RESPONSEABLE

KEY STORY

The story of eutrophication and agriculture of the Baltic Sea

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AUTHORS:

Heidrun Fammler, Hannah Sophia Weber, Tamer Fawzy
(Baltic Environmental Forum Germany)

Merle Kuris, Laura Remmelgas
(Baltic Environmental Forum Estonia)

Kristina Veidemane
(Baltic Environmental Forum Latvia)

Tanya Bryan, Kari Synnøve Johansen
(GRID-Arendal, Norway)

Joanna Piwowarczyk
(guest, Institute of Oceaonology, Poland)

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CONTENTS

1. INTRODUCTION

The Horizon 2020 project ResponSEAble aims to increase the understanding and awareness of how European citizens affect and benefit from the oceans and chose **eutrophication and agriculture** as one of the key challenges (or stories) of the Baltic Sea. As central principle, ResponSEAble focuses on a better understanding about the relationship between a wide range of human activities and their effect on the marine environment. This includes the understanding of the current knowledge system to select target groups and to design new ocean literacy tools for closing existing knowledge gaps.

HELCOM has identified agriculture as the main source of nutrient inputs to the Baltic Sea, and measures and regulations for their reduction are implemented since many years. To reduce eutrophication in the Baltic Sea, ResponSEAble seeks to answer: How literate are we on well-known issues such as eutrophication of the Baltic Sea? Did we target the right stakeholders? Did we communicate the right messages? Who are the actors in the value chain? How can the actors of the value chain be influenced in the way they operate?

In this story of eutrophication and agriculture of the Baltic Sea, instead of following a cause-effect line of activity, pressure and impact, we analysed the diffuse nature of pressures related to agriculture by analysing all the activities and actors across the value chain to understand, how economic activities directly or indirectly connect to it, which drivers occur within the value chain and which opportunities exist for initiating a change.

The story of eutrophication and agriculture in the Baltic Sea provides:

1)

A summary of the existing knowledge about eutrophication and agriculture along the expanded DPSIR framework DAPSIWR (Drivers - Actions - Pressures - State - Impacts - Welfare - Response), reflecting on cause-effect relationships between agriculture and eutrophication. Additionally, an analysis of the agricultural value chain adds socio-economic layers by focusing on the key segments of the economy that are closely linked to the agricultural value chain and presenting the interrelationships and synergies that exist between these activities.

2)

An overview of the key actors and stakeholders in relation to eutrophication and agricultural activities, aiming to identify actors that are connected to main activities of the value chain. Additionally, the story tried to identifiy actors along the value chain that could implement more sustainable practices.

3)

A comprehensive analysis of media from seven countries of the Baltic Sea Region, reviewing the content of the publically available messages about eutrophication, their senders and receivers and their classification within the DAPSI(W)R framework.

The aim of the story was to develop and add a new perspective on the classical eutrophication-related communication by widening the scope of possible actors responsible for initiating the change. In addition, ResponSEAble assessed the existing knowledge system of these actors and gaps in current communication.

2. EUTROPHICATION OF THE BALTIC SEA

The term eutrophication describes ecosystem changes in aquatic systems due to their enrichment with minerals and nutrients such as nitrogen and phosphorus. The enrichment causes algal blooms and their increased biomass enhances mineralisation processes that are decreasing or even depleting oxygen concentrations in the aquatic environment. The consequences are a decrease in water quality, build-up of hypoxic and anoxic zones, death of macrofauna and an overall degradation of the aquatic ecosystem. Eutrophication does not only have major impacts on the natural aquatic environment, but also on the people living in the coastal areas as they depend on the aquatic environment for e.g. services, livelihood opportunities and recreational use. Eutrophication is a major environmental problem in the Baltic Sea region.

The Baltic Sea is one of the world's largest semi-enclosed bodies of brackish water, which is almost entirely land-locked and is characterized by a very limited water exchange. Due to its special geographical, oceanographic, and climatological characteristics, ecosystems of the Baltic Sea are highly prone to environmental impacts of human activities at sea and in its catchment area (HELCOM, 2010). Since the beginning of the 20th century, the Baltic Sea has changed from an oligotrophic clear-water sea into a highly eutrophic marine environment (Larsson et al., 1985). The HELCOM assessments in 2010 and 2014 concluded that the entire open Baltic Sea was affected by eutrophication and that only a few coastal areas were in good ecological status according to the Water Framework Directive (WFD) requirements (HELCOM, 2010, 2014).

While there are several sources for nitrogen and phosphorus in the Baltic Sea, agriculture was identified as the main sector adding these two nutrients to its water bodies (HELCOM, 2015). Currently, 70-90% of nitrogen and 60-80% of phosphorous from the diffuse sources and almost half of the total waterborne inputs to the Baltic Sea originates from agricultural practises (HELCOM, 2015). At the same time, the direct inputs contribute with 7% of total nitrogen and 11% of total phosphorous inputs as relatively small proportions to the total nitrogen and phosphorous inflow to the Baltic Sea sub-basins (HELCOM, 2015).

3. ASSESSING AVAILABLE KNOWLEDGE WITHIN THE DAPSI(W)R FRAMEWORK

The goal of Chapter 3 is to develop a synthesis of the existing knowledge about eutrophication and agriculture. Hereby, a combination of the DPSIR and Ecosystem Goods and Services Framework was applied to capture both the pressures on Baltic Sea ecosystems imposed by human activities and the services and opportunities offered to humans by the Baltic Sea.

In ResponSEAble, we have expanded the known DPSIR framework into the DAPSI(W)R (Drivers – Activities – Pressures – State – Impacts – Welfare – Response) framework with the aim to better represent the depth of the knowledge required to thoroughly reflect cause-effect relationships between agriculture and eutrophication. The DAPSI(W)R framework was applied to produce causal network maps that were essential for understanding relationships between different DAPSI(W)R categories and supported the identification of current knowledge and communication gaps within the topic. The relationships between the DAPSI(W)R categories are visualized in Figure 1.

3.1 DRIVERS

In our DAPSI(W)R analysis, we distinguished between indirect and direct drivers. Indirect drivers include socio-economic processes and can have the ability to alter the level or rate of change of one or more direct drivers. In contrast, direct drivers influence ecosystem processes directly.

3.1.1 INDIRECT DRIVERS:

Demographic drivers, e.g. population variability: The world population continues to grow, especially in developing countries (United Nations, Department of Economic and Social Affairs, Population Division 2017). The global population growth naturally pressures the production of more food and fibre and therefore, the market´s demand for food continues to grow. The demand for cereals, for both food and animal feed was estimated to increase from today´s 2.1 billion tonnes to approximately 3 billion tonnes by 2050 (High Level Expert Forum, 2009).

Economic drivers, e.g., economic growth and development: The economic growth and rise of income levels increase the population´s ability to spend money and therefore raise consumers demands for goods and services in many countries (Gerbens-Leenes et al., 2010). This changing consumption behaviour also has a direct impact on food consumption which additionally results in a higher demand for food production. Economic development has also impacted the development of rapid urbanization, and will continue to have, a profound effect on food consumption patterns (Popkin, 1999). Urbanization also influences the agricultural sector not only by changing consumption patterns, but also in terms of production intensity as it needs to meet the demands from this rapidly growing urban population.

Socio-political drivers, e.g. globalization: Globalization has changed the scope and character of the production and distribution of many goods, including food (Robinson and Carson, 2015). Hence, the production of goods and services currently continues to increase and often involves transnational corporations that have established subsidiaries in many countries. Globalisation processes have had massive impacts on the agri-food sector and the complexities of supplying food to the ever-increasing world population have amplified (Robinson and Carson, 2015). Market globalization has also increased price competition and thereby has caused structural changes along the food supply chain. Trade integration with lower-cost economies may hold down the domestic inflation in the higher cost economies by depressing trade prices and increasing the share of imports in domestic demand (Pain et al., 2008).

Policy outside the environmental sector: In 1962, the initial objective of the EU agriculture policy was to feed the EU population at affordable prices (European Commission, 2012). Today's Common Agricultural Policy (CAP) has evolved substantially since these early efforts and is striving to tackle challenges for developing a fairer, greener and more competitive agriculture. However, the main aims of CAP are to improve agricultural productivity, so that consumers can benefit from a stable supply of affordable food, while EU farmers can make a reasonable living (Eurostat, 2017d). As a result, CAP still favours intensive farming over extensive practices with potentially negative effects on the environment.

3.1.2 DIRECT DRIVERS

Climate change related drivers, e.g. climate change and variability: Agriculture is highly vulnerable to climate change, as farming activities directly depend on weather and climate conditions. In some European regions, especially in northern areas, climate change could potentially be beneficial for farmers as it may lengthen the growing season and improve crop yields due to higher temperatures (European Commission, 2015). However, most environmental impacts due to climate change are likely to be adverse and may lead to economic losses, mainly in regions that are already under pressure due to socio-economic and other environmental factors (e.g., water scarcity; European Commission, 2015).

Global changes in precipitation and runoff patterns due to climate change will continue to increase the flow of nutrients from land into Baltic Sea (HELCOM, 2007). Additonally, increasing global temperatures are expected to intensify the stratification and lower the mixing of aquatic water bodies, to lower the solubility of oxygen in water and to increase the rate of oxygen-depleting mineralization processes (HELCOM, 2013a). As result, the combination of increasing nutrient input due to runoff, the reduced oxygen flux from the atmosphere into water column and the increased depletion of oxygen due to intensified mineralisation processes causes growing hypoxic and anoxic areas in the Baltic Sea (HELCOM, 2013a).

3.2 ACTIVITIES

This section describes activities that are related to the agricultural sector and that are having a direct link to eutrophication by causing diffuse inputs of nitrogen and phosphorus into aquatic ecosystems. In ResponSEAble, we narrowed our analysis to agriculture-related waterborn diffuse sources. Hereby, we identified and mapped two activities that currently add direct pressue to the Baltic Sea and are directly linked to the agricultural sector. The two agricultural activities are crop and animal production and their direct pressure to the Baltic Sea is caused by diffuse nutrient leakage. Additionally, manure storage and the transport of fertilizers is listed as sub-activity under the DAPSI(W)R framework.

3.2.1 AGRICULTURAL ACTIVITIES - CROP AND LIVESTOCK PRODUCTION, AND RELATED SERVICE ACTIVITIES:

Crop production: The term "crop" covers a broad range of cultivated plants including cereals, dry pulses, root crops, industrial crops and green harvested plants. Crop land is defined as areas that are used for crop cultivation. In 2012, crop land including both arable land and permanent crop areas, occupied nearly a quarter (24.7 %) of the total area of the EU-27 (Eurostat, 2015).

Nutrients are pivotal compounds for plant metabolism and growth and fertile soils are rich in nutrients enhancing crop yields. In contrast, impoverished soils reduce crop yields. Traditionally, the rotation of crops and regular fallow periods in combination with the spreading of animal manure as fertilizer, allowed the land to recover parts of its fertility. Since the beginning of the industrial manufacturing of mineral fertilizers, their application became increasingly important and is now the main method used to fertilize soil and to increase crop yields. Hereby, the use of fertilizers varies substantially between regions around the the Baltic Sea region for many reasons, of which one of the most important is that cropping patterns differ (Pau Val and Vidal, 1999). For example, the highest application rates for nitrogen are currently in Germany and Denmark and the highest application rates for phosphorous are in Poland and Finland (mineral fertilizers only; Table 1; HELCOM, 2015). From the nitrogen fertilizer application used for crop production, about 30% is estimated to be lost to the environment (Skorupski et al., 2013).

Livestock production: Livestock production is of very high economic relevance in the Baltic Sea region. Its intensity expressed in livestock units per hectar is currenty highest in Denmark and Germany and lowest in Estonia, Latvia and Lithuania (Table 1; Eurostat, 2017c). In 2015, livestock production accounted for 42% (EUR 145 billion) of the total EU-28 agricultural output and 49% of the agricultural output of the Baltic Sea Region (Eurostat, 2016). Herby, the highest shares in EU animal production output is milk production (35.1%), followed by pig meat (21.5%), cattle (18%) and poultry (12.8%; Eurostat, 2017c).

Since the 1980s, considerable structural changes in EU livestock farming have occured. Small farms with mixed farming practices have gradually been substituted by large-scale farms that are specialised on livestock holdings (Eurostat, 2017d). Between 2010 and 2013, the average of utilised agricultural area per holding increased in most the EU Member States (Eurostat, 2015).

Intensive animal farming can have a negative impact on all spheres of the environment: the air, the soil and – what is the most important for the seas – the water (surface waters, subsoil waters, drainage water). Hereby, the negative impact of large-scale livestock farming on the environment depends on the livestock type and size, the farming technology, and the handling and use of animal fertilisers (Skorupski et al., 2013). Big rearing farms with several thousand animals, which can be defined as "industrial", are having the biggest impact. Animal farms without bedding, which are most often used in pig production, usually also create enhanced nutrient pollution to water bodies (Balcere et al., 2007). Non-litter systems have become increasingly common due to the intensification of livestock production and industrialisation. For example, the collection of liquid animal waste from their stables and its disposal is mechanically simplified as compared to solid manure. However, the structural changes from small to large-scale farms entails that slurry utilization has generally become more problematic: most of the large-scale farms cannot use the amounts of fertilizer they produce as they do not own sufficient land to spread the slurry (Skorupski et al., 2013). These circumstances have provoked farmers to over-fertilize or to carry out their fertilization procedure at an incorrect time and under improper conditions. Over-fertilisation of fields belonging to intensive livestock farms is often reported problem in Belarus, Estonia, Germany, Lithuania, Poland, Russia and Ukraine slurry (Skorupski et al., 2013). The nutrient surplus in livestock farming can be illustrated by the example that in Poland 90% of crop production is consumed by livestock while the share of solid-manure in total fertiliser consumption is only 15%, and around 38% of all fertilisers used are artificial fertilisers (Statistics Poland, 2018).

The storage of manure is another challenge causing nutrients runoff into the environment. Fertiliser disposal requires continuous technical supervision, high flow capacity of the draining system, and the regular collection and removal of manure in litter systems (Skorupski et al., 2013). Poor technical condition or even the absence of fertilizer storage installations increases nitrogen and phosphorus runoff to soil and water. For example, in 2007 only nearly 53% of livestock farms in Poland had well-functioning livestock housing facilities and enclosed natural fertilizer tanks were present in only slightly more than 26% of these holdings. Only 35-45% of all agricultural holdings in Poland are estimated to be equipped with proper manure storage slabs, and only 20-30% of all agricultural holdings in Poland have suitable tanks for fermented urine. Similar conditions concerning fertilizer storage were reported for the countries Belarus, Estonia, Latvia, Lithuania, Russia and Ukraine (Skorupski et al., 2013). In the Baltic Sea region, the loss of fertilizer from livestock production into the the adjactant environment was estimated to be 75% for nitrogen (Skorupski et al., 2013).

Table 1. *Agricultural land, fertilizer application and livestock in countries of the Baltic Sea region. Agricultural land (1 000 ha), application of mineral fertilizer and manure of nitrogen and phosphorus and application of potassium in [kg/ha agricultural land], as well as amount of livestock in cattle, pigs and total in [livestock units/ha agricultural land]. Data are for the entire country in 2010, although manure (nitrogen) is an average from 2008-2011. Russia informed (Natalia Oblomkova, pers. comm.) that in 2010 for Kaliningrad, Leningrad, Novgorod, Pskov regions and Republic of Karelia 22,125 tonnes N of mineral based fertilizer and 714,590 t N of manure-based fertilizer were applied. n.a. = not available (HELCOM, 2015).*

	DK	DE	EE	FI	LV	LT	PL	RU	SE
Agricultural area (1000 ha)	2 700	16 700	950	2 300	1 800	2 800	15 500	n.a.	3 100
Nitrogen: kg N/ha agricultural land									
Mineral fertilizer	73	107	39	62	26	51	70	9.8	57
Manure	84	76	15	43	17	27	31	n.a.	32
Phosphorus: kg P/ha agricultural land									
Mineral fertilizer	3.9	5.6	2.1	6.3	2.2	4.1	8.6	3.6	2.5
Manure	14	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Potassium: kg K/ha agricultural land									
Total application	15	22	7.4	14	6.7	13	24	-	6.8
Livestock units/ha agricultural land									
Cattle	0.42	0.54	0.19	0.29	0.17	0.21	0.28	n.a	0.35
Pigs	1.30	0.38	0.09	0.14	0.05	0.07	0.24	n.a	0.12
Total livestock	1.82	1.07	0.32	0.49	0.26	0.32	0.67	n.a	0.57

3.3 PRESSURES

Pressures are considered as mechanisms through which activities have an actual or potential effect on any part of the ecosystem (adapted from Borja et al., 2006, Atkins et al., 2011). In our analysis' perspectice the pressure is related to the nutrient enrichment of the Baltic Sea and more specifically to nitrogen and phosphorus originating from agriculture.

3.3.1 NUTRIENT AND ORGANIC MATTER ENRICHMENT IN THE BALTIC SEA

Inputs of fertilizers and other nitrogen- and phosphorus-rich substances: The total inputs of nutrients to the Baltic Sea have decreased since the late 1980s and current input levels equal those in the early 1960s (HELCOM, 2014). Despite the reduced inputs, the concentrations of nutrients in the sea have not declined accordingly. The decrease of nutrient concentrations is impaired by the long residence time of water in the open Baltic Sea as well as biogeochemical feedback mechanisms such as release of phosphorus from anoxic sediments, and the occurrence of nitrogen-fixing cyanobacteria blooms in the sub-basins (HELCOM, 2014, Vahtera et al., 2007).

The sources for the inputs of nitrogen and phosphorus originating from agriculture include:

- Atmospheric emissions of airborne nitrogen compounds emitted from fertilizer applications, animal manure and husbandry (HELCOM, 2015).
- Point sources including storage of animal manure (Wassmann and Olli, 2004).
- Anthropogenic diffuse sources: leaching and runoff from agricultural land (Wassmann and Olli, 2004; HELCOM, 2015).

Atmospheric emissions: In 2010, approximately 50% of the total nitrogen emissions were in reduced form (NHx), mainly ammonia originating from the agricultural sector. Agriculture contributes 85-95% of the emitted ammonia (Bartnicki and Valiyaveetil, 2008; HELCOM, 2015). While a major part of emitted nitrogen oxides is transported over long distances before being deposited, ammonium is deposited relatively close to the emission source.

In 2010, the total atmospheric deposition of nitrogen to the Baltic Sea was 218,600 tonnes (HELCOM, 2015). There is a southwest to northeast gradient in deposition, with the highest deposition in the southern and western parts of the Baltic Sea due to dominant wind systems and the location of the main emission sources (Bartnicki et al., 2012; HELCOM, 2015). The sources of reduced nitrogen deposition are mainly HELCOM Contracting Parties. Germany holds the largest contribution (20 700 tonnes), followed by Poland (14 400 tonnes), Denmark (12 400 tonnes), Sweden (8900 tonnes), Russia (4900 tonnes) and Finland (4700 tonnes). Countries outside the HELCOM area, that apply intensive agriculture contributed also largely, with Belarus being the 7th (4500 tonnes), France being the 8th (3500 tonnes) and the Netherlands being the 10th (2600 tonnes) largest contributors. Thereafter followed the Baltic countries Lithuania as the 9th, Latvia as the 11th and Estonia as the 13th largest contributors (HELCOM, 2015).

Waterborn inputs: Agriculture adds 70-90% of the total nitrogen input and 60-80% of the total phosphorous input to the Baltic Sea, originating from diffuse and point sources (waterborne inflow; Bauer, 2015). In 2010, the total waterborne inputs into the Baltic Sea amounted to 758,400 tonnes nitrogen and 36,200 tonnes phosphorus, whereas the input was mostly originating from diffused sources (HELCOM, 2015). In 2010, the greatest contributors of waterborne nitrogen and phosphorus inputs into the Baltic Sea were Poland and Sweden, whereas the smallest contributors were Estonia and Germany (HELCOM, 2015). In the same year, the seven largest rivers entering the Baltic Sea (Daugava, Göta älv, Kemijoki, Nemunas, Neva, Odra, and Vistula) constituted to about 50% of water flow and waterborne inputs. Hereby, the rivers Odra and Vistula showed the highest nitrogen and phosphorus concentrations, and Göta älv, Kemijoki and Neva the lowest. This finding correlates with the extents of agricultural land, the intensity of agricultural practises and the population density, which were higher in the catchment areas of the rivers Odra and Vistula than in the catchment areas of the rivers Göta älv, Kemijoki and Neva (HELCOM, 2015).

Between 1995 and 2010, the total water and airborne nitrogen inputs to the Baltic Sea and to all sub-basins except the Bothnian Bay and Gulf of Riga decreased significantly (HELCOM, 2015). At the same time, a significant concentration decrease was also measured for the total phosphorus inputs in the entire Baltic Sea including the sub-basins of the Bothnian Sea, the Baltic Proper, Danish Straits and Kattegat, except in the Guf of Riga, where phosphorous concentrations showed the opposite: a statistically significant increase. However, data concerning the waterborne input to the Gulf of Riga and to a significant part of the inputs to the Gulf of Finland must be interpreted with caution as they contain high uncertainties (HELCOM, 2015).

3.4 STATE AND STATE CHANGE

The state of an ecosystem or natural environment is defined by its health status and ecosystem functioning. In this section, we classified state and state changes in a selection of biological and chemical parameters of ecosystem and subordinated components in the Baltic Sea that are impacted by eutrophication.

3.4.1 PHYSICAL AND CHEMICAL PARAMETERS

Topography and bathymetry: The Baltic Sea is a semi-enclosed shallow water body (mean depth = 51 m, maximum depth = 459 m; Andersen et al., 2017). Water masses of the Baltic Sea are connected to water masses of the North Sea and the entrance between the two areas is shallow and narrow with sills separating the deeper basins. The Baltic Sea is subdivided into 9 basins by its topography and bathymetry: Kattegat (depth mean/max = 22/120 m), Danish Straits (depth mean/max = 14/50 m), Arkona Basin (depth mean/max = 25/50 m), Bornholm Basin (depth mean/max = 44/100 m), Baltic Proper (depth mean/max = 71/459 m), Gulf of Riga (depth mean/max = 22/56 m), Gulf of Finland (depth mean/max = 34/123 m), Bothnian Sea (depth mean/max = 55/270 m), Bothnian Bay (depth mean/max = 41/127 m; Andersen et al., 2017). Additionally, the Baltic Proper is sub-divided into the Northern and Southern Baltic Proper and the Eastern and Western Gotland Basins.

Mixing characteristics: The water body of the central part of the Baltic Sea is characterized by a relatively deep permanent halocline at 70–80 m and a shallower seasonal thermocline (Andersen et al., 2017), which generally restrict ventilation of the deep water and its mixing with surface water. Diminished mixing of deep water in combination with substantial export production of biomass from the surface into deep water and therby elevated mineralization and respiration rates at the sea floor causes a depletion of oxygen and therefore hypoxia in large parts of the Baltic Proper. Moreover, seasonal and episodic hypoxia is widespread in coastal areas, partly caused by local nutrient inputs and partly due to imported hypoxic water from adjacent areas in the Baltic Sea (Conley et al., 2011; Andersen et al., 2017).

Water clarity and turbidity: In all Baltic Sea areas, the summer-time turbidity has increased and water clarity has decreased during the last century. In open sea areas, good environmental status (GES) for water clarity has been achieved only in the Kattegat and Bothnian Bay (HELCOM, 2014). In the southern Baltic Sea sub-basins, water clarity increased in the last two decades (HELCOM, 2014).

Residence time: The Baltic Sea is subdivided into numerous basins with varying water residence times. In the entire system, the residence time for salt is more than 30 years (Stigebrandt and Gustafsson, 2003), while for separate basins residence times can be considerably lower, e.g. 1–3 months for the Kattegat and Danish Straits (Gustafsson, 2000) and 1 year for the Gulf of Finland (Andrejev et al., 2004; Andersen et al., 2017).

Distribution of salinity: Baltic Sea waters follow a salinity gradient reaching from ~30 PSU at the entrance to ~1 PSU in the northern parts of the Bothnian Bay and in the Gulf of Finland (Andersen et al., 2017). In the central part of the Baltic Sea, the water masses are characterized by a relatively deep permanent halocline at the water depth 70–80 m. The salinities of the different sea basins vary, and their surface salinities are as following: Kattegat: 12.2–30.2 PSU, Danish Straits: 9.6–22.9 PSU, Arkona Basin: 7.6–11.3 PSU, Bornholm Basin: 4.3–8.1 PSU, Baltic Proper: 5.0–7.5 PSU, Gulf of Riga: 4.1–6.2 PSU, Gulf of Finland: 1.2–5.6 PSU, Bothnian Sea: 3.8–6.6 PSU and Bothnian Bay: 1.8–3.9 (Andersen et al., 2017).

Distribution of nutrients: The inputs of nutrients into the Baltic Sea have been reduced in the last years, but their concentrations in the water bodies have not declined accordingly (HELCOM, 2014). During 2007-2011, declining nutrient concentrations have been reported for the Kattegat (N and P), Bornholm Basin (P), Northern Baltic Proper (N) and Gulf of Riga (N and P). However, despite the decline of nutrient inflow, chlorophyll-a concentrations still show no decline or have in the recent years even increased in the Bornholm Basin, Northern Baltic Proper, Bothnian Sea and Bothnian Bay. Thus, the recovery of the Baltic Sea from its eutrophied state is currently slowed down, caused by a combination of long residence times of water in the open Baltic Sea with biogeochemical feedback mechanisms such as increased phosphorus release from anoxic sediments and the prevalence of nitrogen-fixing cyanobacteria blooms in the main sub-basins of the Baltic Sea (HELCOM, 2014).

Distribution of oxygen: Good environmental status (GES) concerning oxygen concentrations has not been achieved in the sub-basins Bornholm Basin, Western Gotland Basin, Eastern Gotland Basin, Northern Baltic Proper and the Gulf of Finland (HELCOM, 2014). Both in the Baltic Proper and in the Bornholm Basin, oxygen depletion has increased below the halocline since the early 1900`s. Especially in the Baltic Proper, the increase of oxygen depletion has been substantial with an increase of about 25% since 1900-1920 (HELCOM, 2014).

