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Spatial analysis of methane emissions from swine enteric fermentation in Ukraine

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Abstract—**Anthropogenic factors are increasingly influencing the climate of our planet and are harmful to the environment. To control the environmental state, it is essential to conduct an inventory of greenhouse gases, analyze the spatial distribution of emission sources, and constantly monitor the amount. Since swine farming is one of most efficient Ukraine's livestock industries, this study is dedicated to calculating methane emissions from swine enteric fermentation and determining their spatial distribution.**

Keywords—methane emission; climate change; swine; enteric fermentation.

I. Introduction

Nowadays, we can observe how due to negligent and destructive human activity the biosphere of our planet is in a state where global catastrophe is just a few steps away. Climate change caused by anthropogenic factors, is considered the main environmental problem of our time. Large-scale melting of glaciers, rising sea levels, changes in the length of the growing season, an increase in average rainfall, extreme drought, and many other things are the consequences of the large accumulation of greenhouse gases in the Earth's atmosphere. Hence, the issue of climate change is becoming increasingly acute. Reducing greenhouse gas emissions requires significant efforts and research at the international, national, and local levels. Thus, scientists are paying more and more attention to this problem and conducting an inventory of emissions and their spatial analysis.

II. Spatial Modeling Emission Processes

According to [1] the share of the agricultural sector in total Ukrainian GHG emissions without LULUCF was 13.2 % in 2020, where enteric fermentation products played a dominant role. Methane is produced in herbivores as a by-product of enteric fermentation, a digestive process by which carbohydrates are broken down by micro-organisms into simple molecules for absorption into the bloodstream [2]. In general, farm animals including cattle, sheep, swine, and others are typically listed in this type of inventory. Therefore, this study focuses on the spatial analysis of emissions from swine enteric methane emissions.

Estimation of GHG emissions from the vital activity of swine was performed in accordance with the Tier 1 methodology from 2006 IPCC Guidelines [2] using the following basic equation $E = EF_t \times N_t / 10^6$, where E is the methane emissions from enteric fermentation, kt CH_4 yr^{-1}; N_t is the number of head of livestock species/category t in the country, the number of swine in our case; EF_t is the emission factor for the defined livestock population, kg CH_4 $head^{-1}$ yr^{-1}, EF_t = 1.5 kg CH_4 $head^{-1}$ yr^{-1} for swine according to IPCC methodology [2].

Further disaggregation of the data obtained using the base equation was performed relying on certain assumptions. Since the State Statistics Service of Ukraine provides information on livestock at the regional level, total emissions were estimated for each region separately.

First, for each year under analysis, the largest agricultural enterprises engaged in swine breeding were identified (122 such pig farms in 2018), and then the corresponding emission amounts were assigned to them. Such objects were specified as point sources (Fig. 1, emissions from enterprises). It was assumed that emissions from keeping swine in households were geographically distributed within rural areas. The World Settlement Footprint (WSF) 2015 map [3] with a resolution of 10 m and a vector layer of Ukrainian village boundaries were used to identify such sources. The livestock population, which was not disaggregated in the previous steps, was distributed in proportion to the area of vectorized pixels of class 10 (grassland) of the MODIS Land Cover Type (MCD12Q1) dataset [4] available at an annual frequency and resolution of 500m. These features (Fig. 1, emissions from private farms), as

