Joint management of Latvian – Lithuanian trans-boundary river and lake water bodies (TRANSWAT) LLI-533

SOURCE APPORTIONMENT OF NUTRIENT LOADS IN TRANSBOUNDARY LAKES

2022

TABLE OF CONTENTS

This document has been produced with the financial assistance of the European Union. The contents of this document are the sole responsibility of project partners and can under no circumstances be regarded as reflecting the position of the European Union.

I INTRODUCTION

In the frame of the “Joint management of Latvian – Lithuanian trans-boundary river and lake water bodies” project (TRANSWAT) LLI-533 financed by the Interreg V-A Latvia–Lithuania Programme 2014-2020, source apportionment of the nutrient loads in the Latvian – Lithuanian pilot lakes was modeled. To evaluate the nitrogen and phosphorus loads in pilot lakes *FyrisNP* tool for catchment-scale modelling of nutrients was used. Modelling was carried out for a period of 22 years (2000-2021).. The year 2021 was analyzed deeply due to the availability of additional N_{tot} and P_{tot} concentration and water level data. Hence the model results for 2021 are more reliable.

Source apportionment of the nutrient loads in the Latvian – Lithuanian pilot lakes (Ilzu (Garais)/Ilge, Galinu/Salna, Kumpinisku/ Kampiniskiai, Lauceses/ Laukesas and Skirnas) are described in this Report as well as a brief insight into the model concept is given in this Report.

II FYRISNP MODEL DESCRIPTION

The dynamic *FyrisNP* model calculates source apportioned gross and net transport of nitrogen and phosphorus in rivers and lakes. The time step for the model is in the majority of applications one month and the spatial resolution is on the sub-catchment level. Retention, i. e. losses of nutrients in rivers and lakes through sedimentation, up-take by plants and denitrification, is calculated as a function of water temperature, nutrients concentrations, water flow, lake surface area and stream surface area. The model is calibrated against time series of measured nitrogen or phosphorus concentrations by adjusting two parameters (Hansson et al. 2008).

Data used for calibrating and running the model can be divided into time dependent data, e. g. timeseries on observed nitrogen and phosphorus concentration, water temperature, runoff and point source discharges, and time independent data, e. g. land-use information, lake area and stream length and width (Hansson et al. 2008).

In order to perform simulations with the *FyrisNP* model, an Excel-file containing all input data is required. The *Excel* data file consists of eight to ten different worksheets depending on features used. It must contain data describing sub-catchments, such as land use, stream lengths and lake areas etc., water temperature, N_{tot} and P_{tot} concentrations in runoff from different land use types, observed P_{tot} or N_{tot} concentrations, minor point sources and major point sources of nutrients (Hansson et al. 2008) (see Chapter III).

Once the *Excel* file is uploaded the data is automatically assigned to the sub-catchments. The model determines the number of monitoring stations. Calibration is performed automatically, starting with the *Monte Carlo* method completed with manual calibration. When the calibration is complete it is possible to view the results - observed and simulated nutrient concentrations. Nutrient loads are calculated by month. In the result section of the model the incoming and the outgoing load in sub-catchment and the source apportionment from various land use types, minor or major point sources are available. The results are available for download as an *Excel* file and can be used for further analysis and graphic depiction.

III DATA FOR SOURCE APPORTIONMENT OF NUTRIENT LOADS MODELING

3.1. Land use data
To perform modeling of the quantification of the nutrient transport the characteristics on the different sub-catchments is needed. These include information on hydrological network of sub-catchments and sub-catchment specific data on land-use.

Corine Land Cover 2018[1] data were used for the land use distribution.

3.2. Hydrological data
FyrisNP requires information on the measured or modelled area-specific runoff (mm/month).

Latvian standard LBN224-15 "Amelioration systems and hydrotechnical structures" was used for the lakes' outflow calculation (mm/month) taking into account the area of lakes basin area.

3.3. Major point sources and minor point sources
It is possible to use in the modeling data from large point sources like wastewater treatment plants (WWTP)[2] and industries as well as data from small point sources such the scattered households with autonomous sewage treatment system.

As the major point sources the last decade average data of N and P amounts discharged from WWTPs acquired from national statistical database “Ūdens-2”[3] (Latvia) was used for the modeling. Additional data of discharged N and P from the Zarasai WWTP (Lithuania) was used for Laucesas/Laukesas Lake’ modeling.

As the minor point sources in the modelling procedure there were used data about residents not connected to centralized sewerage system. It should be noted that data on N and P loads emitted by households are based on assumptions, because of the no accurate data on actual N_{tot} and P_{tot} discharges from households.

