Project: Integrated Nitrogen Management System for the Gulf of Riga (GURINIMAS)

Report of the activities under T3.1

GURINIMAS
Integrated nitrogen management system for Gulf of Riga

Responsible partner: PP4

Authors: Inga Grīnfelde, Laima Bērziņa, Arvo Iital, Linda Fībiga, Arta Bārdule, Solveiga Kadiķe, Ilga Kokorīte, Aiga Krauze, Anete Kubliņa, Argo Kuusik, Dagnija Lazdiņa, Enn Loigu, Karin Pachel, Alvina Reihan, Emīls Rubīns, Viktoria Voronova

Contents

1. Introduction

Water quality of the Gulf of Riga is impacted by economic activities both in Estonia as well as in Latvia. The good status for the gulf, including coastal waters is not yet achieved because of excessive nutrients in water bodies. Nitrogen can provide lots of benefits in food production and industrial products, for example, fertilisers. It can also be the unwanted side product in case of nitrogen emissions to air or discharges to water. Excessive nitrogen loads coming from many land-based sources, within and outside the catchment area of the Baltic Sea Region states, is one of the main causes of eutrophication in the Baltic Sea. Excess nitrogen have effects not only to water systems, but also to terrestrial systems and atmosphere expressed, for example, by ozone induced injuries to crops, acidification and eutrophication effects on forest, soils and freshwater aquatic systems, leaching, eutrophication and hypoxia in coastal and lake ecosystems, etc.

Measures to cut the nitrogen load have been targeted to agricultural, industrial, energy sectors and urban areas that are the main sources of nitrogen in the Baltic Sea catchment area.

The objective of project GURINIMAS is in close cooperation between Estonian and Latvian authorities and research institutions to develop methodology for reducing nitrogen load into the Gulf of Riga. The protection and enhancement of marine environment of the Baltic Sea Area, including the Gulf of Riga, are tasks that cannot effectively be accomplished by national efforts alone but by close regional cooperation. Both countries have a common goal of reduction of nitrogen input in the Gulf of Riga.

The study results provide the opportunity for Estonian and Latvian authorities for more integrated nitrogen management system to plan and implement measures to reduce nitrogen load in coherent way and to reduce nutrient load in the Gulf of Riga.

The implementation of the Integrated Nitrogen Management system will be based on the existing river basin management plans and marine strategies and in frames of the existing bilateral and regional cooperation arrangements.

Main activities in order to achieve project objectives include:

1) Developed methodology for assessment of nitrogen flows based on the OECD research methodology and suitable for Baltic Sea area.

The study aimed to assess exchange of “reactive” nitrogen (Nr) between economic sectors, human settlements and the natural environment in Latvia and Estonia by applying material and substance flow analysis (MFA, SFA) at national scale. The defined system boundary is the territory of Latvia and Estonia including the costal sea as a recipient of riverine and wastewater load of Nr and the atmosphere. All major input and output flows of Nr to and from the defined 12 pools for 2014 in Estonia and mean flows for the years 2012-2016 in Latvia are accounted and analyzed. Compiling and balancing of the nitrogen budget also required assessment of the input and output flows of highly stable N2 to and from the pools, although these flows are not problematic for the environment. N2 could enter the nitrogen cycle by “fixation” by bacteria in soil and water as well as by bacteria that live in symbiosis with leguminous plants. Another pathway is fixing of atmospheric N2 during combustion. Transformation of reactive nitrogen i.e. NOx and NH3 back into N2 closes the nitrogen cycle. These output flows occur from denitrification by denitrifying bacteria, combustion and treatment of exhaust gases. Annexes 1 and 2 to report “Comparative overview of reactive nitrogen (Nr) flows in Latvia and Estonia” provide description of the methodology for assessment of specific Nr flows by pools in Latvia and Estonia (Annex 1. Reactive nitrogen flow by pools in Latvia; Annex 2. Reactive nitrogen flow by pools in Estonia).

2) Composing of nitrogen budget for the defined 12 pools, evaluation and interpretation of research results.

The largest input flows of Nr in Latvia are to agriculture, atmosphere and hydrosphere, accounting 63% of the total input flow to the pools. Moderate proportion of N flows come from food and feed, forest, energy, industry and human settlements pool (31 % from these 3 pools). Rather minor flows of N are related to wastewater, solid waste, aquaculture and transport pools contributing each less than 2 % of the total flow. Major flows (> 50 kT/year) of Nr occur between the stock exchange and agriculture sector (feed for animals and manure back to agriculture sector) and hydrosphere to stock exchange (flow to the Baltic Sea). Big flows of N (30 – 50 kT/year) is also from atmosphere to forest/semi-natural pool, from agriculture to food/feed industry, from stock exchange to hydrosphere pool (transboundary flow), import to and export from atmosphere sector.

The largest input flows of Nr in Estonia are to atmosphere, agriculture and energy pools, accounting 57 % of the total input flow to the pools. Input flow of N to hydrosphere, wastewater and solid waste pools contribute 9% of the total inputs. Rather minor flows of N are related to transport and aquaculture/fishery pools contributing each less than 2% of the total flow. Input of N to aquaculture/fishery pool does not include N flow by imported fish that is assumed to form input to the food and feed industry pool. Major flows of Nr occur between the agriculture and food/feed industry pools due to exchange of food and feed products between these two pools. Considerable flow of Nr is also from industry to energy pool due to input of shale oil and shale gas for energy production. Atmospheric deposition of Nr and N2 fixation by plants as well as transboundary export contributed to considerable N flows between atmosphere and agriculture/forestry pools. Nr emission to atmosphere from industry/energy sectors as well as from the human settlements pool involve N2 emissions from the combustion of fossil fuels, e.g. natural gas, oil shale, shale oil and shale oil gas. Nr emission of environmentally problematic compounds (NOx, N2O, NH3) from these pools form only about 12 % (8 kT/yr) of the total load.

3) Development of the integrated nitrogen management system (GURINIMAS), dissemination of the results to target groups and stakeholders during 3 sectoral seminars in Latvia and Estonia- The result will be presented in final conference in Riga on 13 th September 2019.

The GURINIMAS tool and measures to reduce N flows to the Gulf of Riga provide more integrated nitrogen management system due to described flows between all major economic sectors as well as human consumption and the environment. Final results are compiled further in this document.

Project was implemented by six project partners, two from Estonia and four from Latvia. Project Lead partner is Estonian Ministry of Environment. Project partners: Tallinn University of Technology, Latvia Environment, Geology and Meteorology Centre, Latvian State Forest Research Institute “Silava”, Latvian Institute of Aquatic Ecology and Latvia University of Life Science and Technology.

2. Short overview about the Nitrogen cycle

Nitrogen (N) is a key nutritional element for any life form on earth. The nitrogen cycle is a complex biogeochemical cycle in which nitrogen is converted from its inert atmospheric molecular form N_2 into form that is useful in biological processes.

INACTIVE NITROGEN is gaseous dinitrogen (N_2), it is inert and very stable nitrogen molecule in air that only few organisms can use. The triple bond between nitrogen atoms is very strong and requires a lot of energy to separate them and form reactive nitrogen compounds. The pure air in the atmosphere consists of nitrogen (78%), oxygen (21%) and small amounts of other elements (argon, carbon dioxide, neon, etc.).

$$N \equiv N$$

Strong triple bond in the dinitrogen molecul

REACTIVE NITROGEN (Nr), in other words biologically available nitrogen comprises a variety of active nitrogen compounds in the biosphere and atmosphere.

Inorganic reactive nitrogen compounds are e.g. ammonia (NH_3), ammonium (NH_4+), nitrogen oxide (NO), dinitrogen oxide (NO_2), nitrate (NO_3), nitrous oxide (N_2O, named laughing gas).

alkaline $NH_3 \leftrightarrow NH_4^+$ acid

pH high   pH neutral or low

$$NO \leftrightarrow NO_2 \leftrightarrow NO_3$$

$$N_2O$$

Ammonia (NH_3) is a gaseous toxic form of nitrogen with pungent odor. Ammonium (NH_{4+}) is an ionized nontoxic unstable form of ammonia. In water ammonium and ammonia exist in equilibrium. The equilibrium is very dependent on pH and depends also on temperature. Higher pH and temperature favouring the formation of a molecular ammonia (Purwono et al, 2017).

Organic reactive nitrogen compounds are in live organisms (e.g. proteins, amines, urea), in dead organic material (incl. decay, humus, peat, dead trees in forest, sediment in water bodies). As a result of degradation of complex organic substances into simpler molecules forms at least ammonia (NH_3). Large amounts of immobile organic nitrogen compounds are in fossil organic matter in earth’s crust.

The cycling of the element nitrogen from non-living surroundings through organisms and back again into air is simplified pictured in the figure 2.1.

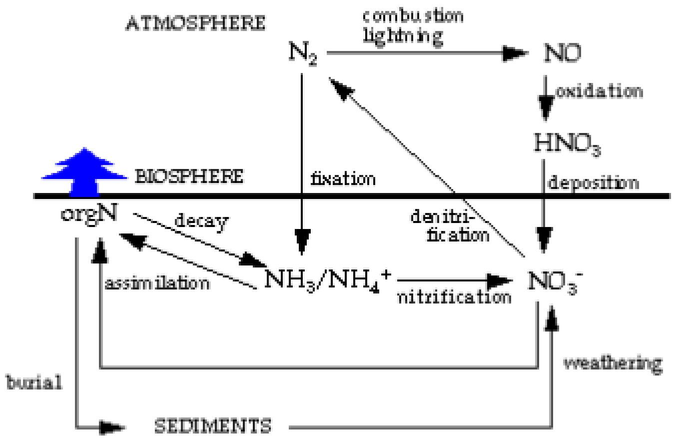


Figure 2.1. The Nitrogen cycle, major processes (Jacob 1999).

In the nitrogen cycle take place a number of basic biochemical reactions. Following itemised basic nitrogen reactions based on Olli 2010:

NITROGEN FIXATION is process, where atmospheric nitrogen is converted into ammonia (NH_3). It is divided into natural and anthropogenic nitrogen fixation.

Natural nitrogen fixation: 1) biological nitrogen fixation by prokaryotes (some bacteria living free or in symbiotic relationship with some plants, including blue-green algae and archaea) using the enzyme nitrogenase; 2) production of NOx by lightning.

Bacteria, archaea + N_2 → NH_3 ↔ NH_4+ (process needs energy)
nitrogenase

Lightning → N_2 + O_2 → product is NO

Anthropogenic nitrogen fixation: 1) the Haber-Bosch process produces ammonia from atmospheric nitrogen and hydrogen under high temperature and pressure (since 1912), ammonia is important part of the nitrogen fertilizers for agriculture; 2) combustion processes release nitrogen from organic matter (e.g. fossil fuel), fixes also N_2 from the air and lead to emissions of NO, NO_2.

the Haber-Bosch process: N_2 + H_2 → product is NH_3

combustion: organic N-compounds, N_2 from air → NO ↔ NO_2

NITRIFICATION: Two-step biological oxidation of ammonium to nitrite/nitrate by bacteria.

I Bacteria (*Nitrosomonas*) + NH_4+ → NO_2
energy for bacteria

II Bacteria (*Nitrobacter*) + NO_2 → NO_3 (aerobic process)
energy for bacteria

AMMONIFICATION: Degradation of organic matter, bacterial conversion of compounds containing nitrogen to ammonium.

Bacteria + organic matter → NH_4^+ (energy for bacteria)

DENITRIFICATION: Bacteria transforming nitrates back to unreactive inert dinitrogen molecula N_2 (in this process arise also some reactive nitrogen compounds like N_2O).

Bacteria + NO_3 + organic matter → N_2 + N_2O e.g.
(anaerobic condition)

Figuratively speaking denitrification process ends the nitrogen cycle.

NITROGEN CASCADE (Figure 2.2.). Anthropogenic reactive nitrogen (Nr) circulates in the biosphere, in the atmosphere, in terrestrial ecosystems, in freshwater and marine systems. Human activities, e.g. agriculture, industries and transport have dramatically altered the nitrogen balance, breaking into the vast reservoir of molecular nitrogen and releasing reactive forms into the environment (An International, s.a.). Fowler et al. (2013) and Stevens (2019) note that over the past century, the amount of Nr from human activities has increased to such an extent that it now exceeds natural fixation, resulting in a more than doubled global cycling of nitrogen. Excess of reactive nitrogen is causing environmental and health problems. Major causes of excess nitrogen are high emissions from agriculture, in particular fertilizer and animal waste and high combustion of fossil fuels (Stevens 2019). Harmful attendant effects are among the others poor air quality, polluted inland and coastal waters from leaching and atmospheric deposition (Stevens 2019).

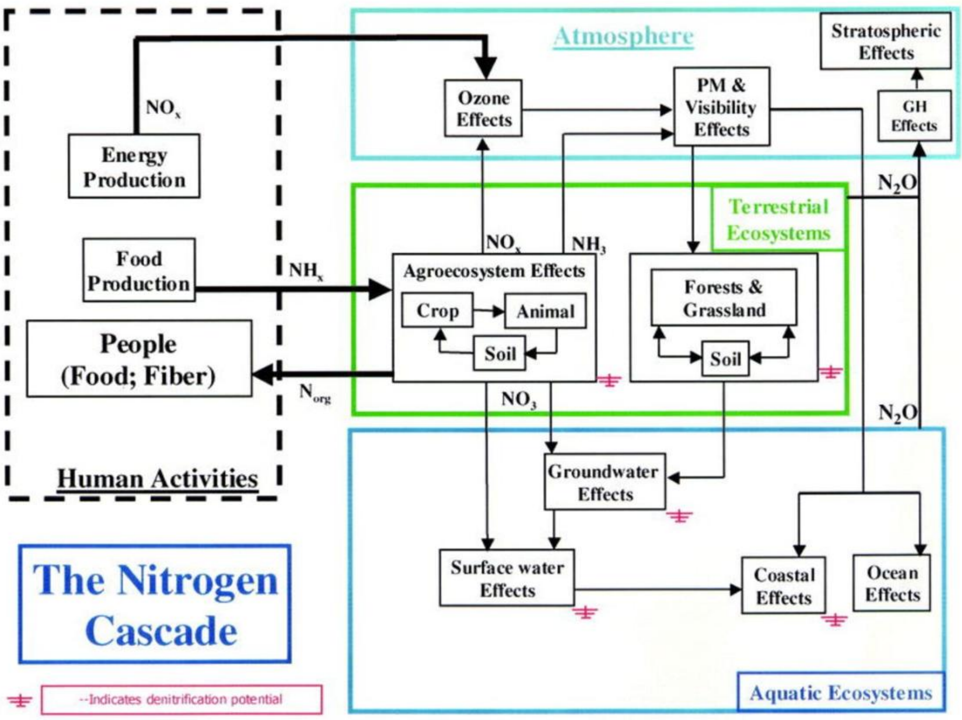


Figure 2.2. Illustration of the nitrogen cascade showing the sequential effects of nitrogen compounds in various reservoirs (Galloway, 2003).

Stevens (2019) brings out that one of the major consequences of increased Nr availability has been an increase in atmospheric deposition of Nr.

The highly reactive compounds (NOx and aerosol, NH_3, NH_4) have atmospheric lifetimes ranging from a few hours (NH_3, HNO_3) to aerosols, which have lifetimes owing to removal by precipitation of a few days to a week (Figure 2.3.) (Fowler et al., 2013). Fowler et al. (2013) notes that reduction in emissions of Nr to the atmosphere would lead to a rapid reduction in most compounds in air and effects on climate and human health would cease after a period of a few weeks (except for effects of N_2O).

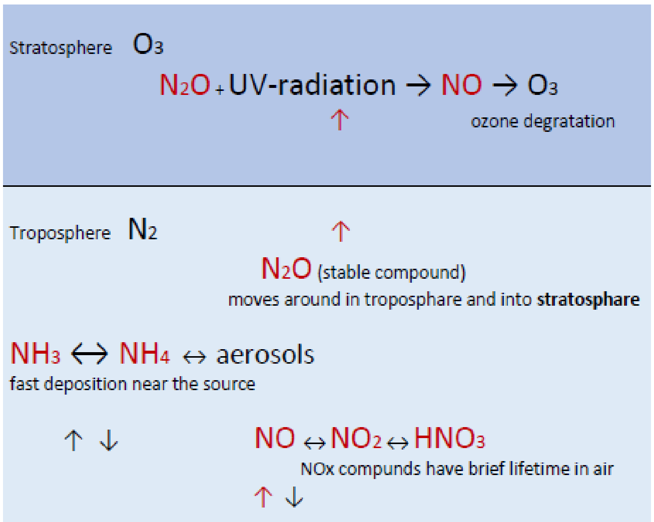


Figure 2.3. Reactive nitrogen compounds in air (compiled according to Olli 2010).

Most of the anthropogenic perturbation of the nitrogen cycle is driven by activity on land, both through the use of Nr in agriculture and through industry, electricity generation and transport (Fowler et al., 2013). In terrestrial ecosystems, the additional N_r leads to enhanced quantities of N_r cycling between vegetation and the soil, with the main removal process being leaching as NO_3 to ground water and denitrification as N_2 back to the atmosphere (Fowler et al., 2013). Major flows of reactive nitrogen (nitrate NO_3) move by riverine transport to coastal waters and the open see. Stevens (2019) notes that Earth's nitrogen cycle has been hugely perturbed at a global scale and there is an urgent need to address the problem of excess Nr in our environment.

3. Estimated local reactive nitrogen loads on catchment area of Gulf of Riga in Estonia and Latvia

Maximum Allowable Inputs of nitrogen (MAI) to the Gulf of Riga adopted in 2013 are 88 418 tons, out of it total loads from Latvia should not exceed 53898 tons and those from Estonia – 13029 tons (HELCOM, 2013; Svendsen et al., 2018). There are no requirements for reduction of N load to the Gulf of Riga, but countries must not increase the loads. According to data from 2014, both Latvia and Estonia have fulfilled HELCOM requirements regarding total N input to the Gulf of Riga, but trend analysis do not show statistically significant decrease of nitrogen loads. In 2016 MAI for Gulf of Riga was exceeded by 105 % or 4136 tons (Svendsen et al., 2018). It should be mentioned that nutrient loads are influenced by water flow to a great extent, therefore HELCOM uses flow-normalized loads in their assessments.

3.1. Nitrogen loads from the territory of Latvia

Concentrations of nitrogen compounds are monitored in five largest rivers of Latvia discharging into the Gulf of Riga: Daugava, Lielupe, Gauja, Salaca, and Irbe. Actual total N loads to the Gulf of Riga from the territory of Latvia varies from 36 000 to 88 000 tons per year (Figure 3.1.1). Highest loads are usually observed in high-water years.

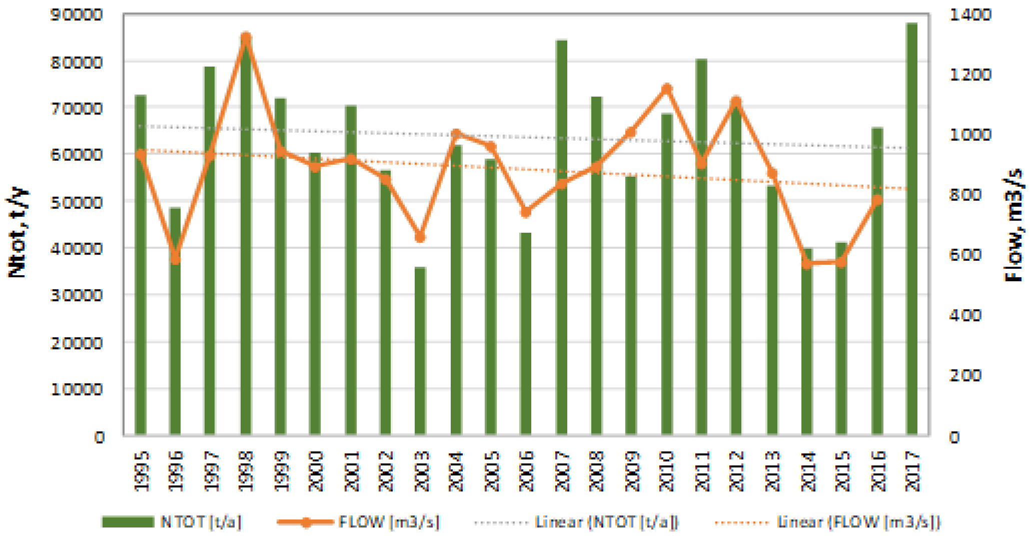


Figure 3.1.1. Changes of water flow and total nitrogen load to the Gulf of Riga from the territory of Latvia (1995-2017).

River flow and total nitrogen loads both to the Gulf of Riga do not show any statistically significant linear trends (Table 3.1.1). Total nitrogen load in the largest river flowing into the Gulf of Riga, the Daugava River, is decreasing by almost 570 t/y, but this trend is not statistically significant. On the other hand, total nitrogen load of the Lielupe River is increasing by 240 t/y, and N-NO_3^- loads – by 260 t/y (Table 3.1.1, Figure 3.1.2). Although these trends are not significant, precautionary measures should be taken within the Lielupe basin, because intensive agriculture practices are taken place here. It should be mentioned that statistically significant increasing concentrations of Ntot and N-NO_3^- are observed in the Lielupe River. Most of the Lielupe catchment in Latvia is also designated as a nitrate vulnerable zone. Both ammonium loads and concentrations in Lielupe River show a significant decreasing tendency. This probably could be explained by measures to decrease pollution from point sources (e.g., WWTPs, farms).

Table 3.1.1. Sen's slope estimates (units/year) for yearly average water flow and loads of nitrogen compounds during 1995-2017*.

River, station	Flow, m^3/s	N_{tot}, t/y	$N\text{-}NH_4^+$, t/y	$N\text{-}NO_3^-$, t/y	N_{tot}, mg/l	$N\text{-}NH_4^+$, mg/l	$N\text{-}NO_3^-$, mg/l
Daugava at Lipši	-1.56	-568.25	-26.98	-281.83	-0.004	0.000	0.004
Gauja, river mouth	0.45	-55.80	-1.66	-27.89	-0.005	0.000	0.003
Salaca, river mouth	0.32	16.54	0.43	9.70	0.010	0.000	**0.012**
Lielupe down-stream Kalnciems	0.25	239.37	**-14.98**	260.88	**0.099**	**-0.003**	**0.088**
Irbe at Vičaki	0.13	-2.69	0.82	1.01	**-0.008**	0.000	**-0.004**

* in bold – statistically significant linear trend at p<0.05.

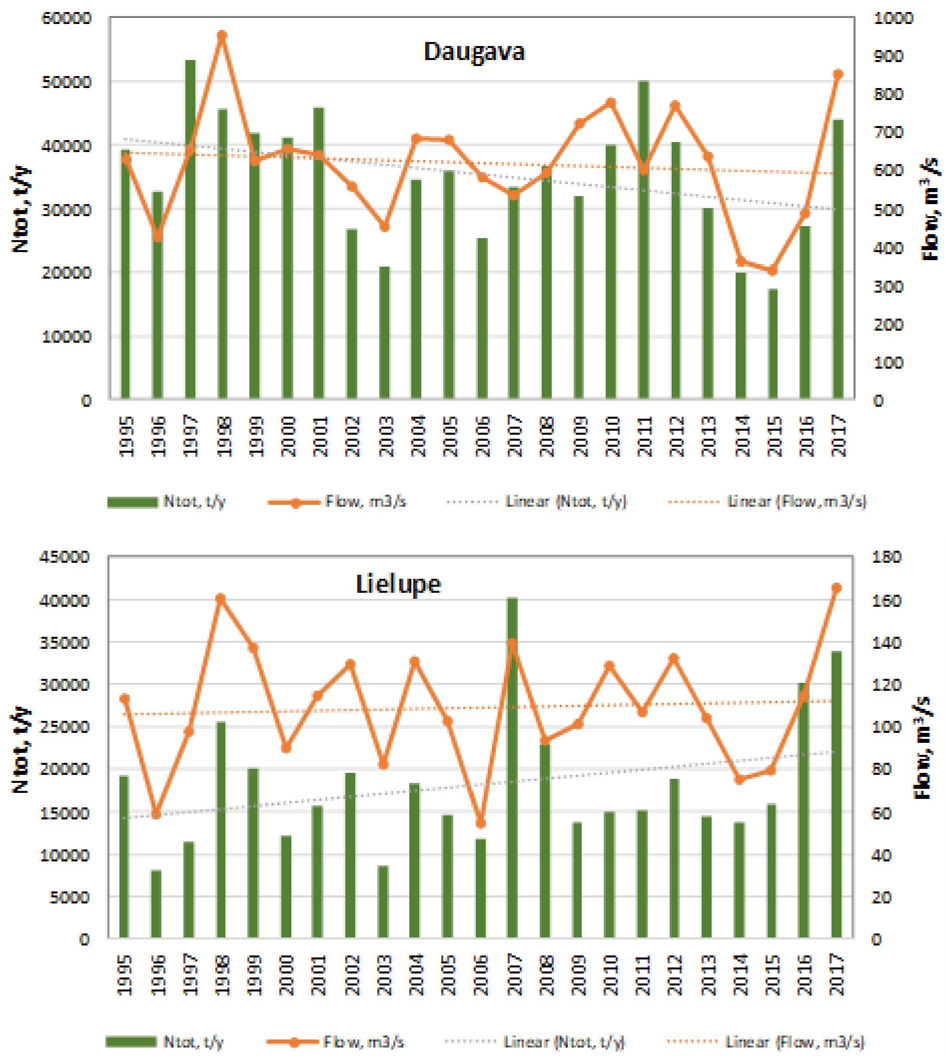


Figure 3.1.2. Changes of water flow and total nitrogen load in Daugava (station Lipši) and Lielupe (station upstream Kalnciems village) Rivers (1995-2017).

Mean annual area-specific nitrogen load of TN that reaches the sea in 2013-2017 are from 3.3 kg/ha in the Daugava River up to 13.1 kg/ha in the Lielupe River basin.

Average use of N fertilizers in 2006 was 30.6 t/ha of utilized agricultural area in Latvia. In 2015, average use of N fertilizers was 53.2 t/ha in Latvia. Despite the remarkable increase in the amount of fertilizer applied for 1 ha (Figure 3.1.3), it is still below the average consumption rates of N fertilizers in EU-28 (74.4 t/ha; EUROSTAT s.a.). Crop yields in Latvia have almost doubled since 2000, indicating more effective nitrogen uptake.

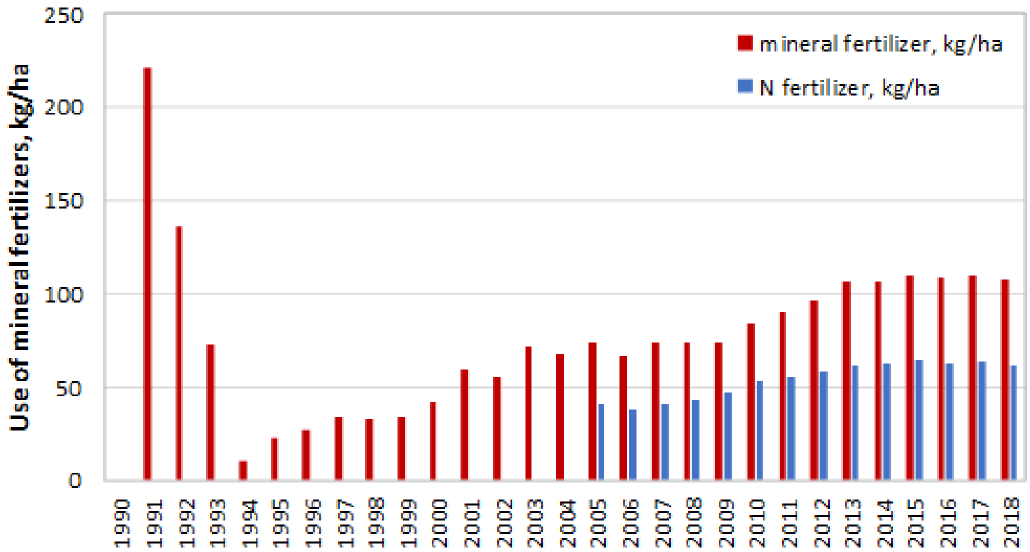


Figure 3.1.3. Use of mineral fertilizers and nitrogen fertilizers in Latvia 1991-2018, kg/ha sown area (Central Statistical Bureau of Latvia and Wegren, 2003).

Climate change impact should also be taken into account when planning measures for nutrient load reduction. Climate change can have an impact on crop yields and agricultural practices, which in turn will influence the losses of nutrients from fields (Oygarden et al. 2014). Extreme weather events, e.g., an intensive rainfall following a drought period, are leading to high losses of nitrogen (Jansons et al. 2011, Oygarden et al. 2014, Lagzdiņš et al. 2015). Increasing air temperatures in winter contribute to precipitation in the form of rain and snow melting and increased water runoff facilitates leaching of nutrients (Kļaviņš et al. 2001, Jansons et al. 2009)

3.2. Nitrogen loads from the territory of Estonia

The river Pärnu has the largest catchment area (6836.5 km2) amongst the rivers discharging to the Gulf of Riga in Estonia. The length of the river is 170.1 km. Downstream part of the river from the Tarbja Dam to the mouth is designated as a valuable fish habitat for salmon, trout, grayling and carp (RTL 2004, 87, 1362; RT I 09.07.2016 1; RTL 2002, 118, 1714; RT I, 29.07.2011, 25)

Long-term trend analysis of TN concentrations by applying the partial Mann-Kendall test (PMK) in the River Pärnu and its tributaries (Klõga and Maharjan, 2015) revealed statistically significant increasing trend at the 5% level since 1992 in 3 hydro-chemical stations out of 6, including the most downstream monitoring station - Pärnu-Oore (Table 3.2.1). The PMK test account for the influence of confounding variables to water chemistry parameters, as water discharge, to assess the trends. Three other stations also indicated increasing tendency in TN content.

