indicates that there are other factors, which are responsible for such high average size of agricultural land holdings[10] (Prow2014-2020 2015). Overall, while the average size of 1 409 649 farms in Poland in 2015 was 10.49 ha, thus being relatively small compared to EU-28 average, which was 16.1 ha in 2013[11]; the number of farms in 2003 amounted to more than 2 million farms and the average farm size was 6.6ha (Prow2014-2020; GUS 2016; Eurostat 2015 and 2017).

It can be argued that while the small size of farms in the south of the country can facilitate wider adoption of recycling principles, issues such as slopes (hilly environment) pose extra challenges for scaling of recycling principles as they require adoption of much more complex farm management practices. Under the latter circumstances, the efficiency of a system that is (at least partially) built upon recycling principles would be much lower (Watson *et al.* 2015). Moreover, as far as natural conditions

[10] The varied farm sizes across the voivodships in Poland is further illustrated in the Map 1 in Appendix **2**
[11] There is a lack of more recent data related to the average farm size in EU-28

are concerned, according to Igras *et al.* (2014), they are by 30-40% worse than the ones in the Western Europe (old EU member states).

2.4.1 Formative histories

The prevalent yet gradually changing farm structure and the wider socio-environmental context in which the Polish agricultural sector is situated; is to a large extent the outcome of post-war politics. Consequently, this sub-section highlights how milestone political decisions, which emerge in response to the heavy accumulation of various socio-economic factors, have the ability to spark a chain reaction across the entire country whose consequences can be felt within the agricultural sector for many decades to come.

Early post-war period

After the period of the WW2, which had a devastating impact on the state of the Polish agriculture and 7.5 million of agricultural land was abandoned, one of the key agricultural reforms that was announced via the Polish Committee of National Liberation, was the creation of the State Agricultural Fund in 1944 (Stola and Szczesny 1982 in: Banski 2009). This fund helped to implement the program according to which agricultural land with the size exceeding 50ha had to be parceled out in order to serve local unemployed farmers, especially those who had big families. The reason behind such forced division of land, which often took place by means of oppressive measures, can be also partly explained by the necessity to provide food for the army. In result, nearly 980 thousands of farms were created or benefited from the state-ruled land allocation that encompassed in total approximately 6.1 million hectares of agricultural land in the period between 1945 and 1949. The farms in this period of time were also characterized by mixed production system (Olszewski 1985 in: Banski 2009; Grzelak *et al.* 2009).

Collectivization period

Once the WW2 officially came to an end, the Polish government initiated the process of agricultural collectivization that lasted until 1956 and led to the emergence of the so-called **State Agricultural Farms**, which were a form of collective farming on numerous plots, which used to produce various types of crops (incl. good quality seeds) and livestock. More importantly, in the early 70s, the state-owned farms began to undergo the process of creation of multi-plant enterprises in order to increase productivity through higher **specialization** in either crops or livestock and mechanization. In order to accelerate such process several demonstration farms were created to show how to effectively manage farms and prevent collapse. Nonetheless, the attempts to pursue economies of scale failed and multi-plant enterprises proved to be **unsuccessful**. In result, smaller farm holdings were revalued in the 80s, yet the farms remained large as their size usually ranged between 4000-10 000 hectares and were comprised of no more than 5 enterprises (Szpak 2005). All in all, the State Agricultural Farms, which were in fact large food cooperatives, helped to ensure independence from imports; largely prevented unfavorable fragmentation of agricultural land; and (intentionally) disempowered private farms whose owners did not have priority to purchase fertilizers or machines, which were under the control of state agencies, and thereby remained small and largely unproductive. According to statistics, approximately 10 thousand of state-owned farm cooperatives emerged, especially in the so-called 'Recovered Territories' in Northern and Western Poland (currently West Pomerania, Lubusz, Pommerania, Warmian-Masurian and Kuyavian-Pomeranian voivodships); and Southeastern Poland (currently Lublin voivodship) where the development of large state-owned farms followed the displacement of Ukrainian people that used to largely inhabit this region. Interestingly, individual farms, which were often pluriactive, occupied nearly 76% of the total agricultural land in the late 80s, thus constituting the predominant type of farm (Banski 2009).

Toward the free market economy: privatization period

After the downfall of the communist regime, Poland entered a new era marked by the shift of the socio-economic system built upon centrally planned economy, which was influenced by the state ownership, into the system based on the free market economy that opened the door to foreign capital. Such political and economic transition was meant to restore a market balance and counteract the economic crisis, which was preceded by the short-lived economic prosperity manifested in increased use of machines, higher productivity or introduction of pension insurance schemes. However, the agreements made with foreign companies to export Polish products only exacerbated high inflation rates and led to heavy indebtedness of State Agricultural Farms, which were no longer perceived as wieldy, and eventually collapsed. According to Slazak (2013), all the state-owned farms, which amounted up to 1 665 and occupied 3.742.380ha of agricultural land (22.6% of the total national land) were ultimately liquidated by 1994 and de-collectivised into small units for leasing or sales to farmers or investors, often those who had ties to companies with foreign capital (Banski 2009)[12]. During this time period many small farmers also received extra financial support to their pensions as long as their land had at least 1ha. The effects of such politics are reflected in the contemporary agricultural landscape in Poland, which remains greatly **fragmented** (Chaplin *et al.* 2007). Overall, during the privatization period Poland became dependent on foreign imports and economic analysis of farms reveal that many (small individual) farms during this period (especially in the late 90s) were much less prosperous when compared to the communist period, unless the farms were under western influence. Even though animal production decreased, small family-run farms had to rely on traditional farming methods such as mixed crops-livestock systems in order to procure organic fertilizers. It is estimated

[12] A great part of the agricultural infrastructure from the communist period was not completely destroyed upon the collapse of state-owned agriculture and the infrastructural remnants of this period currently constitute an integral part of the Polish rural landscape (see image X, X and X in Appendix 6)

that approx. 28% of the total number of farms in 2002 suffered from increasing depreciation of fixed assets (Banski 2009; Wos 2000; Jozwiak 2004). In the light of the above reforms, it is possible to discern a correlation between the average farm size per agricultural land area and the regions, which were greatly dominated by the large State Agricultural Farms and then privatized or leased. For example, the Pommerania voivodship in the North-Western part of Poland, which used to be the major 'hot-spot' for state-owned farms, currently has the highest average farm size (30ha in 2015) (Prow2014-2020 2015; Marshal Office of the West Pomerania voivodship 2015). Moreover, such trends associated with the emergence of big agricultural enterprises allow to discern the phenomenon of increasing **land ownership** by several (or one) individual(s) who tend to just monitor farming activities and facilities and do not work on farm physically. Such phenomenon induces a dangerous shift in power relations, which raises the issue of inequity between farmers (workers) and land owners (employees).

EU membership

In 2004 Poland gained a membership in the European Union, which is a political and economic union encompassing 28 member states and its main policy aim is to ensure free movement of people, goods, services and capital within the internal market. While one of the legacies of the post-communist land privatization in Poland were small scale family and semi-subsistence farms, the EU reforms coupled with the system of subsidies (see next sub-section) have propelled many farmers to **enlarge**[13],

[13] The Figure D1, Appendix D shows that the majority of farms have sizes between 2-5ha. However, while the small farms whose size ranges between 1-15ha are currently on the decline, the farms with the size above 10 and 50ha are on the rise.

specialize in either crops[14] and livestock[15], and **modernize** their farms in order to compete with Western economies on the 'common market' (Banski 2009). According to Ciaian *et al.* (2009), following the accession of Central and Eastern European countries to EU in 2004, which has exposed them to a set of new policies (4.2.1 & 4.2.2) and impacts of globalization (4.1.2), the agricultural sector in Central and Eastern Europe is characterized by a dual structure of farms, which can be split into the following two categories: large corporate farms (CF) and small family farms (FF), the latter ones being highly valued by ERA. However, since Ciaian *et al.* (2009) distinguished these two categories nearly 8 years ago, this typology could be now expanded to include 'medium size family farms' and 'large familial commercial farms' in order to indicate rapid changes in the farm structure, at least in relation to Poland.

By referring to the **organic farming sector**[16] specifically, the financial support for organic farmers under the Rural Development Plan under the Common Agricultural Policy (CAP) (see below) led to the dramatic increase in the number of certified farms that rose from 26 in 1990 to 3809 in 2014; and the percentage of organic area in total agricultural area rose from 0.5% in 2004 to 4.3 in 2014. Moreover, the trends toward increasing farm size and specialization in crops are also greatly discernible in the organic farming sector[17] (see Figure D5, Appendix D and Table C1, Appendix C). Nonetheless,

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[14] There was a substantial increase in the number of **crop-specialist** farms at the expense of decrease in the number of mixed and livestock-specialized farms in the time period between 2005 and 2013. While the crop-specialist farms increased from 39% in 2005 to 56% in 2013, the mixed crops-livestock farms decreased from 37% in 2005 to 29% in 2013; and livestock-specialist farms decreased from 18% in 2005 to 14% in 2013 (see Figure 2, Appendix 4). Approximately 25 000 of the largest farms used to be state owned farms in the past and are currently greatly oriented at crop production (approx. 55% of them produce cereals) (MINROL 2016).

[15] The trend toward specialization in livestock is usually coupled with increasing livestock concentrations. Such trends are illustrated in Figure 3, Appendix 4, whereby pig and cattle production per ha of agricultural land is combined with physical heads in Poland in selected years

[16] Due to the limited space, the brief historic overview of organic farming sector in Poland, which remains at the niche level, is available in Appendix E (E1).

[17] The major decline of organic farms was observed in Lesser Poland and Sub-Carpathian, thus in regions in which the land is highly fragmented (IJHAR-S 2015).

the total number of certified farms was lower by 1345, and certified organic land was lower by 53973ha in 2015 – see Figure D6, Appendix D (Bobik 2010; Willer and Yussefi 2006; GUS 2016).

2.4.2 Common Agricultural Policy (CAP)

The dominant institutional arrangement that comprises a set of regulations and funds at EU level and shapes agricultural policies at national level is the Common Agricultural Policy (CAP). The CAP initially emerged as a measure to ensure food security in the post-war period. However, after Europe gained membership in the World Trade Organization (WTO), which opened its door to global trade, some of the main objectives of the CAP included mitigation of negative effects associated with price volatility of commodities in world markets and improvement of farmers' competitiveness in the increasingly globalized trading environment. Following the Agenda 2000, which is an EU-action program to reform CAP, regional policy and refine EU financial framework, CAP has been also officially concerned with promotion of environmental sustainability. Above all, it has always been committed to improving rural living standards (EC 2012). Currently, CAP grants a substantial amount of subsidies to the European agricultural sector, which constitute 39% of the EU's entire budget. Under CAP 2014-2020[18] €23.4 billion have been allocated to Poland (EC 2015 and 2017). However, in order to receive financial support, farmers need to comply with a complex set of regulations. Regarding the CAP's core structural elements, it consists of the following two main 'pillars':

Pillar 1 - concerns direct payments **based on acreage;** 'young farmers payment' (for farmers under 40 years old); 'greening payment' (see below); market regulations (e.g. export refunds) and policy support.

The main difference between the old (2007-2013) and new CAP (2014-20) has been the introduction of the greening component, namely 'green direct payments', which comprise 30% of direct payments

[18] The stated amount includes 3.2% reduction at EU level that covers all EU Member States

that are eligible to farmers once they comply with the set of obligations related to: (1) ***crop diversification*** (incl. crop rotations); (2) ***maintenance of permanent grasslands*** (net carbon sinks); (3) ***development of ecological focus areas*** *(EFAs)* (incl. nitrogen-fixing crops or buffer zones that can prevent nitrogen leakage to the groundwater) (EC 2013).

Pillar 2 – concerns the so-called European Agricultural Fund for Rural Development (EAFRD), which offers payments for rural development programs/ schemes that are co-funded by all EU member states. If approved by the state, these schemes could be based on recycling principles (EC 2013).

Given that EU member states are greatly heterogeneous (i.e. they vary in terms of historical background and socioeconomic conditions), they were granted a national flexibility to decide on how to implement the Pillar 1 payments and select three key national priorities under the Pillar 2 of CAP. In case of Poland, the CAP subsidies in Poland under the Pillar 1, which are largely based on acreage, have been prioritized by the Polish government over shifting payments to the Pillar 2 since the very beginning of membership in the EU. What is more, the direct payments for big conventional farmers continue to increase under the Single Area Payments System (SAPS) within the CAP 2014-2020 and 25 % of payments falling under Pillar 2 are being transferred to Pillar 1 per year (ARC 2020 2014). Consequently, the farmers continue to increase in size. Likewise, the payments falling under Pillar 2 have been greatly oriented at programs promoting modernization and intensification of the agricultural sector in order to help farmers to better adapt to the network of global dynamics (become more competitive on the common EU market) and pursue economies of scale, which do not support scaling of recycling principles – more follows in the Results & Analysis and Discussion chapters (Ohlund *et al*. 2015).

3 THEORETICAL FRAMEWORK

The main purpose of this chapter is to provide an exploratory and explanatory overview of key theories related to the research topic, which were deemed applicable and desirable to co-create an analytical framework in order to situate and guide the study concerned with challenges and opportunities for up-scaling of recycling principles within the Polish agricultural sector. This chapter constitutes a reference for the type of collected data to construct a model of reality in the next chapters.

3.1 THEORETICAL DIMENSION BEHIND THE CONCEPT OF 'SCALING' OF AGRICULTURAL INNOVATIONS

The previous chapter provided some contextual explanations of agroecological ('recycling') practices, which, from the socio-environmental point of view, are a desirable 'agricultural innovation' that should be integrated into the dominant industrial agricultural system in order to mitigate/reverse negative trends associated with specialization or mechanization. Therefore, it is reasonable to highlight the concept of 'scaling', which comprises two types of 'scaling' based on scope: 'scaling-up' and 'scaling-down'. 'Scaling up' can be then classified into the following four categories: quantitative or horizontal scaling up/scaling out (increase in the number of people involved), functional or vertical scaling up (projects and programs enlarge the scope of activities), political or vertical scaling up/institutionalization (projects/programs induce structural changes) and organizational scaling up, which is also called vertical scaling up/institutional development (organizations are becoming more effective via e.g. better networking or financial resources). Scaling down is the flip side of scaling up (Unwin 1995 and Gundel *et al.* 2001 in: Pachico and Fujisaka 2004). Moreover, it is also worth distinguishing two approaches to scaling: 'push scaling' and 'pull scaling'. While 'push scaling' is challenging and disruptive in nature as it aims to reconfigure the regime; the 'pull scaling' refers to 'aspired system configuration' whereby agenda setting and policymaking can have enabling, stimulating and accommodating effect on an innovation (Wigboldus and Brouwers 2016). Overall, the typology of scaling processes reveals that scaling initiative involves various complex processes, which are context-specific and involve many actors. Interestingly, Wigboldus *et al.* (2016) adopted the **theory of aspects** developed by Dooyeweerd and used 14 different aspects to demonstrate the complexity of scaling (incl. scaling up and scaling down) of environmentally friendly rubber cultivation in Southwest China. Based on these aspects, the Table 3.1 below presents an overview of selected and re-defined aspects in relation to scaling of recycling principles in the Polish agricultural sector, which are greatly based on the previous overview thereof.

Table 3.1: Aspects of scaling recycling principles within the Polish agricultural sector

Aspects of scaling	Type of scaling (incl. scaling up and down)
Quantitative (more/less)	More farmers involved
Spatial (more or less spread)	More medium size farms with mixed crop-livestock production and more medium size farms specialized in one production yet cooperating with neighboring farms to exchange fodder/manure
Physical (bigger, more encompassing)	Larger project needed to support this across the entire country and at regional and local levels
Biotic/sensitive (non-human)	Diversification of crops; improved soil; water and air quality
Biotic/sensitive (human)	Reduced negative health effects resulting from application of mineral fertilizers (and pesticides); high in nutritional value and devoid of toxic cadmium crops
Cultural-formative	Wider adoption of new or previously performed recycling practices
Economic	Reduced expenditure on off-farm resources and extra income from diversified produce; pursuance of economies of scope
Juridical	New policies and legislation stimulating scaling of environmentally friendly recycling practices needed
Aesthetic	Landscape beautification through more diversified produce
Ethical **Certitudinal**	Stimulating wider adoption of 'green' mindsets

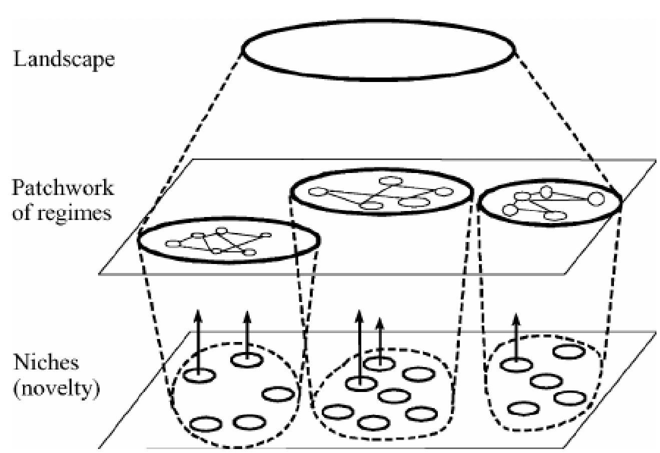
	Working on increased trust among stakeholders and 'green' aspirations to ease the cooperation and overcome logistical obstacles

Adopted from Wigboldus *et al.* 2016

3.2 MULTI-LEVEL PERSPECTIVE FRAMEWORK: DEFINITION AND RELEVANCE

One of the possible theoretical frameworks, which has been frequently used in the field of agriculture to depict in a non-linear way dynamics of structural change and explore multidimensional nature of a transition processes toward new, innovative, agroecological farming models/practices, is the Multi-Level perspective framework (MLP) (Geels 2011; Sutherland *et al.* 2015; Wigboldus *et al.* 2016). This framework constitutes part of the heuristic transition management theory, which conceptualizes complex and multiple structural changes in technical systems, beliefs and values as well as governance structures that occur as a result of various side-effects of systemic failure (e.g. environmental degradation) (Geels and Schot 2010). The MLP clearly illustrates that the sustainable transitions involve '*multi-dimensional interactions between industry, technology, markets, policy, culture and civil society*' (Geels 2012), and by integrating policies with societal domains, it calls for a broader multi-actor changes at institutional level. This approach also opens a room for reflexive governance and recognizes the importance of the development of socio-technical innovations at niche level (Geels and Schot 2010). The multi-level framework consists of three core analytical levels, which are illustrated in the Figure 3.1 below.

Figure 3.1: Multiple levels within multi-level framework



Source: Geels 2002

Landscape level

The exogenous socio-technical landscape (macro-level), usually consists of intangible aspects such as demographical trends, societal values, climate change or political coalitions all of which develop over a large period of time and cannot be easily influenced by the subsequent two levels (Geels 2002; Geels and Schot 2010; Sutherland *et al.* 2015). However, while the landscape dynamics is rather slow as it represents aforementioned wider socio-environmental trends, this level also refers to some external shocks, which can disrupt its relative stability (e.g. oil price shocks or extreme climatic anomalies). In addition, the landscape level is the place where historical setting matters as it helps to explain the occurrence of such trends, shocks and various 'lock-ins', which can (in)directly influence the development of an innovation at the niche level and shape the visions of the future (Darnhofer 2014; Wigboldus *et al.* 2016).

Patchwork of regimes

Patchwork of regimes (meso-level) consists of incumbent, dominant practices and both formal and informal rules, norms and regulations (policies) that maintain the existing system through a network of various actors, social groups as well as institutional and mental arrangements (e.g. corporate governance structures) (Geels 2004; Geels 2011). The socio-technical regimes are highly structured entities, which are often characterized by 'institutional lock-ins' that prevent niches located at the bottom level from bringing radical transformations. Given that regimes are built upon different views, negotiations and agendas, the interactions within regimes are not devoid of internal conflicts. Those who hold power often remain skeptical to alternative practices or technologies as they might have vested interests (Darnhofer 2014). Another characteristic of regimes is their multidimensional nature as they encompass various sub-regimes related to food production, processing, markets (incl. tangible infrastructures and technologies) or consumer consumption patterns; all of which co-evolve with each other (Geels 2002; Geels 2011; Darnhofer 2014). Consequently, the regime level consists of various sub-regimes that have various societal functions (e.g. market sub-regime) that reflect intertwined challenges across several sectors.

Niche level

Niches (micro-level) are the insulated spaces for the development of radical innovations at the local level that can be defined in terms of seedlings capable of brining a systemic change, even though many of them are doomed to perish due to policy or infrastructural restrictions (Geels 2002; Elzen *et al.* 2004). They can be also described as spaces for demonstration projects (Sutherland *et al.* 2015). Overall, niches are the locus where socio-technical innovations emerge and from where they can evolve to substitute and/or complement no longer working, predominant and harmful practices at the landscape level once they are widely recognized at the regime level (Raven *et al.* 2010).

Inter-/Intra-level interactions

The Multi-level framework is concerned with the interplay of various actor groups and demonstrates that a change at the regime level is necessary in order to increase the likelihood of a niche to bring a fundamental change to any given system (e.g. agro-system) (Darnhofer 2014). The transition can occur once the processes across all levels are aligned and the socio-technical landscape effectively pressurizes the patchwork of regimes to transform the existing system. Once the dominant regime is destabilized and weakened by external pressures and internal conflicts, a niche has a bigger chance to break through in the regime. All in all, it can influence the transition when it succeeds in bringing together (external) actors from outside the regime (e.g. consumers, retailers) and (internal) actors at national level (e.g. policy-makers) (Darnhofer 2014). Interestingly, Wigboldus *et al.* (2016) used MLP in combination with the previously mentioned theory of aspects (2.3) to examine scaling of agro-ecological practices in Nicaragua. Wigboldus *et al.*'s (2016) framework was defined as **PR**actice-**O**riented **M**ulti-level perspective on **I**nnovation and **S**caling (PROMIS) and helped to illustrate the complex interactions and dynamics associated with scaling of agricultural innovations.

3.2.1 Relevance

The persistent environmental problems such as eutrophication of the Baltic Sea, climate change or (functional) agrobiodiversity loss are becoming more obvious and indicate systemic failure that has been unfolding over prolonged period of time and requires taking a transformative action (Ohlund *et al.* 2015). Since the encompassing MLP approach helps to understand the successes and failures of implementing a socio-technical innovation to induce a regime shift and has been effectively applied in relation to agro-food regimes (Sutherland *et al.* 2015), in this paper it is adopted to illustrate agro-environmental, socio-economic, technical, political and institutional frame conditions, which shape drivers and barriers (lock-in mechanisms) to scale recycling principles within the Polish agricultural sector (both organic and conventional). Regarding three levels of MLP, the 'landscape level' can be applied to depict the wider agronomic and socio-environmental circumstances, incl. current predominant farming and demographic trends in the agricultural sector, over which there is little control. The subsequent level, 'patchwork of regimes', can refer to the system of dominant structures, practices, formal rules and regulations (e.g. EU and national policies[19]), which might pose both limitations (lock-ins) and opportunities for scaling of recycling practices. For example, rules and regulations are usually designed in response to the challenges in the 'landscape' level and might be influenced by/or remain ignorant to innovations emerging at the 'niche level' - a space for the development of new agricultural practices or technologies (such as recycling principles combined with 'enabling' and 'complementary' technologies) whereby famers who adopt them are key actors, and civil society organizations are fighting for change in the regime level. In order to better classify recycling principles, it might be useful to use typology generated by Padel *et al.* (2010) for the TP

[19] The EU-level Common Agricultural Policy reforms take place every 6 years and cannot be easily influenced by various national actors from the regime and niche levels. Therefore, the CAP reforms could be viewed through the macro-scale lenses at the landscape level (Sutherland *et al.* 2015). However, in this thesis they are regarded as a vital part of Geels's (2002) 'incumbent regime'.

Organic Implementation Action Plan, according to which four distinct types of agricultural innovations can be distinguished: (1) technology innovation (includes 'physical technologies' e.g. machinery that are usually created in scientific and technological labs); (2) know-how innovation (concerns methods and practices that often combine traditional and tacit knowledge with new approaches); (3) organizational innovation (includes changes in management and networking between various stakeholders within the entire agro-food system); (4) social innovation (concerns behavior changes among various social groups). Following this typology, it seems relevant to describe recycling practices as a 'know-how innovation' and an 'organizational innovation', the latter one also describable in terms of new organizational forms and practices, a concept, developed by Karanikolas *et al.* (2015).

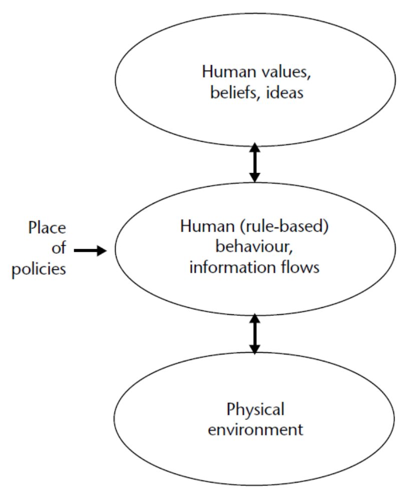
Overall, the MLP approach in this research helps to evaluate conditions under which recycling principles as a know-how and organizational innovation, have the potential to become widespread and bring a systemic change in regime level in order to help the country identify major environmental problems and meet environmental objectives. The MLP approach is also used to examine inter- and intra- level interactions and find out the potential '**lock-ins**', which shape the so called '**path dependencies**' across multiple levels. The concept of 'path dependency' stems from the theory of path dependence, which has its roots in the economic history and is usually used to analyze the limitations of decisions that were made in the past for the future decision making, yet it can also help to explore the economic polarization between Western Europe and Central-Eastern Europe, which has implications for the agricultural development in Poland (Ivanov 2016). These 'path dependencies' can be also referred to as 'institutional ceilings', which impede expansion of certain innovations such as recycling practices. Some types of 'lock-ins', which were mentioned by Wigboldus *et al.* (2016) in the context of the theory of aspects, are as follows:

- **Formative/Technological lock-in** (dominant technology paves the way toward unsustainable practices; limited technical knowledge);

- **Juridical lock-in** (e.g. some policy regulations limit available options);
- **Economic lock-in** (e.g. subsidies for unsustainable agricultural practices);
- **Physical/ biotic lock-in** (e.g. climate change can significantly affect the rate of adoption of certain agricultural innovations; poor quality of soils).

Nonetheless, it is important to highlight that one of the main limitations of the MLP approach is its inability to highlight more 'local dimensions' such as individual farmer's characteristics, beliefs and histories, which likewise create path dependencies and influence adoption of an innovation. By taking a closer look into these 'local dimensions' it is possible to discern that human behavior can deviate from various policies' intents, which are highly influential in scaling of agricultural innovations (Pintér *et al.* 2000). The interdependencies between human (rule-based) behavior ('regime level') and human values, beliefs and ideas as well as wider environmental (physical) conditions ('landscape level') are visualized in the Figure 3.2 below.

Figure 3.2: Three interacting levels of reality



Source: Pintér *et al.* 2000

Since this thesis analyses various policies by taking into account human visions, opinions and expectations, some of the theories related to the field of psychology (and more specifically decision making), which could shed more light into 'local dimensions', are worth applying in this thesis and for this reason are explored in the following sub-sections.

3.3 ADOPTION DECISION MAKING THEORIES

Skeratt (1994) once stated that '*the focus on the individual (also) implicitly reinforces the view of the farmer as an autonomous, decision-making unit, whereas the reality of the decision-making nexus is far more complex and dynamic*'. Similarly, Prager, K. and Posthumus, H. (2010) argued that the decision making process on whether to adopt certain agricultural agro-environmental schemes is shaped by complex frame conditions (surrounding context) ranging from geographic, climatic, biophysical and agronomic conditions to socio-economic and policy conditions. Nonetheless, Prager, K. and Posthumus (2010) also argued that the decision making process is greatly influenced by the type of innovation and farmers' individual characteristics. Overall, the importance of studying individual farmer attitudes that influence farmers' decision to adopt certain agricultural practices has become ubiquitous in the academic circles and has prompted many scientists to design various theories and concepts, which are specifically targeted at adopters of agricultural innovations – farmers. Many of these adoption decision theories in the field of agriculture were built upon the intersection of behavioral and cognitive theories due to the limited ability of economic models to '*conceptualize the social dimensions of knowledge, information, communication and rationality*' (Leeuwis 1993). Some of these theories include the Theory of Behavior Modification (Albrecht *et al.* 1987), where innovation is in the process of 'emerging/evolving', and which assumes that human behavior is a result of the interplay of 'driving' and 'inhibiting' forces in the psychological field (Ndah *et al.* 2009). Another theory is the Theory of Planned Behavior (Ajzen 1991), which was built upon the Theory of reasoned action, and which assumes that behavior can be not only planned and deliberate, but also driven by behavioral, normative and control beliefs. Other theories, which might be applicable in agricultural studies include Theory of utility according to which all individuals are rational; and Value-belief-norm theory (Stern 2000), which mainly assumes that pro-environmental behavior is driven by personal norms. However, many of these theories can be perceived as highly generalized as they render general assertions about what guides people to formulate opinions and make decisions. Therefore, the following theories explore in more depth theories and concepts which are considered as better suited to complement the generic (encompassing) MLP framework with more local/ individual dimensions in order to better reflect (both directly and indirectly) reasons behind existing opportunities and barriers for up-scaling of 'recycling practices' in the Polish agricultural sector.

3.3.1 Diffusion of Innovation theory: definition and relevance

The Diffusion of Innovation Theory was designed by Rogers (2003) and tested specifically in the field of agriculture. According to Rogers (2003), adoption is '*first or minimal level of behavioral utilization'* and diffusion is '*process by which an innovation is communicated through certain channels over time among the members of a social system'*. Based on these definitions Rogers (2003) distinguished four major phases of diffusion (the innovator as disruptive element, the critical phase, transition to the self-sustaining process, final phase of the wave); four types of adopters (innovators, early adopters, early majority, late majority); and proposed several major 'determinants of adoption' with consecutive variables such as: attributes of innovation (relative advantage, compatibility, complexity, trialability, observability); type of innovation decision (e.g. optional, collective, authority); communication channels (e.g. mass media); social systems (e.g. norms and degree of network connection); extent of change Agent Promotion efforts – all of which influence the rate of adoption of innovation.

3.3.1.1 Relevance

Given that the recycling practices were promoted only in the context of organic farming by the BERAS project and only some of the recycling practices have been recognized as part of the national/

international policies, this study is neither concerned with Roger's (2003) 'four types of adopters', nor evaluation of 'efforts of promotion agent', 'communication channels' and 'type of innovation decision' variables. Moreover, the scope of the paper does not allow to accommodate the wider socio-cultural practices and norms, which could influence adoption process. However, in order to explore the relationship between the type of innovation (recycling practices) and farmers' perceptions on adoption of agricultural innovation, it might be useful to take a closer look at Roger's (2003) **theory of perceived attributes**, which distinguishes several 'variables' attached to an innovation. By referring to '**relative advantage**' variable, it is possible to assess the degree to which 'recycling principles' are perceived as a better idea than the commonly performed practices. Similarly, the concept of '**complexity**' helps to assess the extent to which the adoption of recycling practices is perceived as difficult and requires knowledge. Then, the concept of '**trialability**' can explain the '*degree to which an innovation* [recycling practices] *could be experimented at limited basis*' (Rogers 2003). Lastly, the concept of '**compatibility**' helps to highlight the degree to which recycling practices are considered as '*consistent with the existing values, past experience and needs of potential adopters*' (Rogers 2003). However, one significant limitation of this theory might be the fact that this approach is based on the assumption according to which 'what works in one place should be done more of the same in another place', and thereby it tends to overlook complex, dynamic realities. For this reason, in this study the theory of perceived attributes constitutes part of a bigger framework, which conceptualizes complex multi-level interactions.

3.3.2 Concept of environmental attitudes, participation spectrum and styles of (non)participation: definition and relevance

By further referring to farmer's individual characteristics highlighted by Prager (2002), Wilson (1996) in his study of farmers' environmental attitudes for (non-)participation in the agro-environmental scheme (Cambrian Mountains Environmentally Sensitive Areas Scheme (ESA)), demonstrated that farmers' attitudes and decisions are influenced by their age, educational background, the length of working in the field of agriculture and the 'farming philosophy'. Wilson (1996) elaborated on the Morris and Potter's (1995) conceptual approach and classified farmers, who are situated on the agricultural innovation adoption spectrum, into the following six groups:

- **active adopters** ('*enter schemes mainly for conservation reasons*');
- **passive adopters** ('*attracted by the financial inducements*');
- **conditional non-adopters** ('*persuadable based on changes in scheme factors (e.g. payments, flexibility*');
- **resistant non-adopters** ('*unwilling to participate under any circumstance*');
- **potential adopters** ('*precluded from participation*'),
- **conservation oriented** farmers '*on holdings of marginal eligibility*'.

Fish *et al.* (2003) proposed another typology, which was designed to investigate '*land-manager attitudes towards the conservation of rural landscapes in England*' and explain '*how these relate to differing modes and levels of engagement with Environmentally Sensitive Area (ESA) and Countryside Stewardship (CS) schemes*.' Their typology comprises four main characteristics of adopters and non-adopters of agro-environmental schemes that can be referred to as 'styles of participation'. The Table X in the next page depicts four characteristics relatable to **adopters** and **non-adopters**.

Table 3.2: Four types of adopters and non-adopters, i.e. 'styles of participation' by Fish *et al.* 2003

Adopters		**Non-adopters**	
Opportunist	*land managers undertake calculated way of increasing net income on existing practices whilst expressing an interest in the environmental ideas and goals of the scheme'*	**Abstaining**	'*either such practices would not generate an economic return from a feature that would otherwise yield a return, or income would be significantly diminished from more ``productive'' uses of land*'
Modifying	'*regards scheme rewards as central to the reproduction of conservation practices; this style of participation resulted in the modification of existing practices'*	**Disinterested**	'*either such practices would not generate an economic return from a feature that would otherwise yield a return, or income would be significantly diminished from more ``productive'' uses of land*'
Catalyzing	'*strong interest in the conservation value of the practices employed and features*	**Disempowered**	'*flip side of catalyzing participation; whilst actively expressing an interest*

	concerned, but regards the practices involved as supplementary and desirable, rather than integral and necessary to the reproduction of economic goals'		*in conservation practices, were constrained by concerns over issues of cost incurred'*
Enthusiastic	'*beneficial aspects of the schemes that are not directly connected to the interplay of conservation and economy'* e.g. a sense of pride	**Skeptical**	e.g. *'inability to deal with officialdom'*

3.3.2.1 Relevance

The above approaches help to reveal that the forces that drive farmers' decisions, opinions and attitudes to adopt soil protection measures or recycling principles in general, are not always determined by economic factors associated with the adoption thereof. The decision-making on whether to adopt certain farming practices can in fact be also based on the premise that soils are farmers' most precious assets. By expanding Morris and Potter's (1995) concept of 'participation spectrum', Wilson's (1996) approach also demonstrates that apart from farmers' attitudes, structural factors such as 'eligibility' for adoption of specific agro-environmental scheme (which is being used interchangeably with the concept of agricultural innovation in this paper) are equally, if not more, important (Kizos *et al.* 2010). For instance, some farmers might be located in areas that do not create favorable conditions to adopt crops-livestock farming systems (e.g. the good quality of soils might not always encourage farmers to graze livestock). Apart from the availability of eligible habitats, other structural factors might be related to farm size and potential financial benefits stemming from participation in agro-environmental schemes (Wilson 1996). Similarly, the typology of Fish *et al.* 2003, which distinguishes 'Styles of participation and nonparticipation' with the purpose of applying them in the context of landscape conservation in rural England, seems to be relevant in the context of classifying farmers' attitudes toward (non-)adoption of recycling practices in Poland. However, given that land managers often apply various management approaches to different parts of their farms, depending on the wider agro-environmental context, Fish *et al.* (2003) rightly highlighted that these styles are 'mutually exclusive'. For example, some farmers might be catalyzed to adopt crop rotations and cultivate leguminous plants, yet at the same time they might remain disinterested in raising livestock. In this regard, Fish *et al.*'s (2003) approach seems to be quite correlated to Wilson's (1996) concept of 'eligibility'. Overall, this limitation indicates that it is important to provide a wider, dynamic socio-environmental and political background (MLP approach) when investigating the potential to scale agricultural innovations. Since these approaches do not categorize driving and hindering forces related to decision making (e.g. policies or individual farmer's characteristics such as educational background) into specific categories/themes, which facilitate analysis, the Results and Analysis chapter fills this gap by deriving relevant themes when coding open-ended questionnaire responses.

Both approaches were designed to evaluate farmers' attitudes toward agri-environmental schemes, which were already in place. Even though the recycling principles[20] have not been widely recognized by the Polish authorities 'yet' (they do not constitute part of any agri-environmental scheme); some of Wilson's (1996) and Fish *et al.*'s (2003) typologies are deemed worthy of applying in this thesis as they can provide a common ground for the analysis of collected opinions of Polish farmers (both organic and conventional) on the potential (or lack of potential) to diffuse recycling practices in the (near) future.

[20] Some of the recycling principles such as leguminous crops already constitute part of the agro-environmental schemes. However, the concept of 'recycling principles' in this thesis refers to the entire 'package', i.e. mixed crops-livestock systems, crop diversification combined with ley crops and balanced livestock production to land acreage at farm/territorial level, and such has not been implemented yet.

4 RESEARCH METHODOLOGY

This chapter presents the overall research strategy, employed methods of data collection and challenges encountered while investigating the drivers and barriers to scale recycling practices within ecological and conventional agro-food systems in Poland.

4.1 OVERALL RESEARCH STRATEGY

The research methods are highly qualitative in character as they are mainly based on interviews, group discussions and observations. The nature of research is exploratory, explanatory, and descriptive as it describes and explains relationships between various stakeholders in the field of agriculture. Even though the collected data from the observations and interviews with various stakeholders are not representative for the entire regions (not to mention for the whole country) in which the interviews took place, the analysis of results aims to find out commonalities, which are present in the country. Consequently, while each investigated farm tends to be viewed as a separate entity, thus in the line with the atomistic approach (Darnhofer 2014); the nature of this research is greatly nomothetic as it intends to identify and explain commonly occurring trends across the country. In addition, the interviews and group discussions can be described as participatory given that they intend to democratize research design by examining the agricultural context with the full engagement of those who are directly involved in the agricultural sector - farmers (Breitbart 2010). By examining both internal (i.e. farmers' individual characteristics and local knowledge) and external factors (e.g. wider socio-environmental conditions), the research strategy is designed to understand the underlying factors driving the specific forms of behavior and perceptions on the potential to adopt 'recycling principles'. The research is also predictive in character as it intends to forecast the future of both ecological and conventional farming sector in order to better evaluate the potential for the integration of recycling principles in the face of the current challenges.

4.2 METHODS OF DATA COLLECTION

To maximize the understanding of research questions, the research comprises primary data (derived from semi-structured interviews and group discussion) and secondary data (obtained from scientific publications, agricultural institutions incl. the Ministry of Agriculture, and presentations). The qualitative data in form of semi-structured interviews were carried out among a wide variety of stakeholders ranging from farmers and representatives of NGOs to agricultural experts including scholars and private certification bodies. Consequently, it was possible to analyze research questions from different standpoints.

4.2.1 Semi-structured interviews

One of the primary qualitative research methods were semi-structured interviews with 28 farmers (see Table C3, Appendix C), expert interviews and key informant interviews. The semi-structured questionnaires were built upon carefully selected theories and concepts, which were described in more detail in the previous chapter. All the interviews were also recorded and transcribed. The brief overview of key multi-level questions is presented in the Table C2, Appendix C.

The interviews were conducted in the period between mid-February 2017 and end of April 2017; and usually lasted from 20 minutes to over an hour depending on the respondent's knowledge, commitment, available time and energy to discuss various topics. In order to avoid any misunderstandings and encourage respondents to talk more freely, the interviews were conducted in compliance with CEU Ethical Guidelines; were conversational in tone; and were preceded with the explanation of the rationale for the study (incl. overview of recycling principles) and the information on how the collected data were going to be used. In this way, interviewees could make informed judgement about whether they wished to provide answers and whether they preferred to maintain anonymity and confidentiality. When necessary, open-ended questions were also followed by auxiliary (guiding) sub-questions. The questionnaire questions, which referred to opinions, consisted of open-ended questions, which enabled to collect '*factual, descriptive, thoughtful and emotional information*' (Longhurst 2010). Since the semi-structured interviews were aimed at various stakeholders, it was possible to elicit broad, multi-perspective answers, which helped to validate existing literature. Despite inherent difficulties associated with categorizing answers from complex narratives based on open-ended questions, the results were coded into several themes to organize data and facilitate the subsequent analysis under the carefully designed analytical framework. The selected coding technique involved in-depth, line-by-line scrutiny. The extracted themes were subject to critical judgement in order to evaluate their relevance to the study and were then analyzed and discussed within the selected analytical framework (see Chapter 4 and 5).

4.2.1.1 *Farmers*

A total of 28 interviews were carried out among farmers including 14 farmers specialized in organic production and 14 in conventional production. The farmers were found and selected via Agricultural Extension Services operating in each voivodship (which even helped to pre-arrange initial telephonic conversation with farmers prior to calling and prior to visiting); Dr Jerzy Kopiński from the National Institute of Soil Science and Plant Cultivation (IUNG) in Puławy, Poland who arranged phone appointments and provided contact details to 4 conventional farmers in Lublin Voivodship; bio-markets selling organic food produce in Lublin and Warsaw city (see images in Appendix F4); organic farmers' meeting in EKOLAND (farmer's union and a private certification body), Lublin, Poland (see images in Appendix F5); and via a business catalogue containing contact details to various farms and agricultural entrepreneurships across the country (panoramafirm.pl).