3.4. Temperature
Data on measured water temperature (monthly mean) from some station located in the modelled catchment or from a nearby station outside the catchment is needed. If such data are not available, an approximation of water temperatures is acceptable.

[1] Available: https://land.copernicus.eu/pan-european/corine-land-cover/clc2018
[2] Available: https://www.zarasuvandenys.lt/nuotekos.html
[3] Available: http://parissrv.lvgmc.lv/

3.5. Observed concentrations

To perform modeling data on measured nutrient (N_{tot} or P_{tot}) concentrations has to be included. One measurement station per sub-catchment data is provided once a month in mg/l.

Monitoring data from 2000 to 2020 were used in the modeling, as well as data achieved during the project in 2021.

3.6. Type specific concentrations

Type-specific N_{tot} or P_{tot} concentrations (mg/l) in runoff from different land use are needed. One value per month is required. It should be noted that type specific data are largely theoretical and based on assumptions. N_{tot} and P_{tot} runoff volumes from different land uses has been performed at selected sites, and these data might be different for unstudied area.

3.7. Storage

Water level data collected during the project allows to use data of changes in lakes' water storage in modelling.

IV MODELING RESULTS

4.1. Galinu/Salna Lake

The modeling results show that the greatest share of nitrogen loads within the catchment originate from forests and arable lands - 57 % and 33 % respectively. Most important sources of phosphorus load are forests and arable lands as well, runoff from forests accounts for 53 % of P loads and runoff from arable lands for 32 % of the total load in the catchment.

The graphs below (Figure 4.1.1 and Figure 4.1.2) show nitrogen (N) and phosphorus (P) load distributions by sectors in Galinu/Salna Lake catchment for 2021.

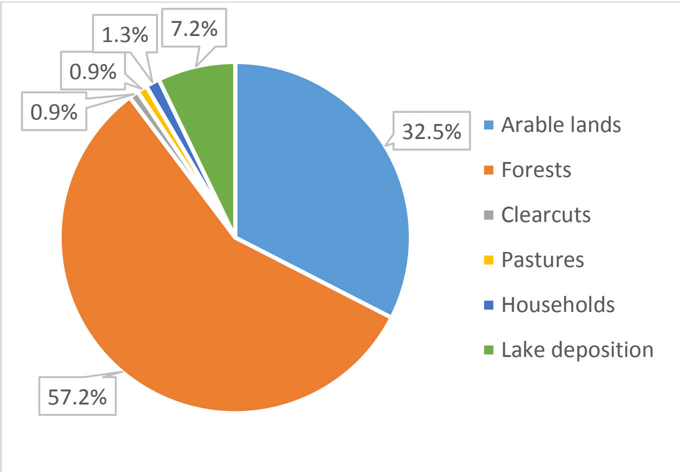

Figure 4.1.1. N source apportionment in Galinu/Salna Lake catchment

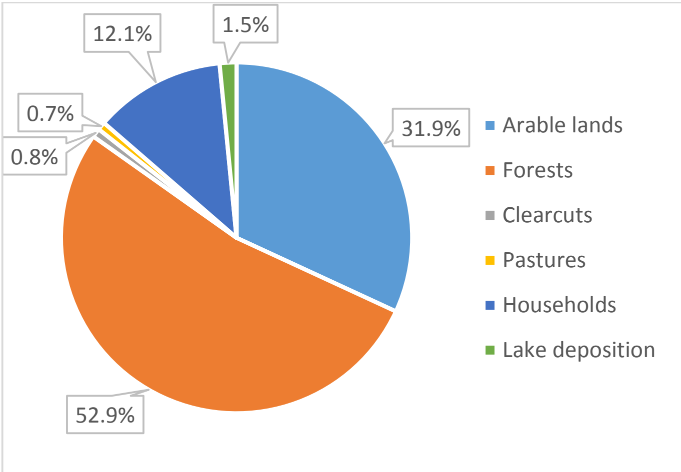

Figure 4.1.2. P source apportionment in Galinu/Salna Lake catchment

Loads are also calculated by months, not just by years. The largest N runoff occurs in spring, while large P runoff occurs as in spring as in summer.

Figures 4.1.3. and 4.1.4. show the N and P load volumes by months in Galinu/Salna Lake catchment in 2021.