Table 3.2.1. PMK statistic and long term trends for TN concentrations at the River Pärnu monitoring stations (Klõga and Maharjan, 2015). Bold type indicates results that are statistically significant at the 0.05 level (two-sided test).

Site no.	River-sampling site	Years monitored	PMK-stat	p-value
35	Pärnu-Tahkuse	1992 - 2015	1.755	0.079
36	Pärnu-Oore	1992 - 2015	**1.969**	**0.049**
37	Vodja-Vodja	1992 - 2015	0.560	0.575
38	Navesti-Aesoo	1992 - 2015	0.502	0.616
39	Saarjõgi-Kaansoo	1992 - 2015	**2.698**	**0.007**
40	Halliste-Riisa	1992 - 2015	**2.010**	**0.044**

Some increase in TN or NO_3-N concentrations have been particularly pronounced in the 2000s (Figure 3.2.1). The study did not reveal any statistically significant trends in discharge in the Pärnu-Oore station over the same time period (Table 3.2.2), although significant increase took place in December (Klõga and Maharjan, 2015). Thus, other factors than water discharge are responsible for increasing trends of the nitrogen content in the river.

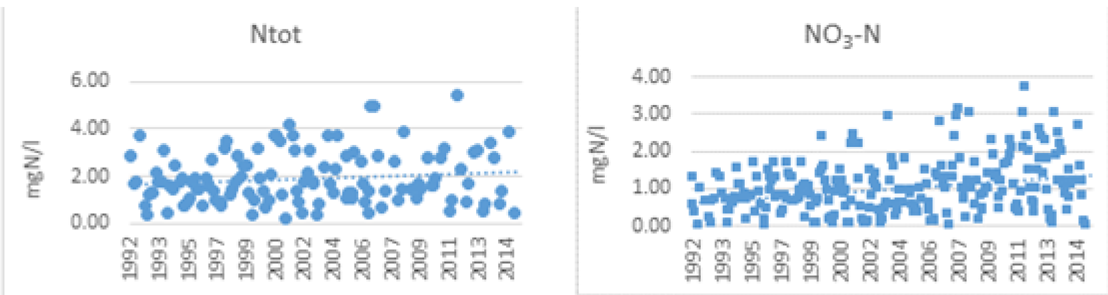


Figure 3.2.1. Concentration of Ntot and NO_3-N at Pärnu-Oore station in 1992-2014.

Table 3.2.2. MK statistic and long-term trend for discharge in the River Pärnu catchment.

No	Station	Years monitored	Annual mean		December
			MK-stat	*p*-value	MK-stat
35	Pärnu-Tahkuse	1992-2015	-0.351	0.725	-
36	Pärnu-Oore	1992-2015	0.575	0.566	2.381

37	Vodja-Vodja	1992-2015	1.332	0.183	-
38	Navesti-Aesoo	1992-2015	0.710	0.478	2.133
39	Saarjõgi-Kaansoo	1992-96; 2011-15	-0.947	0.343	-
40	Halliste-Riisa	1992-2015	0.560	0.576	2.034

Nitrogen load by sewage in the River Pärnu catchment area decreased considerably since 1993 (Figure 3.2.2), although increasing tendency has been detected over the past ten years in the Pärnu River Basin District (RBD). This increase is particularly pronounced for sewage waters from Pärnu WWTP due to increased number of people in Pärnu city that are connected to sewerage system.

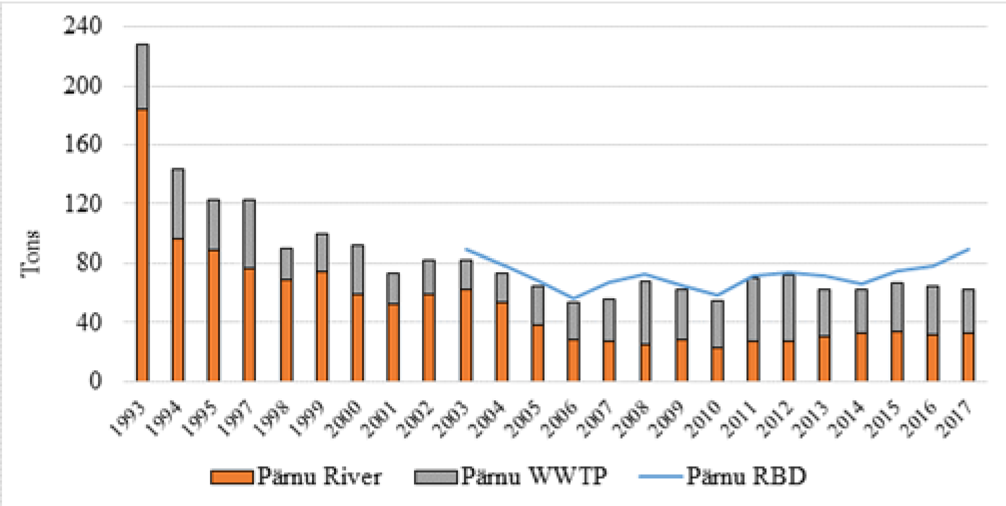


Figure 3.2.2.Nitrogen load by sewage waters to the River Pärnu and in Pärnu River Basin District (RBD) in 1993-2017.

Mean nitrogen load to the Gulf of Riga by the river Pärnu in 2008-2017 was 5364 tons/year (Environment Agency, 2018), that is nearly 1/3rd of the annual riverine load to the sea in Estonia. The load increased since the 1990s (Figure 3.2.3).

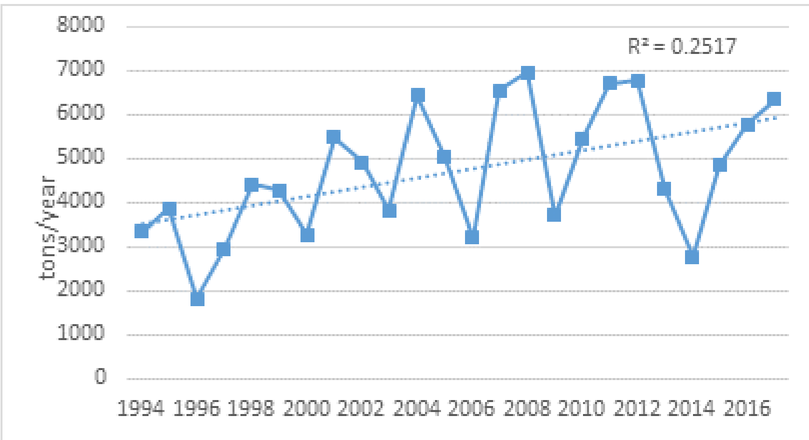


Figure 3.2.3. Nitrogen load to the Gulf of Riga by the River Pärnu in 1994-2017 (Environment Agency, 2018).

Flow normalized nitrogen runoff in the river Pärnu in 1994-2017 also indicates increasing trend (Figure 3.2.4) and rather rapid increase can be seen in the 1990s followed by stabilization of the TN loads to the sea.

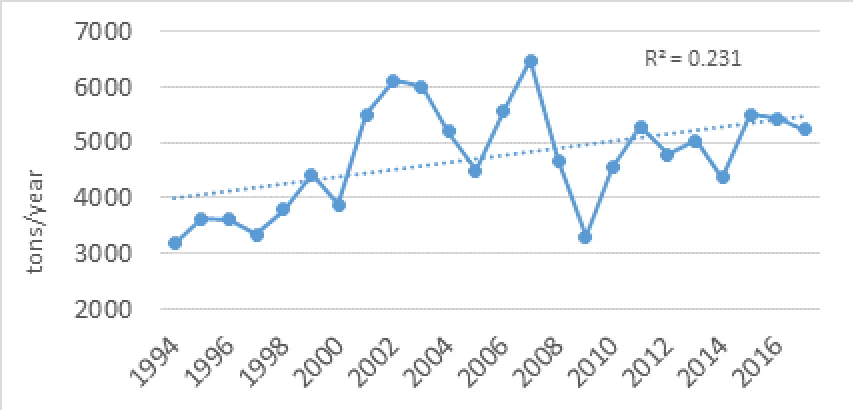


Figure 3.2.4. Flow normalized nitrogen runoff in the river Pärnu in 1994-2017 (Environment Agency, 2018).

Mean annual area-specific nitrogen load of TN that reaches the sea in 2008-2017 is 8 kg of nitrogen per ha of the Pärnu river catchment area (Figure 3.2.5).

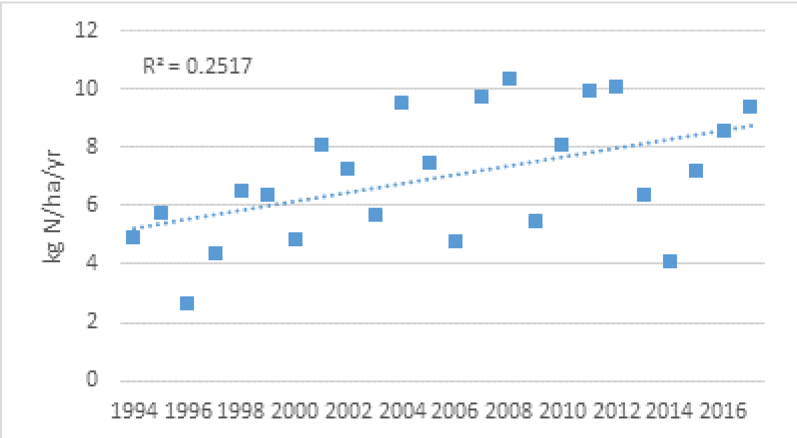


Figure 3.2.5. Mean annual area-specific nitrogen load to the sea in Pärnu River catchment in 2008-2017.

About 60% of the Pärnu river catchments is forest and wetlands and the share of agricultural land is more than 35% (Table 3.2.3).

Table 3.2.3. Main characteristics of the Parnu River catchment area.

River/ sampling site	Catchment area, km^2	Population density (inh./km^2)	Land type			
			Forest (%)	Wetlands, other natural (%)	Agricultural (%)	Arable (%)
Pärnu/Tahkuse	2077	17.7	49.9	10.4	38.1	24.1
Pärnu/Oore	5154	17.7	49.8	12.4	36.3	20.5

Sauga/Nurme	546	11.1	46.9	21.5	30.6	18.7
Navesti/Aesoo	1008	10.6	49.2	13.9	35.9	20.1
Halliste/Riisa	1884	15.2	52.3	13.6	32.9	16.1
Reiu/Lähkma	548	12.2	64.8	15.2	19.3	8.6
Saarjõgi/Kaansoo	191	2.9	62.8	15.8	21.4	14.7

The area of actually used agricultural land in Pärnu county increased by about 13% and the area of arable land by nearly 18% since 2004 (Statistics Estonia). The use of nitrogen fertilizers and manure in the Pärnu River catchment show increasing trend since 2007 (Figure 3.2.6). The yield of field crops in Pärnu county almost doubled since 2004, indicating considerably higher efficiency of plant nutrients use. These changes in landuse contributed to stabilization of nitrogen content in the river as well as the nitrogen runoff.

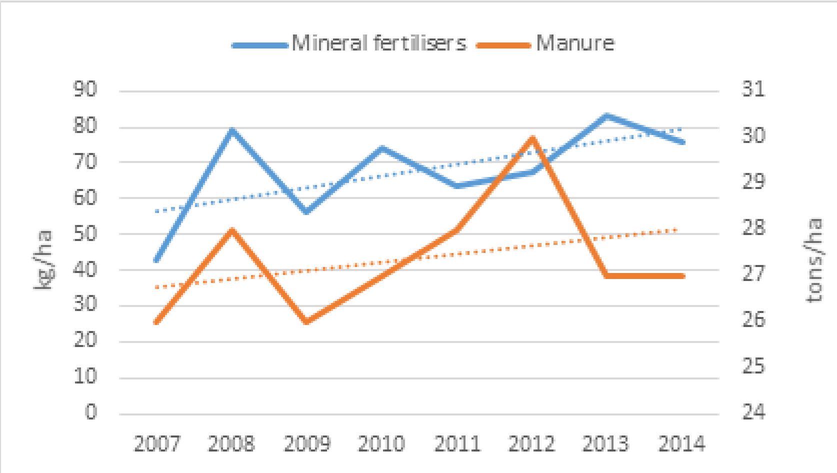


Figure 3.2.6. Use of nitrogen fertilizers and manure per ha of actually fertilized area in Pärnu county in 2007-2014 (Statistics Estonia).

4. Actual status of Gulf of Riga

The Gulf of Riga (GoR) has limited connection with the Baltic Proper. The mean depth of the GoR is 30 m (Stigebrandt ja Wulff, 1987). These conditions determine relatively high concentrations of nutrients in the Gulf that exceed the level in the open sea by two times (Martin, 2017[1]) The salinity is 4−6 PSU in the east part and 5−7 PSU in the west part of the Gulf (*ibidem*). In the figure 4.1. there is pictured the location of monitoring stations for Gulf of Riga for Latvia and Estonia.

Figure 4.1. Network of monitoring stations in the Gulf of Riga in Estonia and Latvia (state monitoring programs for both countries).

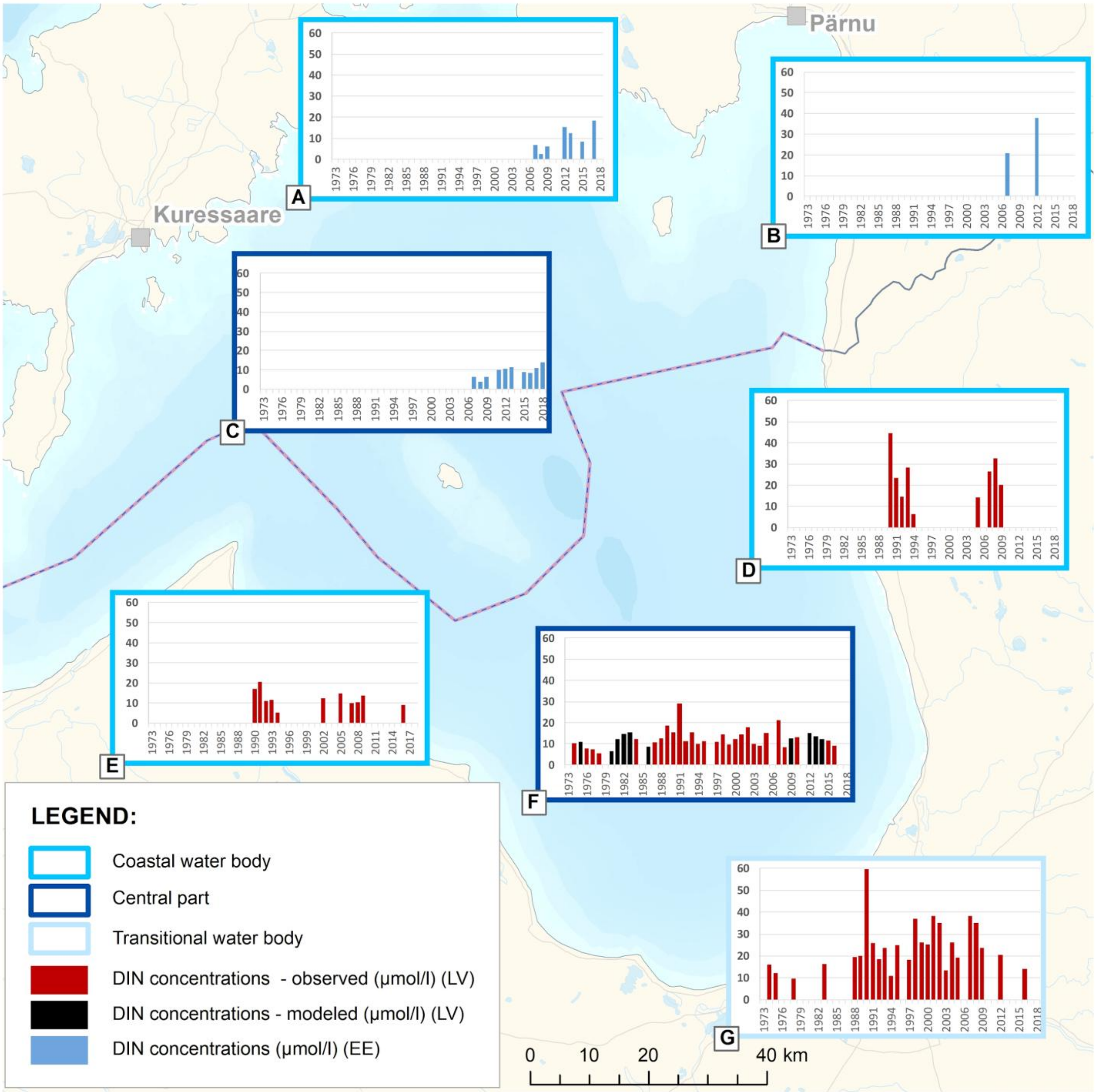


Figure 4.2. Long-term average winter concentrations of dissolved inorganic nitrogen (DIN) in the Gulf of Riga in Estonia and Latvia. In Estonia: A - coastal part, B - Pärnu bay, C - central part. In Latvia: D - eastern coast, E - western coast, F - central part, G - transitional waters of rivers Lielupe, Daugava and Gauja (source for Estonian data: KESE, for Latvian: SMHI)

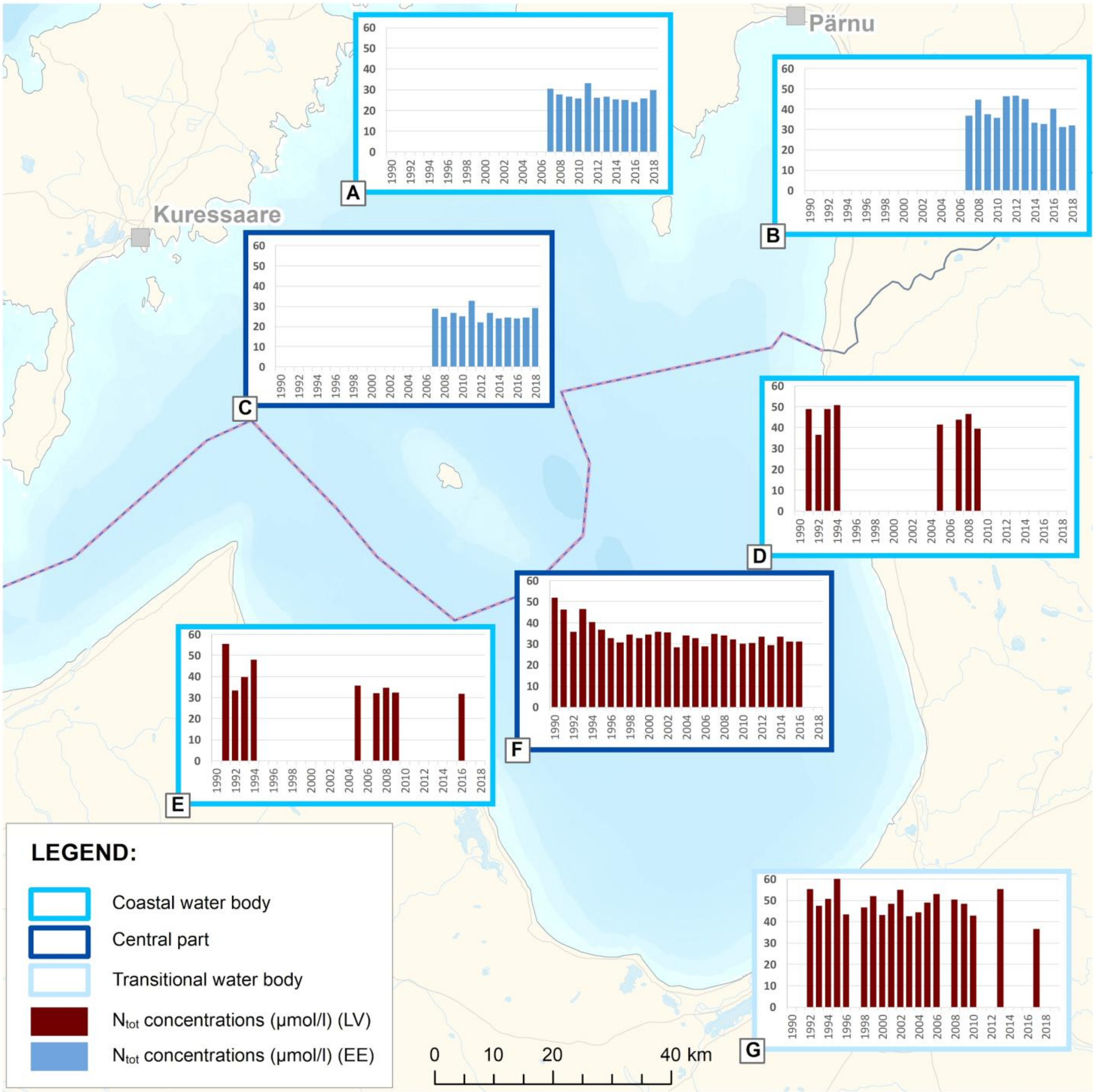


Figure 4.3. Long-term annual mean concentrations of total nitrogen (N_{tot}) in the Gulf of Riga in Estonia and Latvia. In Estonia: A - coastal part, B - Pärnu bay, C - central part. In Latvia: D - eastern coast, E - western coast, F - central part, G - transitional waters of rivers Lielupe, Daugava and Gauja (source for Estonian data: KESE, for Latvian: SMHI)

4.1. Status of the Gulf of Riga - Latvia

<u>Legislative framework for assessment and trends</u>

Assessment of the actual status of the Gulf of Riga and other parts of Baltic Sea was developed in accordance with Article 17(2)(a) of Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for Community action in the field of marine environmental policy (Marine Strategy Framework Directive).

Good environmental status of the marine environment (hereinafter referred as "GES") is defined on the basis of the qualitative characteristics set out in Annex 1 to the Directive.

The evaluation of eutrophication of the Gulf of Riga is based on indicators which, according to EC Decision 2017/848 of 17 May 2017, are combined into groups for the open parts of the Baltic Sea and the Gulf of Riga.

Two indicators are set for the nitrogen – dissolved inorganic nitrogen (DIN) and total nitrogen (Ntot). The indicator DIN (dissolved inorganic nitrogen) represents a winter (January-March) season where biological activity is low and virtually all nitrogen used to grow algae is in the form of dissolved inorganic compounds in the water column. The indicator Ntot is representative throughout the year and include both inorganic and organic forms of nitrogen compounds. These indicators therefore describe the overall enrichment of the marine ecosystem with nutrients (nutrients), both river and point source input, both atmospheric decomposition and atmospheric nitrogen assimilation. The importance of these indicators has increased significantly in recent years, as climate change has led to a change in the seasonal mode of river runoff.

The limit values for the indicators used have been agreed by HELCOM Member States at the meetings of Heads of Delegation (HOD 39-2012 for Dissolved Inorganic Nitrogen (DIN) and HELCOM 38-2017 for total nitrogen).

In coastal and transitional waters, the assessment is based on indicators and limit values developed for the purposes of the Water Framework Directive (2000/60/EC).

Long-term trends in dissolved inorganic nitrogen concentrations

Data about dissolved inorganic nitrogen during the winter season in the open and transitional waters of the Gulf of Riga are available from 1974 onwards. The reconstructed nitrogen concentrations for the Gulf of Riga show that a significant increase in concentrations starts in the 1950 s (Gustafsson, etc. 2012) and reaches maximum values in 1989 (Figure 4.1.1). A decrease in concentrations is observed in subsequent years. At the same time, it should be noted that the increase in long-term concentrations and the reduction in coastal water cannot be assessed because the observations have been made fragmentarily. Observed concentrations in the Gulf of Riga are considerably higher than in the Baltic sea open part in the whole period of observations.

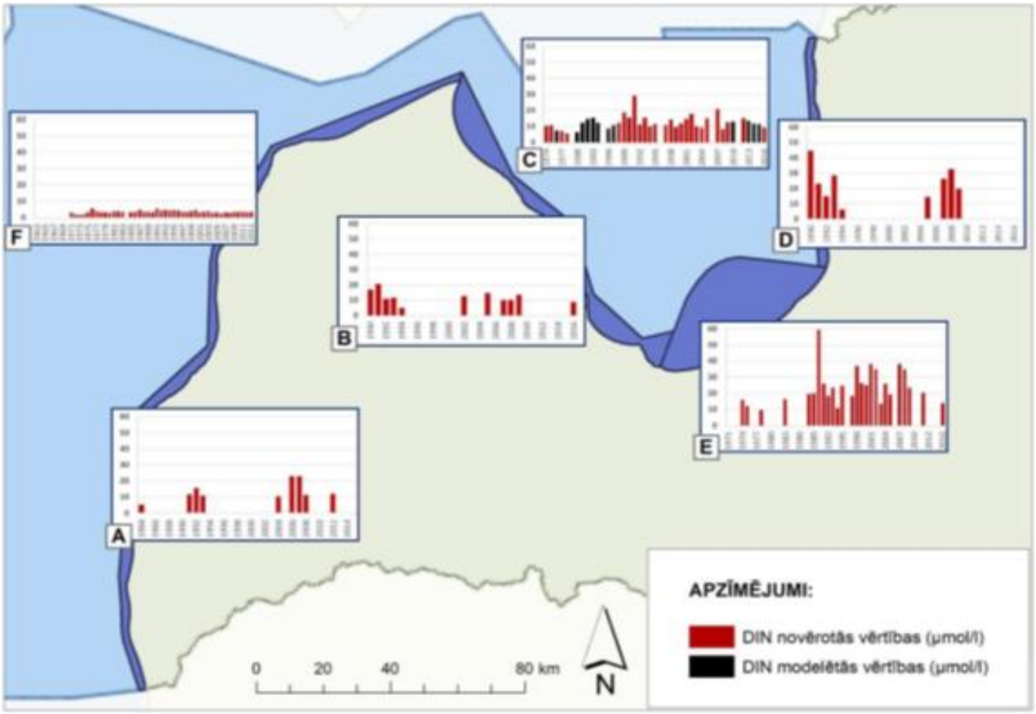


Figure 4.1.1. Long-term average winter concentrations of dissolved inorganic nitrogen (DIN) in the Gulf of Riga and the Baltic Sea. A - coastal part of the Baltic Sea, B - western coast of the Gulf of Riga, C - central part of the Gulf of Riga, D - eastern coast of the Gulf of Riga, E - transitional waters, F - open part of the Baltic Sea (SMHI).

For the evaluation of the trends two subsequent assessments were developed – for the periods 2007-2011 and 2011-2016. Results of the assessment of both above mentioned periods and trend for DIN are shown in Table 1.

Table 4.1.1. Winter season dissolved inorganic nitrogen (DIN) (µmol L^{-1}) limit values, assessment and previous average values, trends, and confidence level of assessment (green cells mean GES, red – not GES)

Water object	Limit value	Period		Trend	Confidence level of assessment
		2007-2011	2012-2016		
Open part of the BS	2.5[1]	3,32	3,34	←→	Low
Coastal part of the BS	8[2]	19,08	12,08[3]	↘	Low
Western coast of the GoR	11[2]	11,26	9,01[3]	↘	Low
Central part of the GoR	5.2[1]	13,82	12,25	↘	Low
Eastern coast of the GoR	11[2]	26,43	-	-	Low
Transitional waters[4]	14[2]	32,30	17,20	↘	Low

[1] HOD 39-2012

[2] Directive 2000/60/EC

[3] Based on one-year data

[4] Influenced by rivers Lielupe, Daugava and Gauja

Long-term trends in total nitrogen concentrations

The results of the annual average nitrogen concentrations observed in the Gulf of Riga with some interruptions are available from 1990-ies. Data about the open parts of the Baltic Sea in the waters from 1970-ies and in the coastal waters as of 1990-ies. The observed increase in concentrations in the open part of the Baltic Sea to the 1990s (Figure 4.1.2.) is well in line with the increase in winter DIN concentrations. However, unlike winter DIN, there is no tendency to decrease in total nitrogen concentrations after 1990. However, the concentrations observed in the open waters of the Gulf of Riga in the 1990 s are higher than in the following years. However, it should be noted that the decrease in concentrations stopped at the end of 1990. At the same time, it should be noted that the increase and reduction in long-term concentrations in coastal water sites cannot be assessed as observations have been made fragmentarily.

