Supply of project management, air quality information management, behavior change and communication services.

Contract No: RFP / MFK /2019/ QCBS / No. 006

TASK D1: Update of the Emission inventory: Detailed methodology for the inventory of emissions of substances in Kosovo, the scope of the electronic database and results.

December 2020

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Contracting Authority	**:**	**Millennium Foundation of Kosovo**
Address	:	Migjeni no.21 (exBank of Ljubljana, 9th Floor) 10000 Prishtina, Kosovo
Contact person	:	Agron Kelmendi, Contract Manager
Telephone	:	+ 383 38 752 110
E-mail	:	agron.kelmendi@millenniumkosovo.org

Beneficiary	**:**	**Hydrometeorological Institute of Kosovo**
Address	:	Rruga Bill Clinton, Nr.86, 10000 Prishtina, Kosovo
Contact person	:	Letafete Latifi, Director
Telephone	:	+383 38 603 842
E-mail	:	letafeter.latifi@gmail.com
Beneficiary	**:**	**National Institute of Public Health of Kosovo**
Address	:	St. Mother Teresa nn, Hospital Circle, 10000, Prishtina
Contact person	:	Dr Antigona Ukehaxhaj
Telephone	:	+383 44 741 471
E-mail	:	antigona_dervishaj@yahoo.com

Consultants	**:**	**NIRAS IC Sp. z o.o., ATMOTERM S.A.**
Address	:	ul. Puławska 182, 02-670 Warsaw, Poland
Contact person	:	Paweł Suśniak, Project Manager
Telephone	:	+48 22 395 71 00
E-mail	:	paw@niras-ic.pl
Address (Project Office)	:	Z2-S2 Lakrishte HZ-A-B-000 LOK/6, 10000 Prishtina
Project Team Leader	:	Dariusz Kobus
Telephone	:	+383 45 885 806
E-mail	:	drz@niras-ic.pl

Date of Report	:	23 December 2020
Prepared By	:	Agnieszka Bartocha, Aneta Lochno, Radosław Obermajer, Marek Rosicki, Ireneusz Sobecki, Piotr Łuczak
Checked By	:	Dariusz Kobus

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Glossary of Terms

CO	Carbon oxide
DH	District heating
EEA	European Environmental Agency
EMEP	European Monitoring and Evaluation Programme
ELVs	Emission limit values
IPPC	Integrated pollution prevention and control
JICA	Japan International Cooperation Agency
KEDP	Kosovo Environmental Data Project
KEPA	Kosovo Environmental Protection Agency
KHMI	Kosovo Hydro-Meteorological Institute (IHMK in Albanian)
KCA	Kosovo Cadastral Agency
KSA	Kosovo Statistical Agency
LCP	Large Combustion plants
MCC	Millennium Challenge Corporation
MESP	Ministry of Environment and Spatial Planning
MFK	Millennium Foundation Kosovo
Mg	Megagram (metric tonne)
NH_3	Ammonia
NFR	Nomenclature For Reporting
NMVOCs	Non-methane Volatile Organic Compounds
NO_2	Nitrogen dioxide
NOx	Nitrogen oxides (as NO_2)
PM_{10}	fine particles with a diameter of 10 µm or less
$PM_{2.5}$	fine particles with a diameter of 2.5 µm or less
SO_2	Sulfur dioxide
Tier	Level of detail used in emission inventory methodology

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1 EXECUTIVE SUMMARY

This report presents a detailed methodology for the inventory of emission sources and final emission inventory results for Republic of Kosovo. A previous version of this report, and the associated excel databases, were produced in May 2020[1].

The emission inventory created as part of this project is the first detailed air emission inventory for the entire area of Kosovo, however it was supported by existing data and other emission inventories available in Kosovo. Kosovo Environmental Protection Agency under the Ministry of Environment and Spatial Planning is providing top-down national air emission inventory under the Convention on Long-range Transboundary Air Pollution updated every year. Some emission data is estimated also at local levels: Drenas prepared first Air Quality Plan for municipality, Prizren developed GHG Emission Inventory. Japan International Cooperation Agency (JICA) developed detailed bottom–up emission inventory for Pristina Agglomeration (including Pristina, Fushe Kosovo and Obiliq municipalities) within the project: *Capacity Development Project for Air Pollution Control in the Republic of Kosovo. Introduction of Framework of Emission Inventory*[2]. All this data was a valuable support for development of emission inventory presented in this report.

The base year for the development of emission database data is 2018, the year for which, according to the Kosovo Hydro-Meteorological Institute (KHMI), measurement data has the best availability. The following emission sources are included in the inventory:

1. Small combustion –heating (also cooking) in domestic, public and business services
2. Transport: roads and aviation
3. Industry: power plants and large industrial installations
4. Agriculture
5. Landfill (Waste)
6. Mines and quarries
7. Natural sources: forests

The inventory of pollutant emissions includes the following substances: particulate matter: PM_{10}, $PM_{2.5}$, nitrogen oxides (NOx), sulfur dioxide (SO_2), carbon monoxide (CO), total non-methane volatile organic compounds (NMVOC), arsenic (As), cadmium (Cd), mercury (Hg), lead (Pb). Update of the air emission inventory was prepared after analyzing the result of the first inventory and air quality modeling in order to improve emission calculation.

The emission inventory methodology is based on EMEP Guidebook 2019[3] and it includes among others:

- quality assurance procedures to achieve the best quality of the inventory,
- key category analysis – which pointed out the following key categories: small combustion, roads, industry (power plants Kosovo A and Kosovo B, combustion processes e.g. Ferronikieli) and agriculture depending on the pollutants,

[1] *Supply of project management, air quality information management, behavior change and communication services. TASK D1: Emission inventory: Detailed methodology for the inventory of emissions of substances in Kosovo and the scope of the electronic database. Prepared by ATMOTERM; MFK; May 2020*

[2] *Kosovo | Kosovo | Countries & Regions | JICA*

[3] *EEA Report No 13/2019; EMEP/EEA air pollutant emission inventory guidebook 2019 — European Environment Agency (europa.eu)*

- uncertainty analysis.

Emission inventory is using the following very important sources of information:

- Spatial data from Kosovo Cadastral Agency (KCA) – layers of roads, addresses, administrative areas, settlements,
- Spatial data from other sources like: OpenStreetMap, Corine Land Cover,
- Statistical data from Kosovo Statistical Agency (KSA) e.g. data on the population, data on businesses registration and public services, data regarding vehicles, data on agriculture,
- Data from other project, e.g.: *Capacity Development Project for Air Pollution Control in the Republic of Kosovo; Introduction of Framework of Emission Inventory*, funded by JICA ("JICA Project")[4] and *Report on Energy Consumption Survey Results* within *Support on Implementing the 3rd Energy Package with focus on Energy Efficiency and Renewables,* funded by EU ("EU Project")[5],
- Data from public institutions like traffic measurement or fleet composition received from the Ministry of Infrastructure,
- Data from municipalities collected during site visits in Gjakova, Peja, Prizren, Drenas and Mitrovice.

Emission factors used in the inventory are based mainly on EMEP Emission Inventory Guidebook (2019).

Emission estimation from small combustion sources (domestic, public and business services sources) is based on energy demand calculations for heating, water heating and cooking purposes by settlements. Energy demand is estimated per person or households using population statistics and for services using number of public buildings (offices, schools or hospitals) or number of services. Calculated energy demand is divided into different types of fuel used for heating, cooking or water heating. Fuel share data is based on surveys conducted by above mentioned other projects.

Emission from road transport is calculated using traffic measurements on national roads conducted by the Ministry of Infrastructure and vehicle register data. Traffic in Pristina and in over cities was adjusted using traffic surveys conducted by JICA in Pristina. Emission was estimated for the following vehicle categories:

- Passenger Cars (PC)
- Light commercial vehicles (LCV)
- Trucks – heavy duty vehicles (HDV)
- Buses

The inventory of point sources in Kosovo includes emitters belonging to IPPC installations, for which the permit was or application for permit was submitted to the Ministry of Environment and Spatial Planning - MESP (about 42 installations). Information regarding parameters of emitters and quantity of substances emitted was taken from the permits or adopted on the basis of expert's experience and similarities with other installations.

For other sources such as asphalt manufacturing, natural sources, aviation and landfills, activity data was obtain from statistical database or from Kosovo Environmental Protection Agency (KEPA).

[4] *Kosovo | Kosovo | Countries & Regions | JICA*

[5] *Report on Energy Consumption Survey Results; Besim Islami; Support on Implementing the 3rd Energy Package with focus on Energy Efficiency and Renewables, funded by EU; action document template (country) empty (europa.eu)*

All emission data and calculations are collected in Excel databases. The databases include input data, calculation method, emission results by municipalities and emission in the grids. There are the following Excel databases:

a. 2018_1.A,_2.A.1_2.C_3B_Industry_v2.xlsx
b. 2018_1.A.3_Main_roads_ v2.xlsx
c. 2018_1.A.3_Other_roads_ v2.xlsx
d. 2018_1.A.4_Small_combustion_ v2.xlsx
e. 2018_11.C_Forests_ v1b.xlsx
f. 2018_2.A.5.a_1.B.1.a_Mining_ v2.xls
g. 2018_1.A.2.f.i_Asphalt_v1.xls
h. 2018_3.B_Agriculture breeding_ v2.xlsx
i. 2018_3.D_Agriculture crops _ v1b.xlsx
j. 2018_5.A_ Landfills_ v1b.xlsx
k. 2018_1.A.3.a_Aviation_ v2.xlsx

The emission inventory should be developed and updated every year. To enable MESP officers (KEPA, KHMI) to continue and update emission inventory in the next years and support development of the emission inventory system in cooperation with Statistical Agency and Cadastral Agency the recommendations were listed in the report. Recommendations include: cooperation on data collection and data harmonization with Kosovo Statistical and Cadastral Agencies (regarding data from upcoming CENSUS 2021), cooperation with municipalities in data collection at local level and cooperation with MESP on data from IPPC and environmental permits.

Final emission results for Kosovo in 2018 year are presented in the table below:

Table 1 Final emission results for Kosovo in 2018 by sector

Pollutant	unit	Small combustion	Transport		Industry	Agriculture	Quarries	Landfill	Total
			Roads	Aviation					
PM_{10}	[Mg/year]	18 883	4 174	0	14 003	1 443	112	0	38 616
$PM_{2.5}$	[Mg/year]	18 397	1 860	0	6 372	204	11	0	26 846
NOx	[Mg/year]	1 976	14 125	44	26 971	4028	0	0	47 145
SO_2	[Mg/year]	1 745	6,7	2,8	44 201	2,8	0,0	0,0	45 958
CO	[Mg/year]	105 363	6 996	31,5	5 970	324	0,0	0,0	118 684
NMVOC	[Mg/year]	15 454	1 245	4,8	61,2	4 126	0,0	0,0	20 891
As	[kg/year]	10	0,13	0,00	0,00	0,00	0,00	0,00	10,3
Hg	[kg/year]	26	5,77	0,00	0,00	0,00	0,00	0,00	31,7
Cd	[kg/year]	382	0,07	0,00	0,00	0,00	0,00	0,00	382,2
Pb	[kg/year]	202	0,65	0,00	0,00	0,00	0,00	0,00	203,1

Analyze of sectoral emissions is presented in the pie charts below. Small combustion is the main emission source in the case of particulate matter. Almost 50% of PM_{10} and 68% of $PM_{2.5}$ come from small combustion. Industry is the second emission source with 37% for PM0 and 24% for $PM_{2.5}$ shares and traffic is the third emission source with 11% and 7% shares in emission respectively. The remaining sectors account for less than 5% of emissions. The industry has the largest share in SO_2 and NOx emissions (96%

and 57% respectively). Transport is the second significant source in the case of NOx emission (30%). Small combustion (domestic and services heating) is the main emission source in the case of CO and NMVOC (89% and 57% respectively). Agriculture is the second source of NMVOC emission (20%).

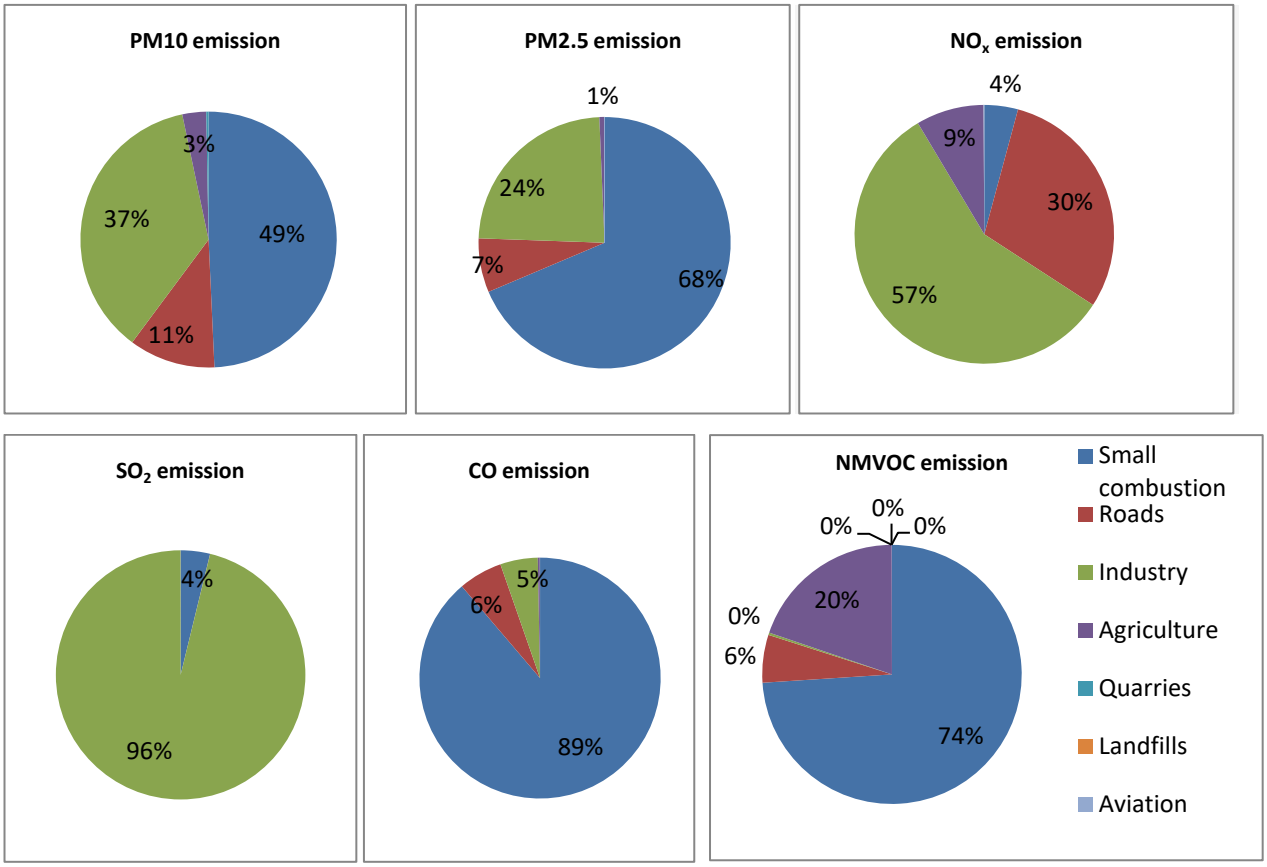
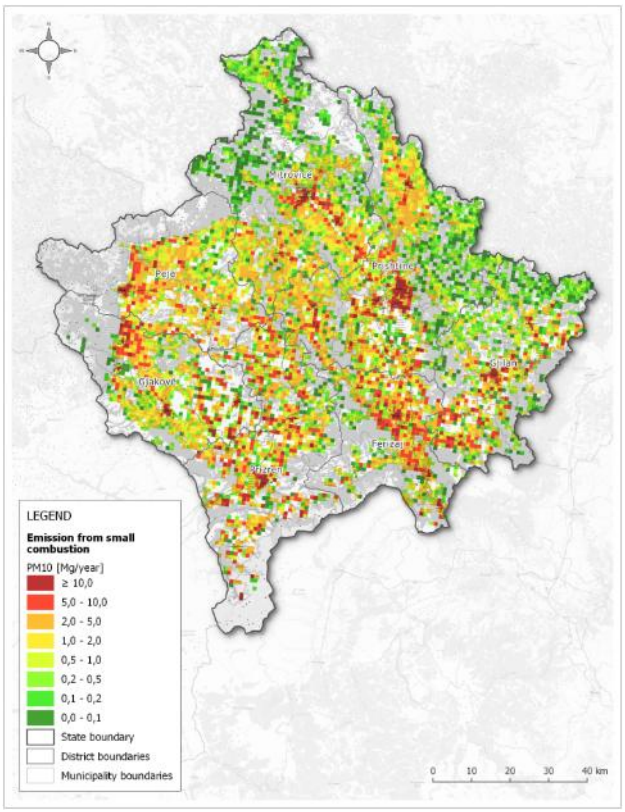
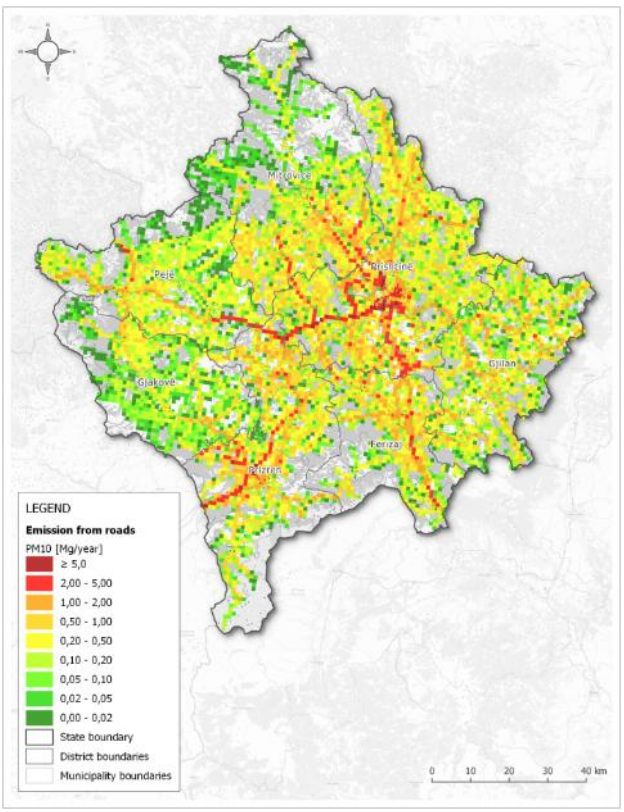
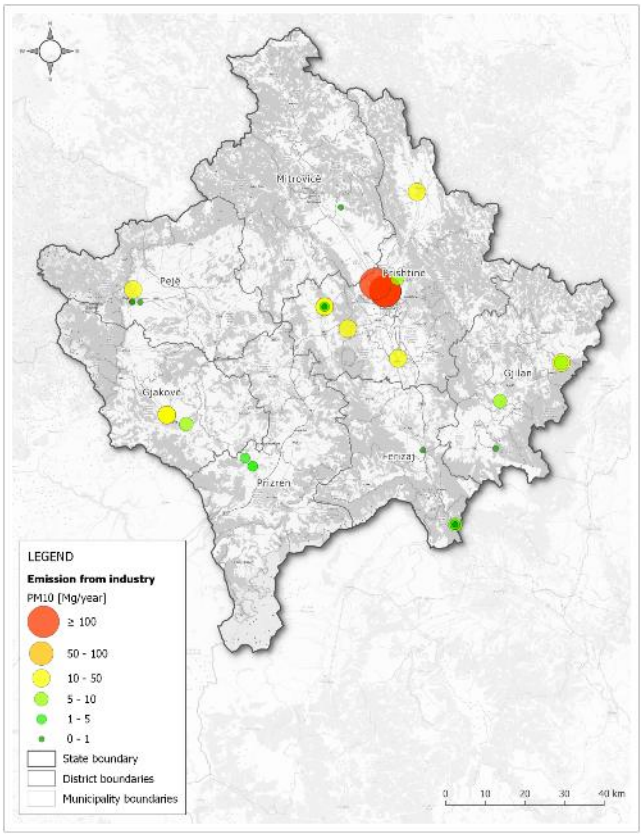


Figure 1 Share of individual sectors in emissions

Spatial distribution for PM_{10} and NOx emissions for the main sources is presented in the maps below.


LEGEND
Emission from small combustion
PM10 [Mg/year]
≥ 10,0
5,0 - 10,0
2,0 - 5,0
1,0 - 2,0
0,5 - 1,0
0,2 - 0,5
0,1 - 0,2
0,0 - 0,1
State boundary
District boundaries
Municipality boundaries
0 10 20 30 40 km


LEGEND
Emission from roads
PM10 [Mg/year]
≥ 5,0
2,00 - 5,00
1,00 - 2,00
0,50 - 1,00
0,20 - 0,50
0,10 - 0,20
0,05 - 0,10
0,02 - 0,05
0,00 - 0,02
State boundary
District boundaries
Municipality boundaries
0 10 20 30 40 km


Mitrovicë
Pejë
Prishtinë
Gjilan
Gjakovë
Ferizaj
Prizren
LEGEND
Emission from industry
PM10 [Mg/year]
≥ 100
50 - 100
10 - 50
5 - 10
1 - 5
0 - 1
State boundary
District boundaries
Municipality boundaries
0 10 20 30 40 km

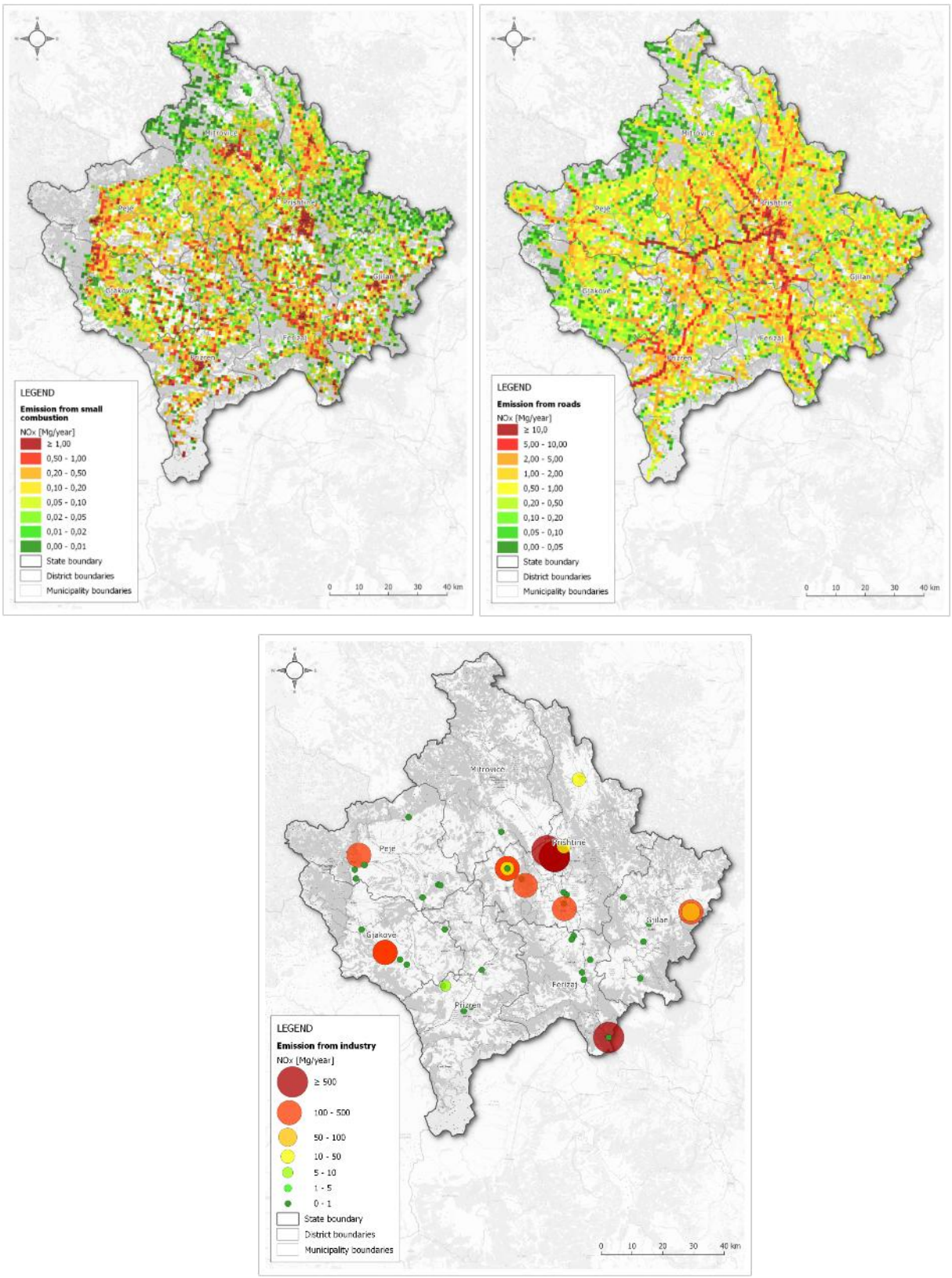


Figure 2 Annual emission of PM_{10} and NOx for the main sources

2 PURPOSE AND SCOPE OF THE REPORT

The purpose of this document is to present a detailed methodology for the inventory of emission sources and results for the Republic of Kosovo. It includes also a description of improvements implemented since the previous report in:*Supply of project management, air quality information management, behavior change and communication services. TASK D1: Emission inventory: Detailed methodology for the inventory of emissions of substances in Kosovo and the scope of the electronic database*, produced in May 2020[6]XXX.

The emission inventory created as part of this project is the first detailed air emission inventory for the entire area of Kosovo There is some available information on emission in Kosovo. Kosovo Environmental Protection Agency under the Ministry of Environment and Spatial Planning is providing top-down national air emission inventory under the Convention on Long-range Transboundary Air Pollution. The database includes data from 2000 year and is updated every year. Some emission data is estimated also at local levels: Drenas City prepared first Air Quality Plan for the municipality with some emission estimations; Prizren City prepared GHG Emission Inventory. Japan International Cooperation Agency (JICA) developed detailed bottom–up emission inventory for Pristina Agglomeration (including Pristina, Fushe Kosovo and Obiliq municipalities) within the project: *Capacity Development Project for Air Pollution Control in the Republic of Kosovo. Introduction of Framework of Emission Inventory* funded by JICA. All this data was a valuable support for development of emission inventory presented in this report. The base year for the development of emission database data is 2018, the year for which, according to the KHMI, measurement data has the best availability. Analysis of 2018 measured (see report on modeling)[7] showed a lot of gaps and a few errors in measurements for NO_2 and SO_2. Therefore the measurement data for 2019 were also viewed during the update. Eventually, due to the available emission data and similar quality of measurement data for both 2018 and 2019 years, 2018 was adopted as the best year for air quality analysis.

The methodology of pollutant emission inventory is based on EMEP Guidebook 2019[8] and presents the following:

a. sources of data on emission sources and levels,
b. values of emission factors to be used for the inventory, and their source of origin,
c. methods of calculations of activity data and emissions (particularly for domestic heating/commercial and transport),
d. recommendations and indications for updates and emission inventory system development,
e. improvements and changes implemented in the emission inventory update
f. other relevant elements of the methodology for preparing the emission inventory.

The scope of the methodology includes the determination of the manner of conducting the inventory of sources of the following at this step:

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[6] *Supply of project management, air quality information management, behavior change and communication services. TASK D1: Emission inventory: Detailed methodology for the inventory of emissions of substances in Kosovo and the scope of the electronic database. Prepared by ATMOTERM; MFK; May 2020*

[7] *Supply of project management, air quality information management, behavior change and communication services. TASK D3: Model and model outputs – Modelling Methodology and Results; Prepared by ATMOTERM; MFK, Kosovo;August 2020*

[8] *EEA Report No 13/2019; EMEP/EEA air pollutant emission inventory guidebook 2019 — European Environment Agency (europa.eu)*

Table 2. Structure of emission sources

Type of the source	Description	NFR code (EMEP Guideline)
Point emission	IPPC installations (with integrated environmental permits or applying for IPPC). Due to lack of sufficient information emissions from production of paints, facades and varnishes was not estimated, landfills and mines were included as other sources respectively and pharmaceutical production emission was considered negligible regarding substances being analyzed. Emissions from asphalt manufacturing (not coming under IPPC but subject to air emission environmental permits) are included in the inventory update.	1.A.1 Energy Industries (Thermal Power Plant, Heat Production, etc.) 1.A.2 Combustion in Manufacturing Industries and construction 2. Industrial Process and Product Use (IPPU) Sector
Area sources	covering municipal and household sector, trade and services sector and public utility facilities	1.A.4 Small combustion – commercial / institutional, residential
Line sources	traffic emission, taking into account national, regional, county and municipal roads. Emissions from railways were considered negligible regarding substances being analyzed and health impact.	1.A.3 Exhaust emissions from road transport, Road vehicle tire and brake wear, road surface wear
Other area sources	agriculture, the areas under cultivation, livestock husbandry (breeding) and the use of fertilizers and agricultural machinery fugitive emissions from the area of extractive industry and quarries, as well as landfills in the region aviation – Pristina International Airport natural emission from forest areas local fires have not been included due to the lack of data.	5 . Waste 3. Agriculture (breeding, cultivation) 1.B.1.a Fugitive emission from solid fuels 2.A.5.a. Quarrying and mining other than coal 1.A.3.a Aviation 11.C. Other natural sources

In addition, the methodology determines the content of the electronic database on emissions from particular sources of emissions from Kosovo. In Annex II (table 2) there is a detail list of sectors according to NFR code which are and are not included in the emission inventory.

The inventory of pollutant emissions includes the following substances:

- PM_{10},
- $PM_{2.5}$,
- nitrogen oxides,
- sulfur dioxide,
- carbon monoxide,
- total non-methane volatile organic compounds (NMVOC),
- arsenic,
- cadmium,

- mercury,
- lead.

2.1 MAIN ACTIVITIES FOR UPDATING OF THE EMISSION INVENTORY

The objective of emission inventory update is to improve emission inventory by:

- Improving activity data collection
- Improving data completeness for key categories of emission sources
- Application – for key categories - of the highest possible Tier in terms of methodology
- Decreasing uncertainty of emission calculation for key categories

The actions taken to update emission calculation are presented in the table below. Description of assumption and data used in the update are provided in the individual chapters.

Table 3. Update of the emission inventory actions

NFR code and source name	Action	Improvement
1.A.4 Small combustion – commercial / institutional, residential	Analyzing district heating data (no. of buildings connected, amount of heat supplied) received from Mitrovice City and Termokos for Pristina	Verification of fuel share basing on real data (not questionnaires) regarding share of district heating
1.A.4 Small combustion – commercial / institutional, residential	Detailed spatial distribution of emission for selected cities: - Identifying areas with overestimation of modelled values - Identifying cell with the highest emission density in cities - Analyzing of large cities building structure After analyses the following changes were implemented in the database: - Increased share of electricity in the apartment buildings/blocks of flats and other high buildings areas in selected large cities - Increased height of selected emission cells (emitters) in the areas of high building in selected cities	More detailed identification of areas of different types of buildings and different types of heating allows for better spatial distribution of emission.
1.A.4 Small combustion – commercial / institutional, residential	Database verification after first modeling: - Overestimation of PM_{10} and $PM_{2.5}$ concentrations – spatial analysis and source apportionment indicate that emission from small combustion is responsible for overestimation - Information on pellet use in Kosovo has been collected	Improvement of emissions: more detailed activity data - step into tier 2

	- Emission factors for pellet and solid fuel new installation were added - Fuel share was modified: pellet use and solid fuel (coal/wood) use in new installation were added	
1.A.4 Small combustion – commercial / institutional, residential	Implementing Pristina's emission database from JICA Project – analyzing emission results from JICA's inventory, improving input data and some of assumptions	Improvement of activity data: pellet use, heat demand calculations
1.A.3 Exhaust emissions from road transport, Road vehicle tire and brake wear, road surface wear	Implementing Pristina's emission database from JICA Project – verification of traffic in Pristina and large cities based on JICA's traffic measurement. Increase of traffic on main streets/roads in Pristina and large cities Verification of traffic at national roads based on JICA's surveys	Calculation of traffic based on JICA's surveys – improving emission calculations
1.A.1 Energy Industries (Thermal Power Plant, Heat Production, etc.) 1.A.2 Combustion in Manufacturing Industries and construction 2. Industrial Process and Product Use (IPPU) Sector 2.A.5.a. Quarrying and mining other than coal	Verification of available activity data, Verification of measurements for Power Plants – comparison with JICA's Report and measurements - JICA emission inventory was adopted in the update Updating of IPPC installations data – including new IPPC permits - no new permits	Improving Industrial and mining databases

Other activities regarded during the first emission inventory:

- Obtaining building and settlements layer: we received addresses points layer for 29 municipalities from Kosovo Cadastral Agency (KCA). Layer was completed with addresses points for the remaining 9 municipalities manually using GIS tool and orthophotomap;
- Analysis of all data collected from cities: Peja, Mitrovice, Drenas, Prizren, Gjakova during site visits in December 2019, January and February 2020. Analyses included data regarding business register and public services and fuel use.

3 QUALITY ASSURANCE PROCEDURES

Quality objectives for Kosovo Air Quality Project emission inventory have been defined as follows:

- maximum possible data completeness for key categories of emission sources;
- inclusion of all other (non-key) categories if their emission data and parameters are available;
- application – for key categories - of the highest possible Tier in terms of methodology;
- positive horizontal check result with the reference region (Malopolska, PL);

- positive air quality results check with the Kosovo verified monitoring network.

It is important to mention that the main focus of the Project is on air quality management and the basic concept of the emission inventory QA/QC follows this goal.

A QA/QC plan has been set to achieve the above objectives. The plan refers to all steps of the methodology starting from the activity data collection and finishing at the use of emission data for air quality modeling tasks.

A general framework of quality assurance in the process of Kosovo emission inventory preparation consists of the following items:

1. **Definition of data collection plan**
2. **Procedures for documentation of data collection**
3. **Procedures for data processing including application of calculation algorithms**
4. **Verification procedure for point sources data**

In the case point sources the following procedures are activated:

- comparison of emission data with emission factors estimates,
- comparison of emission data with data of similar plants.

5. **Verification procedure for area and line sources**

In the case point area and line sources the following procedures are activated:

- check of source activity data collection and storage (check of data entry errors and gaps, check of double counting);
- verification procedure for appropriate use of emission factors, modulation profiles and spatial aggregation/disaggregation routines.

6. **Internal verification of final emission inventory results**

For the final results a check list has been prepared containing procedures for:

- check to compare estimates with other similar territorial units,
- check to compare estimates between source categories,
- an independent review of calculations, assumptions, and documentation by other internal experts not involved directly in the inventory process.