In order to improve the responsiveness and create a relaxed, conversational environment, the initial questions were concerned with professional and educational background of farmers as well as historical background of the farm, including performed agricultural activities. The interviews were also devoid of sensitive questions such as incomes from each source some of the farmers declared. Overall, the interviews with farmers enabled to gather information related to farming profiles such as age group, type of occupations, size of the farms, type of cultivated plants and/or animals bred, number of people working on the farm and types of specific management practices in place (crop rotations, presence of leguminous crops, concentration of animals, integration of both crops and animals, methods of manure storage and crop fertilization). Since these characteristics of agricultural land holdings were also investigated from the historical perspective, it was possible to see how they have been changing over the course of time and what type of political changes contributed to the transformations of respective components of farming profiles. Consequently, it was possible to examine farmers' attitudinal motivations behind their (potential) (non-)adoption of 'recycling practices' in relation to farmers' characteristics and agricultural practices already in place. Given that recycling practices are especially beneficial for the soil nutrient balance in case of organic farming (Granstedt 2012), conventional farmers (especially the ones who have mixed crop-livestock production), were also directly asked whether they have ever considered converting their farms into organic entrepreneurships. On a reverse, those who have already immersed themselves in organic food production were asked whether they have ever thought about starting conventional production.

Rationale for selected farm types and regions

Considering the fact that the adoption of recycling practices is context specific, specific regions in Poland were selected for the study in order to highlight regional differentiation of factors influencing and inhibiting scaling of recycling practices in both organic and conventional farming systems in

Poland. The table 4.1 below presents the selected voivodships[21] and provides a brief rationale for conducting interviews in these regions. In addition, the Figure (Map) 4.1 below illustrates the selected voivodships in terms of geographical location.

Table 4.1: Rationale of selected voivodships in Poland to conduct interviews

Voivodship	Rationale			
	Average farm size	Livestock density/ha	Dominant type of production	Extra information
Lublin (LUB)	7.58ha	0.30 LU/ha	crops (wheat)	-
Greater Poland (GP)	13.43ha	**0.75 LU/ha**	pigs	plain terrain
West Pomerania (WP)	**30ha**	0.16 LU/ha	crops	foreign investments/land ownership; hosted many large state-owned agricultural farms during the communist period
Lubuskie (LU)	20.94ha	0.17 LU/ha	mixed	foreign investments/land ownership
Podlaskie (POD)	12.13ha	**0.79 LU/ha**	crops	-
Sub-Carpathian (SC)	**4.71ha**	0.19 LU/ha	mixed	mountainous terrain

Data source: GUS 2016

Figure 4.1: Map of selected voivodships where interviews were conducted[22]

Image source: Odder 2016; Made in: Adobe Photoshop

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[21] Poland is divided into 16 Voivodships (provinces; in Polish: 'województwo'), which are the highest-level administrative division of Poland, and are further split into counties (in Polish: 'powiats') and communes or municipalities (in Polish: 'gminas').

[22] The voivodship highlighted in yellow color is where the **group discussion with organic farmers** took place (see sub-section 3.2.2 below)

The brief summary of the conducted interviews with farmers in relation to: location of the farm (voivodship), farm size, dominant economic enterprise (e.g. cropping or livestock raising or mixed), types of produce, type of interview (either telephonically or face-to-face) is available in the Table C3, Appendix C. Overall, while it is difficult to accurately measure the optimal farm size for the introduction of recycling principles as it depends on various factors such as the availability of workforce to manage the workload, it is widely argued that the recycling practices are best fitted for small and medium-size land holdings with the size ranging from 10-200ha (Interview with Grandstedt, March 2017). Therefore, even though large land owners might be perceived as theoretically ineligible for the adoption of recycling principles, the interviews with them helped to investigate the factors behind enlargement of agricultural land, which might affect many smaller farmers in the (near) future. In the same way, the smallest farmers, including those who have only 2ha of agricultural land, were not excluded from interviewing and subsequent analysis as they helped to shed more light into the current trends in the Polish agricultural sector. In addition, the interviews included not only ecological and conventional farmers, which already have a mixed crop-livestock farming system and often include some of the specified recycling principles, but also those who are specialized in either crops or livestock production in order to investigate specialized farmers' perceptions on changing their production to adopt an integrated crops-livestock system. Therefore, the interviews with various types of farmers also helped to highlight that farms in Poland bear various characteristics, be it geographical, economic, political or historical, yet all of them are greatly interlinked.

Limitations

It can be argued that some of the answers provided by the farmers were presented in the bright light and did not reveal the real nature of farming practices (especially when the interviews were not combined with empirical observations, which helped to, at least partially and in some cases, reveal the unsustainable side of farming). For example, the owner of a very intensive pig production facility was not willing to talk about the challenges he faces. The answers to retrospective questions might be also shaped by personal experiences associated with the outcomes of decisions made in the past, rather than by the perceptions and visions farmers they had prior to decision making. In addition, in some cases only some of the questions were asked due to farmers' busy schedules; unwillingness to provide more information (especially on phone) due to privacy issues and fear that the researcher was calling from the competing company (such situation mainly took place during phone calls to pig farming industries in Greater Poland); or even fear that the researcher was calling from the big farm enterprise that was mistaken as interested in purchasing land, the latter case resulted even in the inability to fully introduce the reason of calling, not to mention making an arrangement to visit the farm (such situation took place in case of medium-size enterprises in West Pomerania voivodship, which is characterized by high foreign influence and hosts a many foreign companies).

4.2.1.2 *Expert and key informant interviews*

Expert interviews and key informant interviews were conducted with 6 scholars from the National Institute of Soil Science and Plant Cultivation (IUNG), Puławy; Institute of Agricultural and Food Economics - National Research Institute (IAFE-NRI), Warsaw; Environmental University in Lublin; National Institute of rural and agricultural development (IRWiR PAN); as well as representative of Poland at Copa-Cogeca (European Farmers and European agri-cooperatives); representative of Bioekspert Sp. z o.o and a member of EKOLAND in West Pomerania (private certification companies and organic farmers' unions); and representative and co-founder of the museum of State Agricultural Farm in Bolegorzyn, Poland (West Pomerania voivodship). Both expert interviews and key informant interviews enriched the research discussion with external opinions related to policies (incl. CAP and EU Nitrates Directive), historical trends in the agriculture as well as drivers and barriers to scale recycling practices. Interestingly, some of the workers in the Ministry of Agriculture (MINROL) provided responses to several questions in a written form, yet these answers were objective and largely derived from reports already issued by the institution. Similarly, a Country Co-ordinator for Poland from the European Commission provided several answers to questions, likewise, in a very objective way and by making references to various reports due to the lack of permission to provide subjective opinions.

Limitations

Due to high mobility of interviewees and high dispersion of selected farmers across the country, it was impossible to conduct all the interviews face-to-face, which were carried out only with 2 scholars from IUNG and Environmental University in Lublin; and representative of Poland at Copa-Cogeca (Committee of Professional Agricultural Organisations & General Committee for Agricultural Cooperation in the European Union). Moreover, some of the respondents preferred to provide answers via telephone or email due to their busy schedules. Some of the conducted interviews were also highly informal and in some cases only several questions were asked due to aforementioned busy schedules. Given the interdisciplinary character of the questions, some of the respondents were also not willing to provide answers to all of the questions due to alleged lack of sufficient knowledge in respective fields.

4.2.2 Group discussions

Apart from interviews targeted at one individual, a researcher participated in a group discussion, which was conducted during the meeting of organic farmers in Pokrzydowo in Kuyavian-Pomeranian voivodship that is known for high share of organic production in the country (together with Lublin voivodship) (see images in Appendix F9). The meeting took place on the 29th of March 2017. The farmers who gathered for the meeting came from the Kuyavian-Pomeranian voivodship[23] and

[23] The voivodship is highlighted in the yellow color in the Figure 4.1 (p. 54)

neighboring voivodships, namely Greater Poland, Masovia, Warmian-Masurian. Around 40 farmers participated in discussion on the potential to introduce recycling priniples, and which was preceded by the presentation on Ecological Recycling Agriculture (ERA) by Dr Granstedt and Ms Johansson. Many farmers eagerly raised hands to provide answers. The main rationale for the location of the meeting in Pokrzydowo village in Kuyavian-Pomeranian voivodship was the fact that the BERAS project has strong links with one of the pioneers of organic farming in Poland (Mr Mieczysław Babalski) who is residing in Pokrzydowo village and who invited the BERAS team members for the farmers' meeting. Interestingly, Kuyavian-Pomeranian voivodship is characterized by the highest number of organic farms in the region and has relatively high livestock density when compared to other voivodships (0.59LU/ha) (GUS 2016).

Another group discussion took place in the National Institute of Soil Science and Plant Cultivation (IUNG), Puławy on the 19th of April 2017 (see image in Appendix F10). The meeting was, likewise, proceeded with a presentation by Dr. Arthur Granstedt during which he presented his newest calculations related to nitrogen surplus in Poland. Moreover, the findings from the interviews, which were conducted by the BERAS project members (Dr Granstedt and Ms Johansson) with the help of Dr Stalenga and Dr Kopinski from IUNG, as well as by the researcher of this thesis, were presented by the researcher of this thesis on behalf of Ms Johansson who couldn't join the meeting. 5 of the participants during this meeting were workers in the institute where the meeting took place and 2 other participants were representing The Polish Ecological Club (Ms Staniszewska and Ms Jozewicz). The final part of the meeting was a group discussion led by the researcher of this thesis and was based around key open-ended questions created by Ms Johansson. During the discussion all the participants explored possible recommendations for policy-makers, researchers and civil society as a whole on how to facilitate a transition toward more sustainable agriculture (and society), which would be built upon recycling principles.

4.2.3 Empirical observations

The majority of the face-to-face interviews with farmers (x16) were also complemented with empirical observations of agricultural land holdings (x10), which provided a better insight into the conditions under which agricultural activities are being performed and helped to validate information obtained from the interviews. Farm visits helped to observe geographical conditions such as topography of the area (lowlands/highlands), volume of imported supplements in relation to land size (e.g. fodder, seeds, animal concentrates, and/or chemical fertilizers), presence of manure storage pad, as well as types of cultivated crops and livestock bred; all of which have implications for the (non-)adoption of recycling practices under study. The observations were accompanied by field notes and several photographs were taken to document observed activities in the visited sites. The farms, which were subject to observations, are highlighted with ‘‘ symbol in the Table C3, Appendix C.

Limitations

It is important to highlight that field visits took place only during early spring so that it was impossible to observe farming conditions during other seasons. Moreover, empirical observations took place only in 10 farms due to time and logistical constraints – distances between farms, not to mention regions in such a relatively big country like Poland, were hard to overcome due to the fact that the researcher lacks driving license.

4.2.4 Documentary analysis

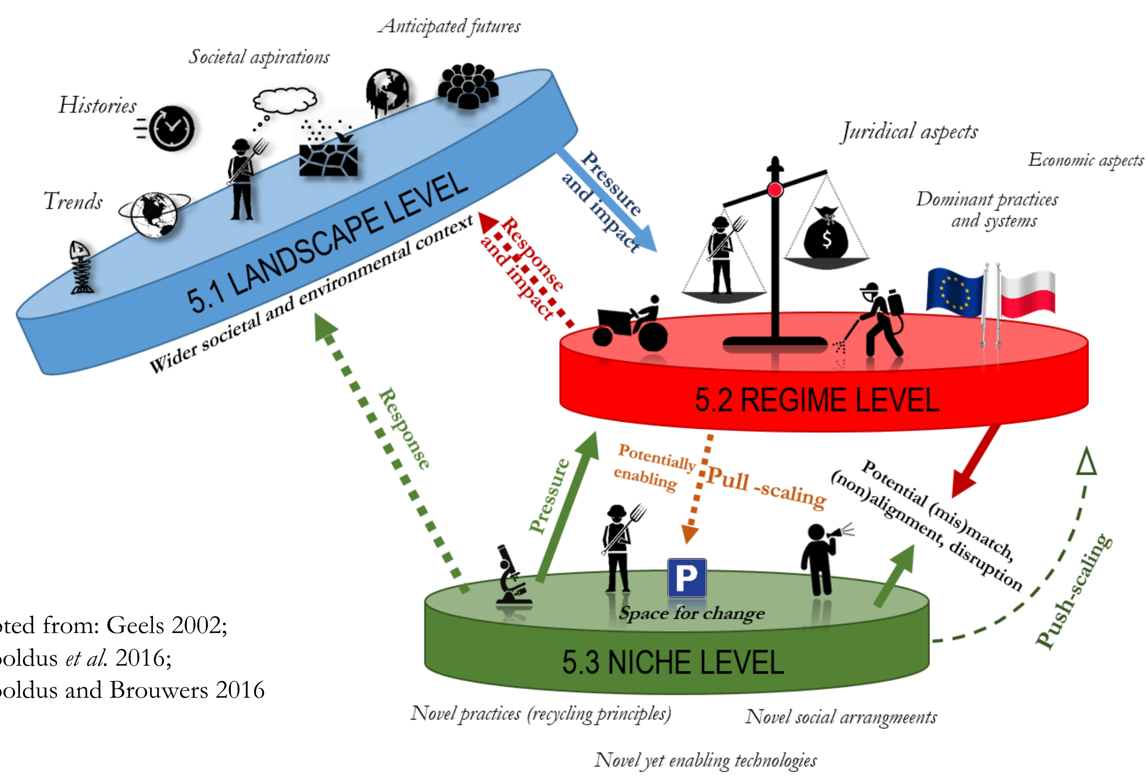
A comprehensive literature review was conducted and was based on various published peer-reviewed articles and reports (incl. official reports issued by governmental institutions such as rural development plans), scientific journals, books and gray literature (reports that lack peer reviews and were published by governments and organizations). The validity and reliability of studied documents and collected data was evaluated based on the reputation of the publishing institution as well as both educational and professional background of authors. The majority of the sources were easily accessible via Internet. The statistical data obtained from national statistics from the Ministry of Agriculture and Agricultural and Food Quality Inspectorate were also converted into graphs when deemed necessary. Besides, Dr Granstedt from the BERAS project shared his calculations on manure nitrogen and surplus nitrogen per each voivodship in Poland in 2014 (incl. correlation between both variables) as well as estimated values of nitrogen, phosphorus and potassium inputs and losses in the agricultural ecosystem in Poland on farms containing 0.6 animal unit/ha between 2008 and 2015 (the calculations were based on statistical data from Eurostat and IUNG). Since the BERAS project members (Dr Granstedt and Ms Johansson) conducted interviews with 7 organic farmers, representatives of two NGOs (Polish Ecological Club and WWF Poland), Agricultural Advisory Services in Gdansk, as well as Jerzy Chroscikowski from the Senate of the Republic of Poland and Michal Rzytki from the Ministry of Agriculture[24], all of whose the author of this thesis did not manage to interview, yet received the permission from the BERAS project to use their interview transcripts, this research paper also integrates qualitative data collected by Dr Granstedt and Ms Johansson during their visits in Poland.

[24] The interviews were conducted in the period between June-August 2016 during BERAS project's visit to Poland

5 RESULTS AND ANALYSIS

This chapter presents descriptive, in-depth analysis of results obtained from interviews, group discussions, empirical observations as well as review of literature through the lens of the multi-level perspective theory and key themes derived from coding of open-ended questionnaires. In order to provide a broader understanding of the underlying causes behind the challenged and limitations for up-scaling of recycling principles; and create a sense of discourse, this chapter is complemented with various extended quotes from open-ended interviewing and connects people's stories to wider historical, institutional (policy) and socio-environmental contexts. More importantly, while the findings are based on several regions, this chapter analyses them in the context of the entire country, unless stated otherwise. In oder to better illustrate the content of this chapter, the Figure 5.1 below and Table 5.1 (next page) present a simplified multi-level perspective framework adopted in this study, which is built upon the key research findings (thematic codes). In addition, the Figure 5.2 and Table 5.2 in the end of the chapter provide a brief overview of key research findings.

Figure 5.1: Multi-level perspective framework for up-scaling of recycling principles within the agricultural farming sector in Poland



Adapted from: Geels 2002;
Wigboldus *et al.* 2016;
Wigboldus and Brouwers 2016

Table 5.1: Outline of the Results and Analysis chapter's content

Scale/ Level	Defintion	Focus area
5.1 Landscape	intangible exogenous environmental (physical), economic, socio-technical and political conditions , trends and societal values that evolve over a long period of time and cannot be easily changed by the regime and niche level; broader historical context	❖ **Terrain, soils and climate (change)** (5.1.1) ❖ **Globalization** (5.1.2) ❖ **Trends toward specialization** (5.1.3) ❖ **Trends toward increasing farm size** (5.1.4) ❖ **Demographic trends** (5.1.5) ❖ **Societal and personal values** (5.1.6) ❖ **Negative environmental externalities** (5.1.7)
5.2 Regime	intangible institutional and mental structures, which shape the socio-environmental, economic and political conditions at the landscape level and propel action at niche level; tangible (material) dominant infrastructure and technology; consumer consumption patterns	❖ **Agricultural policy regime** (5.2.1) ▪ *Common Agricultural Policy (CAP)* (5.2.1.1) ▪ *EU Fertilizers Directive* (5.2.1.2) ▪ *New national law on direct sales vs. processing infrastructure & consumer consumption patterns* (5.2.1.3) ▪ *New law on acquisition of agricultural land* (5.2.1.4) ▪ *Legislative framework on organic farming sector* (5.2.1.5) ❖ **Environmental protection policy regime** (5.2.2) ▪ *EU Water Framework Directive (WFD) & EU Nitrates Directive* (5.3.2.1) ▪ *HELCOM Baltic Sea Action Plan (BSAP)* (5.3.2.2) ▪ *Directive on industrial emissions* (5.3.2.3) ❖ **Dominant technology and practices** (5.2.3) ▪ *Fossil fuel dependent fertilizers* (5.2.3.1) ▪ *Fossil fuel dependent feed concetrates* (5.2.3.2) ▪ *Plant protection products* (5.2.3.3) ▪ *Fossil fuel dependent machinery* (5.2.3.4) ▪ *Biogas industry* (5.2.3.5)
5.3 Niche	protected spaces, which have the potential to influence the dominant regime and respond to some of the key issues within the landscape level by promoting innovations	❖ **Research and Development (R&D)** (5.3.1) ❖ **Civil society (NGOs)** (5.3.2) ❖ **Farm advisory services** (5.3.3) ❖ **Small local markets** (5.3.4)

5.1 Landscape level

The landscape level is concerned with the wider socio-environmental conditions and trends as well as geopolitical arrangements and dynamics, which are greatly shaped by historical trajectories, and can both directly and indirectly influence up-scaling of recycling principles. While the unfavorable topographic and soil conditions are likely to add extra organizational arrangements in order to create a ground for the wider adoption of recycling principles, the rural-urban exodus decreases the availability of workforce necessary therefor. Likewise, the globalization-induced specialization and farm enlargement are depicted as key challenges for up-scaling of recycling principles. This is because the extent to which they have already dominated the agricultural landscape is large and does not seem to decrease in the near future. Moreover, the predominant societal and personal values, are greatly illustrated as impeding factors for the wider adoption of recycling principles. However, this section also argues that the current negative environmental externalities, which are attributable to the current trends within the agricultural sector in Poland, might open a window of opportunity for up-scaling of alternative production methods that have the potential to mitigate negative trends.

5.1.1 Environmental and physical conditions

Terrain vs. land fragmentation

The interviews revealed that the small size of farms can facilitate the wider adoption of recycling principles. For example, a farmer from the Lublin voivodship, which is characterized by the heavy land fragmentation, mentioned: '*When farms are fragmented and small it is easier to manage them as plants are better taken care of and, contrary to big farms which have thousands of hectares, it is possible to abide common rules on timing of agricultural activities such as when to apply fertilizers and pesticides so that you don't apply too much of them*' (LUB_C5). However, it is important to highlight that the farmer from the mountainous Sub-Carpathian voivodship, which is characterized by the heavy land fragmentation, mentioned that the cross-farm cooperation in a hilly environment can be greatly impeded due to the necessity to apply complex and costly farm management practices: '*If I was about to cooperate with another farmer to transport him my manure across hill he would have to pay for the oil*' (SC_O15). Therefore, the land fragmentation could potentially facilitate management of cross-farm cooperation in favor of recycling principles, yet it is likely to be much more challenging in case farms are located in the mountainous terrain. It can be also argued that animal exchanges between mountainous and lowland areas, which could increase outputs per acreage without generating nitrogen surplus, might be challenging due to complex managerial tasks in such a hilly terrain.

Soils

The predominant types of soils are light soils of podsolic origin. The simplified Map B3, Appendix B shows the geographical distribution of key soil types in Poland and across voivodships. In addition, the Figure D7, Appendix D further illustrates that the soil landscape is dominated by the IV soil class (comprising podzolic soils occupying 43.7% of the entire agricultural land) and V soil class (occupying 25.9% of the entire agricultural land), which indicate moderate and poor soils, respectively. Moreover, not only more than 60% of soils are light sandy soils, but also approximately 80% of the soils are acidic and only 20% are characterized by neutral or alkaline pH (Staniszewska and Stalenga 2013; Igras *et al.* 2014; Interview with Dr Stalenga from IUNG, March 2017). Such highly acidic nature of soils was frequently mentioned by interviewed scholars and Dr Wieliczko from IAFE-NRI stated: '*Soil acidification is one of the key environmental problems as it has serious implications for the size of crops; yet there is little action from the local and national governments; no one is highlighting this serious problem*' (Interview, April 2017). Therefore, given that crops usually require mildly acidic to neutral soils for growth, it is advisable to conduct liming. However, the statistical data reveals that the current use of lime fertilizers is not sufficient to balance soil pH (GUS 2016). Overall, even though the nutrient reserves generated by nitrogen fixation via leguminous crops can greatly improve soil conditions to support crops with deep root systems, and thereby maximize benefits stemming from diversification of crops (Granstedt 2012), the shallow character of soils in some of the Polish regions can impede the growth of deep root systems unless a considerable amount of humus in the topsoil in built up – and such process takes several years or decades. Under such circumstances, recoupling of crops and animals is likely to make farmers more self-sufficient but at the cost of converting inputs into outputs to a much lesser extent (Watson *et al.* 2015). It could be argued that by introducing animal production on poor soils (by creating pasture/grazing land and use stable manure on the soils), such process of humus build-up could be accelerated (Interview by BERAS with Dr Tyburski, August 2017). Nonetheless, a farmer from the Sub-Carpathian voivodship who had cattle production only confirmed he does not grow crops as he struggles with shallow soils and he would have to increase livestock concentrations or import fertilizers in order to replenish soil nutrients necessary for crops (SC_O15). Therefore, the key problem here is the uneven spatial distribution of soil types, which vary in terms of fertility and (in)directly contribute to specialization in either livestock or crops and/or heavy reliance on synthetic fertilizers. For example, one crop-specialist farmer from the Greater Poland voivodship, which is characterized by shallow soils stated: '*the soils are here so shallow and root crops require a lot of nutrients so that I need to apply fertilizers. Manure is a precious resource and farmers don't want to sell it as they keep it for themselves*' (GP_C9).

In the light of the above arguments it can be stated that the moderate quality of soils and uneven spatial distribution of soil types can greatly impede the inter-farm cooperation in terms of procurement of relevant farm inputs such as manure or even straw can be greatly impeded (especially given that some farms, which are more specialized in crops rather than animals, are often concentrated in specific regions).

Climate

Poland is located in the North Temperate Zone and its climate is greatly shaped by the dry continental air, which brings cold temperatures; and wet oceanic air, which brings warm weather. Varying weather patterns and daylight hours throughout year are sub-divided into four seasons. Overall, the climate in Poland is currently characterized by increased variability and unpredictability, which has implications for the economic performance of the agricultural sector and can influence adoption of recycling principles. For example, while the winter periods are becoming prolonged and relatively warm, the summer periods, i.e. the growing season, are becoming not only longer but also hotter and drier. Such altered climatic conditions have implications for the vegetation period and are reflected in increased variability of wheat, rye, barely and potato yields (Bochenek *et al.* 2015). Therefore, the increasingly shorter vegetation seasons limit crop diversification and make it much more difficult to cultivate intercrops. Since livestock relies on cereal-based feed, the animal sector is also affected by the climate change due to limited availability of good quality fodder (Nierobca *et al.* 2013; Kozyra 2012). Therefore, the agricultural productivity is greatly challenged by the climate change, which was a frequently mentioned threat during the interviews as it requires adaptation of relevant measures that could provide farmers with economic security. Following this reasoning, it could seem that climate change could encourage farmers to consider the integration of recycling principles, which can help to increase resilience to climatic fluctuations. For example, by integrating crops and animals it is possible to secure income from livestock (e.g. eggs) during challenging periods marked by abiotic stressors such as droughts; and one conventional farmer specialized in milk production in a relatively closed-loop cycle mentioned: '*If only I could sell my cattle at a good price, then I could terminate my animal production and focus only on crops, but there is still a risk I couldn't survive with crops only*' (LUB_C6). Such statement clearly illustrates that mixed crops-livestock production provides medium-size farmers with extra financial security, which might be additionally threatened by the occurrence of extreme weather events. Moreover, by growing leguminous crops it is possible to improve soil structure, which can in turn help farmers to adapt to prolonged periods of droughts during summer; eliminate farmers' fear of losing contracts with recipients of products; and reduce the necessity to pay for insurances, which were reported to be very expensive (GP_O11; Interview with Dr Palas from Lublin University, March 2017). However, it has to be highlighted that the cultivation of leguminous crops (especially perennial legumes), which can also serve as a feed to sustain livestock, requires considerable amounts of water: '*lupine alone requires approx. 60* l^2 *of water per* $1m^2$ *and if it does not receive enough water we don't have crops next year*' (LUB_C2). Therefore, the recycling principle related to the cultivation of leguminous crops should be assisted by other climate-smart farming techniques such as e.g. mulching. Moreover, the interviews also revealed that some of the livestock keepers aim to rely solely on animals of Polish landrance, which can better match local conditions and become more resilient to various diseases. For example, a pig farmer declared to be currently trying to phase out pigs of Dutch landrance in favor of the Polish landrance (GP_C10). When it comes to cattle, many farmers still keep resistant and long-lived races (Holstein-Frisian and Brown-Swiss), which can help to better adapt to climate change and strenghten synergies between various components at farm level (thus helping to maximize benefits of recycling principles, especially in terms of improved feed concentrate autonomy) as they mach local natural conditions (POD_O8; Watson *et al.* 2015).

Overall, it can be argued that farming practices based on recycling principles are likely to be re-considered more frequently as they help to increase farmers' resilience to climatic shocks. Nonetheless, the heavy reliance on fertilizers as well as pesticides combined with increasing land size (5.1.3 and 5.2.3) indicate that many farmers do not apply any adaptation measures to climate change. This implies that the local and national governments do not promote any adaptation measures that could be based on recycling principles (more follows in 5.2.1).

5.1.2 Globalization

Following the country's accession to the European Union, the current trends in the Polish agricultural sector are attributable to the complex, dynamic system of global networks, which shape the political cultures, and provide frame conditions for agricultural innovations such as recycling principles. The interconnectedness of global markets in Poland is reflected in bilateral trade agreements, which stimulate a competition with various trading partners in order to enliven national economies, often at the expense of weakening local economies that fall a victim to the so-called international dumping practices when the prices of exported products are being sold at lower price than the products produced in the country of destination – Poland. While only one farmer mentioned that he feels threatened by the Comprehensive Economic and Trade Agreement with Canada (**CETA**), which carries removal of trade restrictions with Canada and has been ratified on the 15^{th} of February 2017 (Linder 2017); the Deep and Comprehensive Free Trade Area (**DCFTA**), a temporary free trade agreement, which has been established between the EU and Ukraine and enforced on the 1^{st} of January 2016 (MR 2016), was frequently mentioned as a 'threat' to the agricultural sector in Poland and for scaling of recycling principles. For example, one of the farmers from Lublin voivodship (bordering Ukraine) stated: '*If the export of wheat from Ukraine continues, I am not sure if we will have the market for our products. All the eastern mills or facilities manufacturing fodder purchase cerales at lower price, and now possibly lower quality, and they distribute it to various entities across the country*' (LUB_C2). However, as far as the quality of imported products is concerned another farmer mentioned that he feels especially threatened by trade links with Ukraine given that they '*have very fertile chernozem soils, which can feed the world*' (LUB_C1). In addition, another farmer from Greater Poland voivodship, which is located in the West of Poland, added: '*EU allowed duty-free (quota-free) imports of cereals from Ukraine and many more commodities entered the market than expected. In result, the prices of wheat fell dramatically. Nowadays, Poland has such a good road network that it is really easy to deliver goods to various parts of the country*' (GP_C9). Even though none of the farmers mentioned the risks associated with the potential implementation of the Transatlantic Trade and Investment Partnership with the US (TTIP), which is currently being negotiated, it cannot be denied that such agreement could only further intensify farmers' struggles to become more competitive on the global market, thus promoting economies of scale and threatening the existence of local markets (economies of scope) and subsequently economic security of farmers (Thomsen 2016; MINROL 2016). Moreover, farmers' attempts to increase competitiveness propel them to rely on off-farm inputs such as fertilizers or modern machinery; specialize and enlarge farms is order to 'artificially' reduce production costs (e.g. machinery was reported to be expensive) and produce large volumes of outputs. The dynamics of global networks are also reflected in the dependency of agri-food chain on fossil fuels (e.g. oil), which has impact on the prices of agricultural inputs such as fertilizers and subsequently products, and carries high environmental costs (Darnhofer 2014). In order to further highlight farmers' lack of perceived influence on the prices they receive for their products in such a highly globalized economy, it might be useful to quote a farmer who said: '*Apart from sugar mills, there is no contracts for wheat. I don't know if I earn or loose*' (LUB_C2). However, as the sub-section related to subsidies will reveal (4.2.1.1), even the availability of contracts for certain types of crops does not necessarily improve farmers' economic situation.

Either way, by referring to **contracts**, which are supposed to help farmers remain on the market, a big conventional pig farmer from Greater Poland voivodship (producing nearly 15 000 pigs/year) mentioned that he has a contract with a private company, which takes his pigs for raising within their farm facilities and then sends them for export in exchange for fodder. In result, he and many other farmers can be independent from market fluctuations and do not have to worry about global pig prices (GP_C10). Interestingly, the research on the company later revealed, that it had foreign capital. Either way, such contracts seem to work only in case of big animal industries, which are oriented at 'meat quantity' rather than quality, thus contradicting recycling principles favoring economies of scope. For example, another farmer from Greater Poland voivodship owing 20ha farm mentioned: '*Such a small farm like ours does not have any chances to prosper. We even built a modern pig house with air-conditioning and central heating but it's empty. We are unable to compete with all those big industrial animal farms. Mainly bigger landholders remained as they have those contracts with butcheries that buy everything at wholesale prices. They have thousands of pigs*' (GP_C7). In addition, a small organic farmer from the same voivodship (Greater Poland) who was owing 50ha, yet kept only 2 cows and 2 calves (incl. cereals and leguminous crops as well as some vegetables for self-consumption) mentioned that: '*There used to be here a butchery but it has been recently overtaken by a German company to which I delivered all cattle I had, around 20 units. And after I sold them a doctor visited me and told me that this company does not pay. But it was too late. Yet, the same company was calling me and asking if I still have any cattle left so I asked them how they dare to keep calling me if they don't pay. I had manure storage pad, everything. But it's hard to sell at a good price. If I hadn't kept my little animals to raise them on my own, I would have received much less. My friend who is a conventional farmer had thousands of animals and says he received nothing. So how do you see it? Would you keep a bull for 2 years and receive nothing in return? A hospitality-club emerged owing to our money, everything modernized, yet a German company has overtaken it all. Both companies didn't pay*' (GP_O11). Even though the latter case concerns cattle, not pigs, it cannot be denied that such contracts create unfavorable conditions for small and medium scale farmers, who are, unsurprisingly, increasingly becoming specialized in crops, thus are unlikely to adopt recycling principles related to mixed crops-livestock systems unless they are being paid accordingly to their efforts put into work. The situation seems to be even more challenging in case of **organic farmers**, as the same farmer continued: '*I imported expensive organic fodder from Germany and I probably received even less money for one bull than a conventional farmer does as this animal was not very fleshy. But they don't care if it's organic or not as they are not interested in several units'* (GP_O11). Therefore, the smaller farmers feel greatly disempowered as they can easily lose control over their produce in case it consists of export-oriented cash crops and/or animals, even if they are 'secured' by contracts. Interestingly, another organic farmer also mentioned that: '*I used to receive emails that it is possible to lease land in Ukraine for organic production. And while a traditional farmer won't be able to afford it, there will be another 'ecologist' (who might even already has vast tracts of pseudo-organic land) and will lease even more land in Ukraine as there won't be any possibility to control it. So this produce will be certified as 'organic' but in reality you won't even know what is coming to us. And the market will be flooded*' (LUB_O2). The latter statement only further demonstrates the dangers associated with global trade links, which can have enormous consequences not only for the future of the conventional farming sector but also organic food market, whereby the latter might raise more issues of distrust in products labeled as 'organic' among the consumers, and thereby possibly negatively affecting demand for organic food products in case such problems become a reality and are brought into public light.

In the light of the global trade agreements (incl. contracts that have links to global markets) it is also worth discerning the already reappearing issue of **farm ownership** by **foreign investors**, which, apart from lowering the prices of purchased products from farmers, often pursue unsustainable farming practices. Even though Dr Gradziuk from IRWiR PAN mentioned that there are not many farms that are 'overtaken by foreigners' (i.e. that are under foreign ownership) as '*they might constitute around 3% in the entire country*', once the multiple negative socio-environmental externalities originating within such farms such as water pollution among others are taken into account (5.1.7), the overall costs must be immense. However, any cost-benefit analysis that could help to approximate costs does not seem to have been conducted yet. In order to further support such reasoning, a member of EKOLAND in Western Pomerania emphasized that: '*Here we have EU type of land management. There used to be here large state-owned farms, which were subject to privatization and now we have the biggest foreign influence in the entire country. We even don't know who they are. If you earn 0.5eurocent per pig it's already a success*'. Such statement not only validates the previous farmers' stories who decided to abandon pig industry, but can be also explained through the lens of the historical past when the biggest concentration of large state-owned farms during communism period took place in the north of Poland, and which were overtaken by the private land owners (often with links to foreign investors) after the fall of communism. Similarly, an interview, which was published online as part of the article to Pomeranian Newspaper, and conducted with the former farmer and director of the state-owned farm with the total land surface of 5.000ha in West Pomerania voivodship, revealed that following the collapse of the communism, the land was overtaken by an individual from Warsaw, who recently leased the great part of his land to the Scottish company: '*The Scottish company introduced modern machines, but it relies on non-inventory production, which is based on fertilizers, yet excludes manure. Unfortunately, this changes the soil structure*' (Strecter in: Gazeta Pomorska 2011).

Interestingly, one farmer also added: '*Germans and Dutch*[25] *people bought 'our' meat plants so that they could sell their commodities here. In this way meat is being transferred from the West to the East - to Poland, and from the East to the West. However, with all those investments our meat industry is also developing rapidly and the bigger animal industry is, the worse quality of meat it offers, just like in the West*' (GP_C9).

Overall, the repercussions associated with **free market economy** and links to **global markets** generated through the wider global agreements and locally arranged contracts, as well as the issue of farm ownership by foreign investors, are immense and can have great consequences for local economies (and subsequently rural welfare). For example, they can result in decreased prices of imported agricultural outputs that are 'flooding local markets' as well as lowered prices of produced agriultural outputs such as meat. In result, farmers are often propelled to pursue economies of scale and abandon small-scale animal production in order to stay competetive on the 'common market', rather than pursuing economies of scope, which better correspond to recycling principles. The sub-section related to the dominant technology and practices (5.2.3) additionally shows how these aspects are also influenced by the global network dynamics.

[25] Danish companies alone already own 9 big farming facilities in Poland (Wramner *et al*. 2013).

5.1.3 Trends toward specialization

The interviews clearly confirmed that the Polish agricultural landscape is also greatly marked by the trends toward specialization in either crop or animal production (Figure 2, Appendix 4). When asked about the farm's history, the majority of the farmers confirmed to have much more diversified food production in the past, especially in terms of livestock (which provided them with on-farm produced fertilizer - manure), than now. As one farmer from Lublin voivodship dominated by crop production stated: '*It was a zoo. There used to be cows, ducks, etc. and everyone had to have them all and now you have more crops than animals. Now you have more crops'* (LUB_C5). Such trends toward specialization are becoming more notable as farmers are being forced to focus on one work unit in order to adapt to the global dynamics by satisfying global, rather than local, demand. Since cash crops such as cereals are highly desired by emerging economies to serve as fodder for livestock (among other purposes), they remain the most commonly cultivated commodity in Poland (MINROL 2016). Overall, the crop-specialist farms are currently the dominant type of the production and are usually present on large farms, which have at least 100ha (Igras *et al.* 2014). As far as livestock-specialist farms are concerned, they were observed to have increasingly higher concentrations of livestock on small land acreage.

The trend toward specialization is also notable in the **organic farming** (see Table C1, Appendix C). As Dr Stalenga from IUNG during the group discussion with organic farmers in Pokrzydowo rightly concluded: '*80% of ecological farmers in Poland are stockless and among the remaining 20% of farmers who have animals only 10% have ecological animals – the remaining 10% of animals in the organic farming sector are conventionally grown as they have less requirements in relation to their management; e.g. conventional animals don't need to be kept in chains. The situation is getting worse and worse each year.*' The juridical lock-ins associated with such structural changes in the production are explored in the context of agricultural policies (5.2.1).

While specialization does not necessarily impede the scaling of recycling principles in case two farms with different type of production (e.g. one farm specialized in crops and another farms specialized in livestock) are located in close proximity so that a potential cooperation between them could be established, the problem arises when farms in close proximity or within the district are oriented only at one type of production. Given that specific regions in Poland and more oriented at crop production and other more at livestock production, there is a big challenge ahead of local and regional policy makers in terms of balancing production by ensuring that crops and animals are integrated. In order to highlight regional differentiation of Polish farms, which are either mixed or specialized in crops or livestock, it might be useful to juxtapose the total sown area with livestock per 100ha by voivodships[26] According to the the Figure D7 (Appendix D), the voivodships with the highest amounts of livestock such as Podlaskie and Silesian have also relatively low sown area in thousands of hectares. In contrast, several voivodships such as Lublin, Lower Silesian and West Pomerania are the regions with the largest sown area and relatively low numbers of livestock. Therefore, the above mentioned voivodships can be deemed more specialized in either crops or livestock than others.

By referring to the nitrogen from manure, which can help to reflect animal density, and nitrogen surplus, the calculations conducted by Granstedt (Personal correspondence, March 2017) reveal that there is a relatively high correlation between manure nitrogen (animal density) and nitrogen surplus. The nitrogen surplus from manure was the highest in Greater Poland (76.4 kg/ha), Kuyavian-Pomeranian (71 kg/ha) and Łódź (61.7 kg/ha), and the lowest in Sub-Carpahtian voivodship (12.6 kg/ha). However, the livestock density per voivodships is the highest in Podlaskie first (0.79 LU/ha) and then in Greater Poland (0.76 LU/ha), Kuyavian-Pomeranian (0.59 LU/ha) and Lodzkie voivodship (0.57ha) (GUS 2016). The relatively low level of nitrogen surplus in comparison with

[26] There is lack of specific data on type of farming in relation to voivodships

manure inputs in Podlaskie voivodship (42.4 kg/ha vs. 57kg/ha), which has the highest livestock density/ number of livestock heads in the entire country stems from the fact that in Podlaskie voivodship the dominant type of livestock is beef and milk cattle, which is usually grazed on grasslands, thus being 'naturally' more sustainable. In contrast, the dominant type of livestock production in Greater Poland voivodship are pigs, which are raised in high concentrations in confined feeding facilities unless they are raised according to organic standards (the latter one constituting only a fraction of the total pork production in the country as there were only 62 organic pig farms in 2010) (IJHARS 2016). Overall, even though Granstedt's (2017) calculations were concerned with average values for each voivodship, and thereby are highly generalized (they don't show where the key point sources of pollution are), they help to approximate the scale of the problem related to manure surplus. Since these calculations do not inform about the spatial distribution of farms within any given region, yet the Figure D7 (Appendix D) showed that Greater Poland, Kuyavian-Pomeranian and Łodz voivodships have also a great amount of crop production, it could be argued that there is a potential to establish a cooperation between those intensive, livestock-oriented production farms with crop-specialist farms in these regions. However, as the case of pigs shows, this type of livestock is usually raised in confined feeding facilities so that any cooperation between farms at the regional (voivodship) level can be greatly impeded as big animal farm enterprises are likely to be unevenly scattered across the regions and within the country (see Map B4, Appendix B). Poultry industries, on the other hand, are closer to each other than the industrial swine farms (see Map B5, Appendix B), thus possibly easing cooperation with crop-specialist farms.

