Appendix 2

Summary of professional accomplishments

Documentation for the habilitation degree procedure

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Gdańsk, March 2019

SUMMARY OF PROFESSIONAL ACCOMPLISHMENTS

1. **Name and surname:**
   Paweł Wiśniewski

2. **The diplomas and scientific degrees held, including the name, place and year of obtaining them and the title of the doctoral thesis**

- 2005 – Master's degree in geography, specialization: physical geography with landscape protection, Kazimierz Wielki Bydgoszcz Academy, Faculty of Mathematics, Technology and Natural Sciences, Institute of Geography. Master's thesis: *Selected problems of anthropogenic pressure in Nakło nad Notecią commune*, supervisor: dr Roman Dysarz.
- 2005 – Postgraduate studies in oligofrenopedagogy, MILENIUM College of Humanities and Management of Gniezno.
- 2009 – Postgraduate studies in computer science and information technology in schools, Lower Silesian College of Entrepreneurship and Technology in Polkowice.
- 2012 – PhD in agricultural sciences in the field of environmental protection and management, Faculty of Agriculture and Biotechnology, UTP University of Science and Technology in Bydgoszcz. Title of doctoral thesis: *Antierosion soil-protecting forests function on the basis of the areas administered by the RDSF Toruń*, doctoral thesis supervisor: dr hab. Mieczysław Wojtasik, prof. UKW, reviewers: prof. dr hab. inż. Stanisław Rolbiecki, dr hab. Jan Paluszek, prof. UP Lublin.
- 2013 – qualification course "Organization and management of education", Bydgoszcz Vocational Training Centre in Bydgoszcz.

3. Information on employment in scientific institutions

- 2006-2010 – Kazimierz Wielki University in Bydgoszcz, Institute of Geography – academic teacher (contract of mandate), conducting classes on natural basics of sustainable development (practicals), soil science (practicals and fieldwork), hydrology and limnology (practicals)
- from 2013 – University of Gdansk, Faculty of Oceanography and Geography, Institute of Geography, Department of Physical Geography and Environmental Management – Assistant Professor

4. **Scientific achievement consistent with Article 16 paragraph 2 of the Act of Law of 14th March 2003 on academic degrees and title and degrees and title in the arts (Journal of Laws no. 1789 with modifications in the Journal of Laws, 2018 no. 1669)**

a) title of scientific achievement

Agriculture and rural areas in low-carbon economy planning at the local level in Poland

(b) list of publications (author(s), title(s) of publication, year of publication, name of publishing house, publishing reviewers)

The scientific achievement on which the application for the postdoctoral degree is based is a cycle of nine peer-reviewed scientific publications (marked **[A1]** to **[A9]**), thematically related, developed after obtaining the PhD degree, published in the last four years (2016-2019). Six of them (**[A2]**, **[A4]**, **[A5]**, **[A6]**, **[A8] and [A9]**) were published in scientific journals with *Impact Factor* (IF) included in *Journal Citation Reports* (JCR), while three (**[A1]**, **[A3]** and **[A7]**) were published in journals included in part B of the list of scientific journals of the Ministry of Science and Higher Education (according to the latest list from 2017). Two of them are one-author publications and in seven of them, I am the prime author. My contribution to their creation has been specified in Appendix no. 3 and is in accordance with the statements of the co-author (Appendix no. 5). Seven articles (**[A1]**, **[A2]**, **[A3]**, **[A4]**, **[A5]**, **[A8]**, **[A9]**) were published in English, two (**[A6]**, **[A7]**) in Polish.

The list of articles presented below, which is a scientific achievement and is the basis for the application for the postdoctoral thesis, has been ranked according to the dates of their issue. Due to the different duration of the publishing process in individual journals, this order differs from the order of submission of papers for publication.

[A1] Wiśniewski P., Kistowski M., 2016. Local low carbon economy plans in the context of low carbon rural development. Journal of Ecological Engineering, 17(4), 112-119. https://doi.org/10.12911/22998993/63960

12 pts according to MSHE (according to the 2017 list)

[A2] Wiśniewski P., Kistowski M., 2017. Agriculture and rural areas in the local planning of low carbon economy in light of the idea of sustainable development – results from a case study in north-central Poland. Fresenius Environmental Bulletin, 26(8), 4927-4935.

15 pts according to MSHE (according to the 2017 list); IF = 0.673; $IF_{5\text{-}year}$ = 0.611

[A3] Wiśniewski P., Kistowski M., 2017. The use of agricultural soils as a source of nitrous oxide emission in selected communes of Poland. Bulletin of Geography. Physical Geography Series, 13, 39-49. http://dx.doi.org/10.1515/bgeo-2017-0012

13 pts according to MSHE (according to the 2017 list)

[A4] Wiśniewski P., Kistowski M., 2017. Carbon Footprint as a Tool for Local Planning of Low Carbon Economy in Poland. Rocznik Ochrona Środowiska, 19, 335-354.

15 pts according to MSHE (according to the 2017 list); IF = 0.899; $IF_{5\text{-}year}$ = 0.685

[A5] Wiśniewski P., Kistowski M., 2018. Assessment of greenhouse gas emissions from agricultural sources in order to plan for needs of low carbon economy at local level in Poland. Geografisk Tidsskrift-Danish Journal of Geography, 118(2), 123-136. https://doi.org/10.1080/00167223.2018.1436447

25 pts according to MSHE (according to the 2017 list); IF = 1.100; $IF_{5\text{-}year}$ = 1.247

[A6] Wiśniewski P., 2018. Assessment of Greenhouse Gas Emissions from Agricultural Sources at Local Level in Poland. Rocznik Ochrona Środowiska, 20, 1811-1829. (in Polish)

15 pts according to MSHE (according to the 2017 list); IF = 0.899; $IF_{5\text{-}year}$ = 0.685

[A7] Wiśniewski P., Kistowski M., 2018. Importance of issues regarding rural areas and agricultural activities in the objectives and directions of low carbon economy development at communal level. Rural Studies, 50, 49-64. (in Polish) https://doi.org/10.7163/SOW.50.3

12 pts according to MSHE (according to the 2017 list)

[A8] Wiśniewski P., Kistowski M., 2019. Local-level agricultural greenhouse gas emissions in Poland. Fresenius Environmental Bulletin, 28(3), 2255-2268.

15 pts according to MSHE (according to the 2017 list), IF = 0.673; $IF_{5\text{-}year}$ = 0.611

[A9] Wiśniewski P., 2019. Assessment of nitrous oxide emissions from agricultural soils at local level in Poland. International Agrophysics, in press, manuscript with a decision letter. https://doi.org/10.31545/intagr/105530

25 pts according to MSHE (according to the 2017 list); IF=1.242; $IF_{5\text{-}year}$ = 1.267

Summarised factors of the scientific achievement (**[A1]** - **[A9]**):

147 pts according to MSHE (according to the 2017 list); **IF = 5.486**

(c) a discussion of the scientific objective of the work and the results achieved, including a discussion of their possible application

Introduction

The transition to a green economy, reducing greenhouse gas (GHG) emissions – in the light of ongoing climate change – is one of the most important economic and environmental challenges of the modern world. The development of a resource-efficient, "green" and competitive low-carbon economy is one of the nine priority objectives of the EU's *7th Environment Action Programme to 2020* (EU 2014) adopted by the European Parliament and the EU Council. It is also in line with the objectives and priorities of the *Europe 2020 strategy for smart, sustainable and inclusive growth* (EU 2010). The development of such an economy has become the main objective of the draft of the *National Programme for Development of Low Carbon Economy (NPRGN)*, adopted by the Ministry of Economy in 2015. Unfortunately, work on the final adoption of this project was halted in 2016 and its status is currently not entirely clear, and some of its areas of action and arrangements have been transferred to the *Strategy for Responsible Development* (Bach et al. 2016; Ministerstwo Rozwoju 2016).

An effective transition towards a low-carbon economy in Poland, although not without costs and difficulties, can be achieved based on a comprehensive and coordinated action by the central and provincial public administration. However, it also requires planning and implementation of appropriate solutions at the local level. The local plans for a low-carbon economy (PGN) are a relatively new tool for planning the low-carbon development of local government communities. These are strategic documents supporting the acquisition and effective spending of EU funds and contributing, among other things, to the reduction of final energy consumption by increasing energy efficiency, as well as the improvement of air quality in areas where permissible concentration levels have been exceeded. They are equivalent to the *Sustainable Energy Action Plans (SEAPs)* – key documents developed by the signatories of the Covenant of Mayors for Climate and Energy, an initiative of the European Commission involving local authorities and citizens in efforts to increase energy efficiency and the use of renewable energy sources. The tasks included in the PGN should also focus on resource efficiency and low-carbon actions to improve energy efficiency and RES use in all sectors of the economy, with the participation of energy producers and consumers, residents, local authorities, associations and institutions.

