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POTENTIAL OF POLISH SCIENTIFIC UNITS IN THE FIELD OF MITIGATION ACTIVITIES AND RESEARCH ON ADAPTATION TO CLIMATE CHANGE IN THE AGRICULTURAL SECTOR


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Contents

Institute of Agricultural and Food Economics – National Research Institute

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The Institute of Agricultural and Food Economics - National Research Institute is an independent scientific and research centre with 70 years of scientific achievement and experience in analysing economic and production processes in the Polish agriculture and food economy. It was established in 1950 as the Agricultural Economics Institute. In 1983 it merged with the Food Industry Economics and Organisation Institute and since then it has operated under the name of the Institute of Agricultural and Food Economics. By way of the Decision of the Council of Ministers, dated October 2004, it obtained the status of the state research institute and since 1 January 2005 it has operated as the Institute of Agricultural and Food Economics – National Research Institute (IAFE-NRI). The scientific staff of the Institute comprises 6 professors, 12 assistant professors (PhD hab.), 29 doctors (PhD), 23 assistants and 3 technical research specialists, employed in 6 scientific departments: Department of Agribusiness and Bioeconomy; Department of Economics of Agricultural and Horticultural Holdings; Department of Agricultural Economy, Agricultural Policy and Rural Development; Department of Agricultural Markets and Quantitative Methods; Department of Finance and Risk Management; Department of Agricultural Accountancy.

Research in the area of mitigation and adaptation to climate change

Research aimed at assessing the economic impact of climate change in agriculture

The studies are aimed at analysing and assessing the economic impacts of measures taken by domestic farms in relation to climate change and the protection of the natural environment.

The studies conducted by the IAFE-NRI concern:

- Assessing the functioning of farms from areas particularly affected by agricultural drought, including farms from areas with natural or other specific restrictions (less-favoured areas – LFA) against a backdrop of other farms. In Poland, droughts are an increasingly common phenomenon. They not only reduce crop yields and deteriorate the fodder value of livestock crops, but also increase the risk of livestock diseases, weeds and pests of crops, including alien invasive species.

- Assessing the functioning of farms involved in afforestation of land against a backdrop of other farms. Afforestation is an important way to manage agricultural land with particularly difficult conditions for the agricultural production resulting, inter alia, from the unfavourable physical structure of soils and their inherent low content of nutrients, low water capacity, as well as the adverse land relief and unfavourable climate. It plays an important role in the process of carbon dioxide sequestration from the atmosphere and its permanent storage in a form of carbon in wood biomass. It also contributes to reducing the phenomenon of advection in adjacent agricultural fields, which reduces their erosion and consequently weakens the negative impact of increasingly common droughts in Poland on the agricultural production. It should be emphasised that the volume of carbon dioxide sequestration from the atmosphere through afforestation is inventoried in the LULUCF sector, which, according to the existing European Commission (EC) findings, will contribute to limiting the effort to reduce greenhouse gas emissions from the Effort Sharing Regulation (ESR) area after 2020.

- Assessing the functioning of farms from areas of high natural value, including Natura 2000 sites with the high share of permanent grassland and forests, inland waters and other areas not subject to anthropopressure. It should be stressed that farms from these areas play a major role in the climate protection, including through, inter alia, care of the state of permanent grasslands in use which sequestrate large amounts of organic carbon in the soil.

- Calculating the costs of practices in the agricultural production to reduce greenhouse gas and ammonia emissions. In view of the existing EC findings on a need to reduce greenhouse gas emissions from the ESR and ammonia emissions in Poland after 2020, it becomes necessary to disseminate low-carbon practices in the crop and livestock production among farmers. The implementation of such practices on farms may increase the production costs and therefore it is necessary to establish them.

- Valuating agricultural greenhouse gas emissions and assessing the efficiency of emission economy, with a particular consideration given to agriculture. The studies shall be carried out using indirect valuation methods, in which the market price of the emission permit originating in the EU-ETS system is used as a reference point. The valuation of greenhouse gas emissions allows to compare the costs and benefits of a given economic activity in the context of their climate harm. These measures involve the internalisation of externalities in the economic account of agricultural activity.

- Importance of environmental and economic aspects of water consumption in agriculture. The availability of water for agriculture becomes one of the greatest conditions for conducting the agricultural activity. It is required to conduct studies on the economic effects of introducing water charges and its limited availability.

- Determining the type of agricultural development in the context of preservation of soil ecosystem services. Soil is one of basic resources of the natural environment necessary for conducting the agricultural production. It performs many non-productive functions and provides a number of services necessary for human existence. The diversity of services produced by soil creates a need to pay greater attention to its quality, which is largely derived from agricultural practices. The assessment of agriculture through the prism of organisation of farms allows to determine whether the farming method promotes the preservation of environmental services or may violate environmental processes.

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- Indicating the effects of introducing the greening mechanism of the Common Agricultural Policy. The implementation of greening practices stems from the EC legislation which highlights the importance of crop diversification in the context of improving the soil quality, maintaining permanent grassland in order to ensure carbon sequestration, soil and biodiversity protection, as well as an ecological area guaranteeing biodiversity preservation at the farm level. The scope of implemented agricultural practices with a positive impact on climate and the natural environment determines the adaptation of agriculture to ever-changing external conditions.

- Recognising ecological innovations in agriculture, both theoretically and practically. The importance of eco-innovations in agriculture is particularly important in terms of sustainable development, as agriculture is one of the sectors strictly dependent on the natural conditions. Eco-innovations in agriculture are, inter alia, organisational changes, which at the farm level are considered as new and consist in environment-oriented organisation of agricultural production. In terms of the agricultural sector, it is important to popularise environment-oriented organisational solutions which reduce both environmental and climate pressures of agricultural activity and external costs being generated.

- Determining changes that have taken place in fertiliser management in recent years and assessing them in the context of the impact of agricultural production on the natural environment. Proper fertiliser management is one of the most important determinants of sustainable agricultural development. Fertilisation is an indispensable element of agricultural production which, on the one hand, stimulates the productivity of crops and, on the other hand, determines the scale of its environmental impact. The need for proper fertiliser management, including balancing of fertiliser components, is determined by both economic conditions (resulting from costs of fertilisers and production effects of proper fertilisation) and environmental conditions (substantiated by a need to reduce environmental pressure).

Scientific and research base

The studies in this regard are conducted at the Department of Economics of Agricultural and Horticultural Holdings and in the Department of Agricultural Economy, Agricultural Policy and Rural Development. The studies are conducted by the team composed of: prof. dr Wojciech Józwiak, dr Wioletta Wrzaszcz, dr Konrad Prandecki, dr inż. Marek Zieliński and mgr inż. Jolanta Sobierajewska.

Research results

The research results are published in the form of monographs, chapters in monographs in Polish and English, scientific articles, expert opinions and opinions performed for the Ministry of Agriculture and Rural Development (Ministry of Agriculture and Rural Development). The results of the research were included in the following publications:

Zieliński M. 2016: *Emisja gazów cieplarnianych a wyniki ekonomiczne gospodarstw specjalizujących się w uprawach polowych*, seria Studia i Monografie nr 167, IERIGŻ-PIB, Warszawa.

Osuch D. (współaut.), 2017: *Szacowanie emisji gazów cieplarnianych na podstawie danych FADN*, w: *Redukcja emisji gazów cieplarnianych i amoniaku oraz metody adaptacji do zmian klimatu (wybrane zagadnienia)* (red. nauk. R. Borek, Z. Jarosz), seria „Studia i Raporty IUNG-PIB", nr 52 (6), IUNG-PIB, Puławy.

Z badań nad rolnictwem społecznie zrównoważonym [40] Rynkowe i instytucjonalne metody internalizacji efektów zewnętrznych, K. Prandecki,

E. Gajos (red. nauk.), seria „Monografie Programu Wieloletniego", nr 62, IERiGŻ–PIB, Warszawa 2017.

Przedsiębiorstwo i gospodarstwo rolne wobec zmian klimatu i polityki rolnej [5], M. Zieliński (red.), seria „Monografie Programu Wieloletniego", nr 97, IERiGŻ-PIB, Warszawa 2019.

Żak A., Zieliński M., 2019: *Farms participating in the agri-environmental-climate measure against a background of other farms*, "Annals of the Polish Association of Agricultural and Agribusiness Economists", t. XXI, z. 3.

Kagan A., 2018: *Procesy dostosowawcze wielkotowarowych gospodarstw rolnych w kontekście średniookresowego przeglądu WPR oraz polityki kilmatyczno-środowiskowej UE*, IERiGŻ-PIB, Warszawa, 153 s.

Agricultural company and agricultural holding toward climate changes [4], W. Józwiak, M. Zieliński (ed.), "Monographs of Multi-Annual Programme", no. 76.1, IAFE-NRI, Warsaw 2018.

Z badań nad rolnictwem społecznie zrównoważonym [46] *Teoria i praktyka internalizacji efektów zewnętrznych*, K. Prandecki, E. Gajps (red. nauk.), seria. „Monografie Programu Wieloletniego" nr 82, IERiGŻ–PIB, Warszawa 2018.

Zieliński M., 2018: *Możliwości ograniczenia emisji gazów cieplarnianych i adaptacji do zmian klimatu w sektorze rolnictwa (ekspertyza dla MRiRW)*, IERiGŻ-PIB, Warszawa.

Wrzaszcz W., 2018: *Effectiveness of Greening in Poland*, "Studies in Agricultural Economics", Vol. 120, No 2.

Prandecki K., Zieliński M., 2019: Opinia projektu raportu pt. *Climate change adaptation in the agriculture sector in Europe* (opracowanie dla MRiRW), IERiGŻ-PIB, Warszawa.

Wrzaszcz W., Kopiński J., 2019: *Gospodarka nawozowa w Polsce w kontekście zrównoważonego rozwoju rolnictwa*, seria „Studia i Monografie" nr 178, IERiGŻ-PIB, Warszawa.

Dudek M., Prandecki K., Wrzaszcz W., Żekało M., 2019: *Jak powstają innowacje w gospodarstwach rolnych. Analiza i przykłady*, Warszawa, IERiGŻ-PIB.

Wrzaszcz W., Prandecki K., 2019: *Rozwój rolnictwa indywidualnego w kontekście zachowania usług ekosystemowych gleby*, Zagadnienia Ekonomiki Rolnej, nr 3(360).

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The Institute of Plant Protection – National Research Institute is a state scientific-research unit whose history dates back to 1951. The main office of IPP – NRI is located in Poznań and the Branch Office is in Sośnicowice. The Institute consists of 8 scientific institutions, the Plant Diseases Clinic and Bank of Pathogens, the Research Centre of Quarantine, Invasive and Genetically Modified Organisms, laboratories, regional stations and a field station. Total employment: 256 people including 9 people with the title of professor, and 64 people with doctoral degrees.

Research in the area of mitigation and adaptation to climate change

Research Centre of Quarantine, Invasive and Genetically Modified Organisms

Research is focused on the impact of climate change, as well as on the threat and development of pests in agricultural crops

- Predicting threats to agricultural crops posed by agrophages

The main objective of the research carried out in the Department of Monitoring and Signalling of Agrophages is to predict the threat to agricultural crops from diseases and pests as a result of climate change. The results of agrophages signalling are available on the Agrophages Signalling Platform (www.agrofagi.com.pl/lang,1).

The research is aimed at dissemination among agricultural practice of systematic field observations describing the development of development stages of agrophages, which is used to assess the threat to agricultural crops as a result of predicted climate changes. On the web portal Agrophages Signalling Platform there are also available methods of integrated production and protection of various crops taking into account aspects of climate change prevention.