While the specialized, conventional crop-specialist farmers are 'predisposed' to apply higher volumes of fertilizers; unless they are located in proximity to large specialized in conventional animal farms from where they could potentially procure manure, the **livestock-specialist** farms, which occur on farms with areas of more than 50ha, also tend to be highly unsustainable as manure surplus, if inappropriately handled, can lead to soil erosion and water pollution (Igras *et al.* 2014). Moreover, a farmer who is also a vet confirmed that such big animal industries (often called 'HELCOM hot spots') usually apply high volumes of antibiotics[27] so that manure is very 'unhealthy' for soil and crops. In addition, large volumes of fossil-fuel dependent (GM) feed concentrates are being imported (5.2.3.2). What is worse, the interviews revealed that the owners of these farm enterprises in such a globalized economy are unlikely to decrease animal density in order to match it to land ratio, thus only further exemplifying how such specialized farm enterprises with large livestock concentrations pose challenges for up-scaling of recycling principles, which aim to increase self-sufficiency on farm level.

More importantly, given that the recycling principles could be potentially integrated between specialized farms so that a crop-specialist farm could **cooperate** with a livestock-specialist farm, the farmers were asked whether they would be willing to cooperate with each other. While it could seem that such cooperation is unlikely to happen on a large scale in such a globalized world where the economies of scale are greatly favored, an organic farmer from Greater Poland voivodship interestingly pointed out that such cooperation can happen once farmers enter into a mutual contract as typical for big farm enterprises, often with foreign capital (i.e. an **official partnership**) (GP_O11). Even though such extra contracts are likely to further foster the mechanization and modernization, and add an extra bureaucratic layer, it could be argued that they might be worth testing, especially among the larger farms that prefer to maintain commercial production for exports.

Overall, despite the trends toward farm specialization and high livestock concentration, it is also important to mention that there are still extensive farms, which maintain inter-farm cooperation; have no more than 10ha; and/or **maintain mixed production** (such farms are mainly located in Lublin or

[27] '*They even add antibiotics to stimulate animals' growth*' (GP_C9)

Sub-Carpathian voivodships) (Prus 2012; Igras *et al*. 2014). For this reason, the average livestock density in the entire country amounted to 0,45 LU/ha in 2011, thus being below the recommended level by BERAS (0.5-1.0) (GUS 2012). However, Staniszewska and Stalenga (2013), mentioned that despite the fact that these extensive farms have low anima l density, they have also simplified crop rotations and apply artificial fertilizers (especially in case they are located on poor soils).

5.1.4 Trends toward increasing farm size

Following the literature review, another trend, which is currently highly notable in the Polish agricultural landscape and usually follows farm specialization, is increasing farm size, a phenomenon that goes hand in hand with reaping the benefits from economies of scale. As one farmer who used to have a mixed crop-livestock production, yet currently focuses on pig production (incl. on-farm fodder production) mentioned: '*Nowadays you need to focus on a specific harvest, maybe two, and if you take care of it I think all can go well. In the past less farmers had less hectares and they could benefit less. Today you need to have more to benefit. If you have a small farm you are obviously not able to punch one's way out of a paper bag. I am in favor of* ***enlarging*** *and closed loop farming*' (LU_C14). However, the latter part of the same farmer's statement concerning '*I am in favor of enlarging and closed loop farming*' (LU_C14) might be considered as slightly contradictory given that a farming system cannot be effectively 'closed', and thereby function efficiently, once there are large distances within or between farms (in case cooperation between two specialist farms was made viable) as such could only add extra (and possibly infeasible) logistics as well as transportation costs and heavier reliance on fossil-fuel dependent machinery (5.2.3). The bigger farms are getting, the further needs for highly skilled stuff also grow[28]. Additionally, the large farm size

[28] There is a big biodynamic farm ('Juchowo') in West Pomerania voivodship, which occupies 1900ha and was established on infrastructural remnants of large state-owned farm from the communist era. The farm emerged with the help of foreign investors, thus further reflecting how regions with post-communist farms are subject to foreign capital. The farm currently hosts around 370 units of milk cattle and runs three different crop rotations, which include leguminous crops. The land is used as follows: '18% constitutes permanent grassland, 74% arable land (mainly fodder crops), 0.1 % vegetables and 7.9% non-agricultural area' (Watson *et al* 2015). However, the same farm is currently undergoing problems associated with land management due to issues arising from the change of stuff, which needs to be properly trained (Interview with Dr Stalenga from IUNG, May 2017). Moreover, Dr Granstedt interestingly pointed out that in order to make such farm more suitable

was also reported as a factor impeding conversion to **organic farming**, not to mention 'organic applying recycling principles'.

However, it is important to mention that the agricultural land in Poland remains greatly fragmented and over 1 million of farms had size between 1-10ha accounting to approx. 28% of total agricultural land in 2015 (GUS 2016). This is mainly due to geographic conditions (2.4) as well as political decision to parcel out large farms after the fall of communist regime. However, Dr Gradziuk from IRWiR PAN and Dr Wrzaszcz from IAFE-NRI also mentioned that the smallest farms are the ones, which are greatly characterized by unsustainable agricultural practices as they tend to apply large volumes of fertilizers in order to maximize their profits on a small piece of land in the wake of falling commodity prices (Interview, March/April 2017). Such statement was confirmed during interviews by smaller farmers who admitted to apply a lot of fertilizers (LUB_C3; LUB_C4). Moreover, when asked about the future, the majority of respondents mentioned that the trend toward increasing farm size is likely to continue to exist: '*while small farms will keep disappearing, big farms will keep emerging*' (Interview with a certification body from Bioekspert, March 2017).

5.1.5 Demographic trends

The socio-economic composition of rural populations is another aspect, which is likely to have implications for scaling of recycling practices in Poland. Approximately 12.6% of the total population was employed in agricultural sector in 2013, thus being greatly higher than the EU-28 average that was 5.2% in 2013 (Eurostat and Rural Development Report 2013 in: EC 2014). Moreover, 14.7% of farmers were under 35 years old and 8.4% were older than 64 in 2013; thus being far away from the

for recycling principles, it would be better if it was split into at least 5 different farms, thus only further increasing the need for technical management skills and skilled stuff.

average age of farmers in the EU-28 where farmers below the age of 35 make up to 7.5%; and farmers older than 64 constitute 30% of the total number of farmers (Eurostat and Rural Development Report 2013 in: European Commission 2014). Nonetheless, the interviews revealed that rural Poland is experiencing trends toward depopulation and population ageing, which are likely to further decrease availability of workforce to ensure survival of mixed crops-livestock systems and wider application of recycling principles, which are labor and knowledge-intensive. For example, one of the frequently raised issues during the interviewes concerns land inheritance by kids who do not seem to be incentivized by extra payments for young farmers under the CAP and are unwilling to work in the agricultural sector. For example, while two sons of the conventional pig farmer (GP_C10) migrated to seek work opportunities outside the agricultural sector; another farmer mentioned that '*Villages are ageing and there are only 2 young farmers per 60 farms. They don't see opportunities; staying here is not very profitable*' (LUB_C6). By making a reference to **organic farming** sector specifically, an organic farmer who was already complying with all the proposed in this paper recycling principles, stated that: '*It is hard to reach young people and encourage them to work on such farm as they see it's a hard work*' (LUB_O4). The interviewed farmers also commonly mentioned that they are not going to encourage their kids to enter the agricultural sector as they know how challenging and troublesome it can be: *'For sure I won't beg my son to take it – if he wants to sell it let it be'* (WP_O13). However, it is highly likely that these farmlands might be sold to big landowners or even corporations that would convert extensive, often mixed crop-livestock farms, into specialized, big farm enterprises ('business as usual') as it has been already happening since Poland entered EU, especially in West Pomerania voivodship. It is also worth mentioning that the phenomenon of land ownership, which is greatly induced by the lack of successor, removes the burden of expensive workforce as (foreign) companies often hire seasonal workers, and thereby contribute to the intensification of structural unemployment in various parts of the country (Slazak 2013). In order to further highlight the scale of the problem, it can be added that during one phone call one farmer said that if I am not planning to work in the agricultural sector physically, he won't respond to my questions. Likewise, during the focus group discussion during the meeting in Pokrzydowo the concept of 'generational gap' emerged in order to further illustrate unwillingness of young people to stay in the agricultural sector, or at least raise animals, as livestock production requires extra work inputs.

Overall, the highest negative internal migrations in rural areas were in Warmian-Masurian and Lublin voivodships, thus in regions were the collapse of the State Agricultural Farms deprived people of jobs and impoverished the rural areas (especially in the former voivodship) (Banski 2009; GUS 2016). Such trends have been also largely exacerbated by the introduction of pension insurance schemes; increasing education; CAP subsidies, which support modernization and specialization of the agricultural sector (4.2.1.1), thus decreasing the need for workforce; and globalization, which facilitated the flow of people across the borders (Chaplin *et al.* 2007). Moreover, the empirical observations only further revealed that some of the rural areas seem to be characterized by the hidden unemployment and low living standards, especially those, which were affected by the collapse of state-owned farms after the communist period. In addition, the old age of farmers was another reported factor preventing farmers from converting into more sustainable agricultural practices. For example, one dairy farmer mentioned: '*I was considering becoming an organic farmer but I need to earn more as I am not retired yet. Anyways I will quit with the milking cows after I retire with my wife*' (LUB_C6). While recycling principles can be also introduced on conventionally managed farms, yet with lesser success in terms of environmental benefits, the fact that that this farmer is very willing to specialize in crops further indicates that older people are likely to opt for less demanding tasks.

To conclude, it can be argued in the line with Bowen and De Master (2011), that farming in Poland is generally not '*recognized as a lucrative, prestigious and socially recognized occupation*'; and the decreasing workforce is likely to greatly impede conciliation of both (cash) crops and animals, both on the farm level and between farms. The organizational (logistical) issues, which are likely to include extra adjustments in working schedules, collective storing of crops and manure as well as transport of on-farm produced inputs and outputs such as straw or manure between farms (in case the distances between farms require do to so; or even within one farm) might be very difficult to overcome in case such trends continue.

5.1.6 Societal and personal values

The societal and personal values, which can have an impact on the decision of an individual on whether to adopt recycling principles, can be deeply rooted in the traditional values, which are shaped over the course of history. For example, given that the mixed crops-livestock farming systems were largely practiced in the past in Poland until the 1960s, the interviews revealed that there are still family farms, which managed to preserve the traditional farming model as they value autonomy and renewable resources in the landscape. However, as this thesis shows, these mixed farms are becoming greatly marginalized. Moreover, following Hervieu-Leger who investigated perceptions of people on pursuance of farming practices that are based on local, traditional knowledge (permaculture) in post-socialist European countries, such farming practices often serve as '*a constant reminder of the unfulfilled promises of modernity*' (2000 in Brown 2015), rather than '*backwards modernization*' (Gilarek *et al.* 2013 in: in: Bowen and De Master 2011). Similarly, Pine (2007) interestingly pointed out that the socialism promoted the image of a science-oriented, rational and profit-driven farmer, as it was typical in Russia where the farms were massive and clearly oriented at pursuing economies of scale. Small-scale rural family-run farms, on the other hand, were undervalued and sometimes even perceived as committed to pursuing 'illegal' practices within 'the black market' rather than working for the 'welfare of the country'. The core of the prevailing ideology was to match modernity with social equality. And suddenly, one political decision to make a transition toward market economy led to the collapse of large state-owned farms and 'everything' fell apart. For example, one organic farmer observed that: *'there is still this* ***communist spirit****; when it was widely regarded that a tractor is something beautiful and horses are obsolete; that ecology is backwardness, but it's opposite'* (LUB_O1). Therefore, it leaves no doubt that many farmers at present tend to value heavy modern machinery by viewing it as 'progress' as typical of Western countries in such a globalized world, not to mention the fact that reliance on heavy machinery does not require as much knowledge and workforce as agroecological farming methods. Either way, the key aspect here is also the monetary value as according to the economic studies at the farm level, the production costs can be higher in case of adopting recycling principles, which internalize socio-environmental costs. For example, a widely recognized assumption among conventional farmers from increasingly bigger animal industries is that '*if a pig does not grow up to 100-120kg within 3 months, it's deemed no longer cost-effective*' (LUB_C4).

Another societal value, which was quite clearly distinguished during the interviews and seems to contradict recycling principles relates to 'leisure and free time', especially among elderly people, and increasingly among young farmers. For example, one farmer mentioned that: *'We are so tied up at our farm and we can never travel or go on a vacation. We would not, however, recommend our child to work with animals. Even though I like the animals because they keep a nice landscape, I think it would be better for my kids to specialize in crops. But this is my perspective*' (LUB_C6). Similarly, a farmer who was specialized in animal production mentioned: '*I am stuck like my cow, I work 14-16h per day not to mention bureaucratic tasks*' (GP_C8). Moreover, family values, which are based on kinship and support, and were once deeply rooted in the traditional farming systems, especially during the post-war period, seem to be presently undergoing erosion. For example, one young organic farmer mentioned: '*During the communist period life was better, I guess. People were talking to each other, working, there were no machines. I remember there was no TV at my grandma's place and people spent more time outside. Now you do what your neighbour does, you don't behave as if you were part of* *an extinct tribe*' (LUB_O3). Interestingly, the same farmer was interested in recycing principles and said that '*I guess people will start to take care and re-connect only once we are hit by a cataclysm'*. The above statements allow to argue that currently there is **no spirit of cooperation** between people, which is very important as far as scaling of recycling principles, which require complex organisational and negotitation-based arrangements, is concerned. To further support this, one farmer clearly stated that: '*There is no cooperation as everything revolves around money*' (GP_C9). It can be also argued that animal exchanges in between mountainous and lowland areas, which could increase outputs per acreage without generating nitrogen surplus, might be challenging Contrary to societal values, which can be described as inconsistent and malleable by the mainstream media, personal values can be observed to be less easily affected by external influences. One of such personal values, which can be considered as such, might refer to religiosity. For example, one organic farming who created an impression of being highly passionate about his 'organic endeavors', made a **religious connotation** resonating with his values: '*If one day I stand in front of God, what will I tell Him? That I was poisoning people?*' (LUB_O1). In addition, the same farmer used to be a conventional farmer in the past, yet it didn't take him much time to realize that being an organic farming corresponds with his system of beliefs that likewise require a lot of time and efforts to nourish them. Moreover, two organic farmers (who complied with recycling principles) stressed the healing properties of their 'goodies': '*my products are a medicine*' (LUB_O2); '*my consumers treat themselves with my products*' (LUB_O4). Overall, the above examples show that there will be always some people who, in good conscience, will care about the natural environment and soil health based on the premise that 'soil health equals human health'. Therefore, it can be argued that there is a window for scaling of recycling principles as long as those individuals are given an opportunity to share their beliefs and knowledge on what truly sustainable agriculture is.

5.1.7 Environmental externalities

In response to the key and greatly interconnected trends toward farm specialization, modernization (i.e. use of fertilizers etc.) and increasing farm size, two main environmental impacts are worth distinguishing in order to reflect the systemic flaws of the globalized food production system, namely eutrophication of the Baltic Sea and soil depletion, both of which are interlinked. Both phenomena are also exacerbated by physical conditions such as soil type and terrain.

5.1.7.1 *Eutrophication*

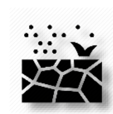
The ongoing eutrophication of the Baltic Sea, which causes toxic algal blooms and according to WWF Poland (2017c), 10% of the Baltic Sea surface constitute the so-called 'dead zones', which are devoid of life. The eutrophication of the Baltic Sea[29] is greatly intensified by the climate change (e.g. algal blooms usually happen in high temperatures in summer) and physical characteristics of the Baltic Sea, which has limited exchange with oxygenated waters from the North Sea. However, HELCOM (2011) estimated that 45 % of total nitrogen and 45 % of total phosphorus inputs are discharged to the Baltic Sea from the agricultural sector. Consequently, the issue of eutrophication is one of many reasons why the recycling principles are re-gaining attention among various research circles. For example, Granstedt *et al.* (2008), calculated that the conversion to organic, recycling- based farm systems that rely on local renewable resources and are free from chemical pesticides, would enable to significantly reduce nitrogen load to the Baltic Sea (even by up to 70%). Moreover, Poland is often considered as one of the major contributors to the eutrophication of the Baltic Sea (see Figure D8 by HELCOM,

[29] The image F1 (Appendix F), which was taken by the Envisat satellite via the European Space Agency on the 11th of July 2010, shows the vast algal bloom spreading across the Baltic Sea (covering 377,000 sq km), which is visible due to presence of chlorophyll that tints the sea waters (and is used by phytoplankton for photosynthesis); and clearly illustrates that the eutrophication is a real thing.

Appendix B). Such heavy loadings are the outcome of the interplay of various factors (see Table C4, Appendix C). Moreover, many lakes and several rivers in Poland are likewise subject to toxic algal blooms and disappearance thereof (Siuda *et al.* 2014). Therefore, it could be argued that there is a window of opportunity to better promote recycling principles in the face of such environmental externalities. For example, the new policies emerging at EU level that are related to nutrient management at the farm level and correspond with recycling principles, are likely to keep pressing the Polish state to implement relevant actions (more in: 5.2.2).

However, as far as non-point source pollution such as eutrophication is concerned (yet in relation to Roger's (2003) attribute of 'observability'), it can be argued that farmers are unlikely to change their farming practices given that eutrophication is not a very 'visible' issue, especially when farmers are located at the distance from affected water reservoirs, and in case they do not perceive/achieve an economic advantage by adopting recycling practices, the latter issue being frequently mentioned during interviews. None of the interviewed farmers reported eutrophication as a negative externality associated with their farming practices.

5.1.7.2 *Soil contamination and depletion*



The historical land use can greatly determine the presence of soil nutrients, which constitute a pre-condition for soil fertility. Given the extensive character of many Polish farms at present, it could be argued that the soils in Poland are rather of a good quality, especially the ones, which were not subject to heavy fertilization during the socialist period. However, considering the heavy use of fertilizers, pesticides and antibiotics (whereby the hindmost takes place in case of animal industries) (4.2.3; 4.2.1.1), it leaves no doubt that the Polish soils are becoming increasingly contaminated by **cadmium**[30]

[30] The country imports high volumes of phosphorus containing toxic high content of cadmium from Sub-Saharan Africa (ranging from 60mg to 90mg/kg) (Paravicini 2016; ICIS 2014)

and **residues of pesticides**, **antibiotics** and pathogens from slurry generated within swine industries (Skorupski 2012). Such situation is only exacerbated by the fact that the vast majority of the Polish land is covered by rather shallow and acid soils (4.1.1.2). Overall, such soil contamination has a negative impact on the lives of soil microbes, which are used to feast on organic matter of low in nitrogen soils. Since the lack of nutrient balance in soils can also inhibit the growth of plants, which constitute source of food for various animal species, the existence of these animals is also exposed to danger. Many plants and animal species also likely to suffer from intoxication by pesticides (Kotschi 2013). Apart from soil contamination, another serious environmental problem, which is pending for immediate action from the regime and niche level is **soil depletion**, which was reported by all of the interviewed conventional farmers as well as crop-specialist organic farmers. For example, one conventional farmer with mixed crops-livestock production (yet oriented at pigs) stated that '*30 years ago when there were many animals and especially cows there was a lot of manure and soil nutrients remained in the soil. The first soil checks were carried out 30 years ago and there was 3.5% of humus layer but now it dropped until 1.4-1.5%. Soil is poor despite the fact that you leave straw on the top*' (LUB_C5). More importantly, this farmer claimed to be self-sufficient from off-farm inputs in 90% and denied using high volumes of fertilizers, which can dramatically change the structure of the soil, due to their high prices. Interestingly, one conventional farmer who is crop-specialist admitted to be currently considering cultivation of leguminous crops as catch crops in order to improve the condition of his soils given that '*farm profits are becoming lower and lower; my soils are depleted*' (LUB_C2). Consequently, it can be argued that farmers are being increasingly pressurized to search alternative ways of soil management, which are likely to be based on recycling principles (at least partially). The same farmer also added: '*maybe there is no humus depletion because I leave straw on the field for the past 25 years and you can see the effect after 7-10 years*' (LUB_C2). However, this statement additionally implies that this farmer does not check his soil, thus indicating an issue which was emphasized by Dr Wrzaszcz from IAFE-NRI, and which can indirectly affect effectiveness of recycling principles once such are in place (Interview, March 2017).

Interestingly, an organic farmer who has been 'organic' for the past 11 years and has already integrated all the proposed in this study recycling principles mentioned: '*After 11 years we see that after difficult winter period when water was retained on the field due to big volumes of rain and snow, we could relatively easily manage it in spring as our soil structure greatly differs from the conventional soil structure. The conventional one has green color and is shining, ours is still evolving and is characterized by high porosity and permeability that ease water infiltration*' (LUB_O4). The above example reveals that the use of synthetic fertilizers can lead to the loss of 'aerial' properties by the soil and thereby the soils' ability to retain humidity, which is very important by the virtue of increasingly prolonged, yet frequently reported, periods of drought. Therefore, once again, it can be argued that there is a window of opportunity for rethinking the integration of recycling principles, which can help to improve soil conditions. Interestingly, according to Dr Gradziuk: '*when it comes to large farms, farmers are becoming more aware of organic fertilizers not in terms of manure but also catch crops and straw'* (Interview, April 2017). Morevoer, one farmer mentioned that nowadays more farmers tend to rely on 'no-tillage' cultivation methods, which can improve the soil structure and enhance efficiency of recycling principles (LUB_C4). Nonetheless, even though farmers are aware of the soil depletion, the interviews clearly showed that many of them still opt for the easiest path to replenish nutrients in the soils by applying synthetic fertilizers, thus only further perpetuating the vicious cycle of soil destruction (more follows in 5.2.3.1).

4.2 Regime level

The agricultural sector, once appropriately managed, can provide a wide array of ecosystem services, whose benefits extend beyond the purely commercial ones (e.g. protection of biodiversity). Such multi-functional character of agriculture is usually the outcome of various policies at local, national or international level. Therefore, in this section recycling principles (being an agro-ecological innovation) are presented as nodal points where various policies and programs within environmental protection regime and agricultural regime intersect. These nodes constitute both barriers and opportunities for up-scaling of recycling principles across the country. Since dominant infrastructure and technologies, which determine agricultural practices, constitute a vital part of the regime level (Geels 2002), they are also analyzed in this section.

5.2.1 Agricultural policy regime

This subsection provides a brief analysis of key policies[31], which are deemed influential as far as scaling of recycling practices in Poland is concerned. The analysis is enriched with opinions of interviewed stakeholders in the field as well as review of literature.

5.2.1.1 *Common Agricultural Policy (CAP)*[5]

National flexibility - a 'misused' opportunity?

Following the Literature Review, the national flexibility of the state to decide on how to spend subsidies coupled with the state's ties to the global markets, have led to the situation whereby the state opts for measures that favor structural rationalization of the agricultural sector in such a globalized world. Even though one of the objectives relates to '*the sustainable management of natural resources and climate action'*, which includes programs aimed at reduction of nitrogen and pesticide inputs and manure leaching (among others), the interviews with farmers and the analysis of environmental protection regime (see 5.2.2) revealed that fulfilling goals under this objective is a very challenging task. For example, despite the fact that some of these programs provide subsidies for leguminous crops, which

[31] Given the limited scope of this thesis, a more detailed analysis of respective policies is available in the Appendix E (E2).

help farmers to become more self-sufficient from fodder inputs produced beyond their farm level, the interviews showed that many conventional farmers keep purchasing imported modified soybeans due to their relatively low costs (see more in 5.2.3.2). More importantly, there are not any promotional/policy efforts aimed at maximization of benefits stemming from integrating crops with livestock. While it could be argued that the national flexibility to select key priorities in the next CAP constitutes a window of opportunity to prioritize other objectives, which could better address recycling principles; the content of the 'Strategy for Sustainable Development until 2020 (with a perspective toward 2030' issued by the Official journal of the Republic of Poland - Monitor Polski clearly indicates that the current structural changes in the agricultural sector such as increasing land size and specialization are highly desirable as they help to increase farmers' competitiveness on the global market, thus implying that the funds for more environmentally oriented, agroecological practices are likely to remain low unless stricter rules are imposed at EU level[32]

How green is 'Green box'[33]?

It could be argued that all of the greening measures outlined in the Literature Review provide a good starting point to scale-up recycling principles. However, by taking a closer look at respective components, dominant practices in the agricultural sector, and stakeholders' opinions; it can be argued that the greening payments under CAP seems to have generated a false image of a conventional farmer who is recognized as 'green', yet 'green' only by definition (Stolze *et al.* 2016). The interviews with farmers and scholars (e.g. Dr Wrzaszcz from IAFE-NRI and Dr Stalenga from IUNG) only further revealed that the current options grant too many exemptions and the crop rotations are becoming less

[32] '*Regional politics is going to keep strengthening potentials toward development and* ***specialization*** *to activate markets and pursue development of local labor markets'* (Dz.U. 2017 poz. 260); note: this strategy was approved by the Polish Council of Ministers.

[33] More detailed analysis in the context of recycling principles is available under Appendix E (E2)

advanced due to the ongoing process of specialization in cash crops[34]; and **crop diversification** rules are greatly simplified (see Appendix E2). It is also worth adding that Dr Gradziuk from IRWiR PAN argued that the greening measures have social character: *'In case a farmer receives 1000zl/ha he won't take care of the land'*. In order to further explain the rationale behind such statement, it is worth mentioning that 'greening payments' are **not** based on the **grazed permanent grassland** (which could then incentivize the sustainable production of cattle) as they were introduced under the premise that permanent grasslands could create net carbon sink. In this way, it can be argued that the produced straw is subject to decomposition, unless it is used for livestock. The fact that some of the permanent grasslands remain ungrazed might be explained through historical lens as many local dairy plants were liquidated after the collapse of communism (Slazak 2013). Farmers, discouraged by the past experiences and living in derelict rural areas without many perspectives on the future might just want to sustain themselves with subsidies. Moreover, upon the removal of milk quotas in 2015[35], the current system of subsidies seems to favor high animal concentrations, which usually occur in confined facilities (MINROL 2016). For example, farmers (incl. those who participate in agro-climate-environmental scheme falling under Pillar 2 and wish to preserve animal genetic diversity) are eligible for extra subsidies for several grazing ruminants, which by grazing on pasture lands, can benefit natural environment e.g. by facilitating carbon recycling. However, an organic farmer from West Pomerania voivodship who has approx. 100 units of cattle (altogether with crop production) valuably pointed out that '*Subsidies do not compensate production costs. Last year I got subsidies for 30 units of cattle and this year you can get subsidies for 20 units so already received less. Before the subsidies for cattle there were subsidies mainly for fodder,*

[34] Organic farmers during the group discussion meeting in Pokrzydowo mentioned that the subsidies for cereals are nearly twice higher than the subsidies for animals. The reason behind such increased subsidies for cereals, which are endowed with relatively high prices, is the rising global demand therefor.

[35] The milk quotas were indicating how much milk each EU member state should produce in order to remain on the common market (thus artificially increasing prices of milk)

and for me it was more profitable as I have many animals to feed and closed loop. Now, people who have only cattle and ***not pasture land*** *benefit more. It's sick, even in the West of Europe the situation is opposite*' (WP_O13). The same farmer, by mentioning that he is currently cultivating approximately 10%[36] of leguminous crops (especially Lucerne) as he is '*not planning to increase the size of his pastureland*', only further implied that he is concerned with sustainable production rather than unsustainable cattle production in confined feeding facilities that are characterized by high shares of genetically modified soybeans (more follows in 4.2.3). Similarly, a conventional dairy farmer owning 20ha highlighted that: '*Subsidies are lower during the past 2 years because* ***complementary payments to pasture lands were taken away****. Even if I had wheat or slaughter animals I would receive the same amount of payment. Instead of developing more when compared to the rest of Europe, we lost*' (LUB_C6). Overall, following the removal of milk quotas, the government seems to have had 'simply' attempted to offset the potential decrease in milk production by providing subsidies for animals, which are likely to be spent on imported GM soybeans and other additives to stimulate milk production and possibly increase animal concentrations (see 5.2.3).

Moreover, given that the subsidies are for acreage and people tend to keep the land for the sake of receiving subsidies, many farmers are unable to buy more land and thereby become eligible for subsidies for certain types of crops and/or animals, which could help to put recycling principles that require integration of crops and animals, into practice. For instance, one organic farmer with mixed crops-livestock production mentioned: '*I don't receive subsidies for my two cows as you need to have at least three of them, yet I cannot buy land here anymore as everyone wants to keep it*' (GP_O11). In the light of such economic and political circumstances, it can be argued that dairy farmers have had to choose between producing milk in large concentrations in enclosed facilities (thus in a conventional way), or sustainably on pastureland, yet with economic difficulties. The latter case usually happened among farmers who were

[36] This number is an estimation made by the farmer and thereby can be perceived as subjective

already endowed with big assets (WP_O13); facing economic problems before becoming retired due to low concentrations of dairy cattle (LUB_C6); and considering whether to quit the dairy sector and pursue crop production (LUB_C6 and GP_O11).

As far as **EFA**s' component, which grants subsidies for leguminous crops that can serve as fodder for animals (among others) (as part of the greening measures) as well as external support for leguminous crops (as part of the agri-environment-climate scheme within CAP 2007-2013) are concerned, it could be argued that dairy farmers receive subsidies for fodder production. However, as the above examples revealed, these subsidies do not provide them with sufficient financial support in such a globalized economy (whereby production costs are high and can only further increase in the face of unpredictable climate conditions), especially upon the removal of 'complementary payments' to pasturelands. While it cannot be denied that the production of leguminous crops has greatly increased during the past few years (see Table 5.2.1, Appendix 5), it is also important to mention that leguminous (nitrogen-fixing) crops can increase the risk of leaching in case they are not integrated with animals grazing on such 'leguminous grasslands', and such finding should be taken into account when designing new policy instruments (FAO 2011).

Moreover, since the certified **organic farms** (Council Regulation (EC) No 834/2007) are automatically eligible for the 'greening payment' (EC 2013a), such concept of equivalence seems to have only impelled national policy-makers to decrease support for the organic farming sector under the Pillar 2. For example, one organic farmer mentioned: '*There is no point of searching financial support from promotional funds or political support from local governments; many educative and promotional projects related to organic farming have not been completed*' (LUB_O6). In addition, organic farmers and those who pursue agri-environmental programs (Pillar 2) can receive financial support from EU '*only to the first 30ha'* (ARC 2020 2014). In result, not only the medium size (40-50ha) and larger farmers (>100ha) remain greatly under-supported, but also smaller farmers (<30ha) (which constitute a majority and the interviews revealed that the small organic farms are the ones) that were observed to employ recycling principles. To sum up, such regulations, which imply insufficient support for organic farmers, can be deemed causal for the stagnation of this sector, which was mentioned in the Literature Review. Interestingly, one organic farmer during the focus group discussion in Pokrzydowo mentioned that there used to be extra subsidies for organic farmers who had mixed crops-livestock production. The further research enabled to find out that such additional financial support amounted up to 20% of bonus for organic farmers who had both animal density between 0.6 LU/ha and 2 LU/ha of the total agricultural land on farm, and only in the period between 2004 and 2006 (Golinowska and Pytlarz-Kozicka 2008). Given that such support never re-appeared since 2006, it can be argued that a step backwards was made as far as sustainable organic production based on recycling principles is concerned.

Overall, while subsidies under CAP were supposed to help farmers counterbalance falling commodity prices (*'Now as a member of EU we have a free movement of goods, yet if we left and this free movement of goods remained, we would go bankrupt as commodities flooding our markets would remain subsidizied by EU. So we need to receive them to balance the prices just like they are in the West'* (GP_C9)), the majority of the interviewed farmers were discontent thereof. For example, one small-scale farmer (owing 20ha) having a relatively closed-loop farm system by raising 15 cows and producing on-farm fodder, and being greatly self-sufficient, mentioned: '*Before EU I had more money than now because now the prices are different. EU support does not compensate prices. All our outputs became cheaper nearly 4 times. Even if someone buys machines it is still very expensive. I would rather go back to times prior to EU accession, but I want my commodity prices back'* (LUB_C6). Such statement indicates that the current system of subsidies does not necessarily compensate decreased prices and increasing production costs in a satisfactory way, and deprives farmers of autonomy. The most content farmers were the ones who were the owners of big farms specialized in either crops or pigs (e.g. an owner of large pig farm enterprise producing approx. 15 000 pigs per year

– GP_C10) due to the fact that the current system of subsidies is for land acreage and the 'greening measures', as stated above, are relatively easy to comply with. While one could even argue that subsidies are allocated to satisfy farmers' ever-increasing desire to buy or lease more land (and afford more technological inputs) in order to receive a status of a 'modern farmer' (whereby such wish could have its roots in the communist period when the image of a rational farmer working on a big farm was widely recognized), the above statement leaves no doubt that farmers often decide to enlarge their farm holdings out of the necessity to remain in the agricultural sector and sustain their families. Given that everyone pursues different living standards and people's expectations can vary greatly when it comes to preferred levels of income due to an interplay of various factors such as family size and marital status. For example, a single middle-aged farmer living alone and owning a 50ha organic farm stated that '*Subsidies are useful because otherwise I would be a truck driver. Even if we work we get little money for everything*' (GP_O9). In this case, it could be assumed that if the same farmer had to sustain a family, the subisdies could be insufficient to satisfy all the necessary living costs unless this farmer was pluriactive (i.e. had sources of income outside the agricultural sector) or had a big, preferably specialized, farm. Morevoer, one farmer rightly pointed out that: '*In 2007-2013 the direct payments better covered the price difference as there was no environmental requirments. Now we have* ***greening measures*** *and the production costs are not fully compensated*' (GP_C9). All in all, the current system of subsidies does not seem to create favorable conditions for farmers with mixed crops-livestock production unless farmers are specialized in either crops or animals, preferably on a big tract of land.

Assymetries of power: small versus big

Since subsidies are greatly based on acreage rather than on what is actually being produced on the farm, it it worth highlighting that they foster polarization between small farmers and big land owners who increasingly take a lead of farms and might not be free from the **vested interests.** For example, one farmer mentioned that: '*EU spoiled a Polish farmer. If subsidies were for production instead of acreage, farmers would be forced to work on the field rather than just chill. Then, those who work hard would get subsidies but the government will never do that as they seem to benefit from such system*' (GP_C10). However, the latter part of the statement not only raises speculations about narrow interests of those in power and the flawed naure of subsidies in general, but also about cognitive dissonance of the respondent who was the owner of a big commercial farm specialized in pig production (producing nearly 15 000 pigs per year) and previously said: '*I don't work, I hire people to work for me*'; '*there is no way any smaller farm can compete with me in this region'* (GP_C10). Either way, a distinction between a farmer who is truly cultivating his own land and the farmer who is doing minimal work in order to receive subsidies or leases the land to another farmer who is working on his field and pays taxes, yet the subsidies are absorbed by the owner, was a frequently mentioned observation that does not seem to create good conditions for scaling of recycling principles, which are work-intensive and aim to establish a cooperation between farms rather than 'taking over weaker farms' and possibly 'specializing them'. In order to further exemplify this, one medium-size farmer from Lublin voivodship mentioned: *'Many people keep their land, 1-2ha and they get subsidies, yet they produce nothing'* (LUB_C3). Another young yet organic farmer from the same voivodship with mixed crops-livestock production and whose total land surface amounts 16ha stated: *'Subsidies sickened the system. I want to evolve and I need land but many elderly farmers keep it as they want subisidies and torment soils*' (LUB_O1). In a smiliar tone, another farmer, yet from the Greater Poland voivodship, which is generally characterized by lesser land fragmentation than Lublin voivodship, mentioned that: *'Subsidies made farmers unwilling to sell their fields – private properites rule this village, there weren't any state-owned farms in here. Then agro-environmental schemes were created and 'they' sow at the lowest possible costs so that you cannot even lease their land in order to make it more productive. For us, it would be very beneficial since we have milk cattle and by enlarging pasture land we could create better conditions for our animals. But it takes a lot of effort. We were starting with 16ha and somehow managed to increase it up to 40ha in total'* (GP_O10).

Nonetheless, whether these smaller lands would be managed more sustainably in case they were leased or preferably sold to other farmers for 'care-taking' (better land use), or whether they rather would be subject to the same scenarios (i.e cultivation with minimal effort for the sake of subsidies), depends on the entity who buys or leases them. While the farmer from Lublin voivodship (LUB_C3), who seemed to be interested in leasing more land, admitted to apply large volumes of fertilizers and was rather sceptial toward recycling principles by considering them as too 'knowledge-internsive' and 'too idealistic'; the biodynamic farmer from Greater Poland voivodship (GP_O10) seemed to like the concept of recycling principles, but at the same time was more leaning toward animal-oriented production. However, since the latter farmer kept purchasing extra animal food additives such as proteins, extra land hectares could help her to become more self-sufficient by using on-farm produced fodder. The least favorable situation seems to be selling or leasing land to **big land owners** who don't produce at all or produce by relying on unsustainable production methods. For example, as the section related to globalization (4.1.2) revealed, the big farm enterprises under private ownership sometimes happen to be based on foreign capital and tend to apply large volumes of synthetic fertilizers and are nutrient-saturated in case they are livestock-specialist. Some of these foreign investors who began to lease Polish agricultural lands (especially before the country entered the EU) are even still eligible for EU subsidies, which are greatly complemented with national budget (WP_O13; Slazak 2013). It is also worth emphasizing that there are also several big farms, incl. organic ones, which do not have any production at all, yet they are still eligible for the system of subisdies (Interview with Dr Wrzaszcz from IAFE-ENRI). An example might refer to 'pseudo-ecological' production of walnuts (which are presently no longer subsidized) on a vast tract of land (100-300ha) by people with ties to the state who additionally labelled those walnuts as 'organic' in order to receive higher premium price. However, in reality, the production of walnuts was not subject to organic production standards (GP_O10; Slazak 2013).

Prior to entering EU there was also almost no **land leasing** - a phenomenon, which adds an extra bureaucratic layer and partially stimulates the trend toward increasing farm size and possibly even land ownership, whereby the latter can occur in case the land after leasing contract can be sold. For example, during the privatization period the lease agreements were typically made for 20-30 year time period (thus some of them can still last) and granted the right of pre-emption, which increases the chances of selling leased agricultural land (usually upon the end of such lease contracts) (Slazak 2013). Moreover, land leasing makes farmers vulnerable to potential land confiscation. For instance, one organic farmer mentioned: '*When I become an organic farmer one guy told me not to lease any land because if you receive subsidies they are jealous and take them away from you. Too risky. But for this reason I cannot enlarge my livestock production*' (GP_O11).

Some of the subsidies under the Pillar 2 are also allocated for **land consolidation** whose main purpose is to manage land more sustainably by re-arranging farms (e.g. to ensure that there is no piece of land that could be effectively used and remains unused), thus potentially creating better conditions for more effective cooperation between farms in case recycling principles are integrated (MINROL 2014). Nonetheless, while some of the farmers mentioned that they don't see any problem with it, various interviewed stakeholders stated that it is a very lengthy process as it involves numerous consultations and meetings with farmers, many of whom remain very reluctant and perceive such process as something that could affect their incomes (Interview with Dr Gradziuk from IRWiR PAN and certification body from Bioekspert, March and April 2017).

Loss of control and vulnerability to policy changes

Another conflicting aspect of the current system of subsidies, which concerns specific types of production, was emphasized by an organic farmer from Lublin voivodship who had integrated production (crops and hens), and highlighted that the reliance on the current system of subsidies, which in many cases seems to be a necessity so that farmers can make ends meet, makes farmers vulnerable to policy changes. According to this farmer: '*For me it's a system of slavery of the 21st century. I am not a manager of my land in its entire sense as the agency it telling me what I should do and what I cannot do. The problem starts when you have 5-year crop rotation system, yet you cultivate perennial fruits such as raspberries or blackcurrants whose rotation ends up in the mid of the 5-year crop rotation. Keeping such rotation with soft fruits does not make any sense as it only creates a ground for the development of diseases and weeds. Crops are becoming lower, yet you have to keep this no-longer-working crop rotation. So let's assume we have 7-year crop rotation system*[37]*: 5-year crops and 2.5-year crops such as soft fruits. If you want to cancel some crops you need to return any subsidies that you took in the second half of the 5-year crop rotation system, especially if you have at least 1ha of cultivated plants. For this reason, agency punished me. I lost quite a large sum of money due to the lack of competency of agro-environmental advisory services. They come and just ask me about the details of my production – what kind of advisory service is it? I want to produce but subsidies are for land acreage*' (LUB_O1). Similarly, an organic farmer from West Pomerania voivodship who likewise had mixed crops-livestock production (sheep, milk cattle combined with wheat and pumpkins) stated that he feels manipulated by the current system of subsidies: '*Yes, it's a system of slavery of the 21st Century. It's about the 5-year system of crop rotations. You have pre-planned crop rotations and 'they' can suddenly interrupt them*' (WP_O13). While it could be argued that the organic farmer from Lublin voivodship was cultivating soft fruits in order to receive the subsidies in first place and diversify production in the second place, it cannot be denied that the subsidies should be allocated for sustainable production rather than cultivation of crops just for the sake of subsidies, often with minimal effort. The above statements clearly indicate that farmers need to adjust to what they are being told as long as they would like to rely on the financial support. In case they deviate from the existing rules, and the example above showed that it is not uncommon, they have to incur financial fees. It is also worth emphasizing that even though soft fruits such as strawberries are currently subsidized without any requirement related to provision of a contract agreement (MINROL 2016),

[37] 7-year crop rotation systems are often the maximum timespans of cropping systems

they are often not subject to any advanced crop rotations. For example, Dr Gradziuk from IRWiR PAN mentioned that a farmer cannot achieve economic benefits by producing 3-5h with organic production methods. According to him, it is important to expand the organic production of e.g. soft fruits to at least 150ha or more in order to obtain real benefits (Interview, April 2017). Moreover, since one of the recycling principles promoted by the BERAS project (that is concerned with organic farming) refers to 6-year cropping systems that have been proven to be beneficial for soils, it seems worthwhile to conduct a comprehensive overview of the current regulations related to subsidies for crop rotations in order to create a solid ground for the wider adoption thereof yet by providing farmers with more flexibility whenever possible.