7. **External verification of emission inventory results**

An external independent audit from the side of end user can be carried out according to the user's requirements and standards.

8. **Air quality models application**

After emission inventories are used as input to air quality models - comparison of modeling results with monitoring data is useful to indicated possible errors in emission inventory data.

A set of QA/QC techniques has been applied to achieve data quality objectives in the process emission database preparation. The table below describes the main techniques involved.

Table 4 QA/QC techniques applied in the process of emission database preparation

Quality Control	Procedures on data management (applies to data used from third parties as well as data generated by NIRAS): • routine checks to ensure data integrity, correctness, and completeness; • measurement units checks; • automated and supervised identification of data errors and omissions; • supplement algorithms implementation; • archiving data files in SVN subversion system. General QC activities: • spreadsheets calculation formulas checks; • spreadsheets completeness checks; • technical reviews of activity data and emission factors.
Quality Assurance	General QA activities: • review of applied QC programme; • comparison of emission results to project of Malopolska Region (PL) inventory; • review of emission maps and their comparison with activities spatial information; • completeness check of archived files.
Verification	Final verification of the inventory and methodological report carried out by the parties external to the inventory team using the methods similar to those described above.

In the cases where expert judgment was needed to find the proper choice of methodology and/or parameter values an expert elicitation procedure was used. This included a check of expert background as well as procedures of proper data structuring, encoding and verification.

4 KEY CATEGORY ANALYSIS

According to the EMEP Guidebook (2. Key category analysis and methodological choice Figure 3-1), key category analysis is determined using qualitative criteria if there is no emission inventory data available. This is the first national detailed emission inventory for Republic of Kosovo; therefore key categories have been determined using qualitative criteria. National emission inventory prepared by KEPA uses top-down methodology and includes some of the emission sources. Cumulative emissions threshold method used in the national emission inventory to identify key categories determines only 2 or 3 sectors. First activities were focused on identification of key categories but also on ensuring maximum base completeness regarding activity data availability.

According to the information obtained from local institutions (MESP, KEPA, KHMI) there are three main emissions sources groups which have impact on people's health in Kosovo:

- Residential - domestic/small business heating - 1.A.4 Small combustion,
- Traffic - 1.A.3 Exhaust emissions from road transport, Road vehicle tire and brake wear, road surface wear,
- Large industry - 1.A.1 Energy Industries (Thermal Power Plant, Heat Production, etc.), 1.A.2 Combustion in Manufacturing Industries and construction, 2. Industrial Process and Product Use (IPPU) Sector, subsector: IPPC.

Local visits and surveys and measurements data analysis confirmed importance of domestic heating and traffic sources in air pollution.

The previous version of this report, and the associated Excel databases[9], determined mass emissions for the key source categories as shown in Table 5 below.

Table 5 Key category analysis based on version 1b of the Excel databases

	NRF	**PM_{10} (Mg/year)**	
Small combustion	1.A.4	23511,9	69%
Roads	1.A.3.	4071,0	80%
Quarries	1.B.1.a, 2.A.5.a	2587,3	88%
Industry	1A.1.a	2521,7	96%
Agriculture	3.	1151,8	99%
Industry	1.A.2	247,5	100%
Industry	2.A.1	39,6	100%
Industry	2.C	16,6	100%
Industry	3.B.4.g.i	14,8	100%
Industry	1.A.1.b	13,5	100%
Landfills	5.	0,1	100%
Industry	3.B.3	0,0	100%
	NRF	$PM_{2.5}$ (Mg/year)	
Small combustion	1.A.4	22904,0	84%
Roads	1.A.3.	1813,0	91%
Industry	1A.1.a	1513,0	96%
Quarries	1.B.1.a, 2.A.5.a	620,8	99%
Agriculture	3.	167,4	99%
Industry	1.A.2	176,8	100%
Industry	2.A.1	28,3	100%
Industry	2.C	11,9	100%
Industry	1.A.1.b	9,6	100%
Industry	3.B.4.g.i	1,1	100%
Landfills	5.	0,0	100%
Industry	3.B.3	0,0	100%
	NRF	**NOx (Mg/year)**	
Industry	1A.1.a	19182,8	45%
Roads	1.A.3.	13867,1	77%
Agriculture	3.	3987,3	86%
Industry	1.A.2	2808,4	93%
Small combustion	1.A.4	1966,4	97%
Industry	2.A.1	773,5	99%
Industry	2.C	296,9	100%

[9] *Supply of project management, air quality information management, behavior change and communication services. TASK D1: Emission inventory: Detailed methodology for the inventory of emissions of substances in Kosovo and the scope of the electronic database. Prepared by ATMOTERM; MFK; May 2020*

Industry	1.A.1.b	172,1	100%
Industry	3.B.3	0,0	100%
Quarries	1.B.1.a, 2.A.5.a	0,0	100%
Landfills	5.	0,0	100%
Industry	3.B.4.g.i		100%
	NRF	**SO_2 (Mg/year)**	
Industry	1A.1.a	14236,2	50%
Industry	1.A.2	11068,6	89%
Small combustion	1.A.4	2164,7	97%
Industry	1.A.1.b	646,0	99%
Industry	2.C	237,5	100%
Industry	2.A.1	92,1	100%
Roads	1.A.3.	6,6	100%
Agriculture	3.	2,8	100%
Industry	3.B.3	0,0	100%
Quarries	1.B.1.a, 2.A.5.a	0,0	100%
Landfills	5.	0,0	100%
Industry	3.B.4.g.i		100%
	NRF	NMVOC (Mg/year)	
Small combustion	1.A.4	19058,5	62%
Agriculture	3.	10265,7	96%
Roads	1.A.3.	1218,3	100%
Industry	3.B.4.g.i	61,1	100%
Industry	3.B.3	0,2	100%
Industry	1A.1.a	0,0	100%
Industry	1.A.1.b	0,0	100%
Industry	1.A.2	0,0	100%
Industry	2.C	0,0	100%
Industry	2.A.1	0,0	100%
Quarries	1.B.1.a, 2.A.5.a	0,0	100%
Landfills	5.	0,0	100%

The analysis identified small combustion, industry (power plants Kosovo A and Kosovo B, other combustion processes e.g. Ferronikieli), roads and agriculture as key categories (depending on the pollutants).

The air emission inventory is to be used for air quality modelling and this analysis should take into account the impact of emission sources on air quality. The amount of emission is just only one of the many parameters which have influence on air quality and human exposure to air pollution. The height of emitters, the location of emission source (e.g. populated, urban areas), dispersion conditions (topography, buildings which impede air dispersion) and meteorology - all have impact on human exposure to air pollution. In all these aspects and with regard to the problematic pollutants PM_{10}, $PM_{2.5}$, NO_2 (for which exceedances are observed), small combustion (domestic and services heating) and roads are the most important emission sources.

Regarding data acquisition three main aspects of building the emission inventory had to be taken into account regarding objective of emission inventory development:

1. Availability of statistical data, level of data (national/regional/municipal/settlement level), updating periods (census – every 10 years, annual)
2. Availability of spatial distribution of data
3. Quality of data

Sometimes more simple data has been selected for use as input for calculation and some more detailed data has not been selected because of lack of information concerning spatial distribution or doubts about data quality. More details are provided further in the document.

Considering above mentioned aspects, emission sources including key emission sources (Table 1 and annex II) have been selected for the emissions inventory. The focus for the update carried out as part of this report has been on on small combustion, transport and some industrial sources.

5 INPUT DATA ACQUISITION SOURCES

Estimating emissions from actual data requires the use of appropriate process-specific emission factors. As part of the inventory of emission sources, a number of assumptions and indicator data were adopted in order to estimate emissions of individual substances. These data are based on literature (2019 EMEP Guidebook), scientific studies and surveys - mostly dedicated to the determination of emissions by inventory.

The input data to be used in the process of preparing the inventory of pollutant emissions for the Kosovo include many sources of varying accuracy and varying spatial distribution level, which have a significant impact on the final results of the generated output information. A description of each of data sources is provided below.

5.1 SPATIAL INFORMATION AND GEOLOCATION PROCESSES

A necessary element of the emission inventory is spatial information contained in the GIS system layers. In order to geolocalize emissions, i.e. to locate sources and emitters in geographical space, it will be necessary to use the following vector layers:

Table 6 Spatial information used in the emission model

No.	Spatial information	Source
1.	Layer of administrative areas (boundaries)	Kosovo Cadastral Agency
2.	The layer of national and regional roads as well as municipal and county roads	own elaboration (object selection, correction and supplementation) based on data © authors of OpenStreetMap available for download at http://download.geofabrik.de/europe.html
3.	Layer of buildings	own elaboration based on data © authors of OpenStreetMap
4.	Layer of settlements	Kosovo Cadastral Agency
5.	Layers of addresses	Kosovo Cadastral Agency

No.	Spatial information	Source
6.	Layer of forests	own elaboration (control and comparison with other available data, calculation of area, assignment to administrative units) based on Corine Land Cover vector database
7.	Areas used for agriculture	own elaboration (control and comparison with other available data, calculation of area, assignment to administrative units) based on Corine Land Cover vector database
8.	Layer of opencast pits, heaps and landfills of bulk materials	KEPA, own elaboration (control and comparison with other available data, calculation of area, assignment to administrative units) based on Corine Land Cover vector database
9.	Boundaries of the emission balance areas for cities	own elaboration based on the inventory of areas, using layers of administrative borders as well as aerial and satellite images of the GOOGLE service
10.	Layers of emission grids	own elaboration for the needs of this project in a given required resolution of the inventory

Based on the vector layers specified above, the GIS system prepares a spatial distribution of emissions for all sources and emitters. Within the framework of the geolocation process, layers are created in which emissions will be assigned to vector objects for reporting and modelling of pollutant dissemination.

Vector layers, satellite and aerial photographs and raster data are used for spatial data. The accuracy of calculations is strongly influenced by the attribute information of the vector layer of settlements and addresses of buildings from the Kosovo Cadastral. Further improvement of data accuracy will be achieved when complete building layer including the number of floors, area of building and the general function of the objects is available.

The following coordinate system is used in databases and in shp files: ETRS_1989_LCC, WKID: 3034. Authority: EPSG. Additionally there is also Kosovo coordinate system added to shp files: Kosovaref01 (Gauss-Krüger/ETRS89).

5.2 STATISTICAL DATA

For the purpose of building the emission model, data from the Kosovo Statistical Agency and Kosovo Statistical Database is used for the base year 2018[10] or, if there are no data for 2018, data for 2017 is used. Census Data 2011 has been used for population calculation and then population has been recalculated to 2018 years using statistical data at more aggregated level (e.g. census population data at settlement level has been converted into 2018 year based on population data from 2018 year at municipality level).

Elaboration of emission data for area sources also includes the following:

- data on the population broken down by administrative units and settlement units,
- data on the housing stock and the age structure of buildings (auxiliary data),
- data on businesses registration and public services.

[10] *Kosovo Cadastral Agency – (http://geoportal.rks-gov.net/*

In case of the traffic emissions database, information on the age and fuel structure of vehicles is used as auxiliary data. On the basis of the age structure of the vehicles, the structure of their exhaust emission factors has been determined accordingly.

With regard to agriculture, data from the 2014 Agricultural Census has been used. It contains detailed data from physical inventory taking broken down by municipality. These data has been compared to data available at central level for 2018. However due to differences in classification update could cause discrepancies. Based on comparisons of available particular activity data (2014 versus 2018) observed changes have been small.

The statistics planned to be used may be burdened with a degree of uncertainty resulting from averaging for specific administrative units and, depending on the type of data, from the way the information is collected (survey, census). At the same time, these are data based on figures and real information that are not subject to estimation.

5.3 DATA FROM OTHER PROJECTS

Data from two projects has been used for area emission calculations:

1. *Capacity Development Project for Air Pollution Control in the Republic of Kosovo; Introduction of Framework of Emission Inventory*, funded by JICA ("JICA Project")[11].
2. *Support on Implementing the 3rd Energy Package with focus on Energy Efficiency and Renewables*, funded by EU ("EU Project")[12].

JICA Project, concerning the emission inventory, focuses on bottom–up emission inventory for Pristina, Obiliq and Fushe Kosovo municipalities. The following data and surveys were used in this emission inventory and the update:

Table 7 List of data and surveys from the JICA Project used in the inventory

	Input data	Type of data which has been analyzed	No of surveys
1	Activity Data of Households	average fuel consumption in division with fuel type and household type	1996, Pristina / Fushe Kosovo / Obiliq
2	Activity data of public institutions and small business	Some data received from municipality offices Office, kindergarten, school, university, bakery, café, restaurant, hotel, shop, warehouse, hospital, others. Average fuel use Fuel using percentage	Bakery: 78 Restaurant: 268 Shops: 506 Schools: 43 Pristina / Fushe Kosovo / Obiliq
3	Traffic measurements in Pristina	Traffic measurements and vehicle registration	3 sessions from 8 to 17

[11] *Capacity Development Project for Air Pollution Control in the Republic of Kosovo; Introduction of Framework of Emission Inventory, JICA ; 2020*

[12] *Report on Energy Consumption Survey Results; Besim Islami; Support on Implementing the 3rd Energy Package with focus on Energy Efficiency and Renewables, funded by EU; 2018*

		received from Ministry of Infrastructure and Transport	points in Pristina

Report on Energy Consumption, produced within the scope of the EU Project, is estimating the energy consumption for different sectors: households, public sector, business sector and transport. Calculation of energy commodities shares for all households in different municipalities and the respective results for three most important energy services, such as space heating, water heating and cooking has been included in the report. Bottom-up methodology has been implemented using also surveys.

Table 8 List of data and surveys from the Report on Energy Consumption (the EU Project) used in the inventory

	Input data	Type of data which has been analyzed	No of surveys
1	Activity Data of Households	average energy consumption division of fuel type used in household in different regions of Kosovo	15 000 – households (2018) in regions: Pristina, Prizren, Mitrovica, Gjilan, Peja, Gjakova, Ferizaj
2	Activity data of public institutions and small business	Average energy consumption	more than 1,000 service facilities in different regions (2018): Pristina, Prizren, Mitrovica, Gjilan, Peja, Gjakova, Ferizaj

5.4 DATA FROM MEASUREMENTS OF VEHICLE TRAFFIC

Traffic measurement has been received from the Ministry of Infrastructure and Transport. The measurements have been conducted using automatic counters at 21 measurements points at different roads (national, highways, regional). The last measurements were conducted in 2016 year. The Ministry has also shared results from traffic modeling for years 2015 and 2020.

In the update, traffic based on above mentioned measurements was adjusted using JICA's traffic surveys in Pristina and in other large cities.

5.5 DATA FROM CITIES

The following cites and municipality offices have been visited:

1. Gjakova
2. Peja
3. Prizren
4. Drenas
5. Mitrovice

The following data has been explored:

- Energy efficiency, heat demand and traffic/transport data available at city level - for instance: Energy Efficiency Plan, Climate Change Plan or Greenhouse Gas Emissions Inventory for the City, Mobility Plan, traffic measurements (for road/street development projects);
- Local power plant with heating system distribution;
- Information (area of buildings or fuel consumption) in public services like schools, offices;
- Number of registered business services (bars, restaurants);
- Other information that could be useful for emission inventory.

Due to the late submission of data, not from all cities, and its incompleteness, most data has not been included in the first stage of the inventory. During the update of emission inventory data provided by cities was analyzed and used to adjust the activity data.

Gjakova

City located in the west part of Kosovo in "Flat Dukagjini", at a height of 335 meters. Municipality has about 94 840 inhabitants (according to KAS, December 31). Out of these, about 41 000 lives in the city. Site visit included meeting in Municipality Office with Directorate of Urbanism and Environmental Protection and city survey. Gjakova Municipality has developed documents regarding environmental aspects: Local Environmental Action Plan, Local Biodiversity Action Plan and Local Waste Management Plan. The main environmental threats are connected to illegal urban development, traffic, waste and wastewater management and natural resources exploitation. Air quality is considered as a major environmental problem caused by domestic heating and traffic. Gjakova city has got district heating with 20 MW oil plant. District heating system covers central and south part of the City. Modernization of power plant is planned – old oil boilers will be replaced by new biomass boilers. Data about number of buildings connected and using district heating received from Municipality Office are presented in the table below:

Table 9 Number of buildings connected to district heating system in Gjakova

Type of buildings	Number of buildings with active district heating (DH)	Number of buildings with passive district heating (DH)
Block of flats	29	29
Houses	158	78
Business services	50	288
Schools	7	2
Hospitals	2	1
Public	7	

The pictures below present (from the left): Municipality Office, old town with small houses, south part of the City with new buildings and hilly small town area with small houses.

Figure 3 Examples of buildings in Gjakova.

Peja

Municipality is located in the west part of Kosovo, Peja City is located at the root of Prokletije Mountains and at the entrance of Rugova Canyon – one of the longest and deepest in Europe. The first part of the canyon lays on the east-west direction which has impact on wind direction and air pollution dispersion. According to the KAS (31st of December 2018) the municipality has 99 115 inhabitants and in Peja City lives about 50 300 citizens. Site visit of the city combined with meeting in the Municipality Office with Directorate of Urbanism and Environmental Protection took place in December 2019. According to Environmental Impact Assessment of Strategic Development Plan for Municipality of Peja 2019 – 2026 air quality in the municipality is one of the best in Kosovo, however there are local problems with air pollution. One of KHMI monitoring station is located in Peja city and it measures urban background. According to the measurements in 2020 (year is not finished yet) there are already 74 days with PM_{10} exceedances of 50 µg/m^3 (limit is 35 days). There were observed exceedances for PM_{10} and $PM_{2.5}$ limit values in previous 2019 year.

Some data regarding fuel use for heating purposes received from the Directorate of Urbanism and Environmental Protection Directorate are presented in the table below. The data comes from Environmental Inspector.

Table 10 Type of fuel used in inspected services in Peja

Activity /sector	Type of fuel	Number of inspected premises
ovens	wood and electricity	28 inspected
bakeries	wood and electricity	29 inspected
restaurants	pellet and electricity	
stores and shps	mainly electricity	
schools	all wood + 1 with oil (heavy)	33
hospitals	pellet	
public administration	3 - heavy oil, 1 electricity	4

The pictures below present (from the left): view at Rugova Canyon form the city, "small combustion" in restaurant, example of residential area and block of flats in Peja.

Figure 4 Examples of buildings in Peja.

Prizren

Municipality is situated in the southeast part of Kosovo at about 400 m above see level. Prizren City lies at the foot of Sharr Mountains. Municipality has 192 712 inhabitants (KAS 31st of December 2018) and 92 200 of them lives in Prizren City. Municipality has prepared Greenhouse Gases Emissions Inventory for Prizren City with 2014 base year as a part of the project: "*Support for Sustainable Prizren - Initiating Urban NA-MAs*" (NAMA - Nationally Appropriate Mitigation Actions). Air quality is one of the environmental threats in the city. Monitoring station run by KHMI shows problem with PM_{10} pollution: number of days with exceedances of daily limit values was 58 in 2019 and 51 in 2020 (for 14th of December 2020). The limit is 35 days. High values of $PM_{2.5}$ are also observed however, under the limit values. During the site visit and

meeting in the Municipality Office with Public Services Department GHG Emission Inventory was presented by the officers. Table below provides some data found in the inventory.

Table 11 Fuel use by business and public institutions in Prizren in 2014 year (Greenhouse Gases Emissions Inventory for Prizren City,)[13]

Base year 2014	Wood	Oil diesel	Pellet	Oil	Lignite	Electricity
	Mg	Mg	Mg	Mg	Mg	mln kWh
business and institutions	3571	62	107	132	2074	4,8

Pictures below present few views of the city: location at root of Sharr Mountains, old town with small and densely arranged houses, wood fuel and typical streets with small houses in Prizren.

Figure 5 Examples of buildings in Prizren.

Mitrovica

The city of Mitrovica is located in northern Kosovo near the junction of rivers Sitnica and Ibar in hilly area. The city is divided into Albanian south part and Serbian north part. Mitrovica municipality (north and south) is populated by 81 401 inhabitants (KAS 31st of December)[14] and about 44 800 people lives in the city. This part of Kosovo used to be a main industrial area with Trepca district (Trepca mining field), the Zvecan smelter plant and the Trepca battery factory. Mitrovica Industrial Park (MIP), with area approximately 150

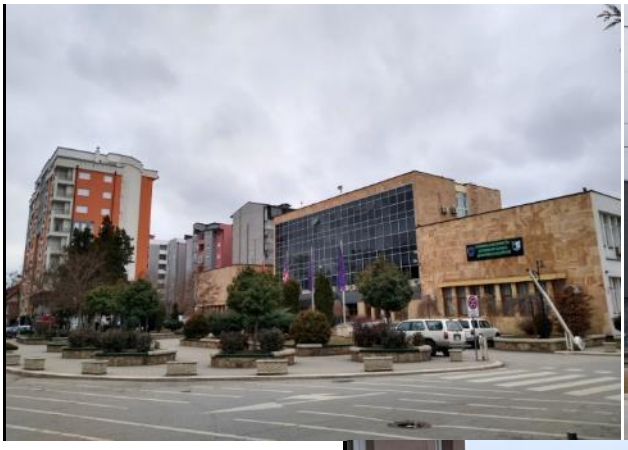
[13] *Greenhouse Gases Emissions Inventory for Prizren City, Baseline Year 2014 GHG Emissions Inventory (Report), Prizren Municipality, UNDP, Austrian Development Cooperation*

[14] *KAS database: https://askdata.rks-gov.net/PXWeb/pxweb/en/askdata/?rxid=c889d148-36de-4009-b6cd-27daabe0c80e*

ha, is located at the eastern part of the South Mitrovica in an open shallow valley of rivers Sitnica and Ibar. This area is adjacent to the populated area.[15] The mine and the factory located within the city are already closed however, the area is still not remediated. According to the report: Consulting services for Environmental Assessment and Remedial Action Plan for Mitrovica Industrial Park: "*The Mitrovica Industrial Park is part of the Trepca conglomerate and has been identified as one of the most severe environmental hotspots in the region".* The report notes that water and land contamination with heavy metals are the main environmental problem of the city caused by the former industrial activities. From air quality point of view dust carried from uncultivated areas may include heavy metals.[16]

Air quality problems in Mitrovica are related to PM_{10} daily exceedances and $PM_{2.5}$ annual concentrations above limit value which are observed by KHMI monitoring station located in the city (urban background). 57 days with exceedances of PM_{10} daily limit value (50 µg/m^3) was observed in 2019 and 51 days in 2020 (on 15th of December).

Pictures below present few views of the city made during site visit in the City and Municipality Office in January 2020: from the left – Municipality Office and higher buildings in the centre of the city, view to the north part of Mitrovica and hills, residential hilly area in the south part of the city, industrial former mine area (MIP) and example of low emitters from services.



[15] *Consulting services for Environmental Assessment and Remedial Action Plan for Mitrovica Industrial Park, Kosovo; Czech-UNDP Trust Fund, October, 2009;*
[16] *Consulting services for Environmental Assessment and Remedial Action Plan for Mitrovica Industrial Park, Kosovo; Czech-UNDP Trust Fund, October, 2009;*

Figure 6 Examples of buildings in Mitrovica.

Drenas/Gllogoc

Drenas City is situated in the central part of Kosovo about 30 km to the west from Pristine. Gllogoc municipality has 60 970 inhabitant and about 6 400 citizens live in the city. City is not large however, in the centre large high blocks of flats are situated surrounded by residential houses. Ferronikeli - large nickel production plant with nickel mine is situated near Drenas to the north. According to the received information from Drenas Municipality Office during site visit in January 2020, the Municipality developed the first Air Quality Plan in Kosovo. Air quality is a problem in the city due to PM_{10} pollution according to the air quality measurements hosted by KHMI. Number of days with exceedances of PM_{10} daily limit was observed in 2018: 51 and in 2020: 41 (15th of December 2020). The Municipality is concerned about impact of Ferronikeli Installation on air quality in the city. The Air Quality Plan includes estimation of emission for the city based inter alia on business and car registers and list of measures for emission reduction and improvement of air quality in the municipality. Communication and education actions are mentioned in the AQP among others. Therefore the emission inventory and air quality modelling, Air Quality Portal developed in this project may strongly support these measures. Table below presents some data from Air Quality Plan for Drenas:

Table 12 Fuel use per year by different activities for heating purposes in Drenas (Air Quality Plan for Drenas City)[17]

Type of activity	Number	Area	Wood	Coal	Electricity	Pellet
		[m^2]	[m^3]	[Mg]	[kWh]	[Mg]
Bakeries	8	no data	2 144	no data	no data	no data
Restaurants	47	no data	no data	no data	no data	no data
Shops	1 465	no data	no data	no data	no data	no data
Schools	34	49 825	3 300	-	-	-
Hospitals	13	6 407	50	-	-	100
Public administration /offices	7	6 657	20	-	-	30
Block of flats	33	21 114 (ground floor)	no data	no data	no data	no data

[17] *Local Air Quality Action Plan 2020 – 2024; Gllogoc Municipality; Gllogoc 2019*

Houses	8 852 active residents	885 200 (ground floor)	no data	no data	no data	no data

Pictures below present different types of buildings and plant - from the left: higher buildings in the centre of the city, residential area, mixture of high and small houses with example of low emitter, Ferronikeli Plant and view at the plant against the city.

Figure 7 Examples of buildings in Drenas.

Pristina

Pristina - capital city of Kosovo located in the northeastern part of Kosovo in a small hilly terrain close to the Gollak Mountains. Officially municipality is populated with 214 688 inhabitants and 156 000 citizen lives in the city. However, it is estimated that city may have much more inhabitants: students and people working in the capital. There are two monitoring stations in Pristina: one in the city centre – near the MESP offices and the other at KHMI location near the exit road to Peja. Measurements show air quality problem with PM_{10} and $PM_{2.5}$. High concentrations of NO_2 are also observed. Data for Pristina was collected by other project including detailed emission inventory for Pristina Agglomeration (Pristina, Fushe Kosovo and Obiliq

municipalities): *Capacity Development Project for Air Pollution Control in the Republic of Kosovo; Introduction of Framework of Emission Inventory*, funded by JICA.

Figure 8 Smog in Pristina

Conclusions from site visits

Municipal authorities in all visited places are aware of air quality problems in the cities and take measures to reduce air pollution. Air quality problem is mentioned as a one of main environmental problems in strategies and plans developed by municipalities. Drenas and Prizren municipalities have prepared dedicated document regarding air pollution: Air Action Plan for Drenas and GHG emission inventory for Prizren. Air quality monitoring is carried out by KHMI in four of the five locations visited. In all these cities exceedances of PM_{10} daily limit are observed. Annual concentrations of $PM_{2.5}$ are high, around 20 µg/m^3 but below the limit value: 25 µg/m^3. Municipalities provided some data which mainly concerned number of buildings and fuel use in public services and business services. Data did not cover all the information needed and was incomplete but was very useful for verifying the main assumptions of emission inventory.

5.6 DATABASES ON EMISSIONS FROM POINT SOURCES (INDUSTRY)

Emission from point sources has been calculated on the basis of IPPC permits, IPPC permits applications and available official reports containing measurements (for KEK, Sharrcem and Ferronikeli). The data from the report: Republic of Kosovo; Expert for Air Pollution Control Final Report, May 2016; Japan International Cooperation Agency (JICA), JFE Techno-Research Corporation was also used for calculation of emissions from Kosovo's power plants.

Due to frequent lack of data regarding the parameters of emitters or emission, "EEA/EMEP Emission Inventory Guidebook", BAT Conclusions and the assumptions based on the experts' experience in similar installation has been used.

6 EMISSION FACTORS USED IN THE INVENTORY

Taking into account the local conditions of Kosovo and the available data on processes, an EMEP Guidebook 2019 emission factors have been adopted which most closely correspond to the conditions of the analyzed processes, as well as guidelines for conducting inventories for the needs of air quality analysis (air quality assessment, national inventories).

6.1 AREA SOURCES OF EMISSIONS (SMALL COMBUSTION)

Emission factors are presented in area sources database: 2018 Small combustion in "factors" sheet as an integral part of the database. The following tiers[18] and factors have been used:

Table 13 Source of emission factors for different fuel types.

Fuel		**Factors source: EMEP/EEA Guidebook 2019; 1.A.4. Small combustion**
LPG		Table 3.4 Tier 1 emission factors for NFR source category 1.A.4.b, using gaseous fuels
Diesel oil		Table 3.5 Tier 1 emission factors for NFR source category 1.A.4.b, using liquid fuels
Wood stoves	**Heating**	Table 3.6 Tier 1 emission factors for NFR source category 1.A.4.b, using biomass
	Cooking	Table 3.40 Tier 2 emission factors for source category 1.A.4.b.i, conventional stoves burning wood and similar wood waste)
	Water heating	Table 3.40 Tier 2 emission factors for source category 1.A.4.b.i, conventional stoves burning wood and similar wood waste)
	Modern stoves	Table 3.41 Tier 2 emission factors for source category 1.A.4.b.i, high-efficiency stoves burning wood 6)
	Ecolabelled stoves and boilers (heating)	Table 3.42 Tier 2 emission factors for source category 1.A.4.b.i, advanced / ecolabelled stoves and boilers burning wood
	Pellet stoves and boilers (heating)	Table 3.44 Tier 2 emission factors for source category 1.A.4.b.i, pellet stoves and boilers burning wood pellets
Lignite stoves	**Heating**	Table 3.3 Tier 1 emission factors for NFR source category 1.A.4.b, using hard coal and brown coal
	Cooking	Table 3.14 Tier 2 emission factors for source category 1.A.4.b.i, stoves burning solid fuel (except biomass)
	Water heating	Table 3.14 Tier 2 emission factors for source category 1.A.4.b.i, stoves burning solid fuel (except biomass)
	Modern stoves	Table 3.19 Tier 2 emission factors for source category 1.A.4.b.i, advanced stoves burning coal fuels

Due to the lack of knowledge and survey on types and age of stoves used for heating - Tier 1 method has been used for emission calculation for the first inventory report. It was assumed that stoves used in Kosovo for space heating are mostly old ones or have old construction. Emission factors for lignite and wood burning have quite high values. During the update new data was provided for modeling. First modelling showed some overestimation of concentrations in the city centers. Information received from cities and comments provided by KEPA after the first emission inventory pointed to the increasing using pellet for heating purposes. Analysis of reports on using wood and pellet in Kosovo or Balkans countries confirmed growing importance of pellet as a fuel19. Regarding these data, new Tier 2 emission factors were added: for wood fuel modern ecolabelled stoves and boilers burning wood and pellet stoves and boilers. For more

[18] EMEP Emission Inventory Guidebook (2019) specifies a choice of Tiers (levels of detail) for each emission source group. The higher the Tier number the higher is the level of detail for emission estimation and better is accuracy of emission result

[19] Pellet Market Overview; AEBIOM Statistical Report 2017,
Kosovo Wood Biomass Assessment; Opportunities And Challenges; USAID 2015
VALUE CHAIN ANALYSIS; Wood Processing Mitrovicë/a Region; UNDP, Ministry for Foreign Affairs of Finland; 2015

specific fuel use like water heating and cooking – Tier 2 methods has been selected.

a) b)

Figure 9 Examples of stoves: a) modern pellet stove used in the modern district of Pristina in an office in an apartment building, b) solid fuel stoves sold in local shops.

6.2 SOURCES OF EMISSIONS FROM SMALL BUSINESS AND SERVICES

For services and business with greater area for heating, such as hospitals, schools and hotels, different factors have been implemented. It was assumed that these services are using boilers for heating (larger facilities) and factors for commercial and institutions have been used. Other business and services: offices, restaurants, bakeries, shops and warehouses have been assumed to have similar facilities like residential (see table above).

Table 14 Source of emission factors for different fuel types.

Fuel		**Factors source:** **EMEP/EEA Guidebook 2019; 1.A.4. Small combustion**
LPG		Table 3.8 Tier 1 emission factors for NFR source category 1.A.4.a/c, 1.A.5.a, using gaseous fuel
diesel oil		Table 3.9 Tier 1 emission factors for NFR source category 1.A.4.a/c, 1.A.5.a, using liquid fuels
wood stoves	**heating**	Table 3.10 Tier 1 emission factors for NFR source category 1.A.4.a/c, 1.A.5.a, using solid biomass
lignite stoves	**heating**	Table 3.7 Tier 1 emission factors for NFR source category 1.A.4.a/c, 1.A.5.a, using hard and brown coal
pellet stoves/boilers	**heating**	Table 3.46 Tier 2 emission factors for non-residential sources, medium sized (>50kWth to ≤ 1 MWth) boilers wood (in the absence of information on manual/automatic feed)

6.3 SOURCES OF EMISSIONS FROM AGRICULTURE (CROPS AND BREEDING)

To calculate emissions from agricultural sources, emission factors from "The EMEP/EEA air pollutant emission inventory guidebook – 2019" - European averages for agriculture, animal breeding and fertilization have been adopted.

Table 15 Agricultural emission –actors - agricultural crops

Source of emission	Factor source
cropland - land cultivation	EMEP Guidebook 3D Crop production and agricultural soils 2019 Table 3.6 and 3.8 tier 2 EFs for agricultural crop operations
cropland - harvest:	
wheat	
barley	
oat	
rye	
grass	
drying of cereals:	
wheat	
barley	
oat	
rye	

Table 16 Agricultural emission factors - animal husbandry (breeding) (data source: EMEP/EEA 2019)

Breeding:	
cattle farming	EMEP/EEA Guidebook 2019 3.B Manure management Table 3.2-3.5)
sheep farming	
goat farming	
horse breeding	
pig farming	
chicken farming	
broiler farming	
goose farming	
duck farming	
turkey farming	
poultry farming on average	

Table 17 Agricultural emission factors - agricultural use of artificial fertilizers

Fertilization:	Unit
emissions from crop fertilization*	EMEP Guidebook 3D Crop production and agricultural soils 2019 Table 3.1
	EMEP Guidebook 3D Crop production and agricultural soils 2019 Table 3.2

* The dust indicators apply to all fertilizers. Other factors apply to nitrogen fertilizers.

Emission factors for working machinery used in agricultural works is based on assumptions concerning machinery operation. The following is assumed:

- average fuel consumption of agricultural machinery - 36 dm^3/ha,
- the annual number of field work with a combine harvester or tractor – 5 (plowing, harrowing, sowing, spraying, harvesting),

- density of diesel oil - 0.83 kg/dm^3.