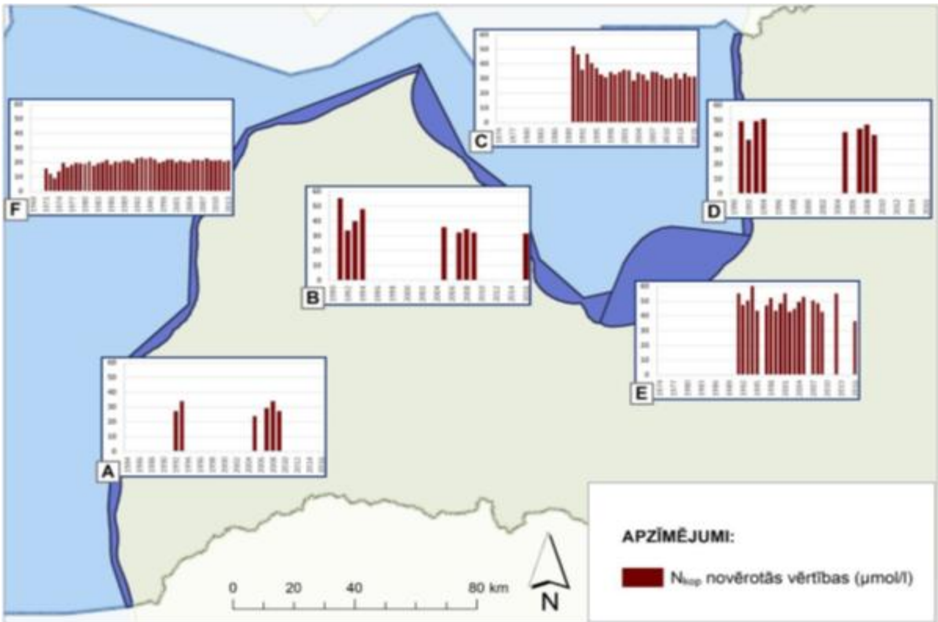


Figure 4.1.2. Long-term annual mean concentrations of total nitrogen (N_{tot}) in the Gulf of Riga and the Baltic Sea. A - coastal part of the Baltic Sea, B - western coast of the Gulf of Riga, C - central part of the Gulf of Riga, D - eastern coast of the Gulf of Riga, E - transitional waters, F - open part of the Baltic Sea (SMHI).

Results of the assessment of trends for N_{tot} in 2007-2016 are shown in the Table 2.

Table 4.1.2. Total nitrogen (N_{tot}) (μmol L^{-1}) limit values, assessment and previous average values, trends, and confidence level of assessment (green – good state, red – not good) and monitoring data (LIAE, 2018)

Water object	Limit value	Long term data (SMHI)		Trend	Conf. level of assessment	Monitoring data, 2018 (LIAE)		
		Period				Season		
		2007-2011	2012-2016			spring	summer	autumn
Western coast of the GoR	35.6[2]	33.2	31.7[3]	←→	Low	33.0–45.5	32.9–44.6	34.1–36.6
Eastern coast of the GoR	35.6[2]	43.3	-	-	-			
Central part of GoR	28[1]	32.4	31.8	←→	Low	24.7–41.3	28.4–39.9	32.9–35.1

Water object	Limit value	Long term data (SMHI)		Trend	Conf. level of assessment	Monitoring data, 2018 (LIAE)		
		Period				Season		
		2007-2011	2012-2016			spring	summer	autumn
Transitional waters	44.1[2]	47.2	45.9	←→	Low	37.4–49.1	32.6–41.0	-
Coast of BS	27.5[2]	30.2	-	-	-	19.7–24.1	24,2–37.3	26.8–40.8

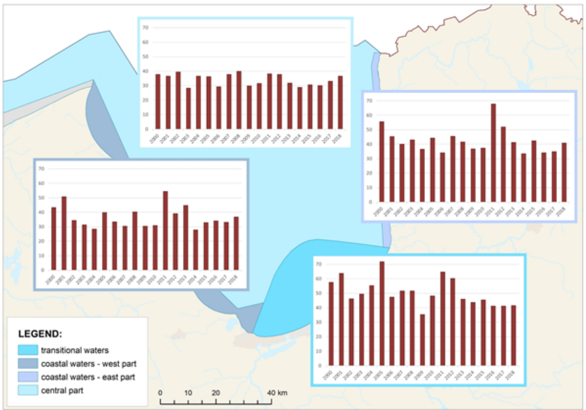
[1] HOD 39-2012

[2] Directive 2000/60/EC

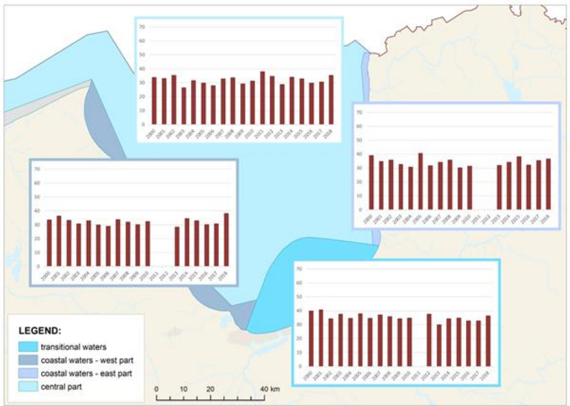
[3] Based on one-year data

N_{tot} data for the period 2000-2018 in all monitoring sites of the Gulf of Riga are shown in the Figure 4.1.3. Long-term trends – nor increasing or decreasing for this period are not observed. Actual data for monitoring sites in 2018 are provided in Figure 4.1.4.

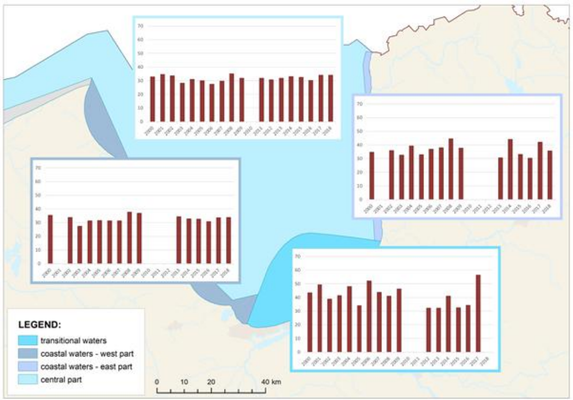
Spring



Summer



Autumn



Winter

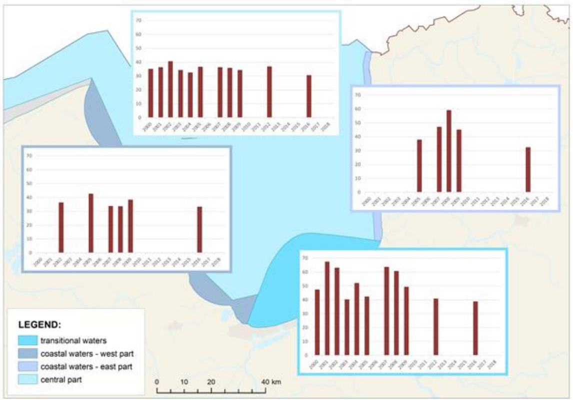


Figure 4.1.3. N_{tot} average concentrations in the Gulf of Riga for the period 2000-2018 for all seasons (LIAE data of marine monitoring for 2000-2018).

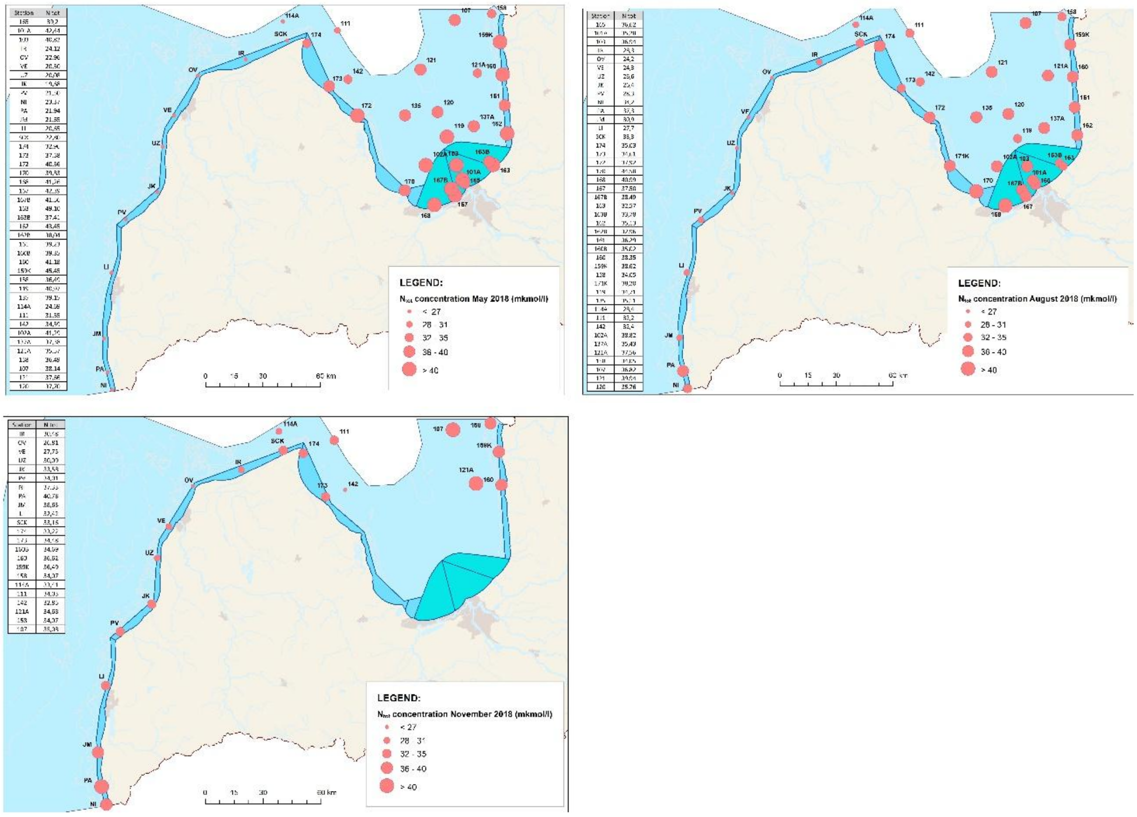


Figure 4.1.4. N_{tot} concentration range for coastal area of Baltic Sea and Gulf of Riga as well as transition zone (influenced by Lielupe, Daugava and Gauja) in spring, summer and autumn of 2018 (average value throughout the whole water layer in each site) (LIAE, 2018)

Riverine loads from the catchment area

Nitrogen loads are highly dependent on the flowrate of the rivers in the year concerned (Figure 4.1.5). Due to the significantly higher level of river flows during the previous period (2007-2011), overall nitrogen loads to the Gulf of Riga were also higher during the previous period than during the second assessment period of 2012-2016. The analysis uses the normalisation of load flow to exclude the effects of interannual variability of rivers. In addition, in the case of Latvia, the total load to the Gulf of Riga is also affected by cross-border transfers from other countries, which are also located in the catchment area of the respective rivers and thus affect the quality of the environment of the respective Baltic Sea basin. In order to compare the changes to the loads occurring in the territory of Latvia, the values of cross-border loads are subtracted from the total loads, as well as the normalisation of loads against river flowrates.

Table 4.1.3. Comparison of nitrogen loads in both assessment periods normalised against river flowrates produced on the territory of Latvia.

Region	**N load (kT/yr**		
	2007–2011	**2012–2016**	**Trend**
Gulf of Riga	43.444	37.167	↘
Baltic Sea	10.106	9.799	↘

Overall, nitrogen load shows a slight declining trend (Table 4.1.3.) that can be explained by the lower river flowrate in 2012-2016 compared to the previous period.

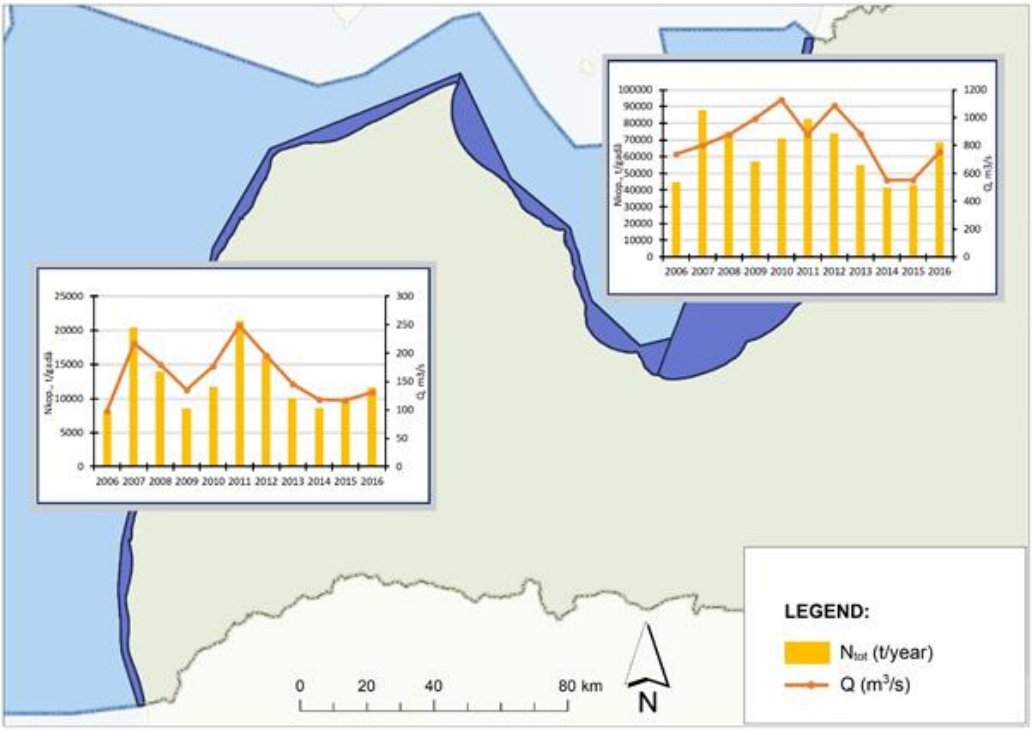


Figure 4.1.5. The dynamics of river flowrates (Q) and nitrogen loads (N_{tot}) to the Gulf of Riga and the Baltic Sea. The displayed loads are the sum of the loads that include the transboundary transfer, which have not been flow-normalised (LEGMC, 2018).

Source apportionment of nitrogen loads in 2006 and 2014, indicates that the relative share of direct loads (urban municipal wastewater) of nitrogen has decreased from 3.4% to 1.0% (HELCOM, 2018). Resources and pathways of nutrients to the Baltic Sea. BSEP No. 153). The atmospheric concentration rate of nitrogen in 2014 (4.9%) has remained around the same level [AI1] [AI2] as in 2006 (4.8%). Consequently, the relative importance of river loads in nitrogen loads has increased.

Baseline scenario for the achievement of good environmental status in the marine environment

Management plans have been developed for all major Latvian rivers (Daugava, Lielupe, Gauja and Venta) (published on the LVGMC website). The measures included in these plans, which are provided in the regulatory documents, constitute a "baseline scenario" for achieving good environmental status in the marine environment. As regards eutrophication, they are the following:

- Directive 2010/75/EU of 24 November 2010 on industrial emissions – concerning incineration of waste (authorisation, penalties, measures to be taken by enterprises)

- Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates of agricultural origin (Good agricultural practice, Information and Education, National Programme/Plan for vulnerable areas, monitoring, etc.)

- Directive 91/271/EEC of 21 May 1991 on the treatment of waste water (Collection of waste water (residential areas), Standards for the treatment of waste water, etc.)

- HELCOM Baltic Sea Action Plan (Determination of load reduction targets, adoption of recommendations for different types of waste water, shipping, etc.)

An analysis of the baseline scenario was carried out in 2015 to assess the effectiveness of the measures contained in it. The analysis used the draft of the basin management plans as it was not completed in this time. Therefore, the assessment of the effectiveness of the measures should be updated after the approval of the basin management plans.

Analysis of the possible effect of implementation of the N load reduction measures

A number of scientific studies have demonstrated the fact that changes in the Baltic Sea take place with a major time lag, as determined by the internal biogeochemical processes of the Baltic Sea. Therefore, according to the common understanding of the timeline of processes in the Baltic Sea, it is accepted that the implementation of measures to improve the state of the marine environment may take a very long time, at least 30 to 50 years, until the desired position is reached. This is highly demonstrated by modeled calculations (HELCOM, 2014) on changes in winter nitrogen and phosphorus concentrations in the surface layer of the waters of the central Baltic Sea (Figure 4.1.6).

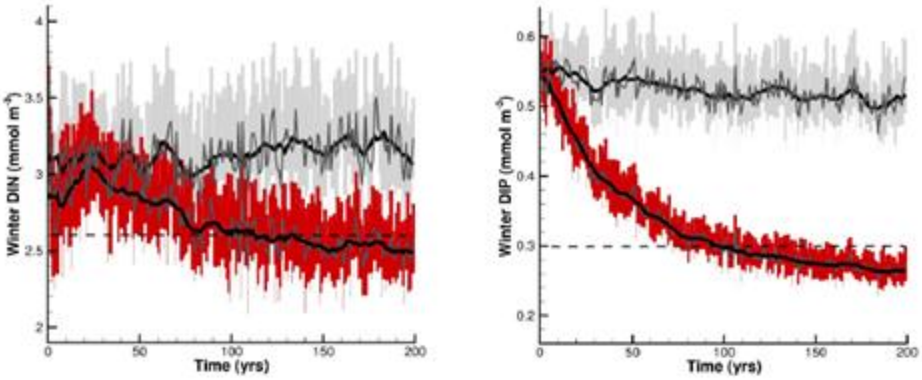


Figure 4.1.6. Changes in winter nitrogen and phosphorus concentrations in the surface water layer of the central part of the Baltic Sea. Grey lines represent a scenario where loads are maintained at the level of 1997-2003, red if the required reduction of loads is carried out. The dashed line is a target concentration. Adapted from HELCOM (2014).

As can be seen from the picture, if measures are implemented (0 year), nitrogen concentrations may initially increase as a result of internal processes and a pronounced decline trend will only be observed after 10 to 20 years, compared to e.g. other nutrient – phosphorus, for which concentrations show a stable decline trend. In general, such forecasts are useful for measuring trends of changes and timeline, but cannot be used to very accurately predictions about a year in which good conditions will be achieved. Therefore, in the implementation of measures aimed at improving the state of the marine environment, the intermediate objective should be to set trends for the reduction of concentrations. Reaching the target concentration remains the final result. In the light of the modelling results, it is justified, in the event of eutrophication, to establish that good environmental status will not be achieved in 2020 due to natural conditions in the Baltic Sea and it is justified to apply an exemption under Article 14(1)(e) of the Marine Strategy Framework Directive.

The nutrient reduction scheme of the HELCOM Baltic Sea Action Plan was revised in the 2013 HELCOM Ministerial Meeting, based on a new and more complete dataset as well as an improved modelling approach.

<u>For the Gulf of Riga and Baltic Proper</u>

Table 4.1.4. Maximum Allowable Inputs and needed reductions for nitrogen (N), in tonnes, agreed in 2013

<table>
<tr><th>Baltic Sea Sub-basin</th><th colspan="2">Maximum Allowable Inputs, N_{tot}, tonnes</th><th>Reference inputs 1997-2003, N_{tot}, tonnes</th><th>Needed reductions, N_{tot}, tonnes</th></tr>
<tr><td rowspan="3">Gulf of Riga</td><td colspan="2">88 417 from which</td><td rowspan="3">88 417</td><td rowspan="3">0</td></tr>
<tr><td>EST:</td><td>LV:</td></tr>
<tr><td>c.a. 13 000</td><td>c.a. 54 000</td></tr>
<tr><td>Baltic Proper</td><td colspan="2">325 000</td><td>423 921</td><td>98 921</td></tr>
</table>

Progress towards the maximum allowable inputs is assessed in the core pressure indicator on nutrient inputs. For each sub-basin and the Baltic Sea as a whole (BAS), average annual total nitrogen input including statistical uncertainty in 2012-2014 are compared with the maximum allowable nutrient inputs (MAI, shown as a blue line)

(Figure 4.1.7.). The average annual inputs in 2012-2014 were calculated using normalized annual inputs and adding statistical. Green color indicates that inputs during 2012-2014 were lower than MAI, red color when they were higher, while yellow indicates that when taking into account the statistical uncertainty of input data it is not possible to determine whether MAI was fulfilled (HELCOM, 2017).

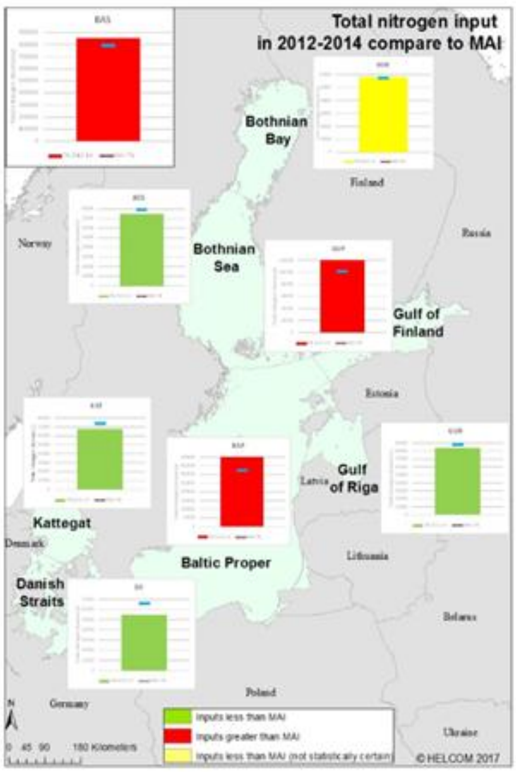


Figure 4.1.7. Comparison of average annual total nitrogen input including statistical uncertainty in 2012-2014 with the maximum allowable nutrient inputs (MAI, shown as a blue line).

Country Allocated Reduction Targets (CARTs) for pollution from both land and air, in tonnes, agreed in 2013 for Nitrogen:

- Estonia – 1800

- Latvia – 1670.

4.2. Status of the Gulf of Riga - Estonia

In Estonia, environmental monitoring is regulated by the Environmental Monitoring Act and resulting regulations. National marine monitoring is organised by the Ministry of the Environment and the Environment Agency. Monitoring is performed by the Estonian Marine Institute of the University of Tartu and Department of Marine Systems of Tallinn University of Technology whose laboratories comply with the accreditation requirements. Since 2016, a new national environmental monitoring programme called KESE https://kese.envir.ee/kese/welcome.action has been used in Estonia designed to collect and publish the monitoring data.

In Estonia, open sea monitoring covers a marine area from the outer border of coastal waters to the outer border or the territorial sea. On the open sea of the Gulf of Riga, monitoring is performed in four monitoring stations (G1, 111, 114, 107) and in the body of coastal waters of the Gulf of Riga and Pärnu, monitoring is performed in six monitoring stations (125, K2, K21, K4, K5, K7) (Figure 4.2.1).

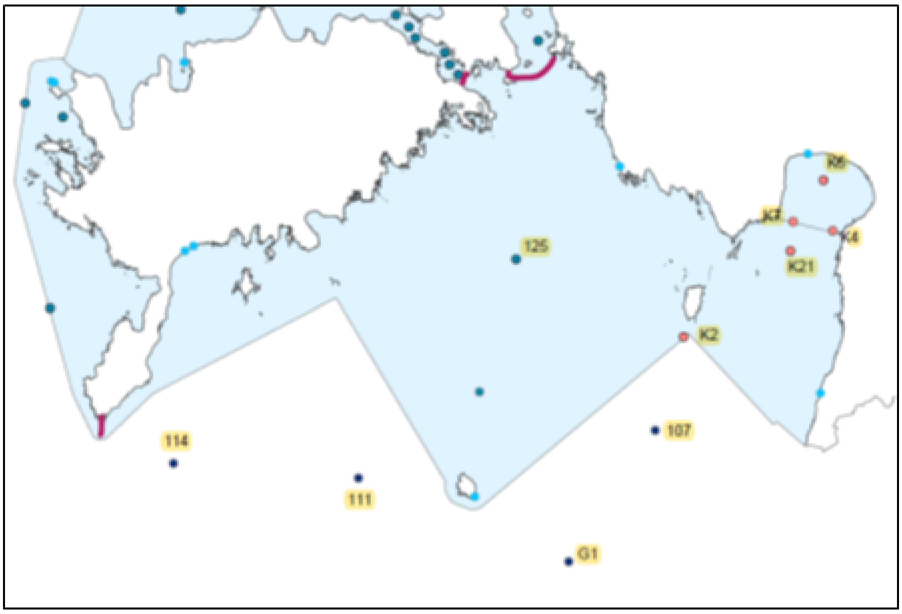


Figure 4.2.1. Location of the monitoring sites in Estonia: the open sea (G1, 111, 114, 107) and coastal water bodies (125, K2, K21, K4, K5, K7) (Environmental Agency, 2019).

Monitoring data forms the basis for the evaluation of marine ecological status. Indicators for the nitrogen content in coastal waters is the concentration of total nitrogen (Ntotal) in the summer and dissolved inorganic nitrogen (DIN) in the winter. To evaluate eutrophication, additional data is collected, such as total phosphorus, chlorophyll a, phytoplankton biomass and summertime water transparency and wintertime phosphate concentration, etc (Environment Agency, 2019).

The basis for the evaluation of the status of coastal waters is Water Act and Water Framework Directive 2000/60/EC. The ecological status of the body of coastal waters is evaluated in a 5 point scale: from very good which indicates no or negligible changes from human activity to very bad. Combined status consists of two parts: ecological status and chemical status. The 5 point scale is not used for the open sea where the indicators have been given the threshold for a good environmental status by HELCOM (Environment Agency, 2018).

Ecological status of the coastal sea area (The Pärnu Bay) in Estonia in 2016 is defined as poor (Martin, 2017[2]).

Provided monitoring report (Martin and Lips, 2017) concludes that the content of total nitrogen decreased by 20-40% since the 1980s and reached to the average level of 14,6 µmol l^{-1} by early 2000s. Some increase in N concentrations during late spring has been recorded over the past decade and N content is back to the mean level typical for the 1990s that is 24 µmol l^{-1} (Figure 4.2.2.) (*ibidem*). The concentration of the sum of nitrites and nitrates (NOx) also revealed increasing tendency during the last decade (Figure 4.2.3.).

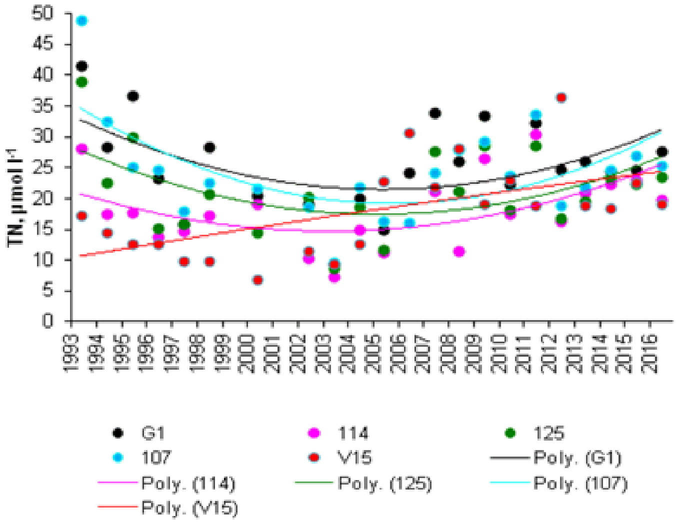


Figure 4.2.2. The content of total nitrogen (TN, µmol l^{-1}) during late spring in upper layer of water (0-10 m) at the Gulf of Riga monitoring stations in 1993–2016 (extracted from: Martin and Lips, 2017).

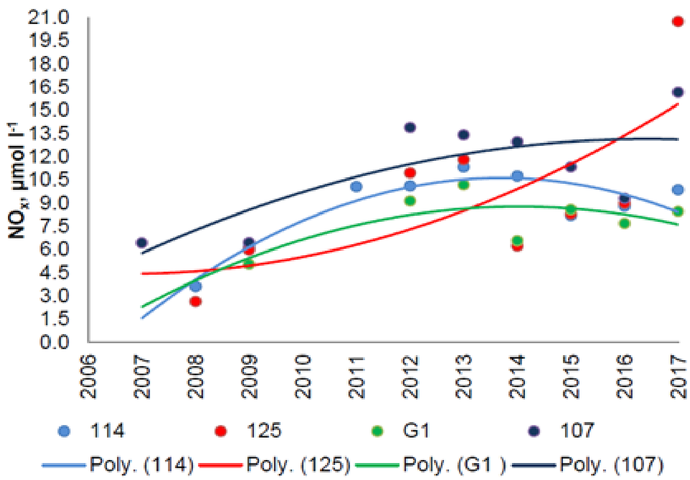


Figure 4.2.3. The content of nitrites and nitrates (NOx, µmol l-1) during winter in upper layer of water (0-10 m) the Gulf of Riga monitoring stations in 2005–2016 (extracted from: Martin and Lips, 2017).

Concentration of TN during summer at the station K5 of the Pärnu Bay close to the river mouth does not indicate any change since 1993 (Martin, 2017[2]), but decreasing tendency is visible at station K21 that is located further from the river mouth (Martin, 2017). The N and P ratio is getting smaller due to increase of the P content over recent years.