- The spread of new crop pests as a result of climate change

In the Institute the pest risk assessments are prepared for Poland in different climate change scenarios (for year 2050 and 2100), including present situation. Based on it the observations are being made about new pest risks. For example, damage to cereals is caused by two species of butterflies from the Tortricidae family, i.e. omnivorous leaftier moth (*Cnephasia longana*) and Meadow shade *Cnephasia pumicana*. Their range and population are monitored.

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Furthermore – both species are also covered by risk analysis (PRA). Climate change has a significant impact on the occurrence of sugar beet pests. In recent years the population of *Bothynoderes punctiventris* has grown considerably in southeastern Poland, as well as the presence of the *Scrobipalpa ocellatella*, which has been a problem since 2019, and the *Zyginidia scutellaris*.

- Research on the impact of climate change on threats from organisms harmful to maize (*Zea mays L.*).

The research aims at constant monitoring of threats to maize from harmful organisms in order to protect Polish maize producers from yield losses due to phytosanitary threats. Detailed observations are made of such elements as: range of harmful organisms, intensity and species composition, knowledge of selected elements of biology, harmfulness and control methods, and an assessment of the impact of climatic conditions on specific harmful organisms.

The economic importance of pests and diseases that prefer higher temperatures has increased significantly in recent years. Observations concern such corn pests as the European corn borer (*Ostrinia nubilalis*), Western corn rootworm (*Diabrotica v. virgifera*) or the periodic appearance of thermophilic species in Poland, flying in hot and dry summers from the Baltic region and North Africa (e.g. cotton bollworm – *Helicoverpa armigera*).

With rising temperatures, the development of fungal diseases of maize caused by microorganisms that prefer higher temperatures and humidity (e.g. fungi of the genus *Fusarium*) is observed.

Scientific and research base

- The Research Centre of Quarantine, Invasive and Genetically Modified Organisms
- Department of Monitoring and Signalling of Agrophages
- Department of Entomology and Agricultural Pests
- Department of Mycology
- Regional Experimental Stations IPP-NRI in Białystok, Toruń and Rzeszów

The Department of Monitoring and Signalling of Agrophages IOR – PIB annually publishes a monography *Phytosanitary status of arable crops in Poland*.

It is the only publication in Poland presenting a picture of crop healthiness and fluctuations in the population, species and regionalization of agrophages. It is also the creation of a database of harmfulness of economically important agrophages in the form of average values of the intensity and harmfulness of agrophages for voivodships and on a national scale. The database can be used to analyse changes in the intensity of occurrence of

Platforma
Sygnalizacji Agrofagów

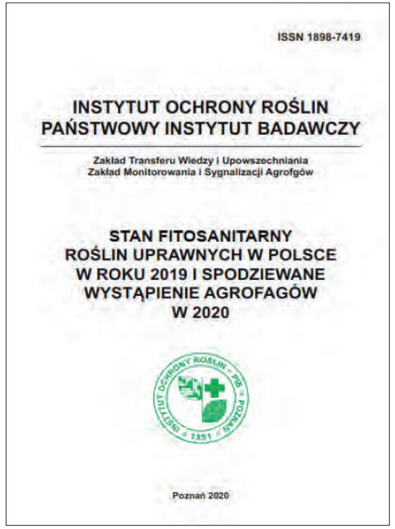
agrophages against the background of the course of climatic conditions in the last dozen or even several decades.

The Institute has a modern facility – the Research Centre for Quarantine, Invasive and Genetically Modified Organisms (SL3), which enables greenhouse and laboratory tests to be carried out with all known quarantine organisms under appropriate isolation conditions. Therefore, it is possible to conduct studies on the susceptibility of Polish plant varieties to particular quarantine agrophages or which constitute a new potential threat due to changing climatic conditions, as well as studies on their biology and control. The Institute performs agrophage risk assessments (PRA – Pest Risk Assessment), which are used both to identify quarantine agrophages and to identify emerging risks to plant health resulting from the increasing transport of goods and progressing climate changes.

Domestic and international projects

In the years 2013–2017, the Institute of Plant Protection – PIB participated together with the Jagiellonian University in the international project *Impact of climate change on biodiversity and spread of invasive species – A study on Arion slugs – WARION*. The main objective of the project was to conduct joint scientific research between Poland and Norway on the impact of climate change on the spread of the invasive species – *Arion vulgaris*.

The scientific research compared the features of the so-called „large Arion complex": *A. vulgaris, A. ater, A. rufus* from at least 10 sites, *A. vulgaris* in south-western France and from at least 30 sites covering the invasive range (i.e. Germany, Belgium, Poland, Denmark, Sweden, Norway). Data have been collected that may be helpful in developing a model to predict the spread of invasive snails in Europe.



Arion vulgaris

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The Research Institute of Horticulture in Skierniewice established on January 1, 2011 by merging the Institute of Horticulture and Floriculture and the Institute of Vegetable Crops. The research program of the Research Institute of Horticulture covers all issues related to horticulture production. Total employment 398 people including 11 professors, 24 doctors of science degree, and 59 with a doctoral degree.

Research in the area of mitigation and adaptation to climate change

Research related to the adaptation of plants to the occurring climacteric changes and reduction of greenhouse gas emissions

- Research aimed at reducing the risk in horticultural production due to climate change. Numerical weather models have been developed used for forecasting soil moisture in orchards and the basis for rational management of irrigation water resources. An integrated irrigation control system for ornamental plants and criteria for integrated irrigation of container ornamental plant nurseries were developed and tested. In order to improve the irrigation process and rational use of water prototype systems for automatic irrigation of container nurseries were developed.

- Research on the development of an innovative cooling system solution allowing for the reduction of energy consumption and abandonment of agents with a high potential of the greenhouse effect. Three prototype refrigeration installations were built; tests of mini-duct heat exchangers and classic air coolers were carried out; measurements of heat exchange and flow resistance of air flowing through the vegetable in the storage room; numerical model of the cooling chamber has been comprehensively developed which may constitute the basis for developing the target solutions of refrigeration systems serving vegetable storage compartments of small and medium storage capacity.

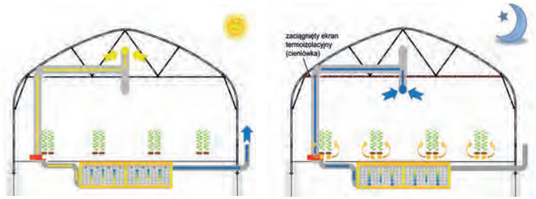
- Development of fertilizers based on leguminous plants The cultivation of leguminous plants and their use for the production of organic fertilizers will contribute to increasing the area of cultivation of these plants and thus to the increased binding of greenhouse gases (CO_2 and N_2O) in the plant mass and reducing atmospheric pollution with these components. These fertilizers have the form of granules, can be stored and used at any time in field and greenhouse production carried out in the soil. These fertilizers can be used for basic (pre-vegetative) fertilization and top dressing for all vegetable species which constitutes a big advantage. They are a source of nitrogen-rich organic matter which provides a nutrient for the development of beneficial soil microorganisms, contributes to enriching the soil with carious compounds and their mine-

ralization provides nutrients to plants including nitrogen and organic compounds that stimulate the growth of plants. As part of the project, the fertilizer value of the dried plant mass of clover and alfalfa was also used for the production of biodegradable organic nonwovens obtained from the processing of waste fibrous raw materials from the textile industry (flax hurds, cotton, and wool waste) and organic fertilizers made of leguminous plants and textile waste.

- A heat accumulator system based on a rock-bed was developed to reduce temperature changes in plastic tunnels. The accumulators stored the surplus heat generated inside the tunnels during the day. These surpluses energy were used to provide heat the cultivated plants at night or on cold and cloudy days. The experiments have shown that the heat accumulator is able to store enough heat to keep the tomato growing at a minimum temperature of 12 °C from mid-April to mid-October. Within 1–2 weeks after the start of using the accumulator it is able to store enough heat to protect the cultivated plants from the frosts. The heat capacity of the accumulator is also sufficient for heating plants even for several cloudy days when the rock-bed cannot be recharged. The use of the accumulator also allows a significant slowing down of the morning rapid temperature increase in the greenhouse, as well as improvement of the microclimate. As a result, when cultivating, e.g. tomato, yield acceleration of up to 2 weeks and more can be achieved, as well as favourable yield distribution in the season, i.e. greater early and late yield are obtained.

There is also observed an improvement of plant health at a reduced crop protection treatments. Currently, the research is continued within own resources. The main aim is focused on developing a simple and low-cost heat accumulator for plastic tunnels which will reduce energy consumption in crops under covers.

Currently, research is conducted to assess the possibility of reducing greenhouse gas emissions to the atmosphere by developing cultivation technologies in unfavourable climatic conditions of energy plants which largely promote the sequestration of organic carbon in soil and at the same time their transfer into energy is an alternative to burning fossil fuels emitting large amounts of CO_2. The environmentally friendly technology of energy plant fertilizings with municipal sewage on degraded soils and waste from methane fermentation used with the ecological soil improver, biostimulant, and ashes from the combustion of the studied



plants was developed. This technology is an alternative to fertilizing with synthetic fertilizers of which the production and use contaminate the environment and emits large amounts of greenhouse gases and is not conducive to CO_2 sequestration in soil.

Scientific and research base

- Department of Agroengineering
- Department of Cultivation and Fertilization of Horticultural Crops
- Department of Cultivars Evaluation, Nursery and Genetic Resources

Research projects

National project: *Innovative technologies of the algae metabolites use and in the elimination of artificial fertilizers in organic production of energy crops and environmental protection* (1029/B/P01/211/40);

Project under the Innovative Economy program: *Development of innovative energy storage technologies in production foil tunnels*, acronym: HortiEnergia;

Project under the Innovative Economy program: *Operational decision-making based on atmospheric conditions*, acronym: PROZA;

Project of the National Centre for Research and Development: *Sustainable irrigation of ornamental nurseries*, acronym: IRRINURS;

Project of the National Centre for Research and Development: *Comprehensive investigation of vegetable storage technology*, acronym: HORTCOOL;

Project of the National Centre for Research and Development: *Processing of waste biomass in combined biological and chemical processes*, acronym: BIOKONWERSJA;

Project from the LIFE+ program: *New soil improvement products for reducing the pollution of soils and waters and revitalizing the soil system*, acronym: BIOREWIT.

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The Institute of Technology and Life Sciences (ITP) was established on January 1, 2010 by the merger of the Institute of Buildings, Mechanization and Electrification of Agriculture (IBMER - founded in 1948) with the Institute of Land Amelioration and Grassland (IMUZ - foundation year 1953). The Institute's headquarters are located in Falenty near Warsaw. The Institute has 10 research facilities located in the headquarters in Falenty and in 3 branches (in Warsaw, Kłudzienko, and Poznań), 5 Regional Research Centres (in Wrocław, Bydgoszcz, Kraków, Elbląg and Szczecin). The Institute also includes research laboratories (3 accredited by the Polish Centre for Accreditation and 3 departamental, prepared for the accreditation process), Product Certification Unit, Environmental Technologies Verification Unit, and 3 Experimental Departments (agricultural holdings) located in Biebrza, Falenty and Poznań. The Institute employs a total of 242 people including 8 people with the title of professor, 15 people with doctor of science degree, and 51 people with a doctoral degree.

Research in the area of mitigation and adaptation to climate change

Research aimed at reducing greenhouse gas emissions from rural areas and mitigating the effects of drought and floods in agriculture

The Institute conducts research aimed at developing new and improving existing solutions, serving among others to reduce greenhouse gas emissions from agriculture and rural areas through:

- Improving the construction of livestock buildings and organization of animal production in the aspect of air protection;
- Development of methods of obtaining energy for farms from renewable sources;
- Inclusion of by-products and wastes into a closed circulation of matter in line with the bioeconomy assumptions; inter alia to minimize harmful emissions;
- Improvement of engineering and technology of village sanitation together with low-emission utilization of sewage sludge, municipal waste and agri-food processing;
- Protection of biodiversity in rural areas with particular emphasis on wetland habitats in the context of carbon dioxide emissions;
- Protection of meadow soils and organic carbon resources contained in them.