Biological parameters: High nutrient concentrations have caused changes in the state of Baltic Sea biodiversity (HELCOM, 2009b). These include high quantities of planktonic algae and other planktonic organisms, mats of macroalgae stranded on shores, reduced distribution of benthic habitats such as eelgrass meadows, or oxygen depletion resulting in the death of benthic animals such as fish. Studies suggested that blooms of toxic phytoplankton species may also inhibit the growth and reproduction of other aquatic organisms (HELCOM, 2009b).

3.4.2 PELAGIC SPECIES AND COMMUNITIES

Phytoplankton: Approximately 1700 phytoplankton species occur in Baltic Sea waters (Hällfors, 2004; Ojaveer et al., 2010). Phytoplankton are the primary producers of aquatic ecosystems: as photosynthetic organisms, they produce energy and biomass by solar energy, carbon dioxide and nutrients and thereby build the basis of the aquatic food webs. For phytoplankton, the ratio between dissolved inorganic nitrogen (DIN) and dissolved inorganic phosphorous (DIP) in the surrounding water is of importance, whereas a DIN : DIP ratio of 16: 1 (in moles; defined as Redfield ratio) provides optimum conditions. Deviations from the Redfield ratio may affect primary production, the concentration and quality of phytoplankton biomass, species composition, and consequently food-web dynamics (HELCOM, 2009b).

Concentration measurements of chlorophyll-a are used as an estimate of phytoplankton biomass (HELCOM, 2009b). In open sea areas, good environmental status (GES) for chlorophyll-a has been achieved only in the Kattegat and Gulf of Riga. In many sub-basins, the summer-time chorophyll-a concentrations have increased until the 1990s (Arkona Sea, Kattegat) or early 2000s (Bothnian Bay, Northern Baltic Proper, Gulf of Riga, Western Gotland Basin) and showed a decrease thereafter (HELCOM, 2014). In the Gulf of Finland, Bothnian Sea and Eastern Gotland Basin, chlorophyll-a concentrations continued to increase after the early 2000s (HELCOM, 2014).

Nitrogen-fixing (diazotrophic) cyanobacteria are an important component of the ecosystem. By their ability to fix molecular nitrogen, the bloom-forming cyanobacteria of the genera Aphanizomenon, Nodularia and Dolichospermum prevent severe nitrogen shortage and resulting starvation in all trophic levels of the ecosystem in the summer. Recent studies showed the highest biomass of nitrogen-fixing cyanobacteria (for June-August) in the Baltic Sea in the Gulf of Finland, whereas no or low biomass appeared in the Bothnian Bay and the Kattegat/Kiel Bight area (Finni et al., 2001, Funkey et al., 2014). Overall, the biomass of nitrogen-fixing cyanobacteria apparently increased since the 1960s the latest. Large blooms of cyanobacteria in the Baltic Sea contribute to eutrophication and oxygen depletion in deep waters due to their ability to produce additional dissolved nitrogen by nitrogen fixation and adding biomass to the aquatic system. Some members of the cyanobacteria community are toxic, such as the species Nodularia sp. and Dolichospermum sp. and can cause intoxication of members of the aquatic food web when occurring in blooms (Wasmund et al., 2015).

Zooplankton: The zooplankton community is a crucial link in the aquatic food web by transferring energy from primary producers to fish (HELCOM, 2009a). In the Baltic Sea, approxiamtely 210 zooplankton species occur (Telesh et al., 2009). Zooplankton is impacted by changes in primary production (bottom-up-control; nutrient-load pressure) and by changes in the structure and abundance of the fish community (top-down-control; fishing pressure; e.g. Adrian et al., 1999; Yan et al., 2008; Martin et al., 2015).

Copepods are important food sources for economically valuable fish species and were proposed as useful indicators for monitoring the health of the Baltic Sea pelagic food web (HELCOM, 2009a). During the past 20–30 years, the copepod communities in the Baltic Sea have undergone considerable community and abundance shifts, whereas the causes triggering the changes and the effects, remain unclear. Some of the observed changes may be explained by climate variability influencing salinity and temperature in the water columns and human pressures such as eutrophication. Shifts in the zooplankton communities were reported to cause a cascading trophic effect impacting the general health, weight of older specimen and reproduction system of Baltic herring and sprat (HELCOM, 2009a). Furthermore, these changes combined with subsequent effects on planktivorous fish stocks have shown to affect growth, health and reproduction of Baltic salmonids (e.g., Ikonen, 2006). Hence, due to the cascade effect through the trophic levels within the Baltic Sea food web, shifts within zooplankton communities can impact human society on a socio-economic level (HELCOM, 2009a).

Fish communities: Baltic Sea fish communities consist of representatives of marine, freshwater, migratory and alien species and glacial relicts. In total, about 100 fish species are known to exist in the Baltic Sea, including about 70 marine species, seven diadromous species (including sea and river lamprey), and 33 freshwater species (HELCOM, 2009a). According to their origin, representatives of these environmental categories have different preferences for environmental conditions and therefore, the composition of fish communities varies in different regions of the Baltic Sea, primarily depending on salinity, water temperature, oxygen content and nutrient concentrations (HELCOM, 2009a).

Fish communities are currently under threat in several areas of the Baltic Sea, as seen by significant declines in the abundances of certain species, the decrease of several valuable fish stocks, or in some cases, the complete lack of large predatory fish. In contrast, eutrophication-tolerant fish species showed an increase in abundance over the last years (HELCOM, 2009a).

Seabirds: High nutrient inflows from the catchment area into the Baltic Sea have resulted in an increased biomass production in the water column, which improved the food availability and general feeding conditions for some bird species, such as the cormorant (HELCOM, 2009a).

3.4.3 BENTHIC SPECIES AND COMMUNITIES

Phytobenthos (Macro-algae, marine angiosperms): At present, 442 species of macroalgae are known for the Baltic Sea including the Kattegat area (Nielsen et al., 1995; HELCOM, 2009a). One of the most important phytobenthic species is Bladder wrack (*Fucus vesiculosus*) due to its wide distribution, high biomass and productivity along rocky and stony coasts. Here, *Fucus sp*. belts play an important structuring role and have a positive effect on biodiversity, providing habitats for species-rich epiphytic and epibenthic communities (Kautsky and Kautsky, 1989; HELCOM, 2009a). Other habitat forming phytobenthic species are for example the red alga *Furcellaria lumbricalis*, charophytes and a marine angiosperm eelgrass *Zostera marina* (HELCOM, 2009a). The overall conservation status of several habitat-forming species in the Baltic Sea is alarming and declines in species abundances as well as distribution have been reported recently (HELCOM, 2009a). While this is at least partly caused by eutrophication, the most effected areas appear to be in the southernmost areas of the Baltic Sea (Anderson et al., 1978; HELCOM, 2009a). In contrast, coastal areas of the northern Baltic Proper recently showed improvements of the conservation status, whereas the natural distribution of several functionally and structurally important species has almost been achieved (HELCOM, 2009a).

Invertebrate bottom fauna: Soft-sediment macrofaunal communities are central elements of Baltic Sea ecosystems and provide important ecosystem functions and services. These functions include, for example, the provision of food for higher trophic levels and enhancing oxygen penetration and biochemical degradation of organic matter in the sediments (HELCOM, 2009a). Multiple stressors affect benthic communities, whereas eutrophication has emerged as the major stressor in the Baltic Sea apparently impacting at all trophic levels in its ecosystems (HELCOM, 2009a). Hereby, the increased occurance of oxygen depleted deep water is likely to be the single most important factor influencing the structural and functional biodiversity of benthic communities in the open-sea areas of the Baltic Sea (Anderson et al., 1978, Karlson et al., 2002). While hypoxia is to some degree a natural phenomenon in the Baltic Sea, it is also clear that the spatial and temporal extent of oxygen deficiency has increased over the past decades due to eutrophication (Karlson et al., 2002; Diaz and Rosenberg, 2008; HELCOM, 2009a)

3.5 ENVIRONMENTAL IMPACTS

As environmental impacts, we defined the adverse consequences of pressures caused by human activities and natural phenomena. The term "impacts" as used in ResponSEAble, defines both environmental and human-related impacts. Nutrient enrichment affects ecosystem functioning in overall reducing its stability (HELCOM, 2009b).

3.5.1 BIODIVERSITY CHANGE AND LOSS:

Changes in phytoplankton communities: Nutrient enrichment in the Baltic Sea causes increased phytoplankton productivity and more prevalent algal blooms in combination with a reduced biodiversity within the phytoplankton community (HELCOM, 2009a). Recent reports showed changes in phytoplankton community compositions such as dominance shifts from diatoms to dinoflagellates during spring bloom periods (HELCOM, 2009a). Blooms of harmful algae, such as cyanobacteria or certain haptophytes, can be a threat to other organisms (HELCOM, 2009a).

Changes in benthic communities: The excess of nutrients during the entire vegetation period often favours opportunistic species with short life cycles and rapid development over the perennial species with lower productivity, which often causes a shift in community composition (HELCOM, 2009a). In many areas of the Baltic Sea Region, the seafloor animals are exposed to widespread oxygen depletion or even complete anoxia. As a result, the biodiversity on the seafloor is often reduced or animal communities are entirely erased. Permanent anoxia is common in deep, permanently stratified basins of the Baltic Sea, such as the Gotland Basin. In shallow areas, oxygen depletion mainly occurs seasonally (HELCOM, 2009a).

Fish and crustaceans require relatively high oxygen concentrations in their environment and therefore react very quickly to its decrease. In contrast, other species (such as polychaetes and mussels) can tolerate low dissolved oxygen concentrations for longer periods. The benthic responses to hypoxia include a shift from communities of large, slow-growing and slowly reproducing species to communities of small, rapidly reproducing organisms. During anoxic conditions, microbial sulfate reduction can cause an increased formation of hydrogen sulphide (H_2S), which is lethal for many organisms especially from higher trophic levels (HELCOM, 2009b).

Eutrophication affects submerged aquatic vegetation on different levels: (1) increased pelagic biomass production reduces the penetration of light through the water column and limits the depth penetration of submerged species such as eelgrass and bladder wrack. (2) increased sedimentation can prevent the settlement of new specimens on the seafloor and reduces the amount of suitable substrate to be colonized by perennial species on all types of substrates (HELCOM, 2009a).

Changes in fish communities: Eutrophication can contribute to increased fish production and affects fish stocks selectively. As an example, increased turbidity of water favours percids and cyprinids and negatively affects salmonids, which prefer clear water. Other effects of eutrophication on fish communities include loss of shelter or spawning ground caused by reduced macro-vegetation coverage (HELCOM, 2009a) or changes in their food base. Often, eutrophication and subsequent deep-water oxygen deficiency have altered the species composition of zooplankton communities, towards a state less favourable to their grazers such as clupeid fish (HELCOM, 2009a). The abundance of cyprinids in the Bothnian Bay, Bothnian Sea, Archipelago Sea and Gulf of Finland has generally increased, concurrent with a decrease in the abundance of piscivores in Archipelago Sea, Gulf of Finland, northern Gulf of Riga and western Baltic Proper. These patterns indicate a response to a rise in water temperatures and potentially also lowered salinity levels and increased nutrient levels in the Gulf of Bothnia (HELCOM, 2012; Olsson et al., 2012; Olsson et al., 2013).

3.6 WELFARE AND ECOSYSTEM SERVICES

Ecosystem services can be defined as the direct or indirect contributions from ecosystems to human well-being at present and/or in the future. Understanding the link between ecosystem functioning and ecosystem service capacity is crucial for a better understanding of the benefit of a healthy environment for humans and vice versa.

Nutrient loads from agriculture affect marine provisioning and cultural ecosystem services as they cause eutrophication, reduced water quality, harmful algal blooms (toxic, e.g. *Nodularia spumigena* or non-toxic, e.g. *Aphanizomenon sp*.), hypoxic and anoxic zones at the sea bottom and thus jeopardize the economic basis of fishery, aquaculture and tourism.

A recent study has reviewed all currently available empirical studies on economic valuation of ecosystem services of the Baltic Sea (Sagebiel et al., 2016). The study concluded that only a few ecosystem services, including recreation and reduction of eutrophication, have been extensively monetarily valued, while many other marine ecosystem services have rarely or never been valued with economic methods (Sagebiel et al., 2016). Another study showed that the economic benefits of achieving a good eutrophication status of the Baltic Sea amount to 3.6 billion EUR annually, while the associated costs account to 2.8 billion EUR per year (Ahtiainen, 2016).

Using the willingness to pay method, H. Ahtiainen, 2016 reported that the benefits of achieving a good eutrophication status vary in the Baltic Sea countries between 6 EUR and 79 EUR per person per year, being the highest rates in Sweden, Finland and Denmark, and the lowest in Latvia, Lithuania and Russia (Ahtiainen, 2016).

3.6.1 PROVISIONING ECOSYSTEM SERVICES

Biomass from wild plants and algae: *Furcellaria lumbricalis* and *Coccotylus truncatus* are among the key red algal species in the Baltic Sea (Martin et al., 2013). Their unattached form is the only economically important algal species in the Baltic Sea, which has been exploited for the extraction of polysaccharides in the area since the 1960s. In the Baltic Sea, the unattached *F. lumbricalis* can be currently found only in semi-exposed habitats of the West Estonian Archipelago Sea (Martin et al., 2013). The unattached *F. lumbricalis* was previously found in Polish waters but the community disappeared due to eutrophication in the 1980s (Kruk-Dowgiałło and Szaniawska, 2008). Outside the Baltic Sea, the unattached form of *C. truncatus* occurs only in the north-western Black Sea, where together with *Phyllophora crispa* and *P. pseudoceranoides* it forms a unique stratum named as "Zernov's Phyllophora field". Zernov´s Phyliphora Field has originally been among the largest accumulations of red algae in the world (Lüning, 1990), but has – due to eutrophication and overharvesting in the 1980s – almost disappeared. However, this unique habitat has partly recovered due to the establishment of a marine reserve (Kostylev et al., 2010; Kersen, 2013).

Biomass from wild animals: The anthropogenic impacts in the Baltic Sea area include elevated nutrient and sediment loads from agriculture and have caused a deteriorated status of some fish species valuable for commercial and recreational fisheries, e.g.: Salmon (ICES Working Group for Baltic Salmon and Sea trout (WGBAST) and Mannerla, 2013). The eastern Baltic cod is suffering from oxygen reduction and the spawning stock biomass of eastern Baltic cod has reduced from almost 650 000 to 87 000 tonnes from 1983 to 1992 (Hinrichsen et al., 2016). Juvenile cod often inhabit macroalgal beds or sea-grass, that are habitats sensitive to light conditions and that may become limited with decreased water transparency. A decrease of predators may result in increase of plankton-eating fish, which may in the following enhance eutrophication. In the Baltic Sea, the decline in cod populations has favoured their prey sprat (Garpe, 2008). This may, however, decrease the number of zooplankton, which feed on phytoplankton. Consequently, the loss of top predators may enhance eutrophication and further reduce water transparency. Sprat dominance is believed to be further stabilized by increased predation on cod eggs and larvae by sprat as well as by the competition between sprat and cod juveniles for zooplankton food (Garpe, 2008).

Flatfish, like the European plaice *(Pleuronectes platessa)* are also significantly affected by eutrophication (Garpe, 2008). Their recruitment is negatively affected by abundant filamentous algae covering shallow soft bottoms. The recruitment loss resulting from current dominance of algal mats has been estimated to result in a reduction of 30 – 40% in commercial catches. Commercial catches of perch, pike *(Esox lucius)* and zander have also declined significantly in the Baltic proper, which is regarding perch and pike probably the result of major recruitment problems (Garpe, 2008).

Biomass from animals bred in *in-situ* aquaculture: Marine aquaculture is strongly dependent on suitable environmental conditions. In the Baltic Sea Region, marine aquaculture is practiced only in few countries (DK, FI, SE, DE) and BSR production forms only about 3% of the EU marine and brackish water aquaculture production (Eurostat, 2010f). One of the (indirect) reasons of the slow development of the sector in the BSR is also eutrophication. According to the 2014 report of the Scientific, Technical and Economic Committee for Fisheries (STECF) on „The economic performance of the EU aquaculture sector (STECF 14-18)", all countries report that environmental concerns are slowing or frustrating the development of aquaculture (STECF, 2014). For sea cage farms, the reduced level of oxygen can influence production and profitability because it increases the risk of diseases and toxins, which influences the farmer's production decisions (STECF, 2014).

Additionally, another threat for aquaculture are algae species that are "ichtyotoxic" (e.g. *Prymnesium parvum, Chrysochromulina polylepis*), because during blooms they can cause mass dying of fish (Brusle, 1995).

3.6.2 MAINTENANCE AND REGULATION OF ECOSYSTEM SERVICES

Maintenance of biogeochemical cycling: Human activities can cause chronic anthropogenic stress on marine and freshwater ecosystems. Such chronic and often gradual acceleration of certain disturbances does not always provoke gradual responses in ecosystem functioning. In contrast, ecosystem processes often continue as usual until they reach a critical threshold followed by a major and rather sudden change. This change, sometimes referred to as ecosystem shift, can be permanent (Garpe, 2008). According to many scientists, the continuous eutrophication of the Baltic Sea has caused a shift of this kind. This process may explain why decreased nutrient emissions have not significantly ameliorated the situation (Garpe, 2008).

Mediation of waste, toxins and other nuisances by ecosystems: Anoxia, which can also be caused by eutrophication, contributes to the storage of hazardous substances in sediments because many hazardous substances remain associated to the sediment under anoxic conditions. However, the loss of sediment-trapping algae and sea-grass as another consequence of eutrophication, may counteract with the burial of hazardous substances (Garpe, 2008).

Maintenance of physical, chemical and biological conditions: The capacity of the marine ecosystem to generate services that are important for society has clearly diminished and resilience has been reduced. Current threats to resilience include all chronic and acute disturbance of human origin which also includes eutrophication (Garpe, 2008).

Lifestyle maintenance, habitat and gene pool protection: Essentially all ecosystem services depend on the direct or indirect maintenance of the habitat as well as on the support of the diversity and ecosystem functioning. Eutrophication impacts many important marine habitats. For example, eutrophication is one of the reasons for the loss of sea-grass meadows that otherwise support a diverse and productive benthic fauna and provide essential nursery and feeding grounds for at least 40 species of fish (Garpe, 2008). Hence, the collapses of seagrass habitats probably have consequences for ecosystem diversity and functioning. A previous report showed that in ecosystems, where sea-grass has disappeared, a reduction of almost 100% of juvenile cod has occurred (Garpe, 2008). The cost of artificially restoring sea-grass beds are estimated at approximately 5 300 EUR/ha. Also, algal beds are important for marine biodiversity and primary production. Like sea-grass beds, they also act as filters against high nutrient input from terrestrial sources. Algal beds are undoubtedly beneficial for food production by providing nursery and feeding habitat for juvenile fish of commercial importance (e.g. pike, perch and cod).

Historically in the Baltic Sea and nowadays in some regions of the world, large algae have been and are used as fertilizer and for food production. Aditionally, algal beds are popular sites for diving and sport fishing. Due to increased nutrient concentrations and reduced water transparency, macroalgae have in some areas been lost and replaced by less productive and supportive habitats including soft bottoms, mussel beds or communities of red or filamentous algae (Garpe, 2008). The downside of this is, that the latter is often washed to the shorelines where they cover beaches causing reduced benefits and increased costs for recreational businesses. Shallow soft bottoms provide habitats and feeding grounds for numerous species (e.g. filter-feeders, sea birds, commercial fish). Soft-bottom habitats are gradually becoming covered by filamentous algae which potentially results in reduced diversity, limited provision of food and decreased values for recreation and aesthetics (Garpe, 2008).

3.6.3 CULTURAL ECOSYSTEM SERVICES

Physical use of seascapes in different environmental settings: The tourism and recreation industries in the Baltic Sea Region depend on the state of the marine environment. Algal blooms caused by eutrophication have negative effects on beach tourism. Visitors who encounter blue green algae blooms may not revisit certain leisure areas. Also swimming bans due to algae may reduce the income of accommodation providers. Additionally, algal growth can also have negative effect on the aesthetic perception of an area. Also reduced transparency and algae mats can have negative effect on fishing and boating (Hasselström, 2008). Besides fisheries and tourism, algal blooms can also impact human health negatively as swimming in blooming water can cause allergic reactions.

The increase of filamentous algae in shallow coastal areas, often results in unattractive malodorous shores. Therefore, for maintaining recreational values, these algal mats are usually removed with substantial costs. For example, the cost of cleaning the shores of the municipality of Strömstad (Skagerrak) was estimated to 70 000 EUR per year. A survey of 1 600 tourism operators in Sweden revealed that intense algal blooms in the Baltic Sea in 2005 caused a substantial decrease in touristic bookings on Gotland during the following summer. On Öland, algal blooms during summer 2005 resulted in a loss of in total approximately 11 million EUR in the tourism and fishing sectors.

Additionally to the aesthetic perception of the area, algal blooms can also have negative effects on the health of humans and animals (Garpe, 2008). Toxic blooms in the Baltic Sea are mainly caused by the cyanobacterium *Nodularia spumigena* and it can cause liver damage for humans and was reported to have a lethal effect on cattle and other domestic animals (Garpe, 2008).

Intellectual, scientific and educational interactions: The provision of educational and scientific opportunities is likely to experience losses from e.g. biodiversity habitat degradation. Museums and aquaria ultimately depend on nature to provide it with organisms, habitats and information (Garpe, 2008).

Cultural heritage: Cultural heritage is being lost, particularly due to resource loss and consequential loss of small-scale industries along our coastlines. Deteriorated environmental conditions in the Baltic Sea reduce the potential for divers to experience our spectacular underwater heritage sites (Garpe, 2008).

Entertainment: Most threats to e.g. biodiversity, habitat and resilience indirectly affect the enjoyment of recreational activities in marine and coastal areas (Garpe, 2008). Reduced transparency and algal mats have negative effect on fishing and boating (Swedish Environmental Protection Agency, 2008). Algal blooms and algal mats decrease recreational value of coastal and marine areas and cause negative impacts and economic losses for tourism and fishing sectors (Garpe, 2008).

Aesthetic perception: Algal growth can also have negative effect on the aesthetics of a seascape (Hasselström, 2008). Loss of scenic value is associated amongst others with environmental deterioration like the presence of putrid algal mats. The loss of scenic values has negative consequences for property value and taxation as well as for local tourism revenues. Scenic values contribute greatly to national identity as well as international reputation (Garpe, 2008).

3.7 RESPONSES

Responses are societal reactions to drivers, activities and pressures that impact the state of an ecosystem and human welfare negatively. Responses can be "legal", "economic", "social and behavioural", "technological" and "cognitive". They can be directed at any other part of the system (e.g. reduction in the number of bottom trawler licenses, the change to a less abrasive gear, or creation of no fishing areas) (modified from Smith et al., 2016). In this section, we have listed measures, initiatives and activities that have been implemented or tested to decrease pressures on the Baltic Sea.

3.7.1 LEGAL RESPONSES: INTERNATIONAL SOFT-LAW

The Baltic Marine Environment Protection Commission - the Helsinki Commission - has for many years raised the issue of nutrient inputs into the Baltic Sea as one of its core action regions.

In 2007, the HELCOM **Baltic Sea Action Plan** (BSAP) was adopted by the Baltic Sea coastal countries and the European Community (HELCOM, 2007). The overall objective of BSAP is to reach a Baltic Sea in good environmental status by 2021, by means of addressing the issues of eutrophication, hazardous substances, biodiversity and maritime activities. The BSAP includes a nutrient reduction scheme based on maximum allowable inputs (MAI) of nutrients to achieve good status in terms of eutrophication and provisional country-wise allocation of reduction targets (CART). For reaching the proposed nutrient reductions targets, "the polluter pays principles" is the strategy of choice (HELCOM, 2015). It is, however, an example of the soft legal instrument that does not provide tools and mechanism to properly assess progress towards its goals. Additionally, and even more important, HELCOM does not have the power to enforce its implementations, if countries are reluctant to undertake agreed actions (Chen at al., 2014).

In 2005, the Helsinki Commission adopted HELCOM Recommendation 26/2, which recommends reporting every six years, including: (1) the quantified waterborne discharges from point sources, (2) losses from non-point sources of pollution and (3) the quantified natural background losses into surface waters - covering the catchment area of the Baltic Sea located within the borders of the Contracting Parties (HELCOM, 2015).

In 2013, the HELCOM ministerial conference designed agri-environmental measures aiming at a reduction of nutrient losses from agriculture by improved nutrient management. During their conference in Copenhagen, the environmental ministers of the HELCOM countries decided to introduce nutrient bookkeeping on farm level in all Contracting Parties by the end of 2018 (Bauer, 2015). HELCOM has also stressed the need to accelerate the process of integration of environmental and sustainable development aspects in agriculture, for instance through reforming the EU Common Agricultural Policy.

At international level, International Maritime Organization and the MARPOL convention is relevant to meet the eutrophication goals. Annex IV of MARPOL Conventions implements measures to prevent sewage pollution by ships while annex VI deals with air pollution (Haahti et al., 2010).

3.7.2 LEGAL RESPONSES: EU

Agriculture-related pressures leading to eutrophication are focused on mainly in nature protection and marine-related policy documents, e.g. strategies and development plans. Within the multi-level governance system, EU directives regulating the field are in place in the Baltic Sea Region member states legislations.

European Union directives are the example of international law that is directly binding for all EU Member States. EU introduced a set of directives that has a direct impact on the ecological status of the Baltic Sea and supports efforts to mitigate eutrophication. The most important legal acts include (Haahti et al., 2010; Chen et al., 2014):

- **'Urban Waste Water Directive' (1991/271/EEC):** aims to protect natural environments including human health by implementing standards concerning urban and industrial waste water treatment

- **'Nitrates Directive' (1991/676/EC):** aims to protect ground and surface water quality and to limit the nitrogen load caused by agricultural practices. It forms an integral part of the Water Framework Directive and is one of the key instruments in the protection of waters against agricultural pressures. Implementation of the Directive by Member States includes identification of water polluted, or at risk of nitrate pollution; designation of „Nitrate Vulnerable Zones"(NVZs); establishment of Codes of Good Agricultural Practice to be implemented by farmers on a voluntary basis; establishment of action programmes to be implemented by farmers within NVZs on a compulsory basis as well as national monitoring and reporting every four years (European Commision, 2018b).

- **'Water Framework Directive' (2000/60/EC, WFD):** aims to achieve good environmental status of all European waters, i.e., surface, transitional, coastal and groundwater. WFD obliges the Member States to draw up River Basin Management Plans (RBMPs) and programmes of measures to meet the WFD's objectives. RBMPs are updated every six years (since 2009, when the first RBMPs were developed).