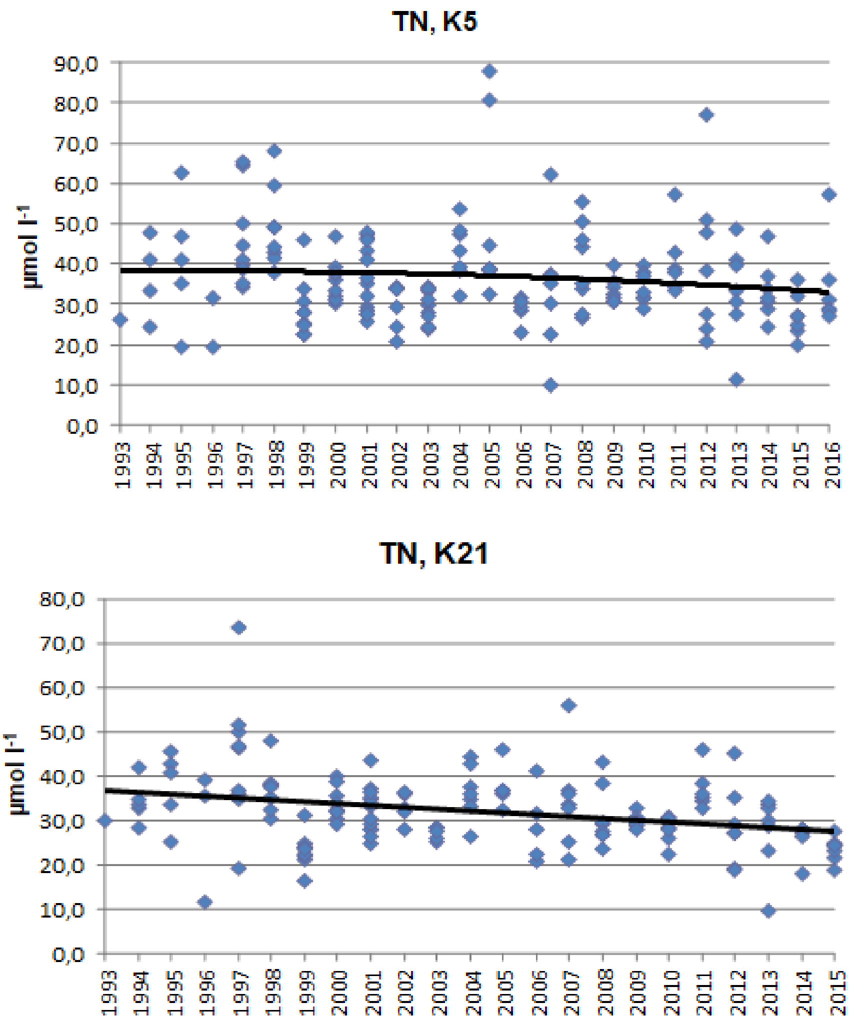


Figure 4.2.4. Mean summer TN concentration (µmol l^{-1}) of the upper layer of water at stations K5 (upper) and K21 (lower) of the Pärnu Bay in 1993–2016 (Martin, 2017).

As follows base on data of the national environmental monitoring programme KESE are evaluated some average values of the nitrogen, see figure 4.2.5.:

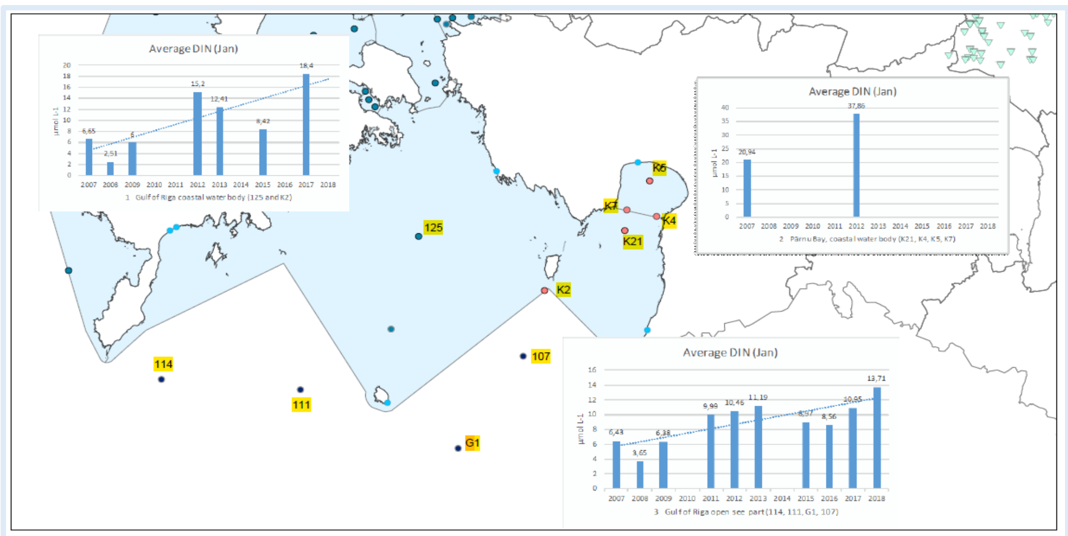


Figure 4.2.5. Long-term average winter (January) concentrations of dissolved inorganic nitrogen (DIN) in the Gulf of Riga for the period 2007-2018. 1 - Gulf of Riga coastal water body, 2 - Pärnu Bay coastal water body, 3 - the Gulf of Riga open see (KESE, 2019).

Table 4.2.1. Winter season dissolved inorganic nitrogen (**DIN**) limit values (µmol L^{-1}), average long term data (**January**) in two periods, trends (KESE, 2019).

Water object	Target value (DIN)	period 2007-2011	period 2012-2016	Trend	2017 and 2018
Gulf of Riga coastal water body	7,4[1]	5.05	12.01	↗	18.40
Pärnu Bay, coastal water body	15,5[1]	20.94[3]	37.86[4]	↗	-
Gulf of Riga, open part	5.2[2]	6.61	9.80	↗	12.33

[1] Stoicescu , Lips, Lips, 2017
[2] HELCOM (HOD 39-2012)
[3] based on 2007 data
[4] based on 2012 data

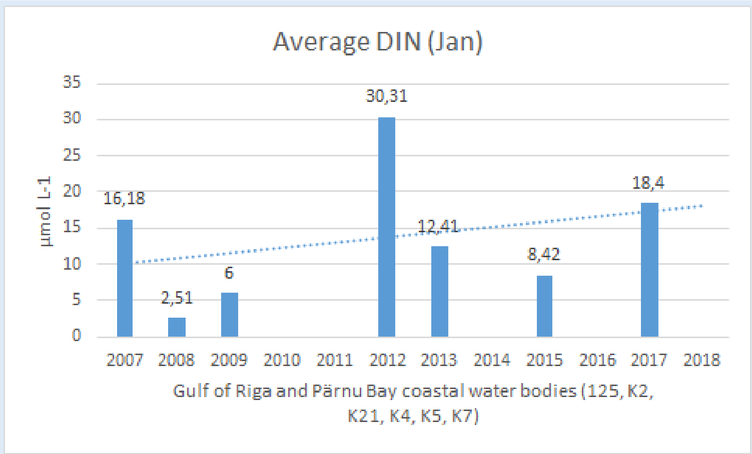


Figure 4.2.6. Long-term average winter (January) concentrations of dissolved inorganic nitrogen (DIN) in the Gulf of Riga and Pärnu Bay **coastal water bodies** according to monitoring stations 125, K2, K21, K4, K5, K7 (KESE, 2017).

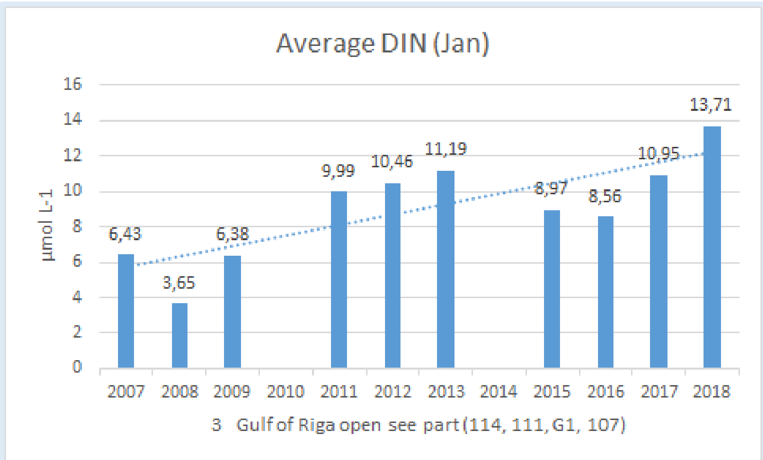


Figure 4.2.7. Long-term average winter (January) concentrations of dissolved inorganic nitrogen (DIN) in the Gulf of Riga **open see**, according to monitoring stations 114, 111, G1, 107. (KESE, 2019).

Table 4.2.2. Total nitrogen (Ntot) limit values (µmol L-1) for coastal water in the summer and annual means concentrations for open see, previous average values in two periods (June-August or May), 2017-2018 trends. (KESE, 2017).

Water object	Limit value	2007-2011	2012-2016	trend	2017 and 2018
Gulf of Riga coastal water body	≤ 19.2[1] for good class	28.26	23.53	↔	29.39
Gulf of Pärnu coastal water body	≤ 23.6[1] for good class	34.52	29.61	↘	27.05
Gulf of Riga, open part of see	28[2]	27.75	24.58	↘	26.88

[1] Minister of the Environment Regulation No. 44 "Procedure for formation of bodies of groundwater and list of bodies of groundwater whose status category must be determined, status categories for bodies of groundwater, values of quality indicators corresponding to status categories and procedure for determining status categories" (28.07.2009)
[2] HELCOM 38-2017

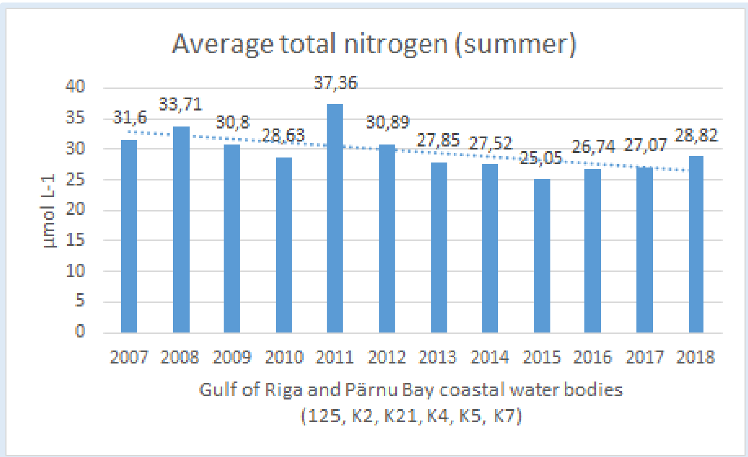


Figure 4.2.8. Average summer (June-August or May) concentrations of total nitrogen at the Gulf of Riga coastal water body area (according to monitoring stations K21, K4, K5, K7) and Pärnu Bay coastal water body area (according to monitoring stations 125, K2) (KESE, 2019).

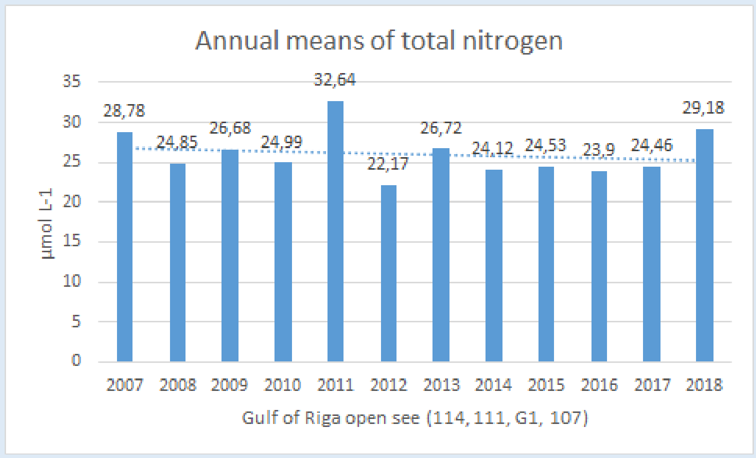


Figure 4.2.9. Annual means concentrations of total nitrogen (Ntot) at the Gulf of Riga open see area (according to monitoring stations 114, 111, G1, 107). (KESE, 2019).

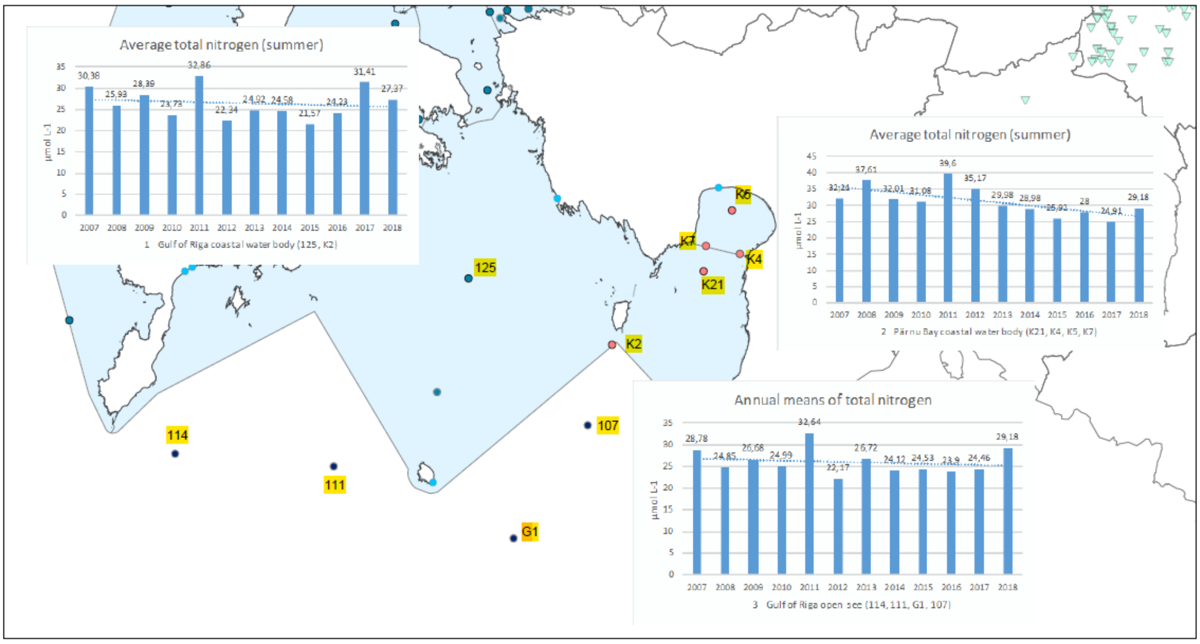


Figure 4.2.10. N_{tot} average concentrations (summer) in the Gulf of Riga for the period 2007-2018. 1- Gulf of Riga coastal water body (blue), 2- Pärnu Bay coastal water body (blue), 3- Gulf of Riga open see (white) (KESE, 2019).

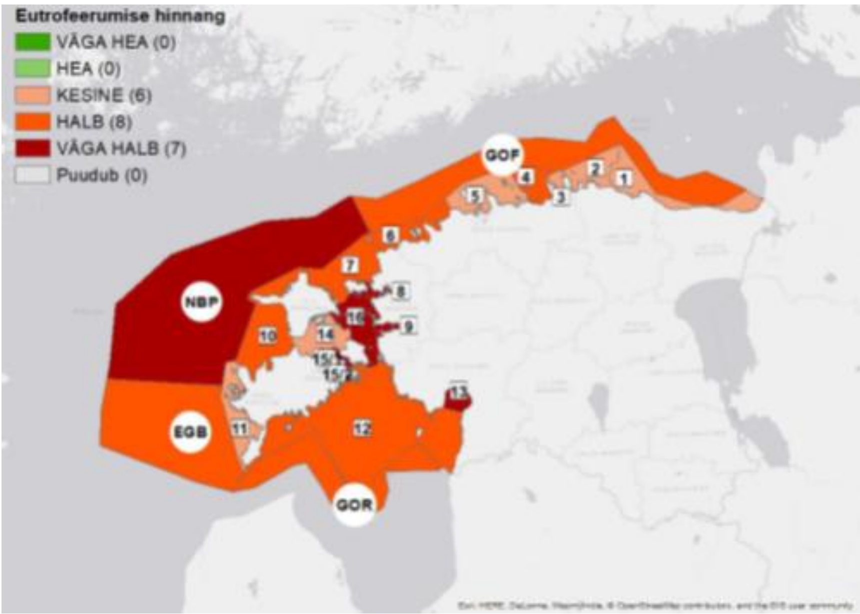


Figure 4.2.11. Assessment of eutrophication for the period of 2011-2016: Pärnu Bay (13) - very bad, Gulf of Riga coastal water body (12) and GOR – bad (Stoicescu jt., 2017).

The status of the Gulf of Riga with regard to nutrient criterium is bad, incl. Pärnu Bay very bad. The overall assessment for eutrophication is that the Estonian marine areas have not achieved a good environmental status with regard to eutrophication. The report Environmental Status of the Estonian Marine Area 2018 has pointed out a good environmental status, incl. with regard to eutrophication, cannot be achieved by 2030 (Klauson et al, 2018).

5. The integrated nitrogen management system to reduce nitrogen load in Gulf of Riga in Latvia and Estonia

The project aims to assess major flows of reactive nitrogen from human activities and consumption and their impacts to the environment.It is well known that reduction of Nr flows from one source could contribute to increasing flow from some other sources. For example, measures to reduce wastewater load of Nr to the environment will increase emissions of Nr to atmosphere and respective load of nitrogen by sewage sludge to the waste pool. Therefore, more integrated measures have been developed to reduce human induced flows of nitrogen to atmosphere and hydrosphere as well as flows due to landfilling of wastes.

5.1. Hydrosphere

5.1.1. Overview

International requirements

HELCOM Baltic Sea Action Plan (BSAP) provide quantitative reduction targets for nutrient inputs in order to restore the good ecological status of the Baltic marine environment by 2021. The goal of the BSAP is to limit the inputs of waterborne and air loads of reactive nitrogen into the Baltic Sea by 800,000 t N yr-1 by 2021. Based on best available scientific knowledge, at or below this value there would be no more significant eutrophication of the Baltic Sea. According to this plan there are set maximum allowable inputs (MAI) and country allocated reduction targets (CART compared to a reference period (1997-2003) (HELCOM 2013c).

Legislation, planning documents regarding measures for decreasing N loads

The protection and use of water resources in the Member States of the European Union is regulated by Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for Community action in the field of water policy. The requirements of this directive in Latvia are laid down in the Water Management Act (15.10.2002) and related regulations of the Cabinet of Ministers. River Basin District Management Plans are regional planning documents for water protection and sustainability, that each European country develop for their river basin districts.

Latvia has four river basin districts - Gauja, Daugava, Lielupe, Venta river basin districts.

River basin district management plans contain Program of measures, where is information on measures to improve the status of water, what are necessary to achieve good water quality. Programs of measures include the basic and additional measures that will have to be implemented by both load generators (different sectors of the economy), water managers (responsible institutions) and any user of water resources. The financial resources needed to implement the measures are, in some cases, provided for in different financial instruments and support programs, but in some cases, funding will have to be found by water users and operators.

Implementation of the basic measures in River basin district management plans is already ensured in accordance with the requirements of regulatory enactments, for example, measures like receiving various permits and licenses, preparing documents like exploitation regulations of lakes, environmental impact assessments, compliance with prohibitions (for example, for restrictions on economic activity in protection zones or for discharge untreated wastewater into environment) are carried out continuously. For first time in Latvia there are set out requirements for decentralised sewerage system and responsibilities for their owners, municipalities, vacuum trucks (Cab. Reg. No. 384) with aim to decrease pollution with wastewater and to increase information about them. As a positive example there can be mentioned updated regulations regarding risk water bodies (Cab.Reg. No. 418), that are set out in river basin district management plans; they are taken into account in the individual support mechanisms, for example, support for rebuilding and restoring drainage systems in catchment areas of risk water bodies is provided only if environmentally friendly solutions are established.

Measures are implemented either across the entire river basin district or for individual bodies of water. There are two types of additional measures: 1) additional measures of national scale; 2) other additional measures. There are 6 directions of action for national scale measures: 1) informing of society and groups of interest about river basin district management plans, their involvement; 2) decreasing influence of hydrological and morphological modifications on water quality; 3) supplementing regulatory enactments and planning documents with conditions and information on water resource management and protection; 4) improving access to information on water resources and their status; 5) actions for improving quality of river basin district management plans; 6) decreasing influence of loads to surface water quality. According to Summary about implementation about programs of measures in 2016 - 2018 and calculation of costs according to Water Framework directive 2000/60/EK requirements these measures are implemented gradually (LEGMC, 2019). According to informative measures, society and stakeholders are being informed about river basin district management plans. According to 3rd group of measures about legislation, the positive aspect is previously mentioned Cabinet Regulations No. 384, but there is not progress regarding natural resource tax changes (all natural resource tax revenue transferred to the state basic budget should be allocated to the financing of environmental protection projects).

Other additional measures are grouped in 9 directions of action: 1) to decrease pollution load of point sources; 2) to decrease pollution load of diffuse sources; 3) to prevent risk of pollution; 4) to reduce pollution from agricultural activities; 5) to reduce pollution from forestry activities; 6) to decrease impact of hydrological and morphological modifications; 7) to improve status of lake water bodies; 8) to decrease impact of anthropogenic pollution on water status, including availability of qualitative information; 9) to provide access to quality drinking water. Measures differ only slightly for river basin districts. Additional measures include improving the efficiency of wastewater treatment plants, improving the efficiency of centralized wastewater collection systems in agglomerations with population equivalent (PE) > 2000 in risk water bodies. In the agricultural sector, the biggest benefits and reduction of nitrogen compounds are for introduction of 2 m vegetation buffer strips on the banks of watercourses and water bodies for environmentally friendly drainage system management. There is noticeable progress for a measure “maintenance of winter green areas or stubble fields”. In agriculture sector for decreasing diffuse pollution there is available support payment “maintenance of stubble fields in winter period”, what is a reason for growth of stubble fields over the years. This measure is implemented in all river basin districts, not only those, that are defined in programs of measures. Other positive aspect is implementation of measures regarding expansion of centralized sewerage networks in agglomerations, restoration of drainage systems and cleaning of watercourses. Till preparing of Summary for previously mentioned report 2016 - 2018, there have not been implemented projects to improve efficiency of wastewater treatment plants. This measure is also not foreseen in EU funding for period 2014 - 2020. There is a positive trend in decreasing pollution load from pollution of human settlements (with wastewater) through Cohesion Fund funding. Management of drainage systems in agricultural and forestry areas, what include also introduction of environmentally friendly elements in renovation work, are implemented in all river basin districts, not only those in programs of measures. These projects include watercourse cleaning, maintenance of polder systems, pump station reconstruction, thus promoting improvement of water status. Financing for this kind of projects come from European Regional Development Fund, European Agricultural Fund for Rural Development. In all river basin districts is performed measure regarding protection of groundwater resources - untreated artesian wells tamponing. Measures related to water management, for example, cleaning of rivers, lakes, improvement of coast areas, developing of management plans are implemented in small part of intended water bodies through various projects, financed by Latvian Environment Protection Fund. In overall river basin district management plans do not have legally - binding status, except for subordinate institutions of Ministry of Environmental Protection and Regional Development of Latvia. That prevents implementation of measures.

According to the status of the Baltic Sea, there has been developed a plan “Action Program for Good Marine Environment 2016-2020 year”, what is approved by the Order of Cabinet in 13.07.2016. According to this program to improve the state of the marine environment and reduce the pollution load from land-based sources, the package of measures for river basin management plans (hereafter "RBMPs") for 2016-2021 is currently the most important. Implementation of all RBMP planned measures could have a significant positive impact, in particular to reduce eutrophication. The full implementation of existing (basic) measures could, in general, improve the state of the marine environment. However, it is concluded that they alone are not sufficient to achieve good marine environmental status. New measures to reduce eutrophication, invasive species and marine pollutant waste, spatial protection measures for marine protected areas and maritime spatial planning as an effective tool for the sustainable use of marine resources have therefore been identified and included in the Program. In addition, the Program foresees research activities to improve the knowledge and information base (scientific research projects).

Estonia has three river basins – West-Estonia, East-Estonia and the Koiva river basin. The protection and use of water is governed by the Water Act (11.05.1994) and its implementing acts, the function of which is to ensure the purity and ecological balance of water. To improve the condition of bodies of water, a water management plan and programme of measures have been prepared for each river basin, and updated every six years. To reduce the impact of loads on the river basins, basic and supplementary measures that were judged to be cost-effective have been developed. The measures can be classified as administrative, technical, consultation and research. The measures are implemented either across the entire river basin or individual bodies of water. The implementation of the programme of measures is organized by the water management committee. The measures are carried out on the basis of an action plan, which the Environmental Board is responsible for preparing and implementing. The action plan proceeds from the significance of the load that impacts the body of water. Conclusions have been drawn regarding the results of the action plan for the period 2016-2017 and the action plan for 2018-2019 is now being implemented (Keskkonnaamet, 2017).

The Gulf of Riga catchment area is located in the West-Estonia river basin, mainly being located in the Pärnu, Läänesaarte and Matsalu sub-basins. The West-Estonia River Basin Management plan for 2015-2021 and its programme of measures distinguish between close to 15 different type of nitrogen load on surface bodies (Keskkonnaministeeriumi, 2016). The most frequent human induced sources of nitrogen include diffuse load from agricultural land, releases of treated wastewater, diffuse load from scattered dwellings not connected to sewerage system, and point source loads from animal farming (Keskkonnaministeeriumi, 2016). About 20 different measures have been designed to reduce these nitrogen load, such as crop rotation in areas under cultivation, introduction of effective fertilization technologies, bringing wastewater treatment plants into conformity with requirements imposed on wastewater, and determining the outlets of wastewater not in conformity with the requirements, among others. The impact of measures applied to coastal waters could probably be detected after many years, as recovery of the coastal waters after reduction of the nutrient load takes time. The measures proposed by the BSAP are partially integrated into the water management plan's programme of measures, such as establishing a water protection buffer zones , balancing of inputs with outputs of plant nutrients field and farm scale, etc (Keskkonnaministeeriumi, 2016).

Of the measures for surface water bodies planned in the action plan for 2016-2017, 56% had been implemented by the end of 2017 and implementation of 10% of the measures was under way. A total of 34% of the measures had not been implemented, and these included, for example, provision of consultation to agricultural enterprises for the preparation of a nutrient balances. However, a nutrient and humic substance balance calculator was being developed for implementation of this measure. Many of the implemented measures in 2016-2017 are administrative (35%) – mainly the reviewing of conditions for environmental permits (Keskkonnaamet, 2018).

The status of groundwater bodies is evaluated every six years. The state of groundwater bodies in the Gulf of Riga catchment area is good. Of the measures planned for groundwater throughout Estonia, 71% had been carried out by the end of 2017. One of the problems related to implementation of the action plans is availability of information if the measure is implemented by the owner. The responsible institution does not have a full overview of whether the measure has been implemented for a specific body of water or not. For example, establishment/preservation of buffer zones for minimizing nutrient runoff from area under cultivations. One solution proposed is the development of a catalogue of measures in the form of an application that can be used by all parties (Keskkonnaamet, 2018).

5.1.2. Proposals

Background for proposed measures, based on GURINIMAS calculations

Maximum Allowable Inputs of nitrogen (MAI) to the Gulf of Riga adopted in 2013 is 88,417 tons (HELCOM, 2013). Recent monitoring data revealed some increase in nitrogen inputs to the Gulf of Riga sub-basin since the reference period 1997-2003 (Svendsen et al., 2015) although the needed reduction according to CARTs to the sub-basin is zero.

Country Allocated Reduction Targets (CARTs) for pollution from both land and air to other sub-basins of the Baltic Sea (Helcom, 2013b) is:

Estonia – 1800 tons (1.8/17.3 = 10% of the actual load)

Latvia - 1,670 tons (most of it to the Baltic Proper)

In **Latvia,** annual input of Nr to hydrosphere is about 76 kT, and 90% of this load reaches the Baltic Sea. Most of the Nr load (or 45 %) to hydrosphere originates outside the territory of Latvia. 27.7 kT or about 37 % of Nr load originates from human activities (mostly agriculture) in Latvia, and the rest is diffuse load from natural territories (this load includes also runoff from forest cutting, peat extraction sites and atmospheric deposition onto wetlands and open water). Human activities generate about 4.3 kg N/ha/yr of the total territory of Latvia. Natural sources generate about 2.2 kg N/ha/year. The mean input to hydrosphere is thus 6.5 kg/ha/yr.