An important aspect of the work carried out at the Institute in the context of adaptation of agriculture to climate change concerns water management in agriculture and in rural areas.

It includes:

- Mitigating the effects of drought and flood risk;
- Development of drainage systems in the aspect of rational management of water resources;
- Optimization of the operation of water and drainage devices.

Examples of research subjects:

- Determination of the CO2 exchange balance with the atmosphere of permanent grassland on organic soils in habitats with diverse water conditions;
- Determination of the CO2 exchange balance with the atmosphere of the agro-ecosystem of sugar beet cultivation under the conditions of conventional and reduced tillage;
- Emission of nitrous oxide (N2O) from organic soils under permanent grassland under diverse water conditions;
- The opportunities to reduce greenhouse gases and gases that affect air quality generated by the agricultural sector – the technological and economic conditions assessment;
- Evaluation of renewable Energy resources in rural areas, in particular biomass, and rationalization of the use.

Scientific and research base

The Institute has an extensive scientific and research base in the area of mitigation and adaptation to climate change in rural areas made of scientific institutions, regional research centers, an accredited laboratory, and departmental laboratories:

- Department of Technology and Emission Reduction in Farm Facilities;
- Department of Renewable Energy Sources;
- Department of Biomass Processing Technologies;
- Department of Engineering and Water Management;
- Department of Nature and Rural Landscape Protection;
- Department of Water Quality;
- Department of Economic and Energy Analysis;
- Department of Rural Technical Infrastructure Systems;
- Department of Plant Production Engineering;
- Department of Grasslands;
- Research Laboratory of Agricultural Technology and Biosystems;
- Research Laboratory of Environmental Chemistry;
- Research Laboratory of Environmental Engineering.

Institute of Technology and Life Sciences in Falenty

Domestic and international projects

Development of an innovative method of air purification in grain and seed driers along with reduction of pollutant emissions. BIOSTRATEG III. 02.04.2018–01.04.2021

Technological innovations and a system for monitoring, forecasting and operational planning of drainage measures for precise water management on the scale of the drainage facility. BIOSTRATEG III. 01.01.2018–31.12.2020.

Technological and nature projects for an innovative, effective, and low-emission economy in rural areas. PW. Multiannual program of the Ministry of Agriculture and Rural Development. 12.12.2016–31.12.2020.

Bioproducts from lignocellulosic biomass obtained from marginal land to fill the gap in the national bioeconomy. BIOSTRATEG III. 01.12.2017–30.11.2020.

Modeling the impact of farms and catchment area use structures on the example of the Puck commune on the quality of land and sea waters located in the Baltic Sea coastal zone – WaterPUCK Integrated Information and Prediction Service. BIOSTRATEG III. 01.07.2017–30.06.2020.

Interdisciplinary research on improving energy efficiency and increasing the share of renewable energy sources in the energy balance of Polish agriculture. BIOGAS & EE. BIOSTRATEG I. 01/04/2015–31/03/2018.

Research and preparation for implementation of energy and heat generation technology in a boiler room powered by micronised biomass. BioCHP. BIOSTRATEG I. 01.06.2015–31.05.2018

Reduction of nitrogen losses from agriculture by promoting the application of slurry acidification techniques in the Baltic Sea region. Baltic Slurry Acidi. Interreg BSR 2013 – 2020. 01.03.2016–28.02.2019.

The impact of climate change on the growth of grasslands, their water conditions, and the state of biomass. FINEGRASS. 01.12.2013–30.11.2016.

Increasing the use of domestic feed protein for the production of high quality animal products in sustainable development conditions. Increasing the use of the potential of permanent grassland in the production of feed protein for dairy cattle. PW/B. Multiannual program of the Ministry of Agriculture and Rural Development. 01.01.2016–31.12.2020.

Adaptation of agriculture in European regions at environmental risk under climate change. ADAGIO. 6. EU Framework Program, Priority 8. Project coordinator: BOKU Vienna. Polish coordinator: Poznań University of Life Sciences. ITP: contractor. 2007–2009.

Technological innovations and a system for monitoring, forecasting, and operational planning of land drainage activities for precise water management in the scale of a land reclamation facility. INOMEL. BIOSTRATEG III, 01.01.2018–31.12.2020.

Operationalization of the increase in water consumption efficiency and flexibility in irrigation systems. OPERA. HORIZON 2020. 01.05.2017–31.10.2019.

Selection of cattle breeding technologies in order to reduce gas emissions, mainly ammonia and carbon dioxide. Ministry of Science and Higher Education 2008–2011.

Water losses and their reduction in rural communes – villages in the Baltic Sea Region, as pilot. VillageWaters. Interreg BSR 2013 – 2020. 01.03.2016–28.02.2019.

Innovative approach supporting monitoring of non-forest Natura 2000 natural habitats using remote sensing methods. HabitARS. BIOSTRATEG II. 01.01.2016–31.12.2018.

Protection of species diversity of valuable natural habitats on agricultural lands in Natura 2000 areas in Lubelskie voivodeship. KIK/25. Polish-Swiss Cooperation Program. 04.08.2011–14.06.2017.

Modeling of European agriculture taking into consideration climate change for food security – phase 2. FACCE MACSUR2. 01.06.2015–31.05.2017.

Detailed assessment of the risk of restitution of the pastoral economy in the Carpathians in the aspect of food security. FACCE MACSUR/SZORG. 01.06.2012–31.05.2015.

Climatic basis for the development of rainfall models for the city of Bydgoszcz, as part of the modernization and extension of the Bydgoszcz rain sewage system t o counteract and adapt to climate change. An electronic database of long-term rainfall data at the Bydgoszcz-IMUZ station was developed and verified (by 2009) and Bydgoszcz-ITP (from 2010 until now).

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Institute of Soil Science and Plant Cultivation - National Research Institute (IUNG-PIB) established in 1950 is a continuator of 150 years of activity of agricultural facilities in Puławy. The headquarters of the Institute is located in the historical Princes Czartoryski palace. Research conducted at the Institute covers a wide range of issues related to crop production and the impact of agriculture on the environment. In the field of environmental research the Institute has the most extensive agrometeorological, soil science and environmental databases in the country covering areas used for agricultural activities in Poland. The Institute employs a total of 334 people including 19 with the title of professor, 17 with doctor of science degree and 66 with a doctoral degree.

Research in the area of mitigation and adaptation to climate change

Research aimed at counteracting the causes and effects of climate change in plant production

The first research related to the assessment of the impact of climate change on agriculture in Poland was published by scientists working at IUNG-PIB in 1993 (Bis et al 1993*) .

Since then a team of scientists headed by Prof. Tadeusz Górski conducted systematic work on assessing the impact of climate change on agriculture and potential methods of adaptation. At the same time Prof. Antoni Faber and his team conducted work related to the assessment of greenhouse gas emissions from agriculture and the possibilities of production of agricultural biomass.

Since 2008 IUNG-PIB is conducting the Agricultural Drought Monitoring System supporting the functioning of agriculture under the conditions of observed climate change (www.susza.iung.pulawy.pl).

*) Bis K., Demidowicz G., Deputat T., Górski T., Harasim A., Krasowicz S. 1993. *Ekonomiczne konsekwencje zmian klimatu w rolnictwie polskim* (ocena wstępna). Probl. Agrofizyki, 68, Ossolineum Wrocław

In 2010 together with the EU FP7 PROFICIENCY project *Strengthening IUNG-PIB proficiency in the field of research on food and feed production, management food security and food quality under global climate change* the problem of climate change becomes a priority determinant of the Institute's competence development. As part of statutory activities and long-term programs financed by the Ministry of Agriculture and Rural Development topics related to adaptation and mitigation of climate change are being discussed (http//klimat.iung.pulawy.pl/; http //biomasa.pw.iung.com/).

In 2013 the results of the work carried out were the basis for the Strategic Adaptation Plan for sectors and areas sensitive to climate change by 2020 adopted by the Polish Government with a 2030 perspective (http//klimada.mos.gov.pl/en/).

A modern IUNG-PIB laboratory built in 2013 is capable of supporting scientific research on a wide range of problems related to the assessment of chemical and biological properties of soils for the need of implementation of adaptation and mitigation measures in agriculture (http//incbr.iung.pulawy.pl/).

From 2015 IUNG-PIB implements the EU HORIZONT 2020 project, BioEcon whose goal is to develop research and fully use the research potential of IUNG-PIB for global strategies in accordance with the principles of bioeconomy (http//bioecon.iung.pulawy.pl/).

Since 2016 as part of the BIOSTRATEG program IUNG-PIB is a leader of the LCAgri consortium that implements the project: *Support for low carbon agriculture able to adapt to observed climate change in the perspective of 2030 and 2050* (http//lcagri.iung.pl/en/.

Within the framework of the project a cooperation is being developed to consolidate efforts related to the implementation of mitigation and adaptation activities in Polish agriculture between the consortium partners: the main producer of nitrogen fertilizers in Poland, i.e. Grupa Azoty SA, the Centre for Emissions Management, the Institute of Environmental Protection, and The Bohdan Dobrzański Institute of Agrophysics of the Polish Academy of Sciences and the agriculture support institutions.

In addition IUNG-PIB participates in several other European projects assessing sustainability, innovative and climate smart farming systems (e.g. FP7 Catch-C) including agroforestry systems (SustainFARM ERA-NET Cofund FACCE Surplus).

Scientific and research base

- Decision Support Systems, yield forecasting, drought monitoring – Department of Agrometeorology and Applied Informatics;
- Measurements of greenhouse gas emissions, biomass availability analyses, Bioeconomy – Department of Bioeconomy and System Analysis;

Institute of Soil Science and Plant Cultivation – State Research Institute

- Analyses of soil properties and land use changes – Department of Soil Science Erosion and Land Conservation;
- Soil microbiological analyses - Department of Agricultural Microbiology;
- Phytochemical analyses – Department of Biochemistry and Crop Quality;
- Molecular analyses – Department of Plant Breeding and Biotechnology;
- Long-term experience - Department of Systems and Economics of Crop Production, Department of Cereal Crop Production

Domestic projects

2003–2008; Extreme meteorological and hydrological events in Poland (assessment of events and forecasting their effects on the human life environment). The task: Effects of extreme phenomena in areas of agricultural activity – selected examples in various natural regions of Poland. Ordered project: PBZ-KBN-086/PO4/2003.

2005–2008; AGROGAS Scientific network created by the Bohdan Dobrzański Institute of Agrophysics PAS, Institute for Building, Mechanisation and Electrification of Agriculture, Institute of Soil Science, Fertilization and Soil Science - NRI, Faculty of Biology and Environmental Protection University of Lodz, Institute for Agricultural and Forest Environment PAS, Faculty of Biology and Agriculture University of Rzeszów.

2008–2011; Determination of occurrence conditions and threats caused by agricultural drought on arable land in Poland, statutory Project IUNG-PIB: 4.1.4.

2010–2012; Plant phenology and terms of field work in the conditions of various scenarios of climate change, statutory Project IUNG-PIB: 4.1.4.

2010–2012; Assessment of biomass production potential for energy purposes (case studies), statutory Project IUNG-PIB: 4.2.6

2011–2014; Assessing the impact of RDPs on sustainable rural development, and reduction of the impact of climate change; statutory Project IUNG-PIB: 4.2.7.