- **'Marine Strategy Framework Directive' (2008/56/EC, MSFD):** aims to achieve good environmental status (GES) of European seas and oceans. The tool for achieving GES are marine strategies where EU Member States must assess the status of their marine waters; determine ,good environmental status' based on 11 descriptors (including a descriptor "Eutrophication is minimised"); set targets, develop and implement monitoring programmes; and finally develop and implement measures to achieve GES. Like WFD RBMPs, the marine strategies also must be updated every six years (next cycle starts in 2018).

The **Common Agricultural Policy (CAP)** aims at reducing the pressures caused by the agricultural activities by promoting the development of agricultural practices preserving the environment (European Commission, 2017a). The European Commission stated that protecting water quality is a key issue of the Common Agricultural Policy with the aim to avoid water pollution through agricultural activity, mainly through a sustainable use of pesticides and fertilisers for avoiding nitrate pollution. CAP instruments for promoting sustainable water management are: 1) support investments for improving the state of irrigation infrastructures or irrigation techniques that require the abstraction of lower volumes of water, as well as actions to improve water quality; 2) the cross-compliance framework that includes statutory requirements related to water protection and management arising from the implementation of the groundwater directive and nitrates directive, as well as GAEC standards, and 3) Payments under Article 38 of the Rural Development Regulation will contribute to the implementation of the WFD (European Commission, 2017a).

- **Council Regulation 1257/1999** on rural development support requires Member States to set up Rural Development Programmes, which shall "provide for agri-environment measures throughout their territories, and in accordance with their specific needs". These programmes must be approved by the EU Commission.

- **Regulation 1782/2003** sets the frames and conditions for farms receiving financial support, the so-called Cross Compliance (CC). The Nitrates Directive as well as other environmental EU legislation is part of the CC criteria.

- **Regulation 1698/2005** provides the basis for Member States' support to farms' investments in manure storages.

- **The Animal By-products Regulation (1774/2002)** regulates the disposal of fallen stock (dead livestock) and other animal by-products.

- **The IPPC Directive (2008/1/EC)** determines that intensive pig and poultry farms must have an environmental approval. The environmental approval is conditioned compliance with all agroenvironmental legislation, use of Best Available Techniques (BAT's) to minimise pollution of water, air and land, and compliance with specified emission limits.

The Bonus project "Go4Baltic (Coherent policies and governance of the Baltic Sea ecosystems) examines coherence, synergies and conflicts between national and international environmental and agricultural policies across the Baltic countries. The aim of the project is to provide policy-relevant advice and recommendations for reductions of the eutrophication in the Baltic Sea in coherence with climate and agricultural policies.

3.7.3 ECONOMIC RESPONSES: INCENTIVE-BASED INTERVENTIONS AND TAX AND SUBSIDY SCHEMES

Agri-environment measures provide payments to farmers who commit on a voluntary basis to environmental measures related to the preservation of the environment and maintaining the countryside. They are a key element for the integration of environmental concerns into the Common Agricultural Policy and were designed to encourage farmers to protect and enhance the environment on their farmland by paying them for the provision of environmental services. For example, farmers can be compensated financially for any loss of income that is associated with measures that aim to benefit the environment or the biodiversity. Agri-environment measures may be designed at the national, regional or local level, so that they can be adapted to specialized farming systems and specific environmental conditions. Since 1992, the application of agri-environment programmes has been compulsory for Member States in the framework of their rural development plans, whereas they remain optional for farmers (European Commission, 2017b).

Agri-environment schemes vary, but the main objectives include (1) the reduction of nutrient and pesticide emissions, (2) the protection of biodiversity, (3) the restoration of landscapes and (4) the preventation of rural depopulation. In all countries, the implementation of schemes is highest in areas of extensive agriculture with a relatively high biodiversity and lowest in intensively farmed areas with a small biodiversity (Kleijn and Sutherland, 2003). Besides enhancing access to the countryside and protecting cultural landscapes and heritage, as well as protecting biodiversity, some schemes also have clear objectives to reduce water pollution (Batary et al., 2015).

There is a variety of agri-environmental measures related to both productive and non-productive land management (European Union, 2005). Various agri-environmental measures can have different impacts on combating eutrophication, agriculture profitability or food prices (Spijkers et al. 2012). BALTIC COMPASS (http://www.balticcompass.org) aimed to assess and evaluate different agri-environmental for prioritizing their use in the Baltic Sea region countries. Priority measures include (according to the BALTIC COMPASS web page):

- promoting long-term grass cultivation, including crop rotation
- promoting vegetative cover (annual winter crops or catch crops) in autumn and winter
- postponing tillage activities from autumn to spring
- replacing deep ploughing with shallow one
- proper fertilization management, including (1) establishing fertilization plan based on soil monitoring, (2) evaluation of input/output nutrient balance for individual fields and farms, (3) avoiding phosphorus fertilizers in the fields where soil is already rich in this element, and (4) avoiding fertilization and manuring in certain times when risk of leakage is the highest
- using the newest scientific and technological solutions for fields fertilization and manuring
- avoiding using fertilizers and manures on lands with significant slopes, near river and lakes, or other land defined as high-risk areas
- improving feeding farm animals, i.e., limiting amount of phosphorus and nitrogen in their diet
- improving manure handling and storage
- constructing sedimentation ponds, wetlands and buffer zones.

3.7.4 SOCIAL AND BEHAVIOURAL RESPONSES

Public education and awareness: The use of environmentally responsible agricultural practices has been promoted in the Baltic Sea Region by numerous national activities and international initiatives. These include e.g. TEHO Plus and Järki programmes in Finland, Greppa Näringen in Sweden, as well as Baltic COMPASS, Baltic MANURE, Baltic DEAL and BERAS Implementation co-funded by the European Union. Activities under these projects include increasing environmental awareness and the use of environmentally sound practices by the farming community, the development of tools and mechanisms for financing and evaluating environmental investments at farm level and the demonstration of cost-effective interventions for improving recycling and retention of nutrients.

Baltic Sea 2020, a private, independent foundation aimed at stimulating concrete measures that improve the environmental quality of the Baltic Sea finances projects that are creative, innovative and improve knowledge of the Baltic Sea until 2020. The Baltic Sea Media Project (2007-2019) is one of the projects supported by Baltic Sea 2020 that produces films and educational materials about Baltic Sea problems and solutions, including eutrophication. BalticSea2020 has, in partnership with Stockholm University, established Baltic Eye: Science for a healthier Baltic Sea (2013-2019), an initiative where top scientists and communication specialists collect, synthesize and provide information about the Baltic Sea to decision makers to enhance the ability to manage the oceans environmental problems.

WWF has Baltic Ecoregion Programme dealing with the Baltic Sea and addressing also the eutrophication problem. One of the initiatives is WWF Baltic Sea Farmer of the Year Award – aiming to inspire farmers in the entire Baltic Sea region to take an active part in combating eutrophication. The award is given to the most Baltic-friendly farmers in recognition for leading the way in innovative measures to reduce nutrient run-off to the Baltic Sea.

WWF is also dealing with increasing consumer awareness, for example developing meat guides in the project CONSUME (2016-2018).

Cooperation: Agri-advisory services are being strengthened through twinning arrangements and collaboration across the Baltic DEAL network (Baltic Deal), new solutions for manure management have been explored and developed by the Baltic MANURE (Baltic Manure) and specific policy instruments and smaller scale watershed solutions were tested and implemented by the Baltic COMPASS (Baltic Compass), while ecological recycling at farm level was successfully investigated in BERAS (Beras International). Initiatives in Russia, carried out by the Balthazar and BASE Projects, addressed transferring good experiences and practices in nutrient management, especially in large animal and poultry farms (HELCOM: Projects).

Interreg Central Baltic Project NutriTrade (2015-2018) implements several effective pilot measures and establishes a Baltic Sea wide nutrient offset platform for identifying and financing cost-effective nutrient reduction measures (Nutribute). NutriTrade also provides policy recommendations for developing nutrient trading as a policy instrument for national and intergovernmental Baltic Sea protection efforts.

The Baltic Sea Action Group, (officially "Foundation for a Living Baltic Sea") is an independent non-profit foundation (2008) based in Finland. BSAG works to find solutions and right actors to restore the good ecological balance of the Baltic Sea. The work is based on constructive cooperations among all levels of society, including the highest political level in all the Baltic Sea countries, public authorities, and the private sector.

Technological responses: Technological innovations support sustainable farming through better resource management, such as better recycling of nutrients in the agricultural ecosystem that cut the demand for fertilisers and reduces dependence on importing mineral fertilizers. Nutrient flows are especially high in the BSR livestock sector as the mineral fertilisers and feed imports represent most of the new nutrients brought into the Baltic Sea Region (Svanbäck et al., 2016). One possible solution is the use of circular economy in agriculture practices which ensure that resources can be productively reused. This does not only reduce demands on (natural) resources, improves efficiency, and reduces costs (Allen, 2015), but also helps to decrease waste as agricultural nutrients (manure) are part of the cycle.

Losses on nutrients to the environment can be minimised if a reasoned fertilization is used, together with 'sustainable' agricultural practices, such as crop rotation, planting cover crops, and ploughing in crop residues. Reasoned fertilization means applying fertilizers, whether mineral or organic, in the correct weather conditions (to avoid run off), at the appropriate stage in crop growth (so that plants take up the nitrogen quickly) and at the correct doses (Pau Val and Vidal, 1999).

Depending on a type of manure and storage, ammonia from stables and during storage can be released into air and cause acidification. Volatilisation can be minimized when injecting the slurry into the soil, instead of spreading it on top of the soil. The result is less volatilisation, but a higher level of nitrogen in the soil, and also a greater risk of leaching (Pau Val and Vidal, 1999). For example, **Agri-Farm** has developed a new housing system both for dairy cows and pig production. These housing systems have a ventilation system that captures ammonia, odour gasses, methane and other emissions at the source. The polluted air stream is cleaned by a special filter addressing various pollutants (Tybirk et al., 2013).

One possibility to minimize the pressure from livestock farming is multifunctional farming practices. A gap between industrial livestock production and crop production means that the excess livestock waste produced by the large livestock farms is no longer considered a fertilizer but a waste product (Skorupski et al., 2013). In the frame of the **BERAS Implementation project**, a network mainly consisting of Ecological Recycling Agriculture (ERA) farms was established that serve as a learning centre. ERA farming means that animal production is adapted to the farm's own fodder production. This should help to keep nutrients in farm's production cycles. It is argued that ERA can reduce more than 50% of the nitrogen surplus and cause no phosphorus surplus compared to conventional farming (BSR Joint Technical Secretariat, 2013).

There are also projects aiming at the recovery of eutrophied water bodies, e.g. Living Coast (2010-2017) initiated by Baltic Sea 2020. Living Coast was a large-scale demonstration project carried out in a bay in Stockholm's archipelago where different measures (e.g. aluminium-treatment of seabottom, measures to reduce impact from agriculture (structure liming, two-stage ditches, sedimentation ponds with lime-scale filters and tile drainage with a lime admixture), improving sewage treatment, implanting bladder wrack) were tested and evaluated for recovering the eutrophic bay.

Baltic Sea 2020 has also „The IPP Program – measures to reduce nutrient-leaching from industrial livestock production (2010-2020)" aiming to reduce nitrogen and phosphorus loads to water. This will be achieved through identification and implementation of measures which efficiently recirculate the nutrients in manure to the plant production. Initially, a series of research studies have mapped the scope of the problem around the Baltic Sea, identified measures and given recommendations for "Best Available Technologies"

The project „Industrial animal farms in the BSR - sustainable practices to reduce nutrient loads" was a part of a long-term campaign (Industrial farming campaign 2015) of the Coalition Clean Baltic and Green Federation ‚GAJA' (Poland), aiming to reduce the negative impact of large-scale animal production on the environment and local communities in the Baltic Sea Region, particularly by reducing nutrient run-off into the sea.

The EU supports research and innovation in the field of agriculture and actions to minimize agriculture-related pressures on the marine environment by different funding streams, e.g. Interreg programmes:

The Interreg BSR project BALTIC SLURRY ACIDI (Reducing nitrogen loss from livestock production by promoting the use of slurry acidification techniques in the Baltic Sea Region (2016-2019) promotes the use of slurry acidification technologies throughout the Baltic Sea Region to reduce airborne eutrophication and create a more competitive and sustainable farming sector.

In the Interreg BSR project MANURE STANDARDS (Advanced manure standards for sustainable nutrient management and reduced emissions (2017-2019) policy makers, authorities, advisors, farmers and researchers create, test and implement tools to determine manure standards for farming practices and policy instruments. The new manure standards are to improve nutrient recycling and reduce nutrient inflow in the Baltic Sea.

The Interreg Central Baltic project NUTRINFLOW (Practical actions for holistic drainage management for reduced nutrient inflow to Baltic Sea (2015-2019) aims at reducing nutrient losses from agriculture through implementing and promoting holistic drainage management and innovative water management measures in agricultural areas.

The Interreg Central Baltic project WATERCHAIN (Pilot watersheds as a practical tool to reduce the harmful inflows into the Baltic Sea (2015 - 2018) helps to reduce inflows of nutrients and hazardous substances to the Baltic Sea from all types of land-based sources by using pilot watersheds and environmental technology.

The Interreg Central Baltic project GreenAgri (Environmentally-friendly Management of Organic Fertilizers in Agriculture (2015 - 2019) aims at reducing nutrient losses from agriculture in Baltic States by introducing and testing environmentally-friendly management.

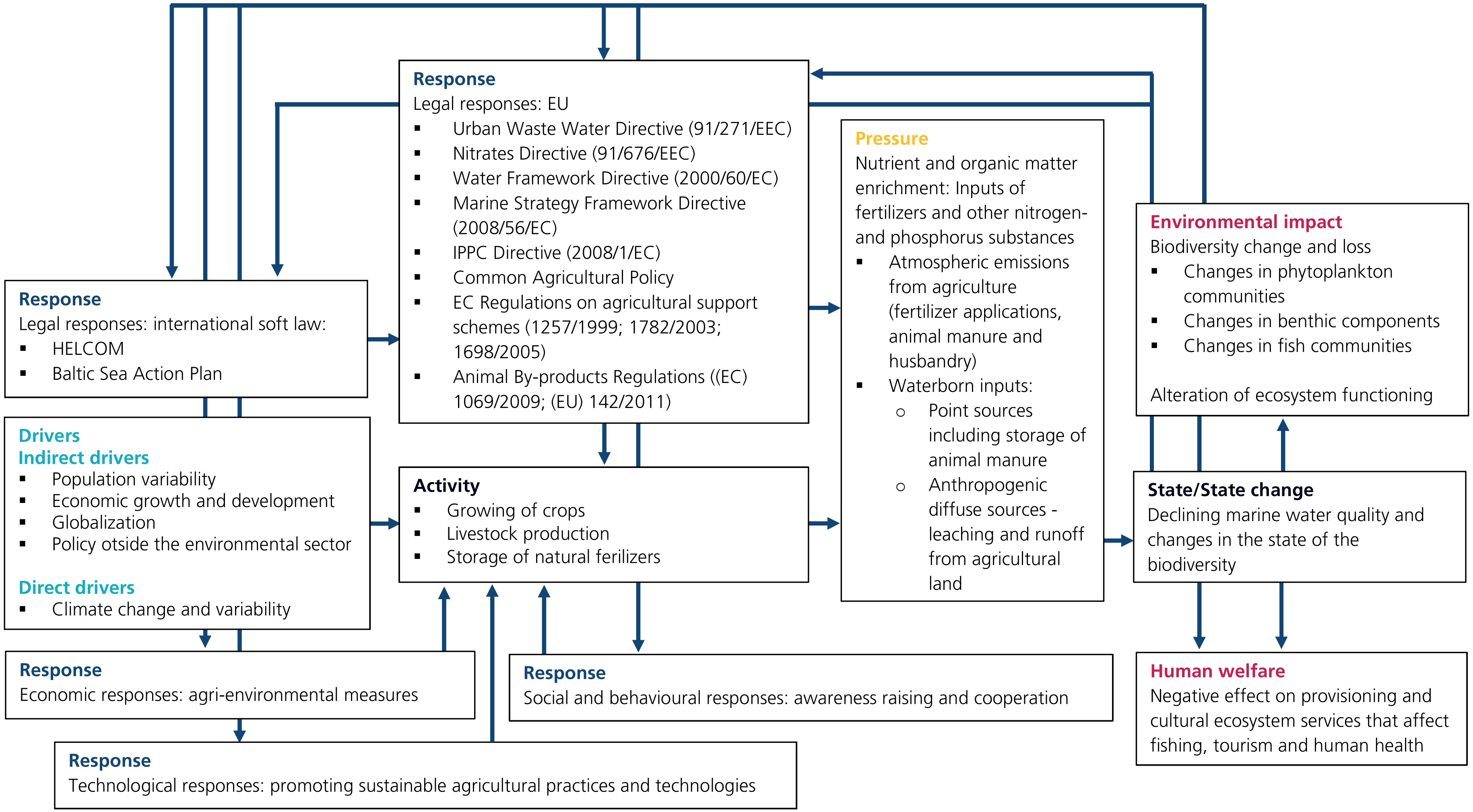


Figure 1. *Interconnections between eutrophication and agriculture as categorized within the DAPSI(W)R framework. Drivers (D), Activities (A), Pressures (P), State (S), Impacts (I), Welfare (W) and Responses (R): Indirect and direct drivers such as population growth and climate change, respectively, impact agricultural activities. Agriculture adds pressure on the Baltic Sea due to nutrient enrichment and thereby impacts its environments and causes a state change. The state change, such as declining water quality has negative effects on human welfare. Hence, to decrease the environmental impact and improve the state of the Baltic Sea, different kind of responses are taken: (1) legal responses such as international soft lows or regulative measures taken on the EU level, (2) economic responses, (3) technological responses and (4) social and behavioural responses – which, in turn, influence the agricultural activities.*

4. VALUE CHAIN OF THE AGRO-FOOD SECTOR IN THE BALTIC SEA REGION

This paragraph displays the key players of the economy that are closely linked to the agricultural value chain and presents their interlinkages and synergies, including sectoral dependencies outside of the Baltic Sea Region. As the Baltic Sea region is part of the EU common market, it is pivotal to focus on the sectoral developments in the EU and to include its position in global agricultural trade and the agro-food market. For receiving a full picture of the agricultural value chain, we analysed the contributions of the Baltic Sea countries to the EU´s total production and trade numbers. Hence, the analysis concentrates on eight BSR countries that are EU member states.

Usually, value chain analyses are used for assessing compeditiveness within a business or a sector. Our assessment was carried out with a different purpose: we defined actors and activities within the value chain with the aim to identify those that can change behaviour towards a positive impact on marine and coastal ecosystems. Hence, we focused on the activities within the value chain that are causing high direct pressures such as agricultural production or indirect pressures caused by other activities Figure 5; Annex 2). In contrast to the agro-food sector, energy production is creating a small pressure in the Baltic Sea as in the EU only 3% of the total amount of cereals are currently used for the production of biofuels (European Commission, 2018a) and is therefore not further considered in this report. Also, the link between the agricultural production and the cosmetics industry is largely unknown and was only a small part of our investigations.

4.1 AGRICULTURAL PRODUCTION

About one third of the EU agricultural production was obtained from the Baltic Sea Region in 2015, where the crop production contributed with 51% and the animal production with 49% to the total agricultural output (excluding Russia; Eurostat, 2016). The shares of crop and animal production in the entire EU28 were with 58% and 42%, respectively very similar, whereas the highest outputs were milk (14.7%), cereals (14.5%), pig (9.0 %) and cattle (7.5%; Table 2; Eurostat, 2017d). Hereby, in most individual BSR countries, the crop yield was higher than the animal products, with an exception for Denmark with high shares of pig meat and milk and Finland with high share of milk and other animal products (Table 2).

Table 2. *Crop and animal output in countries of the Baltic Sea Region and in the EU. Crop and animal output in [%] of total agricultural output; Denmark (DK), Germany (DE), Estonia (EE), Latvia (LV), Lithuana (LT), Poland, (PL), Sweden (SE) and the European Union (EU) (data from 2015; Eurostat, 2017d).*

Output components	DK	DE	EE	LV	LT	PL	FI	SE	EU
Total crops	36.4	52.2	57.5	65.7	64.7	52.5	38.1	51.5	58.0
Cereals	14.0	15.8	27.9	35.3	35.5	16.7	13.4	14.1	14.5
Industrial crops	4.0	7.5	11.0	9.3	10.6	11.5	1.7	3.7	4.5
Forage plants	7.9	12.2	9.1	10.4	9.2	3.9	6.0	18.6	7.8
Vegetables & horticultural products	6.8	10.6	4.6	5.5	4.1	11.6	12.6	9.5	14.6
Potatoes	2.0	1.7	3.5	4.6	1.5	3.0	1.7	3.7	2.7
Fruits	0.4	1.7	1.4	0.3	0.3	5.7	2.4	1.7	6.7
Wine	0	2.4	:	:	:	:	:	:	5.0
Olive oil	:	:	:	:	:	:	:	:	0.9
Other crop products	1.3	0.3	0.1	0.3	3.6	0.2	0.2	0.2	0.7
Total Animals	63.6	47.8	42.5	34.3	35.3	47.5	61.9	48.5	42
Cattle	4.0	9.6	4.5	3.2	4.7	6.3	8.0	11.4	7.5
Pigs	27.7	11.3	8.8	4.9	5.1	8.6	8.4	8.0	9.0
Equines	0.2	0.1	0	0	0	0.2	0	1.1	0.2
Sheep & goats	0.1	0.3	0.4	0.2	0.2	0	0.1	0.5	1.6
Poultry	2.4	3.8	4.0	4.1	5.4	12.2	4.8	3.7	5.4
Milk	18.2	20.2	21.8	15.9	14.8	15.0	27.4	17.9	14.7
Eggs	1.0	1.6	1.5	3.5	1.9	4.9	2.2	3.4	2.2
Other animals & animal products	10.1	0.7	1.5	02.0 5.18	3.3	0.4	11.1	2.6	1.5

4.1.1 CROP PRODUCTION

Cereal production (Table 3): The European Union is one of the world's biggest cereals producers and an important cereals trader (1st on world market for wheat and barley in 2015/2016; European Commission, 2018a). Annually, about 15% of the EU's wheat crop is exported, while large quantities of oilseeds, animal feedstuffs and rice are imported. Currently, from the cereals produced in the EU, nearly two-thirds are used for animal feed, about one-third for human consumption, and 3% for biofuels (Europaen Commission, 2018). Similar shares were reported for cereal consumption in the Baltic Sea Region (Baltic Eye, 2018).

In 2014, the cereal harvest (including rice) in the EU28 was estimated to be around 334.2 million tonnes, which was 13% of global cereal production (Eurostat, 2017b). Hereby, especially common wheat and spelt, barley, grain maize and corn cob mix accounted for a high share (86.4 % in 2014) of the cereals produced in the EU28. Hereby, in 2015 nearly 34% of the EU28 cereal production originated from Baltic Sea region countries, whereas the production of grain per person was the highest in Lithuania (2100 kg), Denmark (1756 kg), Latvia (1535 kg) and Estonia (1167 kg). Hence, all BSR countries except Germany produced more grain per person than the EU average (621 kg per person; Eurostat, 2017b).

Table 3. *Cereals used for production of grain in 2015. Cereals in [tonnes] (Eurostat, 2017b).*

Country	CEREALS [TONNES]
DK	10 023 000
DE	48 917 700
EE	1 535 300
LV	3 021 500
LT	6 066 710
PL	28 002 700
FI	3 682 800
SE	6 168 800
BSR total	107 418 510
EU28	316 767 370

Triticale, the hybrid of wheat *(Triticum sp.)* and rye *(Secale sp.)*, is currently mainly used for animal feed. In EU28 in 2014, the yield of triticale was about 13.2 million tonnes whereas Poland produced 39.9 % of the total.

Sugar beet production: About 20% of the world´s sugar production uses sugar beet, whereas the EU is currently its largest producer accounting for 50% of the global production (Eurostat, 2017g). In 2014, The EU28 produced 128.4 million tonnes of sugar beet, which was an increase of 19.4 million tonnes compared to as in 2013.

Oilseeds production: Rape and turnip rape, and sunflower seeds are the main types of oilseeds produced in the EU28 (European Commission, 2018a). An estimated 24.3 million tonnes of rape and turnip rape were produced in 2014, whereas more than a quarter (25.7%) was produced in Germany.

Vegetable production: The EU produces a broad range of fruits and vegetables due to its variety of climatic and topographic conditions. Hereby, potatoes for human consumption belong to the most competitive segments of EU agriculture. In 2007, with the share of 1.3%, the EU27 was after China the second largest producer of potatoes in the World (European Commission, 2017c).

4.1.2 LIVESTOCK PRODUCTION

Animal production accounted for 42% (EUR 145 billion) of the total EU28 agricultural output in 2015 (Eurostat, 2017c), covering:

1) animals for slaughter or alive for heard renewal or further growing and fattening (57.5% of total output) and

2) animal products such as eggs, milk, wool, ect. (42.5% of total output; Eurostat, 2017c)

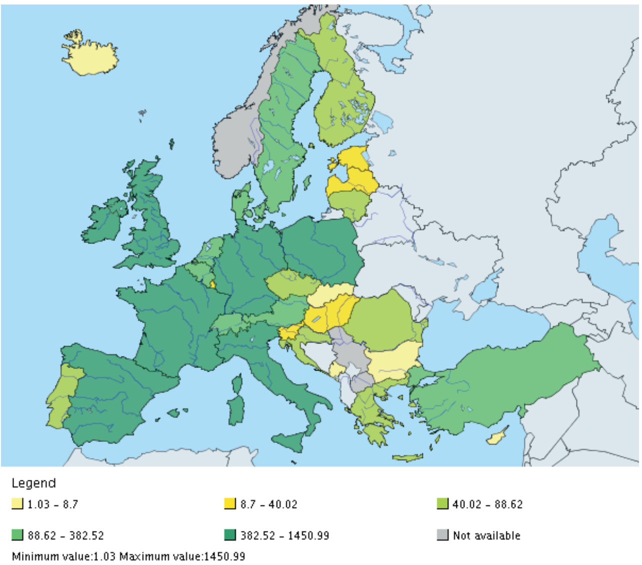
In the BSR at the same time, the livestock density (LSU/ha UAA = number of livestock units per hectare of Utilised Agricultural Area) was the highest in Denmark (1,58 LSU/ha UAA) and Germany (1,1 LSU/ha UAA), and the lowest in the Baltic States (Estonia: 0.32 LSU/Ha UAA, Lithuania: 0.29 LSU/Ha UAA, Latvia: 0.26 LSU/ha UAA; Eurostat, 2017c).