Table 18 Agricultural emission factors - agricultural machinery (data source: EMEP/EEA 2019)

	Unit
agricultural machinery	EMEP/EEA Technical report 2019 1.A.4. Off-road mobile machinery Table 3-1 Tier 1 emission factors for off-road machinery

6.4 SOURCES OF TRAFFIC EMISSION (ROADS)

Traffic emission factors have been evaluated according to 'he EMEP'2019 Guidebook (Tier 3) using local fleet data for aggregation. The aggregation process included fuel data as well. The emission factors (EFs) are calculated for nine speed categories:

- from 30 to 100 km/h, every 10 km/h;
- 10 km/h - as traffic jams.

The emission factors are aggregated for 4 vehicle categories:

- passenger cars;
- light commercial vehicles (LCV);
- heavy duty vehicles (HDV);
- buses.

The basic substances, with EFs directly provided in COPERT in [g/km], are as follows:

- NOx;
- PM (as PM exhaust);
- NMVOC;
- CO.

Fuel consumption factors [MJ/km] are also speed-dependent. They are used to calculate derived EFs for the following substances:

- SO_2;
- heavy metals (As, Hg, Cd, Pb).

Benzene EFs are calculated as a fraction of NMVOC emissions.

All raw values of speed-dependent indicators are calculated using COPERT 5 model.

Table 19 Emission factors from linear sources - exhaust emissions (based on EMEP/EEA 2019)

Vehicle/speed category	NOx	PM_{10}	CO	NMVOC	SO_2
	g/km	g/km	g/km	g/km	g/km
passenger cars					
10 km/h	0,962	0,083	0,716	0,164	0,00061
30 km/h	0,645	0,057	0,419	0,078	0,00039
40 km/h	0,579	0,049	0,346	0,062	0,00034
50 km/h	0,541	0,042	0,293	0,052	0,00032
60 km/h	0,524	0,039	0,256	0,045	0,00030
70 km/h	0,525	0,037	0,232	0,040	0,00029

Vehicle/speed category	NOx	PM_{10}	CO	NMVOC	SO_2
	g/km	g/km	g/km	g/km	g/km
80 km/h	0,545	0,039	0,222	0,037	0,00030
90 km/h	0,583	0,043	0,225	0,036	0,00030
100 km/h	0,643	0,050	0,244	0,037	0,00032
light commercial vehicles (LCV)					
10 km/h	1,660	0,106	2,420	0,211	0,00082
30 km/h	1,173	0,075	1,295	0,146	0,00057
40 km/h	1,010	0,066	0,914	0,122	0,00049
50 km/h	0,897	0,063	0,652	0,102	0,00044
60 km/h	0,835	0,064	0,510	0,087	0,00041
70 km/h	0,822	0,070	0,489	0,077	0,00040
80 km/h	0,861	0,080	0,587	0,073	0,00042
90 km/h	0,953	0,096	0,806	0,073	0,00047
100 km/h	1,099	0,116	1,146	0,078	0,00054
heavy duty vehicles (HDV)					
10 km/h	16,57	0,567	4,46	1,401	0,00331
30 km/h	9,61	0,275	2,18	0,591	0,00182
40 km/h	8,29	0,223	1,78	0,463	0,00156
50 km/h	7,50	0,194	1,57	0,385	0,00141
60 km/h	6,98	0,178	1,46	0,331	0,00131
70 km/h	6,63	0,169	1,40	0,291	0,00125
80 km/h	6,39	0,165	1,38	0,261	0,00120
90 km/h	6,29	0,164	1,37	0,246	0,00119
100 km/h	6,29	0,164	1,37	0,246	0,00119
buses					
10 km/h	20,94	0,505	5,03	1,388	0,00302
30 km/h	9,54	0,238	2,27	0,579	0,00175
40 km/h	8,19	0,197	1,82	0,444	0,00153
50 km/h	7,33	0,174	1,57	0,370	0,00140
60 km/h	6,74	0,160	1,42	0,327	0,00131
70 km/h	6,30	0,151	1,32	0,302	0,00125
80 km/h	5,97	0,146	1,26	0,287	0,00121
90 km/h	5,82	0,144	1,23	0,282	0,00120
100 km/h	5,82	0,144	1,23	0,282	0,00120

It is proposed that the methodology for calculating the non-exhaust emissions and emission factors should be based on the EMEP/EEA emission guidebook 2019 guidelines. The amount of dust resuspension can be determined on the basis of the United States Environmental Protection Agency guidelines for paved roads: AP42, Fifth Edition, Volume 1, Chapter 13.2.1, Paved Roads (source: http://www.epa.gov/ttnchie1/ap42/). The study presents the following coefficients and assumptions. The emission factor resulting from the movement of vehicles on paved roads, taking into account local weather conditions, shall be calculated using the formula:

$$WE_{ext}=(k*(L)^{0.91}*(W)^{1.02})*(1-P/4N)$$

where:

k - particle size multiplier depending on the fraction of the emitted particulate matter [g/km/vehicle],

L - road surface silt loading [g/m^2],

W - average weight of the vehicles travelling the road [Mg].

P - number of days with precipitation greater than 0,254 mm in the analyzed period,

N - number of days in the analyzed period (N = 365 for year).

The k multiplier value for PM_{10} and $PM_{2.5}$ was defined as: 0,62 and 0,15. The average weight of vehicles on the roads was assumed at the level of 2,6 Mg.

The factors of non-exhaust emission from transport and resuspension of drifted dust are presented in the below table.

Table 20 Non-exhaust emission factors from transport

Type of emission	PM_{10} [g/vehicle*km]	$PM_{2.5}$ [g/vehicle*km]
non-exhaust emissions - passenger cars	0,0195	0,0107
non-exhaust emissions - commercial vehicles (vans)	0,0272	0,0148
non-exhaust emissions - heavy duty trucks	0,095	0,095
non-exhaust emissions - buses	0,095	0,054
emissions from road wear and tear - passenger vehicles	0,0101	0,0055
emissions from road wear and tear - commercial vehicles (vans)	0,0101	0,0055
emissions from road wear and tear - heavy duty trucks/buses	0,0513	0,0277
amount of particulate matter resuspension	0,14409	0,0348

6.5 FUGITIVE AND NATURAL EMISSION SOURCES (MINES, QUARRIES, LANDFILLS, AVIATION, FORESTS)

The following tables present the proposed emission factors for other emission sources - fugitive and natural emission.

Table 21 Emission factors from quarries (source: EMEP/EEA 2019. Tier 1 emission factors for source category 2.A.5.a Quarrying and mining of minerals other than coal. Table 3-1).

Source of emission	PM10	$PM_{2.5}$
Quarries	50 g/Mg mineral	5 g/Mg mineral

Table 22 Emission factors from the waste management sector (source: EMEP/EEA air pollutant emission inventory guidebook 2019. 5.A Biological treatment of waste – solid waste disposal on land (Table 3-1))

Waste disposal method	Emission factors		
	PM_{10}	$PM_{2.5}$	NMVOC
	g/Mg	g/Mg	kg/Mg
solid waste disposal on land	0,219	0,033	1,56

Table 23 Emission factors from natural sources (source: Guidelines for regional emission inventories for the needs of current assessments and air quality plan – Polish Ministry of the Environment 2003)

Forest type	NMVOC [kg/(ha x year)]	NH_3 [kg/(ha x year)]
Deciduous forests	10	3,6
Coniferous forests	40	3,6
Mixed forests	25	3,6

For modeling speciation modeling profiles for NMVOCs also contain a breakdown for isoprene and monoterpen from forest areas.

Table 24 Emission factors from aviation (source: EMEP/EEA air pollutant emission inventory guidebook 2019; 1.A.3.a Aviation - Annex 5 - Master emissions calculator 2"16.xlsm", Annex 5 to EMEP/EEA aviation chapter)

Aircraft name	ICAO code	Fuel burn	Nox	CO	SOx	PM_{10}
		kg	kg/LTO	kg/LTO	kg/LTO	kg/LTO
Boeing 737-800	B738	881,10	12,30	7,07	0,740	0,074
Airbus A-320	A320	816,17	11,28	8,25	0,686	0,066
Airbus A-319	A319	688,81	7,46	9,49	0,579	0,058
Airbus A-321	A321	1 034,57	17,29	4,48	0,869	0,178
Embraer ERJ-190	E190	651,65	6,43	12,13	0,547	0,052
Weighted average for LTO cycle (take-off and landing)		825,95	11,22	7,95	0,694	0,078

The five most common types of aircrafts with cumulative share in European movement over 50% were selected for emission calculation, based on flight traffic in Europe in 2015 per aircraft type (Table 2.1. EMEP/EEA guidebook 2019).

7 DETAILED METHODOLOGY FOR THE INVENTORY OF EMISSION SOURCES

7.1 INVENTORY OF POINT EMISSION SOURCES (INDUSTRY)

The inventory of point sources in Kosovo includes emitters belonging to IPPC installations, for which the permit was (11 installations till 2019 Dec.) or application for permit was submitted (42 installations till 2019 Dec.), basing on the document "Integrated environmental permit 05.12.2019.docx" from MESP listing IPPC installations with information about procedure status and type of activity. Document has been presented in Annex 1. During the update of emission inventory the list of IPPC installation was verified and no new installation was added in the emission database. Emission inventories for municipal landfills and mining

activities are included in chapter relating to other sources. According to our knowledge all installation (except BAS Partners) are in operation.

Inventory covers the following information:

a) coordinates of the emitters in KOSOVAREF01 (SR-ORG:9080) system,

b) quantity of substances emitted covered by the inventory [Mg/year],

c) emitter height [m],

d) emitter diameter [m],

e) outlet speed [m/s],

f) concentrations of pollutants [mg/m^3],

g) gas flow [m^3/h],

h) gas temperature at outlet [K],

i) estimated emission time [h/year].

Information from permits was obtained during the visits in Ministry (paper version) or from the website https://mmph.rks-gov.net.

The applications, permits and reports contain deficiencies, also in the emissions of PM_{10} and $PM_{2.5}$. The emission for these types of particulate matter was calculated on the basis respective proportion (between TSP, PM10 and $PM_{2.5}$) of emission factors from EMEP/EEA guidebook 2019.

If there is no data on emitters and their parameters, substitute values were adopted depending on the emission level for a given emitter, according to the simple assumptions like proportions with similar installations, outlet speed between 12 and 15 m/s. Due to lack of data regarding oxygen content and water content of the flue gas, normalised volumetric flow was estimated from actual flow using only the correction by temperature factor. For entities for which there are no coordinates of emitters (most of them), geolocation were carried out on the basis of address data, cadastral data, location maps (print screens) or even general information about location from permits or applications using the following tools:

- State geoportal of Kosovo (http://geoportal.rks-gov.net),
- Google maps,
- Open Street Maps,
- CORINE Land Cover (CLC).

More details about assumptions presented in comm“nts in "2018_1.A,_2.A.1_2.C_3B_Industry_v2.xlsx ”" (“database” sheet).

In the update emission from asphalt manufacturing was added basing on the general raw material consumption from Kosovo statistical yearbook 2019, emission factors from EMEP guidebook 2019 (Tier 2 emission factors for source category 1.A.2.f.i, Roadstone coating (asphalt) plants. Table 3-25) and data for asphalt plants from KEPA containing coordinates and areas of the plants. Emission from each plant was calculated as the proportion of plant’s area share in the total area of the plants.

Emissions from Kosovo's power plants (Kosovo A and Kosovo B) were calculated using data from the JICA report: *Expert for Air Pollution Control Final Report*[20] in the update.

Emission calculation is prese"ted in "2018_1.A.2.f.i_Asphalt"v1.xls".

7.2 INVENTORY OF AREA EMISSIONS (SMALL COMBUSTION)

The database on area sources is a collection of emission and spatial information on emission sources from individual low-power heating systems from the municipal and household sector, commercial and services sector and public utility facilities. These sources include:

- small household stoves and boilers,
- household furnaces (solid fuel stoves for water heating and solid fuel kitchen stoves),
- small boilers supplying heat in commercial and services facilities (bakeries, restaurants, offices, shops, warehouses, hotels),
- boilers in public utility facilities – hospitals, schools, offices.

The following steps are needed for emission calculation for heating purposes and cooking in residential and services sectors:

1. Energy demand calculation
2. Division into energy supply / fuels type
3. Emission calculation
4. Spatial distribution of sources
5. Emission factors (described above)

7.3 RESIDENTIAL EMISSION

Energy demand calculation

As mentioned in the previous chapter, data from two projects was available. The JICA Project included surveys in Pristina region (including Obiliq and Fushe Kosovo municipalities). According to surveys results the fuel use for different kinds of households has been estimated (detached houses, semidetached houses, row or terraced houses, apartments) and fuel use in different kinds of services has been estimated (office, kindergarten, school, university, bakery, café, restaurant, hotel, shop, warehouse, hospital). On this basis the energy demand and fuel share can be calculated but only for Pristina region. The EU Project included larger amount of surveys for all regions in Kosovo. It enabled to calculated heat demand for households for different regions (Pristina, Prizren, Mitrovica, Gjilan, Peja, Gjakova and Ferizaj) by space heating, water heating and cooking. For services, it covered energy demand divided only by two main types: public services and private services and by region. In order to calculate heat demand and fuel share, all municipalities of Kosovo has been assigned to researched regions (table below).

[20] *Republic of Kosovo; Expert for Air Pollution Control Final Report, May 2016; Japan International Cooperation Agency (JICA), JFE Techno-Research Corporation*

Table 25 Assignment of municipalities in regions surveyed in EU Project

1	2	3	4	5	6	7
Pristina	**Prizren**	**Mitrovica**	**Giljan**	**Peje**	**Gjakova**	**Ferizaj**
Pristina	Prizren	Mitrovica	Giljan	Peje	Gjakova	Ferizaj
Podujeve	Dragash	Leposaviq	Kamienice	Istog		
Obiliq	Mamushe	Zvecan	Noveberde	Kline		
Drenas	Rahovec	Mitrovice E	Ranilug	Decan		
Fushe Kosove	Suhareke	Zubin Potok	Partesh	Junik		
Gracanice	Malisheve	Vushtrri	Kacanik			
Lipjan		Sknderaj	Hani Elezit			
Shtime			Shtrepce			
			Viti			
			Kllokot			

Spatial data available from Cadastral Agency and Statistical Agency included:

- Population by settlements Census 2011;
- Population by municipalities 2018;
- Buildings by type, urban/rural region and municipalities Census 2011;
- Dwellings by types of heating source and main type of energy used for heating by municipality Census 2011;
- Localization of the settlements;
- Localization and borders of municipalities.

To verify accuracy of energy demand data, calculation of energy demand using degree-days (climate conditions) has been conducted as an auxiliary method. The following equation has been used for calculation:

$$RHD\ [MWh] = (A * U * DD * HUF * 24 * 10^{-6}) * Ub/Ef$$

where:

- RHD – Real Heat Demand [MWh]
- A – area of house–[m^2]
- U - heating coefficient [W/m^2K]
- DD – degree-days [$^{-}$K day] - 2279 (Celsius-based 3-year-average (2017 to 2019) heating degree days with a base temperature of 15,5 ^{o}C for Pristina Airport, www.degreedays.net; no other meteorological data has been available at time of calculation)
- HUF – use of heat factor – 0,9
- Ub – usability factor- use of heat (due to holidays, work, etc.)
- Ef - efficiency of stove/facility

The most important data (having large impact on results) is heat coefficient for buildings in Kosovo. There is no available data regarding the coefficient for Kosovo therefore it was assumed basing on site views and law requirements concerning building insulation:

Table 26 Law requirements for heating coefficient in residential buildings.

	Polish law requirements for heating coefficient W/m^{2}K for temperature in the room >16^{o}C				Kosovo requirements [21]
	1997	2002	2008	2017	2018
external walls	0,3	0,3	0,3	0,23	0,35
flat roofs and unheated ceilings	0,3	0,3	0,25	0,18	0,3
ceilings above unheated basements	0,6	0,6	0,45	0,25	0,5
internal walls between heated and unheated rooms	1	1	1	0,3	
windows, balconies	2	2	1,7	1,1	1,6
roof windows	2	2	1,8	1,3	1,6
windows between heated and unheated rooms	4	4	2,6	1,3	1,6
exterior doors	2,6	2,6	2,6	1,5	

Analyzing the requirements for heating coefficient and site visits, the calculation included a values of **3,2** [W/m^{2}K] for houses and **1,7** [W/m^{2}K] for apartments (value corresponds to old buildings in Poland). Figure below presents example of typical lack of insulation for residential building:

Figure 10 Examples of residential building insulation in Kosovo (author's photos made during site visits)

Table below presents calculated energy demand for household and by residents/population using two sources of data:

Table 27 Energy demand for household using two methods of calculation

Type of building/dwelling	Type of heating		JICA	Degree-days calculation
		Average area	Energy demand	
		[m^2]	GJ/building/apartment	GJ/year
detached house	Wood	200	**120,8**	**123,1**
	Coal		**100,4**	**127,8**
	Pellet		**84,7**	**112,8**
	Oil (Diesel)			**95,7**
	Gaseous fuel (LPG)			**97,9**
	Electricity			**86,3**
semidetached	Wood	100	**120,4**	**65,3**

[21] *For minimum requirements for the energy performance of building ; Regulation MESP 04/18*

house	Coal		**92,2**	**67,6**
	Pellet		**116,0**	**60,1**
	Oil (Diesel)			**51,6**
	Gaseous fuel (LPG)			**52,7**
	Electricity			**46,9**
terraced house	Wood	70	**93,1**	**52,5**
	Coal		**83,3**	**55,2**
	Pellet		**35,4**	**50,8**
	Oil (Diesel)			**43,7**
	Gaseous fuel (LPG)			**43,3**
	Electricity			**38,9**
apartment	Wood	80	**93,1**	**34,8**
	Coal		**83,3**	**36,5**
	Pellet		**35,4**	**33,8**
	Oil (Diesel)			**29,5**
	Gaseous fuel (LPG)			**29,2**
	Electricity			**26,6**

There has not been enough data to calculate energy demand from oil, LPG and electricity basing on the JICA Project surveys. Small differences in heat demand, based on the JICA Project, between houses and terraced houses/apartments regarding large difference in heating area of households, are puzzling. However, according to 2011 Census, 93% of residential buildings are classified as detached houses, therefore next analyses focused on households.

Table below shows energy demand calculations from the EU Project:

Table 28 Energy demand calculations from the EU Project.

region	Energy intensities for urban and rural for Kosovar households for: (EU Project)						Summary Energy demand	
	Space heating		water heating		cooking			
	GJ/year household	GJ/year person	GJ/year household	GJ/year person	GJ/year household	GJ/year person	GJ/year household	GJ/year person
urban	100,4	19,3	5,6	1,1	6,7	1,3	**112,7**	**21,6**
rural	99,0	19,0	6,1	1,2	5,9	1,1	**111,0**	**21,3**
Pristina	100,4	19,3	5,6	1,1	6,6	1,3	**112,6**	**21,6**
Prizren	86,7	16,6	4,5	0,9	6,5	1,2	**97,7**	**18,7**
Mitrovica	84,4	16,2	4,6	0,9	6,5	1,2	**95,4**	**18,3**
Gjilan	98,0	18,8	4,8	0,9	5,6	1,1	**108,4**	**20,8**
Peja	98,5	18,9	3,9	0,7	5,5	1,1	**107,9**	**20,7**
Gjakova	86,4	16,6	5,9	1,1	6,4	1,2	**98,7**	**18,9**
Ferizaj	95,4	18,3	6,0	1,1	6,3	1,2	**107,7**	**20,7**

Table below presents energy demand calculation for households using all three data sources:

Table 29 Energy demand calculations for three sources/methods.

Method	Energy demand		Remarks
	[GJ/year household]	GJ/year person	
JICA project	102,0	19,6	average for detached houses
EU project	111,9	21,5	average for detached houses
degree-days method	107,3	20,6	average for urban and rural regions

Comparison of data shows slight differences in values, hence it may be assumed that heat demand for household is around 102-112 GJ/year and around 20 GJ per person. Availability of spatial data and heat demand analysis resulted in selection of heat demand factor and method for emission calculation. Population has been chosen as the main activity parameter regarding availability of spatial distribution at settlement level and possibility of conversion from 2011 to 2018 year. Population 2018 has been divided into settlement level proportionally to population 2011 at settlement level. Energy demand (including space heating, hot water and cooking) has been calculated using the EU Project's energy demand factors (converted into GJ/person unit) multiplying by population at settlements for 2018 year.

Division into energy supply / fuels type

Fuel usage share has been used from the EU project, regarding regions. For rural regions district heating share has been added to wood fuel (table 30).

According to the Population Census 2011 two municipalities Obiliq and Fushe Kosovo are characterized by clearly different fuels structure than other municipalities: use of coal is much higher for domestic heating (60% - Obiliq and 51% Fushe Kosovo - share calculation based on number of dwellings using this type of fuel). Coal popularity was probably due to close location of municipalities to lignite mine. However, the modeling results showed some overestimation of the PM concentrations and finally the same fuel shares were assumed for these regions as for other regions in the update.

Another individual case has been analysed for the Mitrovica municipality. Air quality monitoring station is located in the city and it shows much higher SO_2 concentration than in other cities. According to the information received from municipality office, small business and private services use coal for space heating. It may cause higher SO_2 emissions. The share of coal use has been increased. Basing on fuel share for services – the share of coal was increased to 80 % for offices, warehouses, restaurants and shops, to 70% for hotels and hospitals and to 50% for bakeries. It was assumed that hotels and hospitals as large object may use also electricity and oil and bakeries use more wood for heating purposes because of using wood also for baking.

According to the received information from KEPA and from cities, fast urban uncontrolled development is one of major problems in cities and pellet use for heating purposes in domestic house is increasing. Therefore, when updating the emission inventory, it was assumed that modern stoves with low emissions for solid fuels are used in new houses and trend of exchanging old wood stoves with new pellet one is growing. It is estimated that level of pellet use increased from 0 to 32 kg/capita in Kosovo[22] - on average it is about 3% of total energy use for heating purposes. Regarding this data, fuel share regarding wood use was divided into: old stoves, new stoves and use of pellet. Lignite use share was also divided into new and old stoves. General assumptions regarding division into new, old devices and pellet devices are presented in below:

[22] PELLET MARKET OVERVIEW 2017 European Bioenergy Outlook

- Pellet in rural areas: 10% of all wood stoves
- Pellet in urban areas: 20% of all wood stoves
- New wood stoves: 5% of all wood stoves
- New lignite stoves: 20% of all lignite stoves

Regarding overestimation of modeling results in urban areas - fuels share changes were implemented in all main cities in the update of emission inventory. Some specific assumptions for fuels share are listed below:

- For larger cities with block of flats and other high buildings use of electricity was increased to max. 26% (as for Pristina)
- For some cities use of pellets was increased to 25% of total wood use
- For large cities the share of new stoves was increased to 10%
- For cities with dense buildings or large areas of small houses like Prizren and Peje - heating demand was slightly reduce to 16,1 GJ/person

During the emission update data concerning heat sale to different type of consumers was provided by Termokos (Table 29). Kosovo geoportal (KCA) includes map of district heating system. These two data enabled to distinguish areas with and without heating system. The city was divided into two districts: one covering the city area with central heating system and the other – the rest of the city. Share of fuel share differs in these two districts due to the different share of the district heating. The calculation of the heat demand covered by district heating from the first emission inventory was verified by new data.

Table 30 *District heat sale in Pristina in 2018 (Termokos)*

District heating 2018	Residential/domestic houses	Small services	Public services
MWh	127 056,0	12 074,0	83 120,0
GJ	457 401,6	43 466,4	299 232,0

All fuel shares assumptions are included in the database: 2018_1.A.4_Small_combustion Kosovo_v2.xlsx, KSA domestic sheet.

Table 31 *General fuel share in different regions (Source: the EU Project, new assumptions made in the update described above).*

									hot water					cooking			
Energy	**DH**	**Wood old**	**Pellet**	**Wood new**	**Electricity**	**LPG**	**Coal old**	**Coal new**	**Wood**	**Electricity**	**Solar**	**DH**	**LPG**	**Wood**	**Electricity**	**LPG**	**Coal**
Kosovo	3,1%	69,5%	8,2%	4,1%	9,1%	0,7%	4,2%	1,1%	45,5%	37,7%	0,2%	16,3%	0,3%	48,4%	29,4%	21,9%	0,3%
Pristina rural	0,0%	44,4%	5,2%	2,6%	26,2%	1,2%	10,4%	2,6%	1,4%	97,9%	0,1%	0,5%	0,1%	23,3%	61,9%	14,4%	0,4%
Prizren rural	0,0%	68,8%	8,1%	4,0%	17,1%	1,5%	0,4%	0,1%	16,5%	79,6%	0,3%	2,2%	1,4%	34,9%	29,4%	35,6%	0,1%
Mitrovica rural	0,0%	81,2%	9,6%	4,8%	3,9%	0,0%	0,5%	0,1%	2,1%	95,1%	0,5%	2,3%	0,0%	49,4%	25,9%	24,7%	0,0%
Gjilian rural	0,0%	81,2%	9,6%	4,8%	3,9%	0,0%	0,5%	0,1%	45,5%	37,7%	0,2%	16,3%	0,3%	66,5%	19,0%	14,1%	0,4%
Peja rural	0,0%	74,6%	8,8%	4,4%	11,8%	0,0%	0,3%	0,1%	1,5%	97,4%	0,0%	1,1%	0,0%	33,6%	36,8%	29,6%	0,0%
Gjakova rural	0,0%	66,2%	7,8%	3,9%	26,0%	1,7%	0,2%	0,1%	0,3%	99,7%	0,0%	0,0%	0,0%	29,5%	42,0%	28,5%	0,0%
Ferizaj rural	0,0%	81,3%	9,6%	4,8%	4,4%	0,0%	0,0%	0,0%	16,5%	79,6%	0,3%	2,2%	1,4%	38,7%	26,3%	35,0%	0,0%
Examples of urban areas																	
Pristina	21,7%	33,3%	8,9%	2,2%	26,2%	1,2%	5,2%	1,3%									
Pristina DH	66,6%	14,2%	3,8%	0,9%	11,2%	0,5%	2,2%	0,6%									
Pristina no DH	0,0%	42,5%	11,3%	2,8%	33,5%	1,5%	6,6%	1,7%									
Mitrovica	2,4%	57,4%	20,5%	4,1%	15,0%	0,0%	0,5%	0,2%									
Gjilan	2,4%	46,2%	17,8%	7,1%	26,0%	0,0%	0,5%	0,1%									
Gjakova	3,2%	44,7%	17,2%	6,9%	26,0%	1,7%	0,2%	0,1%									

The Figure below presents example of block of apartments in Pristine and individual stove installation and Hotel's restaurant using wood for heating and cooking

Figure 11 Examples of low emission sources and wood used as a fuel (residential and services)

Emission calculation

Emissions for each fuel and for each individual substance shall be determined from the following formula:

$$E = w_E \times P \times E_c \times 10^{-6}$$

where:

E - emission of pollutant [Mg/year]

w_E - emission factor differentiated for pollutant and fuel [g/GJ].

E_c - heat demand [GJ/person×year]

P - Population [no.]

Spatial distribution

Spatial distribution of settlements is available as point coordinates of settlement localization. Layer of settlements outlines/areas has not been available, however layer of addresses point with coordinates for 29 of municipalities has been provided by Cadastral Agency. The addresses points have been completed for the rest of 9 municipalities (point for each building from ortophotomap 2018). It was assumed that one point corresponds to one household. Households at municipality and settlement level may be estimated using population and average household size (5,21 people). The emission from each settlement is reflected by large density of the points / addresses located in the settlement. These assumptions are proper for rural areas, for cities address point may reflect house or block of apartments/terraced houses. Therefore cities have been outlined in GIS tool and emission per address point is calculated separately according to overall

emission for the city. Summarizing, because of availability of spatial distribution of addresses points not of settlements (as areas):

1. Emission calculated at settlement level is auxiliary – not directly used for spatial distribution;
2. Emission is recalculated per address point (as household) but separately for rural (including small towns) areas and cities to reflect properly other structure of buildings in cities (emission for cities is based on emission calculated at settlement level). For rural areas emission for each point is calculated using equation: emission at municipality level minus emission in outlined cities located in the municipality.

The inventory of area emission sources has been prepared in squares according to the following resolution:

- 0.5 km x 0.5 km for cities,
- 1. km x 1 km for other built-up areas.

In the update areas of high building in some large cities were treated differently – cells (area emitters) covered areas of high buildings in centre of cities have an increased emitters' height: from 12 m to 18 m. Additionally Pristina city was analyzed in more detailed way. City was divided into two districts: one cover area of the city with central heating system and other – the rest of the city.

Calculation structure is presented at figure below.

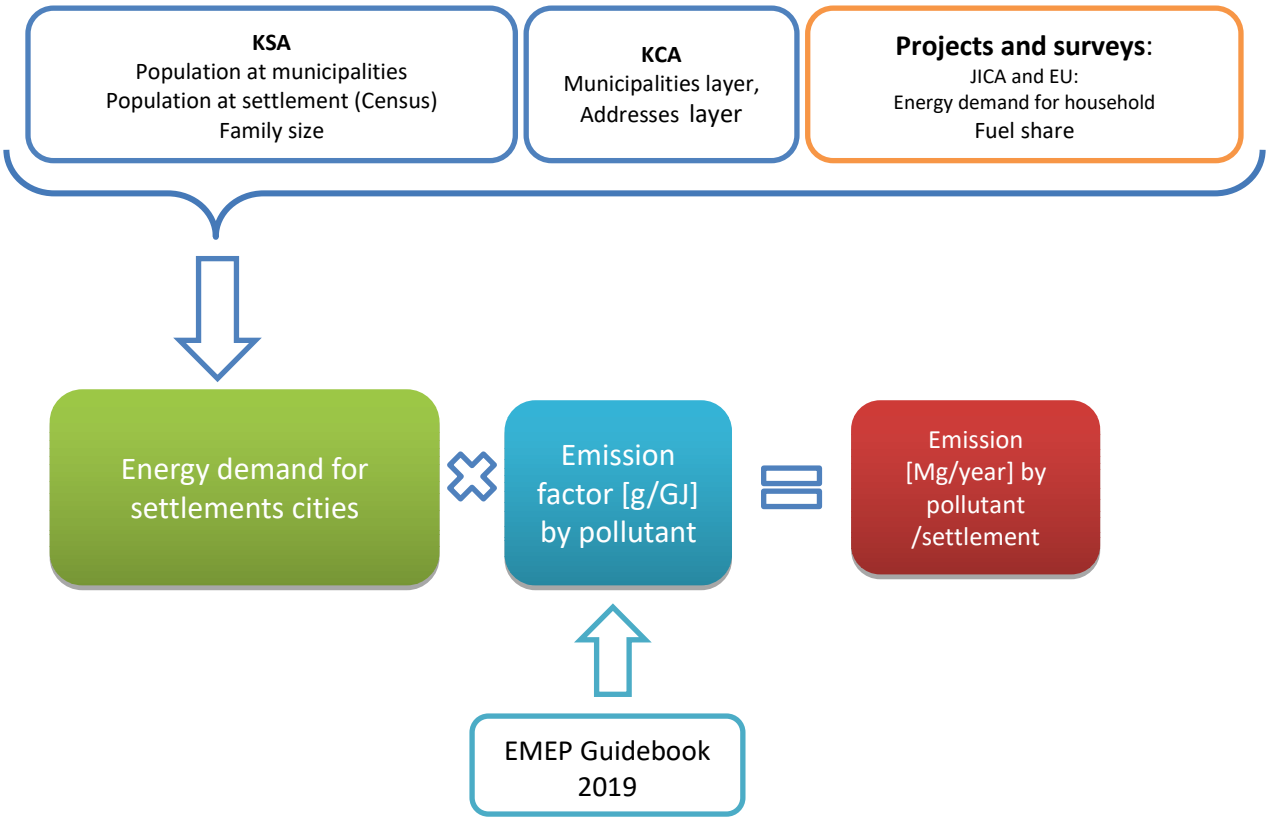


Figure 12 Graph of calculation path and data sources for residential emissions

7.4 PUBLIC AND PRIVATE SERVICES EMISSION

Energy demand calculation

For energy demand calculation form services also the two projects have been analyzed. According to the JICA project's surveys results the fuel use for different kinds of services has been estimated (office, kindergarten, school, university, bakery, café, restaurant, hotel, shop, warehouse, hospital). On this basis the energy demand and fuel share can be calculated but only for Pristina region. The EU Project enabled to calculated heat demand for services only by public services and private services and for different regions. Spatial and statistical data used from Cadastral Agency and Statistical Agency included mainly population at settlement level and number of registered businesses by sector.

Regarding the detail of data, JICA project methodology and surveys results have been selected for emission calculation. The EU Project included very rough division of services (public and private) and it estimated only energy demand by area factor [kWh/m^2 x year]. There is no available data regarding averages area of public and private buildings causes. Average fuel use and fuel share based on the JICA Project have been used. Verification of data has been made – comparison of energy demand factors from both projects is presented in the table below:

Table 32 Comparison of energy demand factors from JICA and EU projects

	EU Project	EU Project	Energy use (JICA Project)	
region	Energy intensities for public services [GJ/ m^2*year]	Energy intensities for private services [GJ/ m^2*year]]	school [GJ/ m^2*year]	hospital [GJ/ m^2*year]
Pristina	0,9	1,1	Diesel 0,3	
Prizren	0,9	1,0	Wood 1,2	
Mitrovica	1,0	1,1	Wood/Coal 1,2	
Gjilan	1,0	1,1	Pellet 0,4	
Peja	1,0	1,1		
Gjakova	0,9	1,1		
Ferizaj	0,9	1,0		
average	**0,9**	**1,1**	**0,8**	**1,4**

Data from both sources shows good consistency. Heat demand for different types of services has been calculated based on average fuel use from the JICA Project surveys. The following fuels parameters have been used in calculation:

Table 33 Parameters of fuels used for recalculation of fuel use to energy use

	Net Calorific Value	Density	Source of NCV
Fuel type	[GJ/m^3]	[kg/l]	
Wood	9,47		Inventarizimi NIcional i Pyjeve Kosovë 2012 , MINISTRIA BUJQËSISË, PYLLTARISË DHE ZHVILLIMIT RURAL , Prishtinë 2013 and polish data for wood density (wet 30%)
Coal	8,1		LIGNITE MINING DEVELOPMENT STRATEGY , EU Pillar, PISG - Energy Office;
Pellet	16,32		IPCC 2006 used by JICA
Oil (Diesel)	43	0,83	IPCC 2006 used by JICA
(LPG)	47,3	0,55	IPCC 2006 used by JICA

Table 34 Unit energy demand by type of sector and type of fuel (based on the JICA Project)

Average of each fuel type	District heating	Wood	Electricity	LPG	Coal	Pellet	Oil	Average
sector	GJ/year	GJ/year	GJ/year	GJ/year	GJ/year	GJ/year	GJ/year	GJ/year
bakery		2540		6698		46		**2540**
restaurant		265		93		85		**148**
cafe		362		48		83		**98**
office		131		117	162	383	310	**220**
shop		331		35	72	177	223	**167**
warehouse		52		12		67		**60**
hotels		473		0	810	305	1333	**584**
hospitals Pristina	901	175	77			35	726	**601**
hospitals Kosovo		202						**202**
schools Pristina		1300				278	1125	**1213**
schools Kosovo		1507						**1507**

Averages of energy use/demand have been used for further calculation. Fuels with small share for the service type were omitted in averages calculations. Number of services has been estimated using the following assumptions and statistics:

Table 35 Assumption on number of services estimation

bakery	relrant	cafe	shops	warehouse	office	hotel	schools (kindergarten, primary, secondary)	hospitals and health activities
1 bakery per 150 household: JICA emission database -	1 restaurant per 100 household: JICA emission database	1 cafe per 100 household: JICA emission database	1% of population (based on JICA project)	0,4% of population (based on JICA project)	1,2% of population (based on JICA project)	Statistical Yearbook	Statistical Yearbook	Statistical Yearbook

Estimation of shops', warehouses' and offices' number has been based on data collected from Obiliq and Fushe Kosovo municipalities in JICA Project and their population (Statistic Yearbook). Due to the lack of other data it was assumed that similar share of these services is in other municipalities.