2011–2015; Information system on climate change and ways of adapting agriculture to such changes, multi-annual Program IUNG-PIB Task 1.1.

2011–2015; Assessment of the possibility of reduction of carbon dioxide emissions from agriculture through its sequestration in soils, multi-annual Program IUNG-PIB Task 1.5.

2013–2015; Agrometeorological conditions in Poland according to climate scenarios for 2030, 2050, 2080; statutory Project IUNG-PIB: 4.1.13.

2016–2020; Development and improvement of evaluation methods and forecasting (modelling) of the environmental and production-economic effects of the CAP and climate change. Multi-annual Program IUNG-PIB Task 1.7.

2016–2020; Analysis of the possibilities for reduction of greenhouse gas emissions, ammonia and nitrates from agriculture in 2030 and and 2050 perspective; Multi-annual Programme IUNG-PIB: Task 2.6.

2016–2020; Assessment of possibility of shaping the level and quality of crop production, taking into account foreseeable climate change; Multi--annual Programme IUNG-PIB: Task 2.4.

2016–2019; **LCAgri**: Support for low-carbon agriculture capable of adaptation to climate change in present and in 2030 and 2050 perspective (http://lcagri.iung.pl/pl/).

2018–2020 TechRol; New eco-energy technologies for sustainable rural development and low-carbon agricultural production.

International projects

2006–2009; CLIVAGRI – Impacts of Climate Change and Variability on European Agriculture, Action COST 734 (http://www.cost734.eu/)

2010–2013; PROFICIENCY – Strengthen IUNG's proficiency on "Managing the Production of Food and Feedstuff, their Safety and Quality under Global Climating Change (http://proficiency-fp7.eu/)

2012–2015; MACSUR – Modelling European Agriculture with Climate Change for Food Security - Research within the scientific network: FACCE-JPI (Joint Programming Initiative for Agriculture, Climate Change, and Food Security) (https://macsur.eu/)

2012–2015; ENORASIS – Optimization in the direction of the environmental sustainability of irrigation management using an integrated system based on high resolution satellite data, advanced modelling, process controls and innovative management services (http://www.enorasis.eu/)

2012–2014; CATCH–C – Compatibility of Agricultural Management Practices and Types of Farming in the EU to enhance Climate Change Mitigation and Soil Health (http://www.catch-c.eu/)

2016; BioEcon – New strategies on Bioeconomy in Poland (http://bio-econ.iung.pulawy.pl/)

2016–2019; SustainFarm – Innovative and sustainable intensification of integrated production systems for food and non-food purposes for the development of agroecosystems resistant to climate change in Europe and beyond.(http://www.sustainfarm.eu/).

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The Institute of Natural Fibers and Medicinal Plants is an interdisciplinary research centre with international the acquisition and processing of natural fibrous and herbal raw materials. The Institute responds to the needs of agriculture, environmental protection, construction, transport, food industry and pharmacy. Institute employs a total of 168 people including 4 people with the title of professor, 8 people with doctor of science degree, and 29 people with a doctoral degree

Research in the area of mitigation and adaptation to climate change

Research related to the impact of reclamation of degraded areas on the binding of CO2 from the atmosphere and adaptation of selected herbal plants to the occurring climacteric changes

At INF&MP research for use of fiber and herbal species to reduce climate change and adaptation of varieties to new conditions are conduct.

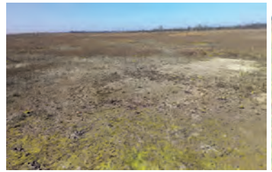
Hemp has large potential for mitigation of adverse climate change. Due to a well-developed pile-type root system, they show low susceptibility to water deficit in soil. Hemp is also a species with very high biomass yield. Cultivation of 1 ha of hemp (fibrous) binds about 2.5 t CO2 from the atmosphere during the vegetation period, which reduces the global warming effect. An important advantage of hemp is also the possibility of growing them on degraded and marginal land, which can be combined with rational development of such sites with the process of mitigation of adverse climate changes. Institute of Natural Fibres and Medicinal Plants in Poznań is implementing a project: „Remediation of degraded land in the region of Lignite Konin by cultivation of industrial hemp" (LIFE11ENV/PL/445). The project is co-financed from the E U Life+ financial instrument and co-financed by the National Fund for Environmental Protection and Water Management. As a part of the project, the technology of agricultural land reclamation degraded by the industry associated with opencast mining was developed. The technology is based on the cultivation of two plants in the crop rotation, i.e. fibrous hemp and alfalfa. The obtained effect was biological composite system stimulates the restoration of the humus layer, increases the nutrient content, improves water-air relations, and creates conditions for the multiplication of soil microorganisms.

The implemented project Integrated system of bioremediation - biorefinering using halophyte species has a similar character. The goal of the project is high knowledge transfer potential - an alternative, economic

solution for restoring agricultural land degraded by salinity during coastal floods, as a result of intensive agricultural practices or as a result of pressure from climate change. The work concerns monitoring the degree of soil purification and halophyte biomass yield, and the obtained biomass is tested for the possibility of using it to produce biocomposite, briquettes for energy purposes and bioethanol. Potential benefits of halophyte biomass based biorefineries will include reducing greenhouse gas emissions and dependence on fossil resources, as well as creating employment opportunities in rural areas and creating new markets for agriculture.

The Institute also co-implements the MAGIC project, whose goal is promote the sustainable development of resource-efficient and economically profitable industrial crops grown on marginal lands. These crops include hemp, among others. In the long term, this strategy is conducive to sustainable economic development for EU bioeconomy and will contribute to the achievement of energy and climate goals by the EU. Further investigation actions include the creation of new breeding tools and strategies towards better crop varieties, the identification and optimization of appropriate agronomic practices with limited input requirements and the development of suitable harvesting strategies and logistics to optimise the biomass supply-chains.

As part of the adaptation of fibrous and herbal varieties to changing climatic conditions, the Institute conducts breeding work on identifying sources of plant resistance to drought stress and breeding new varieties with reduced susceptibility to water deficit in soil. Such works mainly concern crop flax, chamomile and roses. One of their effects was registering a new variety of fiber flax JAN, as well as a variety of MASTAR camomile. These varieties are characterized by stable yields in soil drought conditions.



In order to increase the resistance of genetically produced plants, stimulating preparations based on anti-transpirants are also being developed. Biostimulators have a positive effect on many physiological processes, including stimulate plant immune processes.

Scientific and research base

- Analysis of the quality of fibrous and herbal raw materials
- Technologies for plant biomass processing
- A collection of gene resources of flax, hemp and herbal species as a source of resistance of new varieties to stress factors
- A developed network of field experiences, including provocative fields.

Domestic and international projects

Remediation of Degraded Land in The Region of Lignite Mine Konin by Cultivation of Industrial Hemp, the acronym EKOHEMPKON; LIFE +

Marginal Areas for Growing Industrial Plants: Turning A Burden into Opportunities Acronim MAGIC, Horizon 2020

Integrated System of Bioremediation – Biorefinering Using Halophyte Species Acronim: HALOSYS, 2nd call of ERA-NET FACCE SURPLUS.

INSTYTUT ZOOTECHNIKI
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National Research Institute of Animal Production in Kraków-Balice established in 1950 belongs to the largest Polish scientific and research institutes of national range. The institution conducts scientific research and development works in the field of animal husbandry and all zootechnical issues. The Institute has 10 Scientific Facilities, 9 Experimental Facilities, and 3 accredited laboratories. The Institute employs a total of 281 people including 16 people with the title of professor, 23 people with doctor of science degree, and 64 people with a doctoral degree.

Research in the area of mitigation and adaptation to climate change

Emissions tests and methods to reduce GHG emissions from livestock production

The National Research Institute of Animal Production is a scientific unit with almost 70 years of tradition directly subordinate to the Ministry of Agriculture and Rural Development. The core area of the institute's activity is broadly understood animal production covering both proteomics issues, molecular biology, transgenesis, as well as nutrition, breeding, genomic evaluation animal maintenance technology, after PLF use, computerized herd management systems, renewable energy or environmental protection together with climate change. The National Research Institute of Animal Production has been conducting constant research on various aspects of GHG emissions from animal production since the 1990s while assisting National Centre for Emissions Management in the elements of estimation of emissions from the domestic livestock population. Research covers both nutrition and animal welfare systems, as well as storage and application of natural fertilizers.

The work included mitigation of NOx and CH4 and basic animal species like cattle, pigs, and poultry.

The National Research Institute of Animal Production started to implement the Climate Care Cattle Farming Systems (CCCfarming) project financed under the ICT AGRI ERA-NET, ERA-NET SusAn and FACCE ERA-GAS initiative.

The goal of the CCCfarming project is to develop intelligent cattle farming systems that reduce greenhouse gas and ammonia emissions while maintaining socially and economically sustainable farms. The key assumptions of

the project are production efficiency and care for the climate. Project research will focus on the use of innovative manure maintenance and management systems, novel cultivation systems, precise crop management and ICT data collection techniques.

Scientific and research base

Research in the field of environmental protection and climate change is based primarily on the use of 6 microclimatic chambers with full computer control of all microclimate parameters and direct emission measurement. The chambers can be equipped with various types of equipment including changing the type of floors in a variable temperature range from -30 to 50°C. Field tests utilise portable aerodynamic tunnels equipped with low-speed fans to control the air flow. In this type of tests portable measuring apparatus including 3-column gas chromatograph, FID meters for separate measurement of CH_4, CO_2, NO_x with a breakdown into components, VOC, NH_3, H_2S, etc. are used, as well as autonomous ph, temperature, and relative humidity meters with data loggers.

Teams have also at their disposal extensive equipment of the Institute of Meteorology and Water Management – National Research Institute with the stationary liquid and gas chromatographs, fast IR analysers, as well as mass spectrometer. For the purpose of biological material research, micro reactors with full computer environmental regulation are used. Field and industrial research are carried out in 9 experimental departments scattered throughout the country.

Domestic and international projects

Due to the fact that the institution owned gas chromatograph and photoionization meters enabled in 2003–2005 to undertake research on the impact of renewable heat sources on air pollution in animal buildings.

The aim of the research was to determine the size and scope of emissions of gaseous pollutants from classical and renewable heat sources used in animal production. In the experiment, the products of combustion of such materials as hard coal, heating oil, cereal straw, and wood were determined. The occurrence and amount of the following compounds were analysed: carbon dioxide, carbon monoxide, sulphur dioxide, nitrogen oxides, dioxane, and others. The obtained results allowed to estimate each time the amount of pollutants corresponding to the consumption of 1 GJ. The research also determined the economic effectiveness of using these sources on the basis of unit prices of carriers.

The research on gas emissions was continued on the field of **determining the emission volume of harmful gaseous admixtures created invarious cattle maintenance systems, and the possibility of their reduction** carried out in 2004–2006. The aim of the study was to estimate the emissions of individual gases from dairy cattle breeding and to identify ways to counteract them. The animals were kept in 6 climate chambers, each of them equipped with a different maintenance system. Measurements of emitted gases realized in a continuous manner using an electronic gas concentration meter, as well as a gas chromatograph. At the same time, the microclimate parameters of the chambers were monitored. Emissions of macronutrients, such as ammonia, hydrogen, sulphide, methane, and nitrogen oxides, and additionally organic volatile compounds were subjected to measurements and comparisons.

Increasing protein digestibility while lowering its level in the dose resulted in positive effects in reducing nitrogen losses as well as reducing odour emissions. Attention was also paid to counteracting emissions by means of bedding additives. The best results were obtained using salts lowering pH of faeces and bacteriostatic compounds limiting the number of microflora.