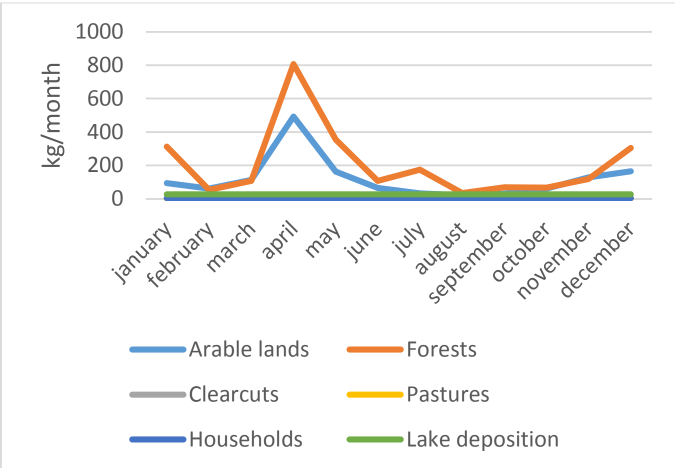

Figure 4.1.3. N load volumes by months in Galinu/Salna Lake catchment

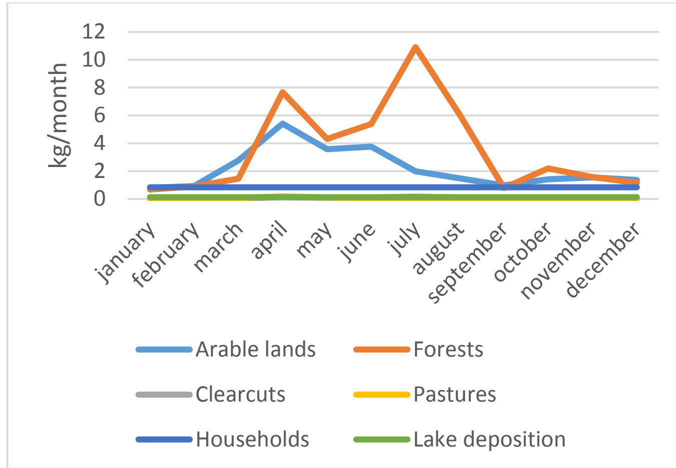

Figure 4.1.4. P load volumes by months in Galinu/Salna Lake catchment

Table 4.1.1. shows the amounts of N and P from different sources in the year 2021 for the Galinu/Salna Lake catchment. It should be noted that not all arable lands and pastures runoff is considered to be an anthropogenic load, because arable lands and pastures also have a so-called *background* - natural N and P runoff. Therefore, it can be concluded that in general the largest N and P load is caused by natural sources.

Table 4.1.1. N and P loads from different sources in Galinu/Salna Lake catchment.

Nutrient	Arable lands	Forests	Clearcuts	Pastures	Households	Lake deposition
N, kg	1427,2	2508,5	38,6	40,9	56,1	314,7
P, kg	25,9	43,0	0,7	0,6	9,8	1,3

4.2. Kumpinisku/Kampiniskiai Lake

The modeling results show that the greatest share of nitrogen loads within the catchment originate from arable lands and forests - 60 % and 23 % respectively. Most important sources of phosphorus load are arable lands and forests as well, runoff from arable lands accounts for 47 % of P loads and runoff from forests for 26 % of the total load in the catchment.

The graphs below (Figure 4.2.1 and Figure 4.2.2) show nitrogen (N) and phosphorus (P) load distributions by sectors in Kumpinisku/Kampiniskiai Lake catchment for year 2021.

