Spatial modeling of greenhouse gas emissions from burning biomass in the residential sector in Volyn region

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Abstract – Spatial model of greenhouse gas emissions from burning biomass in the residential sector in Volyn region is developed. The results of modeling are analysed. The major emission sources are located. Based on performed numerical experiments the digital map and georeferenced databases, containing information about the sources and evaluation of the greenhouse gas emissions, are obtained.

Key words – spatial modeling, residential sector, greenhouse gas emissions, biomass, Volyn region, global warming.

I. Introduction

The energy demand has increased with the development of human society. The largest amount of greenhouse gases (GHG) are emitted in energy sector from burning fossil fuels in order to meet the energy needs of the population. As a result, the concentration of greenhouse gases in the atmosphere has increased by 40% compared to pre-industrial period [1].

In order to solve the problem of GHG emission reduction the effective inventory tools in all sectors of human activity are needed. Residential sector is one of the most considerable sector for GHG emissions reduction. Nowadays several GHG emission inventory approaches in the residential sector are developed [1-3]. But they do not take into account the difference between the energy needs of the population in rural and urban areas. Besides that the approach proposed in [4] makes only the assumption that biomass as well as coal and peat briquettes are burnt mostly in rural areas. Therefore the spatial modeling of GHG emission from burning biomass in the residential sector remains an open challenge.

II. Spatial inventory of greenhouse gas emissions in the residential sector

Spatial inventory of greenhouse gas emissions consists in identification of amounts of fossil fuel burnt in the residential sector and spatial localization of the GHG emission sources with corresponding amounts of emissions. The GHG emission coefficients from burning fossil fuels vary by region as they depend on the fuel type and its chemical characteristics. The burning technology in the household sector does not differ much in different settlements therefore it has no spatial effect on the emission factors. While estimating the GHG emissions for every elementary object (city, town or village) it is almost impossible to calculate the emissions for every house or dwelling. Furthermore such detailed information is not necessary for analyzing spatial GHG emissions for exact region or district. Therefore we consider the settlement as an elementary object. At the level of elementary objects the GHG emissions are determined as sum of GHG emissions from all sources that are contained by this object.

The greenhouse gas emissions in the residential sector depend on the amount of fuel burned by the population in order to meet energy needs. Energy can be obtained from centralized energy sources or from burning fossil fuels. The choice of energy source depends on the level of its' accessibility. The percentage of living area with centralized gas supply, central heating and hot water supply in cities and towns is higher compared to rural areas. Therefore the amount of energy consumed from these sources in urban areas is higher. In rural areas the living conditions differs from those in cities and towns. In these areas much of the energy needs are provided from burning fossil fuels (coal, wood and liquefied petroleum gas) due to the low availability of central energy supply sources.

III. Case-study for Volyn region

The percentage of living area with access to central heating and hot water supply in the Volyn region in urban areas is 71.5% and 50.1% respectively. In rural areas these indicators are even lower (31.3% and 17.7%, respectively) [5]. Although these indicators are not much different from the average for Ukraine, a large part of the population covers their energy needs from burning fossil fuels. Volyn region is one of the leaders in Ukraine in the consumption of the biomass. In 2010 about 82.1 thousand density m^3 was sold to the residential sector. Emission coefficients of greenhouse gases from burning wood is almost twice higher than the corresponding emission factors for natural or liquefied gas and a net calorific value is three times lower. This means that the amount of GHG emissions from burning wood in order to produce a unit of energy are twice higher, than the GHG emissions from burning natural gas to produce the same amount of energy.

Based on the available statistical data of fossil fuel consumption and living conditions [5], using population map for Ukraine [6] and heating degree-days map [7] we developed approach and mathematical model for greenhouse gas emissions estimation from burning biomass in the residential sector of Volyn region. The developed methodology for spatial inventory of greenhouse gas emissions from burning biomass in the residential sector consists of three steps that are performed for every elementary object: (1) assessment of energy demand; (2) disaggregation of the data about burnt biomass; (3) greenhouse gas emissions calculation.

The amount of biomass that is consumed in the residential sector is disaggregated from the regional level to level of elementary objects proportional to the amount of energy that is not provided from the centralized energy sources. The affiliation to urban or rural areas, population density and regional specificity of the statistical information are taken into account. The results of spatial modeling of greenhouse gas emissions are analyzed and

the major sources of emissions are localized using the GIS (geographic information system) tools. (Fig. 1).

Specific GHG emissions from burning biomass in the residential sector in the nothern districts of Volyn region are much lower than in the South of the region. The largest emissions are in Lutskyy district, in particular in the diststrict center – Luts'k.

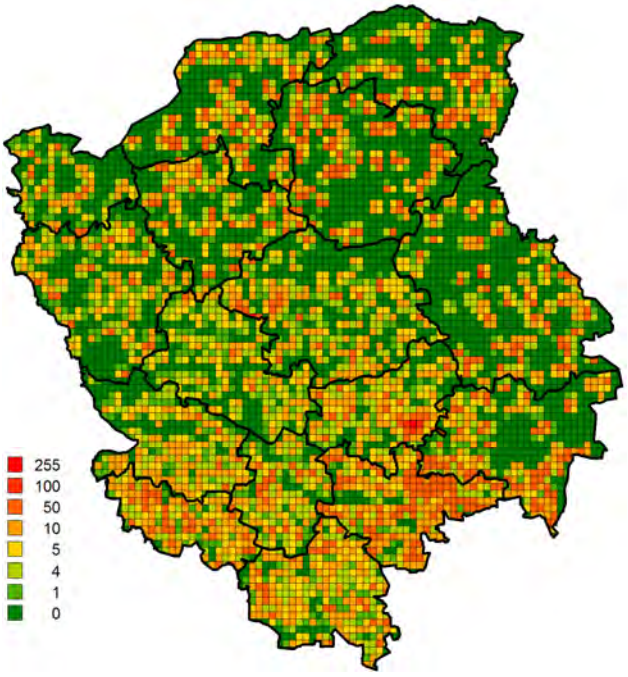

Fig. 1. Specific GHG emissions in residential sector from burning biomass (thousands kg/km^2, CO2-eq., Volyn region, 2010)

Fig. 2. Forests in Volyn region (2010)

In order to verify the developed approach the disaggregated data about burning the biomass in the residential sector was aggregated to the level of districts and compared with the statistical data. In some districts of the region according to data from the statistical department the amount of biomass sold to the population is twice as much as the results of our approach and in others it is in several time less. The statistical department collects data about biomass consumption based on the registry of enterprises that purchase the wood to the population. Such enterprises are located in the districts with rich forest resources and in these districts our approach "underestimates" the wood consumption (Fig. 2). Therefore the developed approach estimates the GHG emissions from burning biomass in the residential sector more accurate than even using the more detailed statistical data.

Conclusion

Developed approach enables to estimate the greenhouse gas emissions from burning biomass spatially with affiliation to the elementary object where it was burnt. Such approach will help the policy makers to locate the major emission sources and plan measures to reduce the GHG emissions in these settlements.

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