The above studies were supplemented with the research carried out in 2006–2008 concerning the **impact of manure storage conditions on the course of decomposition processes**. The aim of the research was to determine the possibilities of biogenic potential reduction and gas emission from stored bovine and porcine manure. The experiment covered 2 tasks within pig and cattle. The first one specifies the absolute values of gaseous emissions and changes in manure composition during its „maturation" process in the conditions of increasing temperatures (spring-summer period) and decreasing temperatures (autumn-winter period). The second task determined the impact of modification of manure storage in conditions of increasing temperatures on the size of biogenic compounds losses. The experiment was carried out in field conditions using wind tunnels. In the period of higher temperatures, the prisms were subjected to a rapid rate of biochemical changes which in effect did not prevent the reduction but significantly limited it. It was found however that creation of manure piles at low (but not negative) temperatures re-

Fot. KOWR

sulted in increased losses of biogenic compounds caused by the absence of a thermophilic phase.

In the years 2006–2010 the task of the long-term program by National Research Institute of Animal Production was implemented *Opracowanie norm i procedur technologicznych chroniących środowisko naturalne przed niekorzystnym wpływem ferm zwierząt z uwzględnieniem specyfiki obszarów szczególnie narażonych (OSN)*. The aim of the task was to determine the scope and scale, as well as standards for the emission of harmful gaseous compounds and odors emitted from farms, as well as to establish and implement procedures to reduce the threat to the environment stemming from the storage of animal manure. During the implementation of the task animal production technologies for particularly vulnerable areas (OSN) were also developed, as well as a system for monitoring the negative impact of farms on the environment. The results obtained here were used to introduce norms of scale, and concentration of animal production in terms of the permissible environmental burden.

In the years 2007–2010 ordered target project NR PBZ-MEiN-5/2/2006 was implemented: *Nowe metody i technologie dezodoryzacji w produkcji przemysłowej, rolnej i gospodarce komunalnej*, in which the institute performed a task devoted to model tests of gas emissions arising from the maintenance of livestock. The aim of the conducted research was to carry out an inventory of dislocations of sources of odour emissions from breeding and to recognize the scope and scale of emissions of zoonotic odours from farms and livestock spaces with the most frequently used systems for maintenance of pigs, cattle poultry. Concurrently to the Program a statutory subject was implemented, devoted more broadly to one of the previously chosen methods of reducing gas emissions, namely the impact of ionization on air composition, and the volume of gas emissions from livestock buildings (2008–2010).

Fot. KOWR

The research was carried out in two tasks here, the first of which was carried out in a controlled environment of climatic chambers, while the second in production conditions. Task 1 specifies the possibilities of using different doses and sources of negative ionization. Task 2 determines the effect of the optimal dose and the most effective source of ionization on the production and animal health results. Based on the obtained results it was found that the negative ionization of gaseous pollutants from livestock buildings is a highly effective method of reducing environmental contamination from this activity. The best reduction properties were characterized by crown ionizers with a capacity of 10,000 and 100,000 (ion / cm^3) and a UV ionizer.

Another method of emission reduction was the filtration of ventilated air from buildings. In the subject of the impact of filtration methods on limiting the degree of air pollution from intensive livestock production (2007–2009) the possibilities of reducing gas emissions through the use of different types of bio filters to direct the transformation of the degree and range of filtration were determined. Filtering material for bio filter was made of peat, shredded bark, chopped straw, and sawdust from conifers. Amount of emission reduction was determined for ammonia, alcohols, aldehydes, ketones, organic acids, phenols, etc. The highest efficiency of filtration for all types was demonstrated by a bio filter equipped with a peat deposit retaining over 60% of gases emitted from ventilation.

The studies described above on the use of alternative heat sources in animal production have found their continuation in the research on the determination of the efficiency of the use of energy-saving technological solutions for the needs of pig farming (2009–2011). In order to achieve the assumed objective, an audit of the electricity consumption of the farm was carried out and the productivity of renewable energy sources (RES) was practically determined for heating, lighting, and ventilation of livestock buildings.

Together with the new assumptions of the country's energy policy in 2011–2014 research was initiated on the impact of the increased share of agricultural by-products on the course of biogas generation processes. The assumptions have been made as to the possibility of reducing emissions of both methane and ammonia from natural fertilizers precisely on the path of cogeneration of energy in biogas installations. Fermentation of mixtures was carried out on the basis of the use of micro fermenters provided with solid substrate and agitator dispensers corresponding to the so-called wet fermentation. Fermentation processes were carried out in anaerobic mesophilic conditions (37^0C) with full control of the direction and parameters of the changes taking place (ph, the amount of biogas, its composition). On the basis of the obtained results it was shown that natural fertilizers can be an effective substitute for maize silage in methane fermentation processes carried out in agricultural biogas plants while maintaining a proper C/N ratio of 26 in the substrate.

With the increasing importance of mitigation of greenhouse gases the attention of research teams has shifted to the development of methods to reduce nitrogen oxides from animal production. (2008–2010). the aim of these studies was to determine the possibility of reducing the emissions of nitrogen oxides arising from the production of dairy cattle, pigs, and poultry. In order to fully achieve the assumed objective the determination of nitrogen compound emission levels including air adhering oxides in bedding, and non-bedding holding systems with the aid of a photoionization gas meter (FID) was performed.

The possibilities of reducing emissions through the use of nutritional supplements, improving the digestibility of nitrogen compounds contained in fodder, as well as chemical preparations as bedding additives were investigated. Air ionizers were also used to increase the amount of reactive particles involved in odour oxidation reactions. The measurements were carried out in microclimatic chambers and wind tunnels environment.

National Research Institute of Animal Production

In view of the multiplicity of EU legislative actions regarding both GHG, and ammonia reduction, as well as the tightening of forms of enforcement of the nitrates directive, a comparative research was undertaken at the NRI AP in the field of methods simultaneously reducing all these impacts.

A research task was dedicated regarding **the adaptation of animal husbandry to environmental protection requirements** (2014–2016). The aim of the research was to develop and verify methods to reduce the emission of volatile gas compounds, as well as the concentration of biogenic compounds from the maintenance of farm animals, storage of natural fertilizers and their monitoring. The research covered three objectives regarding living conditions of farm animals, storage conditions for natural fertilizers, and monitoring of farms for the dispersion of nitrogen compounds.

When summing up the results obtained during the implementation of these studies, one can conclude that the dependence of the reduction of gas emissions on the methods used is quite diversified. The stated range of reduction ranges from 20–80% of the original state. The natural consequence of emission reduction is the increase in deposition mainly of nitrogen in the soil itself. The reduction effect shows a high variability in relation to the gases tested which is mainly related to the physico-chemical conditions of their formation reactions. The reduction methods themselves largely influenced, via their nature, the modification of these parameters. The most effective methods include covering the storage of natural fertilizers. Farming solutions especially floors turn out to be the most effective within farm buildings.

The Plant Breeding and Acclimatization Institute - National Research Institute

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The Plant Breeding and Acclimatization Institute - National Research Institute was established in 1951 as a scientific institution to conduct research in the field of breeding and seed production of agricultural crops, technology of growing oilseed, root and potato plants, as well as implementation, dissemination, standardization and unification works. The Institute operates in six research centers: Radzików, Bonin, Bydgoszcz, Jadwisin, Młochów and Poznań. The Institute also includes six Experimental Departments operating in different regions of the country. After 2000, five companies were created from several Experimental Works. The Institute employs a total of 323 people, including 108 research workers, of which 12 are professors, 9 are associate professors, 61 adjuncts and 26 assistants.

Research in the field of mitigation and adaptation to climate change

Research and work in this area are carried out in the following areas:

- molecular and physiological foundations of resistance to drought and increased efficiency of the use of minerals in cereals, potatoes and maize;

- extending the range of species, optimizing agrotechnics for the production of biomass for energy purposes and extending the variety offer of plants dedicated to energy purposes available to farmers.

As part of this activity, two varieties of grasses for energy and industrial purposes were bred: cv 'BAMAR' variety of tall wheat grass (Elymus elongatus) and cv 'MARDAN' variety of switch grass (*Panicum virgatum*). At the request of enterprises, the Institute also bred 4 varieties of perennial grasses and 1 variety of cup plant (*Silphium perfoliatum*).

Educational and dissemination activities were also carried out in the field of counteracting unfavorable climate changes in agriculture.

Scientific and research base

Activities in the field of creating scientific foundations for mitigation and adaptation to climate change in the area of plant production are carried out in the following Departments and Scientific Facilities of the IHAR-PIB:

- Scientific Branch in Jadwisin: Department of Agronomy of Potato,
- Headquarters in Radzików: Dept. Plant Biochemistry and Physiology, Dept. of Grasses, Leguminous and Energy Plants, Dept. of Genetic Engineering, National Center of Plant Genetic Resources, Botanical Garden (in Bydgoszcz).

Two installations for the production of heat from biomass are perfect facilities for the practical verification of some of the results obtained in the Institute's research. One of them is located in the IHAR Botanical Garden in Bydgoszcz (capacity 2 x 0.2 MW), and the other one in Radzików (1 x 2.25 MW). The latter is fed with biomass from 30 ha of the *Miscanthus x giganteus* plantation growing in the fields of the IHAR-PIB Experimental Station in Radzików. These investments were financed partly from the grants of the National Fund for Environmental Protection and the Eco-Fund.

The Plant Breeding and Acclimatization Institute - National Research Institute

National projects

Projects financed under the subsidy of the Ministry of Science and Higher Education were related to, inter alia, with the use of wheat D genome to improve the efficiency indicators of nitrogen and phosphorus uptake and utilization by hexaploid triticale. The genetic basis of the response of maize to cold was determined and research on the cytolocation of proteins related to this trait was carried out. Molecular markers of drought resistance and aluminum tolerance useful in spring cereal breeding programs were also searched for. The possibilities of using physicochemical and biochemical parameters of the cell wall in the cultivation of cereals with increased tolerance to abiotic stresses were also investigated. Research was also conducted on the response of grasses and potato plants to water shortages.

The variability of the characteristics of selected species of C-4 grasses in photosynthesis for energy crops in Poland was investigated, the impact of different technology of energy grasses cultivation on their yield, technological quality of biomass and carbon binding in soil was investigated. The genetic similarity of *Miscanthus* × *giganteus* ecotypes was also analyzed to verify their clonal origin.

The Institute as part of the Multiannual Program financed by the Ministry of Agriculture and Rural Development, entitled *"Creating a scientific basis for biological progress and protection of plant genetic resources as a source of innovation and support for sustainable agriculture and the country's food security"* (2015-2020) carries out tasks that substantially and practically support breeding and agricultural producers. Breeding materials of wheat, barley, oats, sugar beet, soybeans, produced and selected by molecular techniques constitute a new genetic variability with increased productivity and resistance to biotic and abiotic stresses.

Research is also being carried out on the possibilities of extending the genetic pool of plants as alternative sources of raw materials for the production of energy, paper, construction boards, etc., and application various methods and systems of field cultivation of plants for non-food purposes.

One out of the five areas of the Program is currently implemented by the National Center for Plant Genetic Resources in the field of dissemination of plant varieties less sensitive to the phenomena of drought and flooding as well as frost, and the actions for increasing the biodiversity of cultivated and associated plants.
More information at http://pw.ihar.edu.pl.

As part of the Multiannual Programs in 2008-2013 and 2015--2020, a collection of energy plants was created and expanded in the IHAR-PIB Botanical Garden in Bydgoszcz. It is a place of visits and lessons for schoolchildren and students from Bydgoszcz and the surrounding area. There are over 52 objects within 20 species of trees, shrubs, perennials and grasses for energy or industrial purposes. Annually, the collection is visited by about 500 people.