An important element in the local development of a low-carbon economy and one of the key areas of activity in local plans for its development should constitute rural areas and related agricultural activities (Karaczun and Wójcik 2009; EU 2010; Pandey and Agrawal 2014; Gradziuk and Gradziuk 2016; Żukowska et al. 2016). This is due, for example, to the share of agriculture in the total GHG emission in Poland, which amounts to approx. 8%. This sector is the source of 29.6% of domestic methane emissions and 77.6% of nitrous oxide emissions (KOBiZE 2018). The inclusion of rural areas in local planning for a low-carbon economy is also supported by the large potential of these areas, in terms of the possibility of using their resources to increase carbon sequestration in biomass and soil, reduce GHG emissions, as well as the use of agricultural activity and agri-food processing together with wood biomass for the development of renewable energy, including the production of biogas and biofuels (Głębocki and Świderski 2007; Bański 2010, 2016; Kundzewicz and Kozyra 2011; Rogulska et al. 2011; Colomb et al. 2013; Lugato et al. 2015; Nayak et al. 2015; Kokoszka 2016; Feliciano et al. 2017; Goździewicz-Biechońska 2017; Góral and Rembisz 2017; Peter et al. 2017; Vetter et al. 2017; Faber and Jarosz 2018; Verschuuren 2018). There is also no doubt that the low-carbon economy – defined as the basic element of sustainable development (Węglarz et al. 2015; Pietrzyk-Sokulska et al. 2016) – in relation to rural areas is becoming particularly important. This is also due to the need to take into account the priority role of the natural environment in the production function and strategic development objectives of these areas (Kistowski 2009; Sobczyk 2014; Żmija 2014; Ammirato et al. 2017; Haider et al. 2018). The concept of eco-development includes measures aimed at improving the conditions for economic activity and life in the countryside, while maintaining its specific resources, which include the natural environment, landscape, traditions and cultural heritage. This approach takes into account both the laws of nature and economics through compliance with the chosen direction of development in economic activities, adapted to the existing natural conditions, as well as the needs and will of local communities and environmental protection standards (Urban 2003; Roszkowska-Mądra 2009).

My motivation to undertake a research on the issues of agriculture and rural areas in shaping a low-carbon economy at the local level in Poland, as well as, indications of actions in these areas, enabling reduction of GHG emissions and improvement of the ability to absorb CO_2 arose, among others, after obtaining the results of my work (as a member of the leading team and experts) on the *Pilot program of the low carbon development of Starogard County*, implemented in 2014-2015 within the framework of the "The Good Climate for Counties" project, which was developed by the Institute for Sustainable Development, the Association of Polish Counties and Community Energy Plus and the inhabitants, authorities and institutions of Starogard County (Fundacja... 2015; Wiśniewski 2015). Works on this project, as well as, numerous comments made by representatives of local government units and scientists during scientific conferences, pointed to the insufficient quality of PGNs accepted by Polish local governments and the marginal treatment of agriculture and rural areas.

The scientific objective for the research, achieved results and possibilities of their application

In the light of the conditions and research experience described in the introduction, I concluded that there is an urgent need to undertake a comprehensive research into the issues of rural areas and agriculture in planning and shaping a low-carbon economy at the local level in Poland. The key research objectives of the work constituting a scientific achievement have been adopted:

1. Analysis and assessment of the level of agricultural integration and rural areas in low-carbon economy plans adopted by local governments in Poland.
2. Development of a model solution for effective integration of agriculture and rural areas into local planning of a low-carbon economy.
3. Recognition and analysis of methods used by local governments to calculate the carbon footprint of agriculture for the needs of planning and management of low-carbon development, together with an assessment of their effectiveness.
4. Calculations and spatial analyses of estimated GHG emissions from agricultural sources (with particular emphasis on the use of agricultural soils) for communes in Poland, as a tool supporting low-carbon economy planning at the local level.

Re 1. Analysis and assessment of the level of agricultural integration and rural areas in low-carbon economy plans adopted by local governments in Poland

The paper **[A1]** presents a preliminary analysis of 20 low-carbon economy plans adopted for implementation by rural communes of a typically agricultural character, representing various regions of Poland. The degree and scope of inclusion of issues of agriculture and rural areas in the strategic and detailed objectives as well as priority directions of low-carbon development of communes were analysed and evaluated. The degree and scope of translating the adopted objectives – in accordance with the principles of strategic planning – into specific measures, deadlines, material, financial and human resources, as well as persons or units responsible for their implementation and indicators for monitoring the effectiveness of the implementation of the planned tasks were also assessed. For each of the above mentioned aspects, it was assessed – if it was included in the PGN – whether it was done in a sufficiently broad scope, or to an insufficient degree. An attempt was also made to make an approximate summary assessment of the degree to which the issues of agriculture and rural areas were taken into account in the examined plans for a low-carbon economy, using the bonitation method. The analysis showed that in most of the documents examined, the proposed strategic objectives and priority directions of low-carbon development in agriculture and rural areas were limited to activities leading to increased use of biomass for electricity and heat production and the development of energy crops. Attention was drawn to the omission of agriculture and rural areas in the diagnosis of local conditions and the baseline inventory of GHG emissions, as well as the failure to include the planned measures in the implementation schedules. None of the analysed plans indicated the units directly responsible for the implementation of specific tasks. In most cases, the sources for financing the measures and methods of monitoring the effectiveness of their implementation were also not specified.

The results of the research, published in a paper **[A1]**, were presented during the XXI International Scientific Conference ENVIRO 2016 titled: "Problems of environmental protection and development", organized on 01-02 June 2016 by the Department of Land Reclamation and Environmental Development of the University of Agriculture in Krakow, the Department of Landscape Planning and Ground Desig of the Slovak University of Agriculture in Nitra, The Committee on Agronomic Sciences of the Polish Academy of Sciences and the Association of Hydraulic and Land Reclamation Engineers, Krakow Branch. They also contributed to a broader analysis, covering not only rural communes. Its results were presented in the paper **[A7]**, where the research material constituted 48 selected plans for low-carbon economy, drawn up in 2014-2016 for rural, urban-rural and urban communes (one in each of these groups in 16 voivodships). Due to the objective of the research, it was assumed that regardless of the type of commune, the share of agricultural land in its area should not be lower than 25%, and together with forest land they should occupy not less than 50% of the communes' area. This criterion partially reflects the functions performed in the communes' space, which influence the generated GHG emissions. On the basis of the Local Data Bank of the Central Statistical Office (LDB CSO) data from 2014 concerning the geodetic area of the country according to the directions of use, it was stated that 2,298 communes (92.7%), occupying 93.7% of the country's territory, meet this criterion. The selected communes cover 6200 km^2 (less than 2% of the country's area and 2.1% of the area of communes meeting the adopted criteria) and inhabited by 1149 thousand people (3% of the population of Poland). A comprehensive assessment of the degree to which the problems of agriculture and rural areas were taken into account in the surveyed PGN, carried out using the bonitation method, with the use of a modified solution previously applied in the paper **[A1]** in relation to selected rural communes, indicated its low level. In six out of 48 documents examined this issue was taken into account to a high degree, and only in one – to a very high degree. The weaknesses of low-carbon economy planning include the omission of agriculture and rural areas in the diagnosis of local conditions of communes, including the baseline inventory of greenhouse gas emissions, which is an important element of such a diagnosis and a reference point for the adopted directions of low-carbon development of local government communities. In most of the surveyed PGNs, only a general assessment of the condition of agricultural production space was made, focusing primarily on the structure of land use (in 28 documents), resources and the structure of agricultural land (successively in 38 and 26 plans) and the number of business entities engaged in agriculture, forestry, hunting and fishing (in 25 PGN).

For example, the diagnostic parts of the low-carbon management plans adopted by the typically agricultural communes of Karczmiska and Bestwina are limited to the assessment of agricultural land and forest land, or soil bonitation and sowing structure. In turn, in documents for the urban-rural commune of Biłgoraj, where 55% of the area is agricultural land, and for the city of Nowy Targ with 48% of agricultural land and 36% of forest land, the agricultural sector was completely ignored in the diagnosis of local conditions. Such an approach makes it difficult or even impossible to make a full diagnosis of the situation of agriculture and rural areas in terms of low-carbon development opportunities and adaptation to climate change. Meanwhile – as Nazarko et al. (2013) point out – the stage of diagnosis in strategic planning should consist in the identification of the characteristics of a given area, as well as active and potential external factors which have or may have an impact on these characteristics. A detailed assessment of the current state (local conditions) should be the starting point for establishing appropriate objectives and developing an appropriate action plan for the low-carbon development of communes as well as monitoring its implementation.