Beef and veal production (Figure 2): The EU currently has a bovine herd of around 89 million heads, a total yearly production of nearly 7.6 million tonnes of beef and a self sufficiency close to 100% (Eurostat, 2015).

The BRS countries excluding Russia count about 23.7 million heads and were reported to have a yearly beef production of about 2 million tonnes in the 2016 (Eurostat 2017c). Hereby, the yearly production of beef and veal per person was highest in Denmark (21 kg), Finland (16 kg), Lithuania (15 kg), Sweden (15 kg) and Germany (14 kg), and lowest in Latvia (9 kg) and Estonia (7 kg).

Export and import: The total export of beef and veal from the EU28 was 385 641 tonnes (carcase weight), including about 99 000 tonnes from BSR (ca 26% of EU 28 beef export), which was almost half of the BSR production (Eurostat, 2018). Hereby, the biggest exporters of beef in BSR were Germany (46 151 tonnes), Poland (37 687 tonnes) and Denmark (7266 tonnes). The main beef export partners of EU were Turkey (26 131 tonnes), Hong Kong (27 903 tonnes), Lebanon (27 262 tonnes), Ivory Coast (21 338 tonnes), Ghana (19880 tonnes), Bosnia-Herzegovina (19 256 tonnes), Switzerland (15 812 tonnes) and Philippines (10 256 tonnes).

The total import of beef from third countries into EU28 was 193 972 t, including and import of about 32 400 tonnes into BSR countries (16.7% of EU28 beef import; Eurostat, 2018). EU imports beef mainly from South America (Brazil (83 978 tonnes), Uruguay (28 810 tonnes), Argentina (25 353 tonnes), Australia (18 431 tonnes) and USA (11 427 tonnes; Eurostat, 2018)



COUNTRY	TOTAL PRODUCTION OF BEEF AND VEEL [TONNES]	PRODUCTION OF BEEF AND VEAL [KG/ PERSON]
Denmark	120 600	21
Germany	1 124 000	14
Estonia	9 620	7
Latvia	17 360	9
Lithuania	44 130	15
Poland	471 010	12
Finland	85 760	16
Sweden	143 980	15
EU 28	7 590 340	15

***Figure 2.** Production of beef and veal in EU28 countries in 2015 (Eurostat, 2017c)*

Sheep and goat meat production: The EU counted around 98 million sheep and goat heads (85% sheep and 14% goats) and a total production of about 925 000 tonnes carcass weight in 2013, which accounted to 88% self-sufficiency (European Commission, 2017d).

Export and import: In the same year, the EU exported around 74000 tonnes (8% of its total production) and imported around 212 000 tonnes (23% of its own consumption) mainly from New Zealand and Australia (94%; European Commission, 2017d). Exports of live animals and meat increase since a few years: currently, living animals are mainly exported to the Middle East and North Africa, whereas meat and meat products are ship all around the world with an emphasis to the Far East.

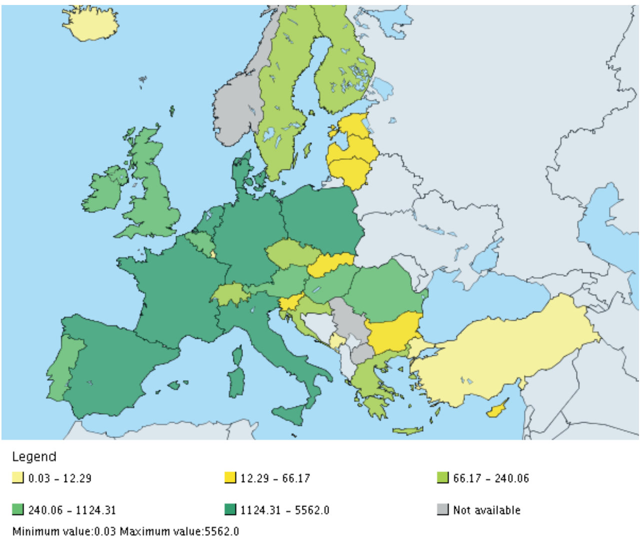
Pig meat production (Figure 3): The EU currently counts about 150 million pigs and is with a yearly production of about 23 million tonnes carcass weight – after China - the world´s second largest producer of pigmeat and the biggest exporter of pigmeat and pigmeat products (Eurostat, 2015). The

EU´s self-sufficiency is about 111% and exports about 13% of its total production. Most of the EU's pigmeat exports go to East Asia and there in particulary to China (Eurostat, 2017c).

The Baltic Sea Region exluding Russia, currently counts over 44 million pig heads and has a yearly pig meat production of about 9.6 million tonnes (Eurostat, 2017c). Within the BSR countries, the yearly pork production per person is the highest in Denmark (280 kg), followed by Germany (68 kg), Poland (50 kg), Finland (35%), Estonia (32 kg), Sweden (24 kg), Lithuania (23 kg) and Latvia (15 kg; Eurostat 2015).

Export and import: The total export of pig and pig meat from EU28 is 1 624 185 tonnes, including about 754 114 tonnes from Baltic Sea Region countries (46% of EU 28 pig and pig meat export; Eurostat, 2018). The biggest exporters of pigs and pig meat in BSR are Germany (362 653 tonnes), Denmark (284 983 tonnes) and Poland (91 706 tonnes). The main pig and pig meat export partners of EU are China with almost half of the EU export (1 156 931 tonnes), Japan (219 799 tonnes), Hong Kong (199 034 tonnes), South Korea (130 582 tonnes) and Philippines (128 831 tonnes; Eurostat, 2018).

The total import of pigs and pig meat into EU28 is 18 400 tonnes, including an import of 13 300 tonnes into BSR countries (72,5% of EU 28 pig meat/pigs import). Hereby, the EU imports pig meat mainly from Switzerland (12 249 tonnes), Chile (1831 tonnes), Norway (1154 tonnes) and USA (979 tonnes; Eurostat, 2018).



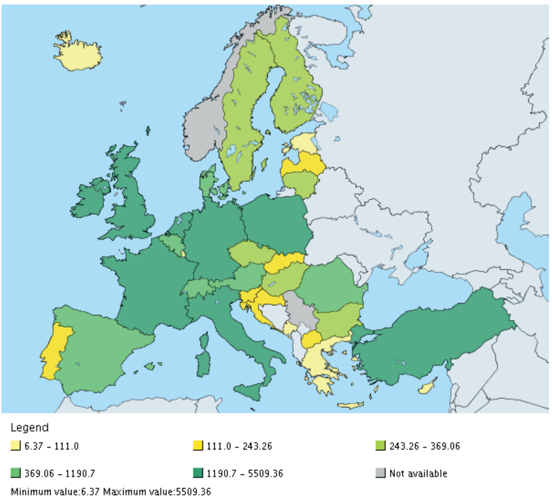
COUNTRY	TOTAL PRODUCTION OF PORK [TONNES]	PRODUCTION OF PORK [KG/PERSON]
Denmark	1 598 700	280
Germany	5 562 000	68
Estonia	42 410	32
Latvia	29 330	15
Lithuania	66 170	23
Poland	1 906 110	50
Finland	191 930	35
Sweden	233 500	24
EU 28	22 957 820	45

Figure 3. *Production of pork in EU28 countries in 2015 (Eurostat, 2017c).*

Poultry meat and egg production: The EU produced 13.1 million tonnes of poultry meat in 2014, importated 0.8 million tonnes and exported 1.5 million tonnes and currently has a self-sufficieny of 103% (European Commission, 2017e).

Export and import: Products exported from the EU are in average of a lower value than the imports (1.37 EUR/kg), and also the range of products as well as the range of destinations are much wider. Half of exports are shared between five destinations (South Africa, Benin, Hong Kong, Saudi Arabia and Ukraine) while the other half goes to countries all around the world (European Commission, 2017e). The European Union is the world's second egg producer and a net exporter of eggs and egg products. The EU imports of poultry meat products are mainly coming from Brazil (60% of total EU poultry meat imports) and Thailand (30%), including poultry breasts and other products, such as cooked preparations etc with an average import value 2.59 EUR/kg (in 2014; European Commission, 2017e).

Milk production (Figure 4): Milk is produced in all EU Member States and is a significant proportion of the value of EU agricultural output, representing a very important part of agricultural economy for some of the individual member states. In 2015, the EU counted around 23 million cows, including around 8 million cows in the BSR (4,3 million in Germany; 2,1 million in Poland; 0,5 million in Denmark). The total EU28 total milk production was estimated to 165 million tons per year in 2014 (Eurostat, 2015). As the milk yield per cow has improved during the last years, the EU dairy herd has been decreasing steadily (Eurostat, 2015).



In the BSR countries excluding Russia, the milk production is 56 million tons per year, whereas the main producers are Germany (32 million tonnes), Poland (11 million tonnes) and Denmark (ca 5 million tonnes; Eurostat, 2015). This corresponds to an EU average milk production of 297 kg per person and a wide range of milk production per person in the individual countries: Denmark: 925 kg, Estonia: 547 kg, Lithuania: 498 kg, Finland: 436 kg and Latvia: 410 kg, Germany: 388 kg, Sweden: 298 kg, Poland 286 kg. EU average collection of cows' milk is 297 kg/person/year.

Figure 4. *Number of dairy cows in EU28 countries in 2015 (Eurostat, 2017c).*

4.1.3 FARMING CHARACTERIZATION

Size of farms

The total number of agricultural holdings has decreased in all BSR countries in the last years (2005 – 2013) whereas the number of large farms (≥ 100 ha) has increased (2005 - 2013; Eurostat, 2015). In the Baltic Sea Region, the amounts of small farms (≤ 10 ha) were the highest in Poland (76% of all farms), Lithuania (76%), Latvia (62%) and Estonia (54%), and the smallest in Finland (17%) in 2013 (Eurostat, 2015). The amounts of large farms (≥ 50 ha) were the highest in Denmark (34%), Germany (30%) and Finland (28%), and lowest in Poland (2%), Lithuania (6%) and Latvia (7%). Medium size farms (10 - 50 ha) dominated in Finland, Germany, Sweden and Denmark. notably, the amount of very large farms (≥ 100 ha) are high in Denmark (20%) and in Estonia (9%), which are both relatively small countries compared to other BSR EU Member States.

Income and subsidies

The contributions of subsidies in factor income[1] of farms are relatively high in the Baltic Sea Region with an EU average of 35% of factor income (Table 4; Eurostat, 2017d). In the BSR member countries Finland, Germany, Denmark and Sweden, the shares of subsidies per ha are higher than EU average, with the highest being in Finland (125%). At the same time, subsidies per ha are lower than EU average in the the Baltic States.

[1] Factor income = agricultural output - intermediate consumption - consumption of fixed capital - taxes + subsidies

AGRICULTURAL ACTIVITIES

- The Baltic Sea Region's agricultural sector is the supplier of an essential produce – food.
- The main agricultural production both in the EU and Baltic Sea Region is livestock production (including dairy farming).
- High share of produced crops is used for animal feed.
- The avarage farm size of the BSR region was 39.5 ha (Russia excluded) which is more than twice the EU avarage.

CLIMATE CHANGE

Has impact on regional distribution and productivity of harvested crop cultures, and input costs of agricultural production.

REGULATIONS AND INITIATIVES

- Common Agricultural Policy (CAP): With the aim to improve agricultural productivity the CAP favours intensive farming over extensive practices which may have negative effect on the environment.
- Subsidies: Share of subsidies in a factor income in most of the BRS countries is higher than the EU avarage (34.57%). The highes pergentage is in LV (65.32/) and FI (125.47%)

ECONOMIC VIABILITY

A need to use their resources in an economically viable (effective) way. Any changes to factor prices (input prices) or in demand for products (output prices) are likely to have an effect on how they use resources (in particular land).

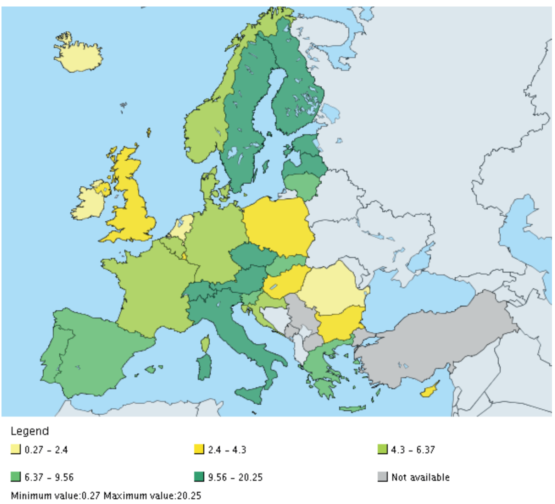
TECHNOLOGICAL INNOVATION AND KNOWLEDGE

- Development of miner fertilizers (including fertilizing technologies) has helped to increase productivity and cut nutrient losses at some extent

Figure 5. *Agricultural production and its main drivers. Agricultural activities are impacted by climate change, economic viability, regulations and initiatives and technologica innovation and knowledge.*

Table 4. *Common Agricultural Policiy (CAP) subsidies in Baltic Sea Region and EU in 2015 (Eurostat, 2017d.)*

		DK	DE	EE	LV	LT	PL	FI	SE	EU28
Share of subsidies in factor income (%, 2015)		48	65	37	63	20	35	125	56	35
Subsidies per ha of UAA (in EUR, 2015)		379	454	146	157	64	225	702	304	288
CAP expenditures 2008-2013	direct payments (%)	87,7	77	38,2	36,7	48,2	47,3	62	69,2	70,6
	market measures (%)	4,4	4,2	1,7	7,0	4,0	7,9	3,1	3,4	7,0
	rural development (%)	7,9	18,8	60,1	56,3	47,8	44,8	34,9	27,3	22,5



Organic farming

The EU's organic market has experienced a steady growth of annually 13% and increased from 10 to 22 billion EUR during 2001-2013 (ECSIP Consortium, 2016). In most countries of in the BSR region, the share of organic crop area from total UAA (%) is higher than the EU average (6.2%; Figure 6), being the highest in Sweden (17.1%), Estonia (15.7%) and Latvia (12.3%). Only in Poland the share is lower than the EU average.

Figure 6. *Area used for organic farming in EU28 countries in 2015 (Eurostat, 2017d)*

4.2 Fertilizers

4.2.1 FERTILIZER PRODUCTION AND RETAIL

In the EU, there are approximately 1000 enterprises (1058 in 2013; Table 5) producing inorganic fertilizers and more than 700 compost producers (Fertilizers Europe, 2016). The EU is a net importer of nitrogen and phosphate fertilizers: while producing 9% of global nitrogen fertilizers and 3% of global phosphate fertilizers, it consumes 10% of global nitrogen, 7% of global phosphate and 10% of global potash (Fertlizers Europe, 2016).

In the Baltic Sea region, the biggest producers of fertlizers and nitrogen compounds are Germany, Poland, Lithuania and Finland (Table 5; Fertilizers Europe, 2016). Between 2003 and 2012, the number of companies have increased in all four countries: in Germany from 37 to 90, in Poland from 86 to 94, in Lithuania from 4 to 8, and in Finland from 11-13. At the same time, the number of fertilizer manufacturers have decreased in some EU countries (Fertilizers Europe, 2016). In contrast, the average size of the enterprises has increased and has almost doubled during the decade.

Table 5. *Number of enterprises and average enterprise size (AES; in million EUR) of the Top 10 fertilizer-producing EU member states (Wesseler et al., 2015).*

	2003		2006		2009		2012	
	NUMBER	AES	NUMBER	AES	NUMBER	AES	Number	AES
Germany	37	64.36	76	40.48	87	37.10	90	52.34
France	195	12.26	169	16.25	114	22.73	128	21.99
Poland	86	12.77	77	15.37	90	11.56	94	25.55
UK	81	17.41	81	23.30	66	-	59	36.93
Netherlands	25	47.69	25	69.54	31	43.47	32	64.62
Spain	214	4.23	268	3.92	274	4.05	264	7.67
Italy	190	4.97	185	7.35	164	7.90	182	10.10
Belgium	29	13.82	32	14.41	21	19.05	49	32.08
Lithuania	4	78.03	7	69.51	8	73.10	8	145.80
Finland	11	33.25	13	33.11	16	30.78	13	65.82
EU-27	1027	13.39	1100	15.62	1116	14.60	1244	21.17

4.2.2 FERTILIZER TRANSPORT

In the Baltic Sea Region, fertilizer transport is of high economic importance. Here, over 70 harbour ports are involved distributing fertilizers, wheras Lithuania and Russia are currently handling the highest fertilizer volumes (Coalition Clean Baltic, 2017). As an example, in Lithuania fertilizer cargo is accounting for 20% of the total cargo turnover at Klaipeda port (Coalition Clean Baltic, 2017).

At the same time, the transport of fertilizer is adding direct pressure to the Baltic Sea: previous estimates of nutrient losses from ports facilities for handling fertilizer and fertilizer-related materials showed, that these activities can cause considerable point sources of nutrient pollution (Coalition Clean Baltic, 2017). Up to several tons of directly bioavailable nitrogen and phosphorus per year (about 0.05% of the bulk cargo) were estimated to end up in the Baltic Sea during ship loading/offloading operations, as well as from temporary open storage and improper stormwater management at port facilities. With the volumes of fertilizer cargo steadily growing in Baltic Sea ports (up to 33 million tonnes per year), it is also likely that fertilizer losses to the environment are increasing.

During slurry transportation, about 60–100 tons of cargo slurry are typically discharged per hold after washing, eventhough the Baltic Sea is declared as a Special Area under MARPOL Annex V (Coalition Clean Baltic, 2017). As fertilizer cargo is usually not classified as containing substances that are hazardous to the marine environment, there is a lack of reception facilities for such cargo residues in ports (Coalition Clean Baltic, 2017). Dry bulk commodities on the other hand are prone to spillage and dust pollution. Ports which handle bulk materials are confronted with critical ship-to shore or shore-to-ship transfer problems. In 2013, the potential loss from 33 million tons of fertilizers handled in the Baltic Sea ports was estimated to account to about 16500 tons (Coalition Clean Baltic, 2017).

4.2.3 FERTILIZER CONSUMPTION

The EU is a net importer of nitrogen and phosphate fertilizers, whereas the European fertilizers market demand is led by export-oriented agricultural countries such as Germany (Mordor Intelligence, 2018). In 2015, the Baltic Sea Region's nitrogen consumption was 32% and the phosphorus consumption was 30% of the total consumption in the EU28 (Table 6). Germany and Poland are currently the biggest consumers of mineral fertilizers in the Baltic Sea region, also per hectar of Utilised Agricultural Area (Eurostat, 2015). Overall, the usage of fertilizers in the EU has declined by more than 20% between 1995 and 2012, whereas the usage of potassium declined from 24 % to 17% and the usage of phosphorus from 21% to 16%. In contrast, the nitrogen usage has increased from 56% to 67% (Wesseler et al., 2015).

In the EU, about 16 milion tonnes of inorganic fertilizers (19.5 million EUR in 2007), more than 1600 million tonnes of manure, and 13 million tonnes of compost are consumed every year. For farmers, the costs of inorganic fertilizers in the EU currently range between 1.6% in Malta and 12.3% in Italy of total costs (Wijnands and Linders 2013).

Table 6. *Mineral fertilizer consumption in the Baltic Sea Region in 2015 (Eurostat, 2017f).*

	N [TONNES]	N [KG/ HA UAA]	P [TONNES]	P [KG/HA UAA]
EU 28	11 081 994	62	1 113 001	6
Denmark	189 114	72	13 674	5
Germany	1 621 905	97	109 602	7
Estonia	51 405	52	4 646	5
Latvia	47 469	25	5 039	3
Lithuania	161 681	54	19 099	6
Poland	1 153 950	80	158 728	11
Finland	143 855	63	10 733	5
Sweden	169 968	56	13 293	4

4.3 FOOD MANUFACTURING

Globalization impacts the EU agro-food sector and its developments substantially, as many countries outside the EU can produce food on a larger scale and at lower costs compared to as in Europe (Figure 8). For instance, economic challenges for the EU agro-food sector emerged with the rise of new competiters from Brasil and Argentina, leading the price for the meat complex and the milk complex, respectively. Globalisation has caused and alteration of the power relations in the global agro-food sector and has increased competition at the industry level, which has resulted in mergers, acquisitions and strategic cooperations. Additionally, many countries and markets have become increasingly liberalized and financial instruments are influencing agro-food prices more than ever before. In the following, new prices and payments schemes have resulted in a decreasing number of farms and inceasing level of productivity and production per farm with the aim of keeping the transaction costs lower (Rytkönen, 2014).

In the EU, the food and beverage industry has remained the largest manufacturing sector with a share of 14.6% (FoodDrinkEurope, 2018). The EU exports of agricultural products to the rest of the world are steadily increasing: Whereas in 2011, the EU exported about EUR 41.5 billion-worth of processed agricultural products to the rest of the world, the exports accounted to EUR 43 billion in 2013 (European Commission: Growth, 2016).

In 2009, the Baltic Sea Region contributed with almost 29% of the EU27 total turnover to the production of food. Currently, within the BSR, the highest turnover of food products is taking place in Germany (also highest in EU28) and Poland (Table 7; FoodDrinkEurope, 2018), which are also the two largest meat manufacturers (Eurostat, 2017c).

Worldwide, the EU remains the largest exporter of pig meat and the second largest manufacturer after China (ECSIP Consortium, 2016). In terms of trade in meat products, the EU is a net exporter except for sheep and goat meat. Pig, sheep and goat meat is mainly exported to the Far East, whereas Hong Kong, Lebanon, Ivory Coast and Ghana are the most important export markets for European beef and veal. The main export destinations for EU poultry meat are South Africa, Benin, Hong Kong, Saudi Arabia and Ukraine. The EU sources its meat mainly from Brazil (beef and poultry), Thailand (poultry), New Zealand & Australia (sheep and goat; ECSIP Consortium, 2016).

Additional to exports, the food and beverage industry plays another essential role in national economies as it coveres more than 15% of the national employments in more than half of the EU member states.

	NUMBER OF ENTERPRISES	NUMBER OF EMPLOYEES	TURNOVER
	[*THOUSANDS]		[MILLION EUR]
EU27	264.1	4091.5	813 590
Denmark	1.5	53.4	19 145
Germany	30.7	799.3	147 948
Estonia	0.4	12.4	1125
Latvia	0.7	23.2	1252
Lithuania	1.1	39	2677
Poland	13.6	396.6	37 959
Finland	1.7	34.4	8 633
Sweden	3.3	59.5	14 840

Table 7. *Manufacturing of food products in Baltic Sea Region countries in 2010. Number of enterprises, Number of employees and turnover [million €] (Eurostat, 2010).*

The EU Food industry represents almost 13% of the turnover of the entire EU's manufacturing industry. Therein, the meat sector, which includes processing and preserving of meat and production of meat products, is the largest sector in the EU food industry (Figure 7). In 2012, the meat manufacturing accounted for 20.5% of the total turnover of the EU´s food and drink industry. The turnover of dairy is ranked at the forth place of total turnover and accounted for 13.6% of the total turnover of the EU´s food and drink industry in 2012 (ECSIP Consortium, 2016). Within the EU28, Germany and Poland were among the largest dairy manufacturers in 2012. The EU28 provides around 20% of the global dairy production and is of of the largest dairy net exporter globally, while China and the Russian Federation are the largest milk importers (ECSIP Consortium, 2016). The cereal products sector remains smaller than meat and dairy sector accounting for 4% of the total turnover of the food and drink industry in 2012. Processing of cereal products currently also has a small share (4%) in the total turnover of the EU food and drink industry, which makes it – in terms of turnover – the smallest sector after fish (ECSIP Consortium, 2016).

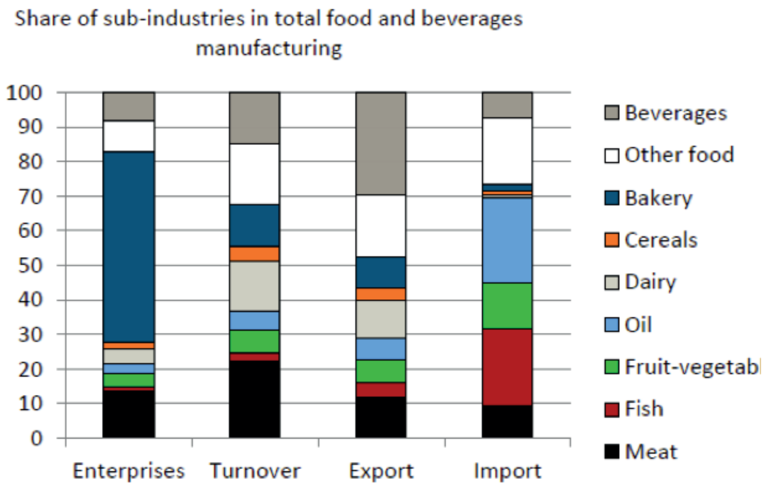


Figure 7. Number of enterprises, turnover and external trade of selected sub-sectors of the food and drink industry in EU28 in 2012 (ECSIP Consortium, 2016).

4.3.1 TRENDS SHAPING THE FUTURE AGRO-FOOD SECTOR

Although the main driver of the EU agro-food sector is globalization, other phenomens occur that are shaping the industry and agro-food production. In addition to supplying products that satisfy nutritional demands, rural and agricultural businesses increasingly also offer recreation and leisure opportunities. Additionally, they increasingly focus on ensuring future environmental sustainability and biodiversity, counteract depopulation of rural spaces, and offer regions and nations a sense of history and tradition. "This local dimension of the agro-food sector is characterized by the production of local food and other agricultural goods, and by a shift in focus from large-scale agriculture to rural development" (Rytkönen, 2014).

Both the demand for organic food and its supply increases globally, whereas the demand currently excels the supply. The EU organic food market forms 41% of the world market being the second largest after the United States (44%). The EU's organic market currently grows by about 13% annually and increased from 10 to 22 billion EUR between 2001-2013. The BSR organic producers form approximately 26% of the producers in the EU28 (Eurostat, 2014). Actual sales levels for the organic food have also remained rather low, staying lower than 7% of total food sales in all member states in 2013 (ECSIP Consortium, 2016).