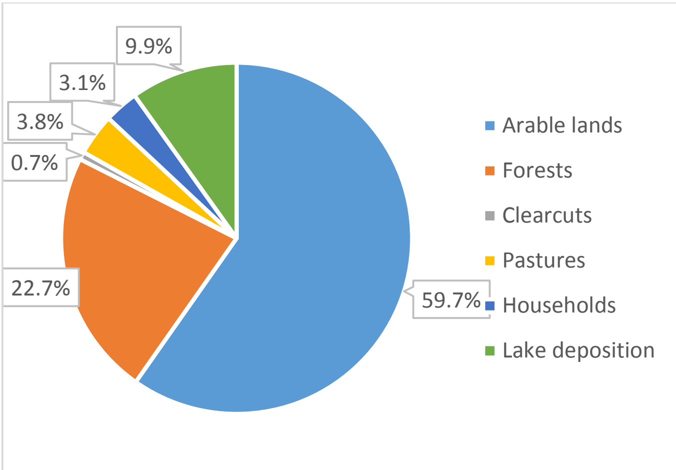

Figure 4.2.1. N source apportionment in Kumpinisku/Kampiniskiai Lake catchment

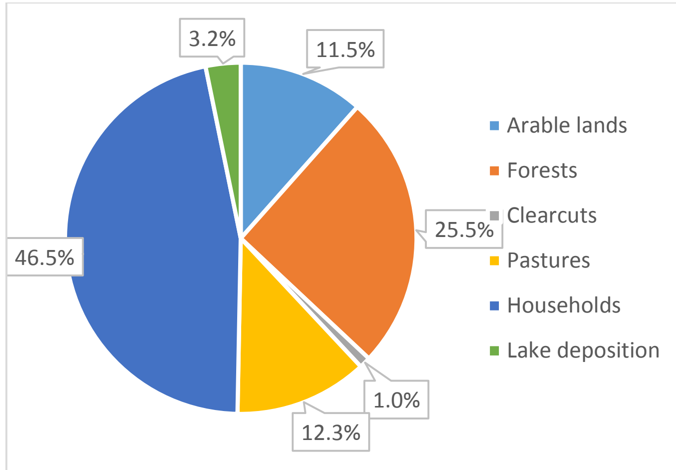

Figure 4.2.2. P source apportionment in Kumpinisku/Kampiniskiai Lake catchment

Loads are also calculated by months, not just by years. The largest N runoff occurs in spring, while large P runoff occurs in both spring and summer.

Figures 4.2.3. and 4.2.4. show the N and P load volumes by months in Kumpinisku/Kampiniskiai Lake catchment in 2021.

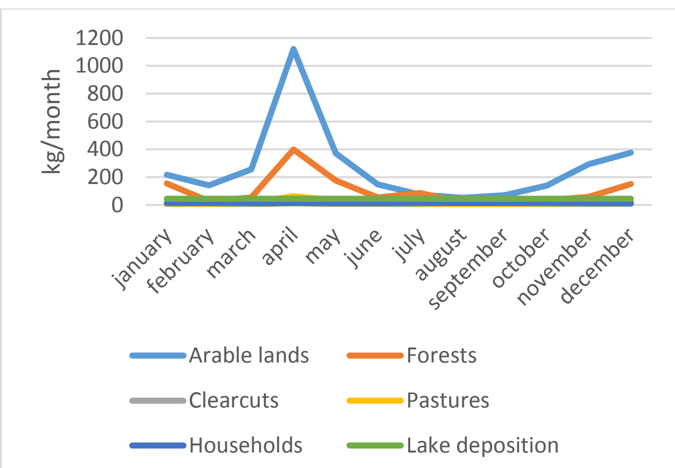

Figure 4.2.3. N load volumes by months in Kumpinisku/Kampiniskiai Lake catchment

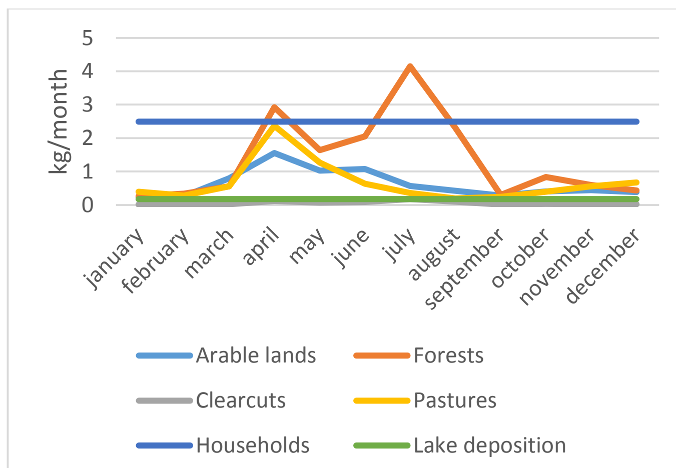

Figure 4.2.4. P load volumes by months in Kumpinisku/Kampiniskiai Lake catchment

Table 4.2.1. shows the amounts of N and P from different sources in the year 2021 for the Kumpinisku/Kampiniskiai Lake catchment. It should be noted that not all arable lands and pastures runoff is considered to be an anthropogenic load, because arable lands and pastures also have a so-called *background* - natural N and P runoff. Therefore, it can be concluded that in general the largest N and P load is caused by natural sources.

Table 4.2.1. N and P loads from different sources in Kumpinisku/Kampiniskiai Lake catchment.

Nutrient	Arable lands	Forests	Clearcuts	Pastures	Households	Lake deposition
N, kg	3248,1	1233,8	39,0	207,7	171,0	536,9
P, kg	7,4	16,4	0,7	7,9	29,9	2,1

4.3. Skirnas Lake

The modeling results show that the greatest share of nitrogen loads within the catchment originate from lake deposition, forests, arable lands and pastures - 29 %, 24 %, 21,2 and 20,8 % respectively. Most important sources of phosphorus load are households, forests and arable lands, pressure from households accounts for 40 % of P loads, runoff from forests for 20 % and runoff from arable lands for 19 % of the total load in the catchment.

The graphs below (Figure 4.3.1 and Figure 4.3.2) show nitrogen (N) and phosphorus (P) load distributions by sectors in Skirnas Lake catchment for 2021.