Division into energy supply / fuels type

Fuel usage share has been used from the JICA Project, regarding type of services. Comparison with the EU Project shows good data consistency. For rural regions district heating share has been added to wood fuel (table below). District heating data received from Termokos was analyzed in the emission inventory update. Comparison of district heating use in business services calculated in the database against real data for Termokos showed good consistency. District heating use in public services is underestimated in the database in comparison with real data. It was assumed that this difference is caused by underestimation of

public offices buildings and heat demand for public building using other fuels is estimated properly. Therefore it does not affect the emission calculation.

Table 36 Fuel share for services

sector	type of fuel DH	Wood	Electricity	LPG	Coal	Pellet	oil	source
private	3%	23%	51%	1%	4%	7%	11%	EU Project
public	4%	26%	51%	1%	4%	3%	11%	EU Project
bakery	1%	42%	50%	5%		2%		JICA survey
restaurant	2%	19%	40%	20%	8%	11%		JICA survey
cafe	2%	18%	46%	20%		14%		JICA survey
office	6%	4%	64%	8%	3%	7%	8%	JICA survey
shop	2%	9%	56%	20%	2%	11%		JICA survey
warehouse		10%	65%	5%		20%		JICA survey
hotels	13%	8%	23%		4%	44%	8%	JICA survey
hotels Kosovo		21%	23%	0%	4%	44%	8%	assumption based on JICA survey
hospitals Pristina	30%	13%	4%				53%	JICA survey
hospitals Kosovo		80%	10%				10%	assumption based on JICA survey
schools Pristina	10%	34%				7%	49%	assumption based on JICA survey
schools Kosovo		80%				10%	10%	assumption based on JICA survey

Emission calculation

Emissions for each fuel and for each individual substance shall be determined from the following formula:

$$E = w_E \times P \times E_c \times 10^{-6}$$

where:

E - emission of pollutant [Mg/year]

w_E - emission factor differentiated for pollutant and fuel [g/GJ].

E_c - heat demand by type of service [GJ/no.×year]

P - number of services by type of service [no.]

Spatial distribution

The main assumption of spatial distribution of services is that their number is proportional to population. Due to this assumption emission from services is added to residential emissions during spatial distribution described in chapter below. Emission recalculated per address point (as household) consists of residential emission and emissions from services.

The inventory of area emission sources has been prepared in squares according to the following resolution:

- 0.5 km x 0.5 km for cities,
- 1 km x 1 km for other built-up areas.

Calculation structure is presented at figure below.

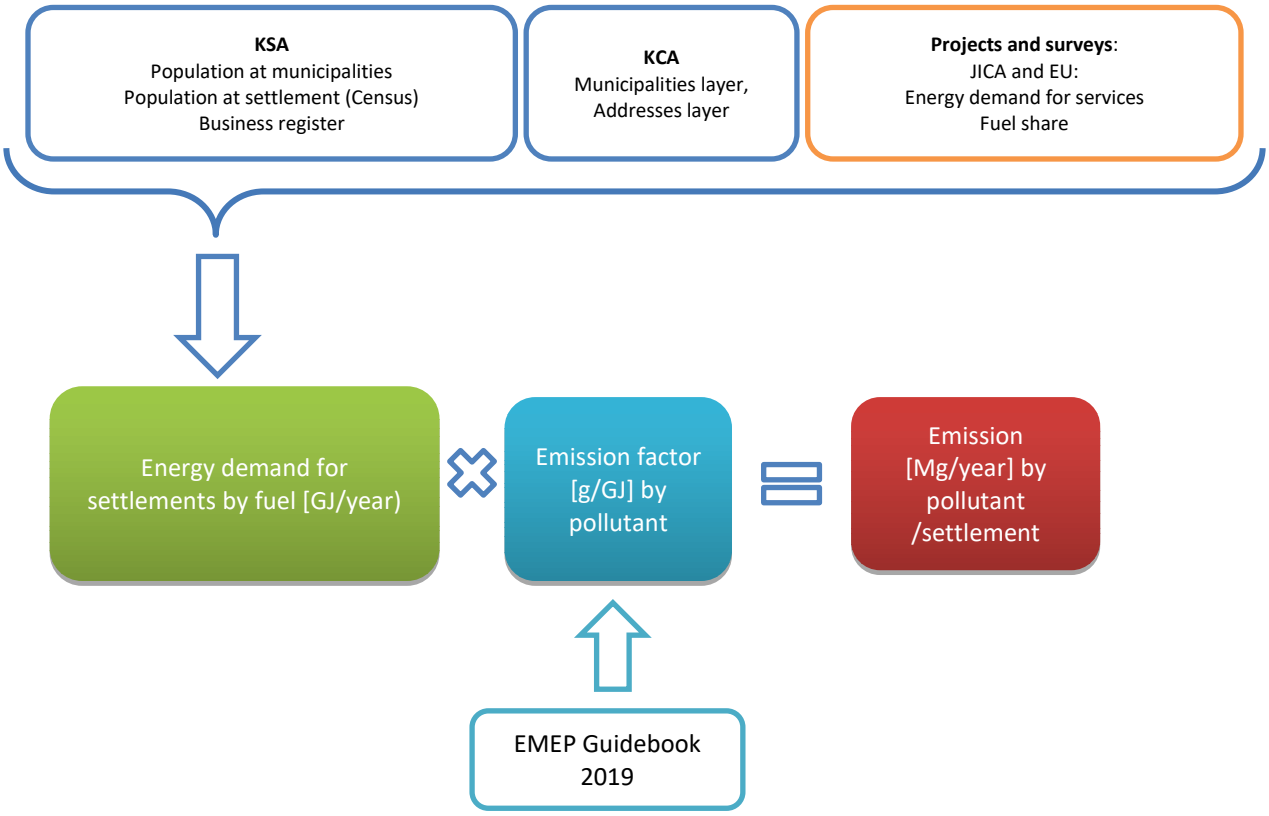


Figure 13 Graph of calculation path and data sources for emissions from services

7.5 INVENTORY OF LINEAR EMISSIONS (TRANSPORT)

The amount of pollutant emissions from road traffic sources (so called 'linear emissions') depends mainly on the amount of vehicle traffic, the impact of which on the environment is additionally differentiated due to the following:

- type of vehicles,
- distribution of vehicle traffic over time,
- type of fuel used,
- speed,
- load and technical condition of vehicles,
- exhaust emissions standards met by vehicles.

Not without significance is also the impact of non-exhaust emissions from tire wear, brake wear, road surface wear and resuspension of road dust, which is directly attributable to the condition of the road surface, the type of roadside or the frequency of road surface cleaning. Additional impact on emissions is caused by such factors as compact buildings around the road, auxiliary elements of road infrastructure (e.g. noise barriers), and the type of vegetation surrounding the road or the terrain.

Kosovo inventory of road traffic emissions includes exhaust gas emissions, non-exhaust emissions and the resuspension of road dust for the following road categories:

- national roads,
- regional roads,
- other urban and rural roads.

Vector layers from Open Street Map resources are used to determine the route of particular types of roads in Kosovo.

The traffic volumes for Kosovo has been evaluated based on the dataset from the Ministry of Infrastructure and Transport containing results of automatic vehicle counting at 21 measurements points (2016 year). Results from traffic modeling for 2020 and 2015 years obtained from the Ministry of Infrastructure and Transport have been also applied. This modeling results set contains average daily traffic flows for the main national and regional roads of the country.

Levels of individual types of emissions depend to a large extent on the operating conditions of the engine, which in turn result from the characteristics of vehicle traffic. Average traffic speeds on urban roads are at the level of 10-50 km/h. On roads outside built-up areas, the average speed range is between 40 and 80 km/h, while on express roads the speed range is higher than 70 km/h. A special speed category of 10 km/h has been assigned to traffic jams.

In order to determine the emission levels from individual communication routes, the road sections is divided into fragments corresponding to the mesh size of the modeling grid. For designated road sections, information on traffic volume has been collected, broken down by categories of vehicles emitting substances. On their basis, the total annual traffic volume [pieces/year] for national and regional roads is estimated.

For other roads, the determination of emissions is based on the same methodology as for national and regional roads, while in the absence of information on traffic volume, the average daily traffic (SDR) in a given year is determined on the basis of measurements conducted by the Ministry and the available traffic models.

If there is no data on traffic on specific roads (specially on other roads, in some cases – main roads) – the following traffic estimation procedure is implemented:

- average traffic intensity factors are calculated for all municipalities (districts) – based on main roads data;
- the “name of class” attributes (defined for each road in Open Street Map - OSM) and their associated calculation indicators were used to model traffic for roads without traffic measurements data

Table 37 Calculation indicators for traffic estimations

name of class	class	calculation indicator
primary	VI	1
primary_link	VI	1
residential	II	0,2
secondary	VI	1
secondary_link	VI	1
service	IV	0,1
tertiary	I	0,25
tertiary_link	IV	0,1
trunk	VI	1
unclassified	V	0,05
living_street	III	0,15
motorway_link	VI	1

The traffic emission database contains the following information:

- coordinates of the road section,
- road category (national, regional, other),
- average traffic speed,
- names of individual streets and roads,
- traffic volume broken down by type of vehicle emitting a substance into the air (passenger cars, LCVs, HDVs, buses) [pieces/year],
- the quantity of substances emitted covered by the inventory [kg/year].

Calculation path for traffic emission in the emission database:

- verification of road sections,
- verification of the volume of vehicles in total on a given road,
- division of traffic volume into categories of vehicles: passenger cars, LCVs, HDVs and buses,
- allocation of emission factors for each type of vehicle on the road,
- calculation of emissions.

During the update of inventory traffic inside the cities was improved and some corrections of national roads going from Pristina were done. Survey of JICA project on traffic in Pristina was used to adjust traffic inside of the cities. The annual traffic volume was calculated for all traffic measurement points on the main streets of Pristina, taking into account the results for holidays and working days. The research was carried out at 23 measuring points. For each national road with a measurement point, the traffic volume was assigned according to measurements, from the main intersection to the exit from the city. The same was done for points on the main urban roads of Pristina, implementing the traffic volumes from the traffic measurements. For the remaining roads in Kosovo, traffic change indicators were adopted based on the

roads exiting Pristina. Separate indicators have been used for urban and non-urban roads. It was necessary to use intensity change indicators for roads in cities such as: Gjakovë, Fushë Kosovë, Mitrovicë, Obiliq, Pejë, Parodvë, Prizren, Ferizaj, Graçanicë, Vushtri, Suharekë, Gjilan, Gllogoc. The adopted traffic indicators for national roads in other cities are based on changes in intensity in Pristina from the measurements:

The adopted traffic factors on national roads in other cities (table below) are based on changes in traffic in Pristina from the JICA project measurements.

Table 38 The adopted indicators for national roads in other cities

	Cars	LCV	HDV	BUS
Traffic increase	150%	150%	60%	170%

These indicators were used only for national and provincial roads.

Traffic volume indicators were adopted also for non-urban main roads in Kosovo starting from Pristina (table below). The indicators are based on JICA project traffic measurement on the main exit roads (national/highways) form Pristina.

Table 39 Adopted coefficients of change of intensity on national extra-urban roads starting from Pristina

	Cars	LCV	HDV	BUS
Road R7	36%	118%	89%	73%
Road R6	60%	90%	90%	50%
Road M-2,M-25	140%	180%	55%	200%
Road M-9;R7	104%	150%	110%	120%
Road M-25.2	140%	120%	90%	140%

7.6 INVENTORY OF OTHER EMISSION SOURCES

7.6.1 Sources of emissions from agriculture (crops and breeding)

Agriculture is a source of air emissions, mainly particulate matter (PM_{10} and $PM_{2.5}$) and ammonia. Based on the CORINE Land Cover 2018 spatial layers and on the information on land use from KSA statistical data, areas that are agriculturally active (e.g. areas of cultivation or areas using agricultural machinery) have been designated.

Emissions from agriculture are also defined by the estimated emissions from animal breeding. Emissions from agricultural machinery and emissions from field crops are determined on the basis of the agricultural area. Crop areas include the following land-use categories:

- Arable land,
- Grain cereals,
- Grain pulses (including pulses for seeds),
- Industrial crops,
- Potatoes (including early potatoes and seed potatoes),
- Fodder crops,

- Roots, forage cabbage and pumpkins,
- Vegetables,
- Other crops in arable land.

The estimated emission has been assigned to the areas of agriculturally active land use, divided into the following emission grid:

- 1 km x 1 km for undeveloped areas.

7.6.2 Sources of fugitive emission – mines and quarries

PM_{10} and $PM_{2.5}$ emission from the quarries were determined basing on the information obtained from KEPA containing, among others, site name, area of quarry and co-ordinates for 190 quarries in Kosovo and the other KEPS's information relating to activity data. Following emission factors were adopted:

Table 40 Emission factors from quarries (source: EMEP/EEA 2019. Tier 1 emission factors for source category 2.A.5.a Quarrying and mining of minerals other than coal. Table 3-1).

Source of emission	PM_{10}	$PM_{2.5}$
Quarries	50 g/Mg mineral	5 g/Mg mineral

Emissions from quarries were calculated using the following formula:

$$E = A \times E\text{–}\times AS$$

where:

E - emission

A - activity data - amount of excavated mineral [Mg/year]

EF - emission factor

AS - area share - share of the area of specific quarry in the total area of all quarries.

7.6.3 Sources of fugitive emission - landfills

PM_{10}, $PM_{2.5}$ and NMVOC emissions from the municipal landfills were determined basing on the information obtained from KEPA containing landfill name and amount of wastes disposed yearly from 2006 to 2018. Following emission factors were adopted from EMEP/EEA guidebook 2019:

Table 41 Emission factors from the waste management sector (source: EMEP/EEA air pollutant emission inventory guidebook 2019. 5.A Biological treatment of waste – solid waste disposal on land (Table 3-1))

Waste disposal method	Emission factors		
	PM_{10}	$PM_{2.5}$	NMVOC
solid waste disposal on land	0,219	0,033	1,56
unit	[g/Mg]	[g/Mg]	[kg/Mg]

* - emission factors are determined for the amount of waste accumulated during the year or incinerated during the year

Emissions from waste management were calculated using the following formula:

$$E = - \times EF$$

where:

E - emission

M - mass of waste deposited during the year [Mg/year]

EF - emission factor.

Data from 2018 was taken. Locations of landfills were determined based on the information from the "Municipal waste management in Kosovo. Status report" published by the Ministry of Environment and – patial Planning - Kosovo Environmental Protection Agency in collaboration with Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH in May 2018.

7.6.4 Natural emission sources (forest)

The natural emission inventory takes into account the emission of precursors of particulate matter from forests. The areas to be inventoried are defined on the basis of vector layers covering forest areas. Emissions from forests are calculated using the following formula:

$E = P \times w_e$

where:

E - emission of pollutant [kg/year].

P - forest area of a given type [ha].

w_E – emission factor [kg/(ha x year)]

Due to the specific composition of non-methane VOCs from forests divided into isoprenes and monoterpenoids (alpha-pinene, beta-pinene, limonene, etc.), a more extensive analysis of the composition of emissions is required.

For this purpose, data from the EMEP/EEA emission inventory guidebook 2019 was also analyzed. In the summary of the guide, the last emission estimates were compared [Simpson et al. (1995) and Guenther et al. (1995)].

According to this estimate, the contribution of isoprenes, monoterpenoids and other VOCs to the total amount of NMVOC from forests is as follows:

- isoprenes 17.9%,
- monoterpenoids 50%,
- other VOCs 32,1%.

Emissions of isoprenes are important ozone modelling, while emissions of different types of terpenes can be equally important despite a number of uncertainties about the behavior of these substances in the air. Literature sources [Guenther et al. (1991, 1993)] indicate that insolation and temperature have a significant effect on short-term changes in isoprene emission levels. The contribution of these substances to emissions is also significantly influenced by such factors as:

- emission differences according to the type of trees,
- period of the year,
- condition of the trees.

Although there are many different types of monoterpenes, most plants emit only two or three types, particularly reactive is ά-pinene. The contribution of these substances to the total number of NMVOCs is significantly hampered to be estimated due to the significant differences in shares for each tree species, especially coniferous trees.

7.6.5 Sources of fugitive emission - aviation

In the update of 11th of May 2020 of this document NOx, CO, NMVOC, SO_2, PM_{10} and $PM_{2.5}$ emissions from aviation were calculated basing on the information obtained from Statistical Yearbook regarding number of flights in Kosovo in 2018 and assumptions made basing on EMEP/EEA guidebook 2019. It's asssumed that all flights are international.

Emission factors were adopted from EMEP/EEA guidebook 2019, chapter 1.A.3.a Aviation. Tier 1 was used. Calculated emission showed that aviation is the marginal source of total pollutants emission in Kosovo (less than 0,1%), so these emissions were not analysed more thoroughly.

More details about emissions calculations from aviation are presented in the spreadsheet "2018_1.A.3.a_Aviation_v2.xlsx".

8 ELECTRONIC DATABASE AND ITS CONTENT

The electronic database contains the results of the inventory of emission sources for the Republic of Kosovo, taking into account the possibility of converting the amount of emission after the change of unit emission factors.

The emission database is created by independent databases (files) prepared in MS Office - Excel package in the form of xlsx files, depending on the type of emission sources.

The emission database is listed in the ***2018_Air_emission_database*** folder, while the lower folders of the data set include particular types of emission sources. Names of files consist of: the year of database, NFR number, name of sector and version number:

l. 2018_1.A,_2.A.1_2.C_3B_Industry_v2.xlsx

m. 2018_1.A.3_Main_roads_ v*2*.xlsx

n. 2018_1.A.3_Other_roads_ v*2*.xlsx

o. 2018_1.A.4_Small_combustion_ v2.xlsx

p. 2018_11.C_Forests_ v*1b*.xlsx

q. 2018_2.A.5.a_1.B.1.a_Mining_ v*2*.xls

r. 2018_1.A.2.f.i_Asphalt_v*1*.xls

s. 2018_3.B_Agriculture breeding_ v*2*.xlsx

t. 2018_3.D_Agriculture crops_ v*1b*.xlsx

u. 2018_5.A_ Landfills_ v*1b*.xlsx

v. 2018_1.A.3.a_Aviation_ v*2*.xlsx

In the emission database, the data necessary to model the dispersion of pollutants is be collected in a structure ensuring legibility, quick change in case of selection of a different set of indicators, as well as the possibility to prepare summary reports for each type of sources divided into municipalities.

8.1 STRUCTURE AND CONTENT OF THE LINEAR EMISSION DATABASE (ROADS)

The linear emission database is broken down by road type to split large data sets into smaller, more user-friendly sets. The name of the emission database (file) describes the type of roads for which emissions are calculated. The entire database is divided into following files:

- database of linear emissions from regional and national roads 'Main_roads'
- database of linear emissions from municipal and county roads 'Other_roads'.

8.1.1 Database of linear emissions from regional and national roads

The database consists of the following bookmarks/spreadsheets:

- catalogue,
- factors,
- emitters_N,
- emitters_R,
- report_N,
- report_R,
- report_Total.

In the 'catalogue' part a list of Kosovo municipalities and their codes is included.

In the 'factors' part of database file the emission factors for different traffic speeds categories and vehicle categories have been collected including exhaust EFs for all substances as well as wear and re-suspension EFs for PM_{10} and $PM_{2.5}$.

The 'emitters' spreadsheets are the most expanded parts of the database. They include detailed data on each of the specified sections respectively of national I and regional (R) roads network. The particular columns contain input data necessary to calculate traffic emissions as well as results in the form of annual emissions. The following attributes are included in the spreadsheet:

- record No. which is equal to emitter ID,

- municipality code and name,
- road No., name and type,
- section length and average traffic speed,
- section start-, mid- and endpoint coordinates,
- section annual traffic volume data divided into vehicle categories (cars, LCVs, HDVs, buses),
- section annual emissions for all specified substances,
- section PM_{10} emissions divided into exhaust, wear and resuspension components,
- section $PM_{2.5}$ emissions divided into exhaust, wear and resuspension components,
- section shares of different processes in PM_{10} emissions,
- section shares of different processes in $PM_{2.5}$ emissions,
- section exhaust emissions for all substances divided into vehicle categories (cars, LCVs, HDVs, buses),
- section tyre&brake wear emissions for all PM species divided into vehicle categories (cars, LCVs, HDVs, buses),
- section road surface wear emissions for all PM species divided into vehicle categories (cars, LCVs, HDVs, buses),
- section resuspension emissions for all PM species divided into vehicle categories (cars, LCVs, HDVs, buses),
- section virtual emitter coordinates.

The 'report' parts show emission values of individual substances aggregated for municipalities. The reports are prepared separately for national and regional roads. Total emissions for main roads are presented as well.

8.1.2 Database of linear emission from municipal and county roads

The database consists of the following bookmarks/spreadsheets:

- catalogue,
- factors,
- emitters,
- report.

In the 'catalogue' part there is a list of Kosovo municipalities and their codes.

In the 'factors' part of database file the emission factors for different traffic speeds categories and vehicle categories have been collected including exhaust EFs for all substances as well as wear and re-suspension EFs for PM.

The 'emitters' spreadsheet is the most expanded part of the database. It includes detailed data on each of the specified sections of municipal and county roads network. The data content is similar to the content of 'Main_roads' database emitters part except of 'Road No.' field which was neglected in this case.

The ‘report’ part shows emission values of individual substances aggregated for municipalities.

8.2 STRUCTURE AND CONTENT OF THE SMALL COMBUSTION DATABASE

The area emission database consists of eight interconnected tabs:

- catalogues – list and numeric code of municipalities,
- settlement (catalogue) – list and numeric code of settlements,
- KSA domestic – includes input data concerning domestic heating from Kosovo Statistical Agency (KSA) – population, average family size, data from projects: energy use and fuel share,
- KSA services – includes input data from Kosovo Statistical Agency (KAS) for services (public and private),
- factors – emission factors,
- database – data for heat demand calculation (domestic),
- database services – data for heat demand calculation – services,
- emission – emission calculation for domestic,
- emission services – emission calculation for services,
- database of emitters,
- reports,
- control – comparison with other emission database.

8.3 STRUCTURE AND CONTENT OF THE AGRICULTURAL (BREEDING AND CROPS) EMISSION DATABASE

The database of agricultural emissions consists of two files:

- database of emissions from breeding
- database of emissions from crops.

Such a division is also possible and justified because of the different location of emissions. Emissions from cultivated areas are distributed in the areas of cultivated fields and meadows, while emissions from animal breeding are distributed in the areas of rural development, and in urban municipalities in the areas of peripheral single-family housing.

The database consists of related spreadsheet tabs, each of which is a separate relational table:

- KSA 2014 – statistical data
- Activity data – data needed for emission calculation,
- catalogues,
- factors – emission factors,
- emitters – spatial distribution of emission,
- reports – summary report - emission by municipality.

8.4 STRUCTURE AND CONTENT OF THE FORESTS EMISSION DATABASE

The natural emission base is the base for the emission of precursors of particulate matter from forest areas. The database consists of related spreadsheet tabs, each of which is a separate table of relations:

- catalogues,
- factor – emission factors,
- database – activity data needed for emission calculation,
- emitters - spatial distribution of emission,
- reports – summary reports of emission by municipality.

8.5 STRUCTURE AND CONTENT OF THE FUGITIVE EMISSION DATABASE - MINES AND QUARRIES

The fugitive emission database is a database for emissions of PM_{10} and $PM_{2.5}$ particulate matter from opencast mines and quarries. The database consists of spreadsheets:

- factors,
- database,
- emitters,
- reports.

8.6 STRUCTURE AND CONTENT OF THE FUGITIVE EMISSION DATABASE - ASPHALT

The fugitive emission database is a database for emissions of NOx, SO_2 and CO from opencast asphalt industry. The database consists of spreadsheets:

- factors,
- database,
- emitters,
- reports.

8.7 STRUCTURE AND CONTENT OF THE POINT EMISSION DATABASE - INDUSTRY

The scoring database consists of related spreadsheets, each of which is a separate table:

- database,
- emitters,
- reports.

For the point emission database, in addition to the basic data necessary for modeling emissions, complementary data are included.

8.8 STRUCTURE AND CONTENT OF THE AVIATION EMISSION DATABASE

The scoring database consists of related spreadsheets, each of which is a separate table:

- Info – includes emission factors,
- Database – includes activity data,
- Emission - includes emission calculation.

9 UNCERTAINTY ASSESSMENT

Uncertainty in emission estimates is a function of the uncertainty of input data i.e. activity data and emission factors, used to compile the inventory. As a general rule, when the Kosovo emission inventory was designed, the activity and emission factors data of lowest possible uncertainty were applied. This rule is included in the data quality objectives definition, especially by possible activity data completeness and application of the highest possible Tier for emission factors. To ensure a proper input dataset for air quality modelling the algorithms for time modulation and spatial distribution of emission data were applied which significantly decreased uncertainty.

A basic uncertainty analysis for specific emission categories is presented in the table below.

Table 42 Uncertainty analysis for specific emission categories

	Activity data uncertainty	Emission factor uncertainty
Energy industries point emissions, NFR 1.A.1	Not applicable. Emission data from measurements.	Emission data from JICA's inventory (based on measurements). 5% error assumed.
Combustion in manufacturing industries and construction (point emissions), NFR 1.A.2	Not applicable. Emission data from ELVs. In the update activity data for quarries were revised and changed. 50% error assumed	Not applicable. Emission data from ELVs. 50% error assumed
Industrial Process and Product Use Sector (point emissions), NFR 2	Not applicable. Emission data from ELVs. In the update completeness of data was increased	Not applicable. Emission data from ELVs. 50% error assumed
Linear emissions, NFR 1.A.3	Traffic data based on measurements (main national and regional roads) – 2% error assumed; other traffic data (modelled) – 10% error assumed; Traffic data in Pristina and some other cites are updated basing on traffic measurements in Pristine conducted by JICA project- it decreased the error below 10%	EMEP GB 2019 emission factors – uncertainty acc. to GB Tier 3 specifications; PM suspension emission factors - uncertainty acc. to US EPA AP-42 specifications
Small combustion – commercial / institutional, residential area sources, NFR 1.A.4	Heat demand calculation and fuel type share were based on questionnaires data analysis. 10%-30% error assumed for households (estimation of error was adjusted basing on modelling results). Error was slightly decreased in Pristina	EMEP GB 2019 emission factors – uncertainty acc. to GB Tier 1 and 2 specifications;

	due to the real data on district heating use in the city implemented in the update. Some improvement of accuracy was also achieved by analysis of pellet use and division of activities into wood and pellet in the update. 50-100% error assumed for service/business activities.	
Other area sources, NFR 1.B.1.a, 2.A.5.a, 3, 5, 11.C	Statistical data used from Census 2014 , statistical data or data from the MESP – 10% error assumed	EMEP GB 2019 emission factors – uncertainty acc. to GB Tier 1 and 2 specifications;

Applied emission factor uncertainty ratings for individual pollutants are presented in the table below. Most of the ratings are based on default values listed in Table2-3 of A.5 EMEP GB 2019 document. For some emission factors specific ratings (bolded) are given with appropriate justification.

Table 43 Emission factor uncertainty ratings for individual pollutants and sectors

	SO_2	NO_x	CO	$PM_{10}/PM_{2.5}$	NMVOC	Heavy metals
Road traffic linear emissions, NFR 1.A.3[23]	A	B	B	B	B	D
Small combustion – commercial / institutional, residential area sources, NFR 1.A.4	A	B	B	B/C	B	D
Other area sources, NFR 1.B.1.a, 2.A.5.a, 3, 5, 11.C	B-D	B-D	B-D	C-E	B-D	D-E

Explanations of uncertainty ratings according to A.5 EMEP GB 2019 document are following:

Table 44 Explanations of uncertainty ratings according to A.5 EMEP GB 2019 document

Rating	Description	Error estimate
A	An estimate based on a large number of measurements made at a large number of facilities or individual sources across a comprehensive range of operating conditions that fully represent the sector	10 %
B	An estimate based on a large number of measurements made at a large number of facilities or individual sources across a range of operating conditions that represent a large part of the sector	20 %
C	An estimate based on a number of measurements made at a small number of representative facilities or individual sources across a smaller range of operating conditions, or an engineering judgement	50 %

[23] For road traffic emissions Tier 3 combined emission factors were calculated using COPERT 5 and local fleet data; the uncertainty of these emission factors is assumed lower than default ratings listed in Table2-3 of A.5 EMEP GB 2019 document

	based on a number of relevant facts.	
D	An estimate based on single measurements, or an engineering calculation derived from a number of relevant facts	100 %
E	An estimate based on an engineering calculation derived from assumptions only	>100 %

It is important to mention, that uncertainty of the emission inventory will be decreasing with the updates planned for next years. The improvement measures will include both data collection and processing. First of all the measures will be implemented for key emission categories with higher uncertainty. All new emission calculation methods proposed by future EMEP Guidebook updates will be applied as well.

A list of proposed activities decreasing uncertainty in the next updates is presented in the next section – "Recommendations for updates". It is planned that in the future updates uncertainty analysis will be included in the documentation together with indications for further improvements. A summary of links between categories, their uncertainties and the updates is presented in the Appendix.

10 RECOMMENDATIONS FOR UPDATES

To enable MESP officers (KEPA, KHMI) to continue and update emission inventory in the next years and support development of the emission inventory system in cooperation with Statistical Agency and Cadastral Agency below there is the list of activities recommended for update and system changes.