FOOD PRODUCTION AND PROCESSING

- The food and drink industry is the largest manufacturing sector in the EU with the share of 14,6%.
- In 2009 the Baltic Sea Region contributed almost 29% of the EU27 total turnover from the manufacturing of food products.
- The meat sector is the largest sector in the EU food industry. In 2012 it was accounting for 20.5% of the total turnover of the EU's food and drink industry, and the dairy sector accounts for 13.6% of the total turnover.
- Germany and Poland are the largest meat manufacturers in the Baltic Sea Region, belonging also in tope five of the EU28.

TECHNOLOGICAL INNOVATION AND KNOWLEDGE

- Innovation in packaging: plays important role in enabling convinience food.
- Innovation in distribution, e.g. e-commerce.
- Innovation in food processing: new types of consumption, new additives, new flavors).
- Social responsibility and awareness i.e taking responsibility for the wider repercussions on climate change, public health, social and economic inequality, biodiversity, animal welfare and the use of scarce resources of certain consumption choices

ECONOMIC AND FINANCIAL DRIVERS

- Economic growth and rise of income levels increase the population´s ability to spend money, as such consumer demand for goods and services also grows. This has a direct impact on food consumption and its patterns, resulting in higher demand for produce.

DEMOGRAPHIC DRIVERS

- Population variability: population growth and ageing population represent critical driving forces for changes in consumers' food and drink preferences.

REGULATIONS AND INITIATIVES

- Environmental regulations (Waste Framework Directive, Renewable Energy Directive)
- EU Novel Food Regulation
- Regulation (EC) No 178/2002 (requires food business operators to be able to identify from whom and to whom a product has been supplied)
- Trade agreements
- Excise duties

SOCIO-POLITICAL DRIVERS

- Globalization has increased competition at the industry level which has resulted in mergers, acquisitions and strategic cooperations.
- Urbanization: impacts of urbanisation on the food and drink industry include a growing role for supermarkets (and transnational corporations) in food sales and a shift in employment within the food system with fewer people working in agriculture and more working in food processing, transport, wholesaling, retailing, and vending.

Figure 8. *Food production and its main drivers: Food production and processing is impacted by socia-political drivers, demographic drivers, regulations and initiatives and technological innovation and knowledge.*

4.3.2 COSMETICS MANUFACTURING

The European cosmetics market grew from a total value of 63.5 billion EUR in 2006 to 77.2 billion EUR in 2016 (Statista, 2018). On a global scale, the European cosmetics market's is the highest, compared to a total value of 38.2 billion EUR in the U.S., the total value of 23.7 billion EUR in Japan, and the total value of 8.2 EUR billion in China (2006 data). The increasing awareness of consumers about health issues, ingredients and sustainability has stimulated EU countries´ demand for cosmetics containing natural ingredients. Consequently, the market of natural and organic cosmetics is fast growing and currently increases from 2-4 % in 2006 by 20% each year (Global Insight, 2007). Currently, role of cosmetics industry within agricultural production remains low. However, with the growing demand of natural and organic cosmetics, the role of the cosmetics industry may become an important player in the agricultural value chain of the future.

4.4 DISTRIBUTION OF FARMING PRODUCTS THROUGH RETAIL AND WHOLESALE

During the last decade, modern retail has developed substantially across the EU. Large modern retail chains (especially discounters) have been opening stores both in their domestic markets and in other Member States. Modern retail is predominant in most of the Member States, which has decreased the number of traditional retail units (fruit and vegetable market, non-branded neighbourhood stores, butchers and bakers). Modern retail is mainly concentrated in the Nordic and Baltic countries (Figure 9).

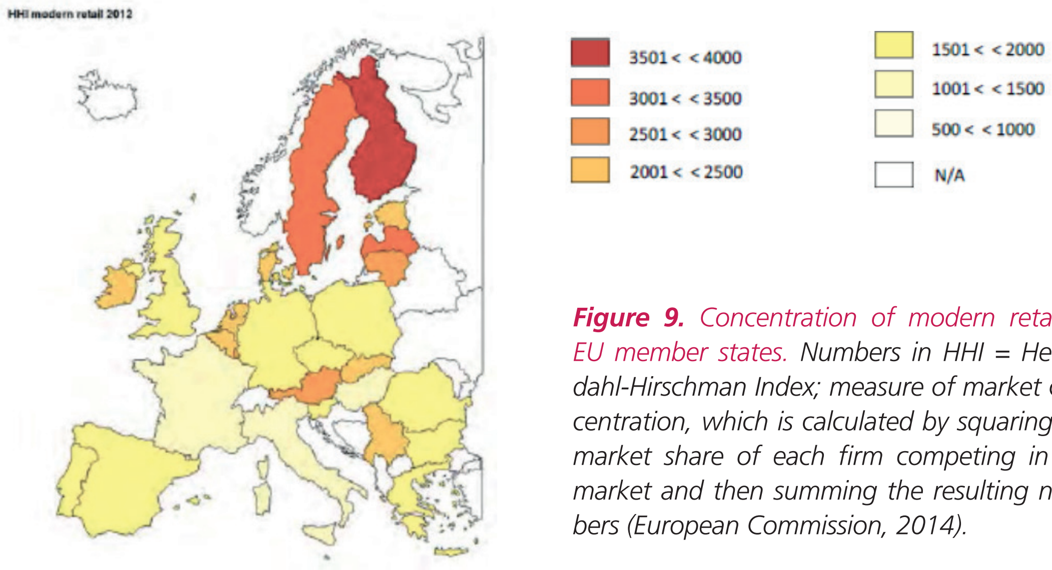


Figure 9. *Concentration of modern retail in EU member states. Numbers in HHI = Herfindahl-Hirschman Index; measure of market concentration, which is calculated by squaring the market share of each firm competing in the market and then summing the resulting numbers (European Commission, 2014).*

The increase of modern retail has impact on choice, and innovation in the food sector. The top 10 European food retailers accounted for 26% of edible grocery sales in the EU in 2000, compared to 31% in 2011. Another important factor that has shaped the sector is retailers' own brands or private label products that have become more and more successful in Europe over the last decade. Private label market share has increased across most product categories in most of the Member States. (European Commission, 2014).

Modern retail has also influenced increasing concentration at the procurement level. This allows retailers to improve their purchasing conditions and enhance market competitiveness. Procurement organisations have existed since 1930s but have developed particularly since 1980s and 1990s. Established cross-border groups have strengthened the retailers' bargaining power through higher volumes with the aim of reducing purchasing costs. This is especially important for large international brands and for private labels. (European Commission, 2014).

4.5 CONSUMPTION OF FARMING PRODUCTS

In the EU member states, household costs on food and drink products vary between 8% and 22% (not including alcoholic beverages; Table 8) of the total income, which is after housing, water and energy the second largest expense. In the Baltic Sea region, there is a large difference in costs for food products between countries, being significantly higher in Baltic countries and in Poland than in the Nordic Region and in Germany (FoodDrinkEurope, 2018).

COUNTRY	EXPENDITURE [%]
EU-28	12.2
Denmark	11.4
Germany	10.06
Estonia	20.3
Latvia	18.2
Lithuania	22.2
Poland	17.1
Finland	12.0
Sweden	12.3

Table 8. *Household expenses on food and non-alcoholic beverages in the Baltic Sea Region countries (Eurostat, 2017e).*

Consumers have become more demanding in terms of food, especially concerning product variety and prices (European Commission, 2018c). The economic and financial crisis in 2008 had a significant impact on EU consumers' purchasing power which also affected their behaviour. Lower prices became a priority for many consumers in the EU. In addition, changes in household composition, an ageing population, increased interest in healthy food and increased environmental awareness have all had an impact on the food retail market in Europe (European Commission, 2018c).

Currently, the EU exports more food products than it imports (trade surplus). In 2012, the recorded trade surplus had a value of 23 billion EUR (FoodDrinkEurope, 2018). Socio-demographic developments such as population growth and ageing population represent critical driving forces for changes in consumers' food and drink preferences (ECSIP Consortium, 2016). "Expected impacts of urbanisation on the food and drink industry include a growing role for supermarkets (and transnational corporations) in food sales and a shift in employment within the food system with fewer people working in agriculture and more working in food processing, transport, wholesaling, retailing, and vending" (ECSIP Consortium, 2016).

Besides global drivers there are several other aspects that are shaping consumer preferences regarding food and drink items. Although the price remains the most important factor determining food choices, the consumers with higher income level often consider other factors such as food safety, quality, long shelf life, non-GMO and expected health benefits (ECSIP Consortium, 2016). In the EU, the food choices of consumers were reported to also have a local dimension: in terms of tracebility in milk and some types of meat, consumers find the information about the country of origin the most important (Eurobarometer, 2014). About 53% of Europeans would even pay a 1 - 2% higher price to receive information about the place of origin on food labels (Eurobarometer, 2014).

These developments show an increasing awareness of the need to consume socially responsible, for example in taking responsibility for the wider repercussions on climate change, public health, social and economic inequality, biodiversity, animal welfare and the use of scarce resources. A survey in 2009 showed that 80% of EU citizens felt that a product´s impact on the environment is an important element when deciding on which products to buy (Eurobarometer, 2014). For some consumers, food should have the smallest possible ecological impact and should therefore not be transported over long distances. Animal welfare is also an increasingly important factor considered by consumers when deciding which food to buy (ECSIP Consortium, 2016). Additionally, the awareness of consumers about the impact of food on their health is increasing as more information about the topic becomes available. Food allargies and intolerances are also important drivers for the increase in attention on food consumption (ECSIP Consortium, 2016).

Another aspect that has gained more importance in consumer choices in the past decade, is the convenience. Due to uncreasing mobilities and lifestyle changes, the demands for convenient products such as meals on-the-go are increasing, also for healthy convencience foods. Especially people who are living in urban areas spend less and less time on preparing meals and consuming food at home and are often supporters of ready-to-go meals (ECSIP Consortium, 2016). There are indications, that there is a clear connection between traditions and the present composition of food consumption: in countries with domestic productions of for example meat, also the consumption of meat is usually high (Nordic Council of Ministers, 2004).

INDIVIDUAL CONSUMPTION

- The European Union market value of organic food exceeded € 2 billion in 2013.
- BSR consumer eats approximately twice as much meat as the global avarage.
- Modern consumption habits and agriculture pollution considered as important threat to the state of the natural ecosystems.
- Opinion that individual choices can influence the state of the natural environment.

ECONOMIC AND FINANCIAL DRIVERS

- Price of organic or environmentally-friendly products as a limiting factor
- Differences in the households' expenses on food and drink in the Baltic Sea region countries

SOCIAL DRIVERS

- Growing role of supermarkets and limited offer of organic food
- Increase demand for the meals-on-the-go products
- Fashionable lifestyles, e.g., vegetarian food

INFORMATION

- Ecolabelling and information on the products of the origin and production process

KNOWLEDGE

- Perceived food safety, food quality and expected health benefiits
- Ethical positions on animal rights and protection of the natural resources

Figure 10. Individual consumption and its main direct drivers. *Individual consumption is impacted by economic and financial drivers, social drivers, knowledge and information.*

Meat consumption

As a global average, the per capita meat consumption has increased from about 20 kg in 1996 to 43 kg in 2014, stating that the global meat production has inceased faster than the world population has grown (Ritchie and Roser, 2017). Hereby, the change across countries is highly variable and is highest across high income countries (Ritchie and Roser, 2017). In most of the Baltic Sea region countries, the present meat consumption per person is almost twice as the global average (Table 9).

Country	MEAT CONSUMPTION [KG/PERSON/YEAR]		
	1961	1992	2013
Denmark	61	102	82
Germany	64	87	86
Estonia	-	61	58
Latvia	-	66	61
Lithuania	-	65	78
Poland	47	76	76
Finland	35	61	77
Sweden	51	61	82

Table 9. Meat (exluding seafood and fish) consumption in the Baltic Sea region. *Meat consumption in [kg /person/year]; these figures do not correct for waste at thehousehold/consumption level (Ritchie and Roser, 2017).*

Food waste

About 88 million tonnes of food in total or 173 kg food per person is wasted annually in the EU (Stenmark et al., 2016).

Food is lost and wasted along the whole supply chain: during farming, processing and manufacturing, in supermarkets and restaurants. However, the biggest food wasters accounting to 72% of food waste in the EU are (1) private households with about 47 million tonnes and (2) processing with about 17 million tonnes (Stenmark et al., 2016). The remaining 28% of food waste is due to losses in food service (11 million tonnes, 12%), in production (9 million tonnes, 10%), and in wholesale and retail (5 million tonnes, 5%; Stenmark et al., 2016). In the Baltic Sea region, four out of eight countries produce more food waste than the EU average (Table 10).

COUNTRY	FOOD WASTE [KG/PERSON]
Denmark	146
Germany	149
Estonia	265
Latvia	110
Lithuania	119
Poland	247
Finland	189
Sweden	212

Table 10. Estimates of total food waste in countries of the Baltic Sea region in 2010 (Stenmarck et al., 2016).

4.6 SUMMARY: THE VALUE CHAIN OF AGRO-FOOD SECTOR IN THE BALTIC SEA REGION

The main activities mapped in the analysis of the Baltic Sea region agricultural value chain were (1) agricultural production (distinguishing livestock and crop production), (2) manufacturing of fertilizers, (3) fertilizer transport, (4) manufacturing of food products, (5) retail and wholesale, and (6) consumption (Figure 11, 12). Crop and livestock production are the activities that are adding direct pressure to the Baltic Sea due to diffused nutrient input. Fertilizer production, storage and transport of fertilizers and human consumption are impacting farming and/or are adding pressure onto the Baltic Sea with point sources.

When reviewing all actors and activities in the agricultural value chain, the story of eutrophication of the Baltic Sea becomes even more complex (Figure 11, 12). Each of the actors and activities have different levels of impact on other activities and/or are influenced by themelves by other actors. The geographic scope of the agricultural value chain is not limited to the Baltic Sea Region but stretches far out and over regional borders (see also Chapter 5).

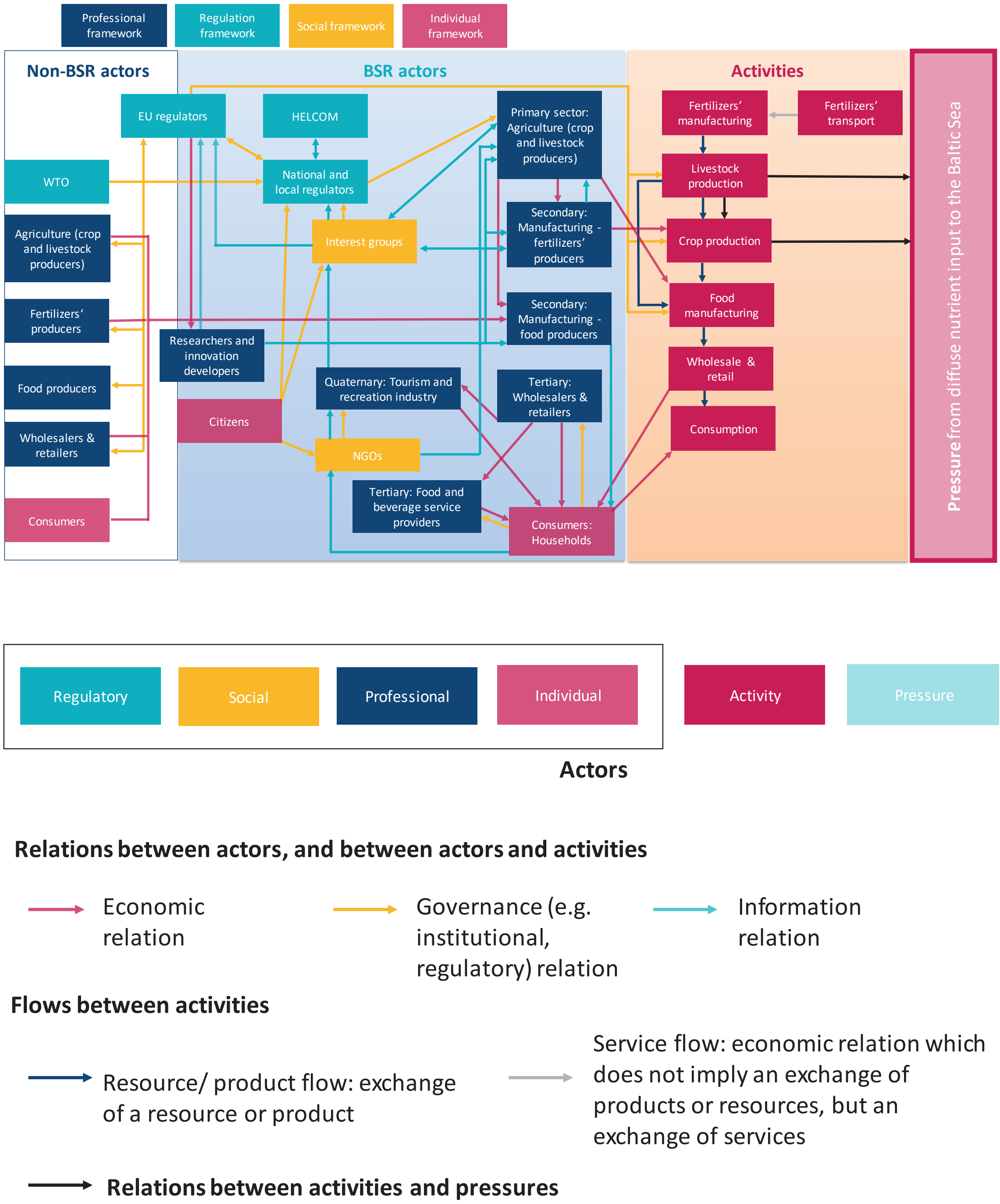


Figure 11. Actors and activities in the BSR agricultural value chain and their interlinkages.

Animal production plays a major role in the agricultural production of the Baltic Sea region, including meeting the high demand for crop production used for animal feed. In the Baltic Sea region, about 70% of crop are fed to animals, while only 30% of crop products are consumed directly by human beings (Baltic Eye, 2016). Countries of the Baltic Sea Region import livestock feed and produce manure in excess compared to the amounts needed for fertilizing crops. Due to the high amounts of manure, it becomes a problematic waste product instead of a recource (Baltic Eye, 2016). In many cases, large amounts of fertilizers for crop production are imported despite high amounts of available manure due to very high meat production, such as e.g in Denmark. Estimates showed that 17% of all nitrogen and 12% of phosphorus from land is derived from manure, the rest is supplied with commercial fertilizers (Baltic Eye, 2016).

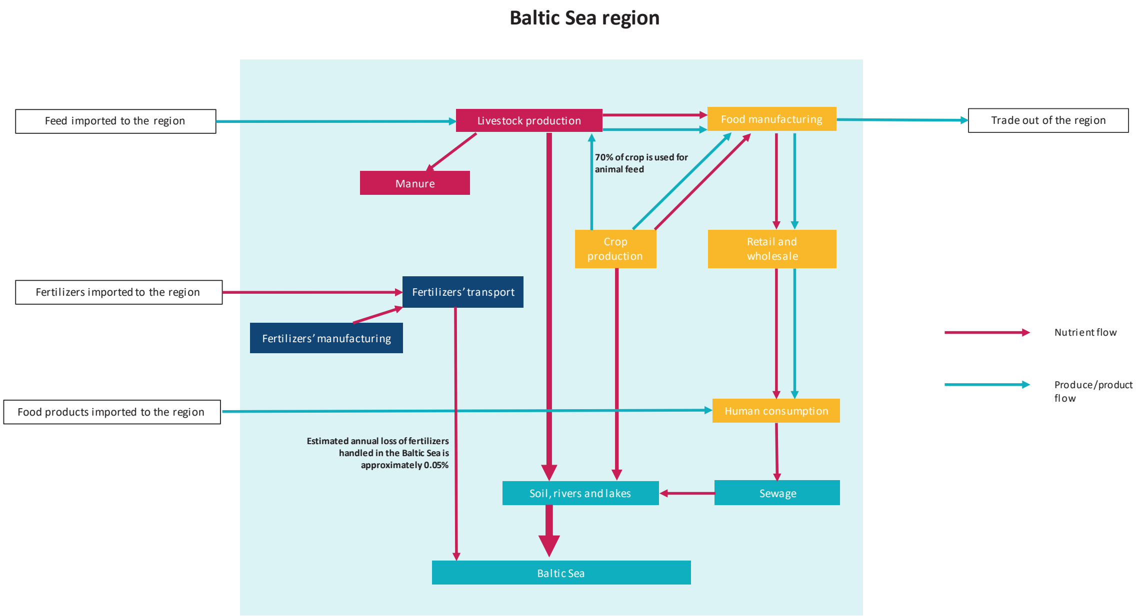


Figure 12. Nutrient and produce flow withing the BSR agricultural system (excluding point sources).

Baltic Sea region EU member states contribute with about one third to the EU total agricultural production. For some product groups such as cow milk and grain, almost all countries of the Baltic Sea Region show higher productions than the EU average (Table 11), indicating the importance of export.

Table 11. Agricultural production of beef/veal, pork, cow milk and grain in countries of the Baltic Sea Region and EU average. *Beef/veal, pork, cow milk and grain in [kg/person] (Eurostat, 2015).*

BEEF AND WEAL [KG/PERSON]		PRODUCTION OF PORK [KG/PERSON]		COLLECTION OF COW MILK [KG/PERSON]		PRODUCTION OF GRAIN [KG/PERSON]	
EU AVERAGE = 15 KG		**EU AVERAGE = 45 KG**		**EU AVERAGE = 297 KG**		**EU AVERAGE = 621 KG**	
DK	21	DK	280	DK	925	LT	2100
FI	16	DE	68	EE	547	DK	1756
LT	15	PL	50	LT	498	LV	1535
SE	14.62	FI	35	FI	436	EE	1166.69
DE	13.68	EE	32	LV	410	PL	737.55
PL	12.41	SE	24	DE	388	FI	671.15
LV	8.82	LT	23	SE	298	SE	626.21
EE	7.31	LV	15	PL	286	DE	599.38

In the present report, we focus on the consumption of organic products as an indicator about consumers readiness and ability to change behaviour. Denmark and Sweden show the highest shares of retail sale of organic food, Germany about double of the EU average and the Baltic States and Poland show sales substantially lower than the EU average and other countries in their region (EUR per person; FiBL, 2018). Viewing organic food production from the perspective of the proportion of organic crop area from the total UAA (%), Sweden, Latvia, Estonia and Lithuania are currently showing the highest proportions compared to other countries in the EU (Eurostat, 2015)

At the same time, the Baltic States and Poland show also the highest proportions of expenses of food and non-alcoholic drink products (Table 8). The EU average expenses of 12.2% for food and beverages are exceled by expenses that are about twice as high in Lithuania (22.2%), Estonia (20,3%), Latvia (18,2%), and Poland (17.1%). Therefore, it can be argued that organic food consumption does not depend on production levels of organic agricultural production but is closely connected to income levels.

It is also important to keep in mind that the Baltic Sea region is part of the EU market and contributes to its agro-food sector. The food and drink industry is the largest manufacturing sector in the EU. This makes it an important economic sector and employer in most of the EU countries. More than one quarter of European food and drink exports are sold to non-EU countries. During 2014-2015, the EU achieved a record trade surplus of 27.6 billion EUR. Currently, the top two best performing exports are meat and dairy products (FoodDrinkEurope, 2018). This may have a great influence in changing the farming structure in the region through consumer awareness, e.g. when regional consumers will eat less meat but consumers in target markets are still demanding meat products the decrease in local consumption may be replaced with increased export numbers.

However, for decreasing the nutrient input to the Baltic Sea, a more systematic approach across the value chain is required.

5. KEY ACTORS OF VALUE CHAIN ACTIVITIES

Chapter 5 presents the results of ResponSEAbles' approach to identify key actors and stakeholders involved in agricultural activities leading to eutrophication. Furthermore, it shows how these actors may drive changes along the value chain towards more sustainable practises (compare with Chapter 3, 4; Annex 2). An additional aim of the analysis was to build solid ground for new strategies on which advanced ocean literacy tools can be developed on – ocean literacy focusing in particularily on eutrophication of the Baltic Sea.

5.1 IDENTIFICATION AND CLASSIFICATION OF ACTORS

According to the ResponSEAble methodology, "actors" were defined as all people and people groups involved in implementing activities or being part of its socio-economic and regulatory context.

Actors have been classified in four categories:

- **Professional framework:** involved in performing the agriculture-relatived activities;
- **Regulative framework:** e g. the European Commission as the actor preparing specific Directives;
- **Social framework:** e.g. environmental NGO lobbying for specific regulations;
- **Individual actors:** e.g., consumers and citizens.

Depending on their role regarding the individual challenge/key story, actors can have different relations: (1) economic or "commercial" relations that can lead to increased wealth, (2) governance relations in the context of the preparation, adoption and implementation of the regulatory framework, or influencing an actor's ability to act, its rights and its obligations, (3) knowledge relations including those that lead to sharing information with a specific actor. The actors were classified within the DAPSIWR framework in the categories **Economic activity** (A) and **Responses** (R) (Figure 13).