Strategic planning in the commune – including low-carbon economy – requires a clear definition of objectives resulting from a specific mission and vision of the local government. They should translate into specific tasks to be performed, for which deadlines, material, financial and human resources and persons or units responsible for their implementation are defined (Szot-Gabryś and Sienkiewicz 2003). The identification of objectives, activities and tasks set out in the analysed low-carbon economy plans carried out in the paper **[A7]** shows that in the area of agriculture and rural areas they are almost exclusively limited to increasing the use of biomass in electricity and heat production, development of energy crops, increasing the area of greenery and introduction of trees and bushes. Only five of the 48 low-carbon economy plans (10.4%) formulated targets that can directly relate to agriculture and rural areas. These include support for private entities in biomass production, increasing the amount of CO_2 absorbed by trees and bushes, upgrading and replacing local heat sources with biomass boilers, increasing the use of RES in electricity production in the agricultural sector and the use of energy from biogas. Specific measures for low-carbon agricultural and rural development (including mainly the construction of biogas plants, the development of individual heat sources based on biomass combustion boilers and small RES installations on farms, as well as the increase in the area and maintenance of existing green areas) were included in only 14 of the 48 surveyed PGNs. Moreover, the units directly responsible for their implementation were not indicated for all tasks. In most cases, the sources of financing and methods of monitoring their effectiveness were also not specified. A detailed description and a comprehensive assessment of the structure, content and formal features of local plans for a low-carbon economy, taking into account all sectors of the economy, were presented in a monograph of my co-authorship (Kistowski and Wiśniewski 2017).

The results of the research published in a paper **[A7]** were presented during the Scientific Conference "Shaping the rural space", organized on 7-8 December 2017 by the Institute of Geospatial Engineering and Real Estate of the UWM, the Society for Rural Development and the Centre for Rural Development of the UWM in Olsztyn.

Re 2. Development of a model solution for effective integration of agriculture and rural areas into local planning of a low-carbon economy

The marginal treatment of agriculture and rural areas in low-carbon economy planning described in works **[A1]** and **[A7]**, probably results from the fact that local governments, during the creation of the PGN, followed the recommendations contained in Appendix No. 9 to the Competition Regulations No. 2/POIiŚiŚ/9.3/2013 announced by the National Fund for Environmental Protection and Water Management for projects concerning the thermal upgrading of public utility facilities and preparation of low-carbon economy plans, as well as guidelines of the Covenant of Mayors for Climate and Energy. These recommendations do not include agriculture among the sectors that must be included in the Baseline Emission Inventory and the planning of investment tasks for low-carbon development. However, it appears that, not least because of the significant share of total GHG emissions and vulnerability to climate change, rural areas and related agricultural activities should be an important area of activity in shaping a low-carbon economy. Therefore, it is necessary to include agriculture and rural areas in local plans for a low-carbon economy, indicating the principles of their functioning and main directions of low-carbon development in rural areas of a given commune, as well as key investment needs, soft and institutional measures, sources of financing and appropriately selected indicators for the needs of monitoring the degree of their implementation in future.

The paper **[A2]** presents proposals, which may constitute a model solution for the inclusion of agriculture and rural areas in the planning of low-carbon economy by local government units (Fig. 1). They are, among other things, the result of my research and analyses carried out during my work on the aforementioned *Pilot program of the low carbon development of Starogard County*. The results of work on this programme should not be generalized on a national scale, due to the regional diversity of rural and agricultural structures in Poland (Bański 2010). However, taking into account the typically agricultural and forest character of the analysed area, located in the southern part of Pomeranian Voivodeship, they are representative for the majority of rural areas located in the lower part of the country.

According to the proposed model, planning by local government units for the development of a low-carbon economy should take into account the specificity of local conditions. In order to properly diagnose the situation of agriculture and rural areas of communes in terms of low-carbon economy, it is advisable to identify strengths, weaknesses, opportunities and threats (SWOT analysis) in two key elements, which include maintaining or increasing the ability to absorb CO_2 and reducing GHG emissions from agriculture and soils. A properly conducted baseline inventory of GHG emissions should be an important element of the diagnosis of local conditions as well as a reference point for the adopted directions of low-carbon development of communes. The results of the SWOT analysis presented in paper **[A2]** indicate a high potential of agriculture and rural areas (including forest areas) in Poland in terms of the possibility of using their resources to increase carbon sequestration in biomass and soil, reduction of GHG emissions, as well as the use of agricultural activity and agri-food processing together with wood biomass for the development of renewable energy, including the production of biogas and biofuels. In the light of the assessment of strengths and weaknesses in the scope of the ability to maintain or increase the ability to absorb CO_2 and reduce emissions from rural areas and related agricultural activity, the following voivodships have the greatest potential in this respect: West Pomeranian, Warmian-Masurian, Podlachia, Greater Poland and Lubusz. This potential, based primarily on large resources of agricultural land and forest land, should be shaped and enriched through the implementation of appropriate principles of functioning and directions of development of low-carbon economy in rural areas. In order to use this potential, it is necessary to identify and eliminate weaknesses and potential threats hindering the maintenance or increase in the ability to absorb CO_2 and to reduce GHG emissions from agriculture and soils, while at the same time implementing the vision of a low-carbon economy in these areas.

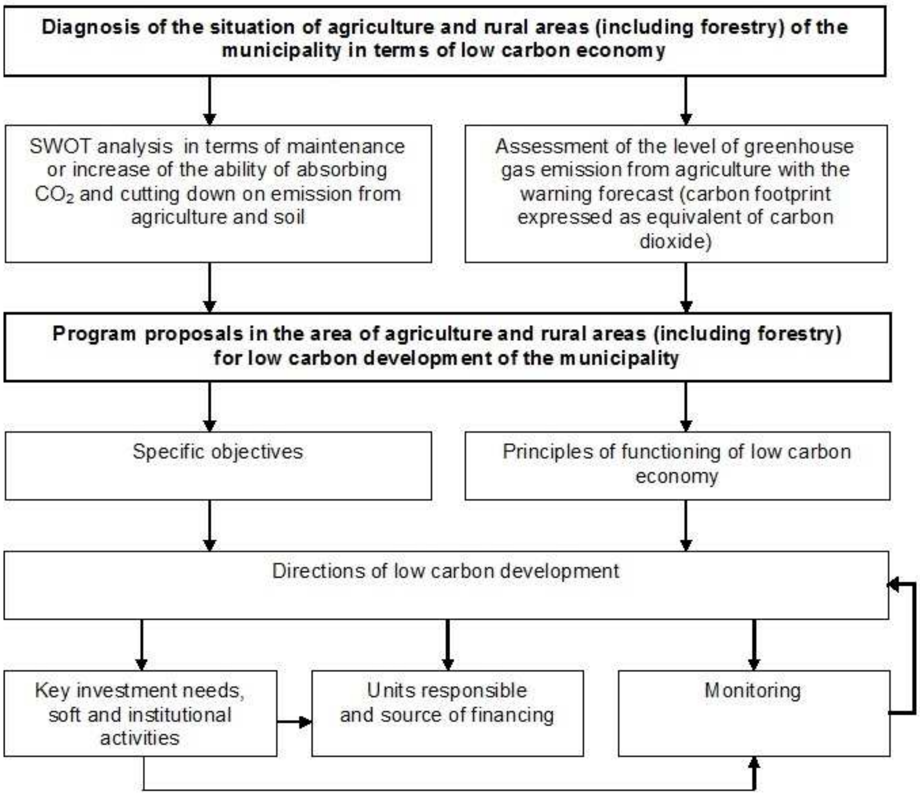

Fig. 1. Model solution for agriculture and rural areas (including forestry) in local planning of a low-carbon economy

Among the weaknesses and threats identified in the paper **[A2]**, in terms of the ability to maintain or increase the ability to absorb CO_2 and to reduce GHG emissions from agriculture and soils, which should be mitigated, include among others: high proportion of weak and the weakest arable soils, periodically or permanently dry, low productivity, poor in organic matter, which limits the ability to absorb CO_2 (Skłodowski and Bielska 2009); high proportion of acidified soils with low retention capacity and low humus content; decrease in the importance of perennial crops, which leave a large amount of biomass in the form of plant residues and improve the nitrogen balance in the soil (Gaweł 2011; Kozłowski et al. 2011); low level of ecological stability of the land surface in Poland (Harasim 2015); large-area management system with monocultures of plants and simplified crop rotation, functioning especially on former PGRs land, and agrotechnology, often conducted in an inappropriate manner, triggering erosion processes, which contribute to the reduction of soil organic matter content and too weak carbon sequestration in the soil (Koćmit 1998; Wojtasik et al. 2008; Nadeu et al. 2015); increased risk of agricultural drought (Kundzewicz 2008; Łabędzki and Bąk 2014; Somorowska 2016); intensification of stress factors affecting crops and forest environment, in particular weather anomalies and extreme phenomena that are increasingly frequent in Poland (Stuczyński et al. 2000; Kundzewicz i Matczak 2012; Jaworski i Hilszczański 2013; Bojar et al. 2014); an increase in the use of physiologically acidic nitrogen fertilisers; monoculture dominance of pine, which caused simplification and impoverishment of stands and often their incompatibility with the habitat (Matuszkiewicz et al. 2013; Łaska 2014).

Taking into account the results of the diagnosis, the paper **[A2]** also presents specific programme proposals, defining specific objectives, principles of a low-carbon economy and main directions of low-carbon development in rural areas. Key investment needs, soft and institutional measures as well as sources of financing and ways of monitoring the planned measures were indicated. The basic role in monitoring should be played by the measures adopted in the PGN, grouped, using the commonly used concept of division of environmental measures, into three functional groups: pressure on the environment, quality (state of the environment) and reaction to sozological problems, manifested by actions in the field of environmental protection (Borys 2005; Kistowski 2006). The paper **[A2]** presents examples of basic measures, which should be treated as a minimum in order to effectively monitor the emission of pollutants from plant and animal production, the condition of the environment and the effectiveness of implementation of low-carbon development directions in rural areas.