Projects from the National Science Centre (NCN)

"Development of a method for assessing the efficiency of water use by monocotyledonous crops by measuring chlorophyll fluorescence and gas exchange ", **NN304267540**, 2011 - 2014.
"Identification and analysis of the functioning of barley GSK3 genes - key components of the brassinosteroid signaling pathway and drought stress tolerance." **OPUS 7**, 2015 - 2018.

Projects of the National Centre for Research and Development (NCBiR)

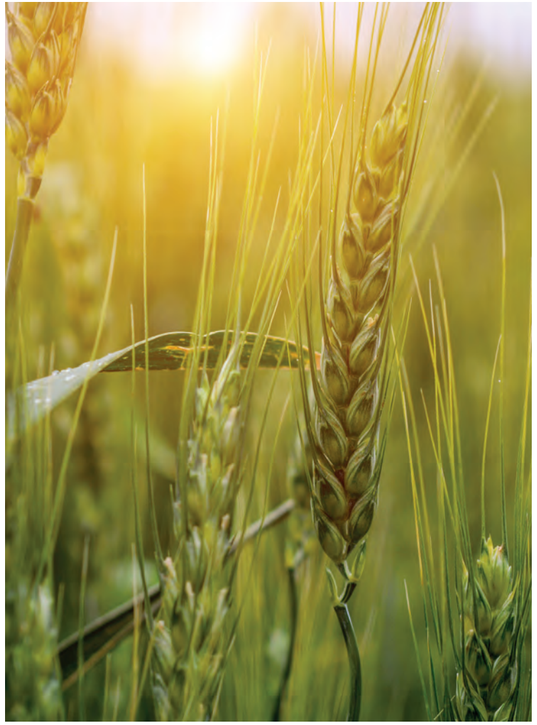
"Technology of cultivation and processing of an innovative variety of a cup plant for the needs of producing cheap renewable energy." no. **POIR.01.01.01–00– 0920/16**; Lider EneCrops sp. z o.o., sp.k., Poznań, 2017 - 2019.

Projects from the National Found for Environmental Proctection and Water Management (NFOSiGW)

"Program of active education, integration and cooperation in rural areas in Poland", no. **POIS.02.04.00-00-0066/16**, Measure 2.4: Nature protection and ecological education, Project type: 2.4.5 Information and education activities environmental protection and efficient use of its resources, Project subtype 2.4.5.b: Capacity building and integration. Lider - Foundation for Sustainable Development, Warszawa, 2017 - 2019.

Foreign projects

PL0073, financed by the Norwegian Financial Mechanism, the European Economic Area and the Ministry of Science and Higher Education entitled *"Modeling of the energy use of biomass"*. IHAR--PIB, as a project partner, performed work on the analysis of the growth dynamics of energy crops and their potential yield, 2007--2010.
FACCE JPI/02/2012 *„Modeling European Agriculture with Climate Change for Food Security"* – project partner, 2012 – 2015.
POTPAT (Polish – Norwegian cooperation) *„Potato pathogen populations in changing climatic conditions of Norway and Poland and the mechanisms of their interaction with host"* - project partner,



Institute of Environmental Protection – NRI
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The subject of activity of the Institute of Environmental Protection – National Research Institute (IEP-NRI) is research and development works in the fields of earth sciences, technical sciences, and agricultural sciences adapting the results of these scientific research and development works to the needs of practice and participation in the implementation of these results research and work.

Supervision over the Institute is carried out by the minister responsible for the climate

Research in the area of mitigation and adaptation to climate change

Substantive support of the whole national policy in the field of air quality and climate

National Centre for Emissions Management „KOBIZE", whose tasks implementation takes place in the organizational structure of IEP-NRI covers with its activities most of the issues related to, among others, greenhouse gas emissions, including:

- Running National Database on greenhouse gas emissions and other substances, gathering information submitted by entities using the environment about emissions to the air and related parameters;
- Developing an annual inventory of greenhouse gas emissions and other substances and submitting inventory reports to the organs of the Climate Convention the European Union and UN agencies;
- Performing tasks for international agreements such as the Climate Convention and the Kyoto Protocol, as well as other conventions ratified by Poland, and related to Poland's membership in the European Union;
- Expert support for the Ministry of the Climate's activities regarding greenhouse gas commitments;
- Greenhouse gas emission projections;
- Analyses regarding the negotiation process under the Climate Convention, as well as the formation of climate policy at the European level in the context of tightening reduction requirements, and the resulting new legal obligations;
- Giving opinions on national reports and international studies including reports prepared by the European Environment Agency (EEA);
- Participation in meetings and preparatory workshops, as well as in cycles of negotiation sessions of the Climate Conference.

Atmosphere and Climate Modelling Department

It provides substantive support for national policy on air, and climate quality using numerical modelling in relation to tasks resulting from national and EU regulations, the tasks of the Department include in particular:

- providing substantive support (including the development of guidelines, recommendations) within the scope of the modelling results in the assessment of air quality;

- providing scientific support for national policies through analysis and calculation of change scenarios using numerical modelling;
- obtaining, updating and processing input data to the air quality model, including geophysical, meteorological and pollutant emission data, data archiving;
- processing of modelling results (including evaluation of results using available measurement information) and their conversion to the format required by recipients, results sharing;
- support a national policy on air quality and climate in relation to the tasks arising from the Environmental Protection Law, using numerical modelling, including assessments and forecasts of air quality;
- performing calculations and analyses in the scope of scenarios prepared for the needs of the National Program for Air Protection;
- substantive support and providing of modelling information for the preparation of reports and information on air pollution for the needs of national and local administration, international organizations and the European Commission as well as public information;
- using data from a Copernicus (CAMS) atmospheric service for the national air quality policy;
- analysis and calculation of climate scenarios in accordance with the IPCC, using numerical modelling.

Climate Change Department

The Department conducts research and development activities supporting the Government's activities in the field of national and international climate policy, the tasks of the Department include in particular:

- Substantive support for international cooperation and conducting research for the United Nations Framework Convention on Climate Change;
- Preparing opinions, expert opinions, bulletins, and reports related to the IPCC's activities;
- Initiating and formulating economic research programs and social issues related to climate change their impact on the economy and strategies to reduce this impact;
- Conducting research on climate change, and its impact on the environment, economic and social activity, as well as an assessment of costs of adaptation activities, and analysis of climate risk;
- Assessment of the implementation of policies, and measures to reduce greenhouse gas emissions;
- Analysis of current and future climatic conditions of Poland based on climate scenarios;
- Popularisation of knowledge about climate change, its effects and its protection, including conducting training in adaptation to climate change for rural cities and municipalities;
- Development of programs for adapting the economy to climate change including consultations and advice on possible actions;
- Preparation of draft adaptation strategies for climate change at the national and local level;

- Monitoring and assessment of the impact of climate change on the economy and implementation of adaptation measures at the national and local level.

Scientific and research base

In addition to the aforementioned, the following departments participate in works on adapting to climate change:

- Department of Integrated Environmental Monitoring,
- Department of Environmental Development,
- Department of Landscape and Environmental Assessments,
- Sewage Technology Centre,
- Department of Nature Protection

Domestic and international projects

Knowledge base of climate change, and adaptation to its effects and channels for its dissemination in the context of increasing the resilience of the economy, environment and society to climate change, as well as prevention and minimisation the effects of extraordinary threats, Operational Programme Infrastructure and Environment, A. Hryc-Ląd MSc;

Support for low-carbon agriculture capable of adapting to climate change now and in 2030 and 2050 perspective (LCAgri). BIOSTRATEG programme, prof. Wiesław Oleszek D.Sc., Ph. D. from IEP - NRI - prof. M. Sadowski D.Sc., Ph. D.

Identification of chemical composition of the organic fraction of particulate matter PM1, PM2,5 and PM10 in non-urban areas in terms of the identification of the origin of the dust and the implied threats to environmental and health, Opus 8 programe, Rafał Szmigielski D.SC., Ph. D. from IEP-NRI mgr inż. K. Skotak;

Energy efficiency through the development of electro-mobility in Poland – Bilateral Cooperation Fund, B. Malowaniec M.Sc., Eng.;

Developing plans for adapting to climate change in cities of above 100 000 residents, B. Rajkowska M.Sc.;

The system of delivery and exchange of information in order to support the implementation of climatic-energy policy, LIFE programme, R. Jeszke M.Sc.;

Climate change adaptation in small and medium size Cities, Bilateral Cooperation Fund, S. Waśniewska M. Sc.;

Stop Smog, Bilateral Cooperation Fund, S. Sulima M. Sc.

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Research in the area of mitigation and adaptation to climate change

The University of Life Sciences in Lublin is a multi-profile higher education institution, which integrates agricultural, biological, veterinary, technical, and economic-social sciences. Scientific research conducted in the area of mitigation and adaptation to climate change in the agricultural sector implemented at this university focuses mainly on issues related to sustainable management, including optimization of plant production conditions with particular emphasis on carbon (C) sequestration in agroecosystems, for example:

- Reduction of its losses in the form of carbon dioxide (CO_2) and water-soluble organic carbon (DOC);
- Increase of the C content in yields, as a result of regulating the properties of the plant growth environment, including the management of nutrients;
- Maintenance (soils rich in SOM) and / or increase of C content in soils mainly due to the use of external organic matter (natural or organic fertilizers and wastes).

The scientific area of interest of the University's employees also includes research related to:

- Impact of cultivation and fertilization (at the level of industrial production technologies and during their use) on the emission of greenhouse gases;
- Limiting the emission of nitrogen from animal production into the environment;
- Organic methods of plant cultivation and animal nutrition;

- Factors determining the development and durability of grassy lands and their importance in the natural environment;
- Production of energy from renewable sources;
- Protection and shaping of water resources;
- Increasing public awareness of, and research on activities conducive to mitigation and adaptation to climate change.

Scientific and research base

The research base of the University of Life Sciences in Lublin is well and modern equipped.

The university has the expertise and organizational means for conducting soil, water, and air analyzes, as well as materials of plant and animal origin.

Scientific research on mitigation and adaptation to climate change is carried out primarily:

- the Faculty of **Agrobioengineering** (at the Department of Agricultural and Environmental Chemistry, Institute of Soil Science and Environment Shaping, Department of Agricultural Ecology, Department of Grassland and Landscape Shaping),
- at the Faculty of **Biology, Animal Sciences and Bioeconomy** (at the Institute of Animal Nutrition and Bromathology), and
- at the **Faculty of Production Engineering** (at the Department of Environmental Engineering and Geodesy, Department of Agricultural, Forestry and Transport Machines, Department of Power Engineering and Transportation).

Domestic and international projects

The expert teams on environmental protection requirements and climate change as part of the NRN Action Plan for 2014–2020, 2017.

Elaboration of innovative method for monitoring the state of agrocenosis with the use of remote-sensing gyro system in terms of precision farming, NCBiR, 2016–2019

Construction of a Polish biogas network based on the model of citizens' social participation, NCBiR, 2015–2016

A Low-cost and environment-friendly system of fertilization and sowingof maize, NCBiR, 2012–2016

Development of modern cereal cultivation technologies for fodder purposes intended for pigs feeding, Support for the Regional Cooperation Network, Human Capital Operational Programme 2007–2013, 2012.

Changes in the quantity and quality of water as a result of irrigation on the drainage facilities of the Łęczyńsko-Włodawskie Lakeland, Ministry of Science and Higher Education 2010–2013.

Eco-Friendly Crop Rotations, OECD, Co-operative Research Programme, The University of British Columbia, Vancouver, Canada, 2010 r.

New methods and technologies for deodorisation in industrial, agricultural and municipal management Ministry of Science and Higher Education, 2007–2010.