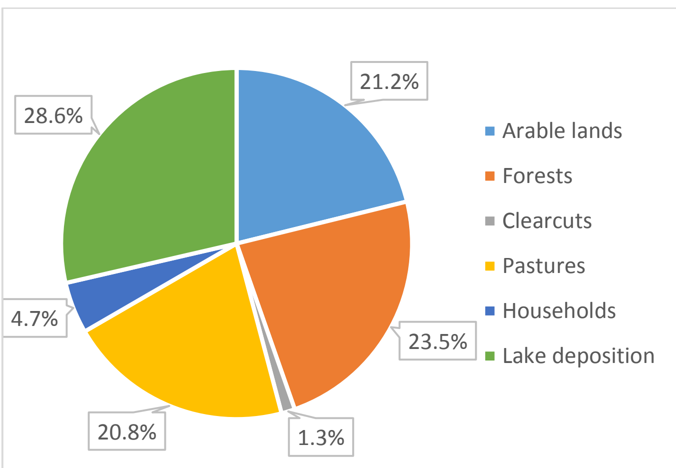

Figure 4.3.1. N source apportionment in Skirnas Lake catchment

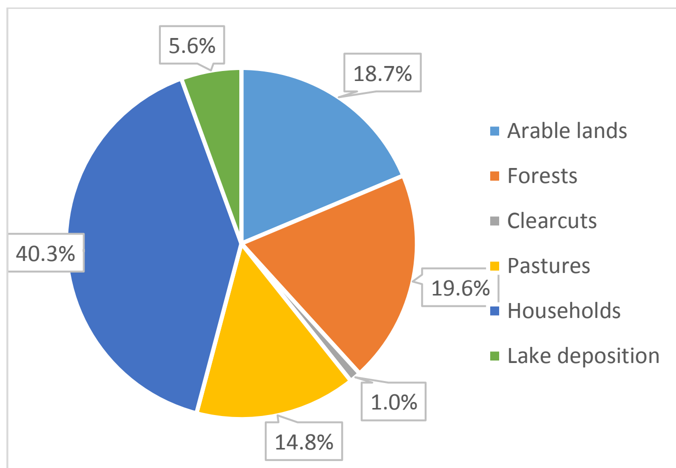

Figure 4.3.2. P source apportionment in Skirnas Lake catchment

Loads are also calculated by months, not just by years. The largest N runoff occurs in spring. An increase of the N runoff is also observed in winter. Large P runoff occurs in both spring and summer.

Figures 4.3.3. and 4.3.4. show the N and P load volumes by months in Skirnas Lake catchment in 2021.

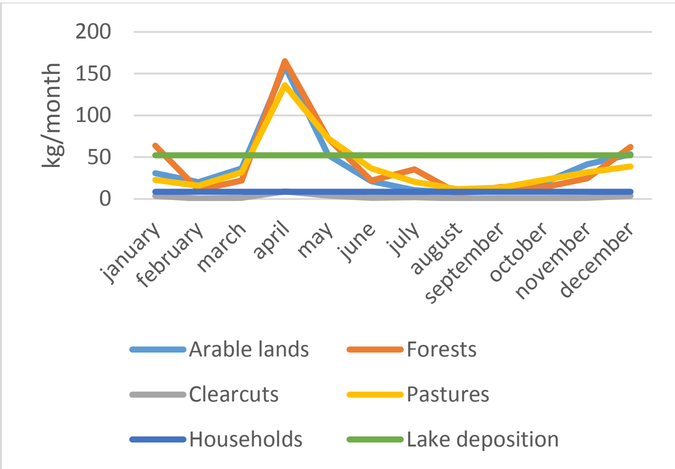

Figure 4.3.3. N load volumes by months in Skirnas Lake catchment

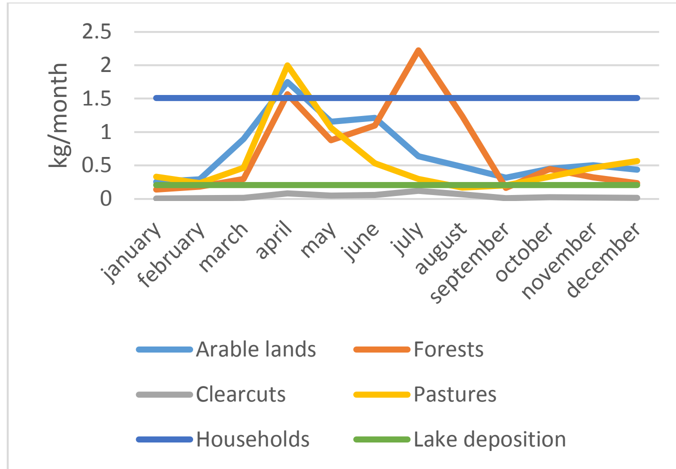

Figure 4.3.4. P load volumes by months in Skirnas Lake catchment

Table 4.3.1. shows the amounts of N and P from different sources in the year 2021 for the Skirnas Lake catchment. It is evident that not all arable lands and pastures runoff is considered to be an anthropogenic load, because arable lands and pastures also have a so-called *background* - natural N and P runoff. Therefore, in general the largest N and P load is caused by natural sources.