Over-bureaucratization

In order to receive financial support or be able to sell livestock, farmers need to comply with a complex set of regulations, which were reported to become much stricter upon accession of Poland to EU. As one farmer said: '*You cannot do everything the way it is required*' (LUB_C1). Such paralyzing nature of the bureaucratic system seems to have only contributed to the decline of mixed crops-livestock production in favor of specialization in crops. For example, one farmer with pig production from Lublin voivodship mentioned: '*You need to record and write down everything, especially since membership in EU: reporting, ear tags, medicine, fodder etc.*' (LUB_C5). Interestingly, the same farmer mentioned that prior to stricter regulations imposed by the EU, '*There used to be cow on every farm. People used to exchange manure, fodder and agricultural outputs between each other, even one could sell animals to another farmer. All those thing were not subject to strict registration. Now EU is pressurizing us with additional regulations*'. Similarly, while one farmer mentioned that '*there used to be more flexible regulations when it comes to animals and everyone had a 'zoo'*' (LUB_C4); a farmer with pig and cattle production added: '*People get lost in Poland but animals never get lost*' (GP_C8). By further referring to the regulations imposed on animals, one farmer also mentioned: '*Now they* [the controlling bodies] *are crazy with avian flu – you have 15 chickens and you cannot even set them free outside for a while in the backyard*', and continued: '*The controlling bodies compared my milk production to food industry and it was even unpleasant to listen to them; there are over 50 regulations to comply with and in the end it turned out all this drama wasn't necessary*' (LUB_C6). While the latter citation might imply that the controlling bodies lack competency, it is also worth mentioning that when it comes to big animal industries, the regulations do not seem to be as strict as they should be, even though large corporate farms tend to specialize in products with higher labour monitoring requirements (Ciaian *et al.* 2009). A telling example could be the fact that according to the data published by an NGO active in Poland in the field of animal welfare (CIWF), Polish farmers occupy the 2nd position in Europe in terms of using the strongest **antibiotics**, which are used in treating humans; and nearly 60% of the total amount of consumed antibiotics in the country are consumed in the livestock sector, amounting up to approx. 600 tons of consumed antibiotics in 2014 (2016). Further examples reflecting the flawed nature of regulations (incl. non-compliance by the state with EU policies) in relation to animal industries are presented in the context of environmental protection regime (4.2.2).

The crop-specialist farming systems, which might seem to be less challenging from the regulatory point of view, are likewise endowed with certain 'juridical lock-ins' that can affect scaling of integrated crops-livestock systems, especially in terms of establishing cooperation between two farms (one crop-specialist and another livestock-specialist). For example, one farmer criticized the current regulation on fixed sowing terms: '*You cannot go to the field not earlier than on the 15th of March as there are plants, which require as quick sowing as the soils still remain humid. In the past you could sow oat starting on the 1st of March because it requires a lot of water and now on after the 15th of March it is becoming worse. After 15th of March your soils is no longer ready for it. Then you have straw rather than good grains for animals or export*' (WP_O13). As far as sowing terms are concerned another farmer specialized in milk cattle, yet from Lublin voivodship, mentioned:

'There could be some subsidies for straw because now whenever they sow it by the end of September, it does not want to grow' (LUB_C1). In a similar tone, another farmer mentioned that the regulations related to sowing crops incl. leguminous plants, are too strict and do not prevent farmers from sowing them during the periods of droughts, which are becoming increasingly unpredictable (LUB_C2). Therefore, it leaves no doubt that such regulation lies in contrast to recycling principles whose aim is to produce as many good outputs as possible, especially given that such cyclical mixed crops-livestock systems have already various inherent limitations (e.g. need for workforce). It worth highlighting that since the current climatic conditions, which are subject to fluctuations, can have a dramatic impact on the vegetation periods and soil humidity that vary across different regions in Poland, it is very important to take into account regional differentiation in terms of climatic conditions and climate models during the policy-making process.

Overall, the regulatory policy arrangements are especially challenging in case of **organic farming**. Apart from the fact that crop production in case of organic farming is more subsidized than in conventional farming (yet not always), one conventional farmer (who once considered organic farming but was discouraged by high inputs of work) mentioned: '*The regulations are often illogical. For example, a friend bought a protein supplement for a calf from a company he shouldn't buy from and he even didn't know about it. And then the controlling body forced him to destroy the manure of that calf*' (LUB_O6). While it can be argued that the friend of this farmer might have used a food additive, which contains GMOs that are prohibited in organic farming sector (as there must have been some reason behind such strict procedure of manure removal), it cannot be denied that the regulations within the organic farming sector are very strict and for this reason tend to discourage farmers from becoming organic. Similarly, Dr. Tyburski, one of the pioneers in organic farming also mentioned that sanctions during inspections, especially in case of animals, are very high (Interview in Pokrzydowo, March 2017). The outcomes of such juridical and economic lock-ins are reflected in the current trends toward specialization in crops, which dominated organic farming sector (5.1.3).

The complex set of mandatory regulations were also regarded as a manifestation of the **unstable nature of political environment**. As one farmer said: '*Here in our agricultural sector everything is going crazy and depending on the political party, everyone is ruling the way he/she wants. But you cannot convert entire farm in one direction and then change again. Every policy-maker says something different. They make up many wrong regulations and then farmers suffer*' (LUB_C6). This farmer clearly indicated that the policies are in a state of flux and do not raise trust in policy-makers who do not seem to provide farmers with a hope for a better future. In a similar, yet more blatant tone, another farmer raised a question: '*Do people need to suffer from hunger so that the officials will understand farmers?*' (GP_O9). Overall, while some of the regulations were regarded by farmers as 'manipulative' and 'redundant', important regulations such as the requirement to conduct soil checks, which are inexpensive and could help to properly reduce reliance pesticides (that are often thrown by sight), and thereby increase farmers' autonomy, exist only in the context of agro-climate-environmental schemes (Interview with Dr Wrzaszcz, March 2017). It can be also added that a limited trust in the government is the outcome of historical past. For example, upon the fall of communism many people with ties to the government were accused of unfair land acquisition (Slazak 2013).

5.2.1.2 *EU Fertilizers Directive*

The EU Fertilizers Directive (Regulation (EC) No 2003/2003) provides a set of regulations in order to ensure that the levels of applied nutrients match up well with crop requirements. It also guarantees free movement of non-organic fertilizers across EU member states. The legislation is relevant in the context of recycling principles especially given that one of the deliverables of the Circular Economy Package is the proposed amendment to the EU Fertilizers Directive, which calls for '*easing the access of organic and waste-based fertilizers to the EU single market, bringing them on a level playing field with traditional, non-*

organic fertilizers' (European Commission 2016c). Such amendment is currently undergoing a procedure of co-decision between the European Parliament and Council. Once adopted, it will be automatically endorsed (European Commission 2016c). However, while it might open a window of opportunity for scaling of recycling principles in terms of reduced inputs of synthetic fertilizers in favor of manure, it can be also regarded as a pathway toward increased exports of dehydrated manure from countries facing problems related to manure surplus (e.g. Belgium) to countries in which several regions face nutrient deficits - Poland (more follows in 5.2.3.1). Therefore, it can be reasoned that such increased trade of manure could only address the symptoms of the already existing problems (i.e. over-fertilization and nutrient deficit), rather than the root causes of the problems pending solutions (i.e. high livestock concentrations and specialization in crops). Moreover, by stimulating the phenomenon of international dumping whereby the by-product (bio-waste) in one country, which most likely has a stronger economy, becomes a fossil-fuel dependent input in another country, which has weaker economy; such regulation could potentially exacerbate the Western-Eastern divide within the EU. Overall, the potentially amended EU Fertilizers Directive might be supportive in addressing recycling principle related to reliance on on-farm produced inputs as long as it is concerned with locally/regionally based re-use of waste materials ('locally closed loop'), rather than across Europe.

5.2.1.3 *New national law on direct sales vs. processing infrastructure & consumer consumption patterns*

On the 1st of January 2017 the new law on direct food sales[38], which was highlighted by several farmers, and whose main purpose is to provide farmers with an opportunity to sell their agricultural outputs produced on the farm directly to consumers, was ratified by the Polish state. Even though it is too early to evaluate the impact of this law on up-scaling of recycling principles, it can be argued that it might help farmers to commercialize uncommon crops, thus opening a window of opportunity for

[38] This new law is a modification of a policy (Dz. U. poz. 1961)

crop diversification. Such new law might also help to reduce high transaction costs, which were reported by Ciaian *et al.* (2009) to be very high in Central and Eastern Europe, especially when small-scale farms were concerned. Moreover, it might increase farmers' resiliency to price volatility as they are now able to sell their produce directly to consumers on the markets (rather than through intermediaries), and process it at farm level, thus in favor of pursuing **economies of scope**. Therefore, this policy might constitute a big step toward increased investments in **local infrastructure**, including processing facilities and distribution channels, and thereby toward creating an opportunity to bring about a renaissance of locally produced foods in the line with the idea according to which local just economies are '*embedded in health, morals, and values*' (Alkon 2008). However, a frequently mentioned problem during interviews was related to the local **processing infrastructure**, which still remains in infancy. For example, one scholar asked informatively: '*Did you know that Poland being one of the largest producers of oats sells them to Germany for processing and then these products return to Poland to occupy shelves in supermarkets?*' (Interview with representative of Poland in COPA-COGECA, March 2017). This example shows that the infrastructure as simple as the one, which is about separating hulls from the groats, is not well developed yet. In addition, as one farmer mentioned: '*We have our own local butcher to which we transport our pigs, but not many as only 30 per week. However, our products are consumed by older people as young people prefer to go to supermarkets such as German Lidl where they can usually buy piglets. These piglets might be even ours, and are usually exported as they were deemed less valuable, and hence pumped with extra chemicals later on*' (GP_C10). Even though this farmer declared to be self-sufficient only in 20%[39] and was producing nearly 15 000 pigs on annual basis, such statement clearly implies that many efforts are required in order to increase local consumption in the face of the market dominance by big supermarket chains, which have a strong lobbying power that enables to guide consumer's eating habits by offering

[39] This number is an estimation made by the farmer and thereby can be perceived as subjective

attractive prices for commodities. In this way, the tendencies toward marketing strategies that promote **meat-based diets**[40], seem to constitute another barrier to encourage big livestock keepers to decrease their meat production in favor of adopting recycling principles. Interestingly, the issue of alleged rise of vegetarianism was raised during the group discussion in Pokrzydowo as one of the limiting factors for maintaining meat (livestock) production. However, it is important to highlight that the integral cyclic agriculture imposes certain limits on the amount of meat that can be produced as it promotes low densities of animals. Therefore, any increase in the number of vegetarians seems to be in line with the possibility for up-scaling of recycling principles. Nonetheless, given the already mentioned lobbying power of meat industries; it can be argued that the demand for meat is likely to continue to grow. The interviews also revealed that despite the existence of animal infrastructure, crop-specialist farmers are unwilling to return to livestock production due to its burdensome nature, which was already mentioned in the context of CAP. One conventional farmer specialized in crops and owing 140ha farm also mentioned: '*I am not able to process my 100 tons of products as only small-scale farms can have their own processing facilities'* (GP_C9).

Another conflicting aspect refers to the burdensome nature of regulations, which become stricter after the accession of Poland to the EU. As one farmer spontaneously commented on this law '*the current sanitary regulations*[41] *imposed by the EU might even mean that farmers won't be able to sell those products anyways*' (LUB_C6).

The limitations associated with processing infrastructure seem to be especially notable in relation to the **organic farming sector**. Even though the number of processing plants increased from 55 in 2004

[40] The International Agency on Market Research, which works on behalf of WHO, revealed via the Polish Press Agency that Polish people tend to eat nearly twice as meat as is required by WHO (PAP 2015).

[41] According to this new law, farmers are required to register the whole selling process and produce everything according to EU standards (Regulation (EC) 852/2004 on the hygiene of foodstuffs) (Dz. U. poz. 1961)

to 484 in 2014 following the system of subsidies (IJHAR-S 2015), the interviews revealed that the processing sector remains highly underdeveloped due to the prevailing imports of processed organic food products and exports of raw organic food products. For example, one farmer when asked about the newly approved law on direct food sales admitted to partially non-comply with this new law: '*I sell processed amaranth grains illegally because I cannot process it on my own. I am processing at my friend's place as he has a bakery and he does it locally in a local mill. The rest is legal. Anyways, there are many situations when Germans will take a pumpkin from us and they cut it and deliver to shops as if it was already German. It's written it's produced in EU and they even won't write it's from Poland*' (LUB_C2). Such confessions not only further show that the processing infrastructure is limited, but also demonstrate that this new law, which is supposed to facilitate trade between farmers and consumers, is likely to stimulate the emergence of profit-oriented producer groups, whereby small farmers can process various agricultural outputs on legal basis, yet they need to compete with larger farmers, which likewise have shares in such producer groups. In addition to this, the current funds under the 2nd Pillar of CAP are expected to help to increase investments in such producer groups (MINROL 2016). Moreover, even though consumers might value healthy, pesticide-free and sustainably produced food, the premium price of products labelled as organic tends to discourage them from buying 'organic goodies', which are often perceived as 'luxury goods' in Poland (PAP 2013; Szeremeta 2005).

Overall, this new law does not necessarily imply that farmers are likely to re-launch or maintain mixed crops-livestock production due to the limited demand for locally produced products in the face of the powerful agro-food industry as well as underdeveloped nature of the local processing infrastructure.

5.2.1.4 ***New law on acquisition of agricultural land***

On the 30th of April 2016 a new law[42], which imposes extra restrictions on sales of land owned by the Agricultural Property Stock of the State Treasury, was ratified by the Polish state. According to this law, private owners of agricultural land can no longer sell their land to any individual (especially foreigner) who is not classified as a farmer (i.e. a person who has agricultural qualifications, farming experiences and has lived in 'a rural commune' for the past 5 years). This law is relevant in terms of up-scaling recycling principles as it is expected to weaken, at least to some extent, the polarization between large farm owners and smaller and medium-size farmers, in order to protect family interests: the family interests, if unprotected, could only intensify the current process of rural depopulation and foreign ownership of agricultural land, which were analyzed in the context of recycling principles at the landscape level (5.1.2 and 5.1.6). In order to further highlight the issue of **foreign land ownership**, it is worth quoting an organic farmer from West Pomerania who stated that, '*The foreign influence here is big and many foreigners want our land. There was once here one guy who substituted a German investor with someone from Poland so that the German guy could but it. They were looking for farmers who have 2-3ha and kept substituting so that they could enlarge their farms. And what the agency did? It was leasing all this land, which was automatically appropriated by German investors. So everything was 'legal' and all necessary papers were in place. You basically bypass the law. And someone else is using the land. And this German guy is sharing subsidies with the guys who helped him to get the land'* (WP_O13). However, the above statement also casts doubt on the effectiveness of the new law, which might be possible to bypass, especially given that the Agricultural Property Agency can approve the sale of land to a private individual as long as the selling entity can prove that it is difficult to sell land to the person with the status of the 'farmer', family, State Treasury or via restructuring procedures. As Krupa-Dabrowska

[42] Dz.U. 2016 poz.585

(in: *Rzeczpospolita Polska* 28 April 2015) interestingly pointed out, the existing regulation is laconic as there is no regulation to document the lack of prospective buyers in case such issue is reported by the farmer. Overall, it can be argued that despite this new law, the land might be sold to companies with foreign capital, which were enabled to put their roots in the Polish territory during the privatization period when they were even exempted from income tax in case they were involved in external activities beyond the agricultural sector (Jarosiewicz 2007). As the subsection related to globalization (5.1.2) revealed, these foreign companies sometimes happen to adopt unsustainable agricultural practices and are unlikely to adopt recycling principles.

5.2.1.5 ***Legislative framework for the organic farming sector***

In addition to subsidies **for** organic farmers through the Rural Development Plan (Pillar 2), this sector is also subject to the national legislation on organic farming (Dz.U. 2017 poz. 1054) as well as rules[43] which help to ensure that organic products are '*healthy, safe and ecologically sound*' (IFOAM 2008). However, even though the scope of the two latter regulations goes beyond the scope of the greening measures falling under the Pillar 1, the research findings imply that there is neither enough promotional programs to support development of local markets and create local demand, nor any partnership between the organic farming sector and state domain (Interview with Ms Metera from Bioekspert, March 2017). Moreover, even though the Framework Action Plan for Food and Farming in Poland in the years 2014–2020 identifies a set of well-stated objectives in relation to organic farming such as '*Diversification and strengthening of distribution channels for organic products*', among others; some researchers highlighted that there is no well-designed and detailed plan to meet these objectives (Stepien and Chudzio 2016). Given that there is a certain degree of national flexibility to implement

[43] Rules for the implementation of Council Regulations ((EC) No 889/2008 and (EC) No 834/2007 on organic production and labelling of organic products with regard to organic production, labelling and control

additional requirements for organic farming sector, which could correspond with recycling principles, it could be argued that some changes could be implemented in relation to the EU regulations on organic certification. While the current rules indicate that '*at least 50% of the animal feed should be produced on-farm or near-farm*' and there is no limit on animal density provided that there is a notable level of self-sufficiency,[44] such rules could be modified in order to ensure that '*animal density amounts to max. 0.1 livestock units per hectare*' and at least '*85% of animal feed is produced on-farm or near-farm'* (Granstedt *et al.* 2008). In this way it would be possible to enable effective recycling of nutrients. In addition, if not at national level, such standards could be issued by private certification bodies like EKOLAND. Nonetheless, since the interviews already revealed that farmers are unwilling to meet higher regulatory thresholds (5.2.1.1), it could be argued that the more complex regulations become, the total land surface of organic farms (especially the ones oriented at livestock production) will continue to decrease. Moreover, it can be added that while two farmers mentioned that certification bodies pressurize them to cultivate at least 30% of leguminous crops (LUB_O2; LUB_O4), not many organic farmers seemed to meet such recommendations.

5.2.2 Environmental protection regime: policies and programmes

This subsection provides a brief overview of key policies and programs, which constitute part of the environmental protection regime and are deemed influential (and 'enabling') as far as scaling of recycling practices in Poland is concerned. A more detailed analysis of respective policies falling under this regime is available in the Appendix E3.

[44] (EC) No 834/2007

5.2.2.1 ***HELCOM Baltic Sea Action Plan (BSAP)***

The Baltic Sea Action Plan (BSAP) is a programme established by the Helsinki Commission with the aim of '*restoring the good ecological status of the Baltic marine environment by 2021'* (HELCOM 2007). The BSAP, which was ratified by Poland in 2007, recognized that 'agriculture is the main source of nutrient inputs to the Baltic Sea' (HELCOM 2007) and requires Poland to achieve the pre-established nutrient reduction targets: 8 760 tons of phosphorus and 62 400 tons of nitrogen by 2021 (HELCOM 2007). These values translate into decrease in nitrogen and phosphorus discharge levels to the Baltic Sea by approx. 25% and 60%, respectively (Pastuszak *et al.* 2014). However, according to the Special report, which was issued by the European Court of Auditors (2016), Poland is one of the countries that have been criticized for not following up on their commitments to the BSAP as the Polish government has not yet adopted the national implementation program for the Baltic Sea action plan (NIP BSAP) and its nutrient reduction targets. This might imply that there is not enough pressure on the dominant (productivist) regime to design strategic solutions, e.g. via the promotion of agricultural activities that are based on recycling principles; or the policy-makers are very unlikely to consider changing the policies to create better conditions for recycling principles. Moreover, according to Staniszewska and Stalenga (2013), given the Poland's annual discharge of nutrients to the Baltic Sea that amounts to 144 000 ton, the requirements set for Poland under the Baltic Sea Action Plan (BSAP), especially in relation to nitrates, are currently highly 'unrealistic'.

5.2.2.2 ***EU Water Framework Directive (WFD) & EU Nitrates Directive***

The EU Water Framework Directive is a legislation, which is meant to be harmonized with the BSAP. This legislation addresses groundwater and surface water pollution through river basin management plans (2000/60/EC). The EU Nitrates Directive (91/676/EEC), which constitutes an integral part of WFD after it was established in 1991 is concerned with nitrate pollution from agriculture by establishing '*Codes of Good Agricultural Practice to be implemented by farmers on a voluntary basis*' that set optimal levels for manure use and storage. Consequently, both legislations can help to increase effectiveness of recycling principles once such are in place, and raise farmers' awareness on the necessity to properly manage nutrients on farm level. For example, the interviewed farmers seemed to be familiar with the regulations, which also propelled many of them to implement manure and slurry storage pads that can significantly reduce nutrient leakages from manure, and thereby maximize efficiency of recycling principles once such are in place (Pastuszak *et al.* 2014; MINROL 2016). However, the application process for subsidies to cover the costs thereof was reported to be burdensome to the extent that in some cases several farmers decided not to invest in manure storage pads when they had an opportunity to do so with financial help (GP_O11; GP_C12).

Moreover, according to the latter legislation, farmers cannot use more than 170 kg of nitrogen (manure) per hectare and year; and are prohibited from applying liquid manure on slopes and frozen land (among other measures). However, even though these rules currently constitute part of cross-compliance within CAP (Pillar 1), the limits can be perceived as overly 'generous' given that the permitted amount of applied nitrogen is four times higher than the amount spread on farms managed according to recycling principles (especially in relation to organic farms) (Granstedt 2012). In addition, one farmer reported that '*we are not allowed to transport manure during winter from 1st of December to 1st of March. But I think it's stupid as during winter period evaporation of nitrogen is minimal and manure is not smelly*' (GP_C8). While nutrient runoff actually increases with frozen ground in case of rainfall or snowmelt conditions (Shanley and Chalmers 1999), it has to be mentioned that winters are becoming less snowy and thereby policies based on careful evaluations of climate and nutrient runoff models are also required.

In addition, following the Art 193 TFEU, both WFD and the Nitrates Directive can '*maintain and introduce more stringent protective measures*' (EU 2010/C 83/01). Therefore, it could be argued that such national flexibility opens a window of opportunity for the inclusion of recycling principles as part of these measures (e.g. by introducing better cross-compliance scheme with EU Nitrate Directive in the CAP post-2020). However, the imposition of stringent protection measures is unlikely to occur, especially in the light of the national objectives related to modernization of agricultural sector (Pillar 2). Moreover, Poland has already been taken to the Court of Justice of the European Union for failing to comply with requirements set by the EU Nitrates Directive. Even though one farmer from Lublin voivodship, where the Nitrate Vulnerable Zones are not present at all[45], heard that NVZs were about to cover the entire Poland (LUB_C5), no significant action to designate them or enforce better policies has been done since standing in front of the Court (InfoCuria 2014; Szolc 2017; EC 2013b)[46].

Overall, such attitudes of policy-makers might again imply that they are very unlikely to consider changing the policies to create better conditions for recycling principles (including introduction of agro-environmental schemes related to recycling principles).

5.2.2.3 *Directive on industrial emissions*

According to the Directive on industrial emissions 2010/75/EU (which used to be IPPC Council Directive 96/61/EC until 2011), farmers are required to obtain an 'Integrated Permit' in case the number of places in a facility is equal or larger than 40 000 places in case of poultry, 2 000 places in terms of pigs above 30kg, 750 places in case of sows; and in case there are 400 units of cows (thus in factory farms/ 'Baltic Hot Spots'). However, this Directive does not require farmers and land owners

[45] The rules in NVZs are more stringent than in non-NVZs

[46] More details are available in Appendix E3

to show fertilization plans, which can be presumed to bring disastrous consequences; and Poland does not require licenses for farms with cattle over 300 LU (European Court of Auditors 2016). Either way, as far as the nutrient recycling, animal welfare and wider ecological and managerial concerns are concerned, it can be obviously argued that such big facilities should not take place at all.

5.2.3 Dominant technology and practices

The interviews clearly revealed that upon Poland's accession to the EU, which maintains strong ties with global markets, many of the Polish farmers invest money in off-farm inputs (e.g. modern fossil-fuel dependent machinery, fodder, fertilizers and pesticides), which help them to achieve higher yields (even if only in the short run) in order to remain (competitive) on the 'common' and global market, and reduce the need for workforce. As one farmer mentioned: '*EU has taught us modernity*' (GP_C8). However, prior to the development of fertilizer industry and farm enlargement, which is usually paired with mechanization and specialization, most of the farmers used to have much more diversified production and relied on much more complex systems of crop rotations than now. For example, one farmer who is currently specialized only in three types of cash crops on a farm occupying 130ha stated: '*In the past, this farm had 5ha. There were 4 horses doing shift work (some of them were working in the afternoon and some of them during the days); there were 5-6 cows and 20 units of pig on fragmented yet increasingly larger farm acreage. Now, having more land, I don't raise animals. Buildings were prepared and I could have had animal production but it is not cost-effective. The animals were gradually being sold around 20 years ago. If I had 3 cows I would be stuck with no profits. You either have a lot or none. Now I use modern machines.* […] *Yes, I rely on fertilizers'* (LUB_C2). Once this farmer, similarly to many other farmers in the country, became an EU citizen, the availability of subsidies, which were expected to counterbalance falling prices of agricultural outputs in such a globalized world, only further propelled him to increase land size and specialize in crops, two aspects which increased his demand for technology that allows to become (artificially) resilient to rising production costs (see below).

5.2.3.1 *Fossil fuel dependent fertilizers*

Given that the production of nitrogen and phosphorus fertilizers is energy intensive and fertilizer prices are highly correlated with oil prices, which are subject to fluctuations, prices of fertilizers are relatively high and are likely to further increase in the future (Darnhofer 2014). For example, one conventional farmer stated that prior to accessing EU, '*I used to buy for 1 quintal [100kg] of wheat 3 quintals of fertilizer. And now it's on reverse as I buy 1 quintal of fertilizer for 3 quintals of wheat*' (LUB_C5). Such high prices of fertilizers might indicate that farmers are likely to explore alternative solutions to boost soil fertility, thus potentially opening a window of opportunity for up-scaling of recycling principles. However, even though mineral fertilizers remain greatly unaffordable among certain groups of farmers in Poland (mainly small-scale farmers), the conventional farming practices are still greatly dominated by the heavy reliance on mineral fertilizers (GUS 2016; PKO Bank Polski 2017, Prus 2012). From the historical perspective, the increase in the application of mineral fertilizers took place during the socialist period (1960-1980) when the government greatly favored large state-owned farms, yet this increase was subject to decline during the transition of Poland to the free market economy in 1990s, and then again increase during the EU membership period when the animal production, and thereby manure, have been gradually replaced by crop-specialist farms (Pastuszak *et al*. 2014; 5.1.3)[47]. The high dependence on synthetic fertilizers is also exacerbated by the fact that Poland is the second largest manufacturer of

47 The consumption patterns of mineral and chemical fertilizers are illustrated in the Figure D9 (Appendix D). The Graph 10 (Appendix D) additionally shows that there is a strong correlation between the sown area and the use of mineral and chemical fertilizers by voivodships.

fertilizers among the EU-28 and produces approx. 1,7 million tons of nitrogen fertilizer per year (Igras *et al*. 2014); and maintains global ties with countries exporting phosphate minerals (e.g. Senegal)[48].

The Figure D11 (Appendix D) shows that the production of phosphatic and especially nitrogenous fertilizers is on the rise. An interview with a pluri-active farmer who was also a truck driver delivering synthetic fertilizers to many farmers across the country only further confirmed that high volumes of synthetic fertilizers are being produced and consumed: '*Trucks go one by one not to mention train transport – these are hundreds of tons of synthetic fertilizers. More and more synthetic fertilizers are being produced*' (LUB_C4). Strikingly, the same farmer also mentioned that large volumes of mineral fertilizers are being delivered to nearby the Podlaskie voivodship, which is characterized by the largest number of cattle in the entire country, thus implying the lack of cooperation between crop and livestock-specialist farms. Similarly, the interviews revealed that even some of the conventional farmers who have mixed crops-livestock production and relatively balanced livestock production (ranging between 0.5-1.0LU/ha), apply not only organic fertilizers (manure) but also **large volumes** of synthetic fertilizers. For example, one interviewed medium-size farmer from Lublin voivodship (owing 47ha) who had mixed crops-livestock production, admitted that, '*A lot of fertilizers are being purchased, approximately 35 tons of mineral fertilizers and 25 tons of organic fertilizer per farm per year. But fertilizers became more expensive. I also have phosphorus from Belarus, they are a bit cheaper*' (LUB_C3). Such statement reveals that despite of owing 34 units of cattle (0.7unit/ha), which already supplies him with organic fertilizer (manure) for crops; this farmer additionally imports extra manure from outside[49]. Moreover, despite the fact that Poland has a well-

48 The extraction of irreplaceable resources such as phosphorus often takes place in politically unstable countries of Sub-Saharan Africa - Morocco, or in Russia, the former one exporting phosphates with a heavy content of carcinogenic and toxic metal cadmium. In case of Poland, given the country's financial involvement in a phosphate mining industry in Senegal and tense relationship with Russia, the country is keen on maintaining high imports of phosphorus from Sub-Saharan Africa. However, the extracted minerals in this part of the world contain high content of **cadmium**, which ranges from 60mg to 90mg instead of 60mg to 20mg/kg, whereby the latter parameters were proposed by the EU (Paravicini 2016; ICIS 2014).

49 High volumes of fertilizers including manure in this farm are depicted in the Appendix F3

developed fertilizer industry, the same farmer confirmed observations by a certification body from Bioekspert, who mentioned that large volumes of fertilizers are currently being imported from Belarus as they might be cheaper (Interview, March 2017). What is also interesting about this farmer is the fact that he somehow managed to procure organic manure, which is a very precious asset and none of the interviewed farmers revealed that they were willing to sell it, thus indicating that there is still some potential for the cross-farm cooperation.

More importantly, it needs to be highlighted that the greening measures falling under the 'Green box' (Pillar 1 of CAP), which concern crop diversification and cultivation of leguminous crops (that can improve fertilizer autonomy in favor of recycling principles) grant exemptions to smaller farms[50], which were also reported to apply large volumes of fertilizers (Interview with Dr Wrzaszcz from IAFE-NRI, March 2017), and the average farm size in Poland was 10.49ha in 2015 (GUS 2016) (5.2.1.1). Likewise, the introduction of agri-environment-climate scheme, which introduced specific requirements regarding crop rotations and leguminous crops does not seem to have any impact on the use of fertilizers (see Figure 10, Appendix 4).

Moreover, when a conventional farmer specialized in crops was asked whether he would like to procure manure from another farmer he replied: '*If I was supposed to use a manure from neighbor, he would have to adjust his soil biota to mine as I don't want any weeds from his farm*' (LUB_C2), thus indicating potential risks associated with content of undesirable species when buying manure from a neighbor; in other words: raising the issue of the necessity to implement extra organizational arrangements that should be based on scientific knowledge in order to create better conditions for scaling of recycling principles, which also concern collaborative operations between farms.

[50] While farms, which have less than 10ha are exempted from complying with crop diversification rules in order to receive subsidies; EFAs that include leguminous crops, are required to be applied on farms, which occupy more than 15ha (MINROL 2014c).

Interestingly, Dr. Gradziuk also mentioned that the innovative precision farming methods (e.g. the so-called smart foliar fertilizers or variable-rate applicators) are becoming more common and receive a great attention from scholars who design new products that enable them to use nutrients more precisely and cost-effectively, especially in the crop and horticultural sector. However, even though such innovative methods are becoming widely recognized and could not only reduce the nutrient discharge from the agricultural sector but also save money by dosing mineral fertilizers that are becoming more expensive, they still constitute part of the bigger, profit-oriented and fossil fuel dependent fertilizer industry, which has a strong lobbying power. On the other hand, it could be also argued that in case there is a peak oil or a conflict, the farmers will be forced to search for alternative ways to replenish nutrients in the soil, thus potentially opening a window of opportunity for the wider adoption of recycling principles.

The situation is also worrying in relation to **organic farmers** who are prohibited from using synthetic fertilizers. The interviews with organic farmers specialized in crop production revealed that they are not always able to obtain 'fresh' manure for the following three reasons: (1) lack of neighbor producing livestock; (2) neighbor raising livestock is not willing to sell manure, which is a precious resource; (3) neighbor raises livestock conventionally so that manure can contain traces of GMOs, antibiotics and hormones, all of which are prohibited in organic farming. Consequently, one of the research findings concerns imports of natural fertilizers from Germany as well as dehydrated manure from organic (yet most likely industrial) farms in countries characterized by high animal density such (e.g. Belgium or Netherland). While the latter type of fertilizer was reported to be used by only one interviewed organic farmer (POD_O8), the participation in organic farmers' meeting in Lublin city in Lublin voivodship, which has a dominant crop production, enabled to unravel that such fossil-fuel dependent yet 'certified organic' fertilizers are being increasingly promoted. The participation of the researcher in the discussion between farmers and 'envoy' (promoter) during the meeting revealed that some of the crop-specialist organic farmers seemed to be interested in this product due to its attractive price, which turned out to be in one case cheaper than manure from neighbor. The relatively low price of such **dehydrated manure** indicates that it does not internalize environmental costs associated with transport thereof, thus making it an unsustainable alternative to 'fresh manure'. However, some of the farmers remained skeptical about the truly 'organic' content of such fertilizer and one organic farmer interestingly pointed out that such imports of manure can be only further facilitated by large farm enterprises with foreign capital owning Polish land: '*In our neighborhood there is a Dutch-owned crop-specialist conventional farm, hundred thousand hectares. And now I have learnt from you that they must have been even importing manure from their country so that they can have a 'closed loop'. You see how everything runs smoothly?*' (WP_O13). Such statement only raises further concerns not only about foreign investments in the country and the phenomenon of land ownership, but also about international dumping, whereby the by-product in one country, which is actually a bio-waste, becomes an inexpensive input in another country. Either way, there are also some exceptions. For example, Ms Jozwiak from the Polish Ecological Club mentioned during the group discussion in IUNG, Pulawy that she once met a farmer who relocated from the Lublin voivodship dominanted by the crop production, to the region in Masovia voivodship, in which he could procure manure. This example clearly shows that some of the young people are highly mobile and even willing to relocate as long as such efforts might help them to satisfy their needs and improve fertilizer autonomy. Therefore, these young people should be the core targets of agricultural policies, which should be able to support their endeavors.

Overall, the fossil fuel-dependent fertilizers, be it mineral or organic, have (to a certain degree) a competitive advantage over agro-ecological practices such as raising animals (which provide fresh manure) in a balanced way, and diversifying crops with leguminous crops, all of which require a lot of knowledge and patience to render visible results. For example, by growing certain types of legumes, especially in combination with other crops, it is likely to achieve lower yields in the short-term. However, as the Chapter 2 revealed, the multi-purpose crop combinations can significantly improve the soil structure in the long run, and the prolonged use of synthetic fertilizers contributes to soil depletion that might ultimately lead to the situation whereby '*even weeds do not want to grow*' (LUB_C9). Consequently, as the sub-section related to soil depletion revealed, some of the farmers are already considering adoption of alternative practices, which comprise recycling principles (5.1.7.2).

5.2.3.2 ***Fossil fuel dependent feed concentrates***

Apart from the fertilizer industry, Poland maintains strong network links with corporations producing feed concentrates and additives that stimulate animals' growth. Such off-farm inputs are likewise fossil-fuel dependent as around 31 million tons of genetically modified soybean products, which are subject to fodder processing, were exported by countries such as Brazil, Argentina and the United States to the EU market between 2013 and 2014 (Kroes and Kuepper 2015). Following Poland's accession to EU, which opened the door to global trade, Poland, alone imported 40 thousands of tons (incl. 10 thousands of tons from EU) in 2014/15 (GUS 2016). One of the observable negative outcomes of such availability of feed concentrates concerns increasing concentrations of livestock on small acreages, which only further drive the emergence of confined animal feeding operations, all of which stand in opposition to recycling principles. By referring to the interviews, the majority of the interviewed specialist-grass or fodder-cropping farmers claimed to already have a closed-loop system as they were producing fodder on the farm. However, the observations and in-depth interviews clearly revealed that in most cases the produced fodder was not enough to feed the entire animal population even when the livestock was kept in relatively high concentrations (more than 0.5-1 animal per hectare). For example, a large-scale pig producer (producing nearly 15 000 pigs/year), whose farm had allegedly a 'closed loop system', (proudly) admitted to be self-sufficient in agricultural inputs only up to 20%[51]: '*We buy 80%. We have nothing because we buy everything from other farmers*' (GP_C10). The main

[51] This number is an estimation made by the farmer and thereby can be perceived as subjective

reasons behind such reliance on feed concentrates seem to stem from the farmers' perceived limited capacity to produce sufficient amounts of crops that that have high enough value of protein. Moreover, one farmer reported that it is convenient to invest in extra protein additives, especially given that the current system of subsidies supports livestock units, and complementary payments for grasslands were removed (GP_C8). Similarly to the consumption of fertilizers, the reliance on feed concentrates implies that the greening component of CAP 2014-2020, which provides extra payments for farmers complying with the 'greening measures' such as leguminous crops (as part of EFAs), as well as extra subsidies for leguminous crops under agri-environment-climate scheme, are not sufficient to improve farmers' fodder autonomy (5.2.1.1). In addition, prolonged periods of droughts, further impede the growth of legumes, which require a lot of water (5.1.1). However, according to the representative of EKOLAND in Western Pommerania Poland is able to become self-sufficient in fodder (Interview, March 2017). Either way, the case of soybeans indicates that there is a great room for improvement in terms of GMOs[52], which could be prohibited from the market in order to make a room for locally grown fodder.

5.2.3.3 *Plant protection products*

Many of the interviewed conventional farmers admitted to apply heavier dosages of pesticides nowadays than in the past[53]. As of farmer who was cultivating only 3 types of cash crops said: '*Now you use more pesticides than before, maybe less were used in the past but had lower quality. Now they are much better and the substances are active throughout the entire period of plant's vegetation. My entire profits come from crops and a good quality of seeds*' (LUB_C2). Moreover, according to a certification body from Bioekspert, '*one of the*

[52] More information on GMO-oriented policies is available in Appendix E4

[53] The Figure D12, Appendix D, shows that high amounts of herbicides and fungicides are being applied yet they seem to be on the rise as the dosages in 2005 were higher than the dosages in 2015

recent reports showed that 49% of food samples were contaminated with pesticides above permitted threshold' (Interview, March 2017). It can be argued that such increased dosages of pesticides stem from the ongoing issue of climate change, which greatly hampers control of pest and disease invasions that are becoming more common (Morelle 2013). However, yet given that pesticides disrupt nitrogen fixation, thus posing a risk for effective diversification of crop production with leguminous crops; by diversifying crops it is possible to evade invasions of pests, weeds and fungi (Potera 2007; Granstedt 2012). Nonetheless, when the same farmer (who was cultivating only 3 types of cash crops) was asked about whether he would be willing to diversify his production as a way of increasing resilience to pests and weeds, he responded that it would include '*too much work on such a big tract of land*' (LUB_C2), thus further signalizing the detrimental impact of increasingly bigger land sizes in such a globalized economy for up-scaling of recycling principles.

5.2.3.4 ***Fossil fuel dependent machinery***

Following the country's access to the EU, which provided farmers subsidies, there has been also a notable increase in the demand for agricultural and fossil-fuel dependent heavy machinery such as tractors to facilitate management of increasingly bigger and crop-specialist farms. For example, during the period 2007-2013 farmers purchased more than 340 000 machines and technical equipment to improve crop and animal production as well as more than 55 800 000 tractors (MINROL 2016). Likewise, the interviews revealed that while in the early post-war period farmers used to rely on draft power (e.g. to spread manure); farmers currently tend to invest a lot of money in a modern machinery, even if that means they have to rely on bank loans, which are very hard to pay off when the prices for commodities are low. For example, while one crop-specialist conventional farmer who owns a farm whose size is 130ha mentioned: '*Now I manage everything with machinery with my son. The machines must be* *modern and efficient'* (LUB_C2); another farmer highlighted that: '*You can take loans but they involve burdensome bureaucracy not to mention the trouble to repay them later on'* (GP_C10).

However, the key limitation of dependence on such modern machinery for up-scaling of recycling principles is their high capacity: '*These modern machines have the capacity to work on 300ha*' (LUB_C2). Therefore, given that the machines are currently designed for large farms[54] (yet the agricultural land in Poland remains greatly fragmented), they seem to propel farmers to further enlarge their fields (and specialize in crops) in order to match the capacity of such machines, thus creating unfavorable conditions for scaling of recycling principles. For example, one farmer mentioned: '*Farmers want to evolve and if a possibility arises they are willing to take any land, even far away. Their machines are so big that it is cost-effective for themselves to drive further away to cultivate fields*' (GP_C7). The above statement implies that owners of such big machines are even willing to travel across large distances to other farms in case they cannot buy/lease land in proximity to their land.