The results of the research published in the paper **[A2]** were presented at the International Scientific Conference "Dresden Nexus Conference: Water, Soil and Waste", organized on 17-19 May 2017 by United Nations University Integrated Management of Material Fluxes and of Resources (UNU-FLORES), Technische Universität Dresden and Leibniz Institute of Ecological Urban and Regional Development (IOER) in Dresden.

Re 3. Recognition and analysis of methods used by local governments to calculate the carbon footprint of agriculture for the needs of planning and management of low-carbon development, together with an assessment of their effectiveness

Definition of a vision for the development of local governments towards a low-carbon economy in the adopted PGNs should be preceded by a diagnosis of local conditions, of which an important element should be the assessment of the level of GHG emissions. In recent years, the carbon footprint has become a popular and promising tool for estimating the amount of emissions caused by human activity, as well as an important instrument in creating pro-ecological behaviour. It has also been applied in planning and managing a low-carbon economy (Finkbeiner 2009; Ercin and Hoekstra 2012; Pandey and Agrawal 2014; Fantozzi and Bartocci 2016; Ibidhi et al. 2017). Despite its widespread use, however, there is no uniform worldwide definition of carbon footprint and the methods of estimating it differ (Hammond 2007; Wiedmann and Minx 2008; Wang et al. 2013; Fang et al. 2014). This hinders the effective use of this tool in quantitative analyses of GHG emissions, mitigation of global warming and adaptation of particular sectors and areas sensitive to change.

In planning and programming documents, the carbon footprint is most often treated as a synonym for CO_2 and other greenhouse gas emissions (including N_2O and CH_4), produced directly and indirectly as a result of human activity, expressed as carbon dioxide equivalent (CO_2eq) (Patel 2006; POST 2006; Carbon Trust 2007; Pandey et al. 2011). This approach is also applied in a paper **[A4]**, in which, together with Prof. M. Kistowski, we assessed the role and importance of the carbon footprint as a tool in planning a low-carbon economy at the local level in Poland, and we have also indicated the changes and modifications necessary for implementation, which may enable its more effective use in managing a low-carbon economy by local governments, especially in rural areas. The research material consisted of local plans for a low-carbon economy, adopted for implementation by randomly selected rural, urban-rural and urban communes, representing all Polish voivodeships. In total, the analysis covered 48 documents of this type – 3 for each voivodship. We assessed the methodology of calculating the carbon footprint used in the analysed plans, particularly, the selection of the base year, gases and sectors covered by the inventory, as well as the adopted emission factors. Based on the GHG inventory results presented in the analysed plans, the carbon footprint (total and per capita) was calculated in particular communes, broken down by type (rural, urban-rural and urban) and sectors included in the inventory. Due to the varied approach of local governments to the choice of base year and control inventory, the paper **[A4]** presents the values of carbon footprint calculated for the last year included in a given document, thanks to which all the presented data come from 2010-2014. In order to unify the results and conduct statistical and comparative analyses, GHG emissions were expressed in carbon dioxide equivalent (CO_2eq), assuming global warming potential (GWP) values determined in the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC 2013).

The study shows in a paper **[A4]** that in all analysed low-carbon economy plans an inventory of GHG emissions was carried out using standard indicators, compliant with IPCC principles, which cover all CO_2 emissions resulting from the final energy consumption in the commune. The standard emission factors are based on the carbon content of individual fuels and are used in national GHG inventories carried out in the context of the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol. The advantage of this method is the fact that Poland – being a party to the UNFCCC – has already gained experience in its application (Burchard-Dziubińska 2014). However, according to this methodology, CO_2 is the most important greenhouse gas, and emissions of CH_4 and N_2O associated with agricultural activity may be omitted. Moreover, CO_2 emissions resulting from the combustion of biomass or sustainably produced biofuels and emissions associated with the use of certified green electricity are treated as zero, which is usually not in line with reality (Bertoldi et al. 2010). None of the communes surveyed decided to use the Life Cycle Assessment (LCA) method, which takes into account the overall emissions over the entire life cycle of individual energy carriers. In addition, in this approach, GHG emissions associated with the use of biomass or biofuels and certified green electricity are considered to be higher than zero. In this case, non-CO_2 GHG emissions also play an important role. The LCA is therefore a noteworthy, possible to be applied at the local level in Poland, standardised method used worldwide by many institutions and governments to determine the carbon footprint, providing a unified, integrated approach to the role of product-level consumption in contributing to GHG emissions (Sinden 2009).

Polish local governments, when developing local low-carbon economy plans, rely primarily on the assumptions and guidelines of the Covenant of Mayors for Climate and Energy, on the principles of Sustainable Energy Action Plans (SEAPs) and Baseline Emission Inventory (BEI). In line with these principles, if local authorities decide to use standard emission factors, an inventory will suffice to include CO_2 emissions. This solution was applied by 77% of the surveyed communes. In four cases the emissions were expressed in carbon dioxide equivalent. However, it was not indicated, which gases – apart from CO_2 – were included in the inventory, nor was it explained, which GWP indicators were adopted. Seven local governments decided to include other gases in their emissions (e.g. CH_4, N_2O, SO_2), but their emissions were not converted into CO_2 equivalent. In the surveyed communes, the basic inventory included mainly emissions from public buildings, housing, transport and public lighting. In slightly less than half of the analysed plans, the industrial sector was also included in the calculation of the carbon footprint, but most often it was limited to emissions from heat sources in industrial plants, excluding plants covered by the EU Emissions Trading System (EU ETS) and medium- and high-voltage industry. Only ten documents include emissions from waste management and water and wastewater management. The agricultural sector is included only in three low-carbon economy plans, one of which assesses the level of CO_2 emissions from agriculture including those from residential buildings. None of the plans analysed included a GHG balance sheet for the high mitigation potential LULUCF sector covering land use, land use change and forestry (IPCC 2003).

The carbon footprint calculated in the paper **[A4]** in particular communes, expressed in CO_2 equivalent in absolute values and per capita, as well as the results of statistical and comparative analyses show a significant variation in GHG emissions. These differences probably result from the specificity of individual communes, but they are also the result of inconsistent methodological assumptions when estimating emissions. The average carbon footprint per capita in the analysed communes is 2.4 Mg CO_2eq lower than the carbon footprint calculated for the *Pilot program of the low carbon development of Starogard County* (Fundacja... 2015). Clear differences are also noticeable in the breakdown by individual sectors. In the case of agriculture, this sector has been practically omitted in the analysed communes, whereas in the pilot programme, in Starogard County, it amounted to 1 Mg CO_2eq/year/per capita. The average carbon footprint per capita calculated on the basis of data contained in the low-carbon economy plans adopted for implementation by the surveyed communes is also 1.5 Mg CO_2eq lower than the carbon footprint for Poland in 2013 and 1.2 Mg CO_2eq lower than in 2014, calculated in the latest report on the global trend in CO_2 emissions, published by PBL Netherlands Environmental Assessment Agency and the European Commission's Joint Research Centre (Olivier et al. 2015). Due to significant differences in the size of the carbon footprint in individual communes, resulting mainly from uneven methodological assumptions, observed not only in Poland, but also in other European countries, such as Norway, Finland and Greece (Larsen and Hertwich 2010; Heinonen and Junnila 2011; Angelakoglou et al. 2015) – there is an urgent need for an effective, coherent and simplified model for the assessment of carbon footprint, applicable to all local authorities, going beyond the guidelines of the Covenant of Mayors for Climate and Energy, in order to take into account the specificities of local conditions. For rural areas, the model should take the agricultural sector as well as the verification of the carbon footprint into account through the gas balance in the LULUCF sector, which is mostly a net absorber.

The results of research published in the paper **[A4]** were presented during the 19th Science and Technology Conference "Prevention of Environmental Pollution, Changes and Degradation", organized on 16-18 November 2016 by the Institute of Environmental Protection and Engineering of the University of Bielsko-Biała.

Re 4. Calculations and spatial analyses of estimated GHG emissions from agricultural sources (with particular emphasis on the use of agricultural soils) for communes in Poland, as a tool supporting low-carbon economy planning at the local level

It follows, from the studies I have described above on the role and effectiveness of low-carbon economy plans adopted by local governments in order to programme and coordinate actions for low-carbon development in Poland that the methods used in these documents to calculate the carbon footprint are not very effective and do not make it possible to determine the actual level of emissions. This is also confirmed in the works of Gradziuk and Gradziuk (2016) and Pietrzyk-Sokulska et al. (2016). Focusing almost exclusively on CO_2 emissions without taking into account other gases and omitting agriculture in the inventory – which in the case of rural and urban-rural communes is particularly unjustified – and makes the amounts of the carbon footprint calculated for the purposes of low-carbon economy plans usually underestimated. This problem was also observed in other European countries, as described in the paper **[A4]**. Therefore, I decided to make an attempt to assess the size of the carbon footprint from agricultural sources at the local level in Poland. I assumed a research hypothesis that a properly conducted carbon footprint assessment is an important and effective tool in identifying the main sources of greenhouse gas emissions associated with rural areas and agricultural activity, as well as priority areas requiring mitigation actions, thereby increasing the effectiveness of local low-carbon policy and contributing to the optimisation of reducing the costs of emission.