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Research in the area of mitigation and adaptation to climate change

Department of Meteorology (http//www.up.poznan.pl/ka/) at the Faculty of Environmental Engineering and Spatial Management, the University of Life Sciences in Poznan has the potential and research infrastructure allowing the measurement of greenhouse gas exchange (GHG) using micrometeorological (eddy covariance method- EC) and chamber methods. These measurements were carried out at stations located on the pit bog (from 2004) over the 65-year-old pine forest on post-agricultural land (from 2008), over the forest area destroyed by the tornado (from 2013), and over the 25-year-old post-fire pine forest (from 2018) as well as over the agricultural areas (2011–2013).

Measurements of greenhouse gas fluxes (CO_2, CH_4, N_2O) at the station located on the Rzecin peat bog (52°45'N 16°18'E 70 km north-west of Poznań) were carried out starting from 2004 with eddy covariance system and with the use of manual and automatic dynamic and static chambers (since 2008).

The research to assess the balance of GHG exchange between the atmosphere and the wet-land ecosystem were carried out as part of numerous international and national projects. One of them, carried out over Rzecin site, was the WETMAN project (2013–2017) funded by the National Centre for Research and Development (NCBR) as part of the Polish-Norwegian Research Program *Central European Wetland Ecosystem Feedbacks to Changing Climate – Field Scale Manipulation* (POL-NOR/203258/31/2013). As a part of the project,

a unique infrastructure for climate manipulation on a peat bog was created to assess the impact of elevated temperature and reduced precipitation sums on the greenhouse gas exchange balance (CO_2 and CH_4). These measurements were carried out using an automatic self-propelled measuring platform equipped with a dynamic chambers system.

Currently, at the Rzecin station several research projects are being carried out simultaneously within NCN grants (OPUS 11, OPUS 13 and PRELUDIUM 13), and international projects RINGO and POLIMOS.

The importance of research conducted on the peat bog in Rzecin are in line with international efforts to assess the response of these fragile ecosystems to globally observed climate change which is necessary for adequate protection of these valuable areas in the future.

Measurements of greenhouse gas fluxes (CO_2, CH_4, N_2O) were carried out at the agricultural experimental station in Brody (52°26N, 16°18'E) which belongs to the University of Life Sciences in Poznań, thanks to the support of two international research projects: GHG Europe project, FP7 (2010–2013), (Collaborative Project, Large scale Integrating Project): *Greenhouse gas management*

in European land use systems, and COST Action ES0903. The measurements were performed by the eddy covariance system (2011–2012) and the system of dynamic and static chambers (2011–2013). Greenhouse gas exchange monitoring was carried out regularly on plots cultivated in a seven-year rotation system with winter rye, winter wheat, spring barley, potato, and alfalfa.

Based on the measurements the following was developed:

- seasonal and annual balances of carbon dioxide exchange;
- annual balances, and seasonal greenhouse gas exchanges (CO_2, CH_4, N_2O) expressed in CO_2 equivalents using the Global Warming Potential index (GWP)
- Net Ecosystem Carbon Balance (NECB), allowing to estimate losses of organic carbon in soil.

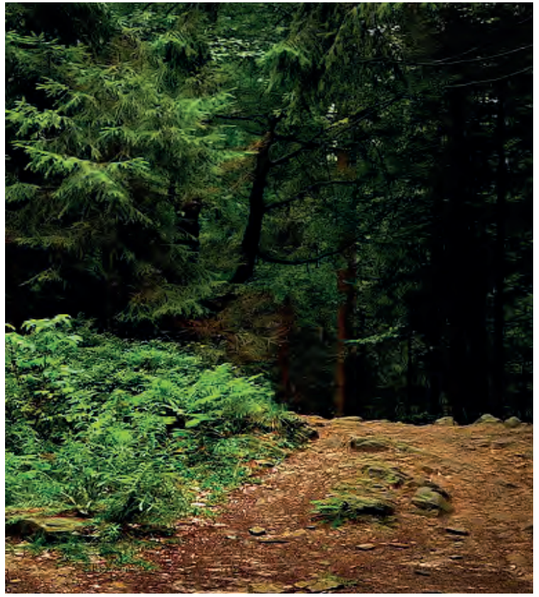
Forests are one of the types of ecosystems occupy about 1/3 of the land area in the world, and in our country, this value is already approaching 30%. Therefore, GHG exchange studies in this kind of ecosystems as well as the impact of various meteorological factors and disturbances on this process are very important in the context of climate change mitigation both on a local and global scale.

In this sense a research and development project entitled: *Estimation of net carbon dioxide exchange between the forest ecosystem on post-agricultural land and the atmosphere*, supported by the General Directorate of State Forests and carried out by researchers from the Department of Meteorology since 2008, besides its scientific value has also the practical importance. The most signigicant results of these multidirectional research in Polish forests include:

- estimation of the amount of carbon accumulated every year in the mid-

dle-aged pine forest (station Tuczno, near Piła) and differences in CO_2 sequestration due to changing meteorological conditions;

- the assessment of CO_2 emissions rate from the forest area after windthrow (stations Tleń, Bory Tucholskie forest), and a comparison of two reforestation techniques of this wind-disturbed site in the context of CO_2 released into the atmosphere;
- carbon balance of a 25-year-old pine forest (station Mężyk, Puszcza Notecka forest) – one of the largest post-fire area in the history of Polish forestry. Measurements from all three forest stations will also be used tobuild a CO_2 exchange model as a function of the age of the forest for the most common tree species in Poland – Scots pine.



These studies are a part of the pilot project *Forest Carbon Farms* aiming at the development techniques that would increase CO2 absorption by Polish forests in order to mitigate global warming in accordance with the Paris Agreement (COP 23).

Department of Agronomy (http//www.up.poznan.pl/kurir/) at the Faculty of Agriculture and Bioengineering at the University of Life Sciences in Poznań, analyzes data from multiple year static experiments carried out since 1957 in Brody related to the sum of precipitation and average temperatures, and their impact on the phenology of crops, and many years of field experiments on fertilization of plants and crop rotation.

Based on the research and analysis of long-term data two publications related to the impact of climate change on phenology were published:

Blecharczyk A., Sawinska Z., Małecka I., Sparks T.H., Tryjanowski P. 2016. The phenology of winter rye in Poland: an analysis of long-term experimental data. Int. J. Biometeorol. 60 (9). 1341-1346. (http://link.springer.com/article/10.1007/s00484-015-1127-2)

Tryjanowski P., Sparks T.H., Blecharczyk A., Małecka-Jankowiak I., Świtek S., Sawinska Z. 2018. Changing Phenology of Potato and of the Treatment for its Major Pest (Colorado Potato Beetle) – A Long-term Analysis. Am.J. Potato Res. 95: 26-32. (https://link.springer.com/article/10.1007/s12230-017-9611-3)

Domestic and international projects

project CARBOEUROPE-IP (2004-2008): *Assessment of the European Terrestrial Carbon Balance,*

project GREENFLUX-TOK, FP6 (2006-2010): *'Micrometeorological techniques for in situ measurements of greenhouse gases exchange,*

project NITROEUROPE-IP, FP6 (2006-2011): *The nitrogen cycle and its influence on the European greenhouse gas balance,*

project INGOS- FP7, INFRASTRUCTURES-2011-1 (2011-2015) *Integrated non-CO2 Greenhouse gas Observation System.*

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Research in the area of mitigation and adaptation to climate change

The University of Agriculture in Krakow actively participates in the area of innovative technologies dedicated to the agricultural and forestry sector related to the progressing climate change. One of the leading organizational units of the University in this field is the Faculty of Production and Power Engineering. Research in the above range conducted at the Faculty covers the following issues:

Greenhouse plant production system using energy accumulators.

It is well known that the search for technical solutions used in production processes should be integrated with the improvement of product quality and reduction of its costs. The Faculty's employees together with the employees of the Horticultural Institute in Skierniewice carried out a research project covering the issue of storing excess heat in energy accumulators. The developed system consists in sucking in, when the temperature exceeds the recommended values for cultivated plants, warm air from the interior of the facility and injecting it into the batteries (stone accumulator, phase and water transition).
In the period of heat demand the stone accumulator is discharged and the heat from the water accumulator is used to heat water for watering the plants. Heated air supplied from the accumulator is distributed using perforated sleeves located around the plant root zone. To control parameter values and drive of executive devices an autonomous (photovoltaic panel powered) control system was used.

The solar system was also used to accumulate heat in the bed of material undergoing phase change (paraffin). Research carried out in production facilities on test plants (cucumbers, tomatoes) showed the usefulness of this system. Obtained savings in the consumption of fossil fuels (and thus reduced emissions of harmful substances to the atmosphere), acceleration and increase in yield, and as a result of the flow of air dried in stone accumulator the decrease in risk of fungal diseases.

The use of geothermal energy resources for greenhouse heating.

One of the basic air pollutants is carbon dioxide. Its basic source is the process of converting chemical energy contained in fossil fuels (including hard coal) into thermal energy. In agriculture primary recipients of large amounts of heat are farms that grow crops in greenhouses or plastic tunnels. Faculty of Production and Power Engineering together with the AGH University of Science and Technology in Krakow, Wageningen University, and companies from the Netherlands are implementing project aimed at developing a new system for supplying large-area crops under covers. The implementation of the project aimes to contribute to the emergence of modern technology for supplying heat to crops under cover based on geothermal energy. The use of a new and renewable heat source will contribute to reducing CO_2 emissions from the combustion of fossil fuels, but will also increase the absorption of gases from the air by plants. In addition, as a result of the project a studies on the geothermal potential of Poland will be created which can be used to supply greenhouses and foil tunnels with heat.
As part of the project a research is also carried out among farmers planting these crops under cover on practical aspects of the use of a new power source for supplying facilities with thermal energy. After completion of the project the construction and commissioning of a modern greenhouse facility fully powered with energy from renewable sources is planned.

Assessment of CO_2, CH_4, H_2S, NO_x, PM_{10}, $PM_{2.5}$ emissions and microbial composition of aerosol around industrial installations and in agricultural areas.

In addition to performing measurements, the possibility of propagation of the analysed pollutants in atmospheric air is evaluated, as well as methods and technologies for monitoring air quality, and solutions dedicated to the given type of emitters that protect the natural environment are proposed.

Production of biogas from waste together with the cogeneration system.

In this regard Faculty of Production and Power Engineering actively cooperates with the industrial sector. The production of biogas from waste is of great importance for the environment. On the one hand, we solve some of the problems associated with the emission of carbon oxides, nitrogen, sulphur, and ammonia to the environment from waste generated during the agricultural production process and on the other we receive energy and ecological fertilizer in the cogeneration system. Polish agriculture aims to close the circulation of biogenic substances in the production cycle, and University's academic staff also contributes to this goal. The conducted research includes the quantitative and qualitative determination of pollutant emissions into the air mainly during the processing of agricultural and food waste, and a digestate in agricultural biogas plants.
The analysis includes both the assessment of the physicochemical parameters of the material undergoing processing and the determination of the biological harmfulness of the microbial aerosol in the vicinity of the installation. Analyses also include the produced digestate (potential fertilizer) in terms of its phytotoxicity, heavy metals and biogenic substances content. The obtained test results are used for numerical research related to the propagation of selected gaseous and particulate pollutants in atmospheric air and their impact on the climate.
As a result of many years of research work many technological concepts have been put into practice in the field of turning waste into biogas. As a result of the work being carried out a design study was created to create a first fully monitored closed system in one of the local agricultural biogas plants. To reach assumed goal Faculty of Production and Power Engineering asked for help specialists from the country, as well as from well-known Fraunhofer Institute for Environmental Safety and Energy Technology UMSICHT. The idea of research is to create a modern plant that produces biogas in two stages, i.e. using hydrogenesis and methanogenesis process. According to estimates, thanks to an innovative approach, as much as 40% more biomethane can be obtained than in the one-stage technologies used. In addition thanks to the use of the scientific potential of Faculty of Production and Power Engineering an innovative program for fertilizing the fields with digestate which is a process residue will be created. Thanks to the multidirectional solution of the problem we not only reduce the emission of pollutants into the environment, but also diversify the generation of energy from unconventional sources.