The situation is exacerbated by the fact that the interviewed farmers did not express any particular willingness to share machines with smaller farms in which they invested a lot of money ('*Everyone wants to have his own tractor'* (LUB_O3)), unless they are willing to share them within small family and friend circles (LUB_C2; LUB_C3). It leaves no doubt that farmers' decisions to make such big investments can be shaped by viewing the reliance on big machinery as a way of 'moving backward', rather than as a way of 'moving forward' as typical of Western countries in such a globalized world (GP_C10). It is

[54] After the collapse of communism and state-owned farms in the early 90s, the country allowed the encroachment of foreign companies to which it sold factories that used to produce machines for small and medium-size farms for re-modernization; or liquidated those factories as part of the larger 'de-industrialization' process. The core motivation behind such decision was the belief that the machinery produced by (once state-owned) factories, was inefficient and cumbersome when compared to Western European countries, which have been clearly oriented at structural rationalization. Consequently, the machines produced by western companies are currently designed for big farms (Banski 2009; Pine 2007; Slezak 2013; Newseria 2013). Likewise, a representative of the Museum of State Owned Agriculture in Bolegorzyn mentioned that during the communist period the majority of the machinery for Polish farmers was made in Poland and was mainly designed for smaller farms (Interview, March 2017).

also worth mentioning that the technology penetrated different regions in the country with different speed. For example, farmers in the Carpathian mountains (Sub-Carpathian voivodship), contrary to those in Lodz voivodship (which went a dramatic de-industrialization after demise of socialism), took much more time to abandon sentiments related to social and reciprocal nature of their work that was based on kinship in order to embrace (at least partially) the 'industrial/ technological spirit' after the collapse of socialism (Pine 2007). Such phenomenon might imply that some farms, especially the ones, which are 'locked' in the mountainous terrain, are still less advanced in terms of technology. Therefore, they may better receive the idea of adopting recycling principles. To further support this reasoning, the study conducted by Chaplin *et al.* (2007) demonstrated that the farms with lower physical capital are most willing to diversify their production.

Interestingly, one farmer also mentioned that: '*In the past there used to be agricultural clubs and farmers could share machines between each other. Now everything is gone'* (LU_C14). Such 'agricultural clubs' were common during the communist period when the so-called State Agricultural Farms (established via the Fund for Agricultural Development in 1959) were allowed to dominate the Polish agricultural landscape. The members of such clubs had access to machines that could be used on sharing basis (Banski 2009). Had such collective sharing of technology via agricultural clubs been maintained, the efficiency of integrated mixed crops-livestock systems based on recycling principles could have been increased (Moraine *et al.* 2014).

On the good side, one organic farming, who is also relying on draft power and seemed to have already adopted recycling principles, stated: '*You need to emulate a Swiss model of land management, which combines old practices with modernity. For example, a good tractor increases efficiency*' (LUB_O1). Such statement further corresponds with the idea behind 'recycling agriculture', which does not exclude any 'modern/technological' devices that could increase its efficiency (e.g. the BERAS project has already promoted three software tools, which can assist in planning of crop rotations).

5.2.3.5 *Biogas industry*

Even though the biogas industry is still emergent, i.e. is not yet deeply rooted in the 'agro-technological' regime in Poland, it can be argued that it's a promising technology whose development can help to cope with manure surpluses. However, it can be also argued that biogas installations can also indirectly influence up-scaling of recycling principles in terms of its potential ability to stimulate enlargement of large pig facilities, which are characterized by high livestock concentrations (that are not balanced with land acreage). Given the limited scope of this paper, the latter reasoning is explained in Appendix 5 (5.6).

5.3 NICHE LEVEL

The niche levels refers to insulated spaces, which can concern research and development (R&D) as well as civil society organizations and initiatives. Nonetheless, whether these spaces can bring a radical change in the established agricultural regime and 'push scale' recycling principles, depends on the willingness of policy-makers to allocate more subsidies in the Pillar 2 of CAP, which could help to better support social infrastructures.

5.3.1 Research and Development (R&D)

One of the important protected spaces in the niche level, which could support scaling of recycling principles, can refer to the field of research and development, which is usually associated with various research initiatives at EU or national level (e.g. programs falling under Horizon 2020[55]) that correspond with recycling principles promoted by the BERAS project. However, whether policy-makers would like to take the research findings related to recycling principles for granted (incl. findings

[55] More details on research initiatives at EU level (Horizon 2020) are available in Appendix E6.

of the BERAS project) and decide to integrate them into rural development programs as well as shift funding from the Pillar 1 to the Pillar 2, remains dubious. In other words, the main challenge here is whether policy-makers would be willing to consider the implementation (and thereby funding) of programs oriented at nutrient recycling over the implementation of those, which support modern, fertilizer-based production methods (e.g. smart fertilizers), which seem to only address symptoms rather than the root causes of the current socio-environmental problems (these fertilizers are part of the bigger, fossil fuel dependent fertilizer industry). It could seem that a promising step is one of the outcomes of the meeting of the Ministers of Agriculture of the Visegrad Group[56], which called for '*the stronger inclusion of the research potential of the Central and Eastern European (EU-13) countries into the implementation of projects within the Horizon 2020 in the field of agriculture, including the bioeconomy*' (Council of the European Union 2016). However, since one of the national objectives is to 'modernize sector' and the precision farming technology is highly valued (and likewise contained within the Horizon 2020) (Interview with Dr Gradziuk from IRWiR PAN, April 2017), it remains dubious whether farmers would like to consider adoption of projects based on traditional knowledge as part of agro-environmental schemes in the current economic climate.

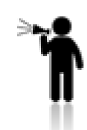
The interviews also revealed that younger generations seem to be often guided by parents (older generations) in favor of pursuing activities that are not necessarily sustainable (e.g. use of fertilizers), yet are describable as 'modern' in a globalized economy (LUB_C2; Interview results by BERAS). Interestingly, one owner of the big pig farm producing nearly 15 000 pigs per year said that he became a pig producer from the very beginning: '*I didn't want to go to army so I bought 12ha and then we increased it up to 200ha. All my life is about pigs*' (GP_C10). When asked why he does not also focus on crops he said: '*No way, I know nothing about it*'. Moreover, even though one farmer mentioned that '*Here in this*

[56] Member of Visegrad group are as follows: Bulgaria, Romania, Slovenia and Poland

area only the best farmers remained, they are all well-educated' (GP_C9), in this area there were only large, modernized, crop-specialist farms. Therefore, it could be argued that the farmers working on these farms could be more interested in pursuing economies of scale at the lowest cost with the help of modern technologies rather than trying to adopt agro-ecological recycling principles, which require more local knowledge that has been passed from generation to generation. As a member of EKOLAND in Western Pommerania mentioned: '*Anyone can be a farmer, but not everyone can be an ecologist*'.

It is also important to mention how one **organic farmer** commented on his academic curriculum: '*there was nothing related to ecology at all, they teach you about 'modern' ways of farm management*' (LUB_O1). Similarly, a member of organic farmers' union (EKOLAND) added that ecological farming disappeared from research and policy agenda: '*the books written by pioneers and scholars on ecological farm*ing *are not easily accessible*'. Such confessions imply that a reform at the University level in order to enable dissemination of knowledge about agroecological practices is required, yet it is likely to be greatly opposed as those in power privilege intensive farming practices, as typical for Western countries. Even though one of the answers provided by the Ministry of Agriculture to the questionnaire concerned coupling crops with livestock as one of the measures helping to make agriculture more sustainable (April, 2017), no action has been taken in this direction.

5.3.2 Civil society (NGOs and farmer unions)



Civil society organizations such as NGOs are another form of 'protected spaces', which can help to share knowledge on recycling principles across the country and lobby to impact the political agenda. For example, organizations such as IFOAM EU are currently lobbying for policy changes, especially within the CAP, which could help to support the integration and scaling of recycling principles, especially in the context of lobbying for better greening measures and removal of mechanisms that enable to shift payments from the 1st Pilar of CAP to the 2nd Pillar (IFOAM 2017). There are several pro-active NGOs at country level such as International Coalition to Protect the Polish Countryside (ICPPC) or WWF (World Wildlife Fund). While the ICPPC is greatly lobbying for the reduced imports of GM soybeans (ICPPC 2017); WWF is spreading the knowledge about the eutrophication of the Baltic Sea and lobbying for changes in the CAP by postulating the reinforcement of the 'polluter-pays-principle' and the use of EU subsidies solely to generate 'public goods', which is important from the perspective of scaling recycling principles. WWF also created the so-called Program for the protection of the Baltic Sea (WWF BEP), which cooperates with WWF branches and partnership NGOs in all nine Baltic States (WWF Poland 2017a and 2017b). Interestingly, the representatives of WWF declared their willingness to conduct trainings for farmers, which would be concerned with recycling principles (Interview by BERAS, August 2016). However, it could be argued, that these NGOs are marginalized in the face of large food corporations, which have a strong lobbying power.

5.3.3 Farm advisory services and Farmers' unions

Following Poland's accession to the EU, the country introduced farm advisory model (FAS), which is governed by the EU Act on Agricultural Advisory Bodies. Apart from helping farmers to solicit EU subsidies, the Polish rural advisory services, which are mainly managed by the public advisory services help to spread the knowledge on farm management practices via trainings or coaching. Therefore, it can be argued that FAS are protected spaces that can help to diffuse the knowledge on recycling principles once they are encouraged to do so. For example, a representative of agricultural advisory services in Pomerania voivodship mentioned that: '*In our region we don't promote huge farms, and we don't give them the advice to go larger and specialize'* (Interview by BERAS, August 2016). The same advisor also revealed that the advisory services have a close interaction with the Ministry of Agriculture and usually do what they are being told by the Ministry (Notes by Sheshti, August 2016). Therefore, it can be still reasoned that the ‘advices’ by advisory services match the productivist agricultural paradigm (5.2.1.1), especially given that the private advisory units keep emerging and are mainly created by large agricultural producers and distributors of products for agriculture that do not value economies of scope (Igras *et al.* 2014).

One issue concerning incompetency of advisory services was raised by an organic farmer who once were charged a penalty fee by the Agency for cancelling a crop rotation during the 5-year cropping system. According to this farmer, ‘*What advisory services suggest, e.g. trainings, is of no use to me and I know more than they know’* (LUB_O1). Since this farmer was a Master graduate in Horticulture and unlike the majority of the agricultural advisors was working in the field, it could be argued that some agricultural advisors in the country might indeed lack competency, and thereby potentially even willingness to promote recycling principles. Moreover, according to Jorgensen *et al.* (2013), there is still not enough attention being paid to recycling principles promoted so far by the BERAS project through agricultural extension services. However, an organic farmer quoted above also mentioned: ‘*It wasn’t until I met Mieczyslaw Babalski – a pioneer of organic farming in Poland, who gave an inspiring lecture during an event called ‘Dobre Zniwa’ (‘Good Harvest’). He made me realize that it is impossible to be a prospering organic farmer’* (LUB_O1). Such statement clearly reveals that it is extremely important to have a well-established network of educated and experienced organic farmers in order to facilitate knowledge exchange and let innovative ideas spread across the country (Mr Babalski comes from the Kuyavian-Pomeranian voivodship). The existence of such inspiring pioneers in the country, who are open-minded and willing to teach other farmers (it is worth mentioning that the same farmer, Mr Bablski, actively participates in BERAS project), opens a window of opportunity for the wider employment of truly sustainable agricultural practices.

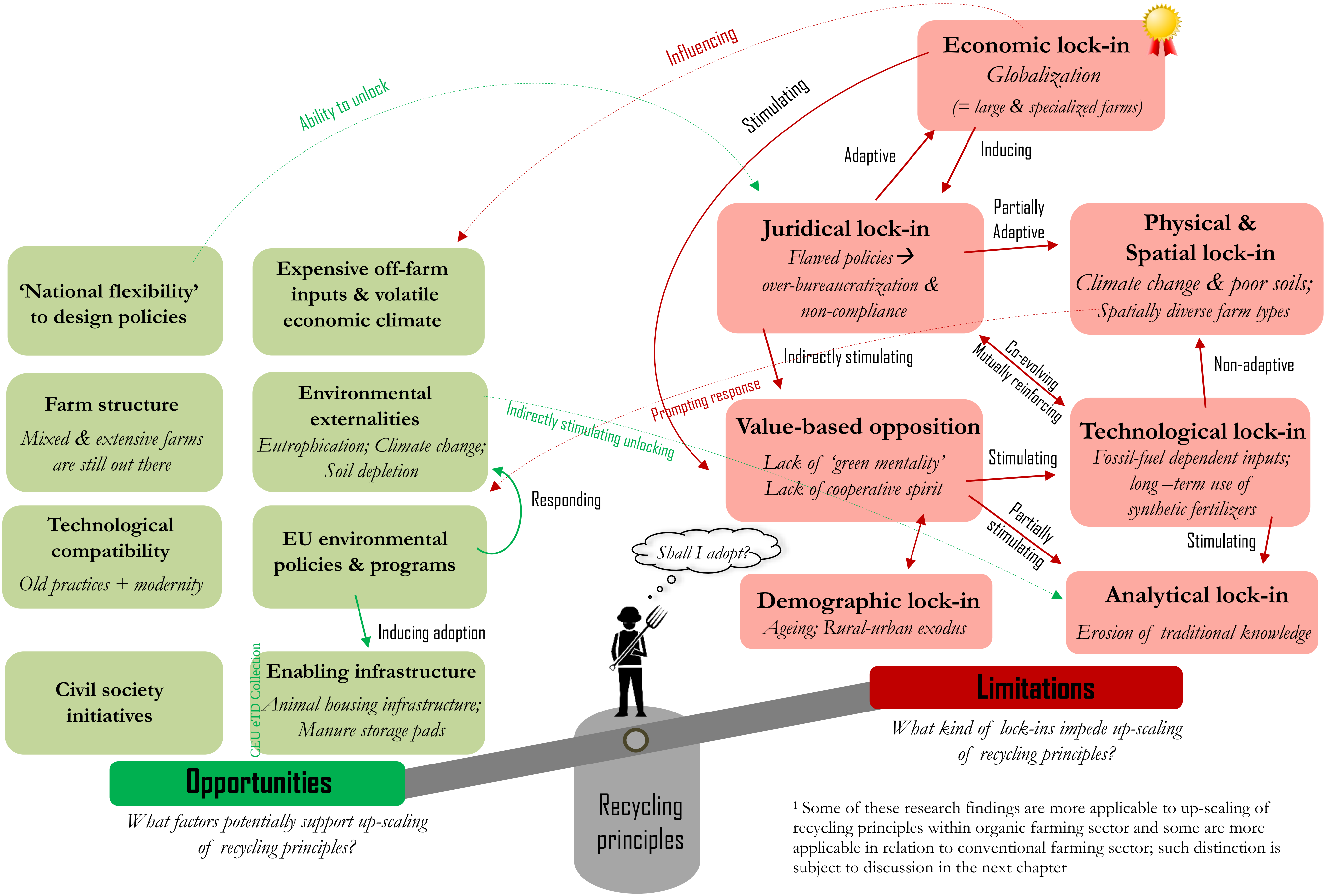
The **farmers’ unions** (e.g. EKOLAND in case of organic farming) also play an important role as they unify farmers (be it organic or conventional) and provide them with necessary practical support.

Interestingly, Dr Gradziuk also mentioned that: '*Around 20 years ago I created a big union of nearly 100 farmers. We were starting from 30ha and we have 200ha. Farmers cooperate together, they buy various farm inputs together as they know that there is a power in unity. It's not a support for producer groups, which usually have purely commercial interest but a union based on mutual support*'. Such statement further implies that farmers can be actually willing to cooperate together as long as there is a platform for such collaboration, which serves their needs.

5.3.4 Small local markets

Small local markets are another area where consumers can support agricultural innovations such as recycling principles and stabilize farmers' incomes. However, as the subsection 5.2.1.3 revealed, the local markets are developing slowly, and the current consumption patterns are unlikely to indirectly stimulate the maintenance of mixed crops-livestock systems. By referring to **organic farming** sector specifically, various studies reveal that the local distribution channels including local food cooperatives as well as processing industry in case of organic farming are still in infancy, and such situation is likely to continue to dominate as long as the agro-food industry maintains its control over food processors and retailers, and (both regional and local) policy-makers do not support local initiatives (Kaziemierczak *et al.* 2014). However, one organic farmer (LUB_O3) mentioned that he is currently selling his products via food cooperative in Lublin city, thus highlighting that such initiatives are out there and require extra support.

Figure 5.2: Overview of key research findings[1]



[1] Some of these research findings are more applicable to up-scaling of recycling principles within organic farming sector and some are more applicable in relation to conventional farming sector; such distinction is subject to discussion in the next chapter

Table 5.2: Challenges and limitations for up-scaling of recycling principles in relation to Roger's (2003) theory of perceived attributes

Perceived attribute	In favor of up-scaling of recycling principles	In disfavor of up-scaling of recycling principles
Comparative advantage	- benefits environment (prevents soil depletion) and helps to restore nutrient balance; - health benefits (organic farming); - relatively better financial security than in case of specialized farms (e.g. if crop sector fails to provide outputs; the livestock sector can provide income) - autonomy in fertilizers and fodder	- high production costs as the environmental costs are internalized - farmers are likely to cooperate as long as they can maximize their economic profits (rather than achieve environmental benefits) - over-bureaucratization
Complexity	- smart cropping strategies can be facilitated with modern technology	- requires more knowledge (e.g. application of synthetic fertilizers is easier than maintenance of crop rotations) - requires extra labor (e.g. to take care of livestock on regular basis) - requires extra organizational skills (e.g. to establish cooperation between two specialist farms)
Trialability	- there are still many traditional mixed crops-livestock farms	- start can be difficult (especially in case of organic farming as weed invasions during the conversion process were frequently reported) - some regions tend to be more specialized in crops and some more in livestock (spatially differentiated types of production) - extra policy regulations are likely to meet objection
Compatibility	- Does not exclude modern technology (promotes sharing of machinery) - Benefits are based on sound science	- Increasingly perceived as 'obsolete'/'backward'
Observability	- Even though benefits such as increased soil permeability are observable after the prolonged period of time, they are long-term	- Benefits associated with improved water quality are not 'tangible' as long as farmers are located in proximity to polluted (and potentially) restored water reservoirs - Mineral fertilizers can help to achieve high yields within a relatively short time, yet the prolonged use thereof can contribute to soil depletion

6 DISCUSSION

This chapter revisits the results presented in the previous chapter and highlights the most significant challenges and opportunities for up-scaling of recycling principles within the conventional and organic farming sector. It also shows how some of the challenges can be turned into opportunities and discusses the complex interactions between respective aspects associated with up-scaling of recycling principles. Lastly, it attempts to briefly depict possible future trajectories within the agricultural sector, which can have implications for up-scaling of recycling principles across the country.

6.1 KEY OBSERVABLE CROSS-LEVEL INTERACTIONS

The application of the Multi-level framework enabled to depict farmers as actors situated at the intersection of '*tensions of different demands linked to different regimes*' (Sutherland *et al.* 2015). It also clearly showed how actors involved in scaling of recycling principles at the niche level find a 'natural ally' in actors from the environmental protection regime. Howeverm the niche actors remain constrained by the dominant agricultural regime in which policy-makers seem to be clearly oriented at structural rationalization of agriculture. In order words, there is a notable policy stigmatism toward knowledge-intensive practices, which can be beneficial for the natural environment, in favor of intensive farming practices whose consequences are manifested in the form of negative socio-environmental externalities at the landscape level (e.g. soil depletion). However, the dominant policies are likely to be destabilized by the landscape-level pressures (e.g. droughts) whose repercussions are becoming more notable in the absence of preventive and adaptive policies. Overall, there is a noticeable tension between national objectives within CAP that contradict the premise behind recycling principles; and environmental protection policies, which set specific targets for nutritional balance to be met by the dominant agricultural regime. Nonetheless, there is not enough action done by the state in the latter direction and the role of actors at the niche level in push-scaling agroecological practices is greatly diminished by the dominant regime in terms of limited social infrastructure (educational services) and the fact advisory services maintain close ties with the state.

6.2 FOREMOST CHALLENGES

The most prominent challenges for the wider adoption of recycling principles can be defined as 'juridical/institutional' and 'economic lock-ins' that (in)directly induce the so-called 'technological lock-in'. All of these lock-ins perpetuate path dependencies and are embedded within the wider socio-economic and environmental landscape context. According to Foxon (2002), '*Institutions may be defined as any form of constraint that human beings devise to shape human interactions. These include formal constraints, such as legislation, economic rules and contracts, and informal constraints, such as social conventions and codes of behavior.*' While these 'formal contraints' can be referred to as policies that 'enable change' in favor of agroecological innovations such as recycling principles, the research findings imply that the dominant agricultural policies can currently only hamper up-scaling of recycling principles. One of the most contested formal contraints refers to the system of subsidies. This is because the highest amount of subsidies is allocated for direct payments (Pillar 1), which are based on farm acreage; rather than on what is actually being produced at the farm level. In result, the subsidies promote farm enlargment, which increases the distance between the farms; has implications for effective inter-farm cooperation and adds extra transportation costs. More importantly, yet correspondingly to the Literature Review, farmers take a dangerous jog on the treadmill of production (i.e. rely on subsidies) in order to counterbalance falling **commodity prices** triggered by their exposure to volatile global markets. Consequently, they are often loosing autonomy over their production and tend to produce crops that are subsidized. The subsidized crops are usually cash crops (e.g. cereals), which are demanded globally, and whose production is deemed cost-effective as long as it occurs on a big scale, preferably on large, monocultural specialized farms. What is more, the uneven spatial distribution of these crop-specialist farms versus livestock-specialist farms creates conditions whereby some areas suffer from nutrient deficit and some others from nutrient surplus, yet the potential cooperation is impeded due to large distances among these farms. While agricultural subsidies were one of the key reasons behind the decision to pursue membership in the EU (Gill 2009); many farmers, especially small and medium-size, admitted that the subsidies can barely compensate increasing production costs. While it could seem that the development of local market infrastructure could help to further mitigate such threats by increasing farmers' resilience to the erratic economic climate and preventing them from abandoning mixed crops-livestock production, the local market infrastructure remains underdeveloped and the demand for locally produced products low. This is because the markets are being flooded with cheap products upon the ratification of bilateral trade agreements with other countries (e.g. CETA).

The complex institutional setting reinforces and co-evolves with the set of dominant technologies and practices. This is because the subsidy-induced farm enlargement and specialization in either crops or livestock are usually accompanied by the reliance on synthetic fertilizers, pesticides, fossil-fuel dependent dehydrated manure, feed concentrates based on genetiacally modified soybeans (stimulating high concentrations of livestock) and fossil-fuel dependent machinery. Even though the prolonged utilization of synthetic fertilizers can contribute to soil depletion, and the capacity of the produced machinery often exceeds the capacity of the cultivated land (thus only further stimulating farm enlargement), such technologies are widely considered to have a competitive advantage over recycling principles, primarily due to labor saving costs in increasingly depopulated rural areas. Overall, the availability of such inputs seems to only outstrip farmers' ability and willingness to rely on local, traditional knowledge, which is perceived as obsolete. Consequently, yet in the line with the Literature Review, farmers are becoming increasingly trapped in the so-called 'technological treadmill', which further reflects the dynamics of global networks (e.g. the above off-farm inputs are fossil fuel dependent). More importantly, the heavy dominance thereof over alternative agricultural practices in the Polish agro-food regime, is strenghtened by the large lobbying power of big corporations producing such inputs/machinery. As such, scaling of recycling principles is a very challenging process by virtue of **contrasting aspirations** not only among farmers but also among policy makers who tend to invest in technological innovations (e.g. precision farming) that are believed to render higher economic returns than those, which are generated by environmental schemes and programs designed to bring about organizational and social changes in farm structure.

Moreover, the state does not comply with certain regulations imposed by the EU environmental protection regime. For example, Poland does not require licenses for farms with cattle over 300LU (European Court of Auditors 2016), and the Directive on industrial emissions (2010/75/EU), EU Nitrate Directive (91/676/EEC) or the Helsinki Convention were reported to be commonly disobeyed, especially when it comes to the livestock sector (see Appendix X). It is important to highlight that the current regulations seem to be more 'bearable' among large farms rather than small farms, which seem to struggle with existing regulations much more. This is because many of these small farms are still run by farmers who are not only owning the land since they were born on it, but are also working on it physically. Overall, such alleged lack of compliance with some of the rules and tendency to favor large farms over small ones, only indicate that any extra ceiling on animals to create a better ground for recycling principles (which should be much, much lower), or introduction of agro-environmental schemes related to recycling principles, are likely to be greatly oppressed as policy-makers are clearly oriented at structural rationalization[57].

In the light of such challenges, yet with regards to the Fish *et al.*'s (2003) and Wilson's (1996) farmer typologies, the great majority of the interviewed farmers can be classified as 'conditional non-adopters' who seem to be likely to adopt a scheme/agroecological innovation as long as they can achieve economic benefits out of it in such a globalized economy ('opportunist participation style'). Since the great majority of farmers (especially conventional ones) perceived recycling principles as not cost-effective due to their knowledge-intensive nature and perceivably lower yields in the face

[57] Such lack of compliance and less stringent regulations for animal industries, especially swine industry, might stem from the fact that Poland is planning to increase exports of pork by 15% by 2020. Paradoxically, pork it one of the major imported commodities in the country (MNROL 2016a).

of climate change, they can be also classified as 'disinterested' therein. Moreover, even though, some of the large-scale (approx. 150ha) 'conditional non-adopters' admitted to have limited capacity to adapt to the ongoing climate change, they did not perceive recycling principles as a good solution in the current economic climate. Likewise, one farmer who stated that there should be programs to rebuild soil humus (LUB_C1), was not interested in adopting recycling principles unless he was incentivized enough by economic means. The interviews also revealed that some of these 'disinterested' yet 'conditional' non-adopters seem to have vested interests as they receive subsidies, yet they produce nothing at all, and thereby limiting the availability of land for farmers who need it to grow forages, thus preventing those farmers from adopting recycling principles. Overall, such attitudes imply not only the flawed nature of policies, whereby the 'greening measures' seem to be just a 'cosmetic mask', but also general lack of interest in environmental protection measures. This might stem from the fact that farmers who were once greatly connected to their land, are currently becoming big land owners who do not seem to behave as if they were guardians of the natural environment. Moreover, the 'disinterested' farmers seem to be also 'disempowered' by the unavailability of workforce and attitudes of young people who are disinterested in agro-ecological practices that are generally perceived as 'backward'. More importantly, even though some of the farmers are willing to protect the natural environment by adopting more sustainable practices such as recycling principles ('conservation-oriented' farmers), they remain 'disempowered non-adopters' who feel forced to pursue less sustainable practices (e.g. apply synthetic fertilizers or import fodder) in order to sustain themselves in a competitive market economy. The 'conservation-oriented' and 'conditional non-adopters' can be additionally described as 'skeptical' due to the complex nature of the bureaucratic system, which seems to discourage many farmers from pursuing animal production (incl. those who had already invested into animal infrastructure such as manure storage pads and animal housing).

6.3 A WINDOW OF OPPORTUNITY?

Since the agri-food chain is becoming increasingly dependent on fossil fuels, the prices of agricultural inputs such as fertilizers are correlated to oil prices. However, in case there is a peak oil or even a political conflict on a global scale, it can be argued that farmers are likely to either abandon agricultural production and allow shrubs and weeds to take over; or pursue extensive agricultural practices, thus opening a window of opportunity for adoption of recycling principles. It can be also reasoned that high prices of fertilizers might contribute to the maintenance of mixed farm enterprises, especially in terms of on-farm mixing given that between-farm mixing requires extra energy supply for transportation. Besides, some of the environmental challenges such as prolonged droughts are already being turned into opportunities for up-scaling of recycling principles as some of the farmers are prompted to search alternative ways of production.

Given that the farming sector in Poland is often accused of contributing to the Baltic Sea eutrophication (HELCOM 2011), the EU policies related to nutrient management are likely to keep pressurizing the Polish state to implement relevant actions to retain nutrients at farm level and increase synergies between farm components. Programs such as Baltic Sea Action Plan (BSAP) or General Union Environment Action Programme to 2020 'Living well, within the limits of our planet' (see Appendix E7) as well as NGOs (e.g. WWF) can be expected to exert further pressure to modify policies and increase farmers' environmental awareness.

Moreover, despite the trends toward increasing farm size and land ownership, the interviews also confirmed that the Polish agricultural landscape remains greatly dominated by small scale, extensive private farms. Some of the small and extensive farmers can be described as 'conservation-oriented' potential adopters who already partially comply with some of the recycling principles (e.g. they have balanced livestock production but import feed concentrates). This is because Poland, being a relatively new EU member state, has not yet underwent modernization of agricultural sector as typical for older member states. Moreover, Dr Wrzaszcz added that the protection of small-scale farmers is a priority that is written in the Polish Constitution (and such was reflected in the new laws on the land acquisition and direct sales) (Interview, March 2017). Therefore it can be noted that the state seems to be torn between conflicting demands linked to social expectations and global trade dynamics. More importantly, given that the national and regional governments have the right to decide on how to allocate EU funds, it could be argued that in case they are steered in the right direction, they could allocate funds in support of farms with mixed crops-livestock production as well as for produced fodder rather than livestock units (more follows in 6.1 Recommendations). More importantly, the agroecological practices based on recycling principles do not lie in oppossition to the statment made by Dr. Gradziuk: '*Farmers want to live in dignity'* as there are various technological tools to support them on the path to toward sustainability.

By further referring to farmer typologies, it can be noted that there are also several '**active adopters**' who are '**enthusiastic**' about protecting natural environment (and their health) by adopting sustainable farming practices and learning from 'pioneers' in the field. These farmers are usually young entrepreneurs ('*organic farmers from flesh and blood*' (GP_O9)) who depend on limited local market infrastructure and some of them are even unwilling to rely on the system of subsidies, which adds extra responsibilities that might lie in opposition to their system of moral values ('*One should be eligible for subsidies as long as he can return the money*' (GP_O9)). According to Slazak (2013), approx. 1 million ha of agricultural land are not subject to any subsidies, even though these farmers could solicit direct payments.

Moreover, some of the active adopters did not display a mood for modernization by putting emphasis on technological artefacts as it took place in the West, thus implying that social expectations, visions and policies are semi-coherent due to internal disagreements. However, there is also a certain degree of 'technological compatibility' between old and modern practices as there are various 'modern' tools to complement the knowledge-intensive recycling principles, and thereby open a window of opportunity for up-scaling thereof once relevant promotional programs are in place.

6.4 Organic vs. Conventional

The recycling principles render the best outcomes once they are employed according to standards for organic agriculture. However, the high production costs (incl. a need for workforce), strict regulations and over-bureaucratization (especially when it comes to animal raising) lead farmers to abandon organic farming, or specialize in organic crop production. Overall, integration/scaling-up of recycling principles within the organic farming sector in Poland is not likely to happen on a big scale (if at all) as the conventional farming sector, which has dominated the agricultural landscape, seems to be better adapted to respond to the growing global demand for products such as cereals. The organic farmers seem to be much more affected by the current system of policies that grant insufficient subsidies to compensate high production costs, than the conventional ones. Even though organic farmers tend to better engage with society, there is not enough demand for organic products inside the country. In result only 1.5% within 4% of organic arable production is estimated to be associated with a real production (Interview with a representative of the Polish Ecological Club, March 2017).

6.5 Looking toward the future

When asked about the future outlook, the interviews revealed that farms are most likely to keep expanding at the expense of the demise of small farms, which are not expected to bring any significant economic gains, especially in the face of the growing absence of farm successors. Moreover, in case the subsidies prevail for land acreage rather than production, and the greening measures remain relatively easy to comply with, the remaining small farms are likely to keep relying on subsidies as a way of income. Therefore, it is likely that the polarization between small and large farms will increase, especially between Northwestern and Southeastern parts of Poland, which had different historical past (Interview with Dr Wrzaszcz, March 2017). Such polarization is only likely to further erode the cooperative spirit among farmers and steer them toward pursuance of economies of scale coupled with reliance on off-farm inputs. However, it is still possible to prevent farmers from repeating the scenario of older EU member states, especially given that is has been already proven detrimental to the natural environment. Similarly, the past experiences from the early 70s when the state-owned farms began to create specialized and mechanized multi-plant enterprises in Poland, likewise demonstrated that such endeavors did not prove to be effective in the long run and ultimately collapsed in favor of smaller farms[58].

While the course of negotiations of EU with WTO as well as within the EU on the future of subsidies remains unknown, some of the positions of old EU Member states such as Germany indicate that they are likely to cut direct payments, as they have already 'learnt from their mistakes' (ARC2020 2015b). In such case, old member states might redistribute rejected funds to new EU member states (i.e. Poland), which have been receiving lower EU subsidies since the very beginning of their EU membership. Either way, whether those funds are to be allocated to agro-environmental schemes (Pillar 2) to the larger extent than now, depends on whether the next CAP reform will again enable policy-makers to easily shift funds from Pillar 2 to Pillar 1. More importantly, even if recycling principles would constitute part of the agro-environmental scheme, they are going remain a voluntary measure, and, basing on interviews, many funds would have to be allocated for it in order to increase farmers' willingness to adopt it. One could also argue that elimination of subsidies could create synergies between farm components and thereby improve fodder and fertilizer autonomy (FAO 2011). However, such situation is unlikely to happen since the EU is a political and economic union that maintains trade links within and outside its domain[59]. In result, the scenario whereby a cooperation between two commercial yet specialized farms is established, seems to be the most relevant as long as it is brought to the forefront of policy-makers at EU and then national level. In such case it might seem that it would be possible to embrace the

[58] Such circumstances reflect the so-called 'paradox of scale' whereby small and diversified farms can be more productive per area than large monocultural farms (Tscharntke *et al.* 2012)

[59] *'If such practices were introduced for conventional farms at EU level, EU would be disqualified in relation to economic currencies in Canada, North/South America*' (Interview with representative of Poland at Copa-Cogeca, Organic farmers' meeting in Lublin city, March 2017)

neo-productivist paradigm according to which '*sustainable intensification agenda linking global-market competitiveness with environmental protection*' (Levidow and Pimbert 2016). However, it can be then argued that under such conditions farmers are likely to cooperate under 'official agreements' and be largely motivated by economic benefits and boosted productivity linked to such cooperation (exchange of raw materials), rather than by the desire to preserve the natural environment and diversify the produce. Therefore, it can be reasoned that the wider policy reforms are a necessary but not a sufficient condition for scaling of recycling principles. What matters is the rise of environmental consciousness, which, once awakened could propel farmers to 'adopt the pace of nature' i.e. use natural resources in a manner that does not disrupt ecological balance, even if at the cost of lower yields and extra 'mental inputs'. In other words, farmers should reassess what components of farming can be regarded as 'productive' and 'efficient'.

7 CONCLUSIONS AND RECOMMENDATIONS

…Closing the loop?

This thesis identified and explored challenges and opportunities for up-scaling of recycling principles within the Polish agricultural sector in the light of the wider exogenous landscape setting (i.e. physical conditions, geopolitical arrangements, societal values and demographic trends) as well as institutional setting, all of which have implications for the development of dominant technologies, practices and infrastructures, and subsequently scaling of recycling principles. By enriching the analysis of relevant agricultural and environmental policies with perspectives of various stakeholders from the field, it revealed that farmers' behaviour tends to deviate from the established norms and regulations, which are not devoid of flaws and tend to only strengthen the industrial agriculture, thus leaving little room for recycling principles. Moreover, while a greater degree of social capital incl. trust are required in order to insinuate a transition toward recycling agriculture, these aspects seem to be eroded by unstable political and economic situation, which is to a large extent the outcome of political decisions in the past. Similarly to Ciaian *et al.*'s (2009) finding, this thesis revealed that many farms in Poland tend to change production structure (i.e. specialize in crops or livestock, increase farm size or increase livestock population) in order to stay abreast of global food demand and fierce competition for land, rather than adjust farm organization and maintain mixed crops-livestock systems, largely due to marginalization of local markets. Subsequently, the majority of farmers were reluctant toward recycling principles and mainly perceived them as not cost-effective and socially illegitimate. Overall, the Polish agriculture is facing a choice of path for the future. It can either steer toward the path of structural rationalization, which causes abnormal nutrient imbalances in the ecosystem that have long-lasting consequences; or begin to adopt better nutrient management practices to restore the nutrient balance and improve the soil structure. As Bloch (in: Schivelbusch 1986) mentioned:

'*(. . .) the crisis of the accident (of uncontrolled things) will remain with us longer to the degree that they remain deeper than the crisis of economy (of the uncontrolled commodities)*'.

Therefore, it now lies in hands of policy makers on whether they decide to empower extensive, small-scale farmers and 'green' conventional farming sector.

7.1 RECOMMENDATIONS

While some of the recommendations already emerged in the previous chapter in the context of opportunities for up-scaling of recycling principles, the brief overview of recommendations for up-scaling thereof is presented below. More importantly, some of these recommendations were built upon suggestions raised by farmers during interviewing.

7.1.1 Policy recommendations

Reform of the Common Agricultural Policy (CAP)

- ✓ Propose inclusion of recycling principles as part of the greening measures in the post-2020 CAP; offer less flexibility in terms of choosing greening components;
- ✓ Incorporate water protection policies and pest prevention and control policies as part of the mandatory cross-compliance scheme (e.g. the EU Nitrate Directive and even EU Water Framework Directive (WFD) in its entire sense could be included in the cross-compliance scheme within the CAP post-2020);
- ✓ Offer less flexibility in terms of selecting key **national objectives** that do not concern, at least partially, areas that subsidize voluntary agro-environmental schemes, which are built upon recycling principles (including payments for promotional activities, advisory services and short food supply chain development);
- ✓ Remove the mechanism that allows to shift budget from the Pillar 2 into the Pillar 1 in order to better use public money;
- ✓ Allocate direct payments for the production and agro-ecological outcomes ('pay for socio-environmental performance') rather than the number of owned hectares or individual actions, which seem to only stimulate vested interests and disempower smaller farms;
- ✓ Strengthen the importance of the **polluter-pays principle** in order to better balance costs and benefits among various stakeholders involved in nutrient management. Such principle could be reinforced by introducing taxes on artificial fertilizers. However, since the wider adoption of recycling principles is not always determined by economic motivations of practitioners and high dependence on subsidies increases farmers' vulnerability to policy modifications, it is important to highlight that it might not be useful to adopt solely purely

economic policy instruments as a way of incentivizing action (incl. subsidies and polluter-pays principle). For this reason, any implementation of such instruments should be carefully evaluated prior to any formal decisions.

Policy reforms (beyond the CAP)

- ✓ Create **Nutrient Policy Framework** (NPF), which has been already proposed by the Baltic Sea Action Plan (2015), and could help to promote integration of recycling principles within the wider EU political landscape; such framework could incorporate all of the policy recommendations below;
- ✓ Create **Soil Policy Framework** (SPF)[60] to recognize the soil as a common public good and a vital component of the nutrient resource bank at EU level (and subsequently national level; to introduce a requirement for farmers to conduct **soil checks** in order to control/monitor the nutrient content in the soil and better know when and what types of measures should to be taken in case there is a severe nutrient deficit/surplus. The mandatory soil checks could raise farmers' awareness about the negative impacts of high inputs of synthetic fertilizers;
- ✓ Create **Phosphorus Directive**[61] to impose stricter regulations on phosphate mining in favor of local resources (e.g. bone char);
- ✓ Decrease or preferably impose ban on **GM soybeans for fodder processing** from overseas and fertilizer use (by coupling it with **energy taxes**, it would be additionally possible to influence production of synthetic fertilizers);
- ✓ Adopt an instrument of command and control within the organic farming sector in order to **prohibit the use of manure from non-organic** farms where animals are being fed with fodder that is grown with the use of synthetic fertilizers to better close the organic nutrient loop, reduce the support for fertilizer industry, and thereby weaken the conventional fertilizer-dependent agricultural sector;
- ✓ Impose stricter regulations and environmental standards regarding manure handling that should take place locally: at the farm level or between farms located in close proximity.

[60] Even though the European Commission adopted a Soil Thematic Strategy (COM(2006) 231) and the Seventh Environment Action Programme, which acknowledge several threats associated with soil degradation, there is no EU law that would more broadly address the soil-related challenges (EC 2016d). Poland also do not have any specific legislation on soil protection, except the Environmental Protection Act (2010/75/EU), which includes several regulations on soil protection and remediation.

[61] While the Nitrate Directive (91/676/EEC) imposes regulations on the permitted levels of applied nitrogen (N) for all EU member states, there is no officially recognized legislation with regards to phosphorus, which is mined in large amounts in politically unstable regions and contains hazardous (both environmentally and for human health) levels of cadmium

However, given that such regulation could only further discourage farmers from raising animals, it might be advisable to provide more subsidies for the cultivation of animal fodder (rather than per LU);

- ✓ strengthen legal standards for obtaining integrated permit as well as introduce higher ceilings on the permitted numbers of livestock sector in order to reduce the concentration of livestock. The needs of animals should be also viewed by taking into account crop and soil requirements;

7.1.2 Multi-stakeholder engagement and public awareness at local level

- ✓ Establish better cooperation between Baltic member states in order to facilitate adoption of a harmonized approach and unify them around the common vision, which has been already proposed by the Baltic Sea Action Group (2015): '*the transition toward nutrient cycling is a key element for European food security*; *For mankind to survive, nutrient issues, including nutrient cycling must become common knowledge*';
- ✓ Insinuate a collective action at the territorial and landscape level to decrease the spatial segregation of crop-specialist versus livestock-specialist farms by engaging various stakeholders across the entire food production chain (i.e. local and regional governments, farmers, scientists, rural advisory services, food, feed, and fertilizer industry, traders and consumers) - such process could lead to the forumulation of new forms of social organizations and circular business models (i.e. bring about the so-called 'macroscopic transition' that affects various forms of social and political organization (Sutherland *et al.* 2015));
- ✓ Introduce extra labels (e.g. 'Organic Plus' label) for agricultural products to imply how the product was produced (i.e. from recovered nutrients) (even though the presence of extra labels on food commodities could cause additional confusion among consumers;
- ✓ Seek (external) funding to create more educational centers, which could also serve as meeting spaces for farmers' unions and young farmers' associations (the latter ones being closer to grassroots organizations)

7.1.3 Future research projects

- ✓ Research on alternative crops that could substitute imported GM soybeans and match specific pedo-climatic conditions that vary across the regions;
- ✓ Explore the potential for the maximization of benefits stemming from recycling principles by adding extra components such as trees which could add extra biomass that could be consumed by grazing animals;

- ✓ Examine the spatial distribution of local markets that could potentially help to assess the viability of introduction of recycling principles in places which are less vulnerable to being outcompeted by specialized farming systems in such a globalized economy;
- ✓ Design interactive and stimulating games so that farmers could familiarize themselves with various components associated with recycling principles prior to adopting them in the field.