Due to the fact that the calculators of GHG emission from agriculture developed so far are, to a large extent, too complicated and often require the introduction of data difficult to access at the level of local governments (Wu 2011; Colomb et al. 2012; Tuomisto et al. 2014), in order to calculate emissions from agriculture in communes, a simplified methodology was applied, implemented earlier in the *Pilot program of the low carbon* *development of Starogard County* (Fundacja... 2015; Wiśniewski 2015). It enables local self-governments to calculate the carbon footprint of agriculture based on publicly available data from public statistics. The proposed solution is consistent with the methodology and standard IPCC indicators (2000, 2006) and focuses on level 1 (Tier 1). However, in order to obtain more accurate data on emissions, it also takes into account elements of the national methodology and emission factors developed by the National Centre for Emission Management (KOBiZE 2014, 2017, 2018) for the purpose of drawing up annual inventory reports. Calculation of the carbon footprint of agriculture in individual communes focused on three main sources of greenhouse gas emissions from this sector in Poland. These include: enteric fermentation of livestock (the main source of methane emissions), animal faeces (source of methane and nitrous oxide emissions) and the use of agricultural soils (source of nitrous oxide emissions). Combustion of plant residues (as a source of methane and nitrous oxide emissions) was also taken into account, although its share in total greenhouse gas emissions is much lower. The data necessary for calculations, concerning the annual consumption of mineral fertilisers, livestock (distinguishing between dairy cows, other cattle, horses, pigs and poultry) and organic soil surface were obtained from the Local Data Bank of the Central Statistical Office (LDB CSO). The annual yields of the main crops (wheat, rye, barley, oats, triticale, cereal mixture, potatoes, rapeseed, maize and legumes) were determined using data on the area sown in particular communes and the average yields of these crops in the voivodship (based on the results of the 2010 National Agricultural Censuses). In order to unify the results and carry out statistical and comparative analyses, the estimated GHG emissions from individual sources related to agricultural activity were expressed in carbon dioxide equivalent, assuming the GWP values specified in the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC 2013). Their values are as follows: 1 for CO_2, 28 for CH_4 and 265 for N_2O.

In the paper **[A5]**, a pilot study on amount of GHG emissions was carried out for the purpose of local planning of a low-carbon economy for 48 selected rural, urban-rural and urban communes, representing all voivodships in Poland. The results of these calculations were confronted with the amounts of carbon footprint (total and per capita) in individual communes, estimated on the basis of the results of the GHG emission inventories presented in the low-carbon economy plans adopted for implementation by these local governments. This made it possible to determine the share of agriculture in total emissions in the surveyed communes. It was found that more than half of the total emissions from agriculture in the analysed communes are related to livestock farming, of which 31.7% comes from enteric fermentation and 20% from animal faeces. The use of agricultural soils (48.2%) is also an important source, in particular direct emission from cultivation of organic soils and application of mineral fertilizers, as well as indirect emission from leaching of nitrogen compounds from the soil. The inclusion of agriculture in the inventory of GHG emissions, according to the proposed methodology, resulted in an increase in absolute emissions of 7.8 thousand Mg CO_2eq/year in relation to the minimum value specified in the low-carbon economy plans adopted by the surveyed communes (which is an increase of as much as 45.4%), 3.2 thousand Mg CO_2eq/year (0.7%) in relation to the maximum value and 12.4 thousand Mg CO_2eq/year (9.6%) in relation to the average value. In per capita terms, this resulted in an increase in the carbon footprint of 1 Mg CO_2eq (35.7%) compared to the minimum size set out in the plans of the communes surveyed and 1.1 Mg CO_2eq compared to the average and maximum size (by 18% and 4.2% respectively). The share of agriculture in total GHG emissions in the investigated communes, estimated on the basis of own calculations, ranges from 0.2% to 57.4%, averaging 14%.

The results of pilot studies presented in the paper **[A5]** confirmed the advisability of taking into account GHG emissions from the agricultural sector and related sources in low-carbon economy plans. In a situation where, in some communes, they produce from 1/3 to more than half of these gases, without their recognition it is not possible to correctly plan actions that are to lead to the reduction of these emissions and their negative effects on the atmosphere, climate and other elements of ecosystems. It has been found that this need applies, particularly, to rural and urban-rural communes, but also needs to be considered in urban communes, where the share of agricultural land and other areas of high biological activity is significant. Therefore (after updating the applied indicators), I decided to calculate the estimated GHG emissions from agricultural sources for all Polish communes. So far, such studies, carried out on such a large scale, have not been conducted in Poland and have been limited to the national or regional level, or had to do with the emissions at the farm-level (Wójcik-Gront 2015; Syp et al. 2016; Syp and Faber 2017; Syp and Osuch 2018; Wysocka-Czubaszek et al. 2018).

The assessment of GHG emissions from agricultural sources for all communes in Poland (except for the communes of Łęknica, Jastarnia and Dziwnów, for which there is no necessary data in public statistics) was presented in a single-author paper **[A6]**. I estimated that the emission from agricultural sources in Polish communes (without emissions from the consumption of energy carriers in agriculture) amounts to a total of 34280.89 thousand Mg CO_2eq, which constitutes 8.9% of the total national emission of GHG. This is 4630.99

thousand Mg CO_2eq more than the emissions indicated in the national inventory report (KOBiZE 2017). This difference may be due to the fact that estimating GHG emissions at the local level allows more detailed data to be used and local environmental and economic conditions to be taken into account. Nearly 70% of emissions from the agricultural sector in Poland come from rural communes, and slightly more than 28% from urban-rural communes. Municipalities are the source of 1.9% of agricultural GHG emissions. Total GHG emissions from agricultural sources in Polish communes range from 0.01 thousand Mg CO_2eq/year in the urban-rural commune of Międzyzdroje to 289.48 thousand Mg CO_2eq/year in the rural commune of Wierzchowo, with an average total value of 13.85 thousand Mg CO_2eq/year and a standard deviation of 14.96 thousand Mg CO_2eq/year. In per capita terms, these figures range from 0.002 Mg CO_2eq/year to 67.15 Mg CO_2eq/year, with a national average of 2.17 Mg CO_2eq/year and a standard deviation of 3.18 Mg CO_2eq/year. In rural and urban-rural communes, the dominant influence of livestock farming on agricultural emissions can be observed. It is responsible, in these units, for over 50% of total emissions from this sector. In urban communes, on the other hand, the land use is the dominant source of emissions from agriculture, which accounts for slightly over 60% of agricultural emissions. The analysis of the spatial distribution of communes and the carbon footprint from agriculture calculated for them, shows that higher GHG emissions from this sector are usually characteristic for the units located in the north-eastern region of Poland and in Greater Poland (Fig. 2). This is probably related to the higher proportion of large farms (over 15 ha) in these areas, intensive animal production and the system of large-area management with monocultures of plants and simplified crop rotation, which still operates there, especially on the former PGRs lands.

Continuing the research on the assessment of GHG emissions from agricultural sources in Polish communes, the emissions estimated in the paper **[A6]** were subjected to further analyses. The paper **[A8]** additionally presents advanced spatial analyses of emissions from individual sources related to agricultural activity, presented with the use of MapInfo Pro software. They helped to identify and assess the spatial variability of the main agricultural emission sources, which, in the future, should facilitate planning and implementation of measures limiting its quantity. According to the research, more than half of the total emissions from agriculture in Polish communes are related to animal husbandry, of which 41.2% comes from enteric fermentation and 18.7% from animal excrements. The use of agricultural soils (40.1%) is also its important source. The highest emission values and the share of enteric fermentation in the total emissions from agricultural sources are characteristic for communes in the central and north-eastern region of Poland, where intensive animal production is concentrated, mainly pigs and cattle.