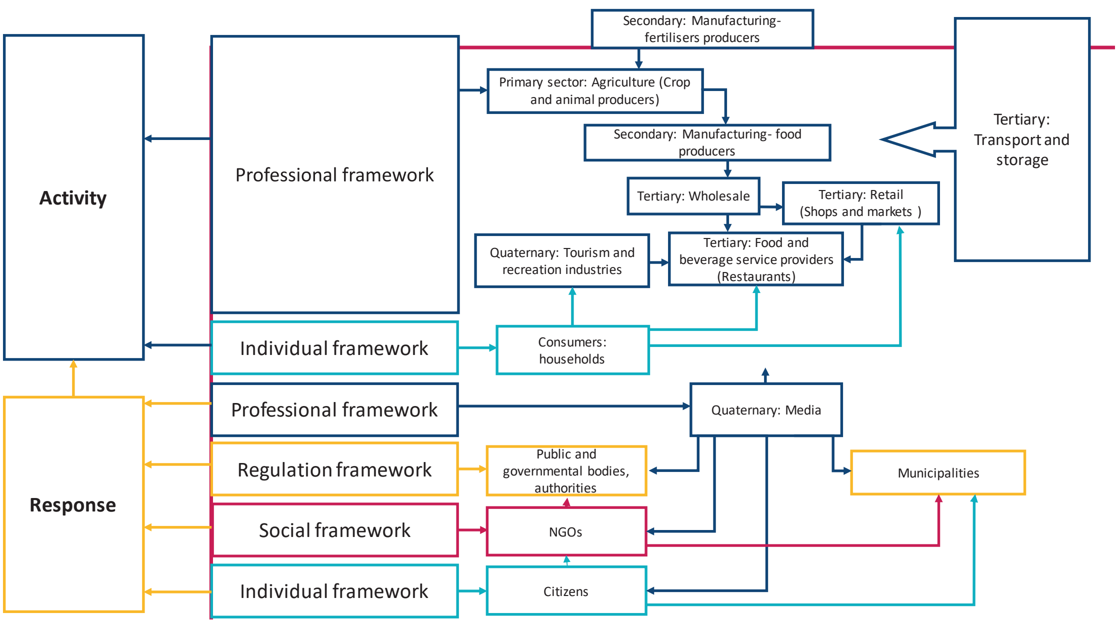


Figure 13. Identification of key actors in the agricultural value chain, according to the ResponSEAble classification.

For purpose of the analysis of existing communication structures and information mechanisms (Chapter 6), the media analysis was carried out including identification of the target audience (receivers of information) and type of publisher (senders of information). Herefore, the classification system of actors was specified in more detail (see Annex 1).

5.2 ANALYSIS OF ACTORS

For the key story of eutrophication and agriculture, the actors have been grouped into two major groups of actors, i.e., direct and indirect actors.

Direct actors were defined as individuals, groups and organizations, whose actions might potentially have the highest influence on the eutrophication sources, and their personal and economic welfare can be strongly affected by changes in the marine environment.

In contrast, **indirect actors** are interacting with direct actors but their links with eutrophication and with the state of marine environment are generally less evident, their welfare is not directly dependent on agriculture resources, but their actions could potentially still contribute to solving the problem. One group of indirect actors could potentially be public and governmental bodies, like European and national legislators, as they define policies and requirements to be followed by certain groups of actors. However, ResponSEAble decided to assign them to direct actors as food market in the European Union are highly regulated and Common Agricultural Policy (CAP) is an important driver (Spijkers et al., 2012; WWF, 2007) and thus they are having strong impact on the pollution sources.

For identifying the power of influence direct and indirect actors have in reducing eutrophication, all identified actors were assessed according to the the following criteria:

- **Influence on activities linked to pressure:** How important is the key actor with respect to activities linked to pressure? For the rating of this criterion, the following was taken into consideration: a) direct influence of the actor to activities leading to pressure b) how important these activities are with respect to pressure and c) the estimated impact of the pressure.

- **Impact on other key actors:** Their ability to potentially influence the behaviour of other key actors. The rating depended on the number of actors they can influence and their estimated influence on pressure.

- **Independence:** How independent is this actor in his decisions making process, i.e. to what extent can he change his behaviour that would have an impact to the eutrophication without being influenced by others?

- **Feasible behaviour change:** How likely or feasible is behaviour change of this actor that will have an impact on pressures in the future? Many key actors are strongly influenced by others or are directly dependent from them (see also criterion Independence). However, for the rating of this criterion only the „resistance" of this key actor to behaviour change is considered.

Thereafter, for each actor and each criterion, scores from 1 to 3 were assigned raccording to: 1 = small influence, 2 = medium influence and 3 = strong influence (Table 12). The sum of the scores are presented by the "Behaviour Change Index (BCI)" that is - in turn - indicating the order of priority of key actors that could potentially be targeted for behaviour change.

The scores of the Behaviour Change Index (Table 12) showed that livestock and crop producers as well as individual actors are scoring the highest, indicating that they have the highest potential to influence eutrophication of the Baltic Sea by behaviour change. However, the BCI also showed that policy developers and decision makers, fertilizer manufacturers, wholesale and retailers and other actors have substantial power to change their behaviour for a healthy Baltic Sea, as discussed in the following.

Table 12. *The Behaviour Change Index (BCI) as metric for the identification of key actors that potentially could be targeted for behaviour change. ResponSEAble classification of actors, key actors, direct or indirect influence onf eutrophication, influence on activities linked to pressure, impact on other key actors, independence, feasible behaviour change, sum of scores (Scoring: 1 = small, 2 = medium, 3 = strong).*

RESPONSEABLE CLASSIFICATION OF ACTORS	KEY ACTORS	DIRECT OR INDIRECT INFLUENCE ON EUTROPHICATION	INFLUENCE ON ACTIVITIES LINKED TO PRESSURE	IMPACT ON OTHER KEY ACTORS	INDEPENDENCE	FEASIBLE BEHAVIOUR CHANGE	SUM OF SCORES (MAX 12)
Professional framework: Primary sector	Livestock farmers (animal producers)	Direct	3	3	1	3	10
Professional framework: Primary sector	Crop farmers (producers)	Direct	3	3	1	3	10
Professional framework: Primary sector	Fishermen	Direct	1	1	1	1	4
Professional framework: Secondary sector	Food industry (manufacturers)	Indirect	1	3	1	2	7
Professional framework: Secondary sector	Fertilisers production	Indirect	2	2	2	2	8
Professional framework: Secondary sector	Organic fertilizers' producers	Indirect	2	2	2	2	8
Professional framework: Secondary sector	Cosmetic industry	Indirect	1	1	1	1	4
Professional framework: Tertiary sector	Transportation sector	Indirect	1	1	1	1	4
Professional framework: Tertiary sector	Wholesale food and beverage chains	Indirect	1	3	2	2	8
Professional framework: Tertiary sector	Wholesalers and distributors of organic & mineral fertilizers	Indirect	2	1	1	1	5
Professional framework: Tertiary sector	Shops and markets (retail)	Indirect	1	2	2	3	8

Table 12.

Professional framework: Tertiary sector	Restaurants (Food and beverage service providers)	Indirect	1	2	2	3	8
Professional framework: Quaternary sector	Tourism and recreation industries	Indirect	1	2	2	2	7
Professional framework: Quaternary sector (Knowledge Sector)	Scientific community (scientific knowledge providers)	Indirect	1	2	2	2	7
Professional framework: Tertiary sector	Media (Print publishing service providers; Electronic media publishing service providers; Online media publishing service providers)	Indirect	1	2	3	2	8
Professional framework: Tertiary sector	Media (Broadcasting service providers)	Indirect	1	2	3	2	8
Professional framework: Tertiary sector	Media (Motion picture video and television producers)	Indirect	1	2	3	2	8
Individual actors: consumers	Private households (regional)	Direct	1	3	3	2	9
Individual actors: consumers	Private households (EU)	Direct	1	2	3	2	8
Individual actors: consumers	Private households (third countries)	Direct	1	2	3	1	7
Regulative framework: regulators and administrators	Decision-makers of various levels (agri)	Direct	2	3	2	2	9
Regulative framework: administrators	Municipalities	Direct	1	2	2	2	7
Social framework: Institutionalized sector	NGOs	Direct	1	2	2	1	6
Social framework: Institutionalized sector	Labelling and certification companies	Indirect	1	2	3	1	7
Social framework: Interest groups	Local communities	Direct	1	2	2	2	7

5.2.1 PROFESSIONAL FRAMEWORK: FARMERS

Farmers as primary professional actors have a direct link and contribution to the pollution loads of nutrients. As proved in previous studies, nutrient input into water bodies depend greatly on agricultural practices, farmers choose (WWF, 2011). The reduction of fertilizer applications to arable crops, catch crops in spring-sown cereals, reductions in livestock numbers and restoring wetlands on agricultural land, are some of the measures which can be implemented by farmers for reducing nutrient emisions (Wulff et al., 2014).

Results from various modelled scenarios confirmed that the alteration of chemical fertilizer application can impact nitrogen loads in streams by 2-6% in Central Germany (Jomaa et al., 2016). Another study showed that the alteration of chemical and manure application can change nutrients by 0-13% for chemical and by 6-7% for manure applications, depending on the intensity of agriculture and area covered by agriculture land use (Thodsen et al., 2017). Therefore, the farmers are an important target audience for awareness rising campaigns on environmentally responsible agriculture, agri-advisory services, and on use of agri-environmental technologies. Projects currently targeting farmers are for example Baltic Compass, BERAS Implementation, Baltic Manure or Baltic Deal projects. Voluntary solutions promoted and implemented by these projects are not only challenging, but they can also negatively influence profitability of the individual farmers. Meeting BSAP reductions plans might not be the priority for farmers, but they do consider sustainable agriculture as important for the profitability of their sector (Spijkers et al., 2012). At least in the long run, sustainability measures taken during agricultural practises must include the effects and sources of eutrophication.

However, a change in the use of fertilisers does not result in an immediate reduction of concentrations of nutrients in rivers. A study of Latvian rivers over a period of dramatic agricultural change in 1987-1998 concluded that long water-transit times in the soil water and groundwater have most likely caused substantial time lag between changes in the input and the output of nutrients in the studied catchments (Stålnacke et al., 2003). Additionally, many measures taken to reduce diffuse losses to inland surface waters, will often take several years before the nutrient input to both coastal and open waters of the Baltic Sea decrease. Moreover, in some catchments, retention in soils, groundwater and inland surface waters are so high that it can require a factor of 5-10 times higher reductions to obtain a given absolute reduction to the Baltic Sea (HELCOM, 2013b).

5.2.2 INDIVIDUAL ACTORS: CONSUMERS

Consumer and societal choices have a great potential to influence both markets and policies, especially as about half of the citizens in the Baltic Sea region are willing to pay for the reduced eutrophication (Ahtiainen et al., 2014). Therefore, consumers (private households) are the second most important group to target within the agriculture value chain after the farmers. Increased consumption of vegetarian food is in fact one of the most cost-efficient way to reduce nutrient input from agriculture sources (Cordell et al., 2009) as 70% of crop production is used for fodder (Svanbäck and McCrackin, 2016). The average vegetarian diet requires the usage of about 4.2 kg phosphate rocks per year while a meat-based diet requires the usage of 11.9 kg phosphate (Cordell et al., 2009). The most optimistic estimates showed that a change from typical western diet to vegetarian diet could limit the demand for phosphate fertilizers by more than 45% world-wide, and in additionally would help to save other resources such as water, energy and land used for agricultural needs (Cordell et al., 2009).

The choice between vegetarian and meat-based diet is not usually based solely on a nutritional value. Individual tastes and food prices are very important factors influencing food choices, but fashion, advertisement, lifestyles, ethical positions and environmental concerns can also play important roles in the European food market. These additional factors open new possibilities for communication and education campaigns to promote life choices that can limit the use of fertilizers and promote a healthy Baltic Sea (Cordell et al., 2009). Consumer choices will ultimately increase environmental awareness of other economic actors in the chain, such as wholesalers, shops and restaurants, and pursue the value change within the value chain back to farmers and their farming practices. However, consumers' and citizens' efforts need to be backed up by legislation and other governmental incentives. Given the character and scale of the food market, the consumers' preferences do not directly affect farming practices. Quotas and various quality requirements set by retailers or food processing companies as well as governmental subsidies are often more important factors that influence farmers' decision-making than the expectations of consumers (Archambault, 2004).

However, it is not an easy task to shape people's diet in a way that it could better embrace protection of the natural environment. For example, the 'Foodweb project' (http://foodweb.ut.ee/) investigated consumers'awareness on relationships between food quality, human health and the state of the environment in the three Baltic Sea countries Finland, Estonia and Latvia. The results of this project demonstrated that the links between eating habits and their influence on the state of the Baltic Sea are not well recognized (Esko et al. 2012). The majority of 'Foodweb project' participants were more concerned about health issues than about environmental risks. There was no significant difference in the attitudes between citizens of these three countries, although ethical issues, including animal rights and influence on the environment, were more important for younger consumers. Food-related environmental risks were quite difficult to conceptualize, and even their effects were often not properly recognized. For example, about 29% of consumers in these three countries combined were not able to assess if euthophication has a positive or negative influence on the the state of the Baltic Sea. Such an uncerntainty was even higher for ocean acidification, the existence of alien species or general loss of biodiversity. Over 60% of the 'Foodweb project' respondents were not aware about the relationship between wetlands and the Baltic Sea. Organic farming was considered to cause less harm than regular farming, and to have neutral or even positive impact on the marine ecosystems (Esko et al. 2012). Although organic food was a common pro-health and pro-environmental choice in all three investigated countries, the consumers underlined that there are still many obstacles for its wider use. Financial contraints were most often mentioned. Finns were willing to pay more for products of better quality, Latvians and Estonians pointed out that the price of organic food should be lower to make it accessible. Other contraints included time needed to prepare healthy meals, limited choice of organic food in local shops and supermarkets, and information drawbacks. The latter problem was related to limited information on the food production processes, no clear distinction between environmentally friendly and unfriendly products and need for more consistent labelling (Esko et al. 2012).

We were not able to find similar studies for other Baltic Sea region countries, but a study by Lorek (2015) provides some insights into Poles' attitudes towards eco-friendly products. The main limitation of this study is its area as it only involved customers of one Polish province located in the South (Silesian Province). This study showed that ecological factors were not important decisive factors for people in the Silesian Province. In 1999/2000, 20% of consumers indicated that ecological criterion is an important part of shopping decisions, in 2012/2014 this number dropped to 12%. At the same time, the author observed the increased consideration for eco-lables and the increased number of eco-farms in the region (Lorek, 2015). As in Estonia and Latvia, the price of organic food (Esko et al., 2012) - was the most important constraint in Poland, but the reluctance to change current lifestyles was also important (Lorek, 2015). Similarly, health benefits were more important for the Polish consumers when purchasing eco-food than any environmental gains (Lorek, 2015).

5.2.3 REGULATIVE FRAMEWORK: POLICY DEVELOPERS AND DECISION MAKERS

Farmers do not exist in a vacuum and their farming decisions are often shaped by the policy developers and decision makers at different regulatory and administrative levels. Agricultural policy at EU level (Common Agricultural Policy = CAP) has been changing over the years. However, the overall goal of CAP is to provide a stable, sustainably produced supply of safe food at affordable prices for Europeans, while also ensuring a decent standard of living for farmers and agricultural workers.

The current CAP 2014-2020 has multiple goals (European Union, 2017): At first, it aims to support farmers to produce affordable, safe and good quality products. By introducing so-called "greening measures", the CAP finally supports farmers for adopting certain farming methods (e.g. share of grasslands in arable land; maintaining an ecological focus area). However, the European Court of Auditors in 2017 concluded that greening is unlikely to provide significant benefits for the environment and climate, estimating that greening led to changes in farming practices on only around 5 % of all EU farmland, although 30% of the EU budget for direct payments to farmers have been allocated for this goal (European Court of Auditors, 2017).

The current CAP also continues to financially support agri-environmental measures implemented voluntarily by farmers. Agri-envionmental schemes form a part of Member State's Rural Development Programme. The schemes include various measures that support achieving environmental objectives, including water protection and nutrient reduction measures (Science for Environment Policy, 2017).

5.2.4 PROFESSIONAL FRAMEWORK: FERTILIZER MANUFACTURERS

Fertilizer producers are possibly the fourth target group for rising awareness activities. There are three kinds of fertilizers in the EU: (1) inorganic fertilizers, (2) manure and (3) compost (Wijnands and Linders, 2013). In the EU average, expenditures on fertilizing materials equals 6.2% of farms' total expenses and they are even higher (7.2%) in the Baltic Sea Region (Wijnands and Linders, 2013). The average use of fertilizers per hectar around the Baltic Sea is 63.0 kilos for nitrogen and 13.2 for phosphorus, whereas the highest expenses are in Germany and the lowest in Estonia (Wijnands and Linders, 2013). In absolute values, Poland has the highest use of fertilizers among Baltic Sea countries - however, Poland is also the country with the lowest use per capita (WWF, 2007).

Inorganic fertilizers are based on gaseous nitrogen or phosphorous rocks, have various nutrient contents, and are produced in about 1,000 companies in Europe. They are sold to farmers or wholesalers, which in addition sell other goods needed for agriculture such as chemicals, feed or farm equipment. Poland, Lithuania and Germany are the most important producers of inorganic fertilizers in the Baltic Sea region, with Germany being the European leader (Wijnands and Linders, 2013). Manure is a by-product of animal husbandry, and it is in majority used on the same farm where it was produced. Very little information is available for the EU on manure production. Manure is transported for short distances only, and its use constitutes an important source of nitrogen (Wijnands and Linders, 2013). Compost is the product of biological decomposition of degradable materials. There is no official data on compost producers in the EU, but about 700 companies are assigned to formal quality assurance system. Compost is usually transported over short distances and its composition can hardly be controlled (Wijnands and Linders, 2013).

5.2.5 PROFESSIONAL FRAMEWORK: WHOLESALE AND RETAILERS

In addion to farmers and consumers, also the food industry and retail/wholesale companies play an important role in the value chain. The food and drink industry has remained the largest manufacturing sector with a contribution of 14,6% to the entire turnover (FoodDrinkEurope, 2018). The food industry has a direct link to agricultural producers and can therefore take concrete actions to reduce the nutrient leakage. Wholesale/retail on the other hand does not have a direct link to agricultural producers, but they are the ones having direct contact with the end consumers and therefore the ability to influence consumer expectations throughout the value chain and vica verca.

5.2.6 VARIOUS OTHER ACTORS

Apart from stakeholders directly affected or linked to eutrophication, there are many entities and organizations that can influence behaviour of various (economic) actors either by introducing legal solutions to mitigate eutrophication (i.e., decision-makers of various levels) or by raising awareness campaigns and pursuing voluntary measures and behavioural change (i.e., NGOs, formal or informal educators or media).

Scientists are another stakeholder group that is not directly linked to the eutrophication value chain but is an important player. Scientists provide knowledge and advice on causes and effects of eutrophication and often (technological) solutions to move towards cleaner Baltic Sea waters (Archambault, 2004).

5.3 KEY STAKEHOLDERS FOR INVOLVEMENT IN THE RESPONSEABLE PROJECT ACTIVITIES

Numerous stakeholders and actors are connected or involved in activities to reduce eutrophication in the Baltic Sea (Table 13). Economic actors are represented by the organisations, which by the legal status are also considered as non-profit, non-governmental organisations, and acting for lobbying for own sector interests, thus belonging to the social framework. However, their members are individual farmers - therefore Table 13 provides an overview over identified organisations also as representatives of appropriate professional actors.

__Table 13.__ List of potential stakeholders interlinked with eutrophication in the Baltic Sea. Type of actors, organisation names and geographical scopes (national, BSR and EU).

	ORGANISATION	NATIONAL	BSR	EU
Farmers; NGOs	Committee of Professional Agricultural Organisations (COPA)			x
	General Confederation of Agricultural Cooperatives in the European Union (COGECA)			x
	The Central Union of Agricultural Producers and Forest Owners (Swedish-speaking areas of Finland)	x		
	Federation of Swedish Farmers	x		
	The Danish Agriculture & Food Council	x		
	Estonian Chamber of Agriculture and Commerce	x		
	Estonian Farmers’ Federation	x		
	Central Union of Estonian Farmers	x		
	German Farmers’ Association	x		
	Latvian Agricultural Organization Cooperation Council	x		
	Latvian Farmer's Federation	x		
	Latvian Agricultural Statutory Societies	x		
	Zemnieku Saeima - ZSA (Farmers Parliament)	x	x	
	Chamber of Agriculture of the Republic of Lithuania	x		
	Lithuanian Farmer's Union	x		
	Lithuanian Association of Agricultural Companies	x		
	Lithuanian Association of Agricultural Cooperatives	x		
	Federacja Branżowych Związków Producentów Rolnych - FBZPR (Federation of Agricultural Producers Union)	x		
	Krajowy Związek Rolników, Kólek i Organizacji Rolniczych - KZRKIOR	x		
	NSZZ RI Solidarność (Niezalezny Samorządowy Związek Zawodowy Rolników Indywidualnych)	x		
	Krajowa Rada Izb Rolniczych - KRIR (National Council of Agricultural Chambers)	x		
	Związek Zawodowy Centrum Narodowe Młodych Rolników	x		
	Baltic Farmers’ Forum on Environment (BFFE)		x	
Fertilisers producers, NGO	The European Consortium of the Organic-Based Fertilizer Industry (ECOFI)			x
	Polish Chamber of Chemical Industry	x		
Regulators, decision makers	HELCOM		x	x
	VASAB		x	x
	Ministries and their subordinated institutions (responsible for marine issues, agriculture, environment)	x	x	x
Scientific community	BALTEX: The Baltic Sea Experiment		x	
	The Baltic University Programme (BUP)		x	
	BalticSTERN (Systems Tools and Ecological-economic evaluation - a Research Network)		x	
	The Baltic Earth		x	
	Relevant national universities and research institutions		x	

Environmental and citizen NGO	Coalition Clean Baltic		x	
	WWF	x	x	x
	OCEANA		x	x
	Marine Stewardship Council			x
	Foundation for a Living Baltic Sea	x	x	
	Baltic Environmental Forum Group	x	x	
	The Baltic Sea NGO Network		x	
	Alliance of Associations Polish Green Network (Polska Zielona Sieć)			
Retailers, NGO	European Community of Consumer Cooperatives (Euro Coop)			x

6. KNOWLEDGE SYSTEM OF KEY ACTORS: TRANSFER AND CONTENT

6.1 TRANSFER OF KNOWLEDGE ABOUT EUTROPHICATION OF THE BALTIC SEA

Which actors are sending out knowlege about the topic eutrophication and which target groups does their information intend to reach? To answer this question, we investigated an extensive set of public media entries about the topic in seven countries located in the Baltic Sea Region: Denmark, Estonia, Finland, Germany, Latvia, Poland and Sweden.

To assess the transfer of knowledge between senders and receivers on both qualitative and quantitative levels, we took a stepwise approach: At first, we focused on the identification of all groups that were actively communicating, and all groups that were targeted by these communication activities. Then, we applied internet-based searches using the platforms google advanced search, facebook and youtube to quantify the knowledge transfer between the senders and receivers. Thereafter, we identified the content of the knowledge transfer and classified it following the DAPSI(W)R framework.

6.1.1 WHO IS SENDING AND WHO IS RECEIVING KNOWLEDGE ABOUT EUTROPHICATION?

For our media analysis in all seven countries, we gathered in total 766 media sources of which 82% were retrieved from the google advanced search, 11% from youtube and 7% from facebook. As information receivers, we identified one to three target groups for each media entry and thereby counted in total 1326 receivers from all identified frameworks of actor groups. During analyzing the media, knowledge providers and receivers have been identified in detail (as proposed in Annex 1) and thereafter, subgroups have been merged in upper-level groups for displaying the big picuture (Tables 14, 15, Figure 14). Most publication years (for 89% of the entries) could be identified and showed that the clear majority (90%) of currently available information about the topic eutrophication has been published between 2008-2017, indicating that the topic received the most public attention in the last decade.

Senders of information (Table 14, Figure 14): The overall picture for all investigated countries showed that representatives of the professional and the regulative framework contributed equally to the knowledge transfer by providing about 34% and 38% of the media entries, respectively. Hereby, within the professional framework, the highest contribution (58%) was provided by the quaternary or knowledge sector, which consisted of professionals such as scientific knowledge providers, educators and knowledge brokers. Within the professional sector, the second biggest knowledge provider was the secondary or manufacturing sector, followed by the tertiary or service providing sector. The quantity of information these three sectors provided was in stark contrast to the very limited contribution of the primary or raw materials sector representing professionals such as crop and animal producers, foresters and fish farmers. Within the regulative framework, about 39% of the senders were representatives of the actor group regulators, followed by news producers (25%) and scientific knowledge producers (21%) and a small contribution from decision makers and representatives of the jurisdiction sector. Also averaged over all seven countries, the social framework contributed to the knowledge transfer with 24% of the provided media sources. Within the social framework, the institutionalized sector, including local, national and European environmental and consumer NGOs, foundations and interest groups, was the far biggest contributor with 88% of all provided information. In the overall picture of all countries, the smallest group of knowledge providers was the group of individual actors with a media contribution of 3%.

Receivers of information (Table 15, Figure 14): The two main target groups receiving information about eutrophication were (1) the individual actors, consisting of consumers, learners and citizens and (2) the crop and animal producers within the primary sector. About 33% of the media entries targeted individual actors, whereas the providers were mainly the knowledge sector within the professional framework and the institutionalized sector (NGOs). Crop and animal producers were targeted by 27% of the information, mainly provided by the institutionalized sector, the secondary sector such as manufacturers and regulators. The knowledge sector and the institutionalized sector were also the two information providers focusing mainly on the general public that was targeted by 15 % of the information. The regulative framework was targeted with about 14% of the provided information, which was further relatively equally distributed between decision makers (33%), regulators (31%), knowledge producers (25%) and news producers (11%). As one of the main providers of information, the social network representing NGOs, foundations and associations was targeted by only 2% of the investigated media sources of the seven countries.

For the individual countries, the distributions of senders and receivers of information of the found media sources diverge from the overall picture and are described in more detail below.

Denmark (Table 14, 15): The Danish research for media output provided in total 69 sources of which 70% were retrieved from google advanced search, 26% from youtube and 4% from facebook. As in the overall picture of all countries, also in Denmark almost all entries (92%) were published between 2008 and 2017.

In Denmark, 46% of all investigated media outputs were sent out by the regulative framework with news producers providing with 46% of all the most information. The second largest group of senders was the professional framework, providing 32% of the media entities, whereas the biggest impact was provided by the knowledge (quaternary) sector with 68% of the entries. In Denmark, we did not find any media outputs provided by the crop or animal producers or other representatives of the primary sector. The social network provided 22% of the media sources with the highest contribution held by representatives of the institutionalized sector (67%) such as national or local environmental or consumer NGOs.

In the Danish media analysis, we identified mainly two target groups per media output (114 entries in total). Knowledge about the topic eutrophication was mainly produced for the target group of individual actors and crop and animal producers, whereas 65% of all information targeted the individual actors and 29% targeted the farmers. Hereby, the information provided for the individual actors, was mainly provided by the knowledge sector, news producers and NGOs, and information provided for the farmers orginiated mainly from decision makers, manufacturers and NGOs.