REFERENCES

Agricultural and Food Quality Agency (IJHAR-S). 2015. *Raport o stanie rolnictwa ekologicznego w Polsce w latach 2013-2014* [Condition of organic farming in Poland. The Report 2013-2014]. Warsaw: Agencja Reklamowo-Wydawnicza A. Grzegorczyk.

Agricultural and Rural Convention 2020 (ARC 2020). 2014. Poland Short Changes its Organic Farmers. URL: http://www.arc2020.eu/2014/03/poland-cap-1/

________. 2015a. *Transitioning towards agroecology: Using the CAP to build new food systems*. Berlin: Arc2020.

________. 2015b. CAP direct payments post 2020: German positions. URL: http://www.arc2020.eu/cap-direct-payments-post-2020-german-positions/

Ajzen, I. 1991. The theory of planned behavior. *Organizational Behavior and Human Decision Processes 50*(2): 179-211.

Albrecht, H., Bergmann, H., Diederich, G., Großer, E., Hoffmann, V., Keller, P., Payr, G., Sülzer, R. 1987. *Landwirtschaftliche Beratung. Band 1: Grundlagen und Methoden* [Agricultural extension services, vol. 1: Principles and Methods]. Rossdorf: TZ-Verlagsgesellschaft.

Alkon, A. H. 2008. From value to values: Sustainable consumption at farmers markets. *Agriculture and Human Values* 25(4): 487-498.

Allard, G., David. C., Henning, J. 2000. *L' agriculture biologique face a son developpement. Les enjeux futurs. Introduction generale* [Organic agriculture faces it development: the future issues]. Paris: INRA.

Altieri, M. 1995. *Agroecology: principles and strategies for designing sustainable farming systems.* Berkeley: University of California.

Baltic Marine Environment Protection Commission (HELCOM). 2007. HELCOM Baltic Sea Action Plan. HELCOM Extraordinary Ministerial Meeting.
URL: http://helcom.fi/Documents/Baltic%20sea%20action%20plan/BSAP_Final.pdf

________. 2011. *Fifth Baltic Sea Pollution Load Compilation (PLC-5).* Helsinki: Helsinki Commission, Baltic Marine Environment Protection Commission, Finland.

Baltic Sea Action Group. 2015. *The Role of Nutrient Cycling in Circular Economy*. Brussels: European Union.

Banski, J. 2009. Historia rozwoju gospodarki rolnej na ziemiach polskich. [History of the development of rural markets in Polish agriculture]. In *Człowiek i Rolnictwo* [Humans and Agriculture], ed. Z. Górka and A, Zborowski, 33-45. Cracow: Instytut Goegrafii i Gospodarki Przestrzennej, Uniwersytet Jagielloński.

Bellon, S., Lamine, C., Ollivier, G. 2011. *The relationships between organic farming and agroecology*. Conference paper for the 3rd ISOFAR Scientific Conference - 17th IFOAM Organic World Congress. Bonn: ISOFAR.

Bobik, M. 2010. *Organic Agriculture in Poland: Chances and Challenges, Project Report.* Munchen: GRIN Verlag.

Bochenek, Z., Dabrowska-Zielinska, Ciolkosz, A., Drupka, S., Boken, V.K. 2004. Monitoring Agricultural Drought in Poland. In: *Monitoring and Predicting Agricultural Drought: A Global Study*, ed. Vijendra, K., Boken, V.K., Cracknell, A.P., Heathcote, R.L. Oxford: Oxford University Press.

Bowen, S., and De Master, K. 2011. New rural livelihoods or museums of production? Quality food initiatives in practice. *Journal of rural Studies* 27(1): 73-82.

Breitbart, M. 2003. *Participatory Research Methods. Key methods in geography*. 2nd edition. London: Sage Publications Ltd.

Ciaian, P., Pokrivcak, J., Drabik, D. 2009. Transaction costs, product specialisation and farm structure in Central and Eastern Europe. *Post-Communist Economies* 21(2): 191-201.

Chaplin, H., Gorton, M., Davidova, S. 2007. Impediments to the Diversification of Rural Economies in Central and Eastern Europe: Evidence from Small-scale Farms in Poland. *Regional Studies* 41(3): 361–376.

Compassion in the world farming Polska (CIWF). 2016. Ratujmy nasze antybiotyki [Save our anytibiotics]. URL: https://www.ciwf.pl/dla-prasy/info-prasowe/ratujmy-nasze-antybiotyki/

Cordell, D., Drangert, J.O., and White, S. 2009. The story of phosphorus: Global food security and food for thought. *Global Environmental Change* 19:292-305.

Council of the European Union. 2016. *Outcome of the meeting of the Ministers of Agriculture of the Visegrad Group extended by Bulgaria, Romania and Slovenia (GV4 + 3) on 26 October 2016 in Warsaw - Information from the Polish delegation (14174/16).* Brussels: European Union.

Darnhofer, I. 2014. *Final Conceptual Framework* in: Farming Transitions: Pathways Towards Regional Sustainability of Agriculture in Europe. Vienna: BOKU - University of Natural Resources and Life Sciences.

Derpsch, R., Friedrich, T., Kassam, A., Hongwen, L. 2010. Current status of adoption of notill farming in the world and some of its main benefits. *International Journal of Agricultural and Biological Engineering* 3(1): 1-25.

Donovan G. 2004. *Fertilizer Subsidies in Sub-Saharan Africa* (A Policy Note Draft). Washington, DC: World Bank.

Drengson, A. 1995. *The Practice of Technology*. New York: SUNY.

Duram, L. A. 2005. *Good Growing: why organic farming works*. Lincoln: University of Nebraska Press.

Elzen, B., F. Geels and K. Green. 2004. Conclusion: Transitions to sustainability: Lessons learned and remaining challenges. In *System innovation and the transition to sustainability. Theory, evidence and policy*, ed. B. Elzen, F. W, Geels and K. Green, 282-300. Cheltenham: Edward Elgar.

Erb, K. 2012. How a socio-ecological metabolism approach can help to advance our understanding of changes in land use intensity. *Ecological Economics* 76: 8-14.

European Commission (EC). 2012. *The Common Agricultural Policy. A Story to be Continued*. Luxembourg: OPOCE.

________. 2013a. *CAP Reform- an explanation of the main elements*. Brussels: European Commission.

________. 2013b. Environment: Commission takes Poland to Court over nitrates and water pollution. URL: http://europa.eu/rapid/press-release_IP-13-48_en.htm

________. 2014. Poland: Common Agricultural Policy.
URL: https://ec.europa.eu/agriculture/sites/agriculture/files/cap-in-your-country/pdf/pl_en.pdf

________. 2015. Poland: Common Agricultural Policy.
URL: https://ec.europa.eu/agriculture/sites/agriculture/files/cap-in-your-country/pdf/pl_en.pdf

________. 2016a. Sustainable Food.
URL: http://ec.europa.eu/environment/archives/eussd/food.htm

________. 2016b. *Circular economy: New Regulation to boost the use of organic and waste-based fertilizers* (Press Release). Brussels: European Commission.

________. 2016c. Circular economy: New Regulation to boost the use of organic and waste-based fertilizers, Press Release. Brussels: European Commission.

________. 2016d. Soils. URL: http://ec.europa.eu/environment/soil/index_en.htm

________. 2017. CAP expenditure in the total EU expenditure. Brussels: DG Agriculture and Rural Development, Agricultural Policy Analysis and Perspectives Unit.

European Court of Auditors. 2016. *Combating eutrophication in the Baltic Sea: further and more effective action needed. Special Report.* Luxembourg: Publications Office of the European Union.

Eurostat. 2015. Agricultural census in Poland. URL: http://ec.europa.eu/eurostat/statistics-explained/index.php/Agricultural_census_in_Poland

_______. 2016. Agri-environmental indicator - specialisation.
URL: http://ec.europa.eu/eurostat/statistics-explained/index.php/Agri-environmental_indicator_-_specialisation

______. 2017. Farm structure statistics. URL: http://ec.europa.eu/eurostat/statistics-explained/index.php/Farm_structure_statistics

Food and Agriculture Organization (FAO). 2001. *Mixed crop-livestock farming: A review of traditional technologies based on literature and field experience*. Animal production and health papers 152. Rome: FAO.

______. 2016. Meat & Meat Products.

URL: http://www.fao.org/ag/againfo/themes/en/meat/home.html

______. 2017. Agroecology Knowledge Hub.
URL: http://www.fao.org/agroecology/en/

Fish, R., Seymour, S., Watkins, C. 2003. Conserving English landscapes: land managers and agrienvironmental Policy. *Environment and Planning* 35: 19–41.

Foxon, T. J. 2002. *Technological and institutional 'lock-in' as a barrier to sustainable innovation*. London: Imperial College Centre for Energy Policy and Technology (ICCEPT).

Gazeta Pomorska. 2011. Były jakie były, ale żywiły. Dokładnie 20 lat temu zlikwidowano Państwowe Gospodarstwa Rolne [They were the way they were, but they were feeding. State-owned farms were liquidated exactly 20 years ago]. URL: http://www.pomorska.pl/rolnictwo/art/7223094,byly-jakie-byly-ale-zywily-dokladnie-20-lat-temu-zlikwidowano-panstwowe-gospodarstwa-rolne,id,t.html

Geels, F.W. 2002. Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case study. *Research Policy* 31: 1257-1274.

______. 2004. From sectoral systems of innovation to socio-technical systems: Insights about dynamics and change from sociology and institutional theory. *Research Policy* 33: 897–920.

______. 2011. The multi-level perspective on sustainability transitions: Responses to seven criticisms. *Environmental Innovation and Societal Transitions* 1 (1): 24–40.

______. 2012. A socio-technical analysis of low-carbon transitions: introducing the multi-level perspective into transport studies. *Journal of Transport Geography* 24: 471-482.

Geels, F. and Schot. J. 2010. The dynamics of transition: A socio-technical perspective. In *Transitions to sustainable development. New directions in the study of long term transformative change*, ed. J. Grin, J. Rotmans and J. Schot, 9-101. New York: Routledge.

Gill, S. 2009. CAP Reform Profile - Poland. URL: http://cap2020.ieep.eu/2009/1/28/cap-reform-profile-poland-2

Główny Urząd Statystyczny (GUS). 2016. Rolnictwo w 2015 roku *[Agriculture in 2015]*. Warsaw: Zaklad Wydawnictw Statytycznych [Statistical Publishing Establishment].

GMWatch. 2016. Largest ever study shows GM crops massively increase herbicide use. University of Virginia. URL: http://www.gmwatch.org/news/latest-news/17218-largest-ever-study-shows-gm-crops-massively-increase-herbicide-use
Golinowska, M., Pytlarz-Kozicka, M. 2008. Analiza dopłat do produkcji ekologicznej w latach 2004-2006 w Polsce [The analysis of the subsidies to ecological production in years 2004-2006 in Poland]. *Journal of Research and Applications in Agricultural Engineering* 53(3): 75-83.

Granstedt, A., Schneider, T. Seuri, P & Thomsson, O. 2008. Ecological Recycling Agriculture to Reduce Nutrient Pollution to the Baltic Sea. *Journal Biological Agriculture and Horticulture* 26(3): 279-307.

Granstedt, A. 2012. *Farming for the Future - with a focus on the Baltic Sea Region*. BERAS Implementation Reports No. 2. Huddinge: *COMREC studies on environment and development.*

Granstedt, A. and Seuri, P. 2013. *Conversion to Ecological Recycling Agriculture and Society: Environmental, economic and sociological assessments and scenarios*. BERAS Implementation Reports 3. Huddinge: COMREC studies on environment and development.

Grzelak, C., Stańczyk, H., Zwoliński, S. 2009. *Armia Berlinga i Zymierskiego* [Army of Berling and Zymierski]. Warsaw: Neriton.

Havet, A., X. Coquil, J.L. Fiorelli, A. Gibon, G. Martel, B. Roche, J. Ryschawy, N. Schaller, and B. Dedieu. 2014. Review of Livestock Farmer Adaptations to Increase Forages in Crop Rotations in Western France. *Agriculture, Ecosystems & Environment* 190: 120–27.

Hendrickson J.R., Hanson J.D., Tanaka D.L., Sassenrath, G.F. 2008. Principles of Integrated Agricultural Systems: Introduction to Processes and Definition. *Renewable Agriculture and Food Systems* 23(4): 265–71.

Herrero, M., Thornton, P.K., Notenbaert, A.M., Wood, S., Msangi, S., Freeman, H.A., Bossio, D., Dixon, J., Peters, M., Van de Steeg, J., Lynam, J., Parthasarathy Rao, P., Macmillan, S., Gerard, B., McDermott, J., Seré, C., Rosegrant, M. 2010 Smart Investments in Sustainable Food Production: Revisiting Mixed Crop-Livestock Systems. *Science* 327: 822-825.

Holt-Giménez, E., Shattuck A., 2011. Food crises, food regimes and food movements: rumblings of reform or tides of transformation? *Journal of Peasant Studies* 38(1): 109-144.

Igras, J., Pokojski, Z., Kowalski, A., Krasowicz, S., Labetowicz, J., Matyka, M., Spiak, Z., Wijaszka, T. 2014. *24 years of Polish agriculture*. Pulawy, Poland: Centrum Kompetencji.

InfoCuria (Case-law of the Court of Justice). 2014. Judgment of the Court (Ninth Chamber) of 20 November 2014, European Commission v Republic of Poland. URL: http://curia.europa.eu/juris/liste.jsf?language=en&num=C-356/13

International Coalition for the Protection of the Polish Countryside (ICPPC). 2017. Anty-GMO. URL: http://www.icppc.pl/antygmo/

International Federation of Organic Agriculture Movements (IFOAM). 2008. Principles of Organic Agriculture. URL: http://www.ifoam.org/about_ifoam/principles/index.html

Ivanov, L. 2016. A Study of The Agriculture Of Poland And Romania in Post-Communist Period. *European Scientific Journal* Vol 12 (10).

Jarosiewicz, M. 2007. Państwowa własność nieruchomości rolnych [State ownership of agricultural properties]. In *Prawo rolne* [Agrarian Law], ed. M. Jarosiewicz and K. Kozikowska, 118-119. Cracow: Wolters Kluwer.

Johansson, S. 2013. *Food or Fuel? Trade-offs between food and biofuels globally and in small-scale organic agriculture* 9Licenciate thesis). Department of Energy and Technology, Swedish University of Agricultural Sciences, Uppsala. Duplicated.

Karanikolas, P., Vlahos, G., Sutherland, L-A. 2015. Utilizing the multi-level perspective in empirical field research: methodological considerations. In *Transition Pathways towards Sustainability in Agriculture: Case studies from Europe*, ed. L.A. Sutherland, I. Darnhofer, G.A. Wilson, L. Zagata, 53-68. Wallingford: CABI.

Kazimierczak, R., Salach, K., Rembalkowska, E. 2014. *Distribution channels of organic agricultural products in Poland - an example of the producers from the Masovian Voivodeship*. Warsaw: The Warsaw University of Life Sciences (SGGW), Department of Functional and Organic Food and Commodities.

Khan, S.A., Mulvaney, R.L., Ellsworth, T.R., Boast, C.W. 2007. The myth of nitrogen fertilization for soil carbon sequestration. *Journal of Environmental Quality* 36: 1821−1832.

Kizos, T., Koulouri, M., Vakoufaris, H., Psarrou, M. 2010. Preserving characteristics of the agricultural landscape through agri-environmental policiess: the case of cultivation terraces in Greece. *Landscape Research* 35(6): 577-593.

Kotschi, J. 2013. *A soiled reputation. Adverse impacts of mineral fertilizers in tropical agriculture*. Berlin: Heinrich Böll Foundation and WWF Germany.

Kozyra, J. 2012. Wpływ zmian klimatu na rolnictwo [Impact of climate change on agriculture]. IUNG. URL: http://www.klimat.iung.pulawy.pl/informacje-podstawowe/ogolna-charakterystyka-wplywu-zmiany-klimatu-na-rolnictwo

Krupa-Dabrowska, R. 2015. Sprzedaż gruntów rolnych: to już koniec wolnego handlu ziemią [Sales of agricultural land: it's the end of free trade of land]. *Rzeczpospolita Polska* (Warsaw), April 28.

Kroes, H. and Kuepper, B. 2015. *Mapping the soy supply chain in Europe* (A research paper prepared for WNF). Amsterdam: Profundo.

Larsson M, Granstedt A. 2010. Sustainable governance of the agriculture and the Baltic Sea _ agricultural reforms, food production and curbed eutrophication. *Ecological Economics* 69(10): 1943–1951.

Leeuwis, C. 1993. *Of Computers, myths and modelling; the social construction of diversty, knowledge, information and communication Technologies in Dutch horticulture and agricultural extension*. Wageningen: Wageningen Agricultural University.

Lemaire, G., Franzluebbers, A., Carvalho, P.C. de F., Dedieu, B., 2014. Integrated crop-livestock systems: Strategies to achieve synergy between agricultural production and environmental quality. *Agriculture, Ecosystems & Environment* 190: 4-8.

Levidow, L., Pimbert, M. 2016. European agroecological practices: Tensions around neo-productivist agendas. *Zeitschrift für Agrargeschichte und Agrarsoziologie* 64(2): 49-60.

Levins, R., Cochrane, W. W. 1996. The Treadmill Revisited. *Land Economics* 72(4): 550-553.

Linder, B. P. 2017. Press Release: CETA - MEPs back EU-Canada trade agreement. Brussels: European Parliament.
URL:http://www.europarl.europa.eu/news/en/press-room/20170124IPR59704/ceta-trade-committee-meps-back-eu-canada-agreement

Loges, R., Kelm, M.R., Taube, F. 2006. Nitrogen balances, nitrate leaching and energy efficiency of conventional and organic farming systems on fertile soils in northern Germany. *Advances in GeoEcology* 38: 407–14.

Longhurst, R. 2003. Semi-structured Interviews and Focus Groups. In *Key Methods in Geography*, ed. N. Clifford and G. Valentine, 117-132. London: SAGE Publications.

Lyne, J.W., barak, P. 2000. *Are Depleted Soils Causing a Reduction in the Mineral Content of Food Crops?*. Madison: University of Wisconsin.

Marshal Office of the West Pomerania voivodeship. 2015. Napływ bezpośrednich inwestycji zagranicznych do województwa zachodniopomorskiego w latach 2007-2013 na tle Polski oraz poszczególnych województw. [Influx of direct foreign investments into West Pomerania voivodship in 2007-2013 in the context of Poland and voivodships]. URL: http://www.coi.wzp.pl/naplyw-bezposrednich-inwestycji-zagranicznych-do-wojewodztwa-zachodniopomorskiego-w-latach-27-213

McGuire, A. 2012. Organic Farming Reliant on Synthetic Nitrogen. Washington State University. URL: http://csanr.wsu.edu/organic-ag-synthetic-nitrogen/

Ministry of Agricultural and Rural Development (MINROL). 2014. Rural Development Project 2014-2020. [Projekt Programy rozwoju obszarów wiejskich w Polsce na lata 2014-2020]. Warsaw: MINROL.

__________. 2016. *Program Rozwoju Glownych Rynkow Rolnych W Polsce na lata 2016-2020* [Marketdevelopment program in Poland 2016-2020]. Warsaw: MINROL.

Ministerstwo Rozwoju (MR). 2016. Umowa o strefie wolnego handlu Unia Europejska – Ukraina [Free trade agreement between the EU and Ukraine]. URL: https://www.mr.gov.pl/strony/aktualnosci/wpisz-tytul-1-3/

Monitor Polski. 2017. Strategy for Sustainable Development until 2020 (with a perspective toward 2030). Dz.U. 2017 poz. 260.

Moraine, M., Duru, M., Nicholas, P., Leterme, P., Therond, O., 2014. Farming system design for innovative crop-livestock integration in Europe. *Animal* 8: 1204-1217.

Morelle, R. 2013. Climate change 'driving spread of crop pests'.
URL: http://www.bbc.com/news/science-environment-23899019

Moss, B., Kosten, S., Meerhoff, M., Battarbee, R.W., Jeppsesen, E., Mazzeo, N., Havens, K., Lacerot, G., Liu, Z., Meester, L., Paerl, H., Scheffer, M. 2011. Allied attack: climate change and eutrophication. Research Brief. *Inland Waters* 1:101-105.

Müller-Lindenlauf, M., Deittert. C., Köpke. U. 2010. Assessment of environmental effects, animal welfare and milk quality among organic dairy farms. *Livestock Science* 128: 140–8.

Ndah, H. T., Schulr, J., Uthes, S., Zander, P. 2010. *Adoption Decision Theories and Conceptual models of Innovations Systems. Overview of exisitng modelling approaches*. Leibniz: Leibniz-Centre for Agricultural Landscape Research (ZALF).

Nierobca, A., Kozyra, J., Mizak, K., Wroblewska, E. 2013. Zmiana dlugosci okresu wegetacyjnego w Polsce [Change of vegetation period in Poland]. *Water Environment Rural Areas* 13(2): 81-94.

Ohlund, E., Zurek, K., Hammer, M. 2015. Towards Sustainable Agriculture? The EU framework and local adaptation in Sweden and Poland. *Environmental Policy and Governance* 25: 270-287.

Pintér, L., Zahedi, K., Cressman, D.R. 2000. *Capacity Building for Integrated Environmental Assessment and Reporting Training Manual.* 2nd edition. Winnipeg: International Institute for Sustainable Development.

Pachico, D. H., Fujisaka, S. 2004. *Scaling up and out: Achieving widespread impact through agricultural research*. Cali, CO.: Centro Internacional de Agricultura Tropical (CIAT).

Padel, S., Niggli, U., Pearce, B., Schlüter, M., Schmidt, O., Cuoco, E.; Willer, H., Huber, M., Halberg, N., Micheloni, C. 2010. *Implementation Action Plan for Organic Food and Farming Research*. Brussels: TP Organics and Brussels and Frick: FiBL.

Pastuszak, M., Stalenga, J., Kowalkowski, T., Kopiński, J., Panasiuk, D. 2014. Impact of forecasted changes in Polish economy (2015 and 2020) on nutrient emission into the river basins. *Science of the Total Environment* 493: 32–43.

Pine, F. 2007. Dangerous Modernities? Innovative Technologies and the Unsettling of Agriculture in Rural Poland. *Critique of Anthropology* 27(2): 183-201.

PKO Bank Polski. 2017. Agro Nawigator: Ceny surowców rolnych i nawozów pod wpływem rosnących cen ropy i mocnego dolara [Agro Navigator: Prices of agricultural products and fertilizers in the face of growing oil prices and strong dollar]. URL: http://www.pkobp.pl/centrum-analiz/analizy-sektorowe/raporty-branzowe/agro-nawigator-ceny-surowcow-rolnych-i-nawozow-pod-wplywem/

Polish Press Agency (PAP). 2013. Organic food – the fastest growing food market in Poland. URL: https://msp.gov.pl/en/polish-economy/economic-news/4836,Organic-food-the-fastest-growing-food-market-in-Poland.html

_________. 2015. Naukowcy: Polacy jedzą prawie dwukrotnie więcej mięsa niż zaleca WHO [Scientists: Polish people eat twice as much meat as it is recommended by WHO]. URL: http://naukawpolsce.pap.pl/aktualnosci/news,407421,naukowcy-polacy-jedza-prawie-dwukrotnie-wiecej-miesa-niz-zaleca-who.html

Potera, C. Agriculture: Pesticides Disrupt Nitrogen Fixation. 2007. *Environmental Health Perspectives* 115(12): 1683–1806.

Prager, K. and Posthumus, H. 2010. *Socio-economic factors influencing farmers' adoption of soil conservation practices in Europe. In Human Dimensions of Soil and Water Conservation: A Global Perspective*, ed. T. L. Napier, 203-223. New York: Nova Science Publishers, Inc.

Program Rozwoju Obszarow Wiejskich 2014-2020 [Rural Development Programme 2014-2020] (Prow2014-2020). 2015. Średnia powierzchnia gospodarstwa w 2015 roku [Average size of the agricultural land in 2015]. URL: https://prow2014-2020.pl/2015/11/13/srednia-powierzchnia-gospodarstwa-w-2015-roku/

Prus, P. 2012. Perspectives for Sustainable Development of Agricultural and Rural Areas. Case Study: Poland. In: *Sustainable Agriculture*, ed. C. Jakobsson, Uppsala: Baltic University Press.

Raven, R., Bosch, S., Weterings, R. 2010. Transitions and strategic niche management: towards a competence kit for practitioners. *International Journal of Technology Management* 51(1).

Rockstrom, J., Steffen, W., Noone, K., Persson, A., Chapin, F.S., Lambin, E., Lenton, T.M., Scheffer, M., Folke, C., Schellnhuber, H.J., Nykvist, B., Wit, C.A., Hughes, T., Leeuw, S., Rodhe, H., Sorlin, S., Snyder, P.K., Costanza, R., Svedin, U., Felkenmark, M., Karlberg, L., Corell, R.W., Fabry, V.J., Hansen, J., Walker, B., Liverman, D., Richardson, K., Crutzen, P., Foley, J. 2009. Planetary Boundaries: Exploring the Safe Operating Space for Humanity. *Ecology and Society* 14(2).

Rogers, E. M. 2003. Diffusion of innovations, fifth edition. New York: Free Press.

Russelle, MP, MH Entz, and AJ Franzluebbers. 2007. Reconsidering Integrated Crop-Livestock Systems in North America. *Agronomy Journal* 99 (2): 325–34.

Ryschawy, J., Choisis, N., Choisis, J., Gibon. A. 2013. Paths to last in mixed
crop-livestock farming: lessons from an assessment of farm trajectories of change. *Animal* 7 (4): 673- 681.

Schiere J.B., and Kater L. 2001. *Mixed Crop-Livestock Farming. A Review of Traditional Technologies Based on Literature and Field Experiences.* Animal Production and health paper. Rome: FAO.

Schivelbusch, W. 1986. *The Railway Journey: The Industrialization of Time and Space in the 19th Century*. Leamington Spa: Berg Press.

Shanley, J.B. and Chalmers, A. 1999. The effect of frozen soil on snowmelt runoff at Sleepers River, Vermont. *Hydrological Processes* 13: 1843-1857.

Skerratt. S. J. 1994. Itemized payment systems within a scheme-the case of Breadalbane. In: *Incentives for countryside management: the case of Environmentally Sensirive Areas,* ed. M. Whitby, 105-134. Wallingford: CABI.

Siuda, W., Kalinski, T., Kauppinen, E.. Chróst, R.J. 2014. Eutrofizacja południowej czesci kompleksu Wielkich Jezior Mazurskich w latach 1977-2011 [Water eutrophication in a southern part of Greater Masurian Lakes in 1977-2011]. *Technologia Wody* 3: 48-62.

Skorupski, J. 2012. Industrial Animal Farming in Poland as a major threat to the natural environment of the Baltic Sea. In: *Development Concept for the Territory of the Baltic Green Belt - A Synthesis Report of the INTEREG IVB Project Baltic Green Belt. Final Report*, ed. H. Sterr, S. Maack, M. Schultz, 45-53. Coastline Reports (20). Warnemünde: EUCC - The Coastal Union Germany e.V.

Slazak, R. 2013. Skutki prywatyzacji polskiego rolnictwa dla społeczności wiejskiej [Consequences of privatization of the Polish agriculture for the rural society]. Association/ Club of Polish intelligence. URL: http://www.klubinteligencjipolskiej.pl/2013/02/skutki-prywatyzacyjne-polskiego-rolnictwa-dla-spolecznosci-wiejskiej/

Staniszewska, M. and Stalenga, J. 2013. Agricultural policy in Poland – facts, legislation and recommendations. In *Policy Recommendations to Save the Baltic Sea: Conversion to Ecological Recycling Agriculture*, ed. L.B. Jorgensen, S. Gerber, P. Wramner, 85-93. Huddinge: *COMREC studies on environment and development.*

Stein-Bachinger, K., Reckling, M., Hufnagel, J., Granstedt, A. 2013. Ecological Recycling Agriculture: Guideline for farmers and advisors Vol I-IV. Berlin: Medialis Offsetdruck.

Steiner, R. 1993. *Spiritual Foundation for the Renewal of Agriculture: A Course of Lectures*. Kimberton, PA: Biodynamic Farming and Gardening Association.

Stepien, A., Chudzio, K. 2016. Development of Organic farming in Poland after 2013 in terms of Agricultural Policy. EUREKA: *Social and Humanities* 3.

Stern, P.C. 2000. Toward a Coherent Theory of Environmentally Significant Behavior. *Journal of Social Issues* 56(3): 407-424.

Stirling, A., 2009. *Direction, Distribution and Diversity! Pluralising Progress in Innovation, Sustainability and Development* (STEPS Working Paper 32). Brighton: STEPS Centre, University of Sussex.

Stolze, M., Sanders, J., Kasperczyk, N., Madsen G. 2016. *CAP 2014-2020: Organic farming and the prospects for stimulating public goods*. Brussels: IFOAM EU.

Sutherland, L., Darnhofer, I., Wilson, G., Zagata, L. 2015. *Transition Pathways towards Sustainability in Agriculture: Case studies from Europe.* Wallingford: CABI.

Svanback, A., McCrackin, M. 2016. *Nutrient recycling in agriculture – for a cleaner Baltic Sea*. Stockholm: Stockholm University (Baltic Sea Centre).

Szeremeta, A. 2005. *Organic farming and market in Poland*. ENOAS, Summer Meeting IV.

Szolc, M. 2017. Polish water under threat as nitrate pollution laws fall short. URL: https://www.clientearth.org/polish-water-under-threat-as-nitrate-pollution-laws-fall-short/

Szpak, E. 2005. *Między osiedlem a zagrodą. Życie codzienne mieszkańców PGR-ów* [Between commune and farm. Daily life of inhabitans of state-owned farm enterprises]. Warsaw: Trio.

Thomsen, B. 2016. CETA's threat to agricultural markets and food quality. Working Group for Local Agriculture, Friends of the Earth Europe. URL: http://foeeurope.org/sites/default/files/euus_trade_deal/2016/10_cetas_threat_to_agricultural_markets_and_food_quality.pdf

United Nations (UN). 2015. World population projected to reach 9.7 billion by 2050. Department of Economic and Social Affairs, New York.

URL: http://www.un.org/en/development/desa/news/population/2015-report.html

__________. n.d. An Agenda 21 for the Baltic Sea Region- Baltic 21. Adopted at the 7th Ministerial Session of the Council of the Baltic Sea States, Nyborg, June 22-23, 1998. URL: http://www.un.org/esa/agenda21/natlinfo/action/baltic.htm

Watson, C., Laitenberger, K., Wolf, P., Pra, A., Stalenga, J., Bogdanovic, V. 2015. *EIP-AGRI Focus Group: Mixed farming systems: livestock/cash crops*. Minipaper 2: Improving the technical efficiency of mixed farming. Brussels: EIP AGRI.

Weis, T. 2007. *The Global Food Economy: the battle for the future of farming*. London: Zed Books.

Wezel, A., Bellon, S., Doré, T., Francis, C., Vallod, D., David, C. 2009. Agroecology as a science, a movement or a practice: A review. *Agronomy for Sustainable Development* 29(4): 503-515.

Wigboldus, S. and Brouwers, J. 2016. *Using a Theory of Scaling to guide decision making. Towards a structured approach to support responsible scaling of innovations in the context of agrifood systems*. Wageningen: Wageningen University and Research

Wigboldus, S., Klerkx, L., Leeuwis, C., Schut, M., Muilerman, S., Jochemsen, H. 2016. Systemic perspectives on scaling agricultural innovations. A review. *Agronomy for Sustainable Development* 36(46).

Wilkins, R.J. 2008. Eco-Efficient Approaches to Land Management: A Case for Increased Integration of Crop and Animal Production Systems. *Philosophical Transactions of the Royal Society B-Biological Sciences* 363 (1491): 517–25.

Willer, H., Yussefi, M. 2006. The World of Organic Agriculture. Statistics and Emerging Trends 2006. Bonn: IFOAM and Frick: FiBL.

Wilson, G. 1996. Farmer environmental attitudes and ESA participation. *Geoforum* 27(2): 115–131.

WWF Poland. 2017a. Common Agricultural Policy [Wspólna Polityka Rolna]. URL: http://www.wwf.pl/co_robimy/morza_oceany_glowna/czysty_baltyk/wspolna_polityka_rolna/
.

WWF Poland. 2017b. Clean Baltic [Czysty Bałtyk]. URL: http://www.wwf.pl/co_robimy/morza_oceany_glowna/czysty_baltyk/

APPENDICES

APPENDIX A: INFORMATION ABOUT THE BERAS PROJECT

This thesis was conducted in cooperation with BERAS project (Baltic Ecological Recycling Agriculture and Society) is presently working on the follow-up project that is lasting from June 2016 until September 2017, and whose special focus is currently on Poland. During this project, the project members (Dr Arthur Granstedt, Ms Sheshti Johansson and Ms Maria Micha) have been also collaborating with two scientists in the National Institute of Soil Science and Plant Cultivation, in Puławy (Dr Jaroslaw Stalenga and Dr Jerzy Kopinski), representative of the Polish Ecological Club – an environmental NGO active in Poland (Maria Staniszewska) as well as several Polish **organic** farmers who converted their farms into Ecological Recycling Agriculture farm model. While the findings that came out of this thesis research were shared with the BERAS project (i.e. analysis of interview results and relevant policies; and overview of the historical background of the Polish agriculture), the BERAS project team members likewise shared their findings, which are specified in Methodology Chapter (3.3.3).

The BERAS project (Baltic Ecological Recycling Agriculture and Society) is a partly EU-financed project, which primarily emerged in response to the ongoing eutrophication of the Baltic Sea that causes toxic algal blooms. Since the agricultural sector is officially considered as one of the major contributors to the eutrophication of the Baltic Sea due to the heavy leaching of nutrients mainly from improperly managed animal manure (HELCOM (2011) estimated that 45 % of overall nitrogen and 45 % of overall phosphorus from this sector are discharged to the Baltic Sea), Granstedt, the precursor of the BERAS project from the Biodynamic Research Institute in Järna, Sweden, decided to come up with the solution during his PhD in 1990 when he designed a model for sustainable agriculture, which later revolved into the already mentioned concept of 'Ecological Recycling Agriculture' under the partly-EU financed BERAS project: '*After PhD I decided to establish this project in Sweden and in 1999 I arranged a bigger agricultural conference where I proposed to do a bigger study and invite partners from other countries. From this point, I started to develop applications on EU level. It was approved in 2002 but it started in 2003 and lasted until 2006 – it was a long process and involved cooperation with about 50 researchers in various Baltic states. First I tried a scientific program for EU. Additional studies were in Finland where I also picked up various types of farms*' (Interview with Granstedt in Jarna, Sweden, February 2017). The key finding/rationale behind the project was the fact that after lengthy calculations and on field trials, mainly in the demonstration farm (*Yttereneby – Skilleby)* in Järna, Sweden (which actually combines two different farms: one focused on crops and another one on milk cattle production), Granstedt demonstrated that a conversion to organic, farm systems, which are based on recycling principles[62], would enable to reduce nitrogen load by 70%, thus making it possible for the Baltic Sea region to fulfil the plant nutrient reduction targets, which were agreed under the Baltic Sea Action Plan (BSAP), and even help to mitigate and adapt to climate change, as well as improve (agro)biodiversity (Einarsson 2012; Granstedt *et al.* 2008; Granstedt 2012).

In the first BERAS project (2003-2006), which was mainly focused on research, 42 calculations based on demonstration farms located in all EU-countries around the Baltic Sea helped to generate scenarios, which demonstrated how a conversion of all agriculture to Ecological Recycling Agriculture would decrease the losses of nutrients to the Baltic Sea. This project was followed by the second EU-project, BERAS Implementation, which lasted between 2010 and 2013 and involved further collaboration with partners in all EU countries surrounding the Baltic Sea as well as field trials in BERAS demonstration farms. As part of the BERAS Implementation project (2010-2013), several BERAS Information Centres (BIC) were established in all EU-countries in the region (including Poland) in order to facilitate knowledge sharing on Ecological Recycling Agriculture (ERA) among farmers and other stakeholders (including agricultural advisory services) and disseminate ERA practices across the regions (see Map X below) (Granstedt, 2013). Moreover, several guidelines on how to convert farm enterprises into resilient socio-ecological farm systems based on recycling principles were elaborated by various scientists and made available online[63] (BERAS 2017). In addition, several software tools, which can be defined as 'enabling technologies' that aid diffusion of recycling principles (e.g. ROTOR tool helps to plan crop rotations; and Nitrogen budget calculator and Legume estimation trainer help to better estimate legume proportion in forages) were introduced (BERAS 2017). A success story of the BERAS Implementation project (2010-2013) was an initiative in Södertälje municipality, Stockholm County in Sweden, whereby the collaboration with the municipality's head of meal services enabled to gradually transform meals at schools, kindergartens and homes for the elderly into nutritious organic meals, which are greatly vegetarian (based on seasonal vegetables) so that any increase in budget has been significantly avoided (Granstedt 2012). Given that Poland is often reported to be one of the major contributors to eutrophication of the Baltic Sea, the current follow-up project has a special focus on Poland (Granstedt *et al.* 2008). Interestingly, since BERAS recognizes consumer aspect as one of the important factors enabling effective integration of agroecological practices, the next project related to public procurement and food in schools is currently under consideration in

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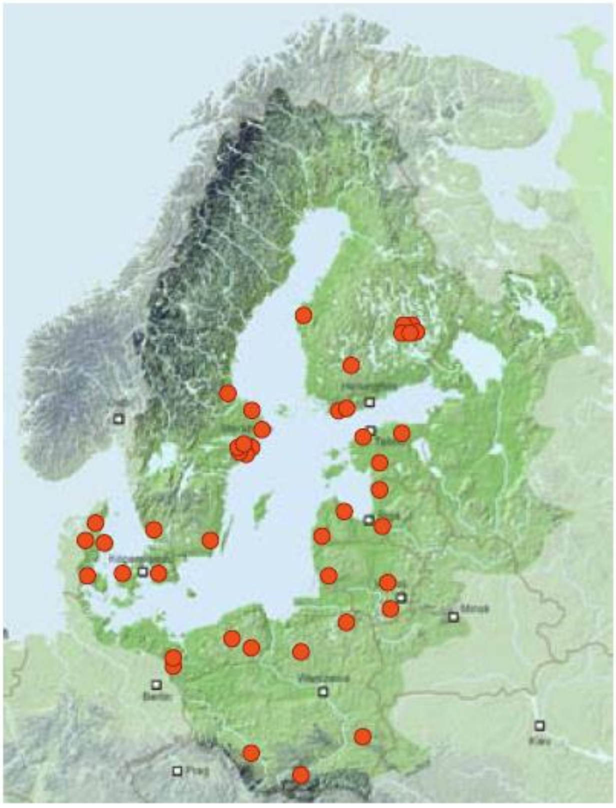
[62] I.e. crop rotations; integrated crops and livestock production; a balance between animal units and acreage, all of which can improve feed and fertilizer autonomy (via reliance on local renewable resources)

[63] http://beras.eu/what-we-do/era-guidelines/

the context of Poland. The BERAS project is also thinking on making the proposal to create the so-called 'Organic+' version of organic farming in order to make this sector even more sustainable (Interview with Grandstedt in Pulawy, Poland, April 2017

42 Ecological Recycling Agriculture farms in Sweden, Finland, Estonia, Latvia, Lithuania, Poland, Germany (the Baltic littoral) and Denmark that participated in pilot studies within the BERAS (Baltic Ecological Recycling Agriculture) project.