***Table 4.3.1. N and P loads from different sources in Skirnas Lake catchment*.**

Nutrient	Arable lands	Forests	Clearcuts	Pastures	Households	Lake deposition
N, kg	461,6	512,3	27,3	453,5	103,4	624,4
P, kg	8,4	8,8	0,5	6,7	18,1	2,5

4.4. Laucesas/Laukesas Lake

The modeling results show that the greatest share of nitrogen loads within the catchment originate from arable lands and forests - 46 % and 35 % respectively. Most important sources of phosphorus load are arable lands and forests as well, runoff from arable lands accounts for 46 % of P loads and runoff from forests for 33 % of the total load in the catchment.

The graphs below (Figure 4.3.1 and Figure 4.3.2) show nitrogen (N) and phosphorus (P) load distributions by sectors in Laucesas/Laukesas Lake catchment for 2021.

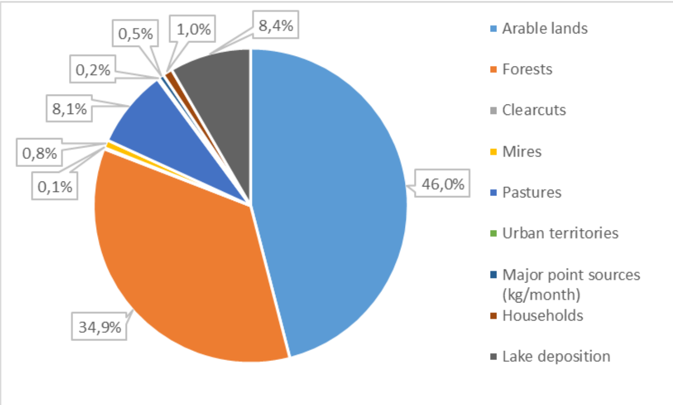

Figure 4.4.1. N source apportionment in Laucesas/Laukesas Lake catchment

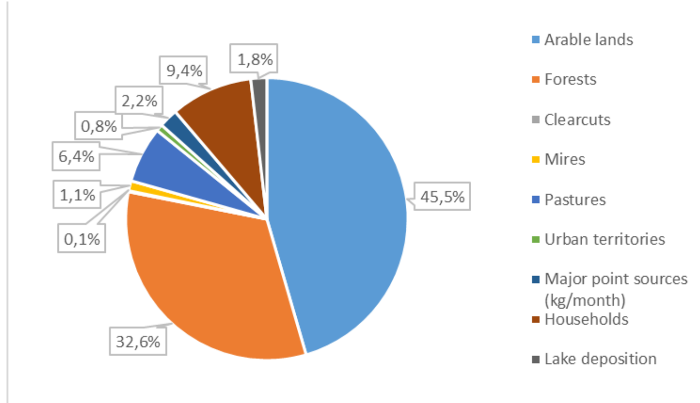

Figure 4.4.2. P source apportionment in Laucesas/Laukesas Lake catchment

Loads are also calculated by months, not just by years. The largest N runoff occurs in spring, while large P runoff occurs in spring and summer as well.

Figures 4.4.3. and 4.4.4. show the N and P load volumes by months in Laucesas/Laukesas Lake catchment in 2021.