Research on the possibilities of processing waste from the agricultural sector with a reduction in the emission of gaseous substances into the atmosphere.

The subject is very complex and requires an innovative approach due to the very high diversity of material. As a result of the conducted research innovative solutions for process air filtration were created. Waste processing is often associated with the formation of nuisance odours which include, among others, volatile sulphur and nitrogen compounds. Thanks to the special constructionof filter beds emission of said substances can be reduced by up to 90%. This result is achieved by special selection of biodegradable materials for a specific waste processing process, and the use of specialized consortia of microorganisms. In the direction of reducing the emission of gases harmful to the environment (including odours, ammonia, and CO_2) Faculty of Production and Power Engineering is investigating the use of biochar as an absorbent. The research results indicate a significant reduction of odour and ammonia emission, and about 30% reduction of CO_2 (depending on the biochar dose) from the biological processing of waste.

Odourless technology of organic compost production using preparations based on effective microorganisms.

As a result of the work carried out a modern composting technology was created which cuts the emission of greenhouse gases into the atmosphere by up to 98%. The waste material that can be processed in it is mainly green and biodegradable waste from the agri-food industry.
Thanks to the development of a modern algorithm of process control and the construction of individual devices the technology can be classified as zero-waste and zero-emission processes. At present to increase work parameters of filtering systems operation, individually designed filter washing using process wastewater are also used. The implementation of modern filtration systems allows for significant reduction of the negative impact of waste on the natural environment.
In this area the Faculty's employees in cooperation with industrial partners developed a technology for sequestering carbon dioxide using waste from the energy industry. The process is based on the chemical bonding of carbon oxides by substances such as for example gypsum from flue gas desulphurisation, phosphorus from the production of phosphoric acid. These reactions known for decades without additional physical factors occur very slowly.
As a result of the project implementation a technology and a laboratory installation were created in which the processes of braking and neutralization of CO_2 in the air take place simultaneously.

Technologies of biological processing of biodegradable waste, and its thermal transformation in the gasification and pyrolysis process.

In cooperation with scientific partners and business entities the employees of Faculty of Production and Power Engineering in Krakow develop a new direction of research in the field of energy and ecological assessment of the process of processing of non-composted organic fractions into biochar in the low-temperature pyrolysis process and its subsequent activation.
The resulting biochar may be recycled back to the process and reused as an absorbent. Developed processes are each time subjected to a multi-variant ecological assessment in life cycle analysis programs (LCA and LCI) in order to indicate an optimal solution in terms of limiting climate change in ecosystems, limiting the negative impact on human life, and reductions in consumption of fossil fuels.

Scientific and research base

Organizational structure of the Faculty includes specialized laboratories enabling the implementation of specific scientific research.These are:

- A complete foil tunnel with an installed system for storing excess heat in energy accumulators. All parameters are measured and archived in the measurement system. The parameters of the surrounding climate are monitored and available online;

- Laboratory of Production Technology and Quality Evaluation of Biofuels – accreditation Polish Centre for Accreditation (PCA);
- Life Cycle Analysis (LCA) SimaPro 8 software;

The following are in the process of obtaining accreditation:

- Laboratory of Physical-Chemical and Microbiological Waste Analysis;
- Laboratory of Experimental Research Techniques of Raw Materials and Biological Products.

Domestic and international projects

Development of innovative energy storage technologies „HORTIENERGIA" in production foil tunnels;

Supporting the heating of the foil tunnel by means of a heat pump;

„EcoRDF" – innovative technology for producing alternative fuel from municipal waste for power plants and combined heat and power plants – a key element of the waste management system in Poland;

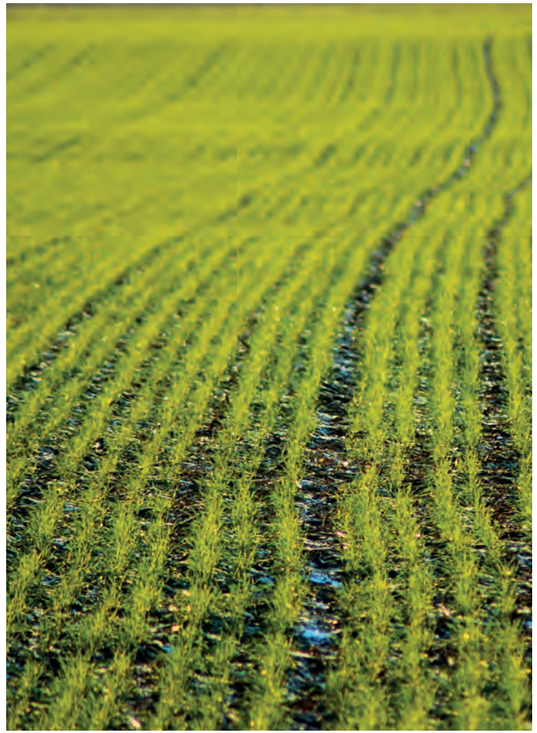
„EKO-BIONOM" Proecological production of organic and mineral fertilizers on the basis of waste: by-products. Development of innovative technologies of energy storage in production plastic tunnels „HORTIENERGIA";

Supporting biomass burning and biogasification;

Development of odourless technology for the production of ecological compost with the use of preparations based on effective microorganisms;

ABF Invest research to search for new ways of managing industrial ashes;

Development of a new generation biopreparation for neutralizing sewage sludge.



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Research in the area of mitigation and adaptation to climate change

Actions in the field of mitigation and adaptation to climate change within the Faculty of Biology and Agriculture of the University of Rzeszów are presented by three units:

- Department of Soil Science, Environmental Chemistry and Hydrology;
- Department of Ecology and Environmental Biology;
- Department of Agroecology.

Department of Soil Science, Environmental Chemistry, and Hygrology

The main objective of the studies of the Department of Soil Science, Environmental Chemistry and Hygrology is the assessment of the impact of the use of different cultivation systems (traditional and simplified), and fallowing on selected physical, chemical and biological properties of soil (biodiversity) in the Podkarpacie region taking into account climate change. The scientific and research base is Podkarpackie Center for Innovation and Research of the Environment in Rzeszów equipped with modern research equipment which are part of the scientific and research buildings of the Biological and Agricultural Department.
The Centre consists of four main laboratories: Soil Physics Laboratory, Soil Chemistry Laboratory, Soil Biology Laboratory, and Soil Microbiology Laboratory. These laboratories are equipped with the latest equipment for soil environment research, e.g. the set for determining the characteristics of the pF curve; penetrologger; turbidimeter; TDR probe set, Dionex ICS

500+; scanning electron microscope (SEM) SU 8010 Hitachi; sets of light microscopes; fluorescence microscope.

The most important domestic project implemented in the field of research and reduction of greenhouse gas emissions and adaptation to climate change was participation in the AGROGAS Network on *Reduction of greenhouse gases and ammonia in agriculture*.

The participants of the AGROGAS Network were six scientific units from Poland:

- Institute of Agrophysics Polish Academy of Sciences (IA PAS), Lublin;
- Institute for Building, Mechanization and Electrification of Agriculture, Warsaw;
- Institute of Soil Science and Plant Cultivation - NRI, Puławy;
- Department of Biology and Environmental Protection of the University of Łódź;
- Institute for Agricultural and Forest Environment Polish Academy of Sciences, Poznań;
- Faculty of Biology and Agriculture of Rzeszów University.

University of Rzeszów, Faculty of Biology and Agriculture


Fot. KOWR

Jadwiga Stanek -Tarkowska Ph.D. from the Faculty of Biology and Agriculture of the University of Agriculture in Rzeszów was responsible for the implementation of the topic *Possibilities to reduce greenhouse gas emissions from agriculture*. After the end of the project the studies are continued at the Department of Soil Science, Environmental Chemistry, and Hydrology. Research aims to reduce greenhouse gas emissions and their impact on the environment using biological indicators – biodiversity of diatom communities and soil enzymatic activity.

Department of Ecology and Environmental Biology

The Department of Ecology and Biology of Biological and Agricultural Environment of the Agricultural University of Rzeszów conducts hydrobiological research (Prof. Krzysztof Kukuła, Aneta Bylak Ph.D.) related to water deficit problems experienced by flowing water ecosystems.

Studies carried out focus in particular on:

- the impact of the increase in air temperature on the lowering of water levels in river valleys especially in the context of their regulation;
- the effect of climate warming on the increase of the temperature of water in rivers and ecological consequences of this phenomenon (in particular the extension of the ranges of some species of fauna on the other hand the shrinking ranges of cold-blooded species);

Department of Agroecology

Department of Agroecology of the Faculty of Biology and Agriculture of the University of Agriculture in Rzeszów conducts extensive research that aims to identify various aspects of the agrarian environment. The issue of climate change is present in the research conducted by the unit and is taken into account in the ongoing projects and presented during the conference.

University of Science and Technology in Bydgoszcz

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Research in the area of mitigation and adaptation to climate change

The University conducts scientific research on changes in the Polish agroclimate as part of two research strategies.

The first one includes studies on current changes in the regional agroclimate based on the analysis of long-term meteorological data originating mainly from agricultural scientific and research units and Institute of Meteorology and Water Management – National Research Institute. In these studies particular attention is paid to the trends and tendencies of changes of unfavourable weather elements (e.g. agricultural droughts, shortening of thermal agricultural periods, frosts, hail, low temperatures in the absence of snow cover in winter) to show a possible increase in their occurrence, hence rising climatic risk for growing plants.

The second research strategy includes determining the effects of anticipated climate change and adaptation activities. The University's specialty in this field is long-term field research conducted since the mid-1970s aimed at the development of irrigation in central Poland. These studies primarily cover issues concerning the desirability of its use in the cultivation of various plant species by determining the production and economic efficiency, as well as changes in yield quality or optimization of irrigation doses in relation to water needs.

The university is a leading centre in the field of plant irrigation in Poland as evidenced by the fact that it is frequently entrusted with the organization

of cyclical symposia devoted to irrigation of plants "Irrigation of plants in light of sustainable development of rural areas - nature-production and technical-infrastructural aspects".

Scientific and research base

The organizational unit conducting research on climate change at the University is the Land Reclamation and Agrometeorology Laboratory of the Department of Agrometeorology, Plant Irrigation and Horticulture headed by prof. J. Żarski.

The unit has a network of meteorological stations located in Bydgoszcz and its vicinity. A particularly valuable unit is the measurement point in Mochełek near Bydgoszcz where measurements and observations have been conducted continuously since 1949. In addition, this point operates in a poorly urbanized and industrialized area and thus is free from the impact of urban anthropogenic factors.

Field experiments have been or are still being carried out at the Agricultural Research Station of the Minikowo Experimental Station, and at many agricultural private farms and forest nurseries.

The second unit performing research in the field of food security risk assessment related to climate change is the Department of Management Engineering headed by Waldemar Bojar Ph.D., DS.c, Prof. UTP.

Domestic and international projects

Research on climate change has been carried out as part of the statutory research of the Faculty of Agriculture and Biotechnology and ministerial grants. The university participated in the international project FACCE JPI – MACSUR *A detailed climate change risk assessment for European agriculture and food security financed by NCBiR and FACCE JPI - MACSUR 2 implemented in 2015–2017, Modeling European Agriculture with Climate Change for Food Security* (the head: W. Bojar Ph.D. DS.c., Prof. UTP).