Proposed measures

5.1.2.1. Table. Proposed measures for reducing nitrogen flows to hydrosphere

Measure	**Related pool from GURINIMAS**	**Group of measure**
Further research and testing is needed to develop effective and cost efficient solutions for **sewage treatment in small-scale** treatment facilities and households in scattered dwellings.	Wastewater Human settlements	Technologies
Increased recycling and reuse of waste water sludge considering considerable load by wastewater although recycling of nitrogen back to the site where food was produced, e.g. agriculture is complicated.	Wastewater Agriculture Food and feed	Technologies
Development of new, cost-effective technologies for **removal of pathogens and micropollutants from sewage sludge**, that could promote a safe use of sludge or its compost as a fertilizer in agriculture, biomass production, cultivation of degraded territories, etc. and recycling of nitrogen	Agriculture Human settlements	Technologies
Testing and application of nature based measures to increase water **retention time**, particularly in **smaller streams and drainage systems,** that could enhance denitrification (**sedimentation ponds**).	Agriculture Forestry	Technologies
Complex **assessment of the impact of sediments removal** to water quality of streams and recipients and impacts to biota, transport of nutrients and air emissions of nitrogen.	Hydrosphere	Research
Development of improved **methodology for assessment** of **natural background load** of N, including emissions to water bodies and atmosphere from peat extraction areas, N runoff from clear-cut forest areas.	Hydrosphere Forestry Atmosphere	Research
Developing an approach to define **good status** for nutrients for all water bodies designated by linking status for biological organisms to the load in the catchment area; ensuring that quality objectives in the upper reaches of the river also contribute to good quality in the lower reaches of the river, and that the quality objectives in the rivers ensure good quality at the sea.	Hydrosphere	Research

Development of spatially **targeted** (field parcels) **measures** to reduce nutrient losses considering pressures, landuse and hydro-geographical conditions. That would make it possible to indicate for example on which fields winter green crops could contribute a lot to reduce nutrient runoff and in which fields buffer zones are utmost important.	Hydrosphere	Research
Promotion of closed cycle of **manure management** (manure spreading equipment, slurry tanks, precision technology for fertilizer application, composting of solid manure) to decrease N losses to water bodies and deposition of reduced nitrogen (NH_3) to the surface of inland water bodies and the coastal sea. It includes switch from N based fertilization norms to P based norms due to unfavourable N/P ratio in liquid manure for the crops.	Agriculture	Technologies
Better international co-operation including exchange of monitoring data and common research especially with non-EU countries is needed to achieve reduction of transboundary pollution loads.	All	International cooperation
Improvement of the **assessment** of environmental impacts of **aquaculture** sector. For better assessment of the real impact on the aquatic environment, it is advisable to carry out additional studies (measurements) on emissions of nitrogen compounds from aquaculture farms or monitoring the environmental impact. Since it is the point source of pollution and the impact is local, local authorities could be involved.	Aquaculture	Research
Improving human awareness regarding dietary preferences and potential impact of **consumption of animal proteins** (particularly red meat products) to decrease nitrogen load by wastewaters and Nr emissions to atmosphere.	Agriculture Human consumption	Environmental awareness
Initiation of studies and development of monitoring system for improved **assessment of N emissions to atmosphere and hydrosphere from diffuse sources** such as agricultural and natural landscapes.	Forestry	Research
Development of science based and targeted measures for management of the **riparian zones.** The measure is essential to maintain a vigorous cover of tree and herbaceous plant vegetation for intercepting sediment and protecting stream banks for erosion. **Increased proportion of broadleaved trees**.	Forestry	Technologies
Avoid specific management activities such as **soil disturbance** and **left harvesting residues** in riparian zone to prevent leaching of nutrients.	Forestry	Technologies
Overland flow areas are very efficient at retaining suspended solids and nutrients catchment. Constructed wetlands retain solids and nutrients by natural processes including sedimentation, denitrification and plant uptake to reduce their transport to downstream water bodies.	Forestry	Technologies
Peak flow control (PFC) structures with runoff regulating pipes have been shown to reduce the transport of suspended solids and	Forestry	Technologies

particulate nutrients in forested areas efficiently.		
Set as obligatory unprocessed **field vegetation protection zones** along drainage systems for drains and ditches, surface runoff receivers, manholes.	Agriculture	Technologies
Wider application of **field and farm scale N budgets**.	Agriculture	Technologies Research
Evaluation of **feasibility** and **efficiency** of all proposed technical measures for conditions of Latvia and Estonia.	Agriculture Forestry	Technologies

It should be noted that some hydromorphological measures, for example, dam removal, may contribute to sediment and related nitrogen increased flow. Dams play an important role by prolonging retention time and enhanced self-purification including emission of greenhouse gases due to decomposition of sediments.

Regarding recommendation about reduction of the production and consumption of animal proteins it should be noted, that it does not necessarily lead to decreasing environmental impacts of farming systems due to possible increasing export of animal products (e.g. Antikainen et al., 2015).

The measure for forestry sector about forming of **riparian zone** tree composition is essential to maintain a vigorous cover of tree and herbaceous plant vegetation for intercepting sediment and protecting stream banks for erosion. When forming the tree species composition in the riparian zone, proportion of conifers, especially Norway spruce, and grey alder (*Alnus incana* Moench.) coppice should be reduced and that of **broadleaves - increased**. Pure Norway spruce forms another type of poorly functioning riparian zones in the forests. In this case, the strong shading of water, acid needle litter and low soil pH values inhibit life processes and thus negatively affect ecological quality of aquatic ecosystems. Removal of leaning and unstable trees close to banks may also be needed, as, in case of windthrow, such trees increase the risk of bank erosion and may cause the input of large amounts of sediment in the watercourse (Ring et al., 2018).

Regarding **grey alder in riparian zones**, it is researched, that they generally have a negative impact on the functioning of riparian zone due to several reasons: 1) the lack of herbaceous vegetation layer and exposed mineral soil under the trees that is highly prone to erosion; 2) low ecological stability and shallow root system of grey alder trees, causing frequent uprooting; the fallen trees block the waterways and, as the soil structure in these stands is often very fine, sediment is washed into the waterbodies causing silting, loss of habitat and spawning areas and general decrease of ecological quality of aquatic ecosystems; 3) although a high amount of deadwood is often formed in grey alder stands, the deadwood dimensions are often small and decomposition - fast; 4) the blockage of waterways radically decreases variety and quality of other ecosystem services potentially provided by the riparian and aquatic ecosystems, for example, recreational opportunities; and in some cases even the human-made infrastructure is destroyed (Urtāns, 2014).

Regarding **wetland buffers**, one major limitation to the use of wetland buffers is that blocking or filling in the ditches in the area raises the ground water level not only in the buffer area itself, but also in the upstream area. In flat areas, other water protection methods should be used instead of wetland buffers. Wetland buffers should also not be established on pristine mire areas with endangered plant species as vegetation in wetland buffer areas undergoes substantial changes due to increased nutrient input from the upstream area (Finér at al. 2018).

Constructed wetlands function to retain solids and nutrients by natural processes including sedimentation, denitrification and plant uptake to reduce their transport to downstream water bodies. Highly efficient suspended solids (SS) retention has been reported, particularly where the SS inputs to buffer areas were large and the size of the buffer area was at least 0.5–1.0% of the size of the whole upstream catchment area.

A sedimentation pond is usually excavated above the **peak flow control** (PFC) **structure** to retain the sediments released even with the PFC structure. Peak flow control structures are not effective for reducing the export of dissolved elements in drainage water. Thus, they should not be designed to be used as the only water protection structure where the loads of dissolved elements are high. The functioning of the PFC structure is dependent on correctly dimensioned pipes that prevent high flow rates. Under optimal conditions, the whole drainage network acts as a water retention area with reduced water flow velocity and erosion risk during the peak flows. A critical point for the functioning of a PFC structure is the proper dimensioning of the base flow, which should be based on the catchment size, average slope, and regional precipitation patterns (Finér at al. 2018).

Some authors (e.g. Bowman, et al., 2013) claim that N removal by denitrification in soil-groundwater-riparian zone as a fraction of the N inflow has not changed during the twentieth century and riverine transport of N has increased at the same rate as the increase in the N budget.

Regarding unprocessed **field vegetation protection zones** there are researches, that 2 m wide zone could provide 67% of the retention of soil particles and erosion products (UK average). Such a bar serves as a "rough filter" for holding erosion products. These obligatory vegetation protection zones could be supplemented with subsidized field vegetation protection zones. For example, the 10 m grassland retains around 65% nitrogen (Jansons, LLU, 2013).

The purpose of **sediment pits and ponds** is to capture sediment and particulate nutrients released from the drainage network maintenance area before they enter the receiving water bodies. Pits and ponds are a deepened and widened section of a ditch, where water flows through a wider flow cross-sectional area, thereby reducing the flow rate (i.e. down to 0.2 m s^{-1} at least). This facilitates the deposition of suspended sediments to the bottom of the pond. In general, the sedimentation ponds are efficient for capturing particles with diameters greater than 0.05 mm. Well-functioning sedimentation ponds reduce sediment transport by 30–40% and are particularly effective for the coarse-textured (grain size >0.63 mm) sediments. Very large ponds (>400 m^3) might be needed to retain >50% of the SS loading. In areas where the inflowing sediment comprises either light organic particles or fine-textured (particle size <0.063 mm) mineral soil, sediment ponds should generally not be constructed (Finér at al. 2018).

Coarse woody debris (CWD) generally has a positive effect on the ecological quality of the watercourse, as it supplies the aquatic organisms with habitat and shelter. The effect, however, may become reversed in case of very large amounts of debris blocking the water flow; and removal of excessive CWD may be needed to restore the ecological quality of the stream and reduce nutrient content in water (Ring et al., 2018).

Depending on the specific situation, **beavers** may have varied effects. Apart from increasing the ecological heterogeneity of the landscape and improving water quality downstream, excessive beaver activity may cause the blockage of water flow in the river and thus have a negative effect on the species that rely on flowing water. Apart from that, according to the latest findings, newly built beaver dams in areas with high content of organic matter and nutrients in the soil may act as nutrient leaching hotspots (Finér at al. 2018; Ring et al., 2018).

5.2. Atmosphere

5.2.1. Overview

International requirements

An objective of the Convention on Long-range Transboundary Air Pollution initiated in 1979 was to limit and, as far as possible, gradually reduce and prevent air pollution. In 2012, a revised Gothenburg Protocol included national emission reduction commitments to be achieved in 2020 and beyond.

European Union requirements

There was adopted Thematic strategy of air pollution by European Commission in 2005, with aim to achieve such air quality which has no negative consequences and risks to human health and the environment. In 2008 there was adopted Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe. It lays down requirements for air quality measurements, limits of concentrations of air pollutants, and the obligation to act when air quality in any air quality monitoring stations is not appropriate. In 2016 there was adopted Directive (EU) 2016/2284 of the European Parliament and of the Council of 14 December 2016 on the reduction of national emissions of certain atmospheric pollutants, amending Directive 2003/35/EC and repealing Directive 2001/81/EC. It sets strict maximum levels of anthropogenic emissions for Member States for major pollutants, including nitrogen oxide and ammonia for period 2020 - 2029, as well as after 2030. There is also requirements to develop and action programme to European Commission for limiting air pollution, that have to be updated at least once in every 4 years.

Legislation, planning documents regarding measures for decreasing N loads

In year 2018 there were adopted amendments to the law “On Pollution” in **Latvia.** These are requirements to lower also emissions of nitrogen oxide in period 2020 - 2029, as well as after 2030. Reduction targets for nitrogen oxides and ammonia are set out in Cabinet Regulation No. 614 “Rules for Reducing and Accounting of Air Pollutant Emissions” (02.10.2018.). Emission reduction targets are set as a percentage reduction for 2005 emissions: 34 % for NOx and 1 % for NH_3.

In the project of Emission Decrease Action Programme of Air Polluting Substances for year 2019 - 2030 according to evaluation of implementation of measures for reducing nitrogen oxides emissions there is concluded, that the reduction in emissions from road transport was mainly due to the increased use of higher environmental quality standards (EURO4, EURO5 and EURO6 cars); the impact of the fiscal measures implemented - Excise Duty and Vehicle Annual Operating Tax, aimed at more efficient and emission-friendly cars, also had an impact; the rapid growth of diesel-consuming cars in the total number of passenger cars in the last five years was negatively affected; the supportive policy of renewable energy resources that replaced imported electricity with electricity from cogeneration plants in Latvia using natural gas, solid and gaseous biomass increased the production of produced electricity, increasing the amount of fuel used, thus increasing emissions; in industry supportive policy of renewable energy resources, replacing natural gas with biomass fuels, decreased emissions. The implementation of energy efficiency policies in households and the service sector, reducing the need for fuel consumption for building heating, reduced emissions in these sectors. The second reason is significant reduction in the use of solid fuels (coal) in these sectors.

There are included in legislation measures, that affect emissions of N_2O both to hydrosphere and atmosphere media and sources of which are agriculture and industry pool (fossil fuel power plants) (see Annex 1 for specific legislation or planning documents):

1) Crop fertilisation plans;

2) Management of nitrate use at vulnerable territories;

3) Improvement of manure management systems;

4) Requirements of manure spreading;

5) Integrated farming;

6) Economic measures driven by Common Agricultural Policy, including

6.1. Introduction of leguminous plants on arable land;

6.2. Organic farming;

6.3. Maintenance of amelioration systems;

6.4. Precision fertiliser application;

7) Implementation of Best Available Techniques.

To atmosphere emissions targeted measure is such economic measure:

- Precision livestock feeding.

There are such restrictions regarding fertilizers and manure in nitrate vulnerable zone (Cab. Reg. No. 834):

- no manure and fermentation residues shall be dispersed between 20 October and 15 March, and for grasslands from 5 November to 15 March;
- Nitrogen fertilizers shall not be disseminated for winter crops from 15 October to 15 March, other crops and grasslands from 15 September to 15 March;
- the use of fertilizers does not exceed the maximum nitrogen limits for crops;
- farmers, who manages agricultural land in area at least 20 ha or grow vegetables, potatoes, fruit trees or berries in area at least 3 ha document the history of fields and, if use fertilizers, each year prepare fertilization plan for each field crop.

And in other country restrictions regarding fertilizers / manure are that they can not be applied on spread upon frozen, water saturated or snow-covered soil; shall be spread on flood-lands and areas under the threat of flood only after the season of possible floods has passed; mineral fertilisers shall only be sown on areas during the crop vegetation period; special requirements for special protection territories; unless composted in advance, faecal residues from septic and dry toilet tanks, by-products from the food industry and waste, or other by-products of organic origin from manufacturing (residues from fish-farms) and waste shall not be used as fertiliser; livestock manure shall be stored inside and near animal holdings; the amount of nitrogen applied with livestock manure in one hectare of agricultural land shall not exceed 170 kilograms per year, which conforms to 1.7 animal units.

Emissions of NOx, NH_3 come mainly from these pools: road transport for NOx, agriculture sector – for NH_3 emissions.

On January 19, 2000, **Estonia** joined the 1988 Sofia Protocol concerning the Control of Emissions of Nitrogen Oxides or their Transboundary Fluxes. The Protocol requires parties to control or reduce emissions of nitrogen oxides.

In Estonia the mean allowed annual content of pollutant nitrogen dioxide (NO_2) in ambient air should be no more than 40 µg/m³ and the mean daily allowed content should be no more than 200 µg/m³. These values may be exceeded no more than 18 times a year. Relevant alarm level is 400 µg/m³ calculated as the mean content of a three hour period. The mean daily allowed content of ammonia (NH_3) is not limited. The mean annual target value is 8 µg/m³ (Limit, 2019). In the case of exceeding contaminants an allowed number of times per year, local government commits itself to compiling an Atmospheric Air Protection Act Plan for improvement of air quality which is updated every five years (Atmospheric, 2019). If their nitrogen oxides emissions (NOx) exceed the maximum permissible level (except ammonia NH_3) which is 0.3 ton/year, organizations have to apply for an environmental permit (license). For ammonia (NH3), the maximum permissible level is more than 1 ton/year (Threshold, 2017).

Incinerator owners have to apply for an environmental permit (license) if the power of the device is 1 MWth or more. For devices of average power (1 – 50 MWth), an EU directive was enforced at the end of 2017 with the aim of regulating air pollution emissions i.e. emissions of NOx (Emission, 2017). Environmental permit holders have to regularly submit a report on the ammount of NO and NO2 emissions, calculation based on state methodology, and provide for calculation of nitrogen special emissions for different fuels. The limit value for NOx depends on the fuel used in the particular device (Methods, 2019). For example, natural gas yields the lowest special emission of NOx, followed by wood. Real measurements are expensive. If above maximum permissible levels are exceeded, companies/organizations have to pay an increased effluent charge. Dinitrogen oxide and ammonia emissions from livestock and poultry farming are also calculated by state methodology (Methods, 2017). To observe limit values and achieving of aims, the state performs national air quality monitoring, relevant information concerning nitrogen dioxide is updated at least every day and, if possible, every hour (Atmospheric, 2019).

At the end of March 2019 EME adopted an "Air pollutants reduction program" for the 2020 – 2030 period in order to reduce amounts of air pollutants, including important nitrogen compounds (Air, 2019). The program is elaborated by the Estonian

Environment Agency and the Republic of Estonia Ministry of the Environment and developed based on Directive 2016/2284/EU of December 12, 2016 directive (NEC-directive, the National Emissions Ceilings). The aim of the program is to gain an overview of local and mobile sources of emissions as well as ways to reduce emissions and elaborate measures. The focus is on energy, industry, transport, agriculture, and solvents. In connection to reduction of nitrogen pollution, Estonia has commitment to reducing emissions during the 2020-2030 period as follows: NOx 18% and NH3 1% as compared to relevant level in 2005; and as from 2030 as follows: NOx 30% and NH3 1% as compared to relevant level in 2005 (Inimtekkeliste, 2018).

5.2.2. Proposals

Background for proposed measures, based on GURINIMAS calculations

Latvia

Emission of Nr to atmosphere from human activities in Latvia accounted in average for 49.5 kT during 2012-2016. About 34 % of Nr emitted by human activities comes from agriculture pool, 22 % - from energy sector, 17 % - from waste and wastewater sector, 13 % - from transport sector and 12 % - from human settlements. According to LIIR (2018), 83.2 % of total NOx emissions in 2016 were generated from energy and transport sector and 85.8 % of NH3 emissions were from agricultural sectors.

Nr emissions to atmosphere from human activities (49.5 kT) exceeds biological fixation (27.0 kT) by 1.8 times.

NEC Directive sets out new emission reduction commitments for Latvia. NOx emissions should be below 61 kT and NH3 emissions – below 44 kT by 31 December 2019. Further, Latvia has to reduce emissions of nitrogen oxides by 32% during 2020-2030, and by 34% after 2030 if compared to emission levels in 2005. Ammonia emissions should be reduced by 1% in 2020-2030 if compared to emission levels in 2005. In 2005, 42.03 kT NOx and 14.90 kT NH3 were emitted. In 2016, 34.85 kT NOx and 16.25 kT NH3 were emitted (EEA, s.a). Emission of NH3 decreased sharply in early 1990s and started gradually to increase after 2000. After 2020, more stringent reduction targets will enter into force, and additional measures to reduce air pollution in Latvia will be needed.

NOx emissions are gradually decreasing also during the last decade due to reduced emissions from transport sector, and combustion of fuel in industry and households. However, analysis of projection scenario “with existing measures” (WEM) reveals increasing emissions from 2015 to 2030 mainly due to fuel burning in industry sector and energy and heat production. According to WEM scenario, NOx target value for 2030 will be exceeded by 21 %. If additional measures will be implemented, then the target value will be exceeded by 11 % (Latvijas gaisu, 2017). It should be mentioned that activities in agriculture sector was not included this analysis.

Growing consumption of fertilizers is the main reason for increasing NH3 emissions during 2005-2015. At the same time, improved storage and management of manure has allowed to reduce NH3 emissions by 7% from this particular agricultural activity during 2005-2015. Analysis of projection scenario “with existing measures” (WEM) predicts increasing NH3 emissions for the whole period and the target value for 2030 exceeded by 19.6 % (Latvijas gaisu, 2017).

Emission of Nr to atmosphere from economic sectors in Estonia accounted 26.1 kT in 2014. The share of NO_X and NH_3 in Nr emissions is almost equal (10.6 and 10.0 kT/yr). Agriculture contributes 31% of the total Nr emissions to atmosphere. Emissions from natural landscapes added 21% of the total air emissions. Transport contributes most of the point source emissions, particularly NOx (20% of the total Nr emission) and human settlements 11%. The share of industries and energy sector is all together 16% of the total emission.

Nr emissions to atmosphere from human activities (26.9 kT) exceeds biological fixation (11.7 kT) by 2.3 times. Human activities contribute about 3.7 times more Nr emissions to atmosphere than all the terrestrial processes in Estonia. This level is quite similar to the European average where anthropogenic emission are 4-fold higher compared to natural (Sutton et al., 2011).

EC directive 2016/2284 (NEC directive) foresee further decrease of air emissions including NOx and NH_3 compared to 2005 level. The directive has been transposed into national law by amendments to the Atmospheric Air Protection Act in 15.06.2018. Estonia should decrease the emission of NOx at least 18% (7.24 th tons) by 2020 compared to the level of 2005 and 30% (12.07 th tons) by 2030. The emission of NH_3 should be decrease by at least 1% (0.11 th tons) by 2020-2030. Actual emissions of NOx have already decreased below the target levels set by the NEC directive for 2020 in Estonia.

The base and air emissions reduction scenarios foresee increase in the share of NO_X emissions of the energy sector from the total energy production in 2030, and it will be 54% and 57%, respectively (8.66 th tons and 8.58 th tons) (Keskkonnaministeerium, 2019). Other sources (fuel incineration by industries, public and domestic sector, agriculture-fishery) contribute 46% and 43% (7.50 and 6.34 th tons), respectively (*ibidem*). The emission of NOx will even increase up to 2025 based on both scenarios and will decrease after 2025 only if suitable measures are implemented.

Nearly 89% of the NH_3 emissions origin from the agriculture sector in 2016. (Keskkonnaministeerium, 2019). Other sectors, e.g. energy production and transport contribute only about 8% and 1% of the total NH_3 emissions, respectively. The emission of NH_3 decreased sharply in early 1990s and started to increase during the second half of the 1990s. This decrease was explained by a reduction in the number of animals and use of mineral fertilizers (Estonian Environment Agency, 2018). Both scenarios foresee further increase in NH_3 emissions from agriculture sector from 9.37 kt in 2015 to 10.86 kt in 2030 (Keskkonnaministeerium, 2019). This increase is explained by probable increasing number of milking cows (up to 10% increase by 2030) and possibly pigs and other agricultural animals as well as increasing yield of milk per cow to the level of 10 000 kg/yr. Emissions of NH_3 will increase also due to increasing use of mineral fertilizers. Therefore, specific measures to decrease emission of NH_3 are needed.

Transport is responsible for 42,5% of air emissions of NOx and 1.2% of NH3 emissions in Estonia in 2016 (Keskkonnaministeerium, 2019). In total, transport sector contributed 19 % (7 kT) of Nr emissions to atmosphere in Estonia in 2014. Per capita emission is 5.3 kg Nr year.

EC directive 2016/2284 (NEC directive) foresee further decrease of air emissions including NOx, and NH3 compared to 2005 level. The directive was transposed into national law by amendments to the Atmospheric Air Protection Act in 15.06.2018. The target level for CO_2 emissions of new cars since 2020 is 95 g/km, that is equal to petrol consumption of 6 liters per 100 km and diesel fuel 4,4 liters per 100km (https://ec.europa.eu/clima/policies/transport/vehicles/cars_en). The fuel consumption of trucks and busses will not change based on the scenarios. Average total road transport mileage will increase by 75% of the GDP in 2019–2022 and by 50% of the GDP in 2023-2039 (Keskkonnaministeerium, 2019).

The developed scenarios foresee achievement of the reduction targets by transport sector, if proposed measures will be applied, despite of the increasing number of transport vehicles and increasing transport mileage. Possible reduction in NOx emissions by applying the proposed measures is about 3387 tons (Keskkonnaministeerium, 2019), that is 915 tons on Nr and about 13% of the emission level in 2014).

Energy sector is responsible for about 50% of the NOx emission in Estonia (Keskkonnaministeerium, 2019), although total emissions decreased since the 1990s. Estonia already achieved the NEC target to decrease the emissions of NOx by 18% by 2020 and further decrease is predicted by following both the base scenario as well as the scenario with additional measures to decrease the emissions (Keskkonnaministeerium, 2019). The latter provide about 1750 tons reduction of NOx emissions (*ibidem*), that is 473 tons of Nr and about 15% of the emissions from the energy sector in 2014). This decrease is predicted partly due to adopted new requirements for incineration technology (Decree of the Minister of the environment No. 4413, adopted in 05.11.2017) and the directive of the European parliament and Council (2009/125/EÜ14) (Keskkonnaministeerium, 2019).

The energy footprint (i.e. air emissions and solid waste from energy production) of Nr is 11.7 kT that is 8.9 kg N per capita per year in Estonia. Import and export flows are not included.

Proposed measures:

5.2.2.1.Table. Proposed measures for reducing N loads to atmosphere

Measure	Related pool from GURINIMAS	Group of measure
Improved sewage treatment technologies for **N removal** ● Increase count of inhabitants connected to secondary or tertiary treatment (less NH_3 emissions); ● Decrease count of dry toilets (less NH_3 emissions);	Hydrosphere	Technologies
Research and development of combustion and energy **technologies to further decrease Nr emissions.**	Energy	Technologies
Application of best available technologies to **reduce emissions from manure and fertilizers management** and storage from barn to field. It includes manure spreading equipment, slurry tanks, precision technology for fertilizer and manure application, covered storage facilities.	Agriculture	Technologies
Slurry acidification in agriculture (reduces or stops ammonia from evaporation from animal manure slurry. These technologies have been tested under Danish conditions and are approved by the Danish Environmental Protection Agency as BAT technologies that Danish farms can utilize to reduce ammonia emissions	Agriculture	Technologies

with up to 70 % (project Baltic Slurry Acidification, 2016).		
Closing the N cycle by enhancing circular economy that would support transformation of sewage sludge and organic wastes, as well as other types of wastes into resource. Technology development to **recover nitrogen** from sewage sludge, wastewater, waste would facilitate nitrogen dosing in agriculture compared to pure compost.	Wastewater Waste	Technologies
Improved methods for **assessment of NH_3 emissions**. NH3 emissions particularly from agriculture sector are considerable compared to other sources. Therefore, improved method is needed to assess these flows. Perhaps more studies are also needed. Now, rather rough methods are in use.	Agriculture	Research
Provision of information about the environmental impacts of food consumption, particularly **consumption of animal proteins** (products) that contributes to decreased nitrogen load by wastewaters, lower Nr emissions to atmosphere and reduced need for agricultural production area due to less animals.	Agriculture Human consumption	Environmental awareness
Improved **assessment of air emissions** of nitrogen from diffuse sources, including natural landscapes.	Forestry	Research
Further development of **public transport systems** (trains, buses, etc.).	Transport	Technologies
Step-by-step withdrawal of older **cars** without **catalytic converters** for nitrogen removal.	Transport	Technologies
Additional measures are very much dependent on the overall technological innovation, e.g. reduced fuel consumption per km, wider use of **electric** and **hybrid cars.** Make electric or hybrid cars more accessible and to improve infrastructure for zero-emission transport.	Transport	Technologies
Reduction of **fossil fuel based energy production** contributes to further decrease in NOx emissions. Shift from the fossil fuels to **renewable**. Increase of **quality of fuel**. Purification and wider use of **biogas** in energy production.	Energy	Technologies
Improvement of the **energy efficiency** of buildings (e.g. improvement of the thermal insulation; including nearly zero energy buildings).	Energy	Technologies
Improvement of information and raising of awareness for general public about our impact on the environment e.g. impact of our daily activities and habits. One of such measures in the future could be the elaboration of "**nitrogen foot print**" calculating tool for Latvia and Estonia. The N-Calculator tool is country-specific to account for energy use, food consumption patterns, and food production practices specific to a particular country. The N-Calculator is currently available online for the United States, Netherlands, Germany, and United Kingdom (N print site, 2011).*	Human settlements	Environmental awareness
NOx relevant **procurement criteria** in energy services.	Energy	Economic
Evaluation of **feasibility** and **efficiency** of all proposed technical measures for conditions of Latvia and Estonia.	Agriculture Forestry	Technologies

*Impact to all environmental media.

There is a risk that applied measures to reduce air emissions will enhance loss of N to hydrosphere if, for example, crop yields remain low due to unfavourable weather conditions.

5.3. Waste

5.3.1. Overview

International requirements

Directive 2008/98/EC on waste stated, that waste management must be carried out without any risk to water, air, soil, plants or animals, without causing a nuisance through noise or smells, or harming the countryside or places of special interest. It introduces recycling and recovery targets to be achieved by 2020 for household waste (50 %). **Directive** of European Parliament and of the Council (EU) **2018/851** (30.05.2018.) amending Directive 2008/98/EC on waste states, that Member States should aim to achieve an indicative Union-wide food waste reduction target of 30 % by 2025 and 50 % by 2030. Member States shall ensure that, by 31 December **2023 bio-waste** is either separated and recycled at source, or is collected separately and is not mixed with other types of waste. The preparing for re-use and the recycling of municipal waste shall be increased to a minimum of 55 % by 2025, of 60 % by 2030, of 65 % - by 2035. **Directive** of European Parliament and of the Council (EU) 2018/850 (30.05.2018.) amending Directive 1999/31/EC on the **landfill of waste** requires, that Member States shall take the necessary measures to ensure that by 2035 the amount of **municipal waste** landfilled is reduced to 10 % or less of the total amount of municipal waste generated (by weight). According to Article 5, point 1 Member States shall set up a national strategy for the implementation of the reduction of biodegradable waste going to landfills. This strategy should include measures to achieve the targets set out in paragraph 2 by means of in particular, recycling, composting, biogas production or materials/energy recovery.