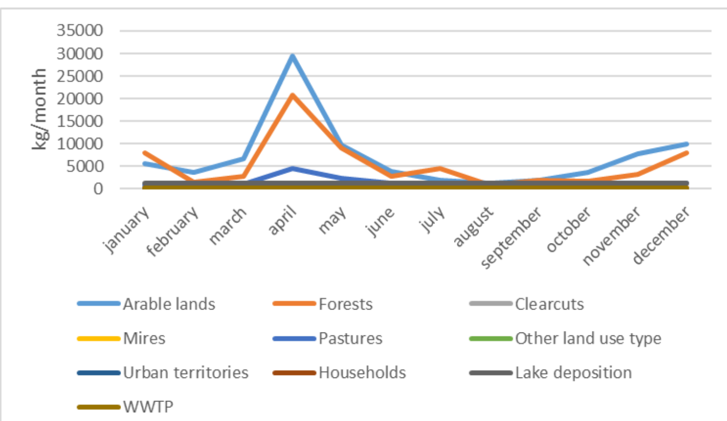

Figure 4.4.3. N load volumes by months in Laucesas/Laukesas Lake catchment

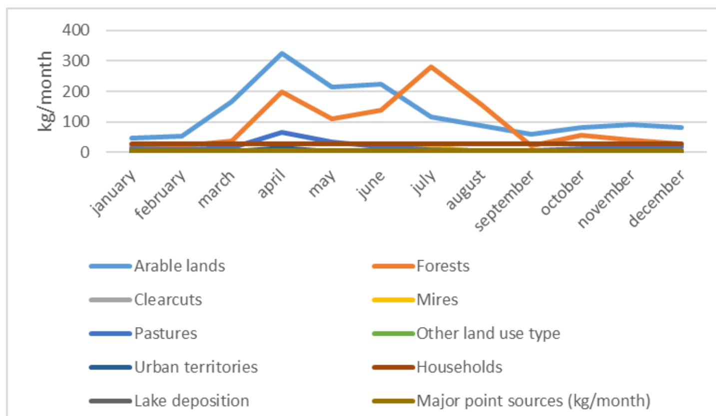

Figure 4.4.4. P load volumes by months in Laucesas/Laukesas Lake catchment

Table 4.4.1. shows the amounts of N and P from different sources in the year 2021 for the Laucesas/Laukesas Lake catchment. It should be noted that not all arable lands and pastures runoff is considered to be an anthropogenic load, because arable lands and pastures also have a so-called *background* - natural N and P runoff. Therefore, it can be concluded that in general the largest N and P load is caused by natural sources.

Table 4.4.1. N and P loads from different sources in Laucesas/Laukesas Lake catchment.

Nutrient	Arable lands	Forests	Clearcuts	Mires	Pastures	Urban territories	Households	Lake deposition	Other land use type	WWTP
N, kg	85288,0	64725,9	240,1	1509,9	14965,4	335,5	1830,8	15550,9	69,2	1009,1
P, kg	1548,7	1109,5	4,1	39,0	218,8	26,8	320,4	62,2	1	73,7

4.5. Ilzu (Garais)/Ilge Lake

The modeling results show that the greatest share of nitrogen loads within the catchment originate from arable lands and forests - 54 % and 34 % respectively. Most important sources of phosphorus load are arable lands and forests as well, runoff from arable lands accounts for 56 % of P loads and runoff from forests for 33 % of the total load in the catchment.

The graphs below (Figure 4.3.1 and Figure 4.3.2) show nitrogen (N) and phosphorus (P) load distributions by sectors in Ilzu (Garais)/Ilge Lake catchment for 2021.

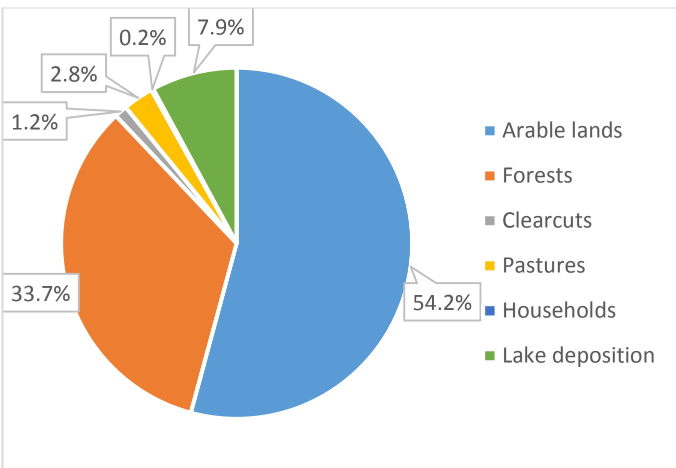

Figure 4.5.1. N source apportionment in Ilzu (Garais)/Ilge Lake catchment

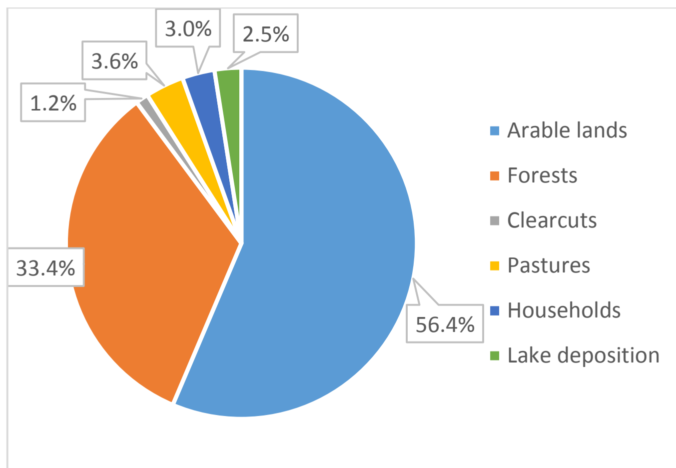

Figure 4.5.2. P source apportionment in Ilzu (Garais)/Ilge Lake catchment

Loads are also calculated by months, not just by years. The largest N runoff occurs in spring. N runoff increasing is also observed in winter. Large P runoff occurs in both spring and summer.