APPENDIX B: MAPS

Map B1: Topography of Poland

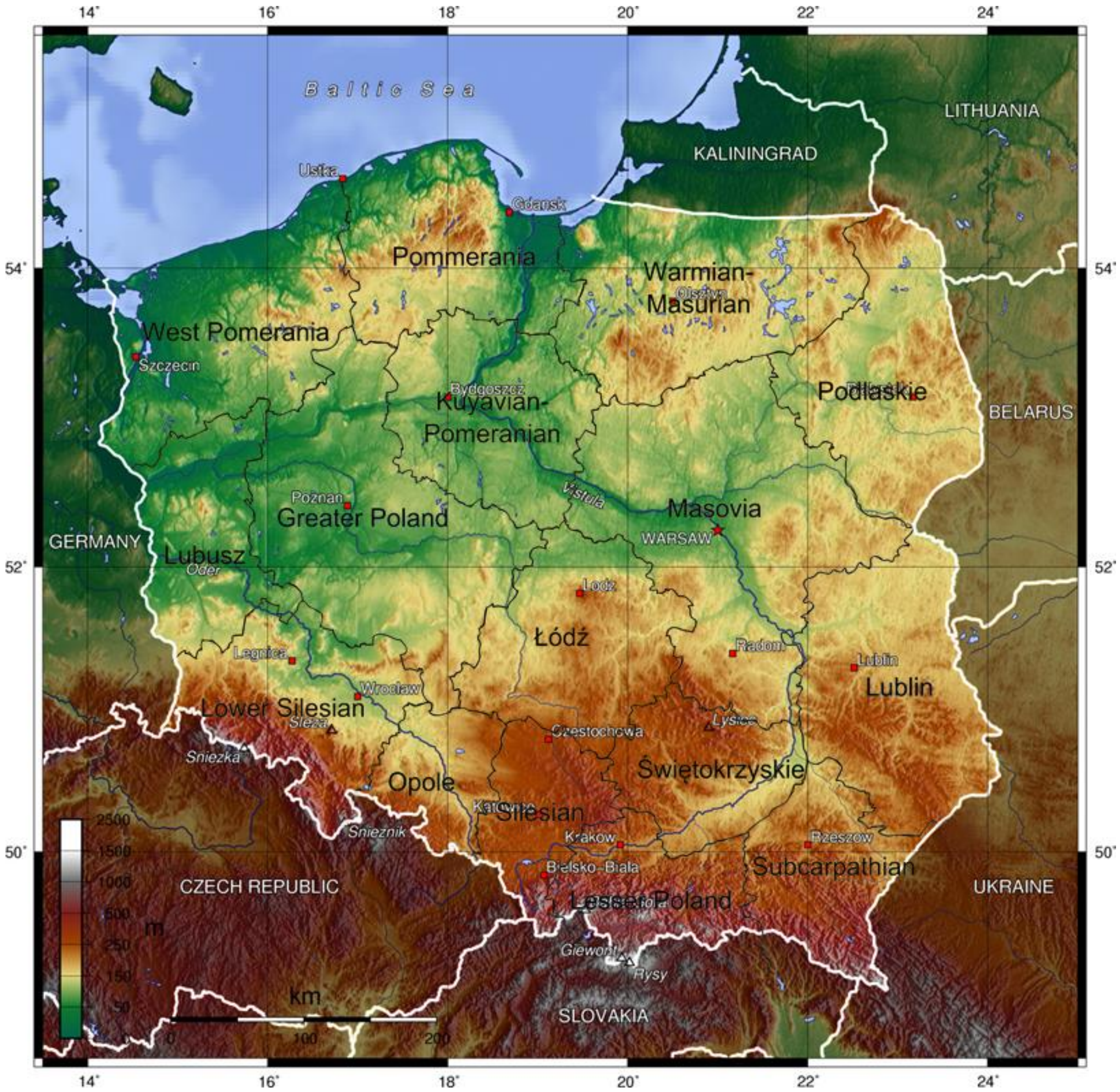
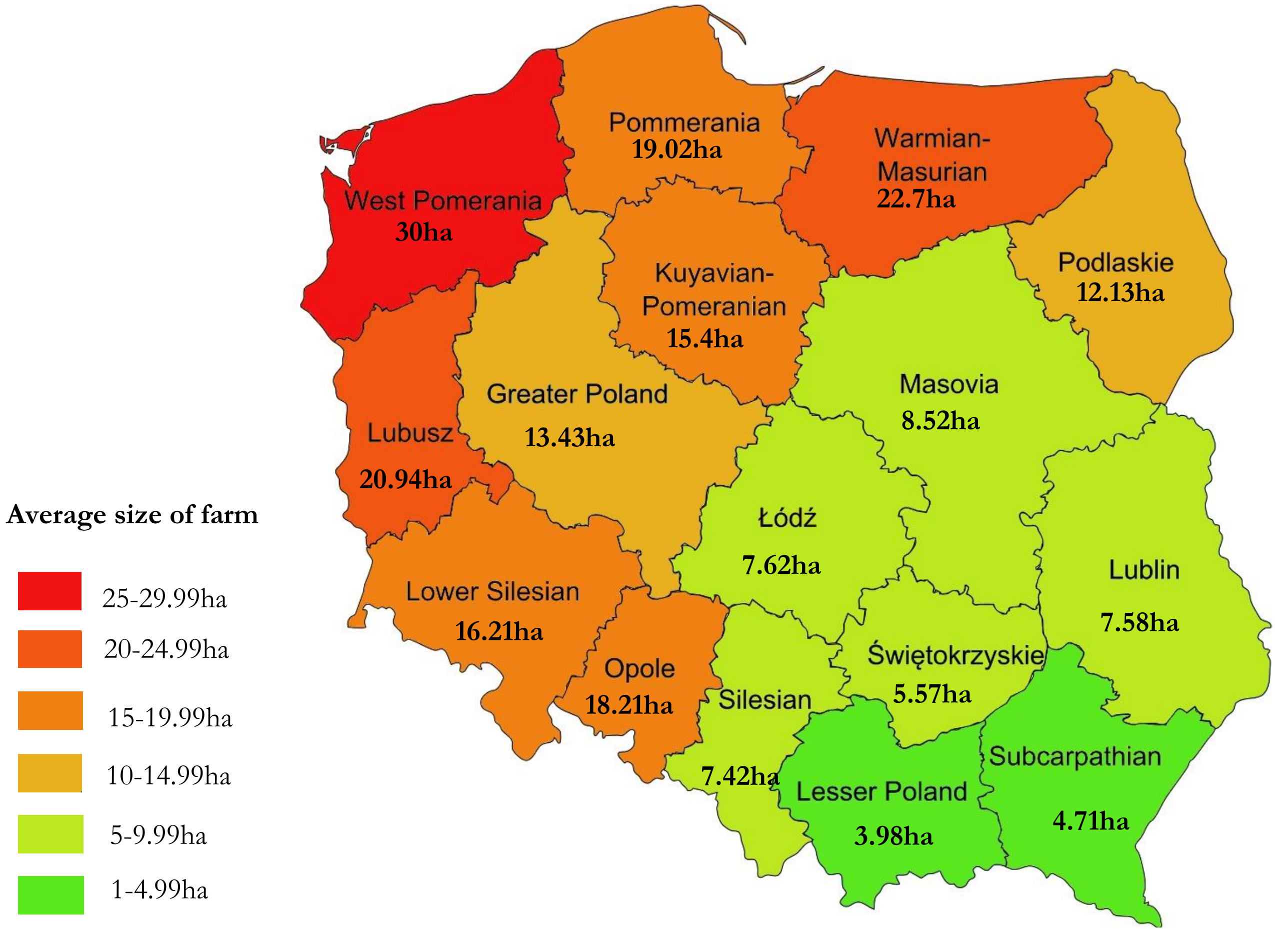


Image source: Captain Blood 2005 and Odder 2016 (Wikimedia Commons); Made in: Adobe Photoshop

Map B2: Average size of farms per voivodships in Poland in 2015



Data source: Prow2014-2020 2015; Image source: Odder 2016; Made in: Adobe Photoshop

Map B3: Dominant soil types in Poland

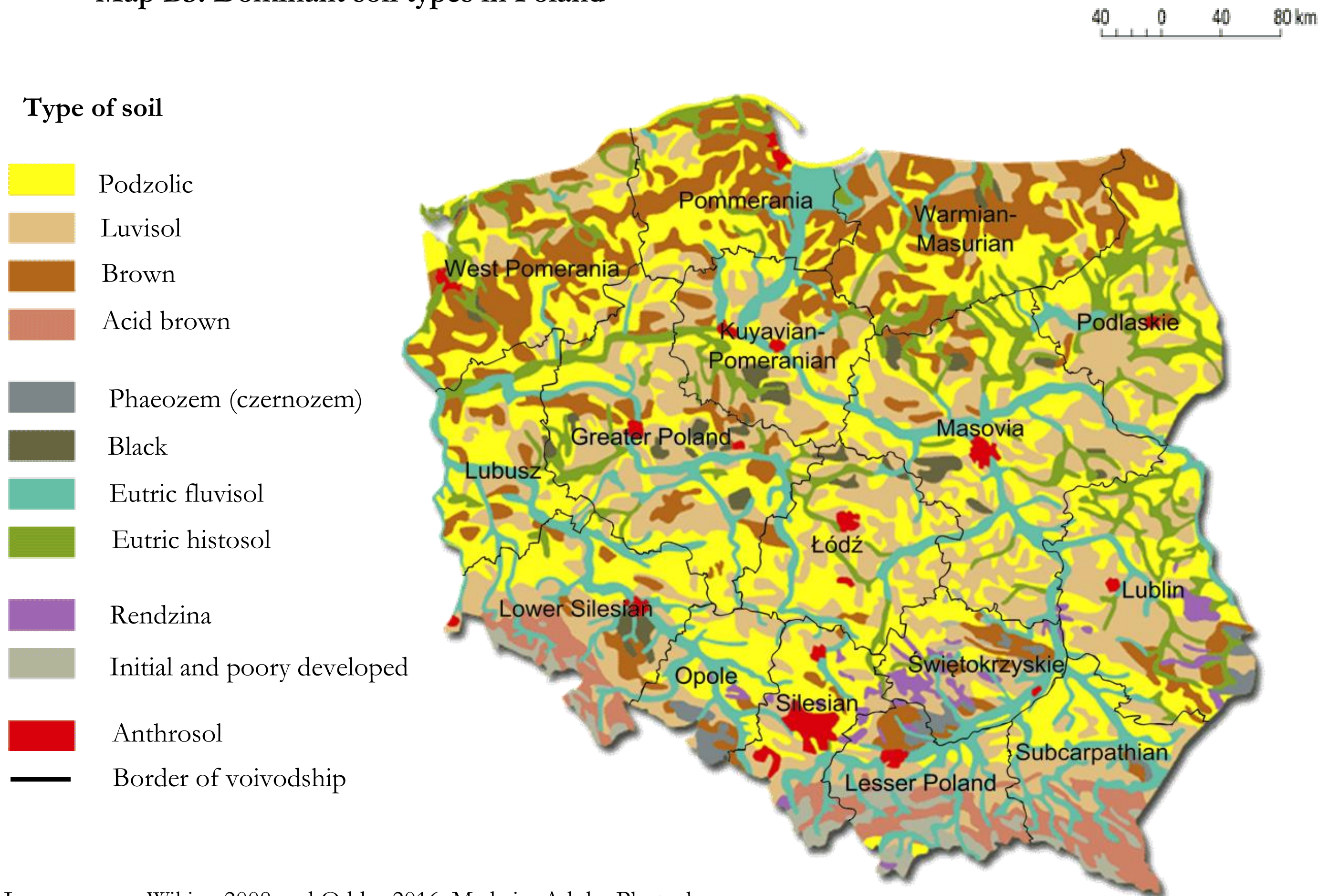
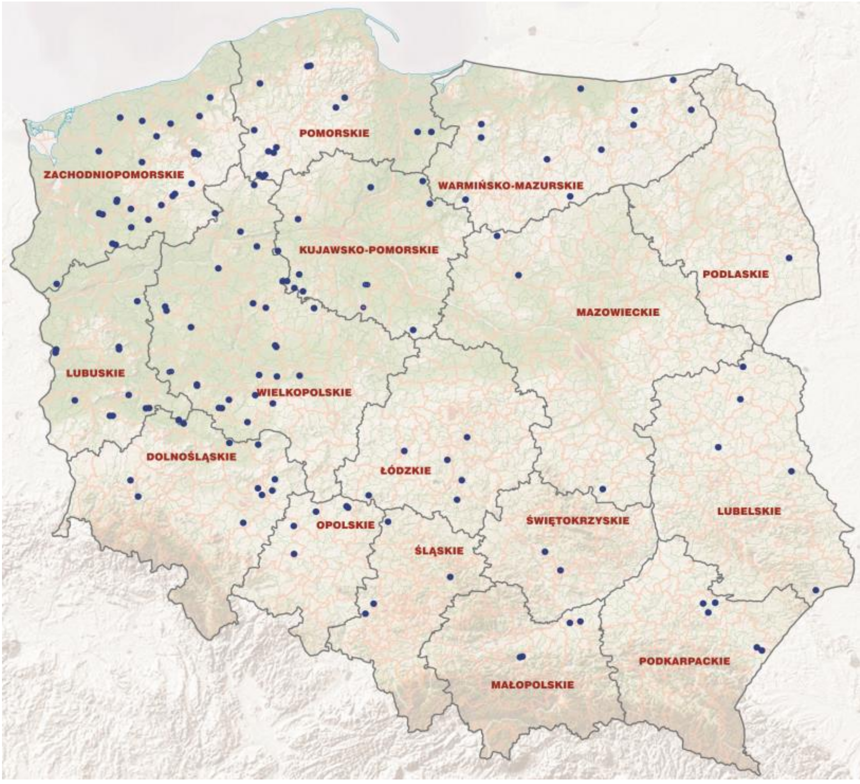


Image source: Wiking 2008 and Odder 2016; Made in: Adobe Photoshop

Map B4: Location of swine industrial farms in Poland



Source: Skorupski 2012

Map B5: Location of swine industrial farms in Poland

Source: Skorupski 2012

Appendix C: Tables

Table C1: Types of organic farming (number and %) in 2013 and 2014 in Poland

	2013		2014	
Organic farms	**Number**	**Rate (%)**	**Number**	**Rate (%)**
Crop-specialist	14 854	55.8%	20 003	80.7%
Mixed crop-livestock	11 744	44.2%	4 795	19.3%

Data source: IJHAR-S 2015

Table C2: A brief overview of key interview questions for stakeholders

Q	**Sample questions for farmers (organic/ conventional)**	**Objective**
1	History/ Background of the farm	To establish rapport and find out about the farm history and farmer's background
2	Type of crops/animals	To find out by production units whether there the production is mixed crops-livestock or specialized
3	Do you cultivate leguminous crops? Could you estimate how much per year? Do you rely on the system of crop rotations?	To find out whether farmers comply with the recycling principles related to crop rotations and leguminous crops (and to what extent)
4	Have you ever considered specializing in crops/animals or having a mixed crops/livestock production? Please explain why yes/not.	To see whether farmers are incentivized/pressurized to change their production type
5	7. Do you cooperate with other nearby farms e.g. to obtain fodder/manure? (If yes, how does it go and if no, would you be willing to cooperate?) How would you rate your level of self-sufficiency (%) ?	To see if there are any synergies between farm components that resonate with recycling principles
6	Have you ever considered becoming organic/ Have you ever considered leaving organic farming sector?/	To evaluate the potential to increase the number of organic farms due to the fact that recycling principles are most effective when applied in the context of organic farming
7	Are you content with the current system of EU policies/subsidies?	To see how EU policies/ subisidies are perceived (regime level) and whether they can affect scaling of recycling principles
8	What threats you observe	To see what are the main challenges; how are they correlated to EU subsidies/ policies; and whether they can affect scaling of recycling principles (landscape vs. Regime level)

9	What is your opinion on ongoing farm intensification and specialization? Have you observed your neighbors/ friends pursuing such production methods?	To see if farm intensification and specialization are considered as threats and how are they correlated to EU subsidies/ policies
10	Have you observed any negative/positive environmental impacts related to your farming practices? If yes, please describe what they are.	To see what are the main environmental challenges associated with production (landscape level)
11	Have you heard about EU Nitrates Directive? If yes, do you comply with it? Do you apply any measures to reduce nutrient leaching?	To see if aspects such as manure storage pad which are complementary and necessary for recycling principles to be effective are in place
12	Where do you sell your products? (domestic/local/international retail markets /abroad for processing)	To see if there is local market infrastructure, which is desirable for scaling of recycling principles
13	What is your opinion on recycling principles? Would you be interested in adopting them? Please explain why yes/not.	To see what are the main challenges and opportunities when it comes to employing recycling principles
14	How do you envision the future of your farm/ agricultural (conventional and/or organic) sector in Poland?	To see what are farmers' visions regarding the future based on the current circumstances (and how they can affect scaling of recycling principles)
15	Do you have any policy recommendations?	To see what are the farmers' desired visions of the future and what measures could help to achieve them (and whether they are correspond with recycling principles)

Q	**Sample questions for NGOs/ scholars/ policy-makers**
1	Background information
2	What kind of environmental problems attributable to the agricultural sector do you consider as the most severe and why?
3	How would you evaluate the effectiveness of CAP 2007-2013 and CAP 2014-2020 (especially in terms of making agriculture more sustainable and promotion of 'recycling principles')? What is your opinion on the current system of subsidies?
4	What is your opinion on the current policies related to the nutrient management in the agricultural sector (e.g. EU Nitrates Directive)?
5	What is your opinion on 'recycling principles'?
6	What are in your opinion the key factors that lead to structural rationalization of the agricultural sector in Poland?
7	What is your opinion on foreign investments in the country? Do you consider them as a threat?

8	What kind of key challenges do you observe in terms of scaling recycling principles within organic and conventional farming sector respectively?
9	What kind of policies do you consider as desirable in order to make agricultural sector more sustainable?
10	How do you envision the future of your farm/ agricultural (conventional and/or organic) sector in Poland for the next 15-20 years? How would you like to view it?

Table C3: Type of investigated farms according to location, farm size, dominant type of production and produce as well as type of research method

Mixed crops-livestock outputs							
F	**ha**	**Produce**	**M**	**F**	**ha**	**Produce**	**M**
LUB_C1	25ha	milk cattle, cereals, rape	☎	**LUB_O4**	13ha	semolina, 'vegetables' & goats, milk cattle and poultry	☺
LUB_C3	47ha	wheat (spring and winter), oat, barley, broccoli, cauliflower, celery & beef cattle	👁	**LUB_O5**	6ha	vegetables & hens, rabbits	☺
LUB_C4	2ha	rape, wheat, oat, potatoes & chickens and 3 pigs	👁	**GP_C11**	500ha	rape, wheat, sugar beets, oat, maize & milk cattle (90units)	👁
LUB_C5	35ha	sugar beet, spring barley, winter rape, winter wheat, peas, potato & pigs (40units + 8 sows)	☎	**GP_O9**	24ha	potatoes, hens, 2 sows	👁
LUB_O1	16ha	cereals, soft fruits, pumpkin & hens	☺	**GP_O11**	50ha	2 cows, 2 calves, cereals, Lucerne, lupine, vegetables	👁
LUB_O2	37ha	onions, carrots, potatoes, pumpkin & horses + 2 cows	☺	**WP_O13**	180ha	cereals, pumpkin, goats, sheep, milk cattle (100LU)	👁

Specialist cropping				Specialist grass/Fodder cropping			
F	**ha**	**Produce**	**M**	**F**	**ha**	**Produce**	**M**
LUB_C2	130ha	wheat, oat, beetroot	☎	**LUB_C6**	20ha	cereals, maize & 15 cows	☎
LUB_O3	4ha	30 types of crops	☺	**GP_C8**	160ha	beef and milk cattle; pigs (180units-approx. 1450/year); cereals	👁
LUB_O6	20ha	soft fruits, vegetables	@	**GP_C10**	200ha	pigs (2000LU; ca 15 000 LU/year); wheat	👁
GP_C7	20ha	winter cereals, winter rye, potatoes (+1 sow - *there used to be 20 sows in the past*)	☎	**GP_C12**	40ha	milk cattle and cereals	👁
GP_C9	140ha	potatoes, sugar beet, rape, wheat	👁	**GP_O10**	40ha	milk cattle	☎
GP_O12	44ha	rape, wheat, vegetables	☎	**POD_O8**	92ha	beef, grains	☎
WP_C13	30ha	wheat	☎	**LU_C14**	150ha	Pigs (150LU), wheat, grass	☎
WP_O14	25ha	70 varieties of vegetables	☺	**SC_O15**	40ha	milk cattle, grains	☎

F – Farmer (C – conventional; O – organic)

M – Method (type of interview/empirical observations)

- Empirical observations and face-to-face interview)
- Telephone interview
- Face-to-face interview (Organic farmers' meeting; local farmer's markets)
- Answers provided via email

Abbreviation of voivodship	Voivodship	Number of interviewed farmers		
		Conventional	Organic	Total
LUB	Lublin	**6**	**6**	**12**
GP	Greater Poland	**6**	**4**	**10**
WP	West Pomerania	**1**	**2**	**3**
LU	Lubuskie	**1**	**-**	**1**
POD	Podlaskie	**-**	**1**	**1**
SC	Sub-Carpathian	**-**	**1**	**1**
		14	**14**	**28**

Table C4: Key factors behind Poland's contribution to the eutrophication of the Baltic Sea

Factor	Explanation
Location	• 99.7% of the Polish land is located in the Baltic Sea drainage basin (HELCOM 2004 in: Pastuszak *et al.* 2014)
Farm structure	• Poland has the largest agricultural area among the Baltic countries (59.8% of arable land in 2013) (Eurostat 2017) • Polish agricultural sector remains greatly conventional as 96% of the total agricultural land is conventionally managed (the certified organic farms constitute only 4.3% of the total agricultural land and the certified integrated production occupies 0.1% of the total agricultural land) (GUS 2016) • increasing volumes of applied synthetic fertilizers (which deplete soil humus and damages buffering properties of soil) (GUS 2016; 4.2.3.1) • the animal industry (causing 'over-fertilization') is growing and in 2010 there were already 752 industrial farms (GUS 2016; Ministry of Environment 2010 in: Skorupski 2012)

Hydrology vs. climate change	• the runoff of nutrient inputs from the two major rivers in Poland: Oder and Vistula (especially from Oder as it has together with Warta a larger drainage network than Vistula Basin and unconsolidated bedrock that facilitates groundwater pathways), which are directed northward toward the Baltic Sea, is accelerated in early spring, when the snow is melting due to warmer temperatures and when there is larger precipitation. However, in the light of the current climatic fluctuations (incl. extreme temperatures that can easily melt ice and bring heavy rainfall), such discharge of nutrients can be even more accelerated (Pastuszak and Witek 2012; Bolle *et al.* 2015[64]; Pastuszak *et al.* 2014[65])
Air emissions	• high levels of air pollution in Poland that are partially caused by livestock-specialist farms can lead to soil acidification, which in turn depletes soil humus and damages buffering properties of soil (Polski Alarm Smogowy 2017)

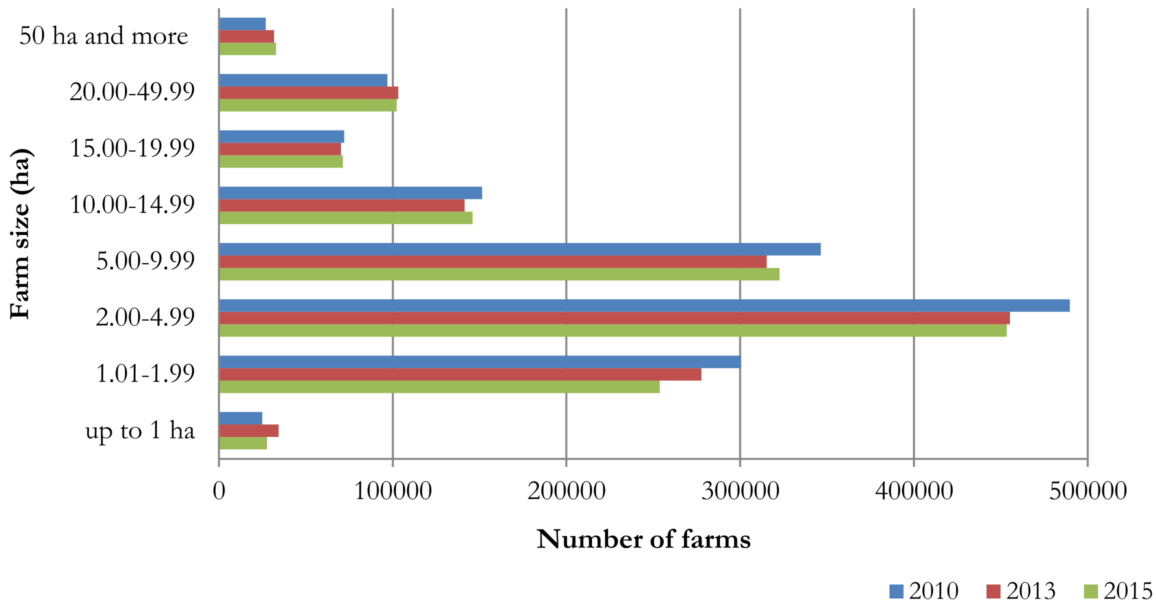
[64] Bolle, H., Menenti, M., Vesuvio, S., Rasool, S. 2015. Second Assessment of Climate Change for the Baltic Sea Basin. Regional Climate Studies. New York: Springer International Publishing.

[65]Pastuszak, M., Witek., Z., 2012. Discharges of water and nutrients by the Vistula and

Oder Rivers draining Polish territory. In *Temporal and spatial differences in emission of nitrogen and phosphorus from Polish territory to the Baltic Sea*, ed. M. Pastuszak, J. Igras, 311-354. Gdynia-Pulawy: National Marine Fisheries Research Institute-Institute of Soil Science and Plant Cultivation - State Research Institute-Fertilizer Research Institute.

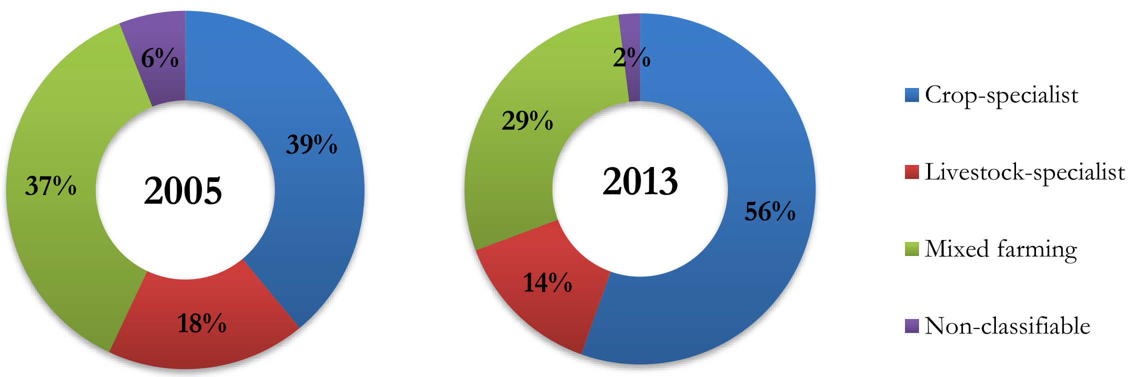
APPENDIX D: FIGURES

Figure D1: Farms by area groups of agricultural land in absolute numbers in 2010, 2013 and 2015 in Poland



Data source: GUS 2016

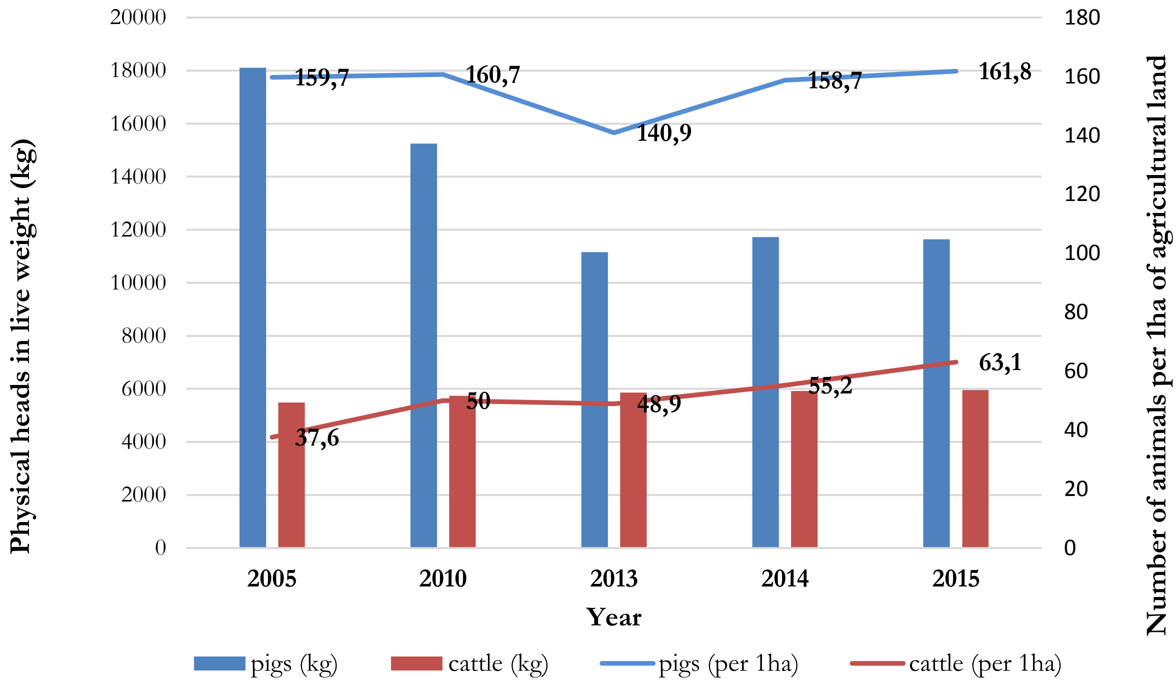
Figure D2: Types of farming (%) among 2 476 470 agricultural holdings in 2005 and among 1 429 010 agricultural holdings in 2013 in Poland[66]



Data source: Eurostat 2016

[66] There is lack of more recent data, which illustrate specialization trends (e.g. for the time period between 2014-2016)

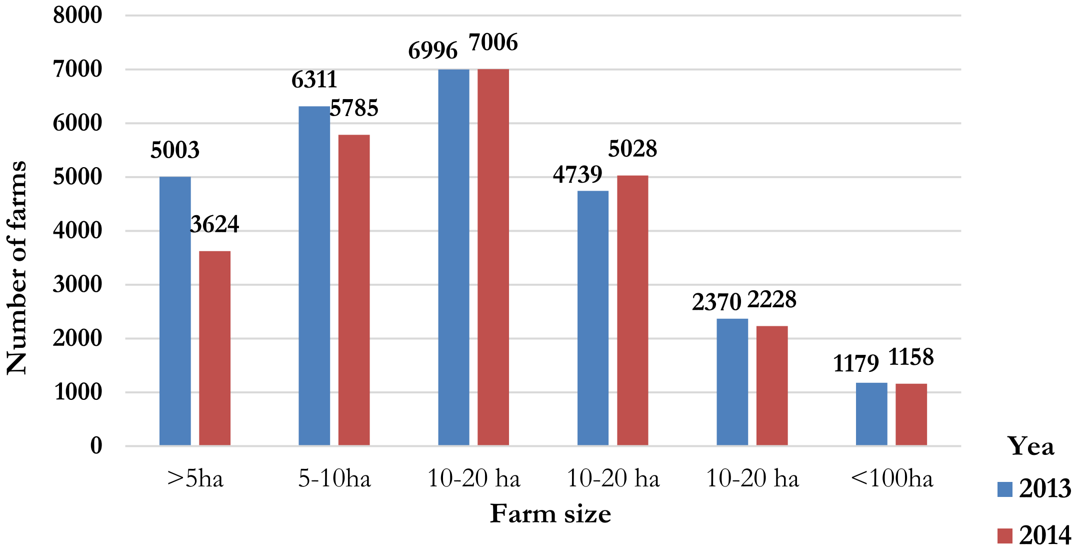
Figure D3: Production of pigs and cattle per 1ha of agricultural land and in physical heads (in live weight in kg) in 2005, 2010, 2013, 2014 and 2015 in Poland



Source: GUS 2016

The Figure D3 above, by combining the production of pig and cattle per 1ha of agricultural land with physical heads in Poland in selected years (after gaining EU membership), shows that since the number of pigs per 1ha of agricultural land continued to increase (despite decline in 2013, which was largely caused by the Russian embargo), yet the total weight of physical heads was significantly lower in 2015 when compared to 2005, the production of pigs has apparently become **more concentrated**, yet less productive, most likely due to low profitability of sustaining small pig populations as the prices of cereals for fodder go up and prices of slaughtered pigs go down, and also possibly due to diseases within confined facilities (MINROL 2016). By referring to cattle, while the total weight of physical heads among cattle has not significantly changed during the past 10 years, yet contrary to pigs, the number of cattle per 1ha of agricultural land continues to increase and was much higher in 2015 than in 2005, the cattle production has also become more concentrated, and contrary to pigs, it seems to be more productive as the total weight of cattle heads has not decreased.

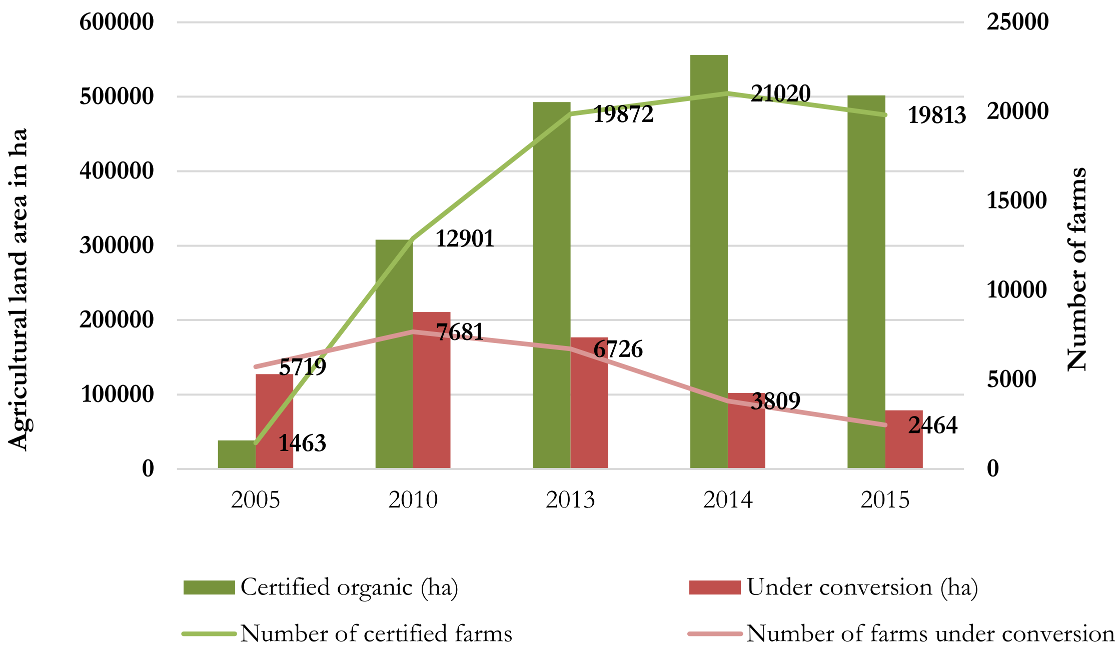
Figure D4: Certified organic farms by area groups of agricultural land in absolute numbers in 2013 and 2014 in Poland



Data source: IJHAR-S 2015

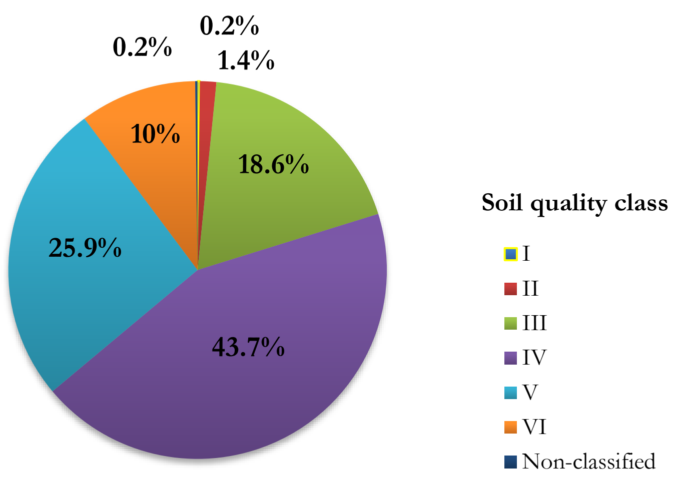
While the number of farms with the size between 1-15ha is declining, the farms that occupy more than 15ha are increasing. However, given that the smaller organic farms still dominate the 'organic landscape', similarly to the conventional sector, there is a high fragmentation in this sector.

Figure D5: The total agricultural land area (in ha) of organic farms and number of farms both certified organic and under conversion to organic in 2005, 2010, 2013, 2014 and 2015 in Poland



Data source: Main Inspectorate of Agricultural and Food Quality in: GUS 2016

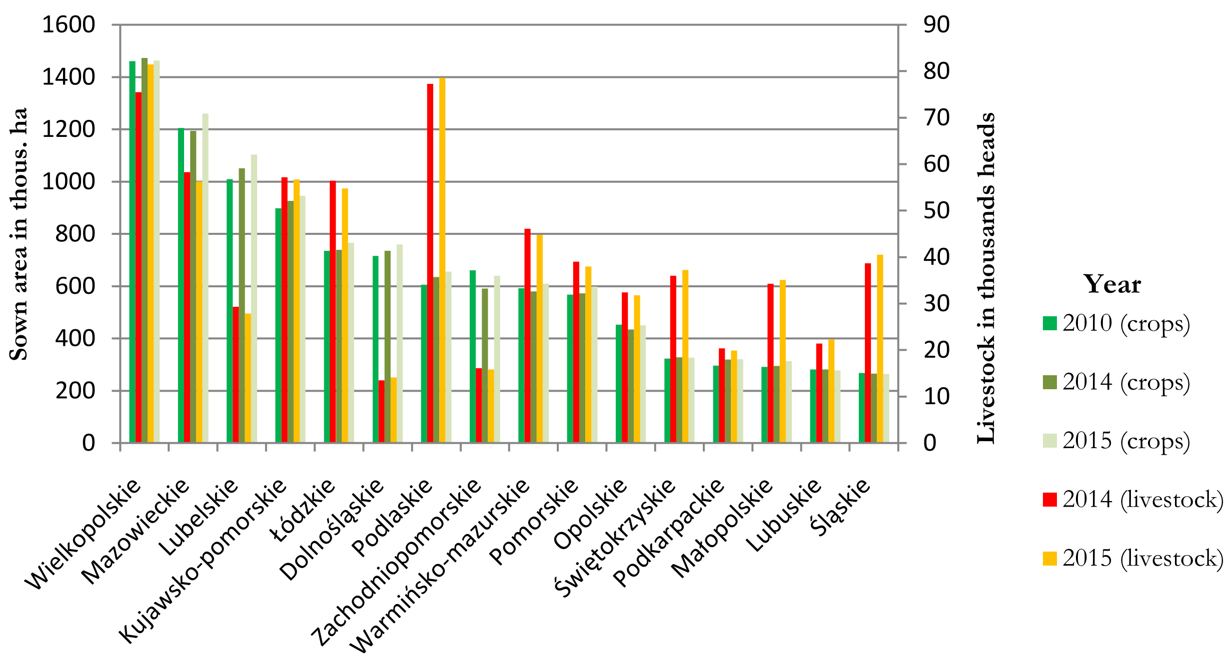
Figure D6: Agricultural land in relation to soil quality classes in Poland



Data source: GUS 2012[67]

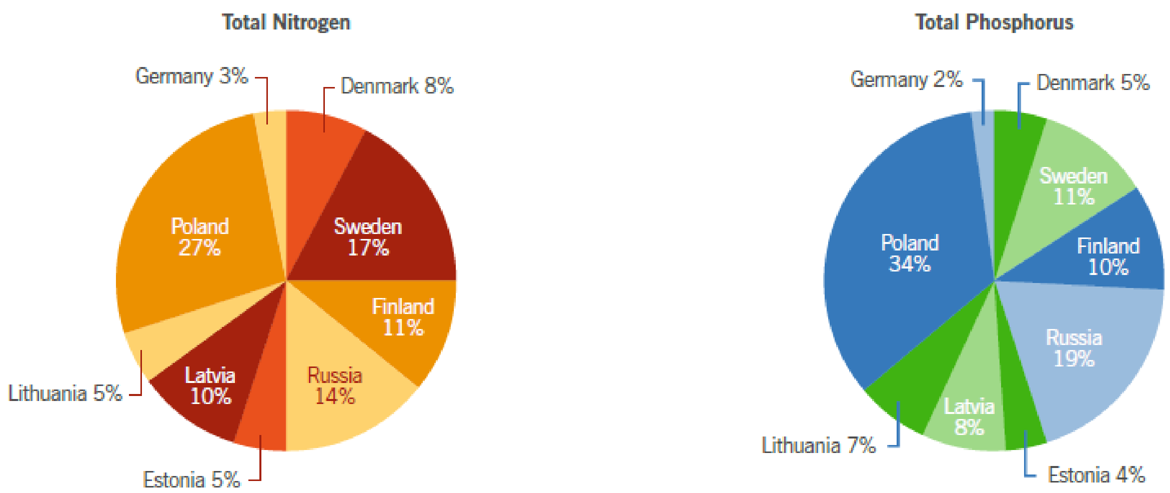
[67] Glowny Urzad Statystyczny (GUS). 2012. *Rocznik statystyczny rolnictwa* [Statistical Yearbook of Agriculture]. Warsaw: Zaklad Wydawnictw Statystycznych [Statistical Publishing establishment].