Estonia (Table 14, 15): In Estonia, we retrieved in total 148 media sources of which 61% was found by google advanced search, 26% by facebook and 13% by youtube. Of these 148 media sources, 88% were produced in the decade between 2008 to 2017 whereas the highest amount of public output being available from the years 2014 - 2016.

The largest amount of information was provided by the professional framework (43%), followed by the social (26%) and the regulative (25%) frameworks. As in the other investigated countries, also in Estonia the quaternary or knowledge sector showed a very high contribution with 30% of the total and 71% of the output provided by the professional framework. Additionally, the tertiary sector showed a significant contribution to the media output, whereas – also as seen in the other countries – the crop and animal farmers as representatives of the primary sector did not show any. Within the regulative framework, it was the regulators that provided the most media outputs (55%), followed by decision makers (21%) and news producers (24%). In Estonia, we did not find any media output provided by scientific knowledge producers.

The knowledge – mainly provided by the knowledge sector and the social sector – aimed at 304 receivers and receiving groups. Crop and animal producers were the single largest target groups with 32% of the provided information being aimed at them, mainly being published by environmental and consumer NGOs. The second and third most targeted groups were the general public and the knowledge sector with 20% and 17% of the published media, largely provided by the knowledge sector and NGOs. Individual actors were mainly approached by the knowledge sector and about 15% of the provided information was tailored for them.

Germany (Table 14, 15): The German media analysis provided a total output of 146 media entries, whereas 74% was retrieved by google advanced search and 26% by youtube. No relevant entries on the topic eutrophication were retrieved from facebook. About 93% of the found entries were produced in the years 2008 - 2017, with the highest amount of outputs originating from the years 2016 and 2017.

In Germany, the largest group of senders were representatives from the regulative framework, providing 44% of all media entries, followed by the social framework with 30% and the professional framework with 24% of all retrieved media sources. Within the regulative framework, the contributions were relatively equally distributed between the knowledge producers (32%), the news producers (25%), the regulators (23%) and the decision makers (20%). Similar as in other investigated countries, the institutionalzed sector – mainly NGOs – contributed in total with 27% and within the social framework with 89% of the output. Within the professional framework, the manufacturers and knowledge sector contributed each about 40% of the information, whereas the crop and animal producers – as in the other countries – contributed with 9% of the output only very little to the overall information flow. Individual actors provided only 1% of the publically available information about the topic.

We counted 235 groups or individuals as targets for the sent information. Here, the by far largest single group was the group of individual actors being targeted by 46% of the information, provided mainly by environmental and consumer NGOs. The regulative framework was the second largest group being targeted by 24% of the information, mainly provided by scientific knowledge producers. About 17% of the information was tailored to reach crop and animal producers, mainly coming from the manufacturing sector. Within the regulative framework, the scientific knowledge producers and the decision makers received the most information from scientific knowledge producers with 54% and 30% of the total, respectively. In Germany, the general public was targeted by 11% of the information and the institutionalized sector with only 1%.

Finland (Table 14, 15): The Finish media analysis retrieved 157 senders in total of which 90% were collected using the google advanced search, 9% was found on youtube and 1% on facebook. About 92% of the output was published in the years 2008 to 2017 with the most hits retrieved from the years 2013 to 2015.

In Finnland, the highest quantity of information (48%) was sent out by representatives of the professional framework. The rest of the output was shared between the social framework (29%), the regulative framework (19%) and the individual actors (5%). Within the professional framework, the knowledge sector contributed with 48% of all entries, followed by the service sector (20%) and the manufacturers (16%). The institutionalized sector contributed with 27% to the total and dominated the knowledge transfer within the social sector with 96% of all media outputs. Individual actors provided with 5% only little knowledge about the topic.

On the receiver side of information, we identified 271 targeted groups or individuals. About half (48%) of the receivers were representatives of the professional framework with crop and animal producers being targeted by far the most with 65% of all entries. Hereby, the knowledge providers were mainly NGOs and representatives from the professional framework. The general public received about 25% and the group of individual actors about 17% of the sent information on the topic, both to the largest extent provided by the knowledge sector and NGOs. In Finnland, the regulative framework was targeted by only 8% of the media output whereas the decision makers were the most frequent target (59%).

Latvia (Table 14, 15): The media analysis in Latvia resulted in 52 media entries which were all collected via google advanced search. About 72% of the output with known publication years were published between 2008 and 2017.

With 40% of the media output, the social framework was the largest contributer of information on the topic, whereas almost all was covered by environmental and consumer NGOs. The second largest group of knowledge providers was the professional framework - mainly the knowledge sector - providing 32% of information, followed by the regulative framework providing 27% of information. Crop and animal producers as well as individual actors were not detected at all as knowledge providers.

The professional framework was in the main focus for knowledge transfer, mainly provided by the knowledge sector, decision makers, regulators and news producers with being targeted by 40% of the information. Within the professional framework, the crop and animal producers were equally targeted as the knowledge sector. In comparison to other countries, knowledge was tailored little individual actors with only 17% of the information being targeted at them – equally to the amount targeted at the regulative framework.

Poland (Table 14, 15): In Poland, we retrieved with 43 media outputs in total the smallest amount of outputs of all countries. Similar as in the other countries, 90% of the output was retrieved from the google advanced search, 10% was retrieved from youtube and no entries were found on facebook. Here, 81 % of the media outputs were published in the years 2018 - 2017, following a relatively even distribution through those years.

The professional framework provided about 58% of all media entries whereas the knowledge sector showed the largest output (72% within the professional framework). Within the professional framework, the manufacturers had the second biggest amount of output (28%) and both the primary and tertiary sector had none. The social framework contributed with 32% of all media outputs, whereas the institutionalized sector and the decentralized networks contributed about equally. The regulative framework provided only about 9% of the information and no information was found to have been sent out by individual actors.

We identified mainly two targeted groups per media entry, adding up to 72 entries in total. The primary sector was targeted by 29% of the information, whereas crop and animal producers were targeted the most (86%) and mainly from manufacturers. Individual actors were targeted by 24% and the general public by 29% of the information, mostly provided by the knowledge sector, environmental and consumer NGOs, foundations and associations. About 11% of the provided information was reaching out for decision maker and regulators, whereas the institutionalized sector was targeted very little with only 7% of the knowledge.

Sweden (Table 14, 15): The Swedish media analysis provided 151 media entries, which were all retrieved from google advanced search (youtube and facebook not carried out). About 92% of the information was published between 2008 and 2017 with the highest amounts of entries being published from 2012 to 2017.

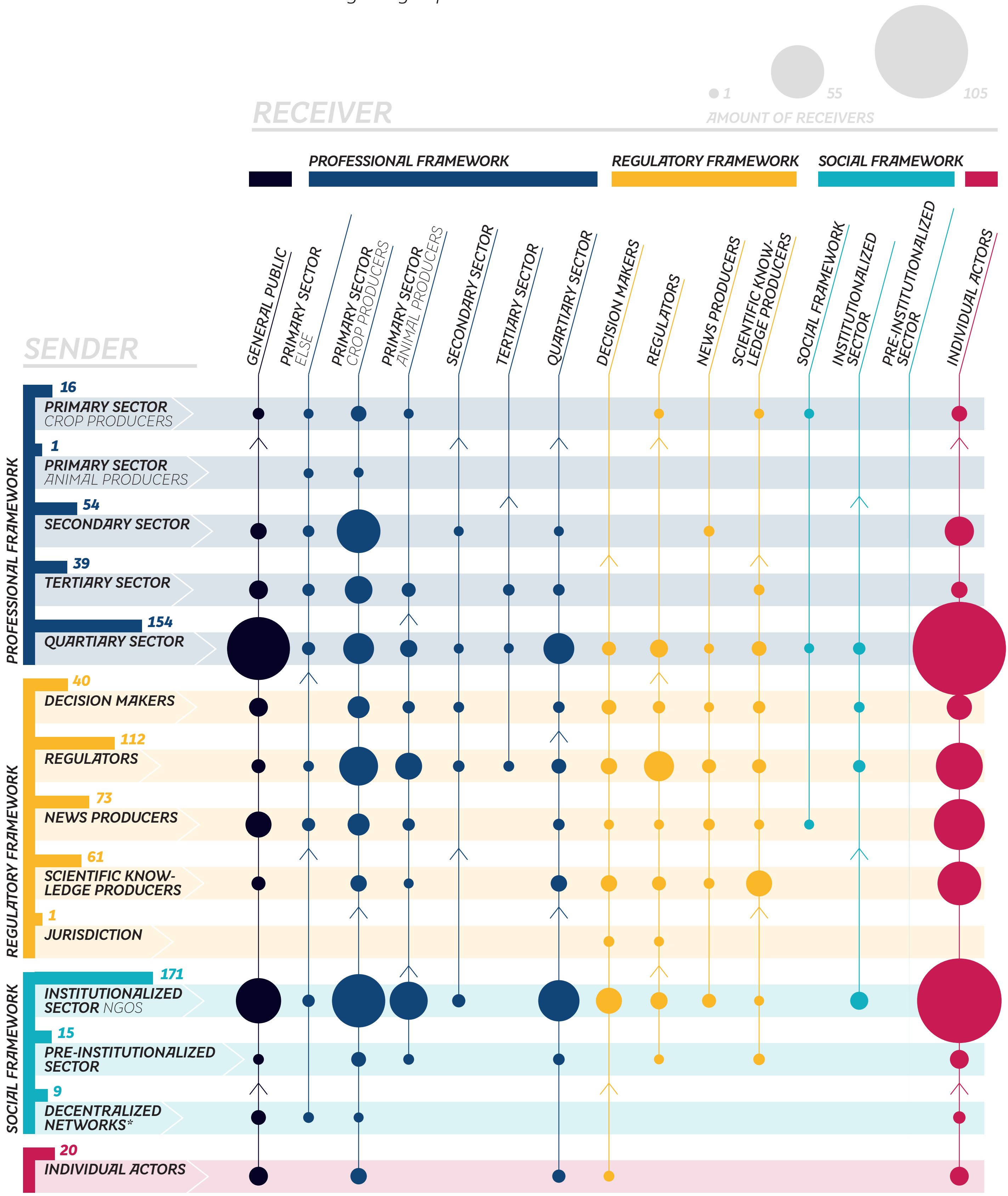
In Sweden, the most information was sent out by the regulative framework, contributing 69% of all entries. The professional framework and the social framework contributed with 19% and 12% of the information, respectively. Individual actors, crop and animal producers contributed with less than 1% of the provided information very little to the public discussion about eutrophication.

In Sweden, we identified mostly 2 target groups per media entry, adding up to 243 receivers and receiver groups in total. We found out that about half of the media output targeted individual actors and about 28% of the media targeted mostly the crop and animal farmers within the professional framework. Contrary to as in the other investigated countries, it was also and mainly regulators and scientific knowledge producers (besides the knowledge sector and NGOs) reaching out to individual actors with information. Regulators also represented by far the biggest group informing crop and animal producers about the topic eutrophication. Regulators, scientific knowledge producers, the knowledge sector and NGOS also targeted the regulated framework with 21% of the total information, whereas decision makers, regulators and news producers were targeted equally.

SUMMARY

In the seven investigated countries of the Baltic Sea Region, the two main target groups receiving information about eutrophication were (1) the individual actors and (2) the crop and animal producers. Information providers targeting individual actors were mostly representatives from the knowledge sector such as scientific knowledge providers and edcucators, and the institutionalized sector such as NGOs. Crop and animal producers were mainly informed by NGOs, the secondary sector representing manufactorers (e.g. fertilizer companies) and regulators.

***Figure 14:** Transfer of knowledge about eutrophication retrieved from media analysis applied in seven countries of the Baltic Sea Region. Senders = total amount of media entities retrieved, receivers = total amount of targeted groups and individuals.*



* AND TEMPORARY DISCRETE EVENTS

Table 14: Senders of information about eutrophication retrieved from the media analysis applied in seven countries of the Baltic Sea Region. *Countries: Denmark (DK), Estonia (EE), FI (Finland), Germany (DE), Latvia (LV), Poland (PL) and Sweden (SE): total quantity of media entities; in brackets: percentage of media related to total media output of the corresponding country; percentages were rounded and not mentioned were < 0.4%.*

Senders of information			DK	EE	FI	DE	LV	PL	SE
Individual actors			1 (1%)	9 (6%)	7 (4%)	2 (1%)	-	-	1 (1%)
Professional framework	Primary sect.	Crop producers	-	-	11 (7%)	3 (2%)	2 (4%)	-	-
	Primary sect.	Animal producers	-	-	1 (1%)	-	-	-	-
	Secondary sect.		5 (7%)	7 (5%)	12 (8%)	14 (10%)	2 (4%)	7 (16%)	7 (5%)
	Tertiary sect.		1 (1%)	11 (7%)	15 (10%)	4 (3%)	1 (2%)	-	7 (5%)
	Quaternary sect.		15 (22%)	45 (30%)	36 (23%)	14 (10%)	12 (23%)	18 (42%)	14 (9%)
Regulative framework	Decision makers		10 (14%)	8 (5%)	3 (2%)	13 (9%)	2 (4%)	1 (2%)	3 (2%)
	Regulators		-	21 (14%)	11 (7%)	15 (10%)	6 (12%)	2 (5%)	57 (38%)
	News producer		15 (22%	9 (6%)	11 (7%)	16 (11%)	6 (12%)	1 (2%)	15 (10%)
	Scientific knowledge prod.		7 (10%)	-	4 (3%)	21 (14%)	-	-	29 (19%)
	Juristication		-	-	1 (1%)	-	-	-	-
Social framework	Institutionalized sector		10 (14%)	35 (24%)	43 (27%)	39 (27%)	18 (35%)	8 (19%)	18 (12%
	Pre-institution. sector		5 (7%)	3 (2%)	2 (1%)	5 (3%)	-	-	-
	Decentralized networks		-	-	-	-	3 (6%)	6 (14%)	-
sum			**69**	**148**	**157**	**146**	**52**	**43**	**151**

Table 15: Target groups receiving information about eutrophication retrieved from the media analysis applied in the seven countries of the Baltic Sea Region. *Countries: Denmark (DK), Estonia (EE), FI (Finland), Germany (DE), Latvia (LV), Poland (PL) and Sweden (SE): total quantity of media entities; in brackets: percentage of media related to total media output of the corresponding country; percentages were rounded and not mentioned were < 0.4%.*

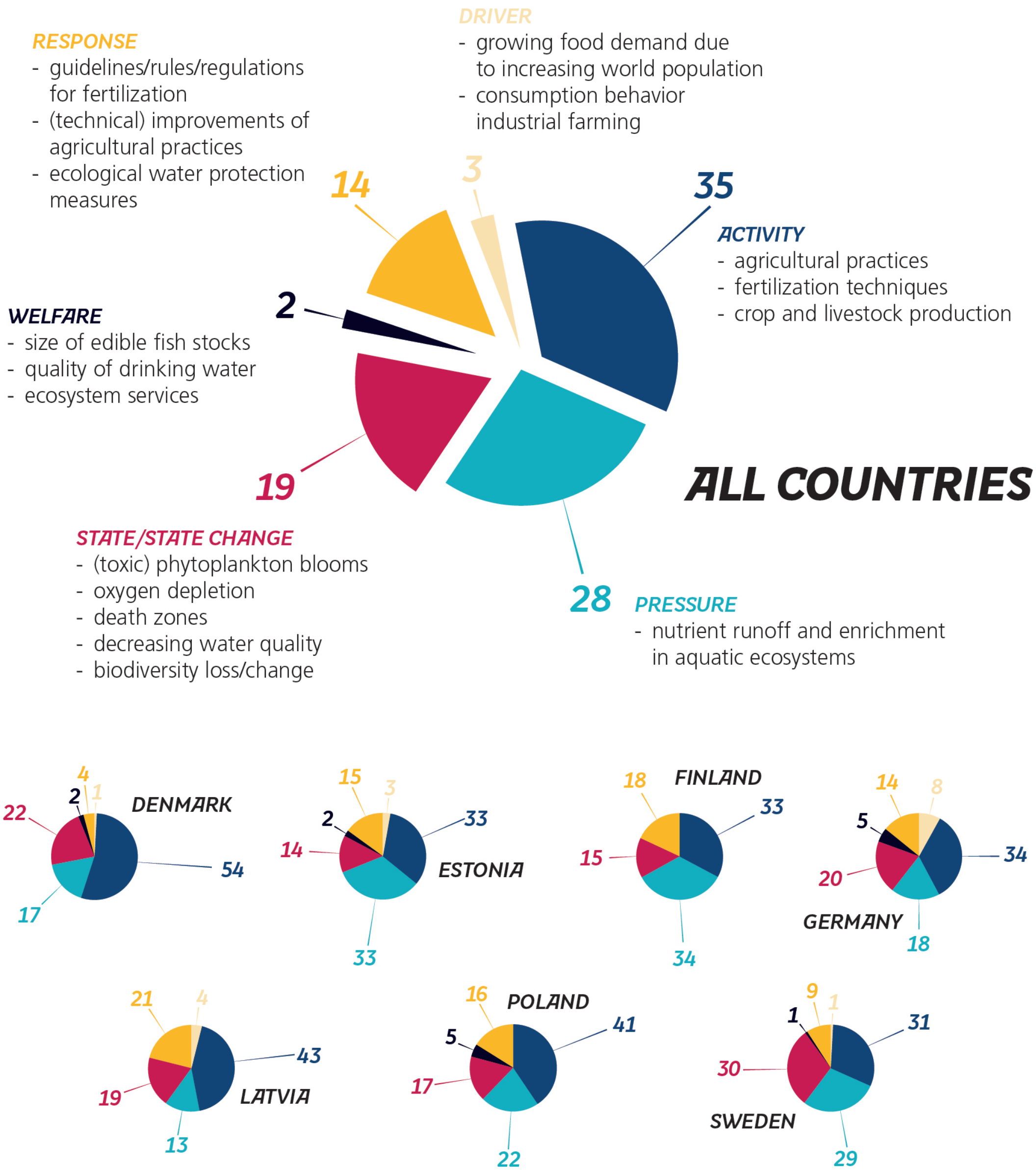
Target groups			DK	EE	FI	DE	LV	PL	SE
General public			1 (1%)	63 (21%)	69 (25%)	27 (11%)	19 (22%)	21 (29%)	2 (1%)
Individual actors			74 (65%)	47 (15%)	47 (17%)	108 (46%)	15 (17%)	17 (24%)	122 (50%)
Professional framework	Primary sect.	Crop producers	29 (25%)	56 (18%)	73 (27%)	33 (14%)	6 (7%)	16 (22%)	39 (16%)
	Primary sect.	Animal producers	4 (4%)	40 (13%)	13 (5%)	3 (1%)	7 (8%)	2 (3%)	17 (7%)
	Primary sect.	All others	1 (1%)	4 (1%)	14 (5%)	-	5 (6%)	3 (4%)	-
	Secondary sect.		-	2 (1%)	5 (2%)	3 (1%)	-	-	2 (1%)
	Tertiary sect.		-	-	4 (1%)	1	1 (1%)	-	-
	Quaternary sect.		-	53 (17%)	23 (8%)	0	14 (16%)	-	11 (5%)
Regulative framework	Decision makers		-	13 (4%)	13 (5%)	17 (7%)	-	4 (6%)	10 (4%)
	Regulators		-	12 (4%)	8 (3%)	8 (3%)	8 (9%)	4 (6%)	21 (9%)
	News producer		-	-	-	1	2 (2%)	-	18 (7%)
	Scientific knowledge prod.		5 (4%)	5 (2%)	1	31 (13%)	3 (3%)	-	1
Social framework	Institutionalized sector		-	9 (3%)	1	3 (1%)	6 (7%)	5 (7%)	-
sum			**114**	**304**	**271**	**235**	**86**	**72**	**243**

6.2 CONTENT OF THE KNOWLEDGE SYSTEM

6.2.1 WHICH CONTENTS WERE COMMUNICATED?

The analysis of knowledge pathways displayed a clear picture in the media of the seven investigated countries: the main receivers of information were individual actors as well as crop and animal producers. In the following, we elaborated which contents the transferred information carried to all target groups and provide information about how the contents were classified within the DAPSIWR framework in the individual countries and in the overall picture of all investigated countries (Figure 15).

Figure 15: Content of knowledge system about eutrophication classified following the DAPSWR framework, retrieved from media analysis applied in seven countries of the Baltic Sea Region. *Countries: Denmark (DK), Estonia (EE), FI (Finland), Germany (DE), Latvia (LV), Poland (PL) and Sweden (SE); numbers = [%] related to the total knowledge content of the individual countries or as average for the overview over all countries combined.*



The published media showed a strong focus on informing about **activities** related to agriculture and fertilization practises, the pressures these practices caused for aquatic ecosystems and the impact or state changes that followed for these ecosystems. About 30 – 50 % of the message contents (Figure 15) published in the seven countries contained or even focused solely onto describing farming activities. Hereby, target groups largely received information about agricultural practices used for crop and lifestock production and different kinds of applied fertilization techniques. Also, advantages and disadvantages of ecological and conventional or industrial farming were discussed to a smaller extent, but usually in the scope of soil quality and species diversity and seldomly related to eutrophication of adjactant water bodies. In most of the countries, a large amount of the entries classified as activity was information material and advertisment of fertilizer manufacturers targeting farmers as potential costumers.

The second biggest part of the story being told about eutrophication linked agricultural activities to **pressures** these add on aquatic systems. Information about nutrient runoff from agricultural land into adjactand water bodies, such as lakes or more specifically the Baltic Sea covered 13 to 43% of the message contents. Hereby, most of the puplications focused on nitrogen and phosphorous sources as main nutrient pollutants.

Most puplications that informed about pressures on aquatic ecosystems caused by agricultural practices, followed the narrative and connected the **impact** of nutrient enrichment in water bodies to a detailed description about the changes of the **state** of the ecosystem that consequently followed. The description of **state** and **state changes** covered 14 – 30 % of the message contribution. In most messages, the ecological cascade caused by nutrient enrichment or "faces of eutrophication" was described in detail as following: increased nutrient input into aquatic ecosystems fuels the growth of phytoplankton, so that often extensive (toxic) algae blooms occur. This causes an enlarged amount of biomass to sink down to the bottom of the water body, where it enhances microbial remineralization processes. The microbes feed on the biomass and at the same time use up oxygen (and other electron acceptors such as sulfate) in the respiration process. Consequently, oxygen concentrations are decreasing and often depleting. In the Baltic Sea, deep basins and strongly stratified water masses prevent the water body from mixing, so that oxygen-minimum-zones, often refererred to as "death zones" occur. At this point, in most investigated media output, the story of eutrophication finds is ending and only in a small part of messages, the loss and/or changes in biodiversity of flora and fauna or more specifically the (mass) death of edible fish was included. A few puplications discussed the interplay between eutrophication and climate change.

The interlink between eutrophication and human **welfare** usually found little attention in the investigated media output. Within the knowledge distributed about eutrophication, the aspect welfare contributed only up to 5% to the content of the messages and was in some countries (Finland, Latvia) not even mentioned at all. In publications in which welfare aspects were included, they focused mostly on the quality of drinking water, loss of edible fish stocks and ecosystem services and very seldomly on the shifts and losses in biodiversity of flora and fauna that also may affect humans` well-being.

In contrast to the link between eutrophication and human welfare being described rarely, the discussion of potential **responses** to stop or reverse eutrophication was often described in the investigated media. Here, with an averaged contribution of 14% among all seven countries (Figure 15), a stark contrast was seen between them: Danish and Swedisch media output discussed potential responses to a much lower extent (4% and 9%, respectively) than Finish and Latvian (18% and 21%, respectively) media.

In most media outputs, the proposed responses were water protection measures such as guidelines, regulations and recommendations from regulative authorities concerning practices of fertilization and fertilizer storage. Especially the HELCOM framework was discussed and evaluated frequently. Also, technical improvements of farming techniques were conversed and ecological farming as solution to avoid eutrophication was recommended. It was apparent from the pool of published responses, that they have emerged from evaluating the impact, state and state change of aquatic ecosystems or specifically the Baltic Sea, following a narrative like: "The enrichment of nutrients in aquatic systems is too high, therefore rules need to be implemented to lower the nutrient outflow from agricultural land." In only very few proposed responses, the value chain of agro-food products was evaluated and interlinked with the consumption behavior of the individual or even set in context with the growing demand for food from a growing world population.

This clearly missing link in the stories about eutrophication and agriculture was also represented in the small contribution of **drivers** described in our investigated media entries. Within the seven countries, only up to 8% of the overal message contents focused on drivers, whereas in media entries of some countries (Finland, Poland) drivers were not mentioned at all. Publications discussing drivers for eutrophication usually focused on the increase of the world population and consumption behaviour linked to a higher demand for livestock production to satisfy the increasing hunger for meat. Consequently, media entries describing these direct or indirect drivers, also usually requested a change in consumption behavior as a response. We found no media entries including thorough evaluations of the value chain of the agro-food sector.

6.2.2 WHICH MESSAGES WERE SENT OUT – AND WHICH WERE NOT?

When reviewing the media entries, we formulated one key message per publication that we perceived as the main or overall take-away for the reader. Thereafter, we weighted these key messages following their abundances for evaluating which kind of information the average receiver may have been subjected to (Table 16). As the individual actors and farmers were the two most targeted groups in all investigated countries, we concentrated in our further analysis on the messages they received.

In this section, we display the four most abundant messages sent to individual actors and farmers, respectively (Table 16). The most abundant message, both target groups received, was the information that during agricultural activities fertilizers of different kinds – mainly inorganic - are used. The second most abundant messages were for both target groups framed as activity – pressure – state/state change. Hereby, individual actors received mainly the messages that agricultural practices cause nutrient pollution, which leads to eutrophication in adjactant water bodies or more specific, the Baltic Sea. In contrast, farmers received the message that agricultural practices must be supported and regulated with respect to becoming more environmentally friendly. The difference in these two messages can be explained by the senders of information that tailored their information to the target group: individual actors were mainly targeted by representatives from the knowledge sector and the institutionalized sector that aimed for informing individuals about the situations. In contrast, farmers were mainly approached by NGOs, manufacturers and regulators with the aim to raise awareness about how their agricultural practices impact the environment and how they could potentially (NGOs, manufacturers) change behavior or which rules (regulators) they should follow.

Besides this slight difference in message contents targeting either individual actors with general information about eutrophication or crop and animal producers with rules and regulations, these two different groups were otherwise targeted with messages containing the same content.