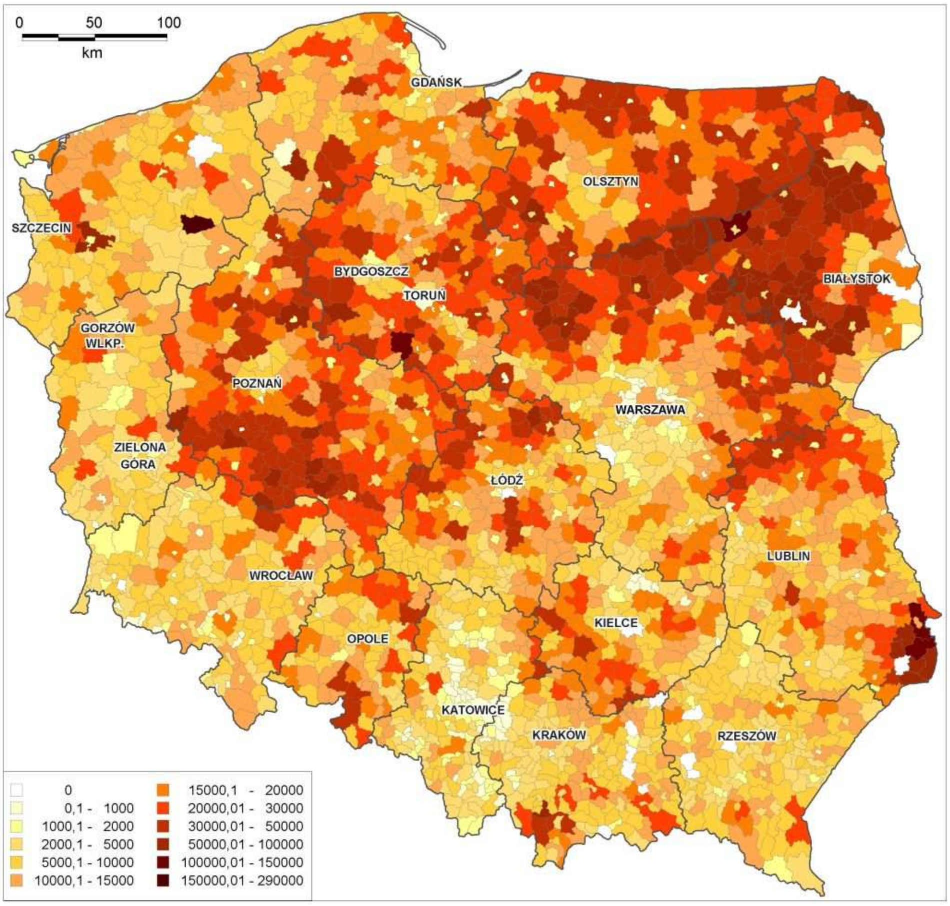

Fig. 2. The annual total GHG emissions from agriculture in Polish communes (in Mg CO_2eq)

Communes in the central part of the country (mainly in the Kuyavian-Pomeranian and Greater Poland Voivodships) are also characterized by a high level of emissions from animal excrements and their high proportion in the total emissions from agriculture. This results from the high importance of pigs in the structure of animal husbandry in these areas. The highest GHG emissions related to the use of agricultural land are characteristic, mainly, for communes located in the northern and north-eastern part of the country, where the share of organic soils is significant. In comparison to the whole country, high emissions from agricultural land use are particularly distinguishing for the communes in south-eastern Poland (near Hrubieszów in the Lublin Voivodeship), where the largest complex of Chernozems used for agricultural purposes in the country is located. Moreover, there are lands of former PGRs (Kałamucka 2017), on which an agricultural management system conducive to greenhouse gas emissions from cultivation is still maintained. On the other hand, the share of agricultural land use in total agricultural emissions – apart from the above-mentioned areas – is the highest in the western and southern parts of the country and near Warsaw, where intensive animal production is of lesser importance. On the other hand, emissions from plant residues combustion and its share in total GHG emissions from agriculture are the highest in the communes of western and northern Poland, which are characterised by the highest percentage of farms growing cereals and the highest average area of cereal crops on farms (Bański 2010).

Nitrous oxide (N_2O) is associated with agricultural activity. It is a greenhouse gas with almost 300 times greater greenhouse effect potential than CO_2 and a very long residence time in the atmosphere, estimated at over 100 years (Bange 2008; Turbiak et al. 2011; IPCC 2013; Schlesinger and Bernhardt 2013; Prather et al. 2015). It is the most important anthropogenic ozone depleting gas (Portmann et al. 2012; Wilson et al. 2013; Broucek 2018) and its concentration in the atmosphere has increased significantly over the last few decades (Finlayson-Pitts and Pitts 2000; Włodarczyk et al. 2002; Stalenga and Kawalec 2008). According to KOBiZE data (2018), nitrous oxide emissions in 2016 (excluding LULUCF sector) was 65540 Mg (4.9% of total GHG emissions), 77.6% of which came from agricultural sources. Poland ranks fourth (after France, Germany and Great Britain) in terms of N_2O emissions from the agricultural sector among EU countries (Eurostat 2017). The use of agricultural soils is responsible for such a large share of N_2O emissions from this sector – it is the source of 67.2% of national nitrous oxide emissions (KOBiZE 2018). Therefore, in papers **[A3]** and **[A9]** N_2O emissions from agricultural soils were assessed at the local level in Poland. The paper **[A3]** presents the results of a pilot study, which covered 48 selected rural, urban-rural and urban communes, representing all voivodships in Poland, using the methodology described in papers **[A5]**, **[A6]** and **[A8]**. The estimated N_2O emissions from agricultural soils were subjected to statistical and comparative analyses. Calculating the Pearson's correlation coefficients, I evaluated the relation between the amount of nitrous oxide emissions and such variables as: mineral fertilizer consumption, livestock, crop yields of cultivated plants and organic soil area. Calculated N_2O emissions were also confronted with the results of baseline inventories of GHG emissions, prepared for the needs of low-carbon economy plans adopted for implementation by the analysed communes. This made it possible to determine the share of N_2O emissions from the use of agricultural soils of the total greenhouse gas emissions in the investigated communes. Pilot studies have shown that almost 50% of total N_2O emissions from agricultural soils in the surveyed communes come from organic soil cultivation. In urban communes, this share is particularly high and amounts to 73%, in urban-rural communes – 51.5% and in rural communes – 39%. These results confirm the assumptions of Turbiak et al. (2011), which indicate that organic soils may be one of the main sources of direct nitrous oxide emissions among soils. They emphasize that after organic soils have been used for agricultural purposes, which is connected with lowering the level of groundwater, organic matter is intensively mineralized in these soils. According to Okruszko and Piaścik (1990), in the climatic conditions of Poland, about 10 Mg/ha of organic matter is mineralized annually, as a result of which up to 400 kg/ha of mineral nitrogen is released to the environment. The use of mineral fertilizers (14.5% of total emissions) and organic fertilizers (10.8%) also has a significant impact on the emission levels in the investigated communes. The leaching of nitrogen to groundwater and surface water (18.4%) is the main source of indirect emissions related to the agricultural use of soils. The results of the conducted statistical analyses indicated, among others, high and very high correlations between the N_2O emissions from agricultural soils and the use of mineral fertilizers, cattle population and the area of organic soils. However, the strength of correlation compounds varies depending on the type of commune. In the case of the rural communes under study, a very high correlation was observed between the amount of N_2O emissions from agricultural soils and the use of mineral fertilizers. In urban-rural communes a very high positive correlation in relation to N_2O emission values is characteristic for such variables as the area of organic soils and cattle population. In urban communes, on the other hand, there is an almost complete correlation between the nitrous oxide emissions and the area of organic soils and the harvest of legumes. The share of N_2O emissions in total GHG emissions in the investigated communes (without other agricultural sources), estimated on the basis of own calculations, ranges from 0.1% to 57.2%, averaging 4.6%.

Based on a pilot study, in the paper **[A9]** I assessed nitrous oxide emissions from agricultural soils for all communes in Poland. Based on the obtained results, I presented a spatial distribution of N_2O emissions from agricultural soils in Poland (expressed as N_2O-N), divided into individual sources of direct and indirect emissions, using GIS tools (MapInfo Pro software). Studies for the whole country showed that annual N_2O emissions from agricultural soils in Polish communes ranged from 0.002 Mg N_2O-N to 437.77 Mg N_2O-N, with the mean value of 21.13 Mg N_2O-N and standard deviation of 23.86 Mg N_2O-N. The highest N_2O emissions from agricultural soils are observed in the communes located in the northern and north-eastern regions of the country, where the share of organic soils is significant (Fig. 3), which is confirmed by the results of a pilot study from the paper **[A3]**. On a national scale, 40.6% of total N_2O emissions related to soil use come from organic soils. The use of mineral fertilisers (17.8% of N_2O emissions) and organic fertilisers (12.9%) is also important. The use of high doses of nitrogen fertilisers is the main source of nitrous oxide emissions in the northern part of Poland. In the north-eastern part of the country there are numerous farms specializing in milk production, and manure is one of the main sources of N_2O emissions. A significant share in the direct emission of nitrous oxide (mainly in the south-eastern part of the country) is also nitrogen fertilization with plant residues (13.2%). Nitrogen leaching into groundwater and surface waters (8.4%) is the main source of indirect emissions related to the agricultural use of soils.