Legislation, planning documents regarding measures for decreasing N loads

Waste Management Law of **Latvia** reglaments, that The national waste management plan and regional plans include measures to promote the use of environmentally friendly materials produced from bio-waste, separate collection of bio-waste for their recovery, composting and recycling, and measures for the treatment of bio-waste. Biological waste is composted in landfills for municipal waste or for composting bio-waste at specially designated sites, or recycled in another way, subject to authorization for the activity in question if a permit has been obtained for the specific activity. In landfill there can not be disposed batteries, accumulators, vehicle batteries, battery waste, separately collected untreated waste of electrical and electronic equipment. Hazardous waste have to be collected separately. They are defined in Cabinet Regulations No. 302 “Provisions on waste classification and properties that make waste hazardous” (19.04.2011.).

Waste management is carried out in accordance with the National waste management plan of Latvia for 2013 - 2020. In it the strategy for decreasing amount of biodegradable waste is included, according to what there should be disposed 35 % of biodegradable waste in landfills in 2020. There is concluded, that based on the assessment of the possibilities of biodegradable waste recycling and taking into account the domestic waste management measures taken in Latvia, both technical measures should be taken to achieve the biodegradable waste management objectives, as well as several regulatory enactments and public education measures.

According to Draft OECD report about Latvia, Waste generation has more than doubled since 2004, despite a decrease due to the economic crisis. In 2016, Latvia managed about 2.5 million tonnes of municipal and industrial waste, including 300 000 to 400 000 tonnes of inert mineral waste and 65 000 to 80 000 tonnes of hazardous waste. About 70% of the waste was recovered. Landfilling, though decreasing, still represents more than 20% of treatment. Official data show that waste from households and other municipal sources amounts to more than 30% of all waste generated, a much higher share than in most other countries. Municipal waste generation grew till 2007, then decreased (with some fluctuations) as the crisis reduced household purchasing power. But, contrary to forecasts in the State Waste Management Plan for 2013-20 based on a declining population, the past five years have again seen a rise in amounts generated. In 2017, every Latvian inhabitant generated, on average, 420 kg of household waste, it is 32% more than the Latvian average in 2005 (318 kg/cap). The recovery rate grew significantly after 2011 with the gradual introduction of separate collection, development of extended producer responsibility systems and increased Natural resources tax on waste landfilling. From basically zero in 2000, the rate had risen to 5% by 2005, 9% by 2010 and 30% by 2016. However, some biodegradable municipal waste, undergoes anaerobic digestion with biogas recovery in specially engineered bioreactor operating since 2016 at the Riga Getlini landfill site.

Composting is set as one of the priorities in waste treatment in Latvia. Composting biological degradable waste is useful. In Latvia that is mostly “park - garden” and “food production” waste. Data about industrial composting became available 2003, when waste treatment companies started waste composting and got IPPC permits for this activity.

Objectives and deadlines: In **Estonia** by 2020, the proportion of biodegradable waste dumped in landfills shall not exceed 20% of municipal waste (Waste Act, 2019). By 2020, the percentage of biodegradable waste recycled shall be 13% of the total mass of municipal wastes. By 2020, 50 % of the glass, paper, metal and plastic in the municipal wastes shall be prepared for reuse or recycled as material (Directive 2008/98/EC of the European Parliament and of the Council on waste). By 2020, the percentage of recycled package waste shall be 60% both in terms of the total generation of package waste as well as per each package type. In Estonia, plastic and paper/cardboard packaging wastes are the most prevalent types of waste, followed by glass, metal and wood packaging waste. Of these, paper and cardboard packaging is most reused. Most of the industrial waste of the timber industry is recycled.

Trends: due to restrictions on dumping, the amounts of mixed municipal waste dumped in landfills have been decreasing in Estonia since 2008. Overall, collection by waste type is on the increase with paper waste/cardboard, metals and biodegradable kitchen and restaurant waste collected the most. Important topics are: prevention of waste generation, reuse, recycling, producer responsibility. Preparatory activities such as waste collection, sorting and crushing before treatment are also regarded as reuse. In 2011, 16.5% of organic substances were recycled or revalued, which is 35% of the total reuse (Keskkonnaministeeriumi, 2013).

Established ceilings and restrictions: Since 2007, waste dumping restrictions have been imposed for landfills which forbid dumping hazardous wastes, liquid wastes, tyres and animal wastes. Since 2013, the proportion of biodegradable waste dumped in landfills was maximally 30%. Safety and quality requirements have been established for compost as a product made from biodegradable waste (Requirements, 2016). A pre-treatment requirement has been established for some wastes to make the waste suitable for further disposal (e.g. bilge water, oil and other liquid wastes, septic tank sediments recovered from ships at ports). Before the use of waste water sludge in agriculture, landscaping and reclamation, the sludge shall be stabilised in a suitable manner and the stabilised sludge spread on the ground shall be mixed with soil or covered with soil within two days after spreading. Samples shall be taken from both the sludge and soil where the sludge is planned to be spread (Requirements, 2017). Leachate generated during composting which flows into recipients shall be compliant to the Water Act. If the landfill has a separate waste water discharge, the maximum allowed concentration of total nitrogen in the waste water is 75 mg/l (Requirements, 2017).

Measures to achieve targets (incl. economic measures): 1) reception and dumping of unsorted municipal waste in landfills is prohibited since 2008 (Waste Act, 2019); 2) according to the Waste Act, a five stage waste hierarchy shall be followed: prevention–preparation for reuse–recycling, composting–other recovery (incineration with energy recovery and anaerobic digestion)–disposal. In lieu of the previous three stage waste hierarchy (prevention–reuse–disposal), the priority is to prevent the generation of waste; 3) excise duty on packaging upon the neglect of the reuse obligation for package waste; 4) waste producer shall apply for a waste permit (or as part of an integrated permit); 5) a waste fee for dumping waste into the environment; 6) development of the End of Waste criteria, in Estonia, the corresponding criteria have been developed for the production of compost, fuel additives from oil shale wastes, biogas fermentation residue (Requirements, 2016) and products from wastewater sludge (Requirements, 2017).

The mechanical biological treatment (MBT) of municipal wastes during which a large amount of mixed wastes with energy value is separated into waste derived fuel is also considered as reuse. The mass incineration, mechanical biological treatment and production of waste derived fuel are becoming the two major technologies for the reuse of mixed municipal wastes (National Waste…, 2014). Biological recycling is composting or soil treatment, these receive garden and landscaping wastes, biodegradable kitchen and restaurant wastes and household wood wastes. With regard to garden and landscaping wastes and kitchen and restaurant waste, aerobic composting is prevalent in Estonia (Alkranel OÜ, 2017). In this, several different solutions may be considered as best practice: windrow composting with membrane and forced ventilation and windrow composting with sufficient mechanical mixing of the windrows; this generates compost as a product which can be marketed (Alkranel OÜ, 2017).

5.3.2. Proposals

Background for proposed measures, based on GURINIMAS calculations

Latvia

About 28 % of Nr in waste origin from food and feed industry, 27% from human settlements, 14% by sludge from wastewater sector, 14 % from industry sector. More about 65% of the incoming Nr remains in waste sector (e.g., in landfills).

According to data from Central Statistical Bureau, 1980 kt of municipal waste (including industrial waste) were generated in Latvia in 2016. 558.5 kT of municipal waste were landfilled and 1138 kT were processed.

It is estimated that one person generates about 0.3 tonnes of unsorted waste per year in Latvia and total amount of municipal waste per person is about 0.4 t/year. About 39 % of unsorted municipal waste from households are biodegradable waste. Paper and cardboard comprise about 8% unsorted wastes. Collected municipal waste is mechanically sorted, however processing / regeneration possibilities for biodegradable and low caloric waste fraction (~ 80 % of the total waste volume) are limited. Currently only ~21% of collected unsorted waste is regenerated (GeoConsultants, 2017).

Estonia

About 49% of total nitrogen in waste originated from Energy sector. It comes from incineration of the oil-shale and formation of fly and bottom ash which is largely landfilled. The share of landfilled Nr from oil shale ashes form 69% of all landfilled wastes. Another major input stream originates from Human settlements (15%) of the total N input, mainly by food losses and organic wastes contributing 15% of the total input. Nr input by food per capita is 6.2 kg/yr. 12% of N of the total input come from food and feed industry these are mainly leftovers from restaurants and food production companies. About 10% of total nitrogen originated from organic waste of agricultural sector.

Regarding the sorting study made in Estonia in 2012-2013 by Stockholm Environment Institute about 32% form organic waste of all mixed municipal waste and 18% are plastic wastes. The larger efforts have to be done to increase awareness of the people towards prevention of waste generation and recycling of valuable materials from the waste stream, which help to implement the circular economy concept into waste management sector and by this minimizes the share of landfilled nitrogen.

As one of the possible measures in waste handling sector can be achievement of the common target of 50% preparing for re-use and recycling of certain waste materials from households by 2020 as proposed by Directive 2008/98/EC on waste (Waste Framework Directive, 2008).

Proposals for measurements

5.3.2.1. Table. Proposed measures for reducing N loads to waste

Measure	Related pool from GURINIMAS	Group of measure
Introduction of the principles of circular economy for all types of wastes, including mineral wastes.	All economic sectors and human consumption	Environmental awareness Technologies Research
Awareness rasing of people towards prevention of waste generation - avoiding the **waste of food.**	Human consumption	Environmental awareness
Provision of more effective infrastructure for separate collection, particularly in human settlements and handling (incl. composting) of **organic wastes** - separate collection of these waste and use of compost in agriculture promotes restoration of soil fertility, decreasing overload of fertilizers. So far nearly 16-19% of the produced food goes to waste pool.	Waste Agriculture Human settlements	Technologies

To introduce an **accounting system** for bio-waste transferred to biogas plants.*	Agriculture Atmosphere Hydrosphere	Research / Information
Graduate ban to landfilling of organic wastes.	Human consumption	Policy
A balanced evaluation of further **usage of** plastic **packaging**, considering pressures on the environment by wasted food on the one hand, and plastic packaging on the other hand.	Human consumption Food/feed industry Agriculture	Technology Environmental awareness

*Impact to all environmental media.

If **compost** is used only on the basis of the amount of nitrogen (N), most of the compost will then have a **surplus of phosphorus** (P) and **potassium** (K) relative to the crop. When reused, these mineral elements and salts can accumulate above the optimum level. Farmers using compost should regularly perform soil tests to assess the accumulation of P, K and salts. Consideration should be given to using other sources of nitrogen fertilizers or to use pulses for crop rotation, especially when P and K levels are higher than optimal (LASA, 2018).

A substantial part of the food is lost, both by producers and by final consumers, and there are large flows of reactive nitrogen to the environment through waste disposal sites or waste water treatment plants. Accordingly, fertiliser used for the cultivation of this food, including nitrogen compounds, is also lost. However, the plastic used for **packaging of food products**, which helps to keep foods longer, causes significant damage to the environment, because biodegradation of plastics takes a long time. A balanced evaluation of the usage of plastic packaging should therefore be carried out, taking into account the pressures on the environment made by wasted food on the one hand, and on the other hand plastic packaging. The development of more easily recyclable plastics would also be desirable, while maintaining the benefits of plastic packaging in the preservation of food products.

6. Description and guide to use GURINIMAS tool

The virtual tool GURINIMAS for the introduction of GURINIMAS main targets and measures. It is a web-based English-language solution, which demonstrate and explain the current situation, targets and actions both to specialists in the field and wider public. The aim of this chapter is to introduce to virtual tool GURINIMAS and give insight of virtual tool structure and possibilities.

The aim of virtual tool GURINIMAS

The virtual tool GURINIMAS is developed with aim to give insight of Nitrogen budget at national level and evaluate impact of mitigation measures on nitrogen flow reduction. The virtual tool GURINIMAS can be used for three purposes:

- **Education** – the knowledge about nitrogen flows of natural and anthropogenic environment is explained by virtual tool GURINIMAS. User can explore nitrogen budget of Latvia and Estonia by pools.
- **Demonstration** – the virtual tool GURINIMAS can be used in total and by sectors to explain relations between anthropogenic activities and natural environments, as well as identify the possible mitigation measures.
- **Support** – the virtual tool GURINIMAS can be used to support decision making in different levels. The evaluation of mitigation measures is fundamental part of virtual tool GURINIMAS.

The conceptual framework of virtual tool GURINIMAS

The conceptual framework of virtual tool GURINIMAS is developed in six levels. The conceptual structure of virtual tool GURINIMAS is presented in Figure 6.1. The 1st level is introduction to virtual tool GURINIMAS and link to country level of virtual tool GURINIMAS where is opportunity to choose Estonia or Latvia nitrogen budget. The 2nd level is country nitrogen budget where user can explore total nitrogen budget where all pools and all nitrogen flows is displayed. The 3rd level of virtual tool GURINIMAS let to open pools and see incoming and outcoming flows. At 4th level is possibility to see nitrogen flows and uncertainty interval of each flow. The 5th level of virtual tool GURINIMAS is mitigation measures level whwrw user can apply intensity of mitigation measure and calculate probable reduction of nitrogen flow. The 6th level is link to additional information source.

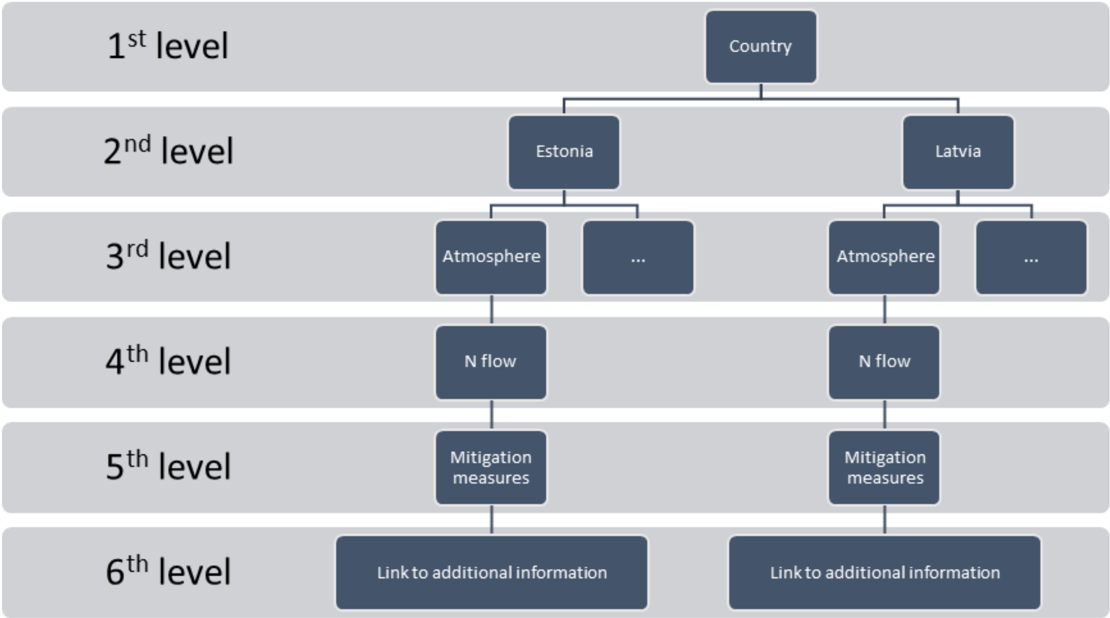


Figure 6.1. The conceptual structure of virtual tool GURINIMAS.

The guide of virtual tool GURINIMAS

The 1st level is front page of vitual tool GURINIMAS where is logo of project partners, project team and link to 2nd level of virtual tool GURINIMAS, see Figure 6.2.

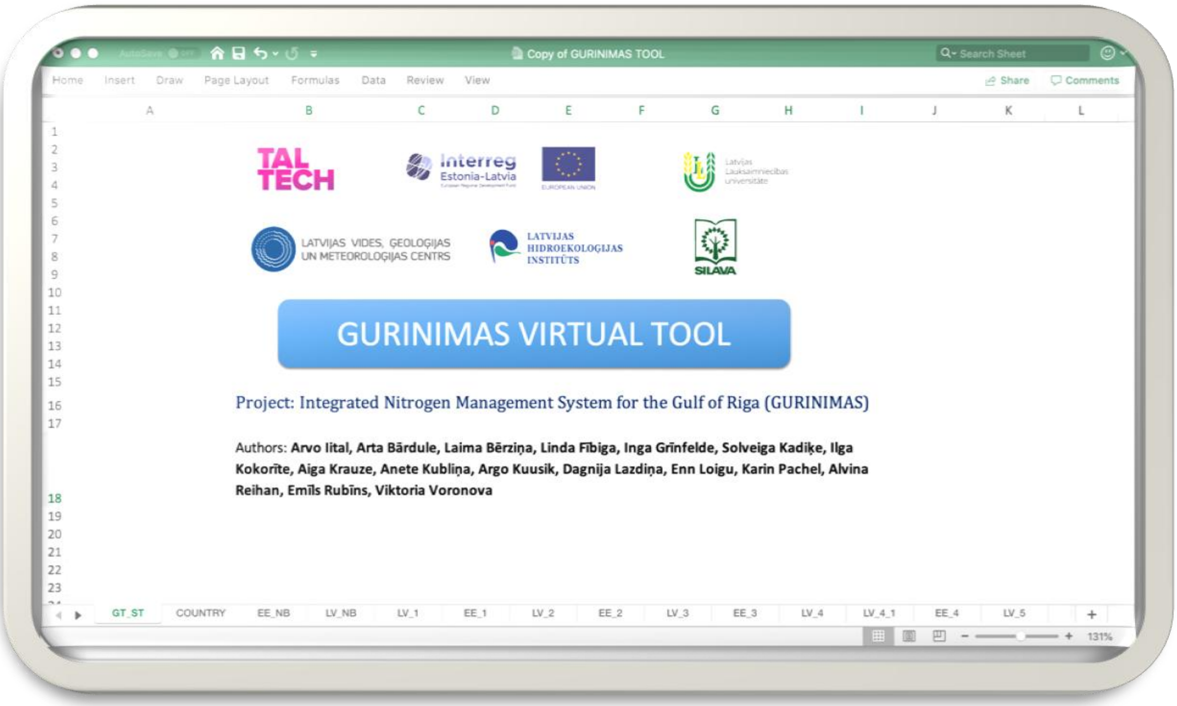


Figure 6.2. The front page of virtual tool GURINIMAS

The 2nd level is link to country nitrogen budget where user can explore total nitrogen budget where all pools and all nitrogen flows is displayed, see Figure 6.3.

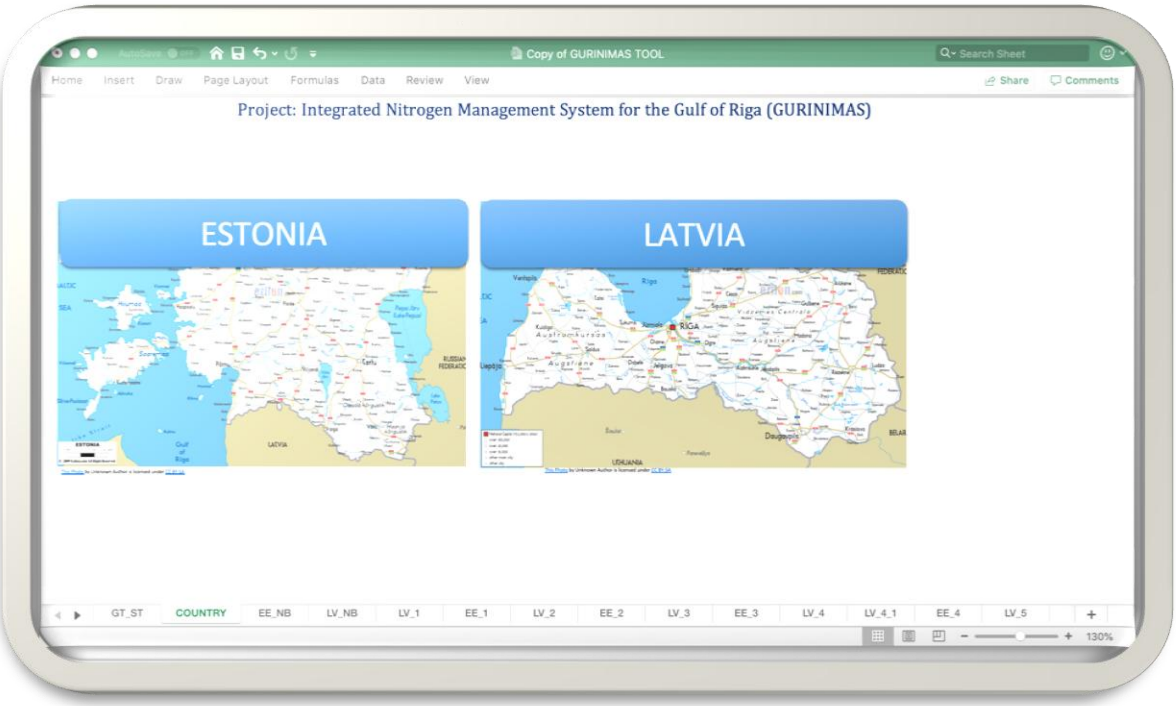


Figure 6.3. The 2nd level of virtual tool GURINIMAS

The 3rd level of virtual tool GURINIMAS show national nitrogen budget and let to open pools and see incoming and outcoming flows, see Figure 6.4.

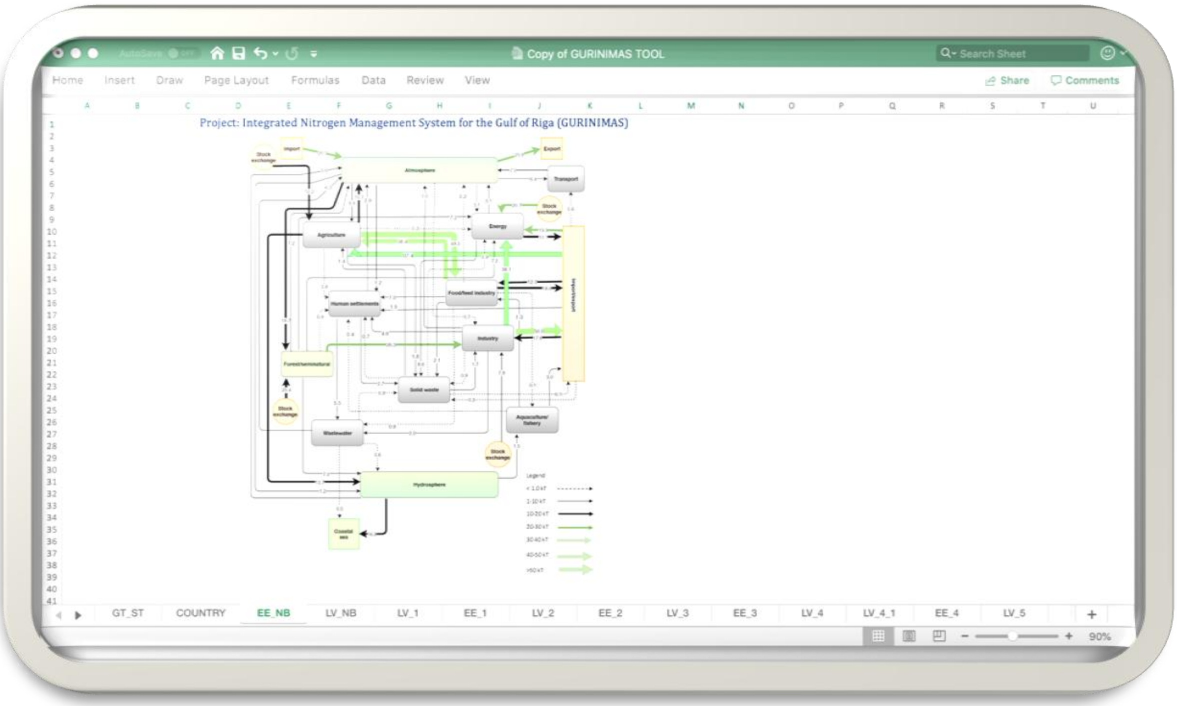
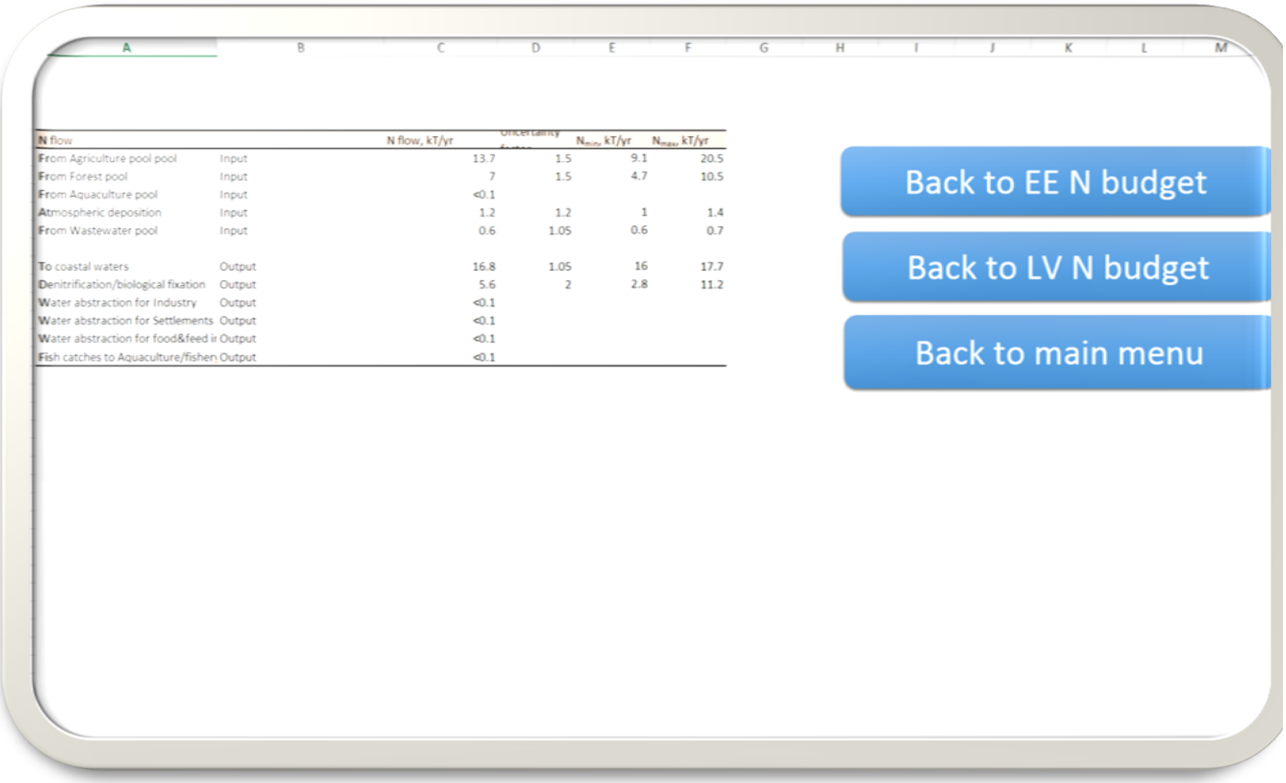


Figure 6.4. The 3rd level of virtual tool GURINIMAS

At 4th level is possibility to see nitrogen flows (see Figure 6.5.) and uncertainty interval of each flow (see Figure 6.6.).