Table 45 List of activities recommended for system changes

task	action	type of action	NFR code
Calculation of heat /energy demand methodology heat coefficient data for buildings at different age for Kosovo (the only law requirements were found in the regulation MESP 04/18: *The minimum requirements for the energy performance of building*)	Verify if there are such requirements and data available in new projects or new law. (according to the received information currently there is no methodology in Kosovo for heat demand calculation)	Such requirements may be introduced or amended in the future decreasing uncertainty	1.A.4 Small combustion – commercial / institutional, residential
Addresses layer (updated)	KCA - verify and have agreement to get building/addresses layer if is completed for most of municipalities	May be introduced in the future decreasing uncertainty improving spatial distribution	1.A.4 Small combustion – commercial / institutional, residential
No. and type of buildings and stoves at settlement Age structure and type of	New 2021 Census - include necessary data for the update	System changes decreasing	1.A.4 Small combustion – commercial /

stoves Fuel use at settlement level Average of area of household and services,		uncertainty	institutional, residential
Small combustion plant – activity data	More detailed emission inventory of small combustion sources in the cities Establish system for updating of such emission inventories Cooperation with local authorities	decreasing uncertainty of activity data	1.A.4 Small combustion – commercial / institutional, residential
Small combustion plant – emissions data	Measurements campaigns of emission from domestic boilers/stoves to determine more accurate emission factors Cooperation with universities or scientific institutes	decreasing uncertainty of emission factor	1.A.4 Small combustion – commercial / institutional, residential
Harmonization of data on the naming and numbering of municipalities and settlements	Names of municipalities and identifier are different in statistical and cadastral databases	KSA and KCA – harmonization, system changes	All sectors
IPPC permits and environmental permits	List of data required in the permits (like height and diameter of emitters, total annual emissions in Mg/year, gas flow in real and standard conditions and temperature, emitter coordinates)	MESP system changes decreasing uncertainty	1.A.1 Energy Industries (Thermal Power Plant, Heat Production, etc.) 1.A.2 Combustion in Manufacturing Industries and construction 2. Industrial Process and Product Use (IPPU) Sector
Data from local level	Business register, data concerning public buildings (heat demand, fuel use), district heating data, traffic measurements from Mobility Plans	MESP KSA, city System changes decreasing uncertainty	1.A.4 Small combustion – commercial / institutional, residential 1.A.3 Exhaust emissions from road transport, Road vehicle tire and brake wear, road surface wear

11 KOSOVO AIR EMISSION INVENTORY RESULTS

11.1 KOSOVO ANNUAL EMISSIONS BY MUNICIPALITIES AND BY SECTOR

The annual emissions by municipalities and by sector for the main pollutants are presented in the tables below:

Table 46 Annual emission of PM_{10} for different sectors and municipalities [Mg/year]

ID	Municipality	Small combustion	Transport		Industry	Agriculture	Quarries	Landfills	Total
			Roads	Aviation					
01	Deçan	524,82	48,78			33,45	0,35		**607,40**
02	Gjakovë	883,17	64,73		175,39	61,69	0,26		**1 185,23**
03	Gllogoc	580,43	205,38		65,76	53,36	23,00		**927,94**
04	Gjilan	909,54	138,74		8,80	51,88	0,23	0,01	**1 109,21**
05	Dragash	368,77	43,62			2,99	36,68	0,00	**452,07**
06	Istog	504,26	46,42			49,64	0,98		**601,30**
07	Kaçanik	459,18	78,39			30,35	1,72		**569,65**
08	Klinë	493,46	100,39			73,75	1,63		**669,24**
09	Fushë Kosovë	366,52	154,77			27,05	0,19		**548,53**
10	Kamenicë	401,40	127,78			27,02	5,40		**561,60**
11	Mitrovicë	872,93	58,02			27,35	15,71		**974,01**
12	Mitrovica Veriore	68,99	2,64			1,04			**72,66**
13	Leposaviq	144,90	19,58			14,43	0,53		**179,44**
14	Lipjan	542,12	221,81	0,31	11,15	64,86	2,07	0,03	**842,34**
15	Novoberdë	97,96	65,01			49,58	2,55		**215,10**
16	Obiliq	173,95	148,00		13 610,56	48,84	0,07		**13 981,42**
17	Rahovec	613,17	58,25			47,31	0,95		**719,66**
18	Pejë	1 040,41	188,43		29,49	53,83	1,60	0,01	**1 313,77**
19	Podujevë	773,06	252,48		12,78	87,70	0,38	0,00	**1 126,40**
20	Prishtinë	1 793,07	436,72			35,14	0,64		**2 265,57**
21	Prizren	1 839,77	378,19		9,14	38,58	9,81	0,02	**2 275,52**
22	Skenderaj	618,14	161,95			78,85	0,60		**859,54**
23	Shtime	263,20	63,00			39,44	1,00		**366,64**
24	Shterpcë	90,43	18,91			14,87	0,46		**124,67**
25	Suharekë	638,31	131,12			40,34	2,13		**811,89**
26	Ferizaj	1 209,43	228,08		0,011	54,94	0,79		**1 493,25**
27	Viti	667,95	67,17			60,53	0,17	0,01	**795,83**
28	Vushtri	684,24	244,37		0,074	68,99	0,23		**997,90**
29	Zubin Potok	70,19	23,80			18,01			**112,01**
30	Zveçan	80,19	8,87			4,74			**93,80**
31	Malishevë	620,47	183,97			60,97	0,70		**866,12**
32	Junik	75,09	1,89			3,04	0,05		**80,07**
33	Mamushë	60,55	0,36			4,94			**65,85**
34	Hani i Elezit	135,98	22,96		41,36	18,60	1,45		**220,34**
35	Graçanicë	110,43	138,92			51,10			**300,45**
36	Ranillug	48,62	21,29		38,84	23,41			**132,16**
37	Partesh	23,00	9,55			13,94			**46,49**
38	Kllokot	35,28	9,57		0,018	6,61	0,02		**51,50**
	Kosovo	**18 883,37**	**4 173,93**	**0,31**	**14 003,38**	**1443,18**	**112,34**	**0,09**	**38 616,59**

Table 47 Annual emission of $PM_{2.5}$ for different sectors and municipalities[Mg/year]

ID	Municipality	Small combustion	Transport		Industry	Agriculture	Quarries	Landfills	Total
			Roads	Aviation					
01	**Deçan**	511,19	21,85			5,73	0,03		**538,81**
02	**Gjakovë**	860,38	28,89		156,81	8,85	0,03		**1 054,95**
03	**Gllogoc**	565,49	92,25		46,97	6,57	2,30		**713,58**
04	**Gjilan**	886,11	61,29		0,660	7,52	0,02	0,001	**955,61**
05	**Dragash**	359,21	19,63			0,52	3,67	0,0002	**383,02**
06	**Istog**	491,18	20,77			4,73	0,10		**516,77**
07	**Kaçanik**	447,28	35,26			6,57	0,17		**489,28**
08	**Klinë**	480,66	44,98			9,37	0,16		**535,17**
09	**Fushë Kosovë**	357,10	69,18			4,91	0,02		**431,21**
10	**Kamenicë**	391,00	56,60			2,72	0,54		**450,86**
11	**Mitrovicë**	851,93	25,76			6,22	1,57		**885,48**
12	**Mitrovica Veriore**	67,26	1,18			0,36			**68,80**
13	**Leposaviq**	141,15	8,82			2,56	0,05		**152,58**
14	**Lipjan**	528,20	99,27	0,31	4,84	6,60	0,21	0,004	**639,43**
15	**Novoberdë**	95,41	28,69			9,51	0,26		**133,87**
16	**Obiliq**	169,47	66,31		6 049,23	7,23	0,01		**6 292,24**
17	**Rahovec**	597,30	26,15			4,67	0,09		**628,21**
18	**Pejë**	1 013,60	84,49		26,89	8,84	0,16	0,002	**1 133,98**
19	**Podujevë**	753,23	111,31		11,80	11,14	0,04	0,0004	**887,51**
20	**Prishtinë**	1 746,94	192,27			3,61	0,06		**1 942,88**
21	**Prizren**	1 792,37	168,92		8,43	4,46	0,98	0,003	**1 975,17**
22	**Skenderaj**	602,10	72,51			8,70	0,06		**683,37**
23	**Shtime**	256,44	28,25			7,09	0,10		**291,88**
24	**Shterpcë**	88,08	8,52			3,39	0,05		**100,03**
25	**Suharekë**	621,76	58,68			4,49	0,21		**685,15**
26	**Ferizaj**	1 178,27	101,82		0,005	5,17	0,08		**1 285,34**
27	**Viti**	650,61	29,82			8,36	0,02	0,002	**688,81**
28	**Vushtri**	666,59	108,87		0,032	8,29	0,02		**783,81**
29	**Zubin Potok**	68,37	11,05			4,49			**83,91**
30	**Zveçan**	78,11	3,98			0,76			**82,85**
31	**Malishevë**	604,36	82,08			7,27	0,07		**693,78**
32	**Junik**	73,16	0,85			0,30	0,00		**74,32**
33	**Mamushë**	58,99	0,16			0,48			**59,63**
34	**Hani i Elezit**	132,45	10,29		30,94	5,91	0,14		**179,74**
35	**Graçanicë**	107,59	61,66			7,60			**176,85**
36	**Ranillug**	47,36	9,45		35,85	5,58			**98,24**
37	**Partesh**	22,40	4,21			2,45			**29,07**
38	**Kllokot**	34,36	4,30		0,001	1,04	0,00		**39,71**
	Kosovo	**18 397,49**	**1 860,36**	**0,31**	**6 372,46**	**204,03**	**11,23**	**0,01**	**26 845,89**

Table 48 Annual emission of NOx for different sectors and municipalities [Mg/year]

ID	Municipality	Small combustion	Transport		Industry	Agriculture	Quarries	Landfills	Total
			Roads	Aviation					
01	**Deçan**	46,59	168,49			66,83			**281,90**
02	**Gjakovë**	91,41	219,43		1 436,23	164,60			**1 911,66**
03	**Gllogoc**	66,27	744,65		1 063,49	177,56			**2 051,97**
04	**Gjilan**	93,27	445,51		0,017	132,28			**671,08**
05	**Dragash**	35,21	157,83			8,63			**201,67**
06	**Istog**	45,68	159,12		0,003	194,74			**399,54**
07	**Kaçanik**	42,50	284,68			38,82			**366,01**
08	**Klinë**	44,08	371,65		0,038	223,17			**638,94**
09	**Fushë Kosovë**	44,85	564,97			73,61			**683,43**
10	**Kamenicë**	37,81	417,49			93,37			**548,68**
11	**Mitrovicë**	111,18	189,65			54,67			**355,50**
12	**Mitrovica Veriore**	9,18	8,93			0,90			**19,01**
13	**Leposaviq**	13,24	75,22			27,62			**116,08**
14	**Lipjan**	65,18	751,43	44,44	162,17	221,95			**1 245,17**
15	**Novoberdë**	8,32	215,51		0,050	58,71			**282,59**
16	**Obiliq**	21,69	520,95		22 933,04	79,34			**23555,01**
17	**Rahovec**	59,88	208,24		0,003	196,78			**464,91**
18	**Pejë**	105,43	657,08		214,19	158,57			**1 135,28**
19	**Podujevë**	93,35	783,39		40,65	268,85			**1 186,24**
20	**Prishtinë**	221,65	1356,21			112,55			**1 690,41**
21	**Prizren**	191,45	1297,23		15,32	124,25			**1 628,25**
22	**Skenderaj**	56,46	536,48			274,19			**867,13**
23	**Shtime**	31,06	222,76			84,54			**338,35**
24	**Shterpcë**	8,07	69,50			9,85			**87,42**
25	**Suharekë**	60,81	455,71		0,018	135,25			**651,78**
26	**Ferizaj**	123,67	768,55		0,209	195,10			**1 087,53**
27	**Viti**	60,09	214,42			171,98			**446,49**
28	**Vushtri**	68,48	788,92		3,19	236,22			**1 096,80**
29	**Zubin Potok**	6,36	101,47			15,32			**123,14**
30	**Zveçan**	7,52	32,83			6,82			**47,17**
31	**Malishevë**	57,22	621,98			194,23			**873,43**
32	**Junik**	7,49	6,80		0,014	12,96			**27,26**
33	**Mamushë**	6,43	1,23			19,99			**27,65**
34	**Hani i Elezit**	12,44	81,52		773,51	11,95			**879,43**
35	**Graçanicë**	12,49	484,96		0,028	112,30			**609,78**
36	**Ranillug**	4,21	72,41		329,29	29,94			**435,85**
37	**Partesh**	2,00	32,78			21,48			**56,25**
38	**Kllokot**	3,14	35,14			18,01			**56,28**
	Kosovo	**1 976,15**	**14 125,09**	**44,44**	**26 971,46**	**4027,95**	**0,00**	**0,00**	**47 145,10**

Table 49 Annual emission of SO_2 for different sectors and municipalities [Mg/year]

ID	Municipality	Small combustion	Transport		Industry	Agriculture	Quarries	Landfills	Total
			Roads	Aviation					
01	Deçan	16,67	0,08		0,000	0,04			**16,79**
02	Gjakovë	32,31	0,10		7 180,85	0,11			**7 213,38**
03	Gllogoc	127,57	0,33		1 578,19	0,12			**1 706,22**
04	Gjilan	34,61	0,22		0,001	0,09			**34,92**
05	Dragash	12,93	0,07			0,01			**13,01**
06	Istog	16,08	0,08			0,14			**16,29**
07	Kaçanik	15,46	0,13			0,02			**15,61**
08	Klinë	15,59	0,16		0,002	0,15			**15,90**
09	Fushë Kosovë	84,70	0,25			0,05			**85,00**
10	Kamenicë	13,31	0,20			0,06			**13,57**
11	Mitrovicë	322,58	0,09			0,03			**322,70**
12	Mitrovica Veriore	2,47	0,00			0,00			**2,47**
13	Leposaviq	4,88	0,03			0,08			**4,99**
14	Lipjan	120,83	0,36	2,75	612,60	0,15			**736,69**
15	Novoberdë	2,98	0,10		0,002	0,03			**3,12**
16	Obiliq	40,22	0,24		32 674,47	0,05			**32 714,98**
17	Rahovec	22,20	0,09			0,14			**22,43**
18	Pejë	37,84	0,31		305,28	0,11			**343,53**
19	Podujevë	173,45	0,40		77,39	0,18			**251,42**
20	Prishtinë	322,89	0,69			0,08			**323,66**
21	Prizren	72,24	0,61		30,22	0,09			**103,16**
22	Skenderaj	21,17	0,26			0,19			**21,62**
23	Shtime	57,51	0,10			0,06			**57,67**
24	Shterpcë	2,87	0,03			0,00			**2,91**
25	Suharekë	22,65	0,21		0,001	0,09			**22,95**
26	Ferizaj	37,16	0,37		0,61	0,14			**38,27**
27	Viti	21,81	0,11			0,12			**22,03**
28	Vushtri	25,27	0,39		2,87	0,16			**28,70**
29	Zubin Potok	2,15	0,04			0,03			**2,22**
30	Zveçan	2,77	0,01			0,02			**2,80**
31	Malishevë	21,65	0,30			0,13			**22,08**
32	Junik	2,61	0,00		0,001	0,01			**2,62**
33	Mamushë	2,33	0,00			0,01			**2,34**
34	Hani i Elezit	4,51	0,04		92,08	0,00			**96,63**
35	Graçanicë	25,13	0,22		0,001	0,07			**25,43**
36	Ranillug	1,51	0,03		1646,45	0,02			**1 648,02**
37	Partesh	0,72	0,01			0,01			**0,75**
38	Kllokot	1,15	0,02			0,01			**1,18**
	Kosovo	**1 744,75**	**6,70**	**2,75**	**44 201,03**	**2,82**	**0,00**	**0,00**	**45 958,06**

Table 50 Annual emission of CO for different sectors and municipalities [Mg/year]

ID	Municipality	Small combustion	Transport		Industry	Agriculture	Quarries	Landfills	Total
			Roads	Aviation					
01	Deçan	2 832,69	84,75		0,000	4,97			**2 922,41**
02	Gjakovë	4 798,26	110,28		897,63	12,72			**5 818,89**
03	Gllogoc	3 443,43	340,48		0,011	14,02			**3 797,94**
04	Gjilan	4 954,46	226,02		0,009	10,19			**5 190,69**
05	Dragash	1 986,17	74,94			0,66			**2 061,77**
06	Istog	2 719,56	78,44		0,002	15,58			**2 813,58**
07	Kaçanik	2 477,93	130,86			2,60			**2 611,39**
08	Klinë	2 663,34	160,08		0,019	17,50			**2 840,93**
09	Fushë Kosovë	2 191,09	247,32			5,62			**2 444,02**
10	Kamenicë	2 161,23	208,75			7,41			**2 377,39**
11	Mitrovicë	5 557,26	96,41			3,94			**5 657,60**
12	Mitrovica Veriore	393,01	4,51			0,19			**397,71**
13	Leposaviq	784,57	31,46			9,04			**825,08**
14	Lipjan	3 213,00	380,93	31,48	90,10	17,66			**3 733,17**
15	Novoberdë	528,54	103,99		0,025	3,91			**636,47**
16	Obiliq	1 037,52	248,41		4 361,42	5,85			**5 653,20**
17	Rahovec	3 308,16	99,93		0,002	15,74			**3 423,83**
18	Pejë	5 681,11	326,08		252,26	12,24			**6 271,69**
19	Podujevë	4 606,67	427,18		108,40	21,11			**5 163,35**
20	Prishtinë	10 415,93	720,83			8,87			**11 145,63**
21	Prizren	10 045,08	636,56		51,02	9,77			**10 742,45**
22	Skenderaj	3 336,02	286,09			21,77			**3 643,87**
23	Shtime	1 557,88	106,45			6,32			**1 670,65**
24	Shterpcë	487,88	31,92			0,50			**520,31**
25	Suharekë	3 441,12	219,48		0,009	10,70			**3 671,31**
26	Ferizaj	6 576,86	387,41		0,113	15,55			**6 979,93**
27	Viti	3 599,82	115,04			13,39			**3 728,25**
28	Vushtri	3 699,64	422,95		3,100	18,66			**4 144,35**
29	Zubin Potok	379,60	42,21			3,61			**425,42**
30	Zveçan	433,91	14,26			2,08			**450,25**
31	Malishevë	3 347,62	308,92			15,32			**3 671,85**
32	Junik	405,90	3,26		0,007	1,04			**410,20**
33	Mamushë	326,75	0,63			1,60			**328,97**
34	Hani i Elezit	733,45	38,06			0,45			**771,96**
35	Graçanicë	659,11	216,33		0,014	8,55			**884,00**
36	Ranillug	262,90	33,92		205,81	1,96			**504,59**
37	Partesh	124,28	14,53			1,54			**140,35**
38	Kllokot	190,78	15,99			1,38			**208,15**
	Kosovo	**105 362,53**	**6 995,66**	**31,48**	**5 969,95**	**324,00**	**0,00**	**0,00**	**118 683,61**

Table 51 Annual emission of NMVOC for different sectors and municipalities [Mg/year]

ID	Municipality	Small combustion	Transport		Industry	Agriculture	Quarries	Landfills	Total
			Roads	Aviation					
01	**Deçan**	420,69	15,26			145,01			**580,96**
02	**Gjakovë**	716,55	19,76		24,75	186,01			**947,07**
03	**Gllogoc**	489,52	61,19			95,90			**646,61**
04	**Gjilan**	738,89	40,38		36,30	162,15			**977,72**
05	**Dragash**	299,01	13,69			13,73			**326,43**
06	**Istog**	405,63	14,29			12,75			**432,67**
07	**Kaçanik**	369,38	23,38			214,08			**606,85**
08	**Klinë**	395,90	28,73			159,66			**584,28**
09	**Fushë Kosovë**	310,21	44,62			139,01			**493,84**
10	**Kamenicë**	324,92	37,86			21,24			**384,03**
11	**Mitrovicë**	758,96	17,13			204,18			**980,26**
12	**Mitrovica Veriore**	56,18	0,81			13,30			**70,29**
13	**Leposaviq**	115,51	5,75			19,92			**141,17**
14	**Lipjan**	461,79	67,93	4,75		51,58			**586,05**
15	**Novoberdë**	78,46	18,79			297,32			**394,57**
16	**Obiliq**	148,66	44,60			168,80			**362,05**
17	**Rahovec**	494,18	18,16			12,88			**525,23**
18	**Pejë**	840,96	57,65			213,23			**1 111,84**
19	**Podujevë**	656,74	74,99			187,97			**919,70**
20	**Prishtinë**	1 491,01	126,34			37,40			**1 654,75**
21	**Prizren**	1 489,94	113,20			60,41			**1 663,55**
22	**Skenderaj**	497,85	51,18			94,97			**644,00**
23	**Shtime**	222,81	19,03			189,89			**431,73**
24	**Shterpcë**	72,61	5,87			113,86			**192,34**
25	**Suharekë**	515,55	38,85			51,69			**606,10**
26	**Ferizaj**	977,42	68,25			24,21			**1 069,88**
27	**Viti**	538,09	20,33			167,21			**725,63**
28	**Vushtri**	550,56	74,68			113,50			**738,74**
29	**Zubin Potok**	55,92	7,77			146,01			**209,70**
30	**Zveçan**	64,15	2,60			11,05			**77,80**
31	**Malishevë**	499,83	54,72			103,63			**658,19**
32	**Junik**	59,91	0,59			0,85			**61,36**
33	**Mamushë**	48,79	0,11			1,31			**50,21**
34	**Hani i Elezit**	109,36	6,74			232,66			**348,76**
35	**Graçanicë**	92,69	38,45			172,05			**303,19**
36	**Ranillug**	38,81	6,15			193,42			**238,38**
37	**Partesh**	18,35	2,58			68,30			**89,23**
38	**Kllokot**	28,13	2,92		0,18	24,78			**56,00**
	Kosovo	**15 453,90**	**1 245,34**	**4,75**	**61,23**	**4 125,93**	**0,00**	**0,00**	**20 891,15**

Table 52 Annual emission of As for different sectors and municipalities [kg/year]

ID	Municipality	Small combustion	Transport		Industry	Agriculture	Quarries	Landfills	Total
			Roads	Aviation					
01	Deçan	0,179	0,002						**0,180**
02	Gjakovë	0,337	0,002						**0,339**
03	Gllogoc	0,533	0,006						**0,540**
04	Gjilan	0,349	0,004						**0,353**
05	Dragash	0,133	0,001						**0,134**
06	Istog	0,173	0,001						**0,175**
07	Kaçanik	0,162	0,002						**0,164**
08	Klinë	0,168	0,003						**0,171**
09	Fushë Kosovë	0,356	0,005						**0,361**
10	Kamenicë	0,141	0,004						**0,145**
11	Mitrovicë	1,155	0,002						**1,157**
12	Mitrovica Veriore	0,031	0,000						**0,032**
13	Leposaviq	0,051	0,001						**0,052**
14	Lipjan	0,507	0,007						**0,514**
15	Novoberdë	0,032	0,002						**0,034**
16	Obiliq	0,169	0,005						**0,174**
17	Rahovec	0,226	0,002						**0,227**
18	Pejë	0,394	0,006						**0,400**
19	Podujevë	0,729	0,008						**0,737**
20	Prishtinë	1,466	0,014						**1,480**
21	Prizren	0,720	0,012						**0,732**
22	Skenderaj	0,217	0,005						**0,222**
23	Shtime	0,242	0,002						**0,244**
24	Shterpcë	0,031	0,001						**0,031**
25	Suharekë	0,230	0,004						**0,235**
26	Ferizaj	0,441	0,007						**0,448**
27	Viti	0,230	0,002						**0,232**
28	Vushtri	0,257	0,008						**0,264**
29	Zubin Potok	0,024	0,001						**0,025**
30	Zveçan	0,029	0,000						**0,029**
31	Malishevë	0,220	0,006						**0,226**
32	Junik	0,028	0,000						**0,028**
33	Mamushë	0,024	0,000						**0,024**
34	Hani i Elezit	0,047	0,001						**0,048**
35	Graçanicë	0,104	0,004						**0,108**
36	Ranillug	0,016	0,001						**0,017**
37	Partesh	0,008	0,000						**0,008**
38	Kllokot	0,012	0,000						**0,012**
	Kosovo	**10,171**	**0,131**	**0,000**	**0,000**	**0,000**	**0,000**	**0,000**	**10,302**

Table 53 Annual emission of Cd for different sectors and municipalities [kg/year]

ID	Municipality	Small combustion	Transport		Industry	Agriculture	Quarries	Landfills	Total
			Roads	Aviation					
01	Deçan	10,39	0,001						**10,39**
02	Gjakovë	18,76	0,001						**18,76**
03	Gllogoc	10,49	0,004						**10,50**
04	Gjilan	19,67	0,002						**19,68**
05	Dragash	7,38	0,001						**7,38**
06	Istog	10,07	0,001						**10,08**
07	Kaçanik	9,32	0,001						**9,33**
08	Klinë	9,82	0,002						**9,82**
09	Fushë Kosovë	6,94	0,003						**6,94**
10	Kamenicë	8,18	0,002						**8,19**
11	Mitrovicë	15,95	0,001						**15,96**
12	Mitrovica Veriore	1,95	0,000						**1,95**
13	Leposaviq	2,96	0,000						**2,96**
14	Lipjan	10,09	0,004						**10,10**
15	Novoberdë	1,91	0,001						**1,91**
16	Obiliq	3,31	0,003						**3,31**
17	Rahovec	12,53	0,001						**12,53**
18	Pejë	22,47	0,003						**22,48**
19	Podujevë	14,61	0,004						**14,61**
20	Prishtinë	34,86	0,008						**34,86**
21	Prizren	39,48	0,007						**39,49**
22	Skenderaj	12,33	0,003						**12,34**
23	Shtime	4,88	0,001						**4,88**
24	Shterpcë	1,81	0,000						**1,81**
25	Suharekë	12,80	0,002						**12,80**
26	Ferizaj	26,30	0,004						**26,30**
27	Viti	13,29	0,001						**13,29**
28	Vushtri	14,49	0,004						**14,50**
29	Zubin Potok	1,44	0,000						**1,44**
30	Zveçan	1,65	0,000						**1,65**
31	Malishevë	12,23	0,003						**12,24**
32	Junik	1,61	0,000						**1,61**
33	Mamushë	1,31	0,000						**1,31**
34	Hani i Elezit	2,74	0,000						**2,74**
35	Graçanicë	1,99	0,002						**1,99**
36	Ranillug	0,97	0,000						**0,97**
37	Partesh	0,46	0,000						**0,46**
38	Kllokot	0,71	0,000						**0,71**
	Kosovo	**382,17**	**0,071**	**0,000**	**0,000**	**0,000**	**0,000**	**0,000**	**382,24**

Table 54 Annual emission of Hg for different sectors and municipalities [kg/year]

ID	Municipality	Small combustion	Transport		Industry	Agriculture	Quarries	Landfills	Total
			Roads	Aviation					
01	Deçan	0,498	0,070						**0,568**
02	Gjakovë	0,915	0,092						**1,007**
03	Gllogoc	1,273	0,292						**1,566**
04	Gjilan	0,961	0,194						**1,155**
05	Dragash	0,361	0,063						**0,424**
06	Istog	0,482	0,066						**0,548**
07	Kaçanik	0,450	0,112						**0,561**
08	Klinë	0,469	0,142						**0,611**
09	Fushë Kosovë	0,853	0,218						**1,071**
10	Kamenicë	0,392	0,179						**0,572**
11	Mitrovicë	2,554	0,081						**2,636**
12	Mitrovica Veriore	0,090	0,004						**0,094**
13	Leposaviq	0,143	0,028						**0,171**
14	Lipjan	1,210	0,316						**1,526**
15	Novoberdë	0,091	0,091						**0,182**
16	Obiliq	0,405	0,210						**0,615**
17	Rahovec	0,615	0,084						**0,699**
18	Pejë	1,088	0,269						**1,357**
19	Podujevë	1,743	0,354						**2,096**
20	Prishtinë	3,510	0,608						**4,118**
21	Prizren	1,957	0,536						**2,493**
22	Skenderaj	0,600	0,232						**0,832**
23	Shtime	0,579	0,090						**0,669**
24	Shterpcë	0,086	0,027						**0,114**
25	Suharekë	0,628	0,186						**0,814**
26	Ferizaj	1,226	0,323						**1,549**
27	Viti	0,639	0,095						**0,734**
28	Vushtri	0,707	0,347						**1,054**
29	Zubin Potok	0,068	0,035						**0,104**
30	Zveçan	0,080	0,013						**0,092**
31	Malishevë	0,601	0,260						**0,861**
32	Junik	0,077	0,003						**0,080**
33	Mamushë	0,064	0,001						**0,065**
34	Hani i Elezit	0,132	0,033						**0,165**
35	Graçanicë	0,248	0,193						**0,441**
36	Ranillug	0,046	0,030						**0,076**
37	Partesh	0,022	0,013						**0,035**
38	Kllokot	0,034	0,014						**0,048**
	Kosovo	**25,898**	**5,903**	**31,801**	**0,000**	**0,000**	**0,000**	**0,000**	**25,898**

Table 55 Annual emission of Pb for different sectors and municipalities [kg/year]

ID	Municipality	Small combustion	Transport		Industry	Agriculture	Quarries	Landfills	Total
			Roads	Aviation					
01	Deçan	3,26	0,008						**3,27**
02	Gjakovë	8,46	0,010						**8,47**
03	Gllogoc	5,26	0,033						**5,29**
04	Gjilan	7,94	0,022						**7,96**
05	Dragash	3,08	0,007						**3,08**
06	Istog	3,19	0,007						**3,20**
07	Kaçanik	2,96	0,013						**2,97**
08	Klinë	2,85	0,016						**2,86**
09	Fushë Kosovë	3,60	0,025						**3,62**
10	Kamenicë	2,75	0,020						**2,77**
11	Mitrovicë	51,19	0,009						**51,20**
12	Mitrovica Veriore	0,00	0,000						**0,00**
13	Leposaviq	0,71	0,003						**0,71**
14	Lipjan	5,26	0,036						**5,29**
15	Novoberdë	0,39	0,010						**0,40**
16	Obiliq	1,70	0,024						**1,72**
17	Rahovec	5,31	0,009						**5,32**
18	Pejë	8,57	0,031						**8,60**
19	Podujevë	7,33	0,040						**7,37**
20	Prishtinë	19,47	0,070						**19,54**
21	Prizren	18,01	0,061						**18,07**
22	Skenderaj	4,34	0,026						**4,37**
23	Shtime	2,52	0,010						**2,53**
24	Shterpcë	0,43	0,003						**0,43**
25	Suharekë	5,50	0,021						**5,52**
26	Ferizaj	9,93	0,037						**9,97**
27	Viti	4,31	0,011						**4,32**
28	Vushtri	5,36	0,040						**5,40**
29	Zubin Potok	0,28	0,004						**0,29**
30	Zveçan	0,45	0,001						**0,45**
31	Malishevë	4,87	0,030						**4,90**
32	Junik	0,56	0,000						**0,56**
33	Mamushë	0,61	0,000						**0,61**
34	Hani i Elezit	0,84	0,004						**0,84**
35	Graçanicë	0,75	0,022						**0,77**
36	Ranillug	0,13	0,003						**0,13**
37	Partesh	0,10	0,001						**0,10**
38	Kllokot	0,17	0,002						**0,17**
	Kosovo	**202,43**	**0,670**	**0,000**	**0,000**	**0,000**	**0,000**	**0,000**	**203,07**

11.2 ANALYSIS OF CHANGES IN EMISSION AFTER THE FIRST UPDATE

The percentage changes in emission after the first update of emission inventory are presented in the table below. Percentage was calculated as:

$$\frac{\text{emission in the update} - \text{emission in the first inventory}}{\text{emission in the first inventory}}$$

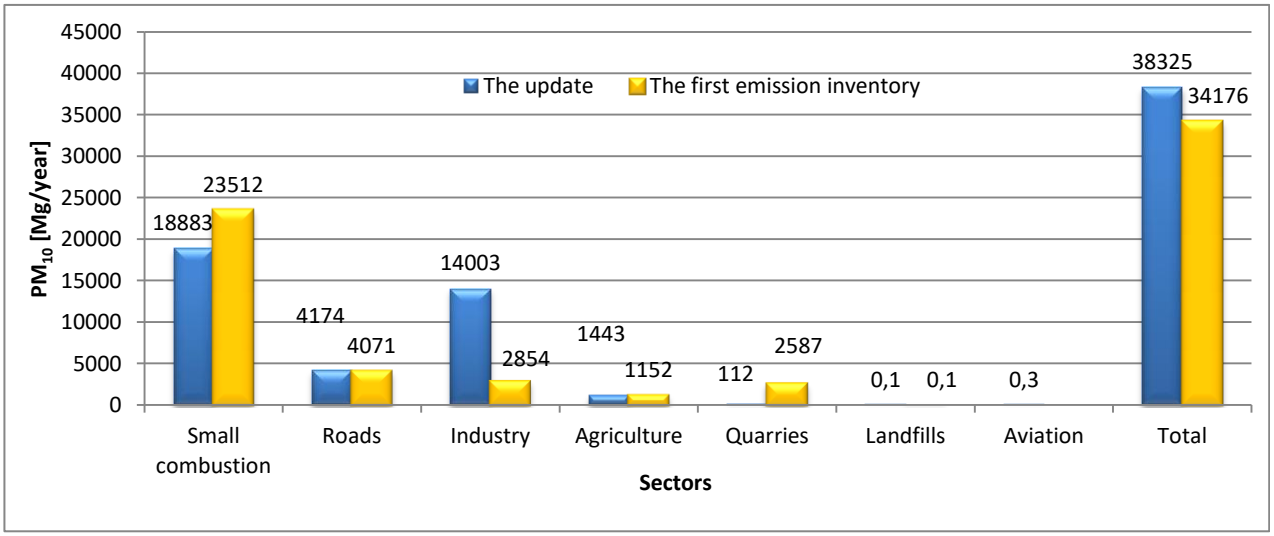
Table 56 The percentage changes in emission after the first update of emission inventory

ID	Muicipality	PM_{10}	$PM_{2.5}$	NOx	SO_2	CO	NMVOC
01	Deçan	-11%	-13%	2%	-3%	-12%	-40%
02	Gjakovë	-15%	-14%	-21%	-27%	-19%	-36%
03	Gllogoc	-42%	-28%	-19%	-31%	-16%	-29%
04	Gjilan	-24%	-27%	2%	-9%	-26%	-31%
05	Dragash	-66%	-40%	0%	-3%	-11%	-49%
06	Istog	-15%	-15%	-1%	-3%	-12%	-55%
07	Kaçanik	-17%	-17%	-3%	-5%	-15%	-13%
08	Klinë	-14%	-14%	0%	-3%	-12%	-25%
09	Fushë Kosovë	-18%	-22%	2%	-61%	-30%	-7%
10	Kamenicë	-26%	-19%	0%	-4%	-13%	-50%
11	Mitrovicë	-36%	-24%	0%	-1%	-15%	-21%
12	Mitrovica Veriore	-52%	-53%	-3%	-22%	-50%	-42%
13	Leposaviq	-21%	-20%	1%	-5%	-17%	-73%
14	Lipjan	-18%	-18%	-1%	-14%	-15%	-35%
15	Novoberdë	-13%	-12%	6%	-3%	-9%	25%
16	Obiliq	375%	246%	19%	113%	-15%	11%
17	Rahovec	-16%	-15%	1%	-3%	-13%	-38%
18	Pejë	-25%	-26%	-7%	-39%	-25%	-47%
19	Podujevë	-15%	-18%	-3%	-28%	-18%	-31%
20	Prishtinë	-10%	-12%	18%	-9%	-11%	-27%
21	Prizren	-26%	-24%	1%	-34%	-21%	-39%
22	Skenderaj	-12%	-14%	1%	-4%	-12%	-32%
23	Shtime	-14%	-16%	2%	-13%	-16%	7%
24	Shterpcë	25%	29%	8%	56%	33%	-46%
25	Suharekë	-15%	-13%	2%	-3%	-11%	-40%
26	Ferizaj	-23%	-25%	-3%	-5%	-23%	-35%
27	Viti	-11%	-13%	1%	-4%	-12%	-16%
28	Vushtri	-17%	-20%	-4%	-24%	-19%	-29%
29	Zubin Potok	-9%	-16%	-8%	-6%	-18%	-47%
30	Zveçan	-16%	-19%	1%	-5%	-17%	-59%
31	Malishevë	-10%	-12%	1%	-3%	-10%	-34%
32	Junik	-20%	-20%	1%	-2%	-18%	-58%
33	Mamushë	-18%	-19%	0%	-3%	-18%	-33%
34	Hani i Elezit	-16%	-13%	-23%	-25%	-13%	61%
35	Graçanicë	2%	-8%	6%	-13%	-12%	41%
36	Ranillug	5%	4%	-21%	-27%	-19%	71%

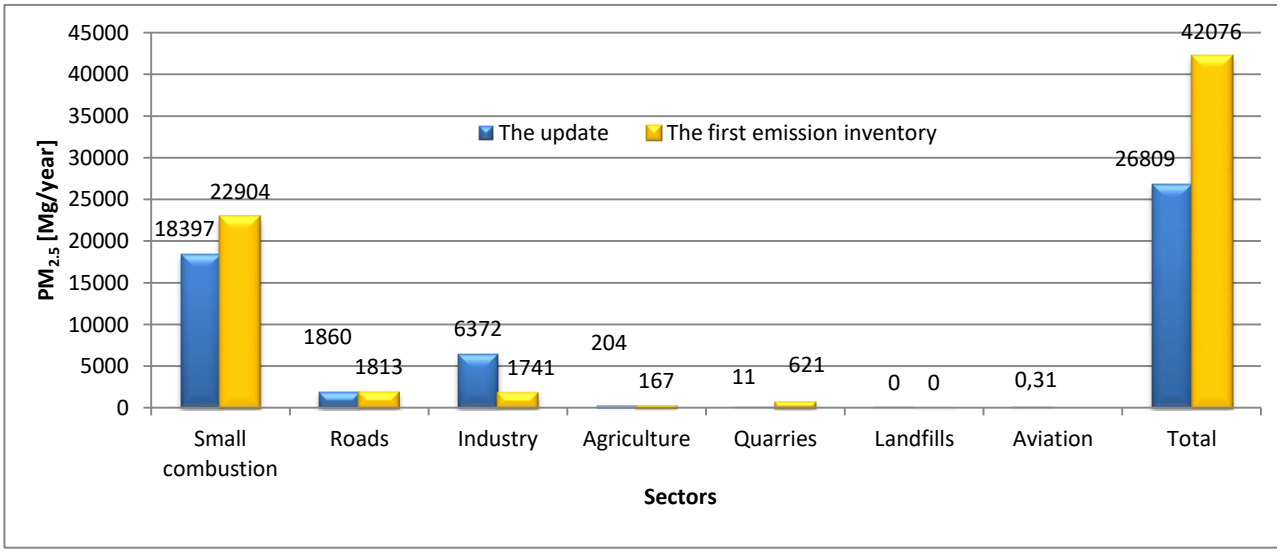
37	**Partesh**	11%	-8%	6%	-4%	-12%	67%
38	**Kllokot**	-11%	-16%	0%	-4%	-15%	-6%
	Kosovo	13%	-1%	10%	62%	-17%	-32%

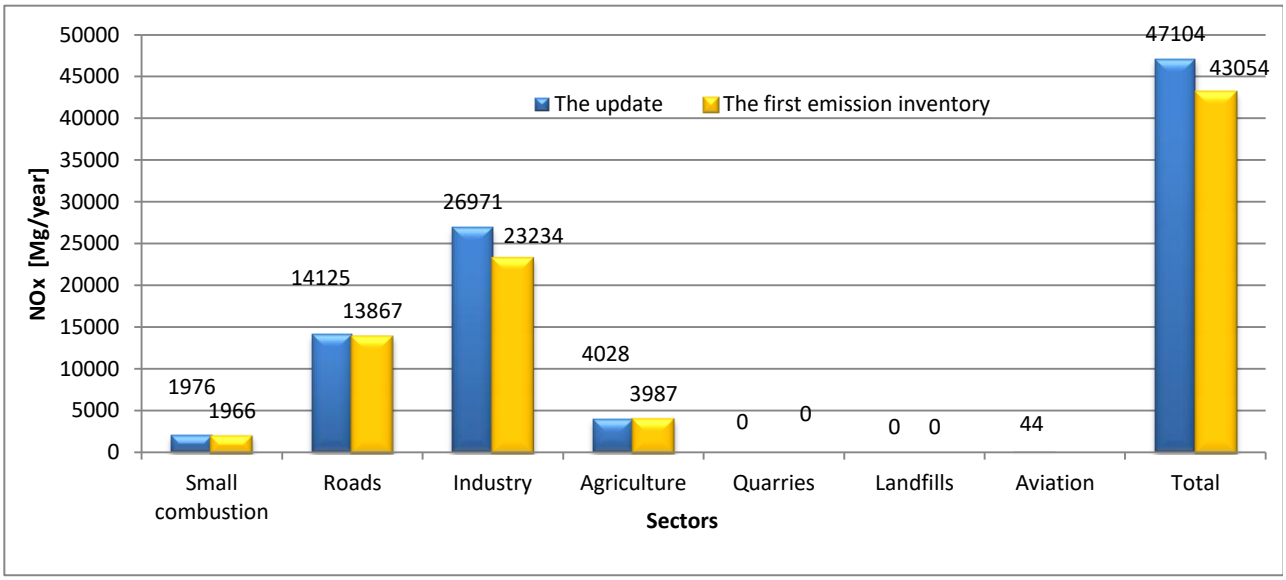
Emissions of all pollutants were reduced in most of municipalities mainly due to the reduction in emissions in small combustion sector. In some municipalities increased of NOx emission is observed where emissions from transport sector have a greater impact. A large increase of emission of most pollutants was calculated for Obiliq municipality due to the correction of emissions from power plants: Kosovo A and Kosovo B. Emissions form JICA's project[24] based on measurements were implemented in the update. In the case of NMVOC significant reduction is due to the correction of emissions from breeding.