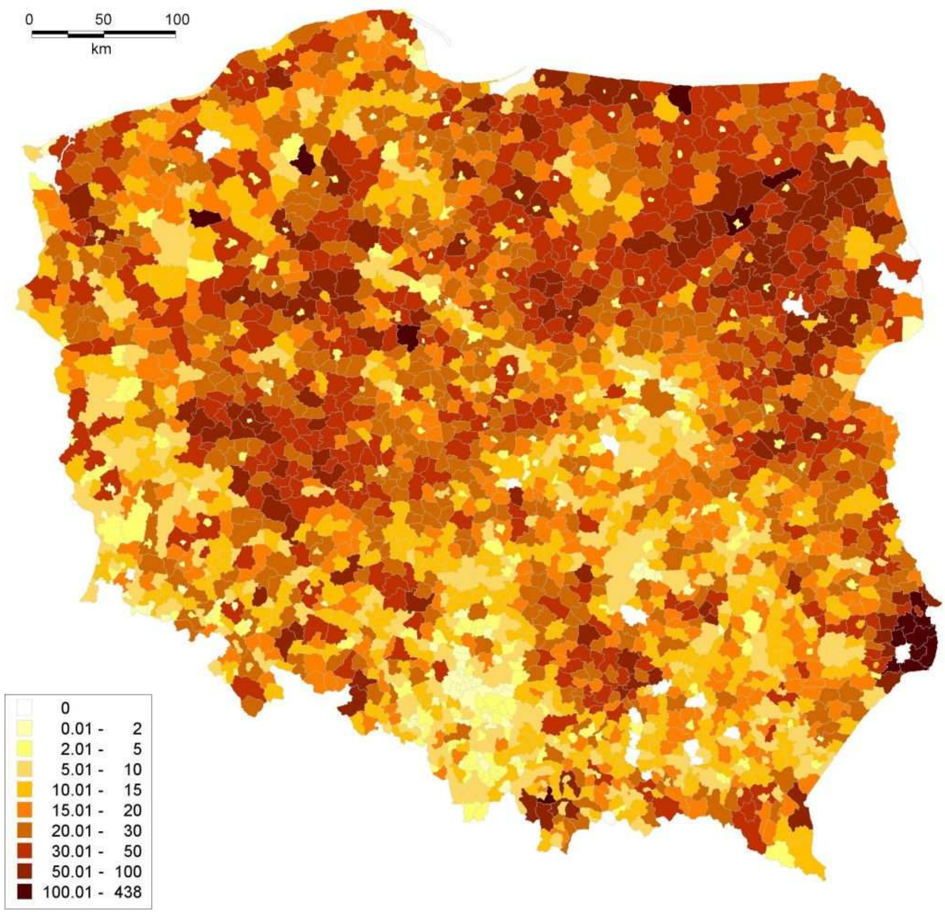

Fig. 3. The annual N_2O emissions from agricultural soils in Polish communes (in Mg N_2O-N)

Of course, it should be taken into account that the GHG emission estimates in particular communes presented in papers **[A3]**, **[A5]**, **[A6]**, **[A8]** and **[A9]** are burdened with high uncertainty (this is also of great importance when estimating the correlation between individual variables). After the analysis and simulation of error propagation (according to

IPCC guidelines) for the results of the pilot study in the paper **[A5]**, the uncertainty of emissions from agriculture at the level of ±38% was obtained. The highest uncertainty (even 150%) is characteristic for a direct N_2O emission from agricultural soils. Studies conducted by Syp et al. (2016) confirmed that GHG emissions from agriculture – in particular N_2O emissions – depend on local climatic conditions combined with the microbiological and physical properties of soils. Therefore, the analysis of existing national and local statistics, industry sources, scientific research and FAO statistics should be the first step in the collection of data by local authorities. Emission uncertainty will vary depending on the data source. Further research is, therefore, required. Syp and Faber (2017) underline that there is now a need for more detailed methods to describe spatial and temporal patterns of GHG exchange in the ecosystem. Markolf et al. (2017) underline that the prospect of GHG emission reductions by individual governments requires targets based on good quality estimates of energy demand and GHG emissions, along with realistic assumptions about the potential for GHG reductions at local level. The literature presents different methods and approaches to the assessment of GHG emissions at the local level in selected European countries, the United States and Australia (Hamilton et al. 2008; Denny and Pederson 2015; Markolf et al. 2017; Sówka and Bezyk 2017). The assessment and analysis of GHG emissions for Polish communes, presented in my papers, may be an important element to be included in this discussion and an example for other countries to study the estimation of local greenhouse gas emissions from agriculture. It should be remembered, however, that – as Bennetzen et al. (2016) emphasized – GHG emissions in agriculture can only be reduced to a certain level. It is, therefore, necessary to focus on other parts of the food-system at the same time in order to increase food security whilst reducing emissions.

The results of the research presented in the paper **[A3]** were presented during the BONARES Conference 2018: "Soil as a Sustainable Resource", organized on 26-28 February 2018 by the BonaRes Centre for Soil Research c/o Helmholtz Centre for Environmental Research – UFZ in Berlin. The results of research presented in paper **[A9]** were presented at the 12th International Conference on Agrophysics: Soil, Plant & Climate, organized on 17-19 September 2018 by the Institute of Agrophysics, Polish Academy of Sciences, Foundation of the Polish Academy of Sciences, and Polish Academy of Sciences Branch in Lublin.

Summary

The presented cycle of publications, which constitutes a scientific achievement and is the basis for submitting an application for the habilitation procedure, fills a research gap on the role of rural areas and related agricultural activity in shaping a low-carbon economy at the local level in Poland. The analysis of the role and effectiveness of local low-carbon economy plans in the programming and coordination of actions for low-carbon rural development and agriculture shows that they are currently of minor importance in this respect. A comprehensive assessment of the degree to which the issues of agriculture and rural areas have been taken into account in these strategic documents indicated its weakness. The proposals presented in my papers may constitute a model solution for the inclusion of these areas in the planning of a low-carbon economy by local government units, which have already been implemented, among others, in Starogard County.

The quantitative assessment of the individual components and cells of the carbon cycle in agroecosystems is still poorly understood. In recent years there has been a growing interest in empirical and model studies of the carbon cycle in the environment. It is currently one of the most dynamically developing fields of environmental science (Miatkowski et al. 2010). However, as I have shown in my papers, the methods of calculating a carbon footprint used so far for local planning of a low-carbon economy are not very effective and do not allow to determine the actual level of GHG emissions. Focusing almost exclusively on CO_2 emissions without taking into account other gases and omitting agriculture in the inventory – which in the case of rural and urban-rural communes is particularly unjustified – makes the amounts of the carbon footprint calculated for the purposes of low-carbon economy plans usually underestimated. This problem has also been observed in other European countries.

My attempt to assess the level of GHG emissions from agricultural activities at commune level has made it possible to identify local sources of emissions related to this sector. The results obtained for the whole country allow to create a database for local governments, which can be used during planning and prioritisation of GHG emission reduction measures at the stage of programming and implementation of a low-carbon economy. The maximum effects of the positive impact of solutions to reduce emissions can only be achieved if the methods and scale of their implementation are adapted to the local needs of individual communes in this respect. The research I have carried out – for the first time on such a large scale in Poland – combined with spatial analyses of emissions from individual sources related to agricultural activity may contribute to the development of regionalisation of the needs to include agriculture and rural areas in the local planning of a low-carbon economy in Poland. Work on such regionalisation should include, in particular: identification of the guiding factors for regionalisation of the needs for mitigation actions, development of regionalisation of these needs, development of typologies of the distinguished regions, identification of regions with the most urgent needs for mitigation actions as well as development of model mitigation solutions.

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5. Discussion of other scientific and research achievements

My scientific interests developed quite early in my geographical studies at the Kazimierz Wielki Bydgoszcz Academy (now the Kazimierz Wielki University), which I attended in the years 2000-2005. Due to the choice of the Master's Seminar, conducted under the supervision of Dr Roman Dysarz, my research interests and thesis topic concerned selected problems of anthropogenic pressure on the environment at the commune level. After graduation (with distinction), working every day at the secondary school (The School of Inland Navigation in Nakło nad Notecią), I started a scientific cooperation with Prof. Mieczysław Wojtasik. Within the framework of cooperation with the Institute of Geography of the Kazimierz Wielki University in Bydgoszcz (contract of mandate), in the years 2006-2010 I conducted classes for students on the natural foundations of sustainable development, soil science, hydrology and limnology. Despite the lack of permanent employment at the university, in cooperation with Prof. M. Wojtasik, I started scientific research initially focused, primarily, on the problem of soil erosion and anti-erosion protection in the young glacial areas of Pomerania and Kujawy. Earlier studies on moraine areas proved the existence of soil erosion even on slopes with low gradients. For example, Koćmit (1998), based on research in the young glacial areas of Pomerania, pointed out that erosion processes increase their range and intensity, covering even landscapes with smaller gradients, and in areas of agricultural land use, among the factors triggering erosion, agrotechnics is at the forefront. Although erosion for many years now has been mentioned as one of the main soil degradation factors (Mazur and Wnuczek 2006; Józefaciuk et al. 2014), the problem of soil environment protection against its impact is underestimated and often overlooked in planning and management works. Lack of interest of administrative authorities in matters of anti-erosion protection and lack of ready-made implementation programmes in the field of anti-erosion reclamation prompted me to join the discussion on the threat of soil erosion and actions to protect the soil environment. In my papers on this subject, I made, among others: an assessment of the scale of soil erosion risk and determined the degree of urgency of anti-erosion protection on the example of several selected communes in the Pomeranian, Kuyavian-Pomeranian and Greater Poland Voivodeships (Wojtasik et al. 2007, 2008, 2009, 2010); assessment of intensity and effects of erosion processes on slopes in young glacial areas (Wiśniewski and Wojtasik 2014c); assessment of the impact of soil erosion on landscape physiognomy (Wiśniewski and Wojtasik 2014b), as well as assessment of the degree of inclusion of anti-erosion soil protection against in county and commune environmental programmes and assessment of the role of these strategic documents in the management of anti-erosion soil protection together with proposals for changes in this area (Wiśniewski 2014a, 2015b; Wiśniewski and Wojtasik 2014a).