Figure 6.5. The 4th level of virtual tool GURINIMAS



N flow		N flow, kT/yr	Uncertainty factor	N_{min}, kT/yr	N_{max}, kT/yr
From Agriculture pool pool	Input	13.7	1.5	9.1	20.5
From Forest pool	Input	7	1.5	4.7	10.5
From Aquaculture pool	Input	<0.1			
Atmospheric deposition	Input	1.2	1.2	1	1.4
From Wastewater pool	Input	0.6	1.05	0.6	0.7
To coastal waters	Output	16.8	1.05	16	17.7
Denitrification/biological fixation	Output	5.6	2	2.8	11.2
Water abstraction for Industry	Output	<0.1			
Water abstraction for Settlements	Output	<0.1			
Water abstraction for food&feed ir	Output	<0.1			
Fish catches to Aquaculture/fishen	Output	<0.1			

Figure 6.6. The uncertanty of nitrogen flows for hydrosphere pool at virtual tool GURINIMAS

The 5th level of virtual tool GURINIMAS is mitigation measures level where user can apply intensity of mitigation measure and calculate probable reduction of nitrogen flow. The calculation algorithm of thecalculation of mitigation measure impact on N flow:

$$E_{AGRHYDmm1} = E_{AGRHYD0} - (E_{AGRHYD0} * FL_{MM1} * RP_{MM1} * PR_{MM1})$$

Where:

$E_{AGRHYDmm1}$ - Nitrogen flow after application of mitigation measure

$E_{AGRHYD0}$ - Nitrogen flow before application of mitigation measure

RP_{MM1} - Reduction potential of applies mitigation measure

PR_{MM1} - Proportion of application area (0-100%)

FL_{MM1} - Proportion of nitrogen flow the mitigation measure can be applied

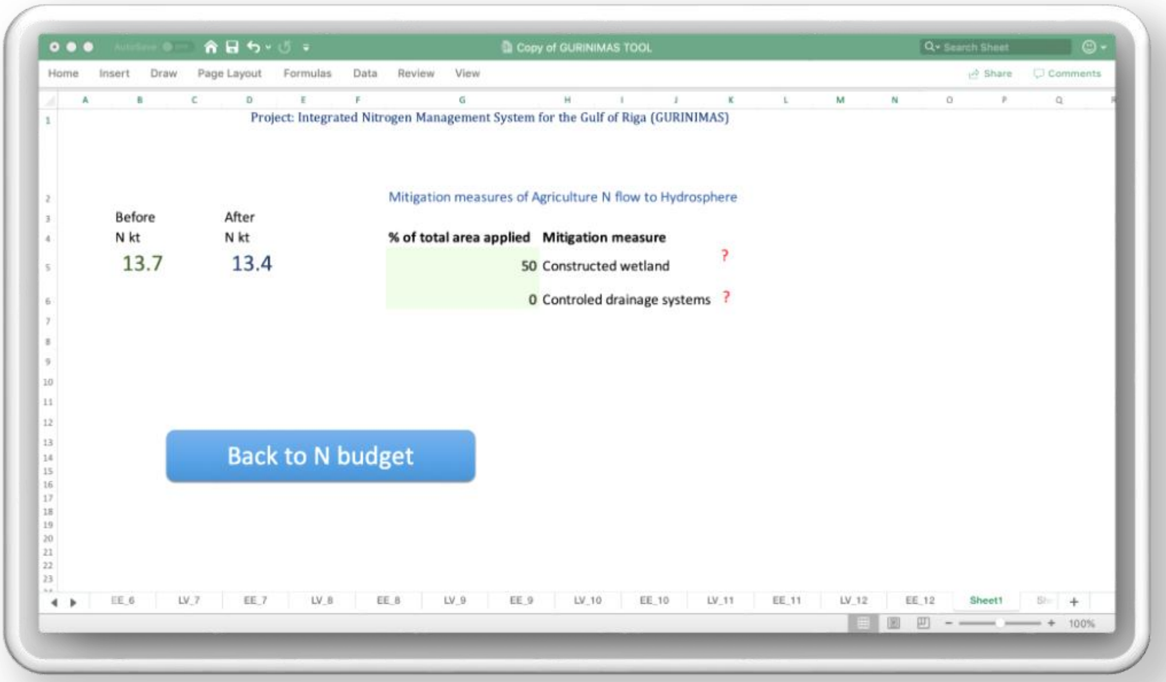


Figure 6.7. The 5th level of virtual tool GURINIMAS

The 6th level is link to additional information source where user can find detailed information about mitigation measure.

In particular, the developed virtual tool of nitrogen management system will be used by the Ministries Environment of Estonia and Latvia continuously on the internet, to provide up-to-date information about the level of nitrogen in the Gulf of Riga, the status of planned measures and achieved outcomes of measures. In addition to virtual tool, the results of analysis will be introduced at the sectoral conferences of both countries and internationally, esp. in the HELCOM meetings and events.

Conclusions and Recommendations

1. Assessment of the reactive nitrogen flows in Latvia and Estonia followed more or less harmonized methodology including the list of the studied pools. However, definition of some specific input and output flows could vary due to available input data and its quality. Therefore, comparison of the results require more deep understanding of the applied methodologies in both countries.
2. Majority of input data origin from the national statistics, studies and reports in Estonia and Latvia. The data about the content of Nr in materials, goods and products origin both from the national sources (e.g. NutriData database) as well as the data banks in other countries. It is possible that in some cases these are not well representative for Estonian/Latvian conditions.
3. Application of statistical methods for data evaluation are usually not suitable for substance and material flow analysis due to the wide range of different type of data with varying degrees of uncertainties (Schwab et al., 2016). Therefore, the uncertainty of all the defined major flows was assessed by expert panel and by applying a method proposed by Hedbrandt and Sörme (2001) and further refined by Antikainen et al. (2005).
4. Uncertainty range of the assessments of diffuse emissions from agriculture and natural landscapes is typically quite large that can be explained by the applied methodology as well as by limited, unreliable or even contradictory input data.
5. Despite of the abovementioned limitations we still think that the major N flows are described with quite reasonable uncertainty and we managed to avoid double counting of flows that appeared to be one of the most difficult methodological problems to overcome.
6. Summarized inputs of the reactive nitrogen (Nr) exceed outputs only by 52 kT/yr in Estonia and 54 kT/yr Latvia when considering all the studied 12 pools.
7. Most of the Nr input to hydrosphere in both countries origin from diffuse sources - about 97% in Estonia, including 61% from agriculture and 53% in Latvia including 34% from agriculture. Point sources contribute only 2-3% of the total Nr load to hydrosphere. One should keep in mind that considerable part of the Nr input load to hydrosphere in Latvia is due to cross-border transport via the River Daugava. It is impossible to control losses of nitrogen from natural land cover types. Thus, measures to reduce diffuse load from agriculture are utmost important.
8. Human settlements contribute the largest portion of Nr by wastewaters to WWTPs in Latvia and Estonia (53% and 66% of the total input, respectively) followed by the load from industries and other sources. Therefore, possible measures to reduce input of N to WWTPs from settlements should focus on changing of the human consumption considering that Nr consumed by food will end up as a load to WWTPs.
9. Calculated Nr load from fish farms to hydrosphere is considerably larger compared to the official statistics that underestimate these flows. Thus, improved methodology should be applied to assess the load from aquaculture facilities, considering particularly possible impacts of the load to sensitive recipients.
10. Air emission of environmentally important Nr by NOx and NH_3 from the energy sector is even smaller than emissions from the transport sector, human settlements and the agriculture pool. Thus, possible additional measures to decrease overall air emissions of reactive nitrogen should target to the agriculture and human settlements pools.

11. It is very important to Introduce the principles of circular economy for all types of wastes, including mineral wastes. It requires awareness rising of people towards reduction of waste generation including food waste and separate collection of organic wastes in households.
12. Long term national scale monitoring and research programs covering different economic sectors, human settlements, natural environment as well as different land use types are extremely important not only to decrease uncertainty of numerical values of Nr flows, but also to highlight economic sectors where reduction of Nr flows to the hydrosphere and the atmosphere is advisable as well as to select the most effective mitigation measures.
13. Improvement of statistical data including improvement of linking between statistical data and monitoring data would promote a better evaluation of the main flows of Nr and clearer selection of the fields where mitigation measures are recommended to be implemented.
14. Evaluation of described mitigation measures of Nr flows indicate the need for additional scientific research confirming and evaluating more comprehensive mitigation effects of proposed measures on reduction of Nr flows.
15. Results of the study highlight a desirability of education and awareness raising of different groups of society including consumers and producers about potential mitigation measures of Nr flows that can be implemented at a household, regional or national level to decrease the total N footprint.

References

1. Action Program for Good Marine Environment 2016-2020 year, approved by the Order of Cabinet in 13.07.2016.
2. Air pollutants reduction programm for the period 2020 – 2030 (2019). Keskkonnaministeerium. https://www.envir.ee/et/eesmargid-tegevused/valisohukaitse/ohusaasteainete-vahendamise-programm
3. Alkranel OÜ. (2017). Jäätmete ringlussevõtuks ettevalmistamise ja ringlussevõtu parimate praktikate kaardistus. Available:https://www.envir.ee/sites/default/files/jaatmete_ringlussevotuks_ettevalmistamise_ja_ringlussevotu_parimate_praktikate_kaardistus.pdf
4. An International Nitrogen Management System, INMS, homepage. (s.a.). Used 23.05.2019. Available: http://www.inms.international/why-care-about-nitrogen
5. Atmospheric Air Protection Act (30.06.2019). Riigi Teataja I. Available:https://www.riigiteataja.ee/akt/113032019034?leiaKehtiv
6. Bouwman, A. F., Beusen, A. H. W, Griffioen, J., Van Groenigen, J. W., Hefting, M. M., Oenema, 0., Van Puijenbroek, P. J. T. M., Seitzinger, S., Slomp, C. P. and Stehfest, E., 2013. Global trends and uncertainties terrestrial denitrification emissions. Source: Philosophical Transactions: Biological Sciences, Vol. 368, No. 1621, 1-11. Published by Royal Society.
7. Cabinet Regulation No. 384 (27.06.2017.) “Regulations Regarding the Management and Registration of Decentralised Sewerage Systems”.
8. Cabinet Regulation No. 418 (31.05.2011.) “Regulations Regarding Water Bodies at Risk”.
9. Cabinet Regulation No. 614 (02.10.2018.) “Rules for Reducing and Accounting of Air Pollutant Emissions”.
10. Cabinet Regulation No. 834 (23.12.2014.) “Regulation Regarding Protection of Water and Soil from Pollution with Nitrates Caused by Agricultural Activity”.
11. Cabinet Regulations No. 302 (19.04.2011.) “Provisions on waste classification and properties that make waste hazardous”.
12. Directive 2008/98/EC of the Euriopean parliament and of the Council (19.11.2008.) on waste and repealing certain Directives.
13. Directive of European Parliament and of the Council (EU) 2018/850 (30.05.2018.) amending Directive 1999/31/EC on the landfill of waste.
14. Directive of European Parliament and of the Council (EU) 2018/851 (30.05.2018.) amending Directive 2008/98/EC on waste.
15. Draft HELCOM Core Pressure Indicator on Nutrient Inputs, 18.04.2017

    Available:https://portal.helcom.fi/meetings/PRESSURE%206-2017-431/MeetingDocuments/7-2-Rev1%20Draft%20HELCOM%20Core%20Pressure%20Indicator%20on%20Nutrient%20Inputs.pdf
16. Draft OECD report about Latvia.

17. EEA (s.a.) Deliveries for National emission Ceiling Directive (NECD) – National emission inventories. Latvia, 2018. Available:http://cdr.eionet.europa.eu/lv/eu/nec_revised/inventories/envwqqufw

18. Emission limit values for the pollutants emitted from combustion plants outside the scope of the Industrial Emissions Act, monitoring requirements for pollution emission and criteria for compliance with the emission limit values". Obligations of holder of air pollution permit or integrated environmental permit (19.12.2017). Riigi Teataja I. Available:https://www.riigiteataja.ee/akt/110112017018

19. Emmission Decrease Action Programme of Air Polluting Substances for year 2019 - 2030. Available:https://cdr.eionet.europa.eu/lv/eu/nec_revised/programmes/envxj3dyg/Gaisa_piesarnojuma_plans__010419_gala.pdf

20. Environment Agency of Estonia (KAUR) homepage. Marine subprogramme of the national environmental monitoring programme. (2018). Available:https://www.keskkonnaagentuur.ee/et/eesmargid-tegevused/vesi/meri/mereseire

21. Fowler, D., Coyle, M., Skiba, U., Sutton, M.A., Cape, J.N., Reis, S., Sheppard, L.J., Jenkins, A., Grizzetti, B., Galloway, J.N., Vitousek, P., Leach, A., Bouwman, A.F., Butterbach-Bahl, K., Dentener, F., Stevenson, D., Amann, M., Voss, M. The Global nitrogen cycle in the twenty-first century (5 July 2013). Philosophical Transactions: Biological Sciences, Vol. 368, No 1621, pp 1-13.

22. Galloway, J.N., Aber, J.D., Erisman, J.W., Seitzinger, S.P., Howarth, R.W., Cowling, E.B., Cosby, B.J. (2003). The Nitrogen Cascade. BioScience, Volume 53, Issue 4, Pages 341–356. Available: https://academic.oup.com/bioscience/article/53/4/341/250178

23. GeoConsultants (2017) Novērtējums par sadzīves, bīstamo un ražošanas atkritumu sastāvu atkritumu apsaimniekošanas reģionos, atsevišķu atkritumu veidu apsaimniekošanu un atkritumu poligonos apglabājamo atkritumu daudzuma samazināšanas iespējām. Projekta atskaite (1.daļa). Available:http://varam.gov.lv/in_site/tools/download.php?file=files/text/Publikacijas/petijumi/vide//VARAM_90_04102016_Nosleguma_zinojums_PD1.pdf

24. Gustafsson, B.G., F. Schenk, T. Blenckner, K. Eilola, H.E.M. Meier, B. Müller-Karulis, T. Neumann, T. Ruoho-Airola, O.P. Savchuk & E. Zorita (2012): Reconstructing the Development of Baltic Sea Eutrophication 1850–2006. Ambio, 41(6), 534–548. DOI 10.1007/s13280-012-0318-x

25. HELCOM 2013 c: Summary report on the development of revised Maximum Allowable Inputs (MAI) and updated Country Allocated Reduction Targets (CART) of the Baltic Sea Action Plan. Available:http://www.helcom.fi/Documents/Ministerial2013/Associated%20documents/Supporting/Summary%20report%20on%20MAI-CART.pdf

26. HELCOM, 2014. Eutrophication status of the Baltic Sea 2007-2011 - A concise thematic assessment. Baltic Sea Environment Proceedings No. 143

27. Inimtekkeliste saasteainete heitkoguste vähendamise riiklikud kohustused Eesti territooriumil ja majandusvööndis, nende täitmise tähtajad ja erandid ning aruandlus (01.07.2018). Riigi Teataja I. Available:https://www.riigiteataja.ee/akt/126062018028

28. Jacob, D. J. (1999). Introduction to Atmospheric Chemistry. Princeton University Press. http://acmg.seas.harvard.edu/people/faculty/djj/book/bookchap6.html#pgfId=108141

29. Jansons , V. (vad.), Ruža, A., Stepiņa, V., 2013. Aizsargjoslu pielietošanas lauksaimniecībā pieredzes izpēte. Latvijas Lauksaimniecības Universitāte Lauku inženieru fakultāte Vides un ūdenssaimniecības katedra. Atskaite par pētījumu projekta izpildi.

30. Jansons V., Abramenko K. & Berzina L. 2009. Risk assessment of the agricultural pollution in Latvia. LLU Raksti 317: 1 -11.

31. Jansons V., Lagzdins A., Berzina L., Sudars R. & Abramenko K. 2011. Temporal and spatial variation of nutrient leaching from agricultural land in Latvia: long term trends in retention and nutrient loss in a drainage and small catchment scale. Environmental and Climate Technologies 7: 54- -65.

32. JŪRAS VIDES STĀVOKĻA NOVĒRTĒJUMS (2018), LIAE, Riga, 2018. http://www.lhei.lv/attachments/article/573/Juras_vides_novertejums_2018.pdf

33. KESE, Keskkonnaseire Infosüsteem homepage. (2016). Used 23.04.2019, Available:https://kese.envir.ee/kese/welcome.action

34. Keskkonnaagentuur (KAUR) koduleht. Lisa 5. Riikliku keskkonnaseire programmi mereseire allprogramm. (2019). Available:https://www.keskkonnaagentuur.ee/et/seire

35. Keskkonnaamet. (2017). Lääne-Eesti, Ida-Eesti ja Koiva vesikondade veemajanduskavade meetmeprogrammi rakendamise tegevuskava 2018-2019. Available:https://www.keskkonnaamet.ee/et/eesmargid-tegevused/veemajanduskavad/tegevuskava/tegevuskava-2018-2019

36. Keskkonnaamet. (2018). Ülevaade veemajanduskava meetmeprogrammi rakendamise tegevuskava ellu viimisest Lääne-Eesti, Ida-Eesti ja Koiva vesikondades 2017. aastal. Available:https://www.keskkonnaamet.ee/sites/default/files/Veemajanduskavad/vmk_tegevuskava_ulevaade_2017.pdf

37. Keskkonnaministeeriumi kodulehekülg. Jäätmevaldkonna ülevaade 2013. Used 07.05.2019. https://www.envir.ee/et/jaatmed

38. Keskkonnaministeeriumi kodulehekülg. Lääne-Eesti vesikonna veemajanduskava perioodiks 2015-2021. Meetmeprogramm, Lisa 1. (2016). Used 15.04.2019 Available:https://www.envir.ee/et/eesmargid-tegevused/vesi/veemajanduskavad

39. Klauson, A., Lotman, A., Jaanus, A., Kuus, A., Põllumäe, A., Martin, G., Lips, U. (2018). Eesti mereala keskkonnaseisund 2018. 81 p. Available:https://www.envir.ee/sites/default/files/2019.05.29_koondaruanne_msrd.pdf

40. Kļaviņš M., Rodinov V., Kokorīte I., Kļaviņa I. & Apsīte E. 2001. Long-term and seasonal changes in chemical composition of surface waters in Latvia. Environ. Monit. Assess. 66: 233- -251.

41. Klõga M., Maharjan B. 2015. Temporal trends in nitrogen concentrations in Estonian rivers. Journal of Water Security, 1 (4), 37−45.10.15544/jws.2015.004.

42. Lagzdiņš A., Jansons V., Sudars R., Grinberga L., Veinbergs A. & Abramenko K. 2015. Nutrient losses from subsurface drainage systems in Latvia. Acta Agric. Scand., Sect. B 65(sup. 1): 66- -79.

43. LASA - Latvijas Atkritumu saimniecības asociācija, 2018. Vadlīnijas "Atkritumu stadijas izbeigšanās nosacījumu izstrāde bioloģiskajiem atkritumiem". Available:http://www.lasa.lv/wp-content/uploads/2018/04/Vadl%C4%ABnijas.docx

44. Latvijas gaisu piesārņojošo vielu emisiju prognozes 2020., 2025. un 2030. Gadam, 2017. Projekta atskaite. Available:https://www.meteo.lv/fs/CKFinderJava/userfiles/files/Vide/Gaiss/Piesarnojums/Atskaite_FEI_2017_final_v2.pdf

45. Law "On Pollution" of Latvia.

46. Finér. L., Čiuldienė, D., Libiete, Z., Lode, E., Nieminen, M., Pierzgalski, E., Ring, E., Strand, L., Sikström, U. 2018. WAMBAF – Good Practices for Ditch Network Maintenance to Protect Water Quality in the Baltic Sea Region. Available:https://www.skogsstyrelsen.se/globalassets/projektwebbplatser/wambaf/drainage/good-practices/good-practices-for-ditch-network-english.pdf

47. LEGMC, 2019. Summary about implementation about programs of measures in 2016 - 2018 and calculation of costs according to Water Framework directive 2000/60/EK requirements (Latvia).

48. LIAE monitoring data, 2000-2018.

49. Limit and target values for air quality, other limits and assessment thresholds for air quality", Annex 1 (09.03.2019). Riigi Teataja I. https://www.riigiteataja.ee/aktilisa/1060/3201/9012/KKM_m8_lisa1.pdf#

50. Martin, 20171. Rannikumere ülevaateseire 2016. Aruanne. Leping: 4-1/16/58, TÜ Eesti Mereinstituut, 155 p.

51. Martin, 20172. Rannikumere operatiivseire 2016. Aruanne. Leping: 4-1/16/60, TÜ Eesti Mereinstituut, 155 p.

52. Martin, G. and Lips, I., 2017. Avamereseire 2016. Aruanne. Leping: nr 4-1/16/59. TÜ Eesti Mereinstituut. TTÜ Meresüsteemide Instituut, 104 p .

53. Methods for the measurement and computational determination of the pollutant emissions from animal and poultry farms to the atmosphere (01.01.2017). Riigi Teataja I. Available:https://www.riigiteataja.ee/akt/122122016004

54. Methods for the measurement and computational estimation of the pollutant emissions from combustion plants to the atmosphere (25.03.2019). Riigi Teataja I. Available:https://www.riigiteataja.ee/akt/122032019009

55. N print site, 2011. Available: http://www.n-print.org

56. National Waste Management Plan 2014–2020. (2014). Ministry of the Environment. Available:https://www.envir.ee/sites/default/files/riigi_jaatmekava_2014-2020.pdf

57. National waste management plan of Latvia for 2013 – 2020.

58. N-print site. Available: http://www.n-print.org/CountryNFootprints

59. Olli K. 2010. Lämmastikuringe. Tartu Ülikool Ökoloogia ja maateaduste instituut.

60. Oygarden L., Deelstra J., Lagzdins A., Bechmann M., Greipsland I., Kyllmar K., Povilaitis A. & Iital A. 2014. Climate change and the potential effects on runoff and nitrogen losses in the Nordic-Baltic region. Agric. Ecosyst. Environ. 198: 114- -126.

61. Pärnumaa Keskkonnateenistus, 2003. Pärnu alamvesikonna veemajanduskava. Eesti. Keskkonnaministeerium, 174 p.

62. Project "Baltic Slurry Acidification". Start of project – 2016. Available: http://balticslurry.eu/about-the-project/

63. Project of Emission Decrease Action Programme of Air Polluting Substances for year 2019 – 2030. Available:https://cdr.eionet.europa.eu/lv/eu/nec_revised/programmes/envxj3dyg/Gaisa_piesarnojuma_plans__010419_gala.pdf

64. Purwono, Rezagama, A., Hibbaan, M., Budihardjo, M.A. (2017). Ammonia-Nitrogen (NH3-N) and Ammonium-Nitrogen (NH4+-N) Equilibrium on The Process of Removing Nitrogen By Using Tubular Plastic Media. Journal of Materials and Environmental Sciences, 2017, Volume 8, Issue S, Page 4915 – 4922. Available:http://www.jmaterenvironsci.com/Document/vol8/vol8_NS/522-JMES-2876-Purwono.pdf

65. Requirements applicable to treatment and routing of effluent and rain water into receiving bodies of water, limits of pollution indicators for effluent and rain water and measures for enforcement of these requirements, Annex 1 (01.01.2017). Riigi Teataja I. Used 07.05.2019. Available: https://www.riigiteataja.ee/akt/116122016006

66. Requirements for fermentation residue generated in the production of biogas from biodegradable waste (22.05.2016). Riigi Teataja I. Available:https://www.riigiteataja.ee/akt/119052016009

67. Requirements for manufacturing of products from wastewater sediment (31.07.2017). Riigi Teataja I. Available:https://www.riigiteataja.ee/akt/128072017004

68. Requirements for the production of compost from biodegradable waste (01.01.2016). Riigi Teataja I. Available:https://www.riigiteataja.ee/akt/119122015010

69. Requirements for use of wastewater sediment in agriculture, landscaping and recultivation (02.12.2017). Riigi Teataja I. Available: https://www.riigiteataja.ee/akt/129112017006

70. Ring, E., Andersson, E., Armolaitis, K., Eklöf, K., Finér, L., Gil, W., Glazko, Z., Janek, M., Lībiete, Z., Lode, E., Małek S., Piirainen, S. Good practices for forest buffers to promote good surface water quality in the Baltic Sea region — A handbook, 2018. Available: https://www.skogsstyrelsen.se/globalassets/projektwebbplatser/wambaf/riparian-forests/good-practices/english---good-practices---forest-buffers.pdf

71. Specified list of activities in areas which need a waste permit to create waste, and production output and waste amounts for which no waste permit is required (04.09.2010). Riigi Teataja I. Available:https://www.riigiteataja.ee/akt/13354609

72. Stevens, C.J. 2019. Nitrogen in the environment. Excess nitrogen causes problems in developed nations, but nitrogen-poor soils threaten food security elsewhere. Science, 363 (6427), 578-580. Available:https://science.sciencemag.org/content/363/6427/578.full

73. Stigebrant, A., Wulff, F. 1987. A model for the dynamics of nutrients and oxygen in the Baltic proper. Journal of Marine Research 45: 729–759.

74. Stoicescu, S.-T., Lips, I., Lips, U. (2017). EL merestrateegia raamdirektiivi (2008/56/EÜ) kohane merekeskkonna seisundi hinnang teemadel eutrofeerumine ja hüdrograafilised muutused (D5 ja D7). Tallinna Tehnikaülikool, 13-25 p.

75. Svendsen, L.M., Larsen S.E., Gustafsson, B., Sonesten L., Frank-Kamenetsky D. 2018. Progress towards national targets for input of nutrients. Online.

76. Threshold output values for activities and threshold amounts for pollutants from where on air pollution permit is required for the plan (19.12.2017). Riigi Teataja I. Available:https://www.riigiteataja.ee/aktilisa/1141/2201/7010/KKM_m67_lisa.pdf#

77. Urtāns, A., 2014. Latvijas upes. Stāvoklis. Problēmas. Risinājumi. BSP-25, Rīga, 2014. gada 21. Novembris.

78. Waste Act (15.03.2019). Riigi Teataja I. Used 07.05.2019, Available:https://www.riigiteataja.ee/akt/113032019068

79. Waste Management Law of Latvia

80. Wegren S. K. 2003. Land reform in the former Soviet Union and Eastern Europe. Routledge.

ANNEXES

Annex 1

Measures for reducing nitrogen flows to hydrosphere and atmosphere pool in Latvia (LV) and in Estonia (EE)

	Type of measure / implementation		**Planning document**		**Legislation**	
	LV	EE	LV	EE	LV	EE
1. To ensure the quality of **bathing waters** in accordance with the requirements of regulatory enactments, increasing the quality of life of inhabitants and ensuring sustainable use of natural resources ● wastewater collection, treatment ● creation of toilets ● waste collection	Basic measure - included in legislation		River basin district management plans 2016 - 2021	Estonian river basin management plans 2015 - 2021	Cabinet Regulation Nr.692 “Procedures for setting up, maintaining and managing water quality for bathing places” (28.11.2017.)	“Water act” (11.05.1994); Regulations Nr.74 “Requirements for bathing water and beaches” (03.04.2008)
2. To provide quality **drinking water** supply in accordance with the requirements of regulatory enactments, improving the quality of life of inhabitants and ensuring sustainable use of natural resources ● To comply with the conditions included in the **permit** for the use of water resources issued by the regional environmental board regarding the **maintenance of water protection zones, monitoring of groundwater, openings in water wells**, measurement of water level, installation of sampling points, maintenance and provision of pump rooms against flooding, and protective measures for fish protection at surface water extraction sites etc. ● Perform appropriate **drinking water treatment** of substances harmful to human health without deterioration of quality of drinking water. ● Perform regular **monitoring of drinking water**, if more than 50 people are supplied with drinking water or amount of it is more than 10 m3/per day, control its compliance with drinking water quality requirements. ● **Control the safety** requirements for drinking water from the water abstraction point to the consumer. ● **Inform inhabitants** about **drinking water** safety and quality, give advise on the measures to be taken for quality assurance and improvement.	Basic measure - included in legislation		River basin district management plans 2016 - 2021	Estonian river basin management plans 2015-2021	Cabinet Regulation Nr. 736 “Regulation Regarding a Permit for the Use of Water Resources” (23.12.2003.) Cabinet Regulation Nr. 235 “Mandatory Harmlessness and Quality Requirements for Drinking Water, and the Procedures for Monitoring and Control Thereof” (17.11.2017.) Protection Zone Law (05.02.1997.)	Minister of Social Affairs Regulation No. 82 “Quality and control requirements and methods of analysis for drinking water” (31.07.2001) Minister of the Environment Regulation No. 75 “Procedure for formation of bodies of groundwater and list of bodies of groundwater whose status category must be determined…”* Minister of Social Affairs Regulation No. 1 “Quality and control requirements for surface water and groundwater used or planned to be used for producing drinking water” (01.07.2003) Minister of Social Affairs Regulation No. 82 “Quality and control requirements and methods of analysis for drinking water” (31.07.2001)
3. Additional enforcement of environmental requirements (measures for the protection of surface water and groundwater) in animal husbandry buildings		planned additional measures		Estonian river basin management plans 2015-2021		
4. To ensure the use of **sewage sludge** in accordance with the requirements of regulatory enactments ● for application of sewage sludge on **agricultural land**, fulfill the specified requirements (time of application, place, protective zones, etc.) ● in **forestry** sewage sludge, compost of appropriate quality are incorporated into the soil, not used as topsoil	Basic measure - included in legislation	Basic measure - included in legislation	River basin district management plans 2016 - 2021	Estonian river basin management plans 2015-2021	Cabinet Regulation Nr.362 "Regulations Regarding Utilisation, Monitoring and Control of Sewage Sludge and the Compost thereof" (02.05.2006.)	Minister of the Environment Regulation No. 78 “Requirements for use of wastewater sediment in agriculture, landscaping and recultivation” (30.12.2002) Minister of the Environment Regulation No. 24 “Requirements for manufacturing of products from wastewater sediment” (19.07.2017)