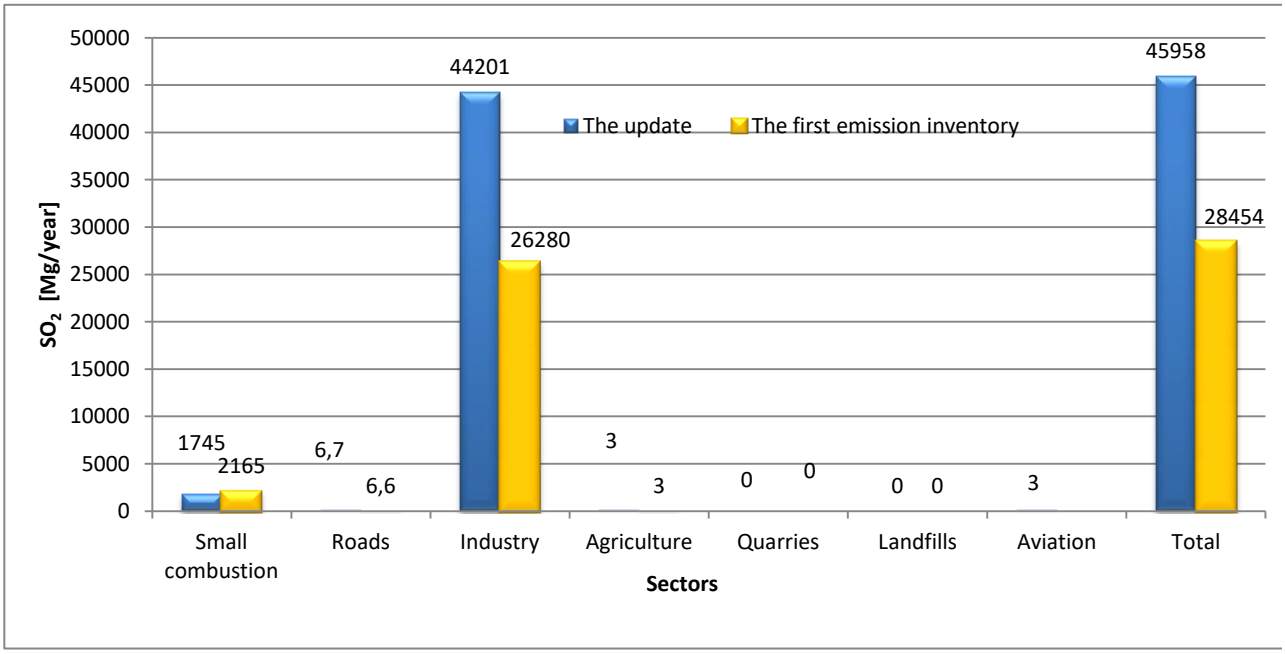
The figure below presents emission changes between the first emission inventory and the update for the main pollutants by sector. In the update emissions from small combustion sector have decreased, except for NOx, where emissions are almost the same. This is due to the introduction of more detailed emission factors for pellets and new wood facilities. Change in emission factor, based on measurements conducted by JICA in 2016, resulted in significant emission decreased from Kosovo power plants (industry sector). Emissions from roads for all pollutants increased due to the corrections of urban traffic in the update. Methodology for calculating emissions from mining and quarries was changed and emission factor from EMEP Guidebook was applied. This resulted in large drop in emissions. Changes in emissions in agriculture sector are due to the correction of emissions from breeding.

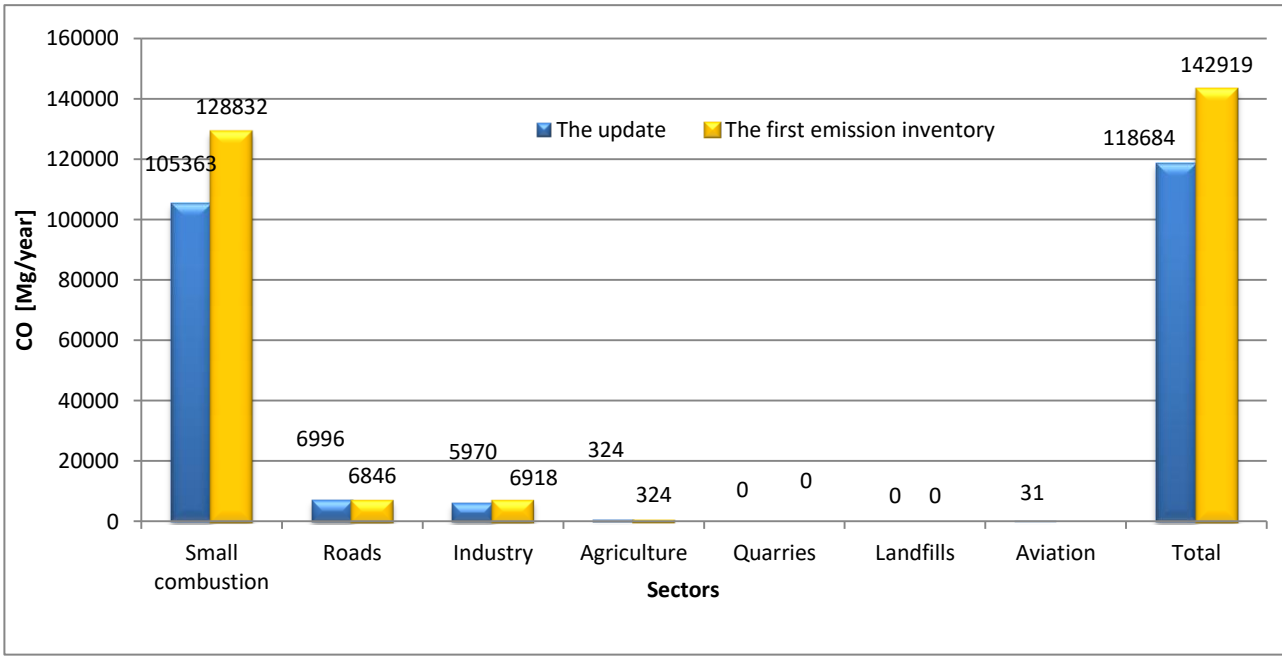


[24] *Republic of Kosovo; Expert for Air Pollution Control; Final Report; Japan International Cooperation Agency (JICA); JFE Techno-Research Corporation; May 2016*


45000
40000
35000
30000
25000
20000
15000
10000
5000
0
PM2,5 [Mg/year]
The update
The first emission inventory
18397
22904
1860
1813
6372
1741
204
167
11
621
0
0
0,31
26809
42076
Small combustion
Roads
Industry
Agriculture
Quarries
Landfills
Aviation
Total
Sectors


50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
NOx [Mg/year]
The update
The first emission inventory
1976
1966
14125
13867
26971
23234
4028
3987
0
0
0
0
44
47104
43054
Small combustion
Roads
Industry
Agriculture
Quarries
Landfills
Aviation
Total
Sectors


50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
SO2 [Mg/year]
The update
The first emission inventory
1745
2165
6,7
6,6
44201
26280
3
3
0
0
0
0
3
45958
28454
Small combustion
Roads
Industry
Agriculture
Quarries
Landfills
Aviation
Total
Sectors


160000
140000
120000
100000
80000
60000
40000
20000
0
CO [Mg/year]
The update
The first emission inventory
105363
128832
6996
6846
5970
6918
324
324
0
0
0
0
31
118684
142919
Small combustion
Roads
Industry
Agriculture
Quarries
Landfills
Aviation
Total
Sectors

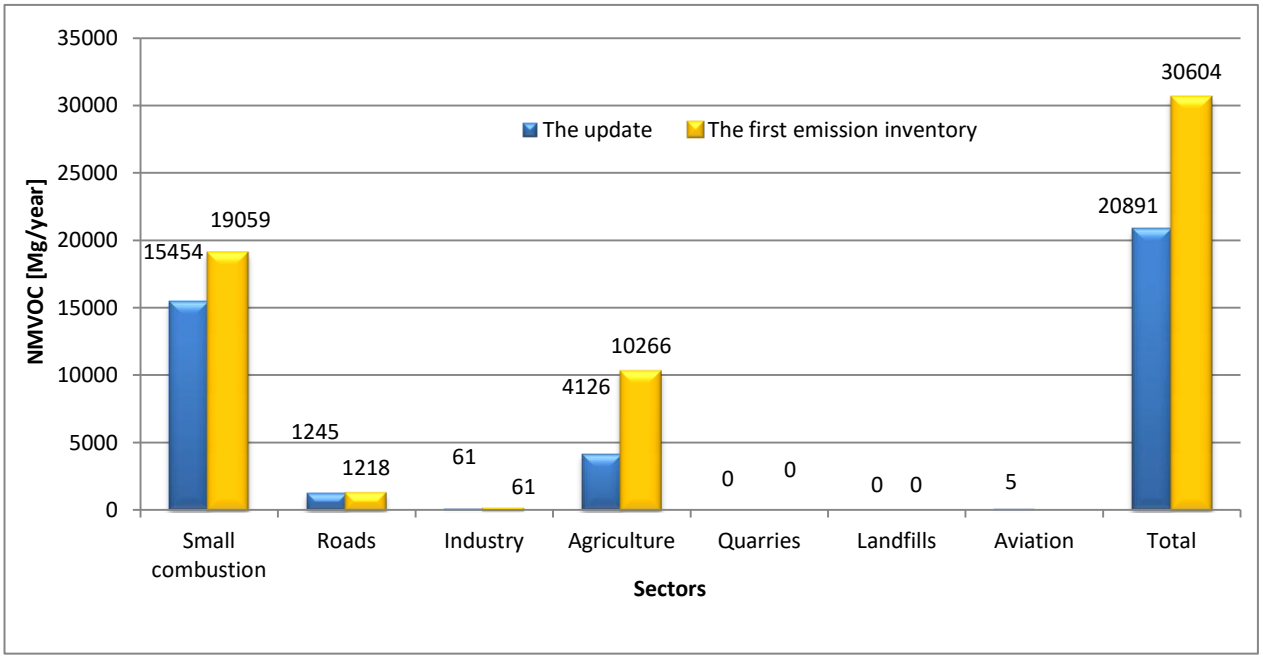


Figure 14 The changes in emission after the first update of emission inventory by sector

11.3 SECTORS EMISSION CONTRIBUTION ANALYSIS

Sectors contributions to emission of selected pollutants are presented in the pie charts below.

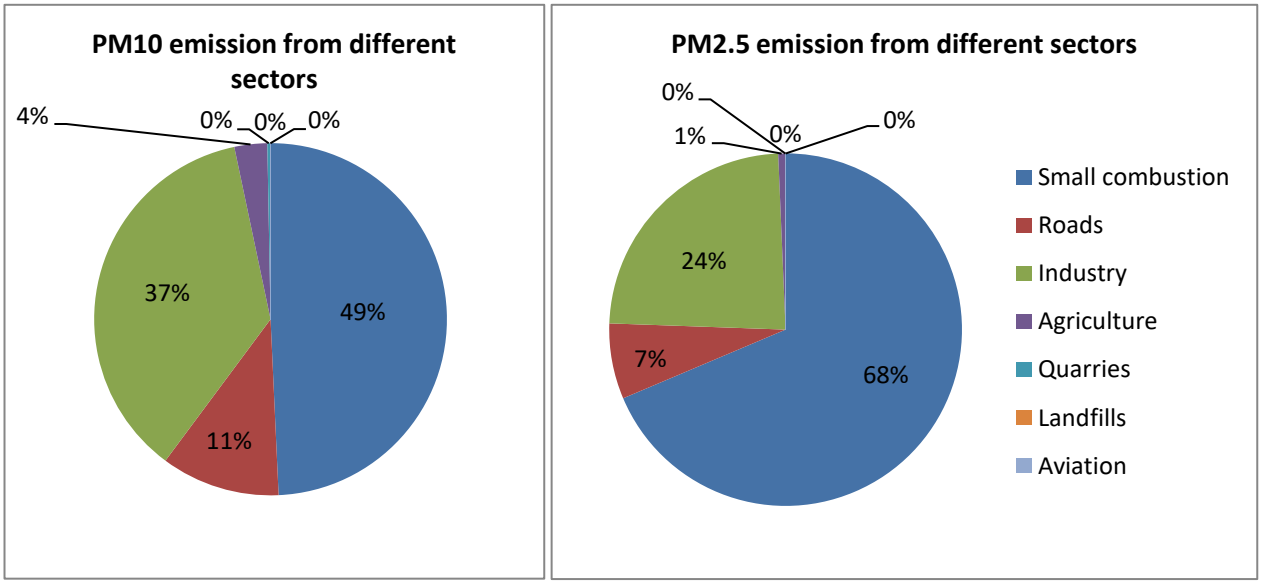


Figure 15 Share of individual sectors in PM emissions

Small combustion is the main emission source in the case of particulate matter. Almost 50% of PM_{10} and 68% of $PM_{2.5}$ come from domestic and service heating. Following the revision of emissions calculation for

Kosovo's power plant, industry is the second emission source with 37% for PM0 and 24% for $PM_{2.5}$ shares and traffic is the third emission source with 11% and 7% shares in emission respectively. The remaining sectors account for less than 5% of emissions. The industry has the largest share in SO_2 and NOx emissions (96% and 57% respectively). Road transport is the second significant source in the case of NOx emission (30%). Small combustion (domestic and services heating) is the main emission source in the case of CO and NMVOC (89% and 57% respectively). Agriculture is the second source of NMVOC emission (20%).

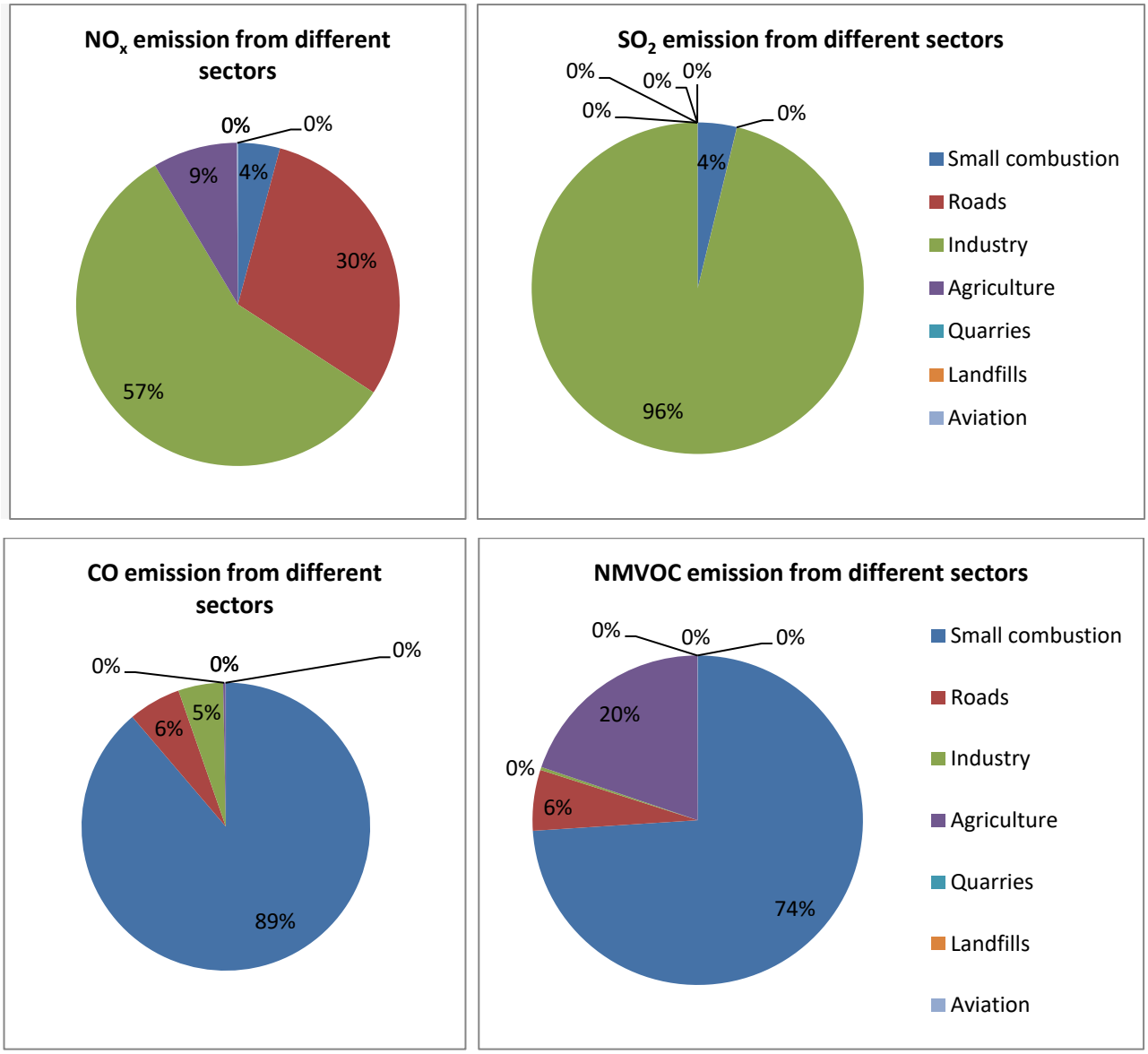


Figure 16 Share of individual sectors in gaseous pollutants emissions

Small combustion is the main source of heavy metals emission. However, emissions of heavy metals from industry are not included.

11.4 SPATIAL DISTRIBUTION OF EMISSION

Spatial distribution of emission is presented in the following maps:

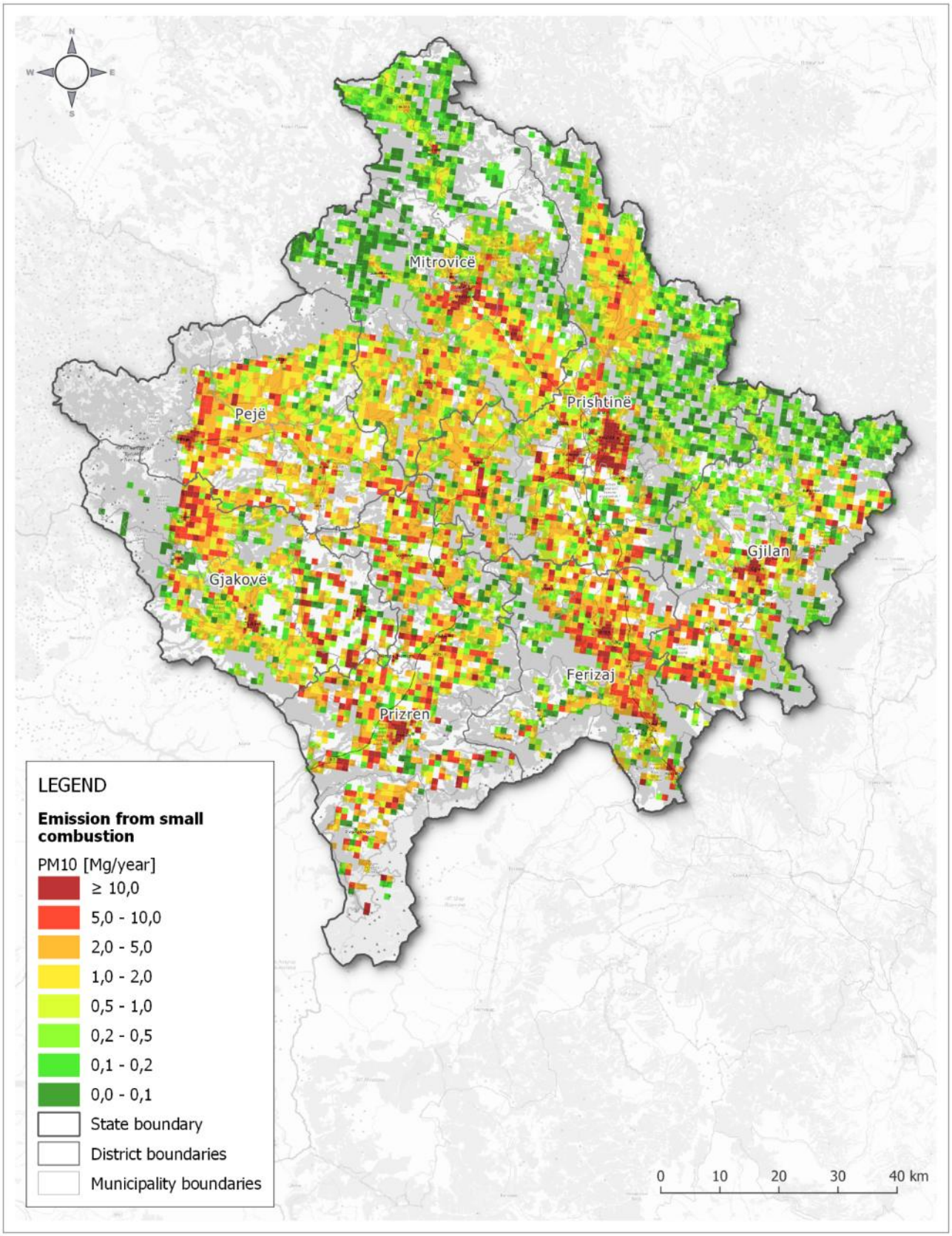


Figure 17 Annual emission of PM_{10} from small combustion (domestic, public and business services)

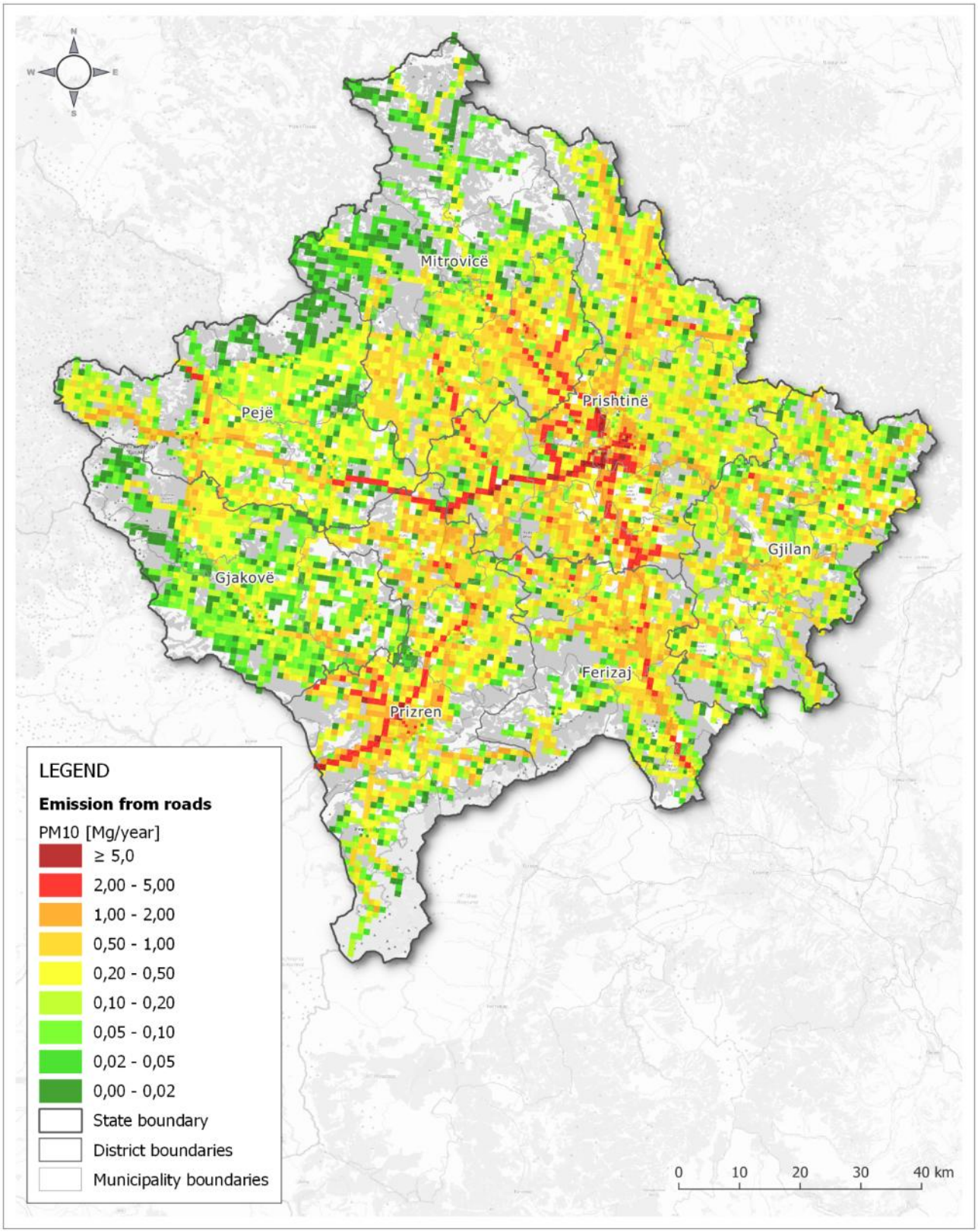


Figure 18 Annual emission of PM_{10} from transport (roads)