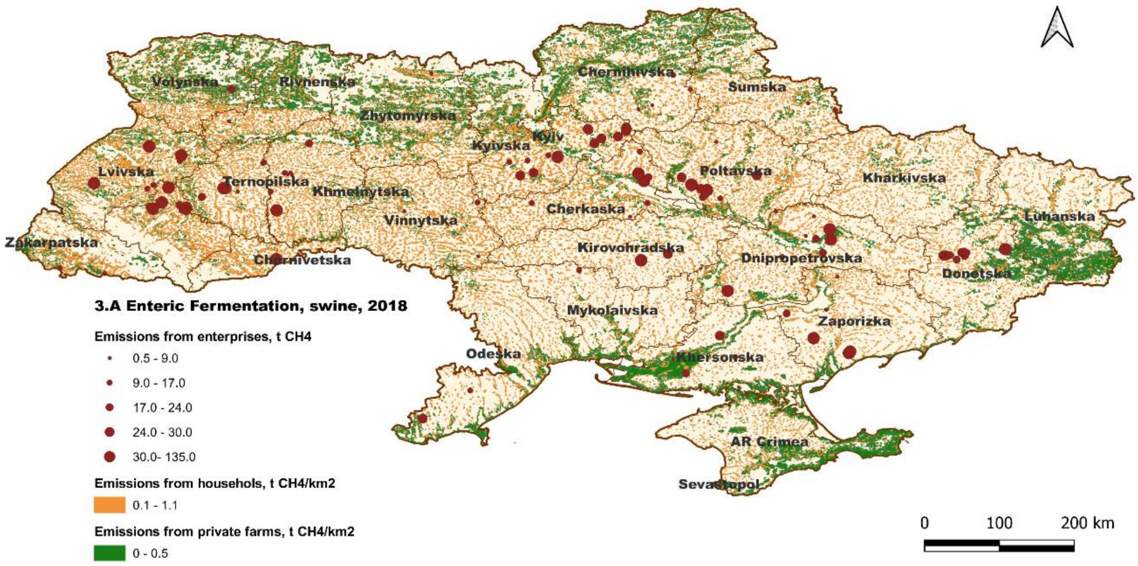

Figure 1. Spatial distribution of methane emissions from swine enteric fermentation in 2018

well as objects derived from WSF (Fig. 1, emissions from households), were defined as the polygon emission sources.

Thus, the following emission disaggregation factors for the polygon emission sources of administrative region *r* were obtained:

$$\xi\left(x_{r,i}\right) = \frac{area\left(x_{r,i}\right)}{\sum_{j=1}^{n_r} area\left(x_{r,j}\right)}, \qquad (1)$$

where $x_{r,i}$ is the *i*-th element of region *r*; n_r is the number of emission sources in the region *r*.

Hence, the estimation of GHG emissions from the vital activity of swine was carried out according to the following mathematical model:

$$E^{CH_4} = \sum_{i=1}^{n} E_i + \sum_{r}\left(\sum_{j=1}^{m_r} \xi\left(h_{r,j}\right)\cdot E_{h,r}\right) + \sum_{r}\left(\sum_{j=1}^{p_r} \xi\left(f_{r,j}\right)\cdot E_{f,r}\right), \qquad (2)$$

where E^{CH4} is the annual total methane emissions from enteric fermentation; E_i is the emissions calculated using the basic formula for the *i*-th enterprise; $\xi\left(h_{r,j}\right)$ and $\xi\left(f_{r,j}\right)$ are the disaggregation coefficients for the *j*-th distribution object of emissions produced in the *r*-th region as a result of the activities of households (*h*) and private farms (*f*), respectively; $E_{h,r}$ and $E_{f,r}$ are the total emissions caused by keeping animals in households and private farms in the *r*-th region, respectively. Similar calculations were conducted for 2010, 2015-2021. The comparative histogram of emissions for the corresponding years is given in Fig. 2.

III. Conclusions

All significant negative impacts on the environment are destructive. Therefore, it is time to act in order to improve and normalize the current environmental state. The spatial distribution of greenhouse gas emissions is important for the determination of the geographical characteristics of the emission sources, the calculation of

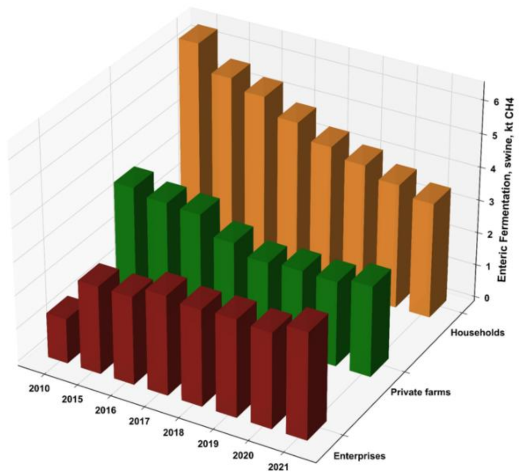

Figure 2. Comparative histogram of methane emission values from swine enteric fermentation

their amounts, and further analysis. That is why, in the context of this study, vector digital maps of the distribution of methane emissions from swine enteric fermentation in Ukraine for 2010, 2015-2022 were generated in accordance with the IPCC methodology [2].

References

[1] National Coordination Agency, "Submission under the United Nations Framework Convention on Climate Change and the Kyoto Protocol 2023," Dessau-Roßlau: Umweltbundesamt, 2023.

[2] Task Force on National Greenhouse Gas Inventories, "Industrial Processes and Product Use," Japan: Institute for Global Environmental Strategies, vol. 3, 2006.

[3] M. Marconcini, A. Metz-Marconcini, S. Üreyen, D. Palacios-Lopez, W. Hanke et al, "Outlining where humans live, the World Settlement Footprint 2015," Scientific Data, vol. 7, 2020, pp. 1–14.

[4] C.O Justice, J.R.G Townshend, E.F Vermote et al. "An overview of MODIS Land data processing and product status," Remote Sens. Environ., vol. 83(1-2), 2002, pp. 3–15.