Hereby, as described in the previous section, a substantial number of messages sent out followed the frame activity – pressure – state/state change – response: Agricultural practices cause nutrient pollution of (aquatic) environments, which lead to their eutrophication. To decrease nutrient pollution, (regulative) water protection measures must be considered and applied (Table 16).

The analysis of the message contents linked to receivers reveiled mainly two shortcomings in the current puplic communication of the topic eutrophication:

1. The close link between the eutrophication state of the Baltic Sea with indirect and direct drivers on one side and human welfare on the other side was very rarely covered. The story of ecosystem degradation due to eutrophication is currently mainly told without connecting it to consumption behavior, the value chain and the agro-food industry. So far, this led to responses mainly focusing on damage control and trying to minimize nutrient input into ecosysems.

2. Senders of information have been reaching out to a large variety of target groups, but the narrative of the messages have been mainly the same.

We find that reviewing and closing these shortcomings is pivotal when designing new ocean literacy to tackle eutrophication.

Telling the entire story about eutrophication instead of focusing on parts of it, while adapting the information more to the needs and backgrounds of the individual target groups could be powerful in supporting their capability to act. We provide suggestions and ideas how to do so in Chapter 7.

Table 16: Four most communicated messages received by individual actors and crop and animal farmers, *classified by the DAPSWR framework with D = driver, A = activity, P = pressure, S = state/state change (state change instead of impact), W = welfare and R = response, for all seven countries in which media analysis have been performed (DK, EE, FI, DE, LV, PL, SE) and classified with the DAPSWR framework.*

ALL COUNTRIES: INDIVIDUAL ACTORS

1.	A	During agricultural activities (e.g. crop production), (mineral/organic) fertilizers are used.
2.	A-P-S	Agricultural practices cause nutrient pollution of (aquatic) environments which leads to their eutrophication (specific: eutrophication of the Baltic Sea).
3.	A-P-S-R	Agricultural practices cause nutrient pollution of (aquatic) environments, which leads to their eutrophication. To decrease nutrient pollution, (regulative) water protection measures must be considered/applied.
4.	A-P-S-R	Agricultural practices cause nutrient pollution of (aquatic) environments which leads to their eutrophication. To decrease nutrient pollution, (regulative) protection measures must be applied and fertilization/fertilizer storage must be improved (e.g., as part of ecological agriculture).

ALL COUNTRIES: CROP AND ANIMAL FARMERS

1.	A	During agricultural activities (e.g. crop production), (mineral/organic) fertilizers are used.
2.	A-P-S	Agricultural practices must be regulated and/or supported to become environmentally friendly.
3.	A-P-S-R	Agricultural practices cause nutrient pollution of (aquatic) environments, which leads to their eutrophication. To decrease nutrient pollution, (regulative) protection measures must be applied and fertilization/fertilizer storage must be improved.
4.	A-P-R	Agricultural practices cause nutrient pollution of (aquatic) environments and must be regulated by water protection measures and improved fertilization techniques.

6.3 PERECEPTION OF THE CURRENT KNOWLEDGE SYSTEM

6.3.1 PERCEPTION OF THE CURRENT KNOWLEDGE SYSTEM BY REPRESENTATIVES OF THE VALUE CHAIN

In spring 2017, interviews with selected key stakeholder of the agro-food value chain were carried out to assess the state of their knowledge about eutrophication and to identifiy the potential for their behaviour change.

The interviews were carried out as telephone assessments with 5 representatives of different sectors within the value chain, which were considered as key actors due to adding direct pressure to the Baltic Sea or due to having the highest impact on other actors in the value chain. The interviews were semi-structured, whereas the interviewees were at first presented with the main findings of our value chain analysis and the list of key actors. Thereafter, they were questioned about their views on their own roles and impacts within the agro-food system.

The following sectors (number of interviewees) were chosen:
1) decision makers (1 person)
2) farmers (2 persons)
3) retail/wholesale (2 persons)

All interviewees agreed that the presented value chain (Annex 2) covers all the most important actors. In addition, transport and logistics were named as important sectors, although the link between the transport sector and the release of nutrients into the environment was not mentioned. A few interviewees indicated that the value chain could include fertilizer sellers in addition to fertilizer manufacturers. All key actors understood their role in the value chain, whereas both farmers and retail/wholsale see each other as the ones with the biggest potential for behaviour change.

Both interviewed farmers previously took part in environmental projects that were dealing with the nutrient leakage aspects. Also, representatives from retail/wholesale can see that the nutrient leakage issue has become increasingly relevant also to them. However, they could not see their concrete role in it, such as being part in projects targeting nutrient leakage from agriculture. Some interviewees mentioned local outlets that are currently cooperating on local projects related to restoring the health of the Baltic Sea.

The interviewed representatives from retail and wholesale admitted that they are within the value chain the key link between consumers and other actors- especially between the food industry and consumers. Wholesale/retail representatives also pointed out the important role of the food industry as they are directly interlinked with the farmers. The importance of starting change also outside ot the BSR region through political iniiatives was highlighted – with the biggest role being seen on governments.

In contrast, farmers see retail, wholesale and food manufacturers as the key actors who need to change their attitude. It was also pointed out by a farmer that most of the money made in the value chain goes to the retail and wholesale sector and very little money reaches the farmers.

Although farmers were rather critical towards the food manufacturing sector and the retail and wholesale sector, they also admitted that the change should take place across the whole value chain, and that farmers have the biggest opportunity to lessen the burden added on the Baltic Sea - as they are the ones adding the pressure and having the tools. Additonally, interviewees pointed out that the society as an entity is a key for initiating the change.

Farmers are the key actors that see which preconditions would be required for a better implementation of the practices decreasing the nutrient leakage to the Baltic Sea. Here, several aspects related to scientific proofs, support for investments and subsidies were pointed out. Additionally, consumer choices and circular economy were mentioned. Representatives from the retail and wholesale sector currently view their role in the value chain as not powerful enough to decrease the leakage of nutrients into the environment.

The representative decision maker pointed out that national agricultural decision makers need to control the application of fertilizers much stricter than currently done.

6.3.2 EVALUATION OF THE VALUE CHAIN AND BEHAVIOUR CHANGE

In addition to the phone interviews, we presented our findings to an environmental economic researcher. We introduced Dr. Dennis Collentine (University of Gävle) to the value chain analysis and asked for feedback on our findings regarding the economic drivers behind the key activities and how to change their behaviour.

Additionally, the value chain analysis, including the analysis on possible behavioural change, was presented at the Baltic Sea regional workshop (WP4): „How literate are we on well-known issues such as eutrophication of the Baltic Sea?", on June 14th and 15th, 2017. In this workshop, ResponSEAble findings including the value chain were discussed throroughly with decision makers from BSR countries, including representatives from HELCOM.

Main conclusions and recommendations for the development of future ocean literacy are:

- Knowledge does not always lead to action as humans are driven by different value systems. For initiating behaviour change, other factors than knowledge need to be analysed, for example values that influence decisions.

- Cognitive dissonance - people denying knowledge because it is too painful to accept - is another aspect that shall be also considered in the context of ocean literacy. It is important to address people by developing different communication strategies responding to cognitive dissonance. This also includes politicians who take decisions impacting the environment.

- People usually take care for the things they know. Feeling connected with the oceans (and Baltic Sea) makes them care more.

- Ocean literacy is a tool for people to understand the consequences of their actions. But there are many literacies expected from citizens, which may be overwhelming. Therefore, it would be important to assess where different literacies overlap.

- Agriculture is an economically-driven sector in the global market. Hence, changing the consumption patterns only in the BSR does not change the production patterns in the region. A holistic approach will be needed to minimize pressure added to the Baltic Sea.

- Experience from work with consumers shows that providing advice and solutions is usually more impacting and relevant than discussing solely the problems.

- There is a need for strong enforcement of already existing policy goals (MSFD and WFD). One option is to use stronger regulatory instruments, e.g., toward regulating farming practices. Economic arguments may not work properly as economic lobbies usually more powerful than lobbists that care about environment.

7. OPPORTUNITIES FOR CHANGE THROUGH A BETTER KNOWLEDGE SYSTEM

Knowledge is often associated with pro-environmental behaviour (Zelezny, 1999). Information and the way it is transferred can lead to an increase of personal responsibility, influence people's perceptions, and drive behavioural change leading to more sustainable behaviour. The starting point of the Horizon2020 project ResponSEAble was that an ocean literate person has the capacity and willingness to act appropriately both individually and socially, and in professional and private activities that could impact the marine environment. An ocean literate person is aware of the importance of the ocean, understands the ocean's influence on humans, and the influence of humans on the ocean (as an individual, professional and social beings). Also, the person knows what to do to protect the ocean, and to seize opportunities the ocean offers (act responsibly) and can communicate responsibilities for the ocean to others. Therefore, ResponSEAble's concept of ocean literacy builds on three main pillars:

(1) which knowledge do people need to have,
(2) who needs to receive information and
(3) how should this knowledge be communicated.

Where do we stand in terms of current knowledge and information and how is it in line with the role, actors play in the value chain?

Below, we described the key actors, their role in the current communication about eutrophication as well as possibilities for future information exchange and involvement. Selected stakeholders have either an important role in knowledge transfer or have the biggest influence across the value chain.

PROFESSIONAL FRAMEWORK

Farmers

- Existing measures and communication are largely targeted to farmers
- Farmers are an important target group, but they need to consider economic sustainability before deciding to change their practices. It would be supportive for farmers to receive more real-life success stories and information about technological solutions and circular economy. Environmentally friendly technical solutions developed by scientists should be better communicated to reach farmers for their implementation. Additionally, the implementation of these new environmentally friendly farming practises should be also made affordable for farmers through policies/subsidies.
- Most farmers are aware of the need to fulfil water protection requirements, but do not always know the reasons behind and the consequences of it or have even heard of the word "eutrophication". This indicates that there is still a necessity to increase ocean literacy for farmers.

Wholesale and Retail

- Wholesalers and retailers are one of the least targeted stakeholders despite their high influence on other actors in the value chain.
- Most wholesalers and retailers currently do not connect their activities to the status of the Baltic Sea or other aquatic ecosystems. For tackling eutrophication of the Baltic Sea, the development of ocean literacy tools raising awareness for wholesalers and retailers is pivotal.

- Wholesalers and retailers operate in a highly competitive market. They have opportunities for taking the advantage of the changing societal discourse and can contribute to a change of consumer behaviour through campaigns and awareness rising. Therefore, retailers are potential allies in their own interest for increasing ocean literacy of consumers.

Food manufacturers

- Food manufactures have a key role in the value chain but are currently very little targeted by the communication about the eutrophication status of the Baltic Sea.
- Food manufacturers currently do not connect their activities to the status of the Baltic Sea and therefore should be more intensively targeted in future awareness raising activities.
- Future communication should not only include regional actors, but also target at least EU level actors within this target group.

Fertilizer producers

- Fertilizer producers currently provide a lot of information about the use of fertilizers, also including sustainable practices.
- There is a potential to include fertilizer producers more intensively for a wider knowledge transfer. The knowledge of fertilizer producers about the link between fertilizers and eutrophication should be investigated and new ocean literacy tools should be developed accordingly.

Scientific knowledge providers

- Although scientific knowledge providers are the main knowledge producers, this group often lacks capabilities to communicate the results to a wider audience.
- Scientific knowledge providers could benefit from closer cooperation with NGOs: the latter provide the resources that can communicate scientific knowledge within the bigger picture, including drivers, economic conditions and potential responses.

REGULATIVE FRAMEWORK

Decision-makers of various levels (agri)

- The group of decision-makers are an important knowledge provider, but they are often not sufficiently informed about the topic eutrophication, especially about the aspect welfare.
- The Baltic Sea Region is part of a global market and therefore, there is a risk that changing only local consumption patterns does not have enough impact on the global value chain.
- In addition, eutrophication must be tackled politicially at the EU level to impact the whole EU agro-food sector. Therefore, communication and messages on a political level are needed. As mentioned above, NGOs can play a major role in collecting and summarizing perspectives on the whole story narrative, including driving forces, economic interests, environmental aspects and on the whole range of potential responses.

INDIVIDUAL FRAMEWORK

Consumers

- One of the main targeted groups in the communication about eutrophication of the Baltic Sea is the group of consumers.
- Consumers can have an impact on the practices of farmers and food manufacturing by influencing retailers.
- We see an opportunity for changing consumer behaviour due to the already rising awareness on health and environmental issues. It is important to acknowledge that health issues are often more important when changing consumption choices. The knowledge about eutrophication and its impact on marine ecosystems and welfare are not common knowledge and awareness about this must be increased. This is important to implement before moving to ‘what can you do to make a change’.

SOCIAL FRAMEWORK

NGOs

- NGOs play a key role in the current transfer of knowledge between producers and receivers.
- NGOs are often more prone to tell the entire story as they usually own an independent position within the societal structure.
- This group can potentially collect perspectives from all parts of the narrative and pass them on to important groups of actors in a targeted manner. They can increase reliability of key messages by cooperating with scientific institutions.
- Communication channels used by NGOs are often still traditional and should generally become more interactive, creative and innovative.

8. SUMMARY

The entire Baltic Sea is affected by eutrophication and agriculture was identified as a key source of nutrient input. Although this is known since decades, the current communication about eutrophication focuses almost solely on activity-caused pressures and corresponding state changes of the Baltic Sea but circumnavigates around shedding light on drivers behind it.

The global demand for agricultural products rise, consumption patterns change and food waste increases - and there are many drivers behind it, including population growth, economic growth and rapid urbanisation.

Globalization has changed the scope and character of the food production and distribution:

- increased production,
- increased complexity of food supply,
- concentration of retail into international chains,
- market globalization causing increased price competition and increased share of imports

Is the agricultural value chain actually a pressure chain? Farmers are pressured by wholesale and retail to produce high amounts of food and food products at cheap prices, whereas market globalisation pressures wholesale and retail. The results are increasing imports and exports trades and hence, increasing price competition. Hence, how much pressure is added to the Baltic Sea by agricultural practises is largely dictated by the complex structure of the agricultural food chain – from producers to consumers – which stretches far beyond the borders of the Baltic Sea Region.

Today, most responses – on an economic, social and behavioural level – aim to tackle eutrophication by targeting farmers and are mainly linked to water protection measures. However, the usual responses are only seldomly linked to the agro-food value chain, production and consumption patterns. This paradigm is also supported by the current eutrophication-related communication, where most messages focus onto describing farming activities, and pressures, these activities add to aquatic environments, but lack a comprehensive display of the interconnection between farming and the agricultural value chain. Since a few years, campaigns targeting individual consumers to raise awareness about the impact of meat and dairy consumption on the enivornment are increasing (e.g., WWF, 2016).

Moreover, the interlink between eutrophication and human welfare gains very little attention in the prevailing communication about the topic, which means that the ecosystem degradation is largely disconnected from us humans.

Thus, we are hardly challenged to rethink our behavior in our own interest.

For gaining back a healthy Baltic Sea, it is high time to more forward from focusing on damage control, such as attempting to minimize nutrient outflow from agricultural land and step towards implementing substantial changes across the agro-food value chain.

Our study shows that most actors in the value chain are currently not aware of how their every day decisions and actions are conflicting with the well-being of marine ecosystems - and us humans that are strongly connected to it.

Increasing ocean literacy adapted to the target groups could serve as a tool and first step for calling to action. New ocean literacy tools must include the illustration of the connection of every actor in the agro-food value chain with the negative effects they potentially cause in the Baltic Sea and their interconnection with other actors.

Each one of us is part of the story about eutrophication of the Baltic Sea. Hence, by understanding our own position in the overall economic structure, we can find a starting point to change our own behaviour and influence the behaviour of other consumers, policy makers and the agro-food industry the - through a communication from the field to the plate.

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10. TABLES AND FIGURES

TABLES

FIGURES

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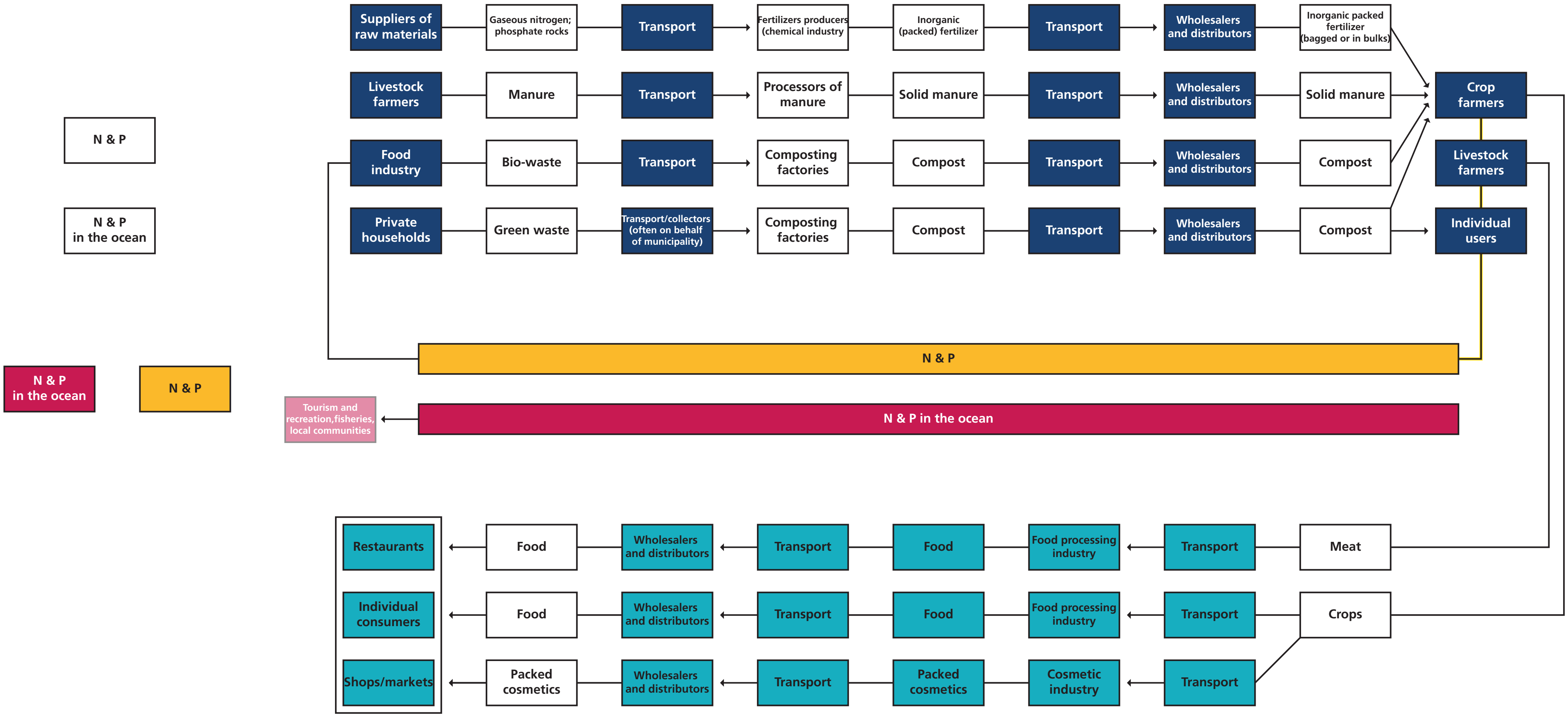
11. ANNEX

Annex 1. Classification of actors and stakeholders of the agricultural value chain

General Public
Professional framework
Primary sector (raw materials)
2.0.1. Fishermen
2.0.2. Fish farmers
2.0.3. Animal producers
2.0.4. Crop producers
2.0.5. Foresters
2.0.6. Miners and mining companies
2.0.7. Quarrying companies
Secondary sector (manufacturing)
2.1.1. Manufacturers
2.1.2. Construction service providers
2.1.3. Renewable energy producers
2.1.4. Non-renewable energy producers
2.1.5. Electric power transmission and distribution service providers
Tertiary sector (production of services for consumption and exchange of goods)
2.2.1. Water management service providers
2.2.2. Water management support service providers
2.2.3. waste management service providers
2.2.4. Waste management support service providers
2.2.5. Maritime transport service providers
2.2.6. Maritime transport support service providers
2.2.7. Air transport service providers
2.2.8. Air transport support service providers
2.2.9. Land transport service providers
2.2.10. Land transport support service providers
2.2.11. Wholesalers
2.2.12. Retailers
2.2.13. Accomodation service providers
2.2.14. Food and beverage service providers
2.2.15. Print publishing service providers
2.2.16. Electronic media publishing service providers
2.2.17. Online media publishing service providers
2.2.18. Software publishing service providers
2.2.19. Broadcasting service providers
2.2.20. Sound recording and music publishing service providers
2.2.21. Motion picture video and television producers
2.2.22. Computer programming consultancy and related service providers
2.2.23. Information system services providers
2.2.24. Telecommunication service providers
2.2.25. Telecommunication support service providers
2.2.26. Architects and engineers
Quaternary sector (Knowledge Sector)
2.3.1. Scientific knowledge producers
2.3.2. Veterinary service providers

2.3.3. Educators
2.3.4. Sport educators
2.3.5. Knowledge brokers
2.3.6. Artists
2.3.7. Cultural service providers
Regulatory framework
Legislators
3.0.1. EU legislators
3.0.2. National legislators
3.0.3. Local and regional legislators
Administrators
3.1.1. EU administrators
3.1.2. National administrators
3.1.3. Local and regional administrators
Jurisdiction
Social framework
Institutionalized sector (e.g. NGOs)
4.0.1. Local NGOs
4.0.1.1. Local environmental NGOs
4.0.1.2. Local consumer NGOs
4.0.1.3. Other local NGOs
4.0.2. National NGOs
4.0.2.1. National environmental NGOs
4.0.2.2. National consumer NGOs
4.0.2.3. Other national NGOs
4.0.3. International NGOs
4.0.3.1. International environmental NGOs
4.0.3.2. International consumer NGOs
4.0.3.3. Other international NGOs
4.0.4. European NGOs
4.0.4.1. European environmental NGOs
4.0.4.2. European consumer NGOs
4.0.4.3. Other european NGOs
4.0.5. National interest groups
4.0.6. International interest groups
4.0.7. European interest groups
Pre-institutional sector (movements)
Decentralized systems (Networks)
Short-term, temporally discrete events (Plateaus)
Individual actors
Consumer
Learners
5.1.1. School pupils
5.1.2. University students
5.1.3. Vocational School students
5.1.4. Life-long-learners
Citizens
Sportspeople
5.3.1. Surfers
5.3.2. Divers
5.3.3. Boaters

Annex 2. Agri-food value chain causing eutrophication of aquatic ecosystems. *Actors and activities of economic sectors for fertilizers value chain, exchanged resources and products, economic sectors for simplified crop and meat value chain and flows and pathways between these actors that lead to an enrichment of aquatic ecosystems with nitrogen and phosphorous and eventually to their eutrophication.*



Economic sectors for fertilizers value chain; excluded related sectors: energy, storage, construction

Resources/products exchanged

Economic sectors for simplified crop and meat value chain

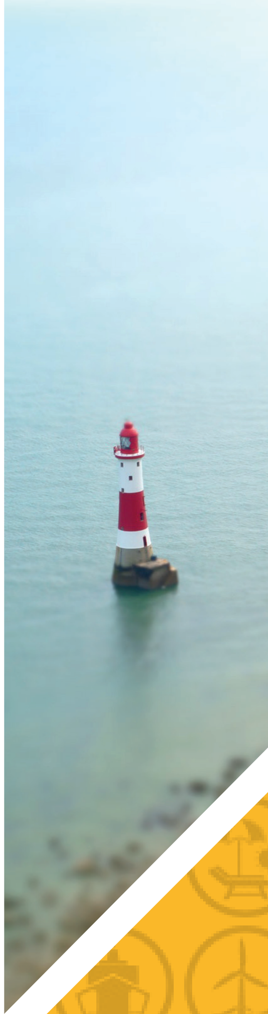
* Livestock farmers are also the direct source of N & P into the Baltic Sea

** Crop farmers provide crop to livestock farmers

Annex 3. Identification of activities and actors related to the agricultural value chain following the ResponSEAble classification.

ResponSEAble classification of Activities	ResponSEAble Classification of actors	Key Actors
Agriculture: Crop and animal production, and related service activities	Professional framework: Primary sector	Livestock farmers (animal producers)
		Crop farmers (producers)
Fishing	Professional framework: Primary sector	Fishermen
Manufacturing: Manufacture of food products	Professional framework: Secondary sector	Food industry (manufacturers)
Manufacturing: Manufacture of basic chemicals, fertilisers and nitrogen compounds, plastics and synthetic rubber in primary forms	Professional framework: Secondary sector	Fertilisers production
		Organic fertilizers' producers
Manufacturing: Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations	Professional framework: Secondary sector	Cosmetic industry
Transportation and Storage	Professional framework: Tertiary sector	Transportation sector
Trade: Wholesale	Professional framework: Tertiary sector	Wholesale food and beverage chains
		Wholesalers and distributors of organic and mineral fertilizers
Trade: Retail	Professional framework: Tertiary sector	Shops and markets (retail)
Accommodation and Food Service Activities: Restaurants and mobile food service activities	Professional framework: Tertiary sector	Restaurants (Food and beverage service providers)
Arts, Entertainment and Recreation	Professional framework: Quaternary sector	Tourism and recreation industries
Scientific research and development	Professional framework: Quaternary sector (Knowledge Sector)	Scientific community (scientific knowledge providers)
Information and Communication: Publishing of books, periodicals and other publishing activities	Professional framework: Tertiary sector	Media (Print publishing service providers; Electronic media publishing service providers; Online media publishing service providers)
Information and Communication: broadcasting activities		Media (Broadcasting service providers)
Information and Communication: Motion picture, video and television programme activities		Media (Motion picture video and television producers)
Consumption and Household Activities	Individual actors: consumers	Private households (regional)
Consumption and Household Activities	Individual actors: consumers	Private households (EU)
Consumption and Household Activities	Individual actors: consumers	Private households (third countries)

	Regulative framework: regulators and administrators	Decision-makers of various levels (agri)
	Regulative framework: administrators	Municipalities
	Social framework: Institutionalized sector	NGOs
	Social framework: Institutionalized sector	Labelling and certification companies
	Social framework: Interest groups	Local communities



KEY STORY

The story of eutrophication and agriculture of the Baltic Sea

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The note builds on the ideas and contributions from different partners of the project and is a living document as the project progresses.