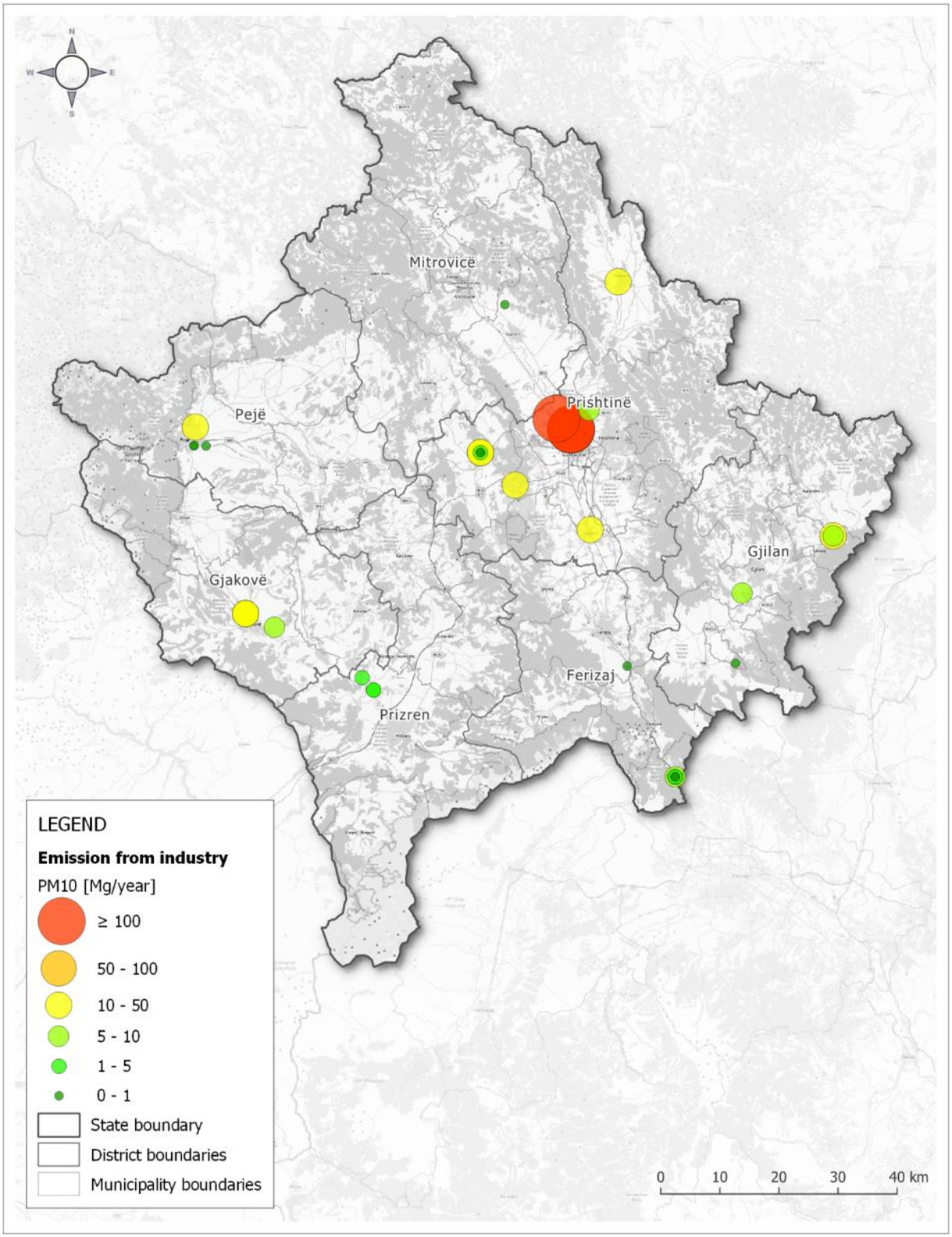


Figure 19 Annual emission of PM_{10} from industry

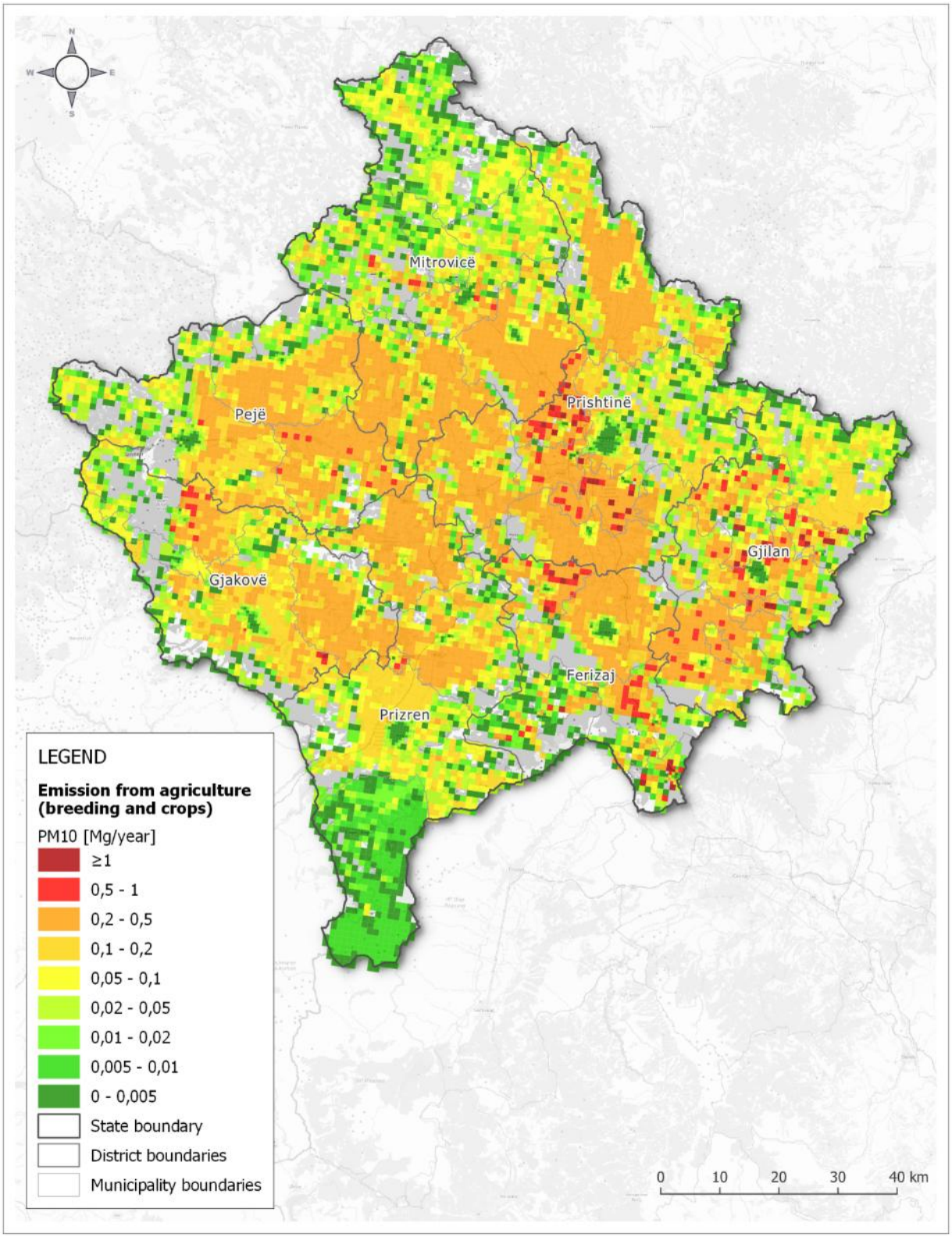


Figure 20 Annual emission of PM_{10} from agriculture

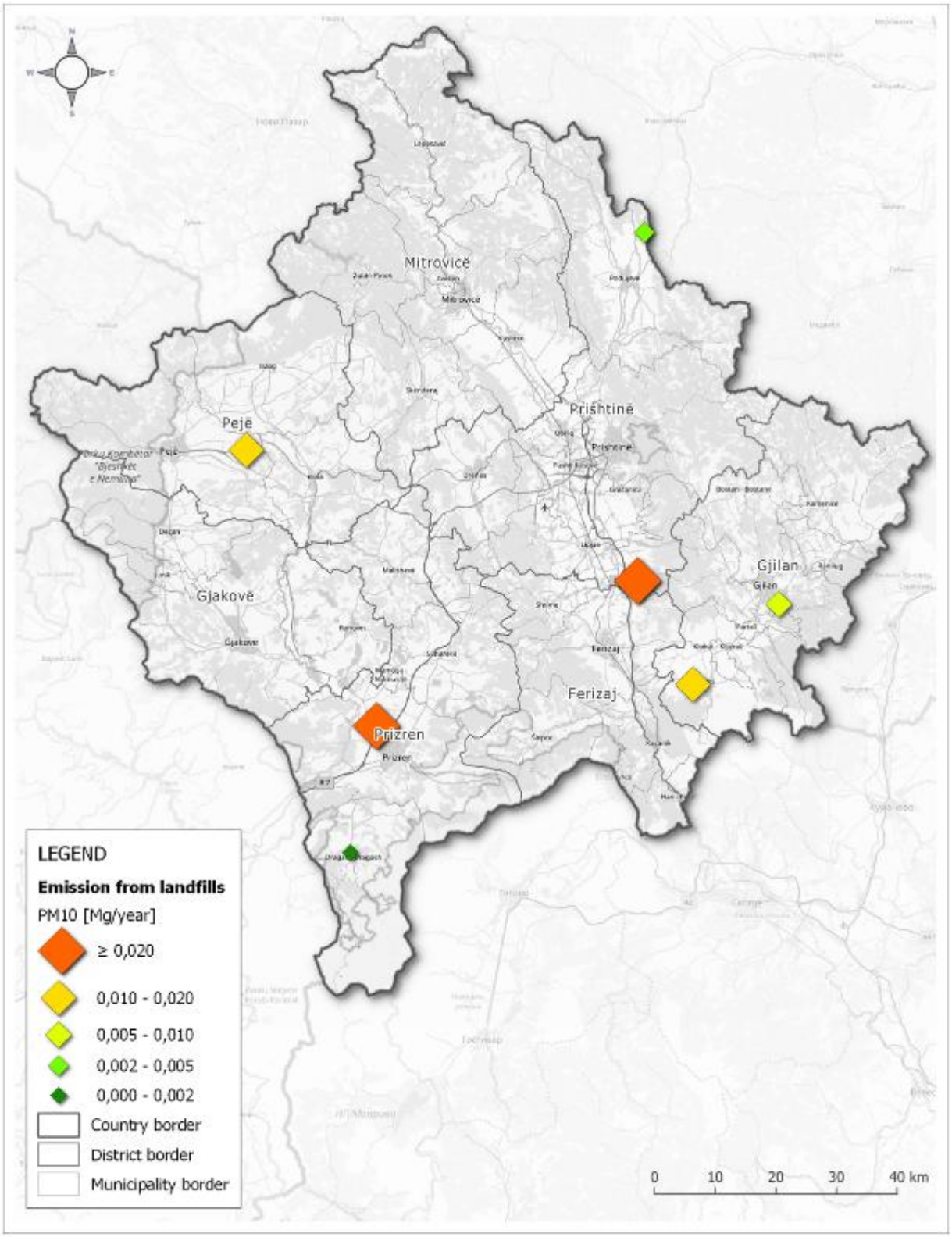


Figure 21 Annual emission of PM_{10} from landfills

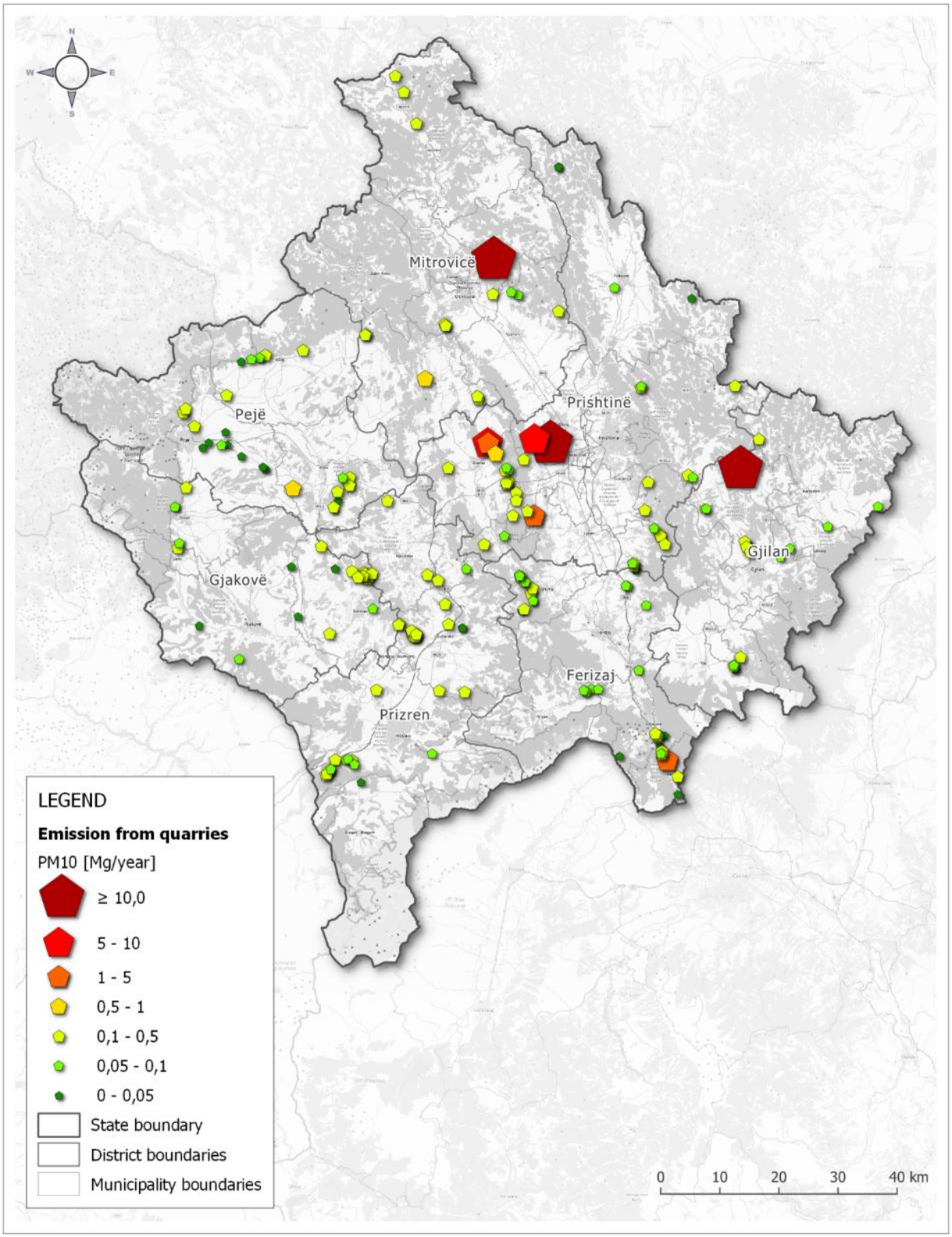


Figure 22 Annual emission of PM_{10} from mines and quarries

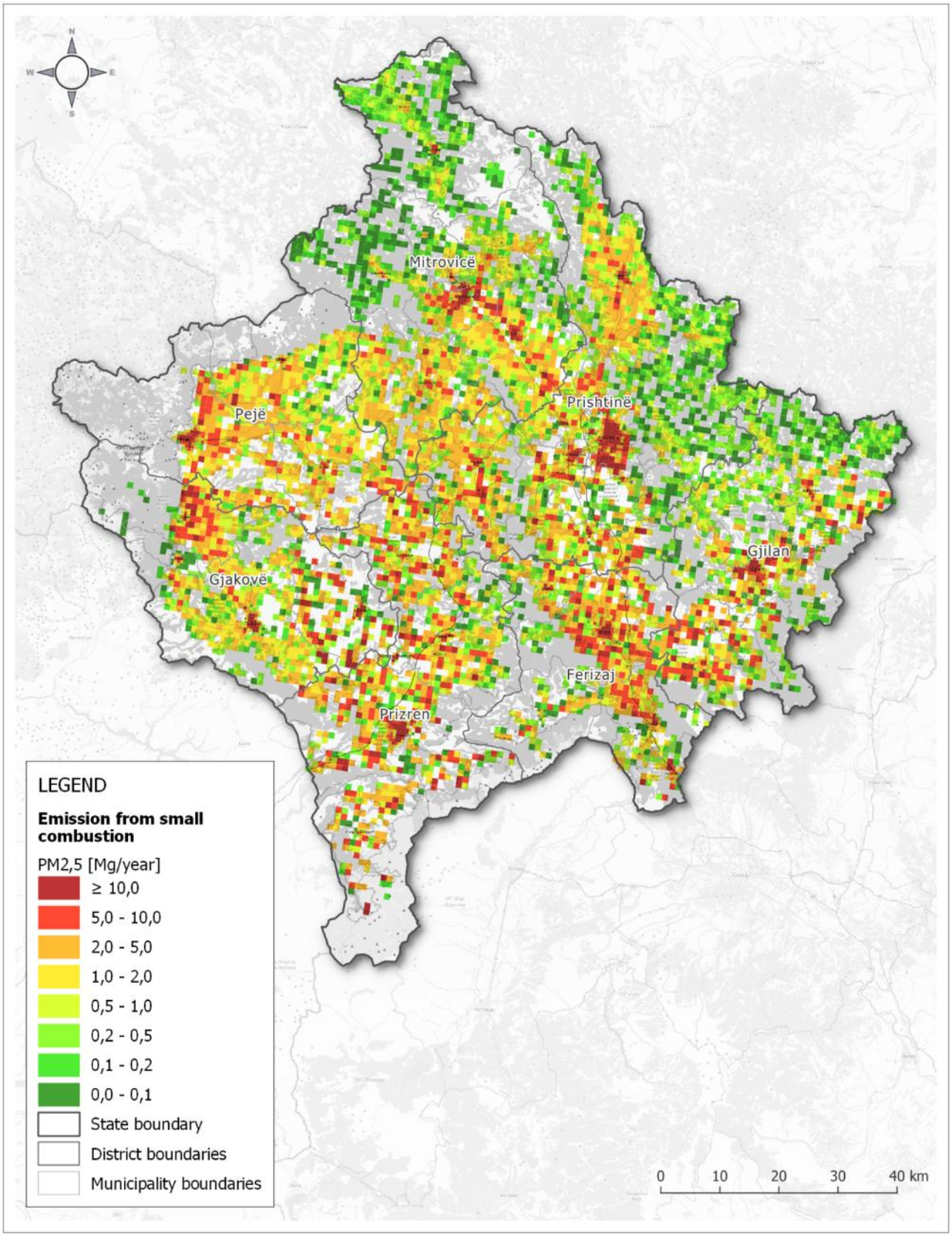


Figure 23 Annual emission of $PM_{2.5}$ from small combustion (domestic, public and business services)

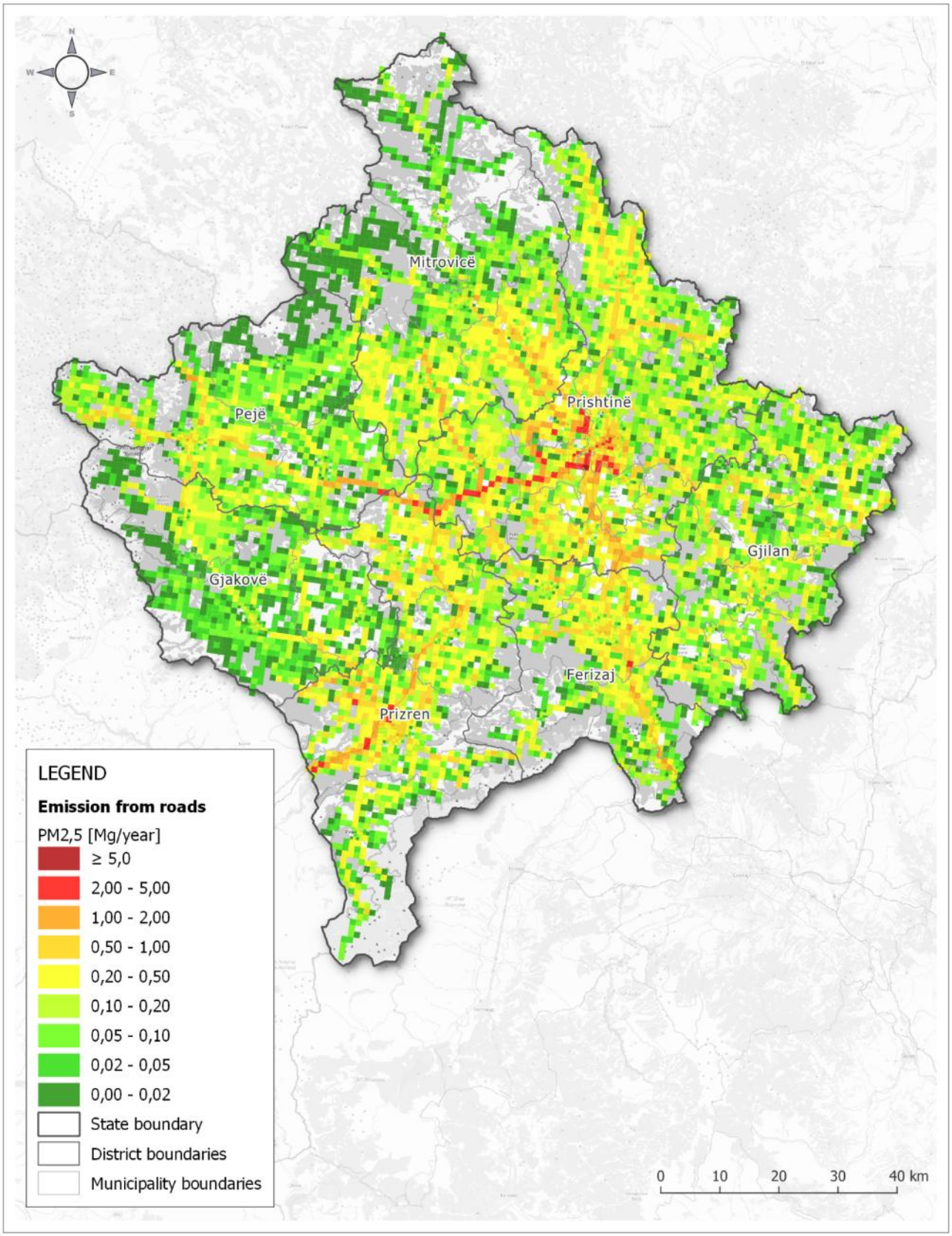


Figure 24 Annual emission of $PM_{2.5}$ from transport (roads)

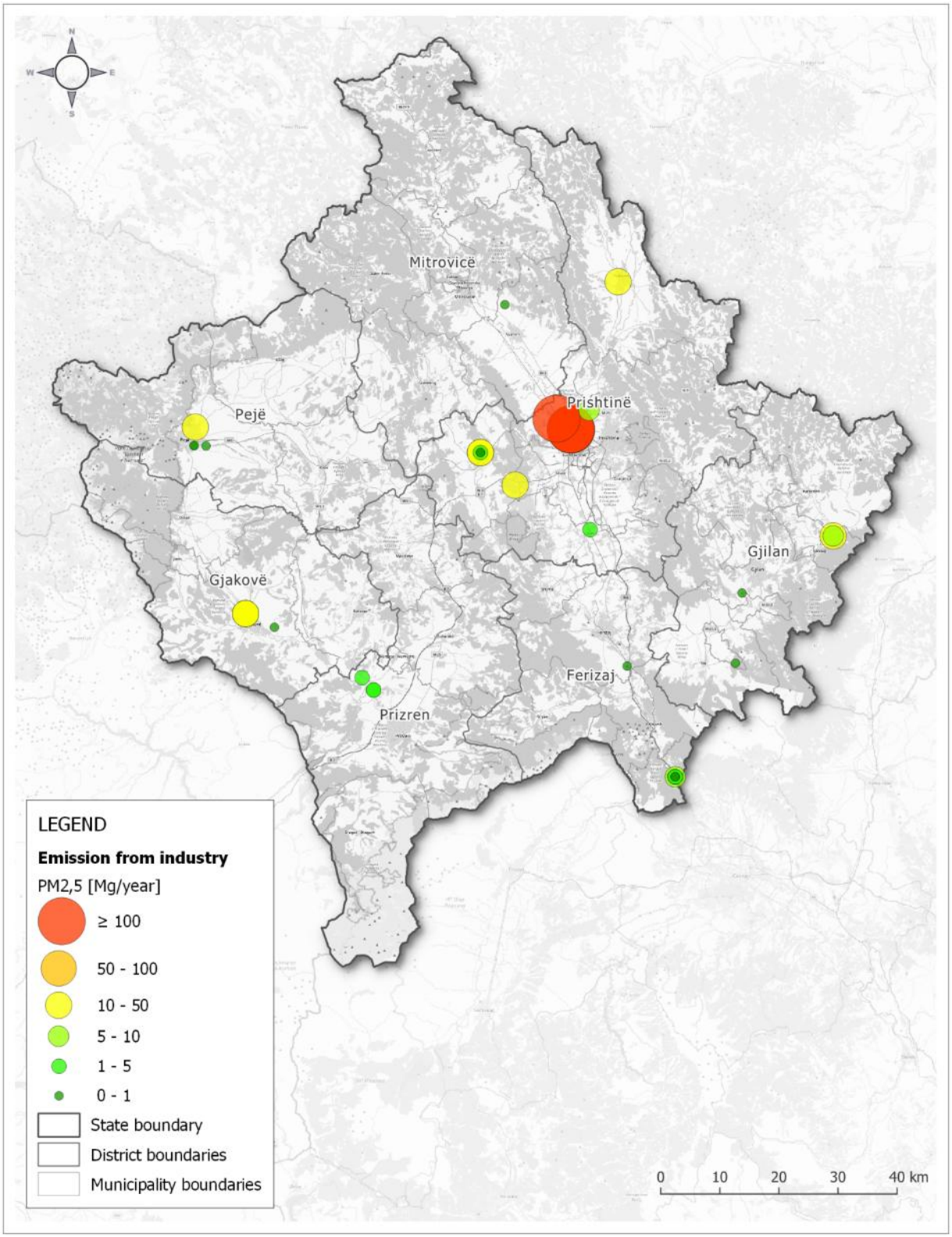


Figure 25 Annual emission of $PM_{2.5}$ from industry

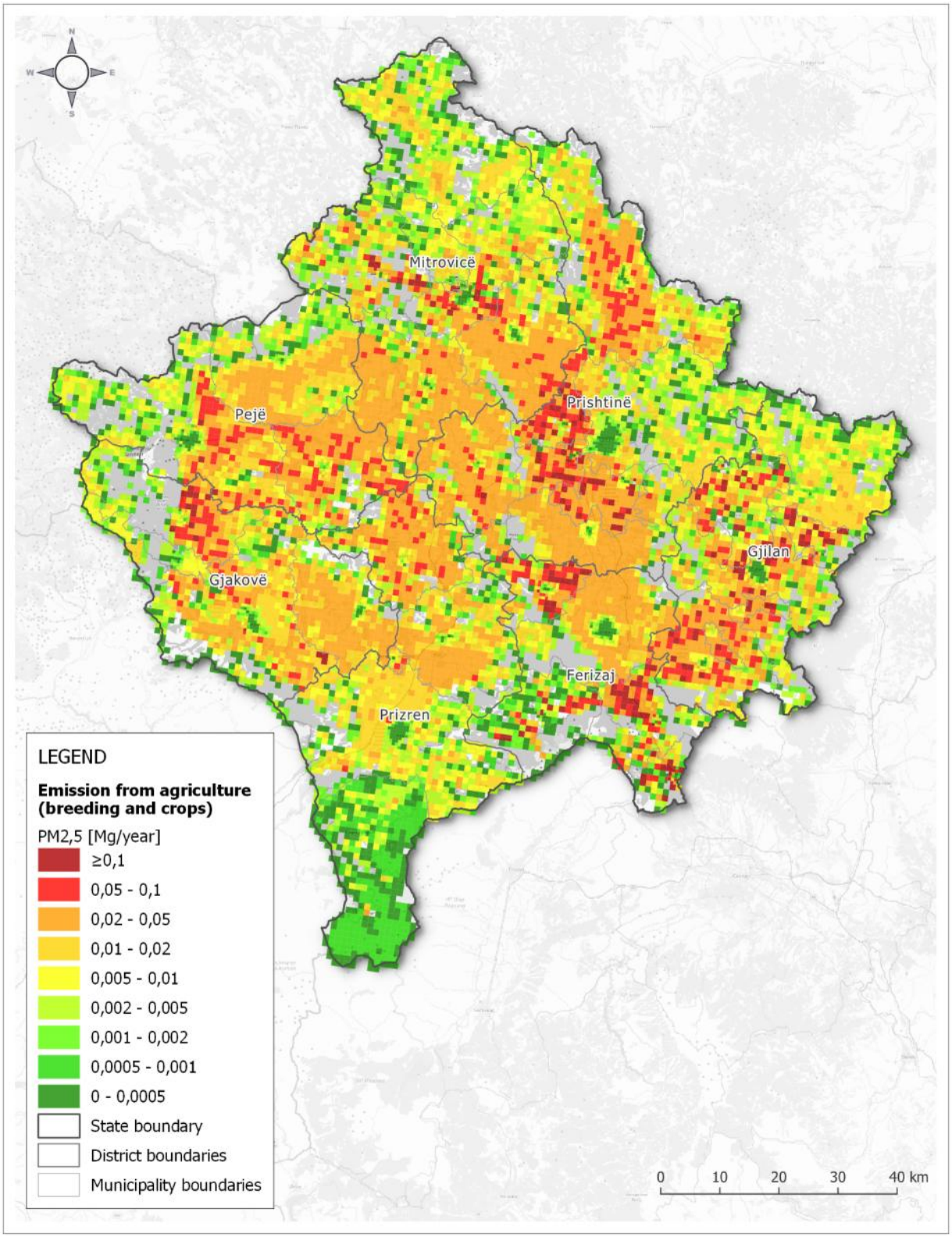


Figure 26 Annual emission of $PM_{2.5}$ from agriculture

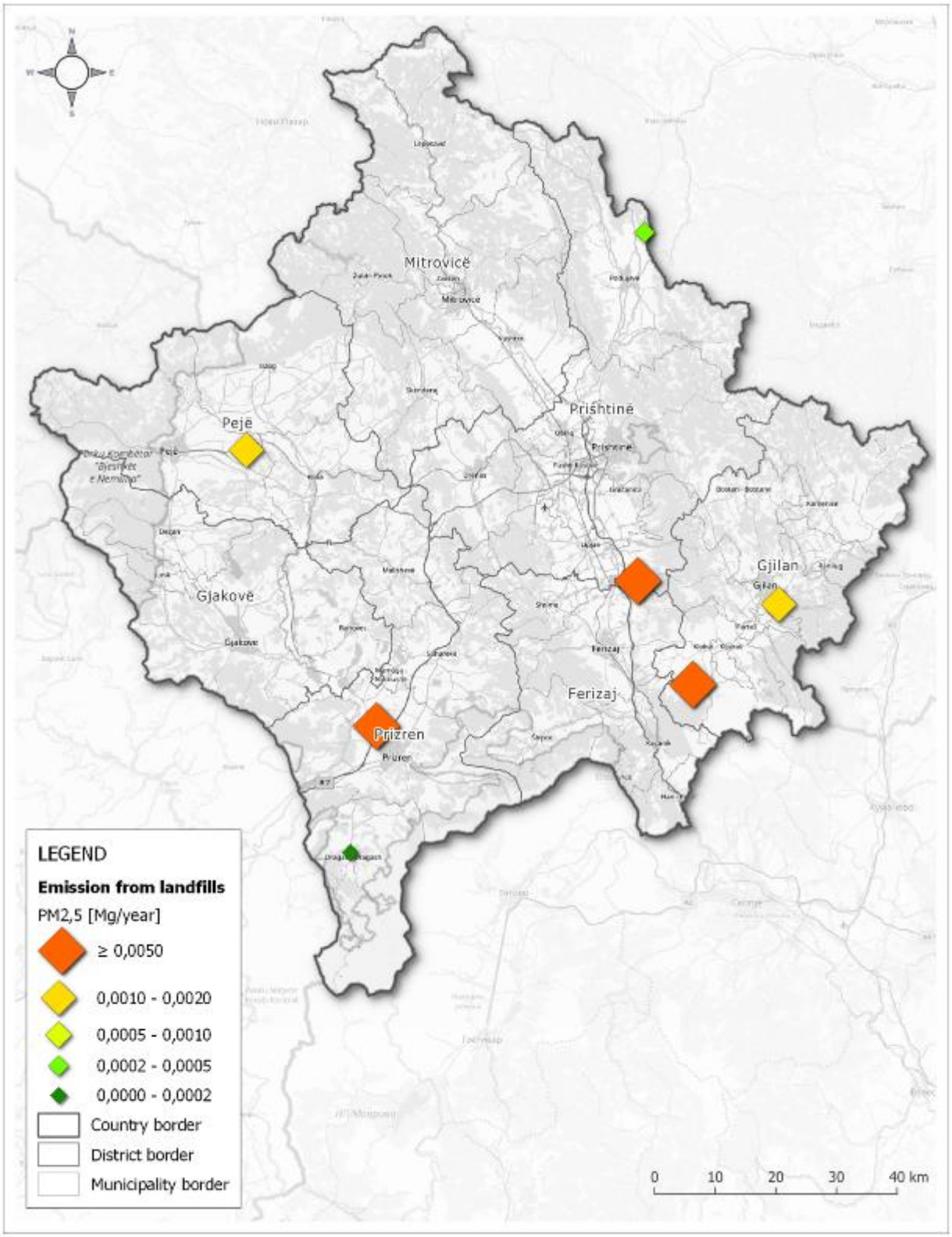


Figure 27 Annual emission of $PM_{2.5}$ for other sources – landfills

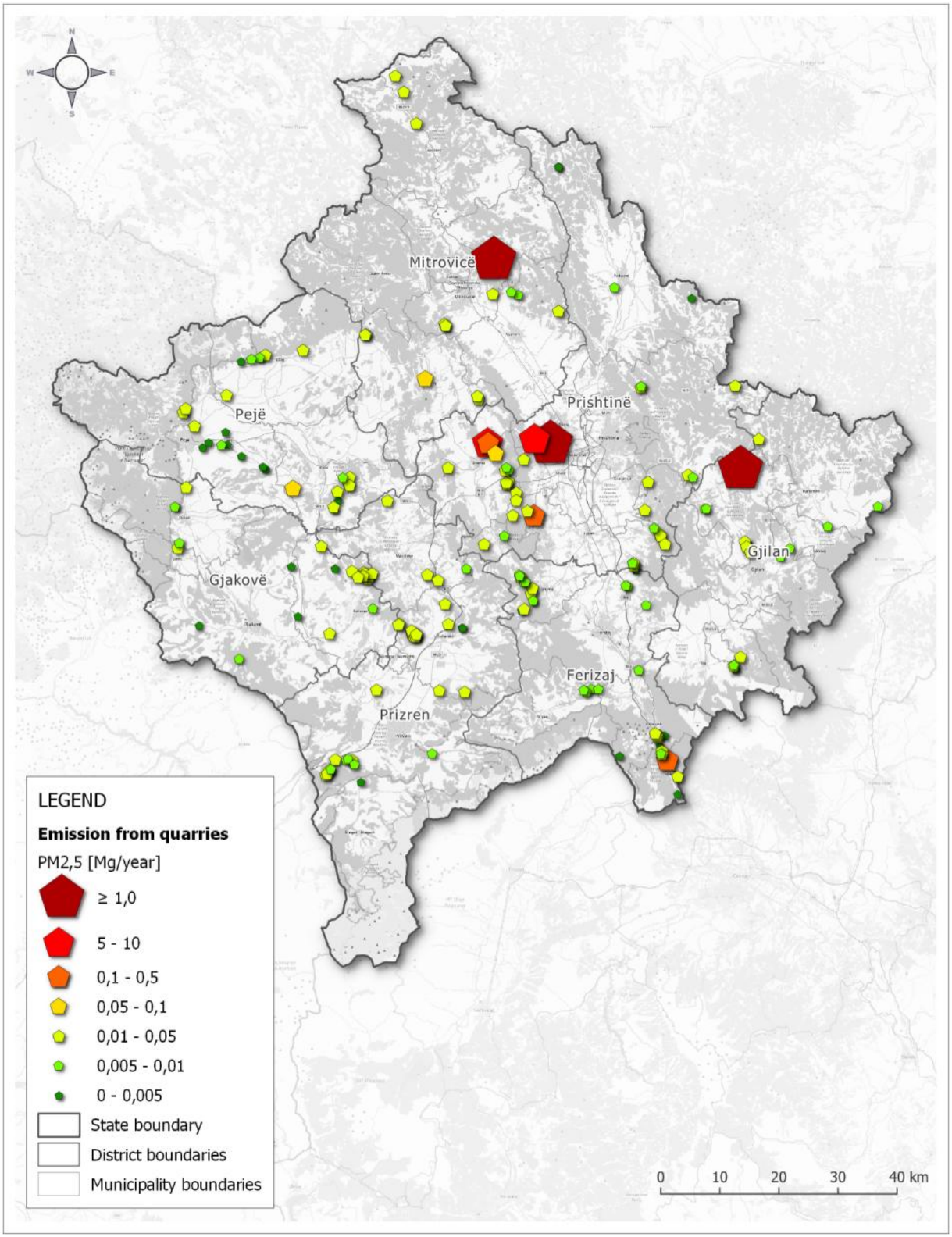


Figure 28 Annual emission of $PM_{2.5}$ from mines and quarries

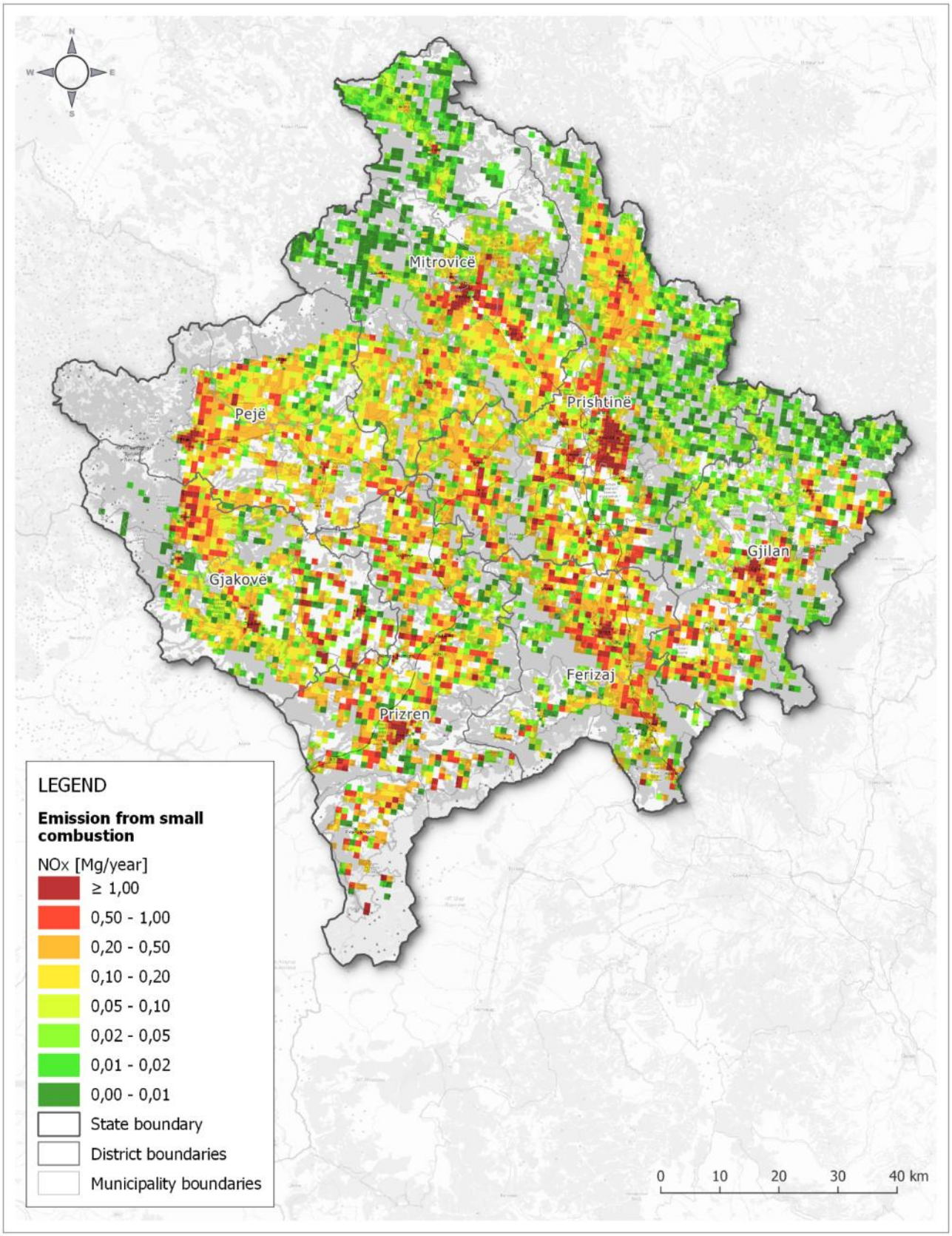


Figure 29 Annual emission of NOx from small combustion (domestic, public and business services)