● use appropriate quality sewage sludge for **greening, brownfield recultivation**, etc. ● to carry out **storage** of sewage sludge by reducing its negative impact on the environment or **disposal** at disposal sites of other treatment plants						
5. To ensure **wastewater treatment** according to the requirements of regulatory enactments, reducing load of pollution in waters ● It is forbidden to enter **wastewater into groundwater** (except cases referred to in paragraph 23 in Cabinet Regulations Nr. 34) ● Install a **centralised sewerage system** in all villages and cities, where population equivalent (PE) ≥ 2000, in other places - if the municipality decides on its necessity ● To ensure **collection, disposal of wastewater and related waste from centralised and decentralised sewage system** in accordance with the requirements of regulatory enactments; ● The discharge of untreated wastewater, municipal wastewater and sewage sludge into surface water or environment, as well as rainwater drainage, is prohibited; ● To carry out appropriate treatment of centrally collected wastewater: * in settlements with PE 2000 - 10000, secondary treatment is performed; * in residential areas with PE> 10000 more intensive biological or other system wastewater treatment; * in residential areas with PE> 100000 more intensive biological or other system wastewater treatment; * in residential areas with PE <2000, appropriate waste water treatment; ● If the **industrial wastewater** is discharged **into the centralized wastewater collection system**, the operator must enter into an agreement with the owner of the wastewater collection system or the treatment plant manager and carry out the pre-treatment of the company's wastewater according to the contractual requirements; ● For **industrial wastewater** (biodegradable substances), that is discharged directly in receiving waters, waste water treatment according to regulatory requirements should be carried out (Annex 5: Tables 1, 2). ● If the discharge of wastewater is into **risk water body** due to point source pollution, the emission limits shall be set at a maximum of 25% more stringent than in the Annex of Cabinet Regulations Nr. 34 ● In the planning of territory development centralized collection and treatment of wastewater is ensured in building territories	Basic measure - included in legislation		River basin district management plans 2016 - 2021		Cabinet Regulations No. 34 "Regulations Regarding Discharge of Polluting Substances into Water" (0.01.2002.)	
● Determining wastewater outlets not in conformity with requirements, and setting requirements for permit issuance or elimination of the outlets		planned additional measures		Estonian river basin management plans 2015-2021		
● Reviewing conditions of environmental permits and where appropriate, imposing conditions in accordance with section 24 of the Water Act (depending on the body of water, up to 30% stricter requirements) in the case of a > 2000 ie wastewater treatment plant		basic measure		Estonian river basin management plans 2015-2021		
● Supervision regarding compliance with requirements of legal acts and conditions of permit in the case of a > 2000 ie wastewater treatment plant		basic measure		Estonian river basin management plans 2015-2021		
● Bringing wastewater outlets of > 2000 ie wastewater treatment plants into conformity with requirements established (ensuring the quality of water of both outlet and receiving water body)		basic measure		Estonian river basin management plans 2015-2021		

• Updating and implementing action plan for nitrate-vulnerable area with the objective of minimizing the risk of nitrate pollution arising from agricultural production		basic measure		Estonian river basin management plans 2015-2021		
• Preparation and establishment of rules on in situ handling of wastewater		planned additional measure		Estonian river basin management plans 2015-2021		
• Supervision of compliance with the rules for in situ handling of wastewater		planned additional measure		Estonian river basin management plans 2015-2021		
• Consultation for handling of wastewater pursuant to the requirements		additional measure		Estonian river basin management plans 2015-2021		
• Supervision of compliance with the requirements with Section 24 of the Water Act (requirements for treatment of wastewater and routing of wastewater and rain water into receiving bodies of water)		planned additional measure		Estonian river basin management plans 2015-2021		
• Reform of in situ handling of wastewater (collection of wastewater or establishing small treatment plants for reducing nutrient load)		planned additional measure		Estonian river basin management plans 2015-2021		
6. To ensure **environmental impact assessment** in accordance with the requirements of regulatory enactments • Perform an initial environmental impact assessment for activities affecting Natura 2000 sites, protection zones, groundwater or surface water bodies, protected areas, human health, etc. • Submit application of planned activities, documents in state institutions, municipalities or port authorities and receive acceptance. • Fulfill the requirements for water, habitat, species protection, industrial accident prevention etc.	Basic measure - included in legislation		River basin district management plans 2016 - 2021		Cabinet Regulation No. 30 "Procedures by Which the State Environmental Service Shall Issue Technical Regulations for the Intended Activity" point. No. 21. (27.01.2015.)	
7. To ensure reduction or elimination of **nitrate pollution caused by agricultural activity** in accordance with the requirements of regulatory enactments	Basic measure - included in legislation		River basin district management plans 2016 - 2021		Cabinet Regulation Nr. 834 "Regulation Regarding Protection of Water and Soil from Pollution with Nitrates Caused by Agricultural Activity" (23.12.2014.)	Government of the Republic Regulation No. 288 "Water protection requirements for fertilizer and manure storage facilities and silage storage locations and requirements for use and storage of manure, silage juice and other fertilizers" (28.08.2001)
• To ensure maintenance of minimum vegetation in autumn and winter period – at least 50 % from total agricultural land in nitrate vulnerable area.					Cabinet Regulation Nr.1056 „Requirements for Integrated Cultivation, Storage and Labelling of Agricultural Products and the Procedures for Control Thereof" (15.09.2009)	Minister of Agriculture Regulation No. 36 "Form for field record and procedure for maintaining field record" (09.04.2003)
• To develop crop fertilization plans in farms where fertilizers are used in area of 20 ha and more; Users of professional plant protection products should develop a fertilization plan for each crop throughout the country.					Cabinet Regulation Nr. 829 "Special Requirements for the Performance of Polluting Activities in Animal Housing" (23.12.2014.)	Minister of the Environment Regulation No. 11 "Grounds for determining slope of ground surface and exceptions in fertilizing sloping areas" (10.05.2016)
• Comply with fertilizer spreading requirements (do not spread on frozen, wet, snowy soils, floodplains, flood-prone areas, buffer zones, slopes in nitrate vulnerable area > 10 °, it is not allowed to disperse, apply into soil 100 m from the watercourse / watercourse coast; after dispersing litter manure and fermentation residues apply into soil within 24 hours, liquid manure and slurry - within 12 hours, in autumn for field fertilization liquid manure and fermentation residues should only be used in combination with plant residue after incorporation into the soil by peeling or plowing.					Cabinet Regulation Nr. 126 "Procedures for Granting of Direct Payments to Farmers" (10.03.2015.)	Minister of Rural Affairs Regulation No. 64 "Extent of protection zone for artificial recipients and procedure for activity within protection zone" (10.12.2018)

• Perform an inventory of fertilizers (list and document all organic fertilizers obtained, purchased or sold for at least 3 years if fertilizers are applied in> 20 ha, fruit and vegetable farms -> 3 ha). • When designing new animal housing, plan in the project construction of manure storage facilities. • Comply with greening requirements (to ensure crop diversification, to create and / or maintain ecologically important areas and to preserve perennial grasslands).					Cabinet Regulation No. 829 “Special Requirements for the Performance of Polluting Activities in Animal Housing” (LV)	Minister of Rural Affairs Regulation No. 32 “Requirements for renovation project for a joint artificial recipient maintained by the state” (14.03.2019)
• Supervision of compliance with requirements established in the Water Act on use of fertilisers, additional checks on misuse (making supervision more effective)		Planned additional measure		Estonian river basin management plans 2015-2021		
• Introduction of effective fertilizing technologies		additional measure		Estonian river basin management plans 2015-2021		
• Preparation of spreading plans for adherence to time and quantity-based restrictions on spreading of manure and thereby verification of nutrient runoff from area under cultivation		Planned additional measure		Estonian river basin management plans 2015-2021		
• Additional supervision regarding completion of the field record		Planned additional measure		Estonian river basin management plans 2015-2021		
• Shortening the permitted spreading time (amendment to the Water Act, EE)		additional measure		Estonian river basin management plans 2015-2021		
• Adherence to crop rotation in areas under cultivation		additional measure		Estonian river basin management plans 2015-2021		
• Provision of consultation to agricultural producers for preparation of nutrient balance		additional measure		Estonian river basin management plans 2015-2021		
• Renovation or animal farming facilities or construction of new animal farming facilities (including manure and silage storage facilities) for avoidance of environmental risks stemming from production (LV and EE, but not in LV RBD management plans). In LV requirements for storing of manure outside animal shed refer to farms with more than 10 AU (animal units), and 5 AU in vulnerable territories.		additional measure		Estonian river basin management plans 2015-2021	Cabinet Regulation Nr. 834 “Regulation Regarding Protection of Water and Soil from Pollution with Nitrates Caused by Agricultural Activity” (23.12.2014.)	
• Verification of existence of manure storage facilities and their conformity to environmental requirements		Planned additional measure		Estonian river basin management plans 2015-2021		
• Tightening the threshold level of animal units related to obligation of the existence of manure storage facility (amendment to the Water Act)		additional measure		Estonian river basin management plans 2015-2021		
• Imposition of environmental requirements as needed to alleviate potential environmental impact caused by winter feeding and rest areas for animals grazed year-round (supplementation of the Water Act)		additional measure		Estonian river basin management plans 2015-2021		
• Establishing environmental measures on artificial recipients (sedimentation pools, marshes) on cropland		Planned additional measure		Estonian river basin management plans 2015-2021		
8. To ensure protection of surface and groundwater against pollution / damage caused by plant protection products in accordance with the requirements of regulatory enactments • To comply with the **prohibition** on the use of **fertilizers** and chemical plant protection products in **strict protection zones** around surface water bodies as defined in the Protection Zone Law	Basic measure - included in legislation		River basin district management plans 2016 - 2021		Protection Zone Law	
9. Ensure the preservation of **biological diversity** by protecting and managing natural habitats, wild flora and fauna in accordance with regulatory requirements	Basic measure - included in legislation		River basin district management plans 2016 - 2021			

● Comply with procedures and conditions for the establishment, conservation, management, etc. of the protected area; ● To comply with the rules of protection and use of specially protected nature territories, to take protection and maintenance measures; ● It is forbidden to change the water level with activity, to promote erosion, to get mineral resources; there is prohibited forestry activity, use of motorized vehicles, chemicals, recreational objects, bathing sites, land transformation, fish farming; ● In specially protected nature territories the permission is need before using sewage sludge or compost in agricultural areas; ● To comply with water quality standards for **priority fish waters** to ensure the preservation of priority fish habitats.						
10. To ensure the **prevention and control** of the **risk of pollution** and major **accidents** involving dangerous substances in accordance with the requirements of regulatory enactments ● The operator of the polluting activity must submit an application for Regional environmental board authorization and comply with the measures set out in the permit and recommended guidelines (**best available technology**, environmentally and humanly less harmful activities, accident prevention measures, etc.). ● When issuing permits for polluting activities, State Environmental Service takes into account the environmental quality **objectives** set in the **management plans** and in accordance with the regulatory enactment on the emission of pollutants in water, **stricter emission limits** for pollutants in case wastewater of the company is discharged into the **risk water body**. ● When performing a polluting activity, the operator shall take **measures** to prevent the occurrence of **pollution** or **reduce its emissions**, as well as shall perform the monitoring of the polluting activity. ● To **foresee risk reduction measure**s and restrictions in **teritorial plans** in places that may affect waters, protected areas, protection zones, etc.	Basic measure - included in legislation	Basic measure - included in legislation	River basin district management plans 2016 - 2021	River Basin Management plans 2015-2021	Cabinet Regulation No. 1082 "Procedure by Which Polluting Activities of Category A, B and C Shall Be Declared and Permits for the Performance of Category A and B Polluting Activities Shall Be Issued" 30.11.2010.	Minister of the Environment Regulation No. 39 "Quality limits for hazardous substances in groundwater" (11.08.2010) Minister of the Environment Regulation No. 75 "Establishing requirements for hazardous substances directed into public
11. To ensure **water protection** in accordance with the requirements of regulatory enactments, increasing the quality of life of the population and ensuring sustainable use of natural resources ● To comply with the requirements of the Protection Zone Law on restrictions in the **protection zones** of surface water bodies. ● **Technical regulations** issued by the State Environmental Service must be obtained if **cutting of aquatic plants** is planned for private surface watercourses and water bodies during the period from 1 April to 31 July. ● When cleaning or deepening the surface water bodies, the **cutted aquatic plants** should be collected to prevent recontamination of the water body with easily degradable organic substances and sediment accumulation. ● To ensure the operation and maintenance of amelioration systems, to comply with the regulated requirements for their use, maintenance and preservation so as to minimize environmental damage.	Basic measure - included in legislation		River basin district management plans 2016 - 2021	River Basin Management plans 2015-2021	Protection Zone Law (05.02.1997.) (LV) Cabinet Regulation Nr. 475 "Procedures regarding the Cleaning and Deepening of Surface Water Bodies and Port Basins" (13.06.2006.) Amelioration Law (14.01.2010.) (LV) Cabinet Regulation Nr. 936 "Nature protection rules for forest management" (18.12.2012.) Law on Forests (24.02.2000.)	

● To control the construction, operation and maintenance of drainage systems, to update the **amelioration cadastre.** ● Use **soil erosion-free techniques** in **forest** management. ● To fulfill the **defined clear-cut area** of the Baltic Sea and the Gulf of Riga **coastal protection zones** in the restricted economic zone, in **protected areas along wetlands and waters**. ● In the protection zones of surface waters there must fulfill **prohibition of main felling** at 10 m wide strip along the coast and the prohibition of clear-cut at 50 m wide strip along the coast and in floodplain. ● To carry out the restoration of the watercourse within 1 month, if the water runoff in ditches, streams and rivers is disturbed after the development of the felling area. ● To **manage landfill** or landfill waste in such a way as to prevent pollution of surface water and groundwater, in compliance with the conditions included in the regional environmental board permit, as well as to eliminate the causes and consequences of environmental pollution near the landfill or waste dump if environmental pollution has been detected at that site.					Cabinet Regulation Nr. 1032 "Regulations Regarding the Construction of Landfill Sites, the Management, Closure and Re-cultivation of Landfill Sites and Waste Dumps" (27.12.2011.)	
● Study into load arising from rainwater and specifying necessary measures		additional measure		Estonian river basin management plans 2015-2021		
● Designing a system on significant infrastructure sites for collection and cleaning of rain water as required (sedimentation ponds, sand and oil traps etc.)		additional measure		Estonian river basin management plans 2015-2021		
12. **Decrease** load of **point source** pollution into water ● Improving the efficiency of wastewater treatment plants by providing additional wastewater treatment in agglomerations with CE> 2000, affecting water bodies at risk; ● Improvement of the operation of centralized wastewater collection systems, ensuring the establishment of actual connections and expansion of networks in agglomerations with CE> 2000 – including affecting water bodies at risk.	Additional measure *Not implemented*** *Implemented partly*		River basin district management plans 2016 - 2021			
13.**Decrease** load of **diffuse source** pollution into water ● Provide **control** over wastewater management in **decentralized sewerage systems**, agree on improvements if necessary; ● Improvement of **rainwater collecting system**; ● **Reconstruction** of existing **artesian wells**; ● Untreated **artesian wells tamponing**.	Additional measure *Implemented partly* *Implemented partly* *Not implemented* *Implemented*		River basin district management plans 2016 - 2021			
14.To ensure **reduction of pollution** caused by **agricultural** activity	Additional measure		River basin district management plans 2016 - 2021			

● Maintenance of **winter green areas** or 'stubble fields'; taking into account a 2 m wide **vegetation buffer strip** on the banks of watercourses and watercourses, as well as ditches of drainage systems;	*Implemented*				Cabinet Regulation No. 171 "Rules for the granting, administration and monitoring of national and European Union support for the improvement of the environment, climate and the countryside in the 2014-2020 programming period" (07.04.2015.)	
● Reconstruction and restoration of environmentally friendly agricultural drainage systems, including environmentally friendly drainage system elements (sedimentation basins, two-stage drainage ditches, etc. in Annex 12 of 30.09.2014. Cabinet Regulation No. 600);	*Implemented partly*				Cabinet Regulation No. 600 “Procedures for granting national and European Union support in the form of open calls for projects for "Investment in tangible assets”” (30.09.2014.)	
15.To ensure **reduction of pollution** caused by **forestry** activities						
● Reconstruction and restoration of environmentally friendly forest amelioration systems, including environmentally friendly drainage system elements (sedimentation basins, two-stage drainage ditches, etc. in Annex 12 of 30.09.2014. Cabinet Regulation No. 600)	*Implemented partly*					
● Maintenance works on artificial recipients (removal of impediments to flow, cleaning streambeds of debris and sediment, maintenance of banks of artificial recipients) in forest land.		planned additional measure		River Basin Management plans 2015-2021		
● Establishing environmental measures on artificial recipients (sedimentation pools, marshes sumps) on forest land		planned additional measure		River Basin Management plans 2015-2021		
● Studies into the condition of land improvement systems and monitoring for planning maintenance works and environmental engineering works		planned additional measure		River Basin Management plans 2015-2021		
● Training, consultation and information materials in the field of planning of environmental measures (for designers of land improvement systems)		additional measure		River Basin Management plans 2015-2021		
16.**Reduce** the impact of **hydrological** and **morphological modifications** on water status	Additional measure		River basin district management plans 2016 - 2021			
● Treatment of rivers (control of the degree of overgrowth with aquatic plants, cleaning from waste), clean up of shore in accordance with the conditions of good practice with the aim of improving the ecological quality of water, cutting of macrophytes in regulated sections of rivers;	*Implemented partly*					
● Deepening of watercourse and construction of infrastructure for water flow;	*Not implemented*					
● To carry out a survey of small HPP reservoirs, to assess the impact of their status on water quality and to determine the necessary management measures (water plant extraction, strain removal, etc.)	*Not implemented*					
● To perform a research about impact of morphological modifications on water quality in outfall in lake and lake outlet, by proposing specific solutions and implementing them.	*Not implemented*					
17. **Improve status** of **lake** water body quality	Additional measure		River basin district management plans 2016 - 2021			
● Prepare **operating rules** for the **use of lakes and water** (for example, for waste management, car wash on the shores of the lake, maintenance of gardens, etc.), to develop a lake management plan, to carry out cleaning of the lake and its surroundings.	*Implemented partly*					

● To **clean the lake** (control of overgrowth with aquatic plants, cleaning of water from waste) and cleaning up its surroundings with the aim of improving the ecological status of the lake. ● Formation of **constructed wetlands**; ● **Improvement of lake functionality**: 1) cutting of aquatic plants in the direction of the dominant winds and increasing the effect of waves; 2) reduction of overgrowth with bushes, creation of natural grasslands and sand lanes to the lake in the directly adjacent shoreline; 3) Creating wind corridors by cutting shrubs and, if necessary, trees to promote lake waving and improve lake functionality. 4) reduction of overgrowth with aquatic plants if the overgrowth of the lake is more than 30%. ● Additional monitoring for at least 3 consecutive years for load identification; assessment of sources of load and causes of poor quality.	*Not implemented* *Not implemented* *Not implemented*					
18. To reduce the impact of anthropogenic pollution on water status, incl. ensuring the availability of quality information ● Additional monitoring for at least 3 consecutive years for load identification; assessment of sources of load and causes of poor quality (for river water bodies).	Additional measure *Implemented partly*		River basin district management plans 2016 - 2021			
18. Reduce the load of nutrients into coastal sea ● Management of direct discharges of stormwater to minimise the load of nutrients, contaminants and litter (EE)		planned measure	Program of measures to achieve good environmental status in the marine environment 2016 -2020	Estonian maritime policy 2012-2020, the programme of measures 2017		
19. Perform surface water and groundwater quality monitoring to assess quality of water	Included in legislation		Environmental Policy Guidelines 2014-2020		Cabinet regulation Nr. 92 "Requirements for the Monitoring of Surface Water, Groundwater and Protected Areas and the Development of Monitoring Programmes" (17.02.2004.) (LV)	Minister of the Environment Regulation No. 75 "Procedure for formation of bodies of groundwater and list of bodies of groundwater whose status category must be determined, status categories for bodies of groundwater, values of quality indicators corresponding to status categories list of pollutants posing a risk to groundwater, threshold values for content of these pollutants and quality limits in groundwater, methodology determining the background level and procedure for determining status categories for bodies of groundwater" (29.12.2009)
20. Organize **educational measures for farmers**, explaining the importance and implementation of buffer zones and other agri-environmental measures, encouraging to use measures from Rural Development Program for decreasing negative impact of agricultural activity on quality of waters.	National scale additional measure		River basin district management plans 2016 - 2021			

21. To use several channels of communication to **inform the main target groups** (municipalities, non-governmental organizations, farmers, foresters, national regulatory authorities, educational institutions, managers of specially protected territories, mass media) to inform **about** existing **River Basin Management plans**, discuss the development of new plans, gain information about implemented water management measures, involve the target group in obtaining the necessary information for river basin management planning, develop and implement joint projects that promote the implementation of the action program.	National scale additional measure		River basin district management plans 2016 - 2021			
22. To develop the **regulatory framework** for the provision and use of **public water management services (water supply and sewerage)**, as well as the provision, use and accounting of **decentralized sewerage services**, to reduce environmental pollution from buildings and structures not connected to centralized sewerage systems and to promote the establishment of new connections to sewerage networks. Prepare the conditions for a decentralized sewerage system registration procedure.	National scale additional measure		River basin district management plans 2016 - 2021			
23. Establish **common requirements f**or waste water management in **decentralized systems**.	National scale additional measure		River basin district management plans 2016 - 2021			
24. To to organize **informative** events, meetings and other ways to cooperate with the Latvian Association of Local and Regional Governments, municipalities, administrations of planning regions to explain the measures set out in the river basin management plans, their connection with spatial plans and development programs, management of public waters, discuss co-operation in implementation of measures	National scale additional measure		River basin district management plans 2016 - 2021			
25. To to amend the regulations of the Cabinet of Ministers No. 418 "**Regulations Regarding Water Bodies at Risk**" to include new risk water bodies and exclude those, that no more are classified as riska water bodies.	National scale additional measure		River basin district management plans 2016 - 2021			
26. To **modernize** the **technical equipment** necessary for water **monitoring**	National scale additional measure		River basin district management plans 2016 - 2021			
27. To **modernize existing environmental information systems**, ensuring the integration of different databases and efficient exchange of information, feedback. To include information about **fisheries** and pond farms and amount of farmed fish, to make it possible to assess impact of fishing activities on water quality and quantity.	National scale additional measure		River basin district management plans 2016 - 2021			
28. To introduce **new mode**l for modelling and analysis of loads.	National scale additional measure		River basin district management plans 2016 - 2021 (LV)			
29. To **cooperate with authorities of Lithuania and Estonia** , responsible for development and implementation of River basin management plans, with aim to prepare **international river basin management plans** for common river basin districts.	National scale additional measure		River basin district management plans 2016 - 2021 (LV)			
30. To carry out preparatory work for **more precise groundwater characterization**, including delineation of water bodies, adding data, modelling of loads.	National scale additional measure		River basin district management plans 2016 - 2021 (LV)			
31. To **restore the methodologies for the classification** (types, water bodies) and **evaluations** necessary for the development of all river basin management plans, including supplementing or refining the criteria and their thresholds for assessing the relevance of agricultural and forestry activities.	National scale additional measure		River basin district management plans 2016 - 2021 (LV)			
32. To prepare information about of **gaps of data** for preparing existing river basin management plans, to draw up a plan and take the necessary action for obtaining more detailed information for next river basin management plans.	National scale additional measure		River basin district management plans 2016 - 2021 (LV)			

33. To identify problems and necessary measures to improve the **protection of small rivers.**	National scale additional measure		River basin district management plans 2016 - 2021 (LV)			
34. Involve groups of stakeholders in **river maintenance and restoration activities**.	National scale additional measure		River basin district management plans 2016 - 2021 (LV)			
35. To perform a **research** to determine the **contribution of various sources of pollution** (communal sector, industry, agriculture, forestry, natural runoff) **to the load of biogens** in the Baltic Sea in order to apply effective reduction measures to the polluters.	National scale additional measure		River basin district management plans 2016 - 2021 (LV)			
36. To continue international cooperation and conclusion of international agreements about decrease of transboundary pollution and improvement of water quality; harmonization of monitoring programme and joint assessment of ecological quality.	National scale additional measure		River basin district management plans 2016 - 2021 (LV)			
37. To continue work on the conclusion of the **Trilateral Government Agreement** between the Republic of **Latvia**, the **Russian** Federation and the Republic of **Belarus** on Cooperation in the Use and Protection of the Water Resources of the **Daugava / Zapadnaya Dvina Basin**.	National scale additional measure		River basin district management plans 2016 - 2021 (LV)			
38. Increase of land area under **organic farming** relative to total agricultural land. Farming methods with environmentally friendly influence on nature, reduction of synthetic nitrate use and leaching, increased biodiversity. The state support for organic farmers through subsidies.	*Implemented 2014 - 2020*	Implemented 2014 - 2020	National Development Plan of Latvia for 2014-2020 (NDP2020) set the plan to increase organic agriculture area to 15% by 2030 in relation to total agricultural area. 2014-2020 Rural Development Programme.	Estonian Organic Farming Development Plan 2014-2020 (i.a. set the plan to increase organic agricultural area 15% by 2020 comparing to 2014 level) Estonian Rural Development Plan (ERDP)		

Explanations

* Minister of the Environment Regulation No. 75 "Procedure for formation of bodies of groundwater and list of bodies of groundwater whose status category must be determined, status categories for bodies of groundwater, values of quality indicators corresponding to status categories list of pollutants posing a risk to groundwater, threshold values for content of these pollutants and quality limits in groundwater, methodology determining the background level and procedure for determining status categories for bodies of groundwater" (29.12.2009)

** Information taken from working materials for development of report for European Union "Water Framework Directive: Programmes of Measures - 2018 reporting"

	Measures related to N_2O emissions into atmosphere. Data source: https://cdr.eionet.europa.eu/Converters/run_conversion?file=lv/eu/mmr/art04-13-14_lcds_pams_projections/pams/pams/envxiiolw/lv_mmr-pam_report.xml&conv=524&source=remote

Annex 2

Measures for reducing nitrogen flows to atmosphere pool in Latvia and in Estonia

Measure	Implementation of measure till 2018		Legislation	
	LV	EE	LV	EE
Support for evolving of **precision agriculture technologies** in crop growing farms to reduce nitrogen use Measure is associated with promoting of nitrogen fertilizer use reduction and consequently with reduction of nitrogen amount in the run-off. This will reduce N_2O emissions from the use of synthetic fertilizers and indirect N_2O emissions from soils. **Voluntary**/negotiated agreements, because financial support for farmers is available, if a farmer develop precision agriculture technologies in the farm with the aim to reduce GHG emissions.	Implemented 2014 - 2020	2015 - 2020	Law On Agriculture and Rural Development (2004) Regulations of the Cabinet of Ministers No. 600 "Procedures for granting national and European Union support in the form of open calls for projects for "Investment in tangible assets"" (30.09.2014)	Estonian Rural Development Plan (ERDP) for 2014–2020 (direct subsidies in the case of the implementation of requirements, Minister of Agriculture Regulations)
Employ less contaminative technologies as related to muck (spread out of manure): injection of slurry directly into soil		planned measure		"Air pollutants reduction program" for the 2020 – 2030 period
Plough mineral fertilizer fast into soil during fertilization of cultivated plants (combined sower)		planned measure		"Air pollutants reduction program" for the 2020 – 2030 period
Support for evolving of **precision livestock feeding approach in cattle breeding farms** to develop feeding plans and promote high quality feed use to increase the digestibility. The main aim of measure is to promote high quality feed use for animals to increase the digestibility and reduce CH_4 emissions. **Voluntary**/negotiated agreements, because financial support for farmers is available, if a farmer develop precision livestock feeding technologies in the farm with the aim to reduce GHG emissions.	Implemented 2015 - 2020		Law On Agriculture and Rural Development (2004) Regulations of the Cabinet of Ministers No. 600 "Procedures for granting national and European Union support in the form of open calls for projects for "Investment in tangible assets"" (30.09.2014)	
Introduction of **leguminous plants** on arable land Support to use of legumes as green manure and fodder in crop rotation. Financial support is defined in Regulations of the Cabinet of Ministers No. 126 (2015), that establishing procedures for receiving payments for climate and environmentally friendly farming practices, including legumes in crop rotation. Measure is associated with promoting of nitrogen fertilizer use reduction. This will reduce N_2O emissions from the use of synthetic and organic fertilizers.	Implemented 2015 - 2020	2015 - 2020	Regulations of the Cabinet of Ministers No. 126 "Procedures for Granting of Direct Payments to Farmers" (10.03.2015)	Estonian Rural Development Plan (ERDP) for 2014–2020 (direct subsidies in the case of the implementation of requirements, Minister of Agriculture Regulations)
Promotion of **biogas** production	Expired 2010 - 2015	Expired (2007-2013)	In financial period of 2007-2013 the support was provided by national Rural Development Programme within the sub-measure 312/311(3) for the agriculture sector business entities & service cooperatives to develop the production of electricity and heat in CHP mode by utilising biogas fermented in anaerobic processes from biomass of an agricultural or forestry origin.	Development Plan on the Promotion of Biomass and Bioenergy Use for 2007-2013 (measures for research); "Renewable Energy Action Plan Until 2020" (no subsidies for the production of biogas); National Transport Development Plan 2014-2020 (to promote implementation of biomethane as transport fuel)
Elaborate less contaminative technologies for manure storage: keep liquid manure (slurry) in storage covered by a roof made from tent or concrete or store manure in a container made from steel or plastic		planned measure		"Air pollutants reduction program" for the 2020 – 2030 period

Data source for Latvia: Reporting on policies and measures under Article 13 of Regulation (EU) No.525/2013 of the European Parliament and of the Council. Available: http://cdr.eionet.europa.eu/Converters/run_conversion?file=lv/eu/mmr/art04-13-14_lcds_pams_projections/pams/pams/envxiiolw/lv_mmr-pam_report.xml&conv=524&source=remote