Figure D7: Sown area by voivodships in 2010, 2014 and 2015 combined with livestock per 100ha by voivodships in 2014 and 2014 in Poland



Data source: GUS 201

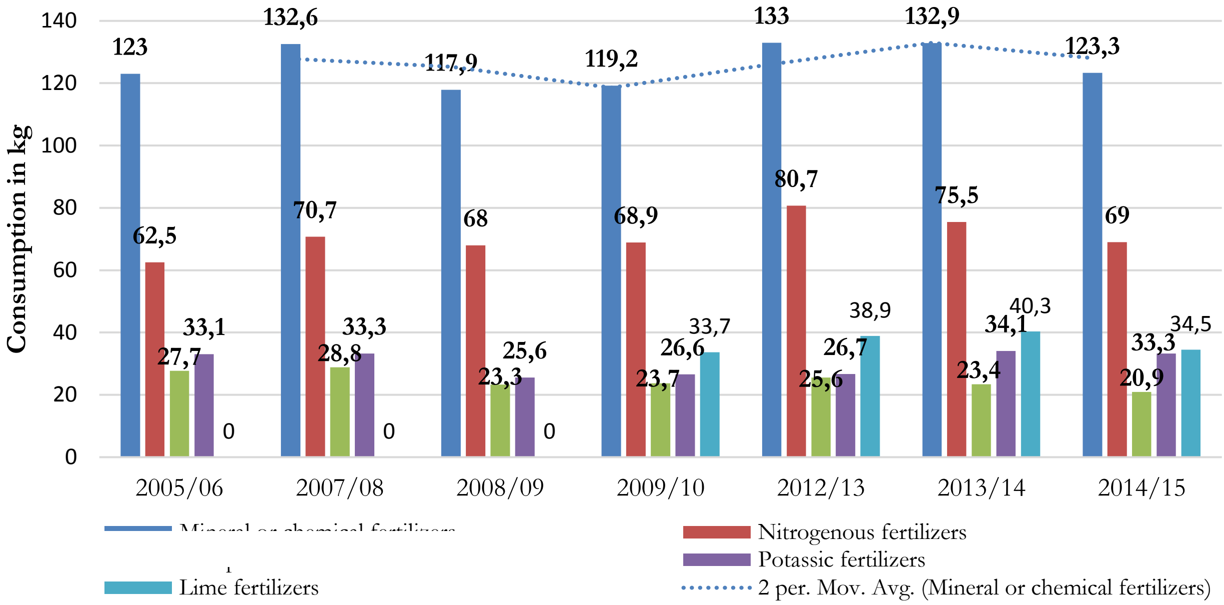
Figure D8: Nitrogen and phosphorus load from the countries within Baltic Sea Drainage area in 2010[68]



Source: HELCOM 2010 in: Granstedt 2012

[68] It is important to mention that these graphs take into account the overall estimated nutrient inputs (not only from agricultural sector but also from urban wastewater).

Figure D9: Consumption of mineral or chemical and lime fertilizers in terms of pure ingredient and per 1ha of agricultural land in kg between 2005 and 2015* in Poland

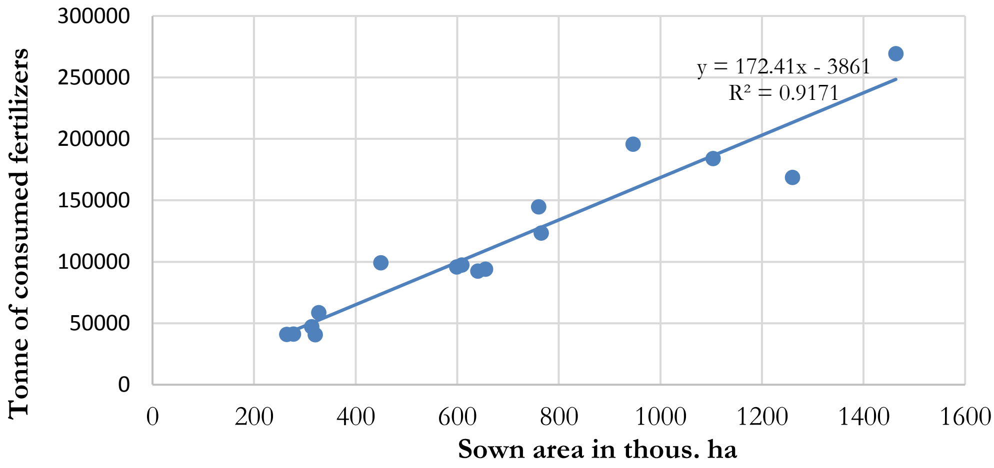


* No data for the consumption of lime fertilizers in 2005/06; 2007/08 and 2008/09

Data source: GUS 2016

The Figure D9 illustrates that the consumption of synthetic fertilizers after Poland gained membership in EU (2005/06) was on the similar level in 2014/15. However, soon after 2005 and shortly before 2014, there was a period of increased use of fertilizers. The major decline took place between 2008 and 2010 (possibly due to the fluctuations of oil prices). Overall, even though the consumption of synthetic fertilizers was lower in 2014/15 than in 2012-2013, it cannot be denied that it remains on a high level and synthetic fertilizers are the dominant technology, which lies in contract to recycling principles that promote the use of organic manure.

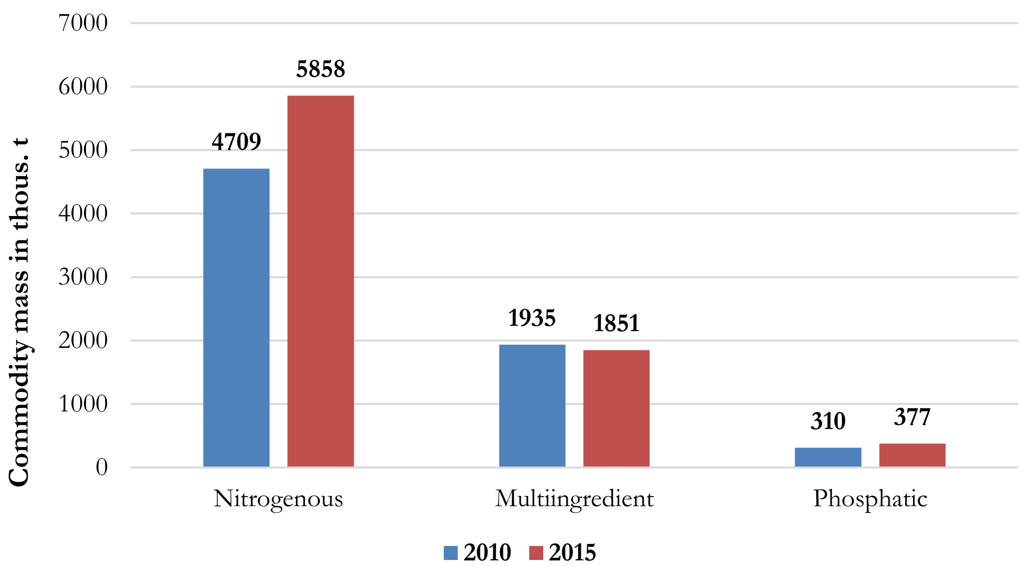
Figure D10: Correlation between sown area and use of mineral or chemical fertilizers by voivodships in 2015



Data source: GUS 2016

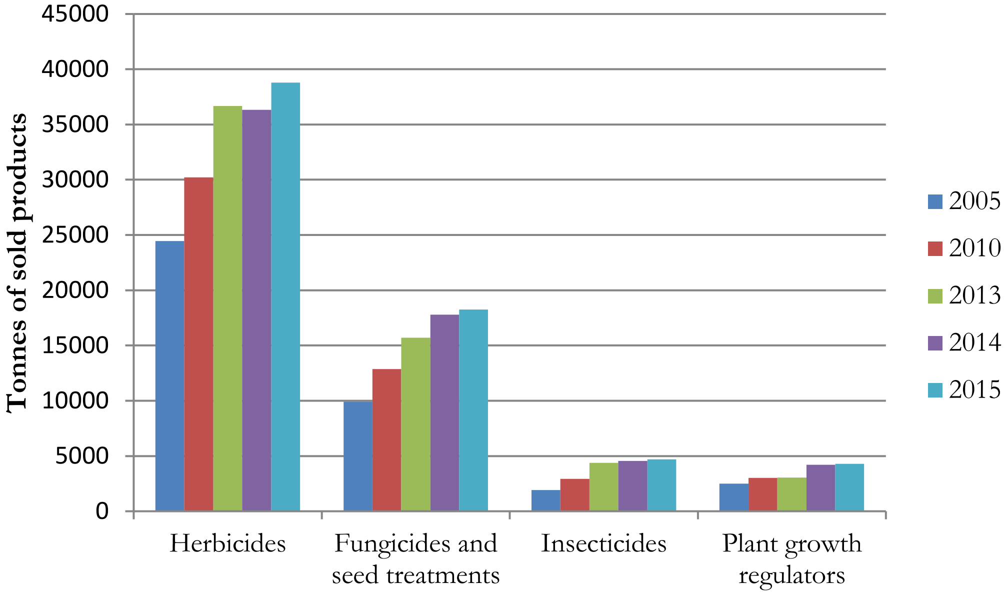
The Figure D11 shows that there is a strong correlation between the sown area and use of mineral or chemical fertilizers by voivodships in 2015. The highest amounts of mineral and chemical fertilizers are applied in Greater Poland, Kuyavian-Pomeranian, Lublin and Masovia voivodships, thus in regions where the production of crops (especially vegetables that require much more nutrients and hence fertilizers) is the highest (Figure D7).

Figure D11: Production of mineral and chemical fertilizers in 2010 and 2015 in Poland



Data source: GUS 2016

Figure D12: Sales of plant protection products in tonnes in 2005, 2010, 2013, 2014 and 2015 in Poland



Data source: GUS 2016

Appendix E: Additional (textual) information[69]

E1: (Historical) overview of the organic farming sector in Poland

Organic farming sector remains largely underdeveloped in Poland because its development was largely suppressed during the communist regime. Even though the concept of organic farming re-appeared in 1960 when Julian Osetek used to practice biodynamic farming on a 3ha farm, mainly due to ideological motivations; it wasn't until Osetek's public lecture on his farming practices in 1981, during which he managed to inspire wider academic circles to raise public awareness on biodynamic farming. One of the professors who was greatly inspired by Osetek's findings, was dr Mieczyslaw Górny - a specialist in soil ecology, who helped to spread the knowledge on biodynamic farming, which became recognized as an alternative farming method in Poland after the fall of the communist censorship in 1989 when the first organic farmers' association – 'Ekoland' was established and quickly become a full member of IFOAM (International Federation for the Organic Agriculture Movements) in 1990 (Szeremeta 2005). Moreover, since the majority of organic farms were private enterprises already prior to the collapse of communism in 1989, the privatization of agriculture did not significantly affect the organic sector (Bobik 2010). Overall, the highest number of organic farms is in Warmian-Masurian (4244 farms in 2014), West Pomerania (3549 in 2014) and Podlaskie (3453 farms in 2014). These numbers correspond with the highest total organic land surface per voivodship and thereby it can be concluded that the key 'organic regions' are located in the north of the country where there were the biggest concentrations of state-owned farms during the communist period, and which were subject to privatization after the economic crisis that led to their collapse (IJHAR-S 2015).

E2: Common Agricultural Policy (CAP)

The allocation process of CAP payments under both pillars is strongly related to historical trends. Following the accession of Poland to EU in 2004, the country, being a new EU Member State has received significantly lower amount of direct payments (25% of the EU level) under Pillar 1 than old Member States. For example, while the country received €16 525 billion (€421 per Polish citizen) during the period of its first CAP reform (2007-2011), an older member state such as Sweden was granted with €4882 million (€508 per Swedish citizen) (European Commission 2013). Such conditions of decreased payments were set from 2004 until 2014, to allow Poland steadily increase its inputs and yields, thus driving the never-ending cycle of expansive growth of farm units. In relation to direct payments under the new CAP (2014-2020), the Polish agricultural sector is

[69] References, which are not included in the thesis' bibliography are added in the form of footnotes.

supposed to receive subsidies amounting €23.4 billion (the stated amount includes 3.2% reduction at EU level that covers all EU Member States) (EC 2014). Nonetheless, the amount of subsidies under the current CAP (2014-2020) still remains lower when compared to new Member states (Czyzewski and Stepien 2014).

Given that each member state has the national flexibility to decide on the scope of selected measures and on how to implement the First Pillar payments, the CAP subsidies in Poland under the 1st Pillar (which mainly provide financial support based on acreage) were prioritized by the Polish government from the very beginning of EU membership, and thereby incentivized Polish farmers to enlarge their farms in order to become more competitive on the common EU market whose members pursue economies of scale, which do not support scaling of recycling principles. A study carried out by Ohlund *et al.* (2015), which investigated the structural changes in the agricultural sector under 2007-2013 CAP scheme, clearly revealed that while the EU average farm size amounted up to 12ha in the time period between 2000 and 2011, in the same time period the number of farms in Poland, which occupy more than 50 ha increased by 34% and the number of small scale farms covering less than 5 ha decreased by 25%. By referring to the CAP 2014-2020, while nearly 1.35 million farmers benefit from direct payments, only a minority of them (incl. approx. 26 000 organic farmers who are expected to receive up to €699 961 515 during the duration of current CAP) receive payments from the 2nd Pillar (RDPs), which amount up to €13.5 billion (incl. €8.6 billion from the EU budget plus €4.9 billion of national funding) (MINROL 2016).

Moreover, the direct payments in Poland are allocated for 4 sectors of **animal production** (cattle, milk cattle, sheep and goats) as well as 4 sectors of **crop production** (soft fruits such as strawberries), high protein crops, hops, beetroots, starch potatoes, tomatoes and hemp) (MINROL 2016). According to MINROL, these payments '*can be allocated only when they are necessary in order to incentivize farmers to maintain certain level of production and not to stimulate production growth*' (2016a). Therefore, it could be reasoned that the main rationale behind such payments is to help farmers to maximize their economic profits, and possibly achieve certain environmental benefits as far as subsidies for grazing animals and leguminous crops are concerned. However, given that farmers who solicit payments for some types of crops such as starch potatoes or tomatoes need to have cultivation contracts as a proof that they need to produce certain amount of crops and at certain price, it could be argued that such subsidies indirectly stimulate production growth, which might be unsustainable (i.e. encouraging farmers to simplify crop rotations in favor of producing solely cash crops) (MINROL 2016).

'Green box'

The main difference between the old (2007-2013) and new CAP (2014-20) has been the introduction of the greening component, namely 'green direct payments' (**Pillar 1**), which in case of Poland are greatly the continuation of 'payments for Agricultural Practices beneficial for the Climate and the Environment' that **began in the context agri-environment-climate scheme within CAP 2007-2013**, and include 30% of direct payments that are eligible to farmers once they comply with the set of obligations related to:

- *crop diversification* (incl. crop rotation; it is based on the size of farmland);
- *maintenance of permanent grasslands* (which is a net carbon sink);
- *development of ecological focus areas (EFAs)* (which constitute at least 5% of farmland and include features such as nitrogen-fixing crops or buffer zones, among others, that can prevent nitrogen leakage to the sea) (EC 2013).

Given that certified organic farming (Council Regulation (EC) No 834/2007) encompasses all main components from the 'greening measures', certified organic farmers are automatically eligible for the 'greening payment' (European Commission 2013). In addition, once all these 3 mandatory components are met, there are 4 other voluntary components available to farmer, namely: redistributive payment for the first hectares (arts 41-42); payment scheme for Less Favored Areas (LFAs) (arts 48-49); coupled support for production for economic or social reasons (section VI); and a simplified system for 'small farmers'. Moreover, in order to receive these payments, there are also basic standards and 18 statutory management requirements (incl. public, animal and plant health; animal welfare; animal welfare; environmental protection; good agricultural and environmental condition of land); that farmers need to comply with (thus forming the so-called 'cross-compliance' regime). In addition, the costs related to applying these rules need to be paid by the farmers in accordance to **'polluter-pays-principle'** (EC 2013). In case of non-compliance, farmers are eligible only for 70% of direct payments, thus still a great amount of money, which can be spent on enlarging and specializing their farms at the disadvantage of recycling principles.

The respective components of greening measures are analyzed in more detail below.

(1) **Crop diversification**

Crop diversification can enhance nutrient recycling once it includes nitrogen-fixing crops in combination with perennial grass and/or clover, the latter one constituting part of EFAs. However, it can be argued that **crop diversification** is largely simplified and farms, which has less than 10ha are **exempted** from it; the farms between 10 and 30ha need to have at least two crops (whereas the main crop and cereals cannot occupy more than 75% of total arable land); and the farms with over 30ha are required to have at least three types of crops (whereas the main crop cannot occupy more than 75% of arable land and two main crops combined together cannot cover more than 95% of arable land) (MINORL 2014c). There are also several **exemptions** from diversification, which do not create favorable conditions for the adoption of recycling principles (e.g. in case 75% of total arable land is used to produce grass for fodder or is constituted by permanent grassland). Alternatively, farmers can diversify their production as part of the agri-environment-climate scheme, which came to life during the CAP 2007-2013, by rotating at least 4 main crops within one year, whereby the main crop and cereals cannot exceed 65% of the total arable land and smaller than 10%, and at least 3 groups of crop rotations need to be introduced within 5 years (Package 1: Sustainable agriculture defined in Regulation (EU) No 1307/2013) (MINROL 2014).

Overall, it could be argued that the current regulations on crop diversification can be criticized of being **relatively easy to comply with** as they does not promote any advanced crop diversification, which could really enhance soils (reduce the necessity for fertilizers) and prevent crops from insect and weed infestations, among other benefits, but rather constitute 'minimum' requirements.

(2) **Maintenance of permanent grassland**

By referring to the component related to the maintenance of permanent grassland, 21.3% (309 2834ha) of the Polish territory was covered with permanent grassland and meadows in 2015 (GUS 2016). Interestingly, the land with permanent grassland and meadows covered 20.3% in 2003 (GUS 2008)[70], thus implying that there was **no significant change** at all after the payments, yet the permanent grasslands were definitely 'maintained'.

(3) **Development of ecological focus areas (EFAs)**

Since EFAs, which were allowed by the Polish government for collective implementation, are required to cover **only 5%** (and possibly 7% since 2018) of arable land in farms that occupy more than 15ha, it can be argued that such conditions exclude many smaller farms, which constitute a majority of farms in Poland (the average farm of the size was 10.49 ha in 2015) and might also tend to apply large volumes of fertilizers (Eurostat 2015; MINROL 2014).

However, given the high reliance of Polish farmers on synthetic fertilizers and dominance of conventional farming sector as well as trends toward increasing farm size, it could be argued that

[70] Główny Urząd Statystyczny (GUS). 2010. *Charakterystyka obszarow wiejskich w 2008 r.* [Characteristics of rural areas in 2008]. Warsaw: Zaklad Wydawnictw Statytycznych [Statistical Publishing Establishment].

even 5% of EFAs containing nitrogen-fixing crops could be deemed beneficial on the premise that such regulation could encourages farmers to phase out/ reduce the reliance on mineral fertilizers. Either way, it is important to mention that the production of leguminous crops **has greatly increased** during the past few years as farmers are eligible not only for 'greening payments' once they comply with several requirements, but also due to the fact that they are eligible for already mentioned extra financial support for leguminous crops that likewise fall under the 1st Pillar of CAP. Interestingly, such payments were already established in 2011 and continued since then (MINROL 2011). The table below illustrates that the amount of sown pulses for grain for feed has especially increased after the introduction of greening measures. However, the table also shows that the amount of sown perennial legumes for feed remains at low levels and it was especially low in 2014 and 2015, most likely due to intensifying droughts (perennial legumes are less water efficient than annual legumes).

E2_1: Sown area of pulses for grain and perennial legumes in 2005, 2010, 2013, 2014 and 2015 (as of June and in thousands of ha)

	Year	**2005**	**2010**	**2013**	**2014**	**2015**
Pulses for grain	**consumer**	33	43	40	53	91
	feed	86	129	133	163	316
Perennial legumes	**feed**	84	124	131	75	93

Data source: GUS 2016

On the other hand, the current rates of fertilizer consumption (and import of modified soybeans) imply that the current rate of use of leguminous crops is not enough to significantly replace off-farm inputs. Therefore, it could be argued that taxes on fertilizers to further increase the share of leguminous crops could be considered. However, it is worth highlighting that the **leguminous** (nitrogen-fixing) crops **increase the risk of leachin**g in case they are not integrated with animals grazing on such 'leguminous grasslands' – such finding should be taken into account when designing new policy instruments (FAO 2011).

Another conflicting aspect related to the **greening component**, which might affect the scaling of recycling principles, is the fact that **organic farmers** and those who pursue agri-environmental programs can receive financial support from EU '*only to the first 30ha*' (ARC 2020 2014). Consequently, not only the medium size (40-50ha) and larger farmers (>100ha) remain greatly under-supported, but also smaller farmers (<30ha), which constitute a majority. It can be also argued that the concept of equivalence ('I am an organic farmer so I am automatically eligible for money from the 'green box'') implies that organic farmers receive limited support from the Pillar 2 of CAP as they are already eligible for payments from the Pillar 1 (under the 'cover' of greening), which are paradoxically based on the farm size. It can be reasoned that such regulation might be responsible for the recent decrease of the total surface of organic farms in Poland, especially in relation to small organic farms.

Pillar 2

Given that EU member states are greatly heterogeneous due to complex historical background and different socioeconomic conditions, they were granted a national flexibility to select three key national priorities under the **Pillar 2 of CAP**, and which indicate key areas that they wish to subsidize through the Rural Development Program that comprises agro-environmental schemes. The Polish government has opted for the following priorities (out of six available options) for the 2014-2020 time period:

(1) '*Fostering the competitiveness and productivity of the agri-food sector*,
(2) *Ensuring the sustainable management of natural resources and climate action,*
(3) *Achieving a balanced territorial development of rural economies through development of local infrastructure, investments in education, culture and public services as well as creation and maintenance of employment*' (European Commission 2015)

By referring to first objective related to (1) ***'Fostering the competitiveness and productivity of the agri-food sector'***, the financial support is concerned, among other measures, with providing annual payments for people leaving agricultural sector in order to encourage them to transfer to '*110 000 ha of land from small holdings to holdings whose area is close to the average national size*' (EC 2014). As part of this objective, there are also funds to incentivize young farmers to create '*29 000 new,* ***modern and competitive*** *farm enterprises*', and make good strategic plans on how to enable **land consolidation**. Unsurprisingly, the highest funds whose aim is to facilitate land consolidation concern the most fragmented voivodships (Sub-Carpathian, Lesser Poland, Lublin, Lower Silesian and Silesian) (EC 2014; MINROL 2014). In the light of these goals, it can be argued that they are greatly concerned with modernization and intensification of agricultural production that goes hand in hand with pursuing economies of scale, thus with two pathways, which are not favorable from the perspective of scaling recycling principles. To further explain this, Poland as a new EU Member State, has had to adapt to not only to the global market dynamics but also to new EU regulations (e.g. via national top-ups of (initially) partial direct payments) at the expense of pursuing wider environmental goals. These adaptation measures included investments primarily in the infrastructure (e.g. to meet EU sanitary standards), modern machinery and entrepreneurships

(Ohlund *et al.* 2015). Therefore, the goals of Polish policy-makers within the agricultural sector have been 'rationally' more dependent of the path toward productivist-modernization approach, and have been more concerned with investments in technological innovations and infrastructures (the current investments are greatly targeted at milk, beef and pig sectors) rather than promotional efforts to scale up restorative practices whose aim is to improve the state of natural environment (EC 2014). On the good side, it could be argued that **land consolidation** might be beneficial for scaling of recycling principles as it is likely to improve arrangements of fields, which is important for effective cooperation between farms. However, given that the subsidies under CAP 2007-2013 enabled to consolidate only 85 000ha of agricultural land, it leaves no doubt that it is a very lengthy process. The highly infeasible nature of procedures associated with attempts to consolidate land in CAP 2007-2013 even resulted in relocating funds allocated to land consolidation into other activities under the Rural Development Program in CAP 2007-2013 (Lorencowicz *et al.* n.d). Moreover, it could be also argued that other funds, which might be beneficial as far as scaling or recycling principles is concerned, could be funds for modernization of small farms that amount up to €699 961 515) (MINROL 2014). However, these funds can be considered as insignificant when the amount of financial support for bigger farm enterprises, which are greatly oriented at pursuing economies of scale, is taken into account.

As far as the second objective related to (2) ***'Ensuring the sustainable management of natural resources and climate action'*** is concerned, the key priority of this objective, which is relatable to recycling principles, is to reduce nitrogen and pesticide inputs, manure leaching as well as to make grazing more environmentally friendly (incl. improvement of technical infrastructure for ruminants) and preserve animal genetic resources, the latter one helping to ensure that animals can better adapt to natural conditions (EC 2014; MINROL 2014). However, as the sub-section related to EU Water Framework Directive reveals, these goals still remain greatly **unmet** and are pending urgent action.

By referring to the objective related to the (3) ***'Achieving a balanced territorial development of rural economies through development of local infrastructure, investments in education, culture and public services as well as creation and maintenance of employment'***, it can be argued that it is in the line with the concept of the 'Ecological Regenerative Agriculture'. While the concept of 'local infrastructure' could refer to the development of processing infrastructure for the (organic) food products that could help to create short production chains, 'the investments in education' could help to introduce educational efforts to raise awareness of environmentally friendly farming practices (and even knowledge on organic food labels, which remains limited) (PAP 2013). In other words, this objective corresponds with the goals of the Sustainable Food

Societies (SFS), an outcome of the BERAS Implementation Project, which showed that by adopting recycling principles in combination with wider social initiatives (such as sustainable diets), it would be possible to create local jobs and enliven/create small rural economies before they are absorbed by economies of scale (Granstedt 2012). However, the processing infrastructure receives much less support (€693 million) than the measures, which are oriented at supporting modernization of farms (€2 816 064 486) (MINROL 2014). Moreover, even though more than 1 800 producer groups are expected to be created, these groups (and even processing industries) do not seem to be very concerned with small, locally-active processing companies but rather with efforts to have larger shares on the global market (EC 2014).

Overall, it could be argued that the national flexibility to select key priorities in the next CAP constitutes a window of opportunity to prioritize other objectives, which could better address recycling principles. For example, the objective related to '*Ensuring the sustainable management of natural resources and climate action'* could bring about more agro-environmental schemes concerned with recycling principles to choose from. Another possible priority could relate to '*innovation and training in rural areas*', which, once prioritized (and if such priority is re-offered in the next CAP), might further help to fill the knowledge gap among farmers with regards to recycling principles (Stein-Bachinger *et al.* 2015)[71]. Nonetheless, following the content of the report issued by the Ministry of Agriculture, it was clearly indicated that the current structural changes in the agricultural sector such as increasing land size and specialization are highly desirable as they help to increase farmers' competitiveness on the global market, thus implying that the funds for more environmentally oriented, agroecological practices are likely to remain low unless stricter rules are imposed at EU level (**REF**). Moreover, an expert of Baltic Sea protection in WWF Sweden, rightly stated that: '*Nowadays the system of agro-environmental protection schemes is like a labyrinth, complicated web of countless sub-measures and variants; there is no possibility to find out what exactly has been done and what are the effects of such actions*' (Gladth in: WWF 2017b), thus only further highlighting the flawed nature of programs falling under the Pillar 2, namely the issue of limited transparency ('blurred baseline').

[71] Bachinger, K., Reckling, M., Bachinger, J., Huufnagel, J., Koker, W., Granstedt, A. 2015. Ecological Recycling Agriculture to Enhance Agro-Ecosystem Services in the Baltic Sea Region: Guidelines for Implementation. *Land 4*:737-753.

E3: EU Water Framework Directive (WFD) & EU Nitrates Directive

The EU Water Framework Directive is a legislation, which is meant to be harmonized with the BSAP. This legislation addresses groundwater and surface water pollution through river basin management plans (2000/60/EC). The EU Nitrates Directive (91/676/EEC), which constitutes an integral part of WFD after it was established in 1991 is concerned with nitrate pollution from agriculture by establishing '*Codes of Good Agricultural Practice to be implemented by farmers on a voluntary basis*' that set optimal levels for manure use and storage (for the period of at least 4 months).

The EU Nitrates Directive requires EU member states to designate the so-called Nitrate Vulnerable Zones (NVZ), which are obliged to comply with the Codes of Good Agricultural Practice (with an exception that the minimum storage capacity of manure amounts to 6 months in the NVZs). However, in case of Poland the NVZs constitute only 7.4% of the country's arable land (i.e. 4.46% of country's land surface) (EC 2014).

Moreover, according to Skorupski from the GAJA Federation lobbying against industrial farms (2012), '*the Polish Ministry of Agriculture refuses public access to information about 6 fertilization plans claiming that this is market sensible, private information and local communities around big farms have been entirely deprived of the possibility of controlling proper manure management'*. On the good side, it can be argued that the existence of the monitoring program to control the amounts of nitrogen in the soils for fertilizer management in several regions in Poland (e.g. Greater Poland), and the fact that every river basin catchment in several regions in Poland has a water management plan that tries to address point and non-point pollution, steer agricultural sector in the right direction (Ecologic Institute 2014). Nonetheless, in 2013 Poland was taken to the Court of Justice of the European Union as it failed to ensure that water pollution by nitrates was in the accordance with the requirements set by the EU Nitrates Directive. The country was also greatly accused for not implementing a sufficient number of NVZs and relevant measures to combat pollution with nitrates (EC 2013b).

Even though the Polish government declared in front of the Court in 2014 that it will enforce a new Water Act on the 1st of January 2017 (InfoCuria 2014), no significant action in this direction has been done as no draft has been passed to the Polish Parliament yet, and the proposed regulations were full of flaws. For example, small farms, which still dominate the Polish agricultural landscape and according to Dr Wrzaszcz and Dr Gradziuk they tend to be 'unsustainable' (i.e. apply high volumes of fertilizers) (Interview, March/April 2017); were not required to comply with more stringent regulations. In result, the country is threatened of incurring serious financial penalties (Szolc 2017). Such attitudes of policy-makers might imply that they are very unlikely to consider changing the policies to create better conditions for recycling principles.

E4: GMOs

The feed concentrates are largely based on the genetically modified soybeans. By making a further reference to the policies related to GMOs, it can be mentioned that Poland is one of the few countries in the EU, which prohibited the use of GMOs in fodder in 2006. However, such ban never became a reality as it was subject to moratorium, which was enforced in 2012 and allowed the use of GMO soybeans until the end of 2016. After this period, the moratorium was again extended with the objective to last until 2021, especially given that all EU members approved it and the production of pork and poultry was believed to become less cost-effective without extra support[72].

E5: Biogas industry

Even though biogas plants, which enable to generate bioenergy through anaerobic manure digestion during which harmful pathogens and bacteria are broken down, are not yet deeply rooted in the 'agro-technological' regime in Poland, these 'clean-technologies' are becoming increasingly recognized and keep emerging. For example, the Ministry of Agriculture and Rural Development in Poland has initiated a plan to modify the requirement (Dz. U. 2007) according to which farmers are currently obliged to use 70% of slurry on agricultural land, which has more than 750 places for sows and more than 2000 pigs whose weight exceeds 30kg; in favor of using up to 100% of this slurry for the production of biogas (MINROL 2016; Mazurek 2017)[73]. While it could seem that such facilities could generate 'bioenergy' in a country, which is greatly dependent on coal, such production of energy from biogas plants is only minimal and might only further stimulate the enlargement of such large pig facilities ('to produce more biogas and bio-fertilizer'), which potentially create unfavorable conditions for scaling of recycling principles. As the representative of EKOLAND in Western Pomerania mentioned: '*If you earn 0.5eurocent per pig it's already a success because what matters is manure and slurry for biogas*' (Interview, March 2013). Therefore, even though fermented slurry is a good bio-fertilizer, such amendment of the regulation is definitely not

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[72] Mamos, E. Polska nie jest skazana na GMO. Ma swoje białko [Poland is not forced to import GMOs. It has its own protein]. URL: http://www.polskieradio.pl/42/5202/Artykul/1669108,Polska-nie-jest-skazana-na-GMO-Ma-swoje-bialko

Losz, K. 2012. GMO przedłużone [GMO extended]. URL: http://www.naszdziennik.pl/ekonomia-polska-wies/3900,gmo-przedluzone.html?d=1

IAR. 2016. Moratorium na zakaz sprowadzania pasz z GMO przedłużone [Moratorium on imports of GMO fodder is extended]. URL: http://inwestycje.pl/rolnictwo/Moratorium-na-zakaz-sprowadzania-pasz-z-GMO-przedluzone;280829;0.html

[73] Mazurek, S. 2017. Letter from undersecretary of the Ministry of Environment - Mazurek, S. to the Marshal of Sejm - Kuchcinski, M. Warsaw: Ministry of Environment.

favorable as it seems to take advantage of the already existing environmental problem (high concentrations of pigs) in order to generate even more environmental problems (i.e. further enlargement of the so-called 'HELCOM hot spots', which are also the sources of various diseases; and in terms of possible over-fertilization of fields with slurry that can result in soil acidification). Interestingly, a representative of an agricultural university farm in Greater Poland voivodship, which has in plans a construction of a biogas facility, added: '*Energy policies are a big problem and you need to show that you will produce a certain amount of energy, unlike in Germany were installations are independent*' (GP_C11). Such statement allows to reason that in order to produce the required amount of bioenergy (biogas) it is necessary to increase the number of animals, yet in the light of the current regulations most probably beyond the capacity of the land.

Moreover, such biogas plants are usually funded with the foreign capital ('*We even don't know who they are*' – Interview with a member of EKOLAND in Western Pomerania, March 2017). For example, the first biogas plants installed by large pig facilities were funded by Dutch investors (Bioenergia 2013)[74], which are the largest exporters of Dutch landrace pigs that have dominated pig industry in the Polish agricultural sector (GP_C8; GP_C10). While such companies tend to create a 'greener image' of such big industrial facilities by investing into biogas infrastructure, it could be argued that they are not devoid of vested interests.

Either way, as far as the efficient nutrient recycling, animal welfare and wider ecological and managerial concerns are concerned, yet in relation to scaling of recycling principles, it can be obviously argued that such big facilities should not take place at all as they only add extra environmental problems, which are seemingly being masked by the newest technologies such as biogas that only address symptoms rather than root causes of underlying problems (high animal concentrations). What is worse, such big pig facilities (combined with the production of biogas) are likely to further emerge, especially given that one of the objectives of the state is to further increase pork exports by 15% (MINROL 2016). Paradoxically, the dramatic decline in pork in recent years, made it one of the major imported commodities (5 million of pigs are being imported) and the current outbreak of African Swine Fever (ASF) in Ukraine, Russia and Lithuania has only led to decline in overall imports of pork by Poland (Banski 2009; MINROL 2016; Council of the European Union 2016).

[74] Bioenergia. 2013. Lider polskiego rynku biogazowni ostrzega: biogazowniom w Polsce grozi krach [Leader of the Polish market of biogas plants is warning: Polish biogas plants can collapse]. URL: http://gramwzielone.pl/bioenergia/5911/lider-polskiego-rynku-

E6: Research and Development (R&D)

One of the biggest research initiatives at EU level is Horizon 2020 - the largest EU Research and Innovation program that acts as a financial umbrella that provides funds for research and design of flagship programs and initiatives (innovations) whose objective is to ensure competitiveness of Europe in the global market[75]. This program is worth highlighting in the context of recycling principles as it involves several agricultural projects that, similarly to the BERAS project, seem to correspond to the integral cyclic agricultural model depicted in this paper, and could constitute a solid ground for the development of national rural development programs (Pillar 2 of CAP) that would promote integral cyclic agriculture; or at least inspire farmers through the creation of demonstration projects. For example, the **TP Organics** - European Technology Platform for Organic Food and Farming (which is already hosting a BERAS project) has distinguished 12 priority topics as part of the Work Programme 2018/2020 and under the two major categories of Societal Challenge 2 of Horizon 2020 - Sustainable Food Security and Rural Renaissance, where the former is concerned with building socio-ecological resilience of food production system, and the latter focuses on the creation of conditions to integrate agricultural innovations into both organic and conventional farming systems. The review of these topics enabled to conclude that these research initiatives open a window of opportunity to scale recycling principles on a bigger scale as some of them are directly addressing important issues incl. the necessity to 'improve soil management' (via crops rotations, crop mixtures and manure among others), 'co-design, organize and cooperate for sustainable farming systems', 'implement the circular economy for nutrients' or 'strengthen the knowledge and innovation systems for organic farming'[76]. Similarly, the European Innovation Partnership for Agricultural Productivity and Sustainability (EIP-AGRI) is another platform co-funded by Horizon 2020 and the EU Rural Development Policy; and encompasses several projects that resonate with recycling principles presented in this paper, e.g. 'Mixed crops-animal farming systems' (MFS)[77].

E7: General Union Environment Action Programme

According to Decision No 1386/2013/EU (General Union Environment Action Programme to 2020 'Living well, within the limits of our planet'): "*Further efforts to manage the nutrient cycle in a more cost-effective, sustainable and resource-efficient way, and to improve efficiency in the use of fertilizers are also required.*

[75] https://ec.europa.eu/programmes/horizon2020/

[76] TP Organics. 2016. Priority topics for Horizon 2020; Work Programme 2018/2020. Brussels: TP Organics.

[77] EIP-AGRI. n.d. Mixed Farming Systems: Livestock/Cash crops. URL: https://ec.europa.eu/eip/agriculture/en/content/mixed-farming-systems-livestockcash-crops

Such efforts call for investments in research and improvements in the coherence and implementation of Union *environment legislation to address those challenges, tightening standards where necessary and addressing the nutrient cycle as part of a more holistic approach which integrates and creates links between existing* Union *policies that play a role in tackling eutrophication and excessive nutrient releases, and avoids a situation whereby nutrient emissions are shifted across environmental media*." While it can be argued that the mentioned 'efforts' to improve nutrient management might relate to the rise of precision farming methods, which are part of the fertilizer manufacturing industry, the recognition of the importance to address the nutrient cycle via the systems thinking approach, constitutes a great first step to lobby for more locally based management of nutrients, and thereby recycling principles.

APPENDIX F: IMAGES AND VISUAL RECORDS FROM THE FIELD

F1: Bloom-filled Baltic

Image source: European Space Agency 2010, Labelled by: BBC 2010 [Image belongs to Wikimedia Commons - the free media repository]

F2: Impressions from the recycling (dairy) farm in Järna, Sweden

F3: Impressions from the conventional farms in Lublin voivodship

Overview on the farm (47ha in total) and EU-subsidized machinery

Potassium from Belarus (LUB_C3)

Large volumes of nitrogen fertilizers produced in Poland (LUB_C3)

Silage from corn (LUB_C3)

Manure mixed with straw (lack of manure storage pad as the farmer allegedly did not exceed required 170 kg of nitrogen (manure) per hectare and year (5.2.2) (LUB_C3)

Cattle in chains (LUB_C3)

Overview of farm – LUB_C4. No manure storage pad as it has only 2 pigs and 11 chickens (in total 2ha).

Pigs (LUB_C4)

Chickens (LUB_C4)

F4: Organic farmers market in Lublin city

F5: Meeting of organic farmers in Lublin city (EKOLAND – Organic farmers' association)

F6: Impressions from the farms in Greater Poland voivodship

Cattle enclosure (GP_C8)

Swine facility – approx. 180 units in total (GP_C8)

Manure storage pad (GP_C8)

Development of new infrastructure for pigs (GP_C8)

Fodder storage (GP_C8)

Pig grower concentrate produced in Poland (GP_C8)

Mixed crops-milk cattle farm – in total 500ha (GP_C11)

Reminiscent of state-owned farm from the communist periods(‘PGR’)

Conventional pig farm (GP_C10)

Slurry storage pad (GP_10)

A large swine facility with the capacity of storing 2000 pig units (GP_C10)

Ecologically grown farm animals (free-roaming) (GP_O11)

Machinery to manage grains (GP_O11)

Certified organic *Ornithopus* (the bird's foot) seeds (for after-crops) imported from Germany (GP_O11)

Overivew on the 'organic' field – 50ha (GP_O11)

Overview on the farm (free-range chickens) (GP_O9)

Manure storage (GP_O9)

Overview on the 'organic' field – 24ha in total (GP_O11)

F7: Impressions from the organic farm in West Pommerania voivodship

Overview on the certified organic mixed crops-livestock farm, which used to be a state-owned agricultural farm (WP_O9)

Remaining infrastructure from the communist period (GP_O9)

Facility for cattle for the winter period (GP_O9)

Manure storage pad and renovated (with the help of EU subsidies) post-communist cattle housing infrastructure (GP_O9)

F8: Impressions from the Museum of State Agricultural Farms in Bolegorzyn village, West Pommerania voivodship

Poster to the left: '*We will make State Agricultural Farms role model, socialist farms'*

Poster to the right: *'Village welfare is a city welfare'*

'Orientational agenda of protection of specific plant types' in the period of State Agricultural Farms

Polish machinery in the period of State Agricultural Farms

F9: Organic farmers meeting in Pokrzydowo village, Brodnica county (Kuyavian-Pomeranian voivodship)

Starting from the left: Ms Maria Staniszewska – a representative from the Polish Ecological Club; Mr Mieczysław Babalski – one of the pioneers of organic farming in Poland; Dr Jarosław Stalenga from the Institute of Soil Science and Plant Cultivation (IUNG) in Puławy, Poland; Dr Artur Granstedt – precursor of the Ecological Recycling Agriculture project; and Ms Sheshti Johansson – researcher from the BERAS project (23rd March 2017)

Overview on attendees (farmers from Kuyavian-Pomeranian voivodship as well as from neigboring voivodships: Warmian-Masurian, Greater Poland, Masovian

F10: Meeting in the Institute of Soil Science and Plant Cultivation (IUNG) in Puławy, Poland

Dr Arthur Granstedt giving a presentation on ERA (19th April 2017)