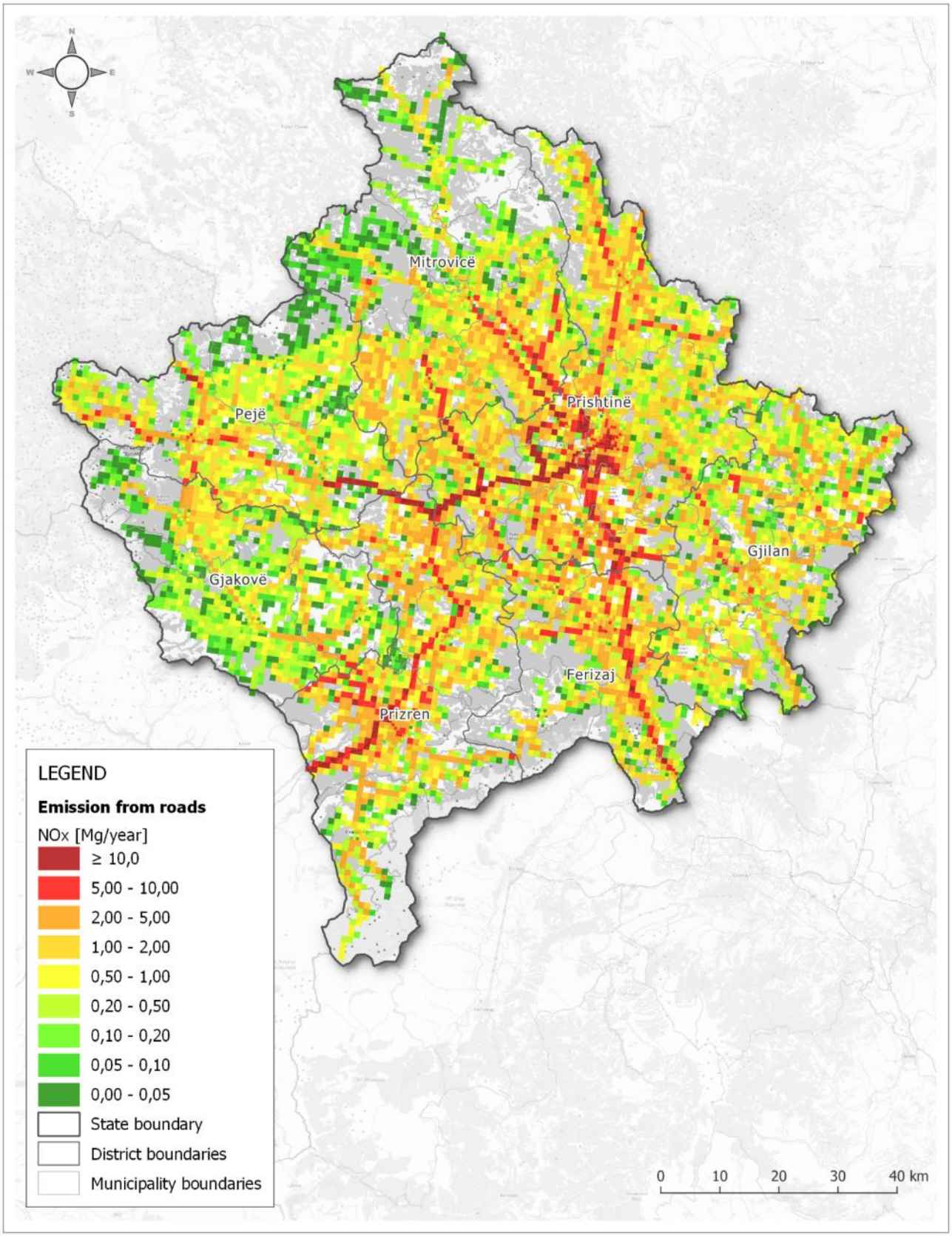


Figure 30 Annual emission of NOx from transport (roads)

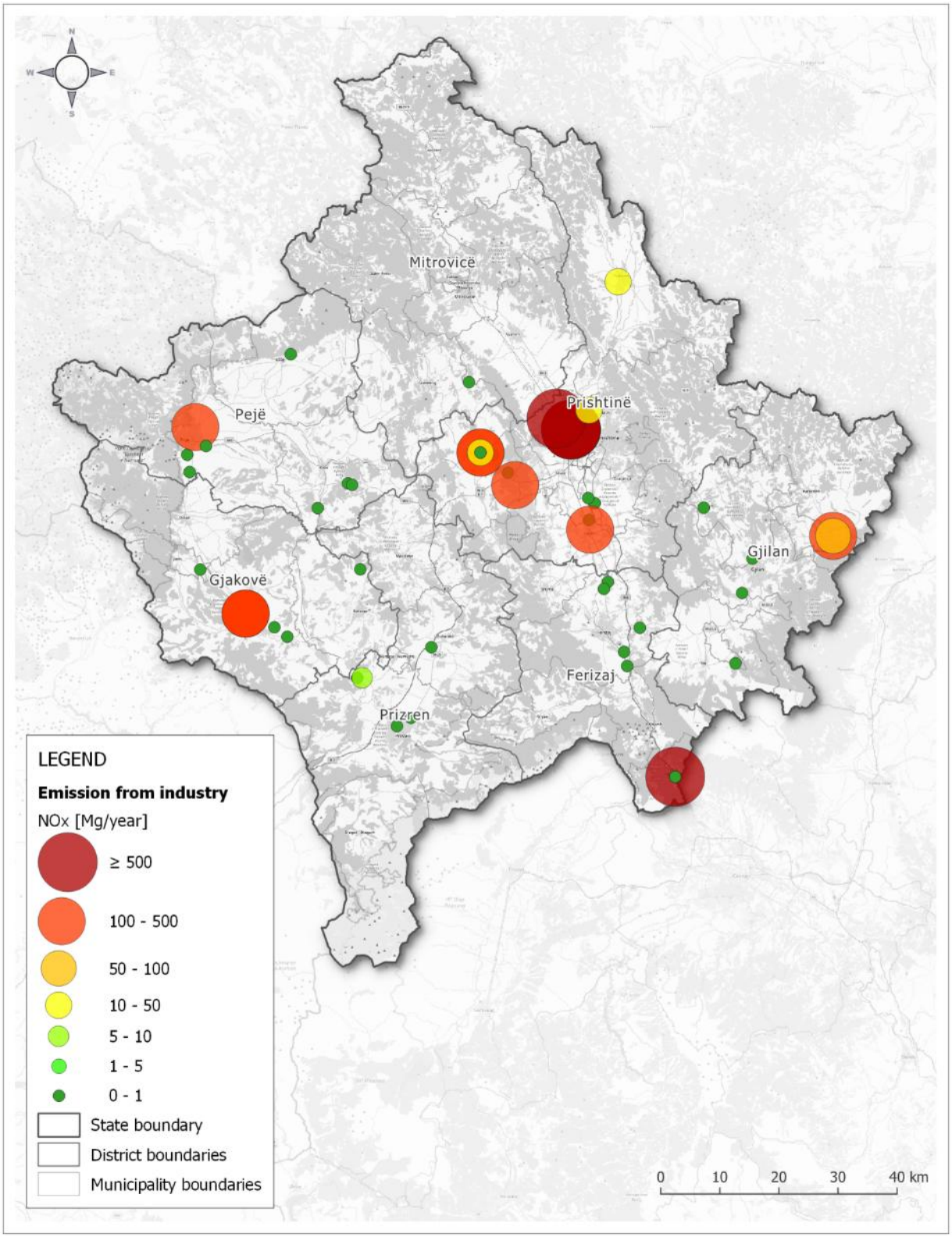


Figure 31 Annual emission of NOx from industry

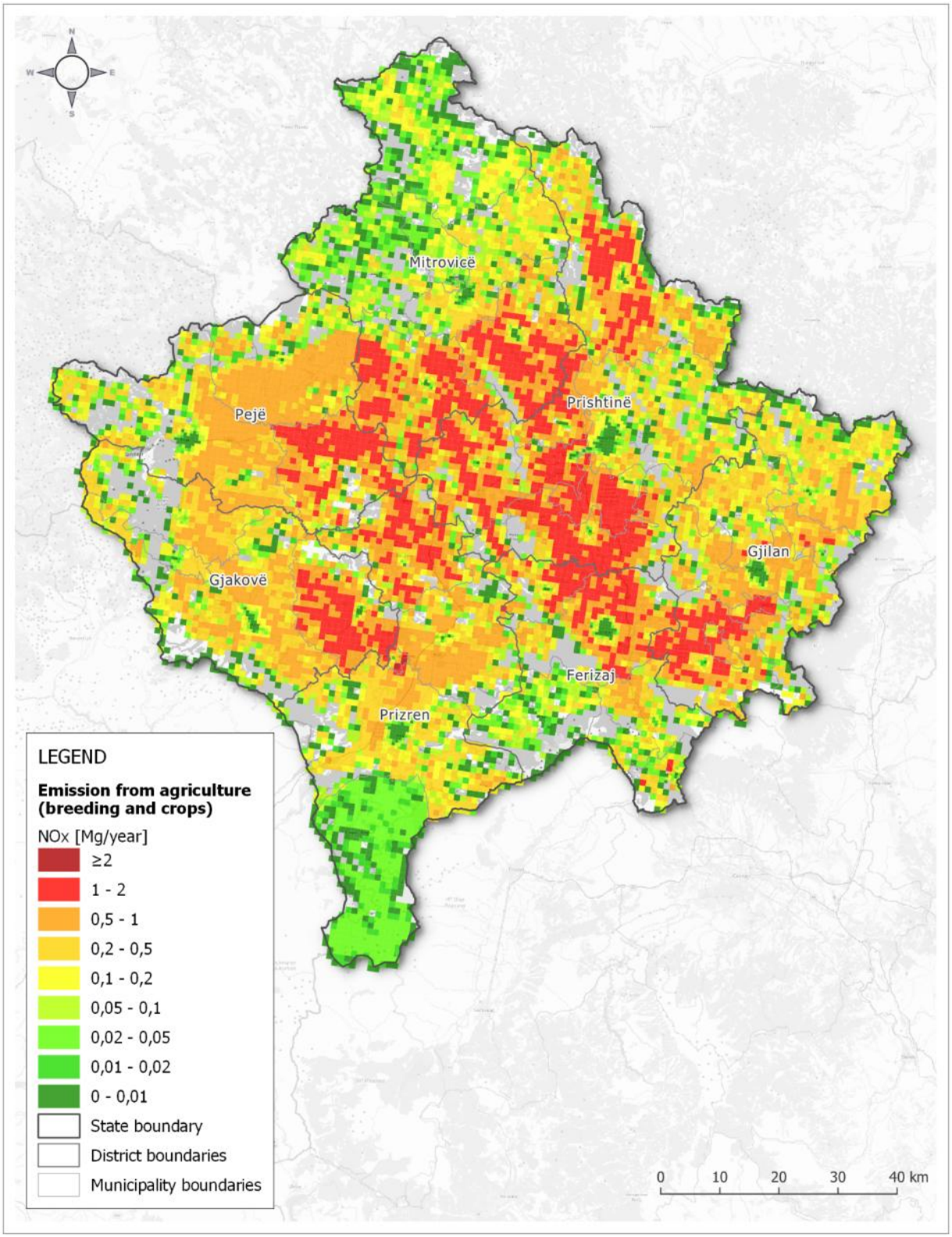


Figure 32 Annual emission of NOx from agriculture

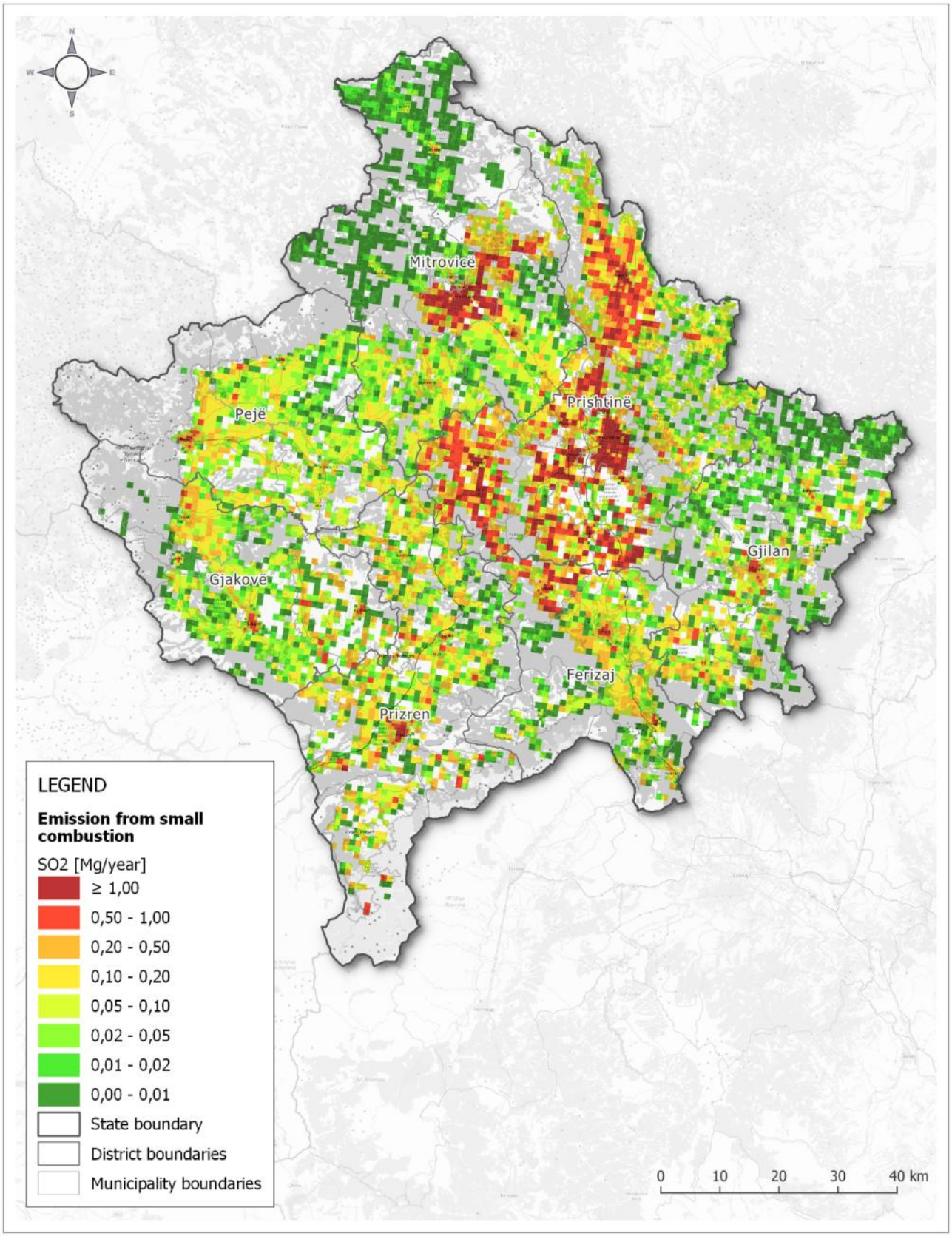


Figure 33 Annual emission of SO_2 from small combustion (domestic, public and business services)

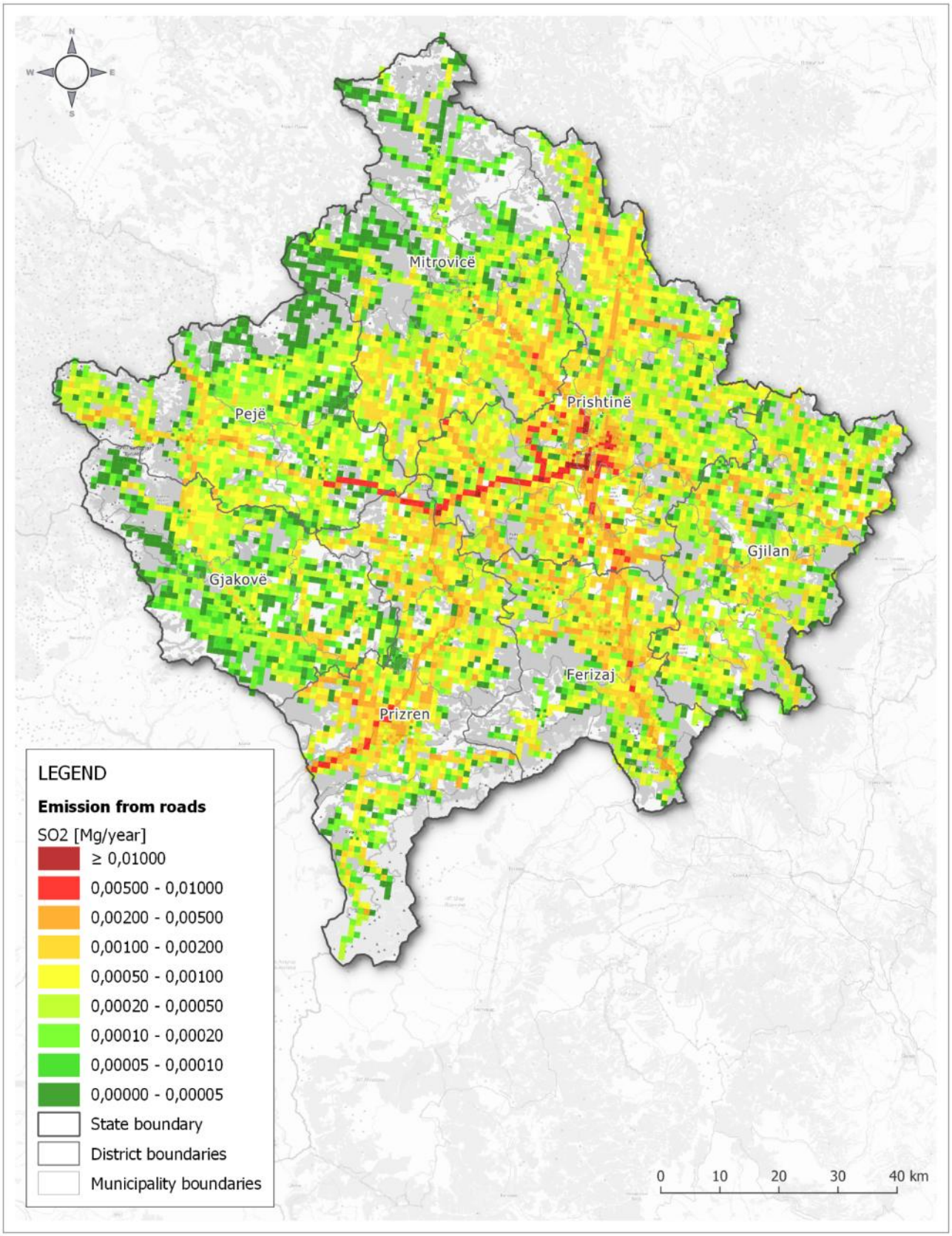


Figure 34 Annual emission of SO_2 from transport (roads)

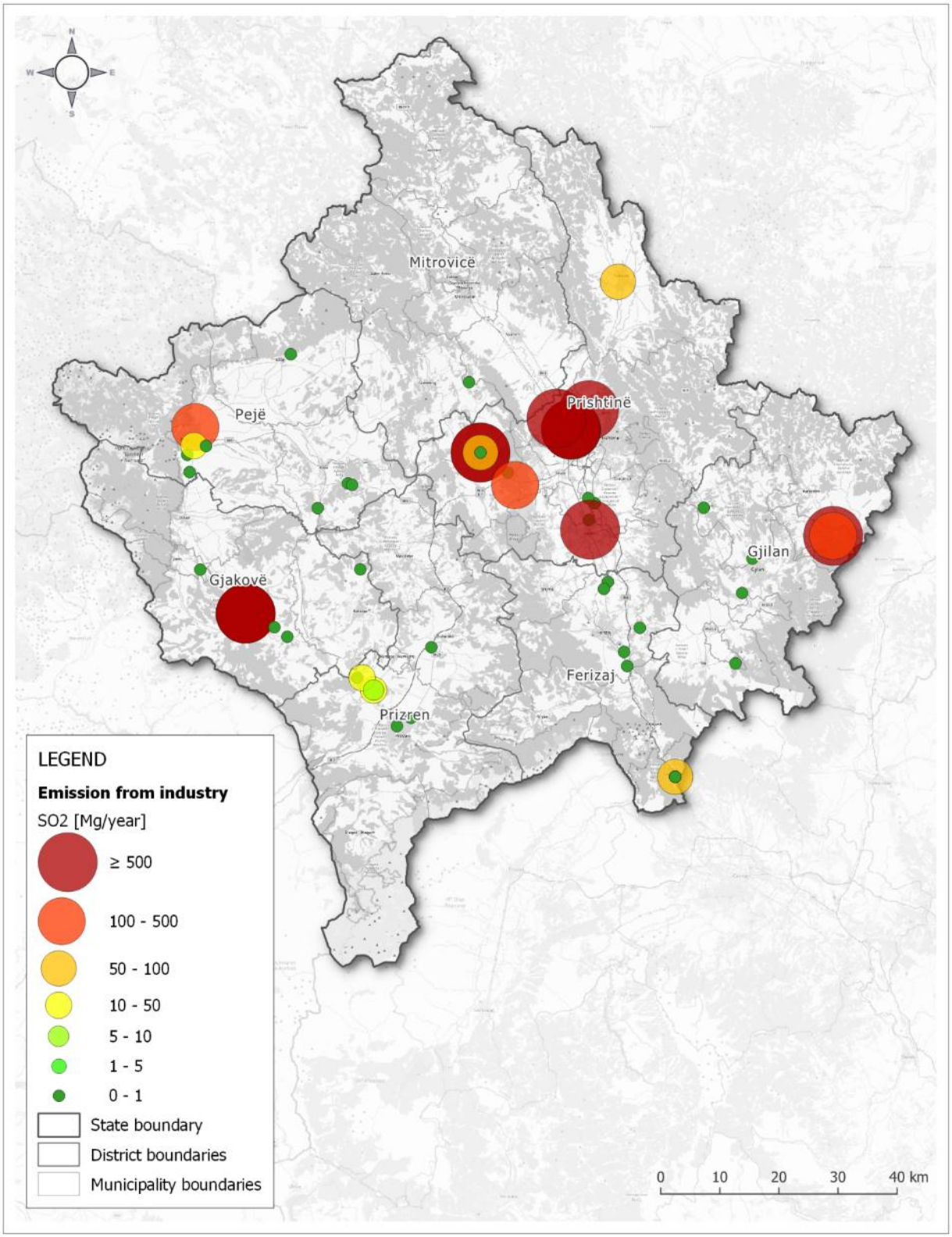


Figure 35 Annual emission of SO_2 from industry

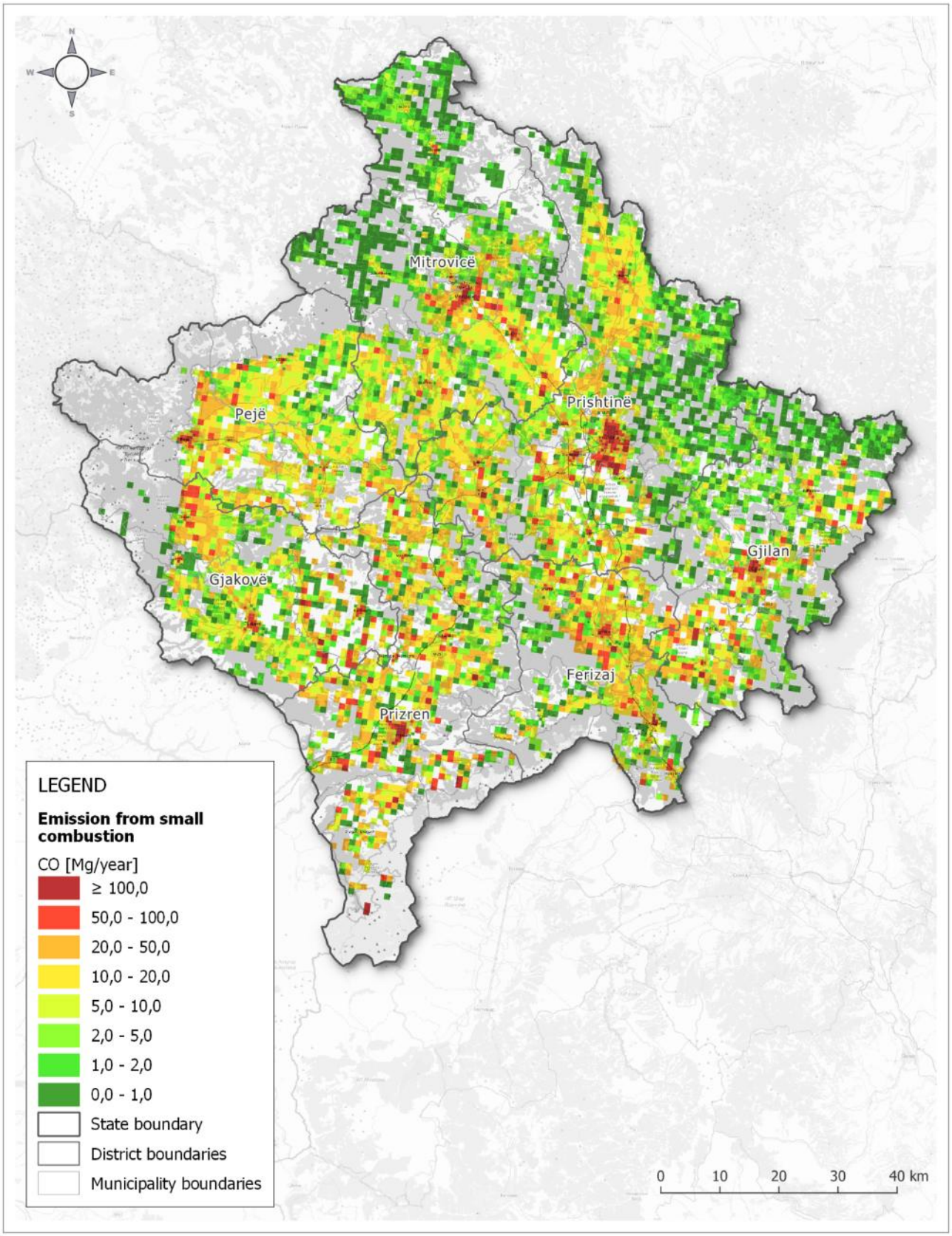


Figure 36 Annual emission of CO from small combustion (domestic, public and business services)

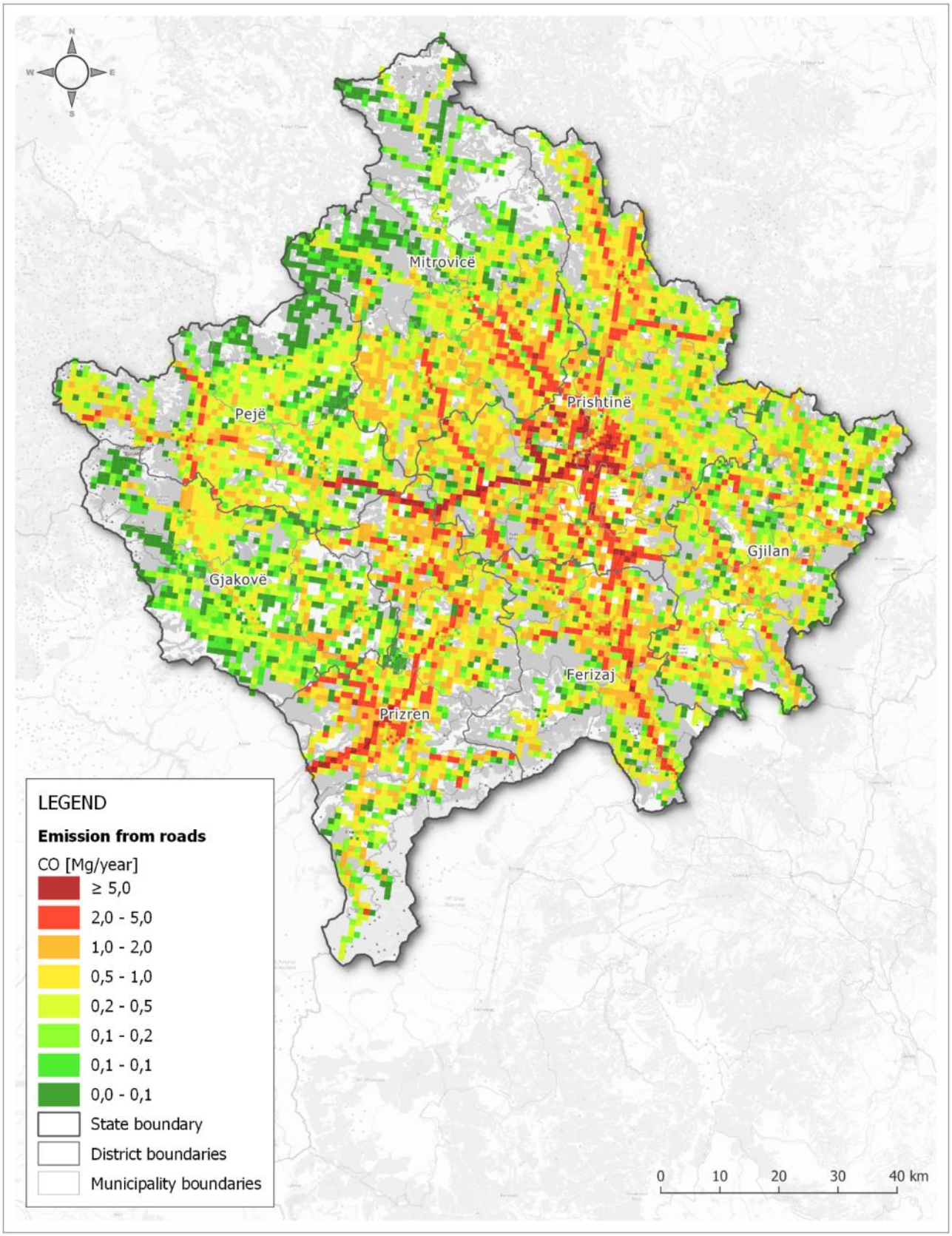


Figure 37 Annual emission of CO from transport (roads)

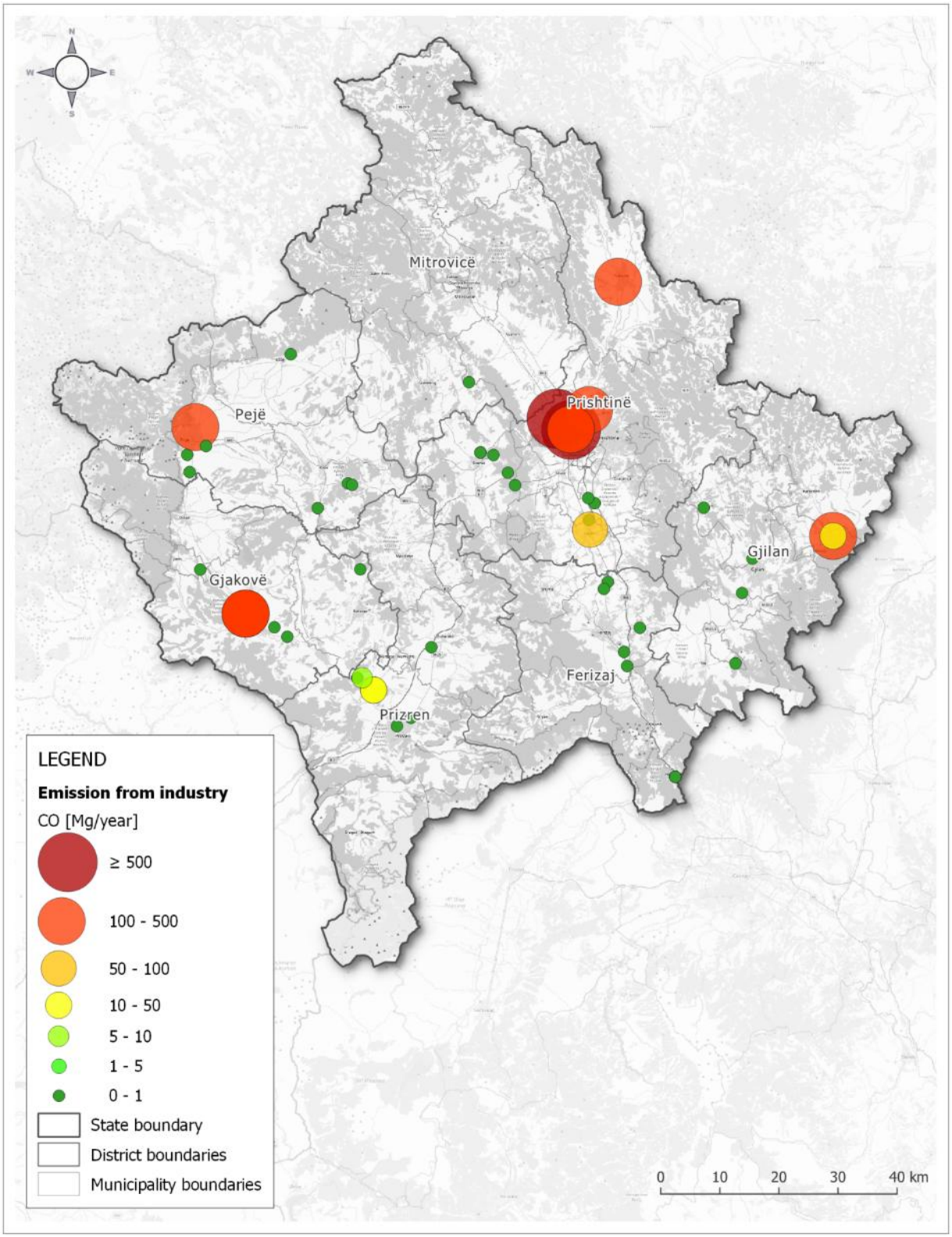


Figure 38 Annual emission of CO from industry

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