Figures 4.5.3. and 4.5.4. illustrate the N and P load volumes by months in Ilzu (Garais)/Ilge Lake catchment in 2021.

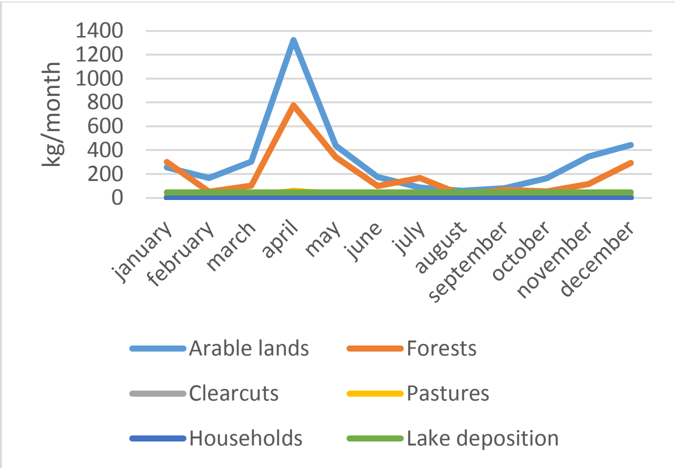

Figure 4.5.3. N load volumes by months in Ilzu (Garais)/Ilge Lake catchment

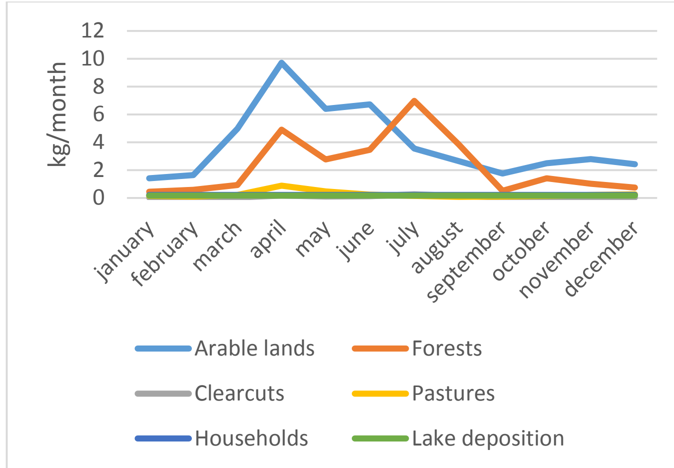

Figure 4.5.4. P load volumes by months in Ilzu (Garais)/Ilge Lake catchment

Table 4.5.1. shows the amounts of N and P from different sources in the year 2021 for the Ilzu (Garais)/Ilge Lake catchment. It should be noted that not all arable lands and pastures runoff is considered to be an anthropogenic load, because arable lands and pastures also have a so-called *background* - natural N and P runoff. Therefore, it can be concluded that in general the largest N and P load is caused by natural sources.

Table 4.5.1. N and P loads from different sources in Ilzu (Garais)/Ilge Lake catchment.

Nutrient	Arable lands	Forests	Clearcuts	Pastures	Households	Lake deposition
N, kg	3835,8	2386,7	83,6	198,7	14,1	558,0
P, kg	46,4	27,5	1	2,9	2,5	2

CONCLUSIONS

N and P loads were modeled for all pilot lakes included in the project. The modeling results showed that the main sources of pressure for almost all lakes are forests and arable lands. In the case of arable lands some part of the runoff should be considered as a natural load due to the *background* load from arable lands and pastures as well.

It can be concluded that most of the pressures affecting the pilot lakes are of natural origin, however, the modeling results for 2021 could be improved by including additional information on nutrient discharges from WWTP in 2021 as well as more accurate type-specific concentrations.

REFERENCES

Hansson, K., Wallin, M., Djodjic, F., Orback, C. 2008. The FyrisNP model Version 3.1 – A tool for catchment-scale modelling of source apportioned gross and net transport of nitrogen and phosphorus in rivers. A user´s manual. Institutionen för miljöanalys, SLU.