The results of the research presented in the above mentioned works were also presented during oral presentations or poster sessions at several national scientific conferences (a complete list in Appendix 3), organized, among others, by SGGW in Warsaw, IUNG-PIB in Puławy, ITP in Falenty and UP in Wrocław, as well as in a lecture during the plenary session at the International Scientific Conference "Science for economy and environment", organized by the Faculty Faculty of Agrobioengineering at the University of Life Sciences in Lublin.

Research on the degree of risk of soil erosion in young glacial areas of Pomerania and Kujawy, as well as the literature on the subject, prompted me to undertake a detailed research on the role of forests legally recognised as soil-protecting in preventing soil erosion. After an initial research conducted in the area of Szubin Forest Inspectorate (Wiśniewski and Wojtasik 2010, 2012), I undertook an attempt to identify and evaluate the antierosive function of soil-protecting forests in the areas managed by RDSF in Toruń. I was prompted to undertake these studies by the lack of studies devoted to a detailed analysis of the condition and structure of soil-protecting forests in Poland and their effectiveness in counteracting erosion in the young glacial landscape (the literature on the subject is dominated by works from mountain areas or loess areas). The results of these studies were the main element of my doctoral thesis, on the basis of which, in 2012, the Council of the Faculty of Agriculture and Biotechnology UTP University of Science and Technology in Bydgoszcz awarded me the degree of PhD in agricultural sciences in the field of environmental protection and management.

After my employment as an assistant professor at the Department of Physical Geography and Environmental Management at the University of Gdansk, I continued my research on soil-protecting forests and their role in reducing erosion processes. In 2015, my postdoctoral monograph was published by UG Publishing House (Wiśniewski 2015c). The research results on the structure and role of soil-protecting forests within the borders of the Regional Directorate of State Forests in Toruń, supplemented and enriched with numerous spatial analyses, were published in the Bulletin of Geography. Physical Geography Series (Wiśniewski and Kistowski 2015). As the effect of the scientific cooperation established in 2017 with Professor Michael Märker, representing the Department of Earth and Environmental Sciences, Pavia University, there is paper in the prestigious journal Geoderma (45 pts according to MSHE, IF = 3.740), in which we assessed the role and effectiveness of soil-protecting forests in reducing soil erosion in young glacial landscapes, comparing the intensity and effects of erosion processes and soil properties on variously used slopes in the north-central part of Poland (Wiśniewski and Märker 2019).

My participation in the *Pilot program of the low carbon development of Starogard County* became an impulse to undertake research in the second, very current research trend, concerning the problems of rural areas and related agricultural activity in the planning of low-carbon economy at the local level in Poland. Apart from the works constituting a scientific achievement, which are the basis for submitting an application for the habilitation procedure (described in detail in point 4), I have published a number of authorial scientific articles, directly related to this subject matter (including Wiśniewski 2014b, 2015d, 2016, 2017a, 2017b). Together with Prof. M. Kistowski we are also co-authors of a scientific monograph (Kistowski and Wiśniewski 2017), in which we have made a comprehensive characterisation and evaluation of the low-carbon economy plans adopted by local governments, drawn up on the basis of our previous experience in the analysis of strategic documents. The book also analyses the inclusion of agriculture and rural areas in the PGN.

Apart from the above mentioned two main directions of research, in my scientific works, I also dealt with the following issues: agromelioration needs of soils and their equivalent density (Wojtasik and Wiśniewski 2006, 2016), financing environmental protection with particular emphasis on the soil environment (Wiśniewski et al. 2007), possibilities of inland navigation development and its impact on the environment (Wiśniewski 2013, 2015a) and the importance of river valleys as ecological corridors (Czochański and Wiśniewski 2018). These issues were also presented by me in popular science articles, in such journals as: Aura, Eko i My, Ekopartner, Kronika Wielkopolski.

The values of selected measures of my publication activity are presented below. The total number of 47 published papers consist of: 35 peer-reviewed scientific articles (including 8 journals with IF, 24 in Polish, 11 in English, published in Poland, Germany, the Netherlands and Denmark), 2 scientific monographs, 4 chapters in monographs, 6 popular science articles. 22 papers are of my exclusive authorship, in 20 papers I am one of two authors, in 5 one of three. I am the prime author or corresponding author in all of my multi-author papers.

Tab. 1. Selected measures of publication activity

Period	Total numer of papers	Number of papers with IF	Numer of papers with MSHE points	Total MSHE* points	Total IF*
Before obtaining PhD (I 2006 - VIII 2012)	14	-	9	42	-
After obtaining PhD (IX 2012 - III 2019)	33	8	31	403	9.651
Total	**47**	**8**	**40**	**445**	**9.651**

* According to the points valid in the year of publication (articles published in 2017-2019 according to the 2017 list)

- Number of citations by Web of Science – **18**; h-index by Web of Science – **3**
- Number of citations by Google Scholar – **76**; h-index by Google Scholar – **5**

So far, I have participated in 44 international and national scientific conferences, symposia and seminars (34 after obtaining PhD), during which I have presented a total of 20 oral presentations or posters. I worked twice in the organizing committee of scientific and local government conferences devoted to the revitalization of waterways (in 2009 and 2010).

After obtaining PhD, I became the head of two research projects aimed at developing young scientists from the Faculty of Oceanography and Geography of the University of Gdansk. In cooperation with the Institute for Sustainable Development, I took part in the implementation of the *Pilot program of the low carbon development of Starogard County,* carried out within the framework of the “The Good Climate for Counties” project, which was developed by the Institute for Sustainable Development, the Association of Polish Counties and Community Energy Plus. Currently, I am one of the contractors of a research project, carried out in 2017-2020 as part of the SONATA 12 competition, financed by the National Science Centre. In the project entitled: "Socio-economic, environmental and technical conditions of electrical transport development and operation in Poland" (headed by Dr Marcin Połom from the Department of Regional Development at the University of Gdansk). I am the coordinator of the module responsible for the environmental aspects.

In 2014, on the basis of an original research project, I received a scholarship for young scientists under the project "Educators for the elite – integrated training program for PhD students, post-docs and professors as academic teachers at University of Gdansk", financed from European Social Fund. In 2016 and 2018 I was awarded, individual award of the second degree and team award of the second degree, by the Rector of the University of Gdansk for a series of scientific publications published.

After obtaining PhD, I started cooperating, as an expert, with the Ministry of the Environment, National Centre for Research and Development (NCBR), Foundation for Polish Science (FNP) and the Office of the Marshal of the Pomorskie Voivodeship. As part of this cooperation, I participated in the substantive assessment of 15 applications for funding of projects implemented under the Operational Programme Infrastructure and Environment in the field of environmental impact assessments, as well as I reviewed 7 applications for funding of projects under the NCBR Applied Research Programmes in the field of biological, agricultural, forestry and veterinary sciences (path A), 8 applications under the strategic research and development programme "Environment, agriculture and forestry" – BIOSTRATEG, 15 applications under the Smart Growth Operational Programme (for NCBR and FNP) and 6 applications under the Regional Operational Programme for Pomorskie

Voivodeship. I was also a reviewer of 13 scientific articles in Polish and foreign journals, including those with an IF (Energy Research & Social Science).

For several years, I was the secretary of the Bydgoszcz Ecological Society. Currently I am a member of the Bydgoszcz Scientific Society. I am also a member of the editorial board of Geography and Tourism magazine, published by the Institute of Geography of Kazimierz Wielki University (6 pts according to MSHE 2017 list, currently aspiring to the Scopus database).

I provide active scientific care for students. For four years, I have been running a bachelor's seminar in the third year of geographical studies (at that time I was a promoter of 53 bachelor's theses, as well as a reviewer of about 35 bachelor's theses and 4 master's theses). Currently, I also act as a research supervisor for students pursuing an individual study programme with scientific support.

Within the framework of scientific cooperation and popularization of science, in recent years, I have cooperated with the Chełmiński and Nadwiślański Complex of Landscape Parks, Gdańsk University of Technology, Nicolaus Copernicus University in Toruń as well as High School IX in Gdynia – giving lectures and carrying out thematic sessions during workshops and field exercises and lectures organized for academic and school youths and residents. This year, I also started cooperating with the Museum of the Koscierska Land, which will result in the publication of a reviewed monograph showing the history and environmental values of Kościerzyna (edited by Prof. Krzysztof Jan Mikulski). I was also appointed a member of the Regional Geographical Olympiad Committee in Gdańsk for the term 2019-2021.

A detailed list of published scientific papers together with information on didactic achievements, scientific cooperation and popularization of science is attached as Appendix No. 3.

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