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PILOT SURVEYS AIMED AT METHODOLOGICAL IMPROVEMENT IN AGRI-ENVIRONMENTAL STATISTICS AND THE DEVELOPMENT OF GRASSLANDS STATISTICS

Final report

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INTRODUCTION

The implementation of the project "***Pilot surveys aimed at methodological improvement in agri-environmental statistics and the development of grasslands statistics***" is possible thanks to the support of the European Commission and was carried out under Grant Agreement No. 08413.2014.005-2014.687.

The team consists of the representatives of the following units: the Agriculture Department, the Programming and Coordination of Statistical Surveys Department, the Statistical Office in Olsztyn and subcontractors: representatives of the Institute of Soil Science and Plant Cultivation – the State Research Institute in Puławy, the National Research Institute of Animal Production in Kraków-Balice , the Institute of Geodesy and Cartography and the Institute of Technology and Life Sciences in Falenty.

Agriculture is a division of economy where increased activity leads to external effects adverse to the environment. Reducing the negative environmental effects of agricultural activity is one of the basic objectives of the EU's agricultural policy. The negative impact of agriculture on the environment is visible, among others, in a relatively high share in the total emission of ammonia (NH_3) and greenhouse gases to the atmosphere, and a growing consumption of fertilisers in order to achieve maximum profit. The increase in the consumption of mainly nitrogen and phosphorus fertilisers has a negative impact on soil and water in rivers, lakes and oceans, and organisms living in soil and water, and, consequently, on human health.

Nitrogen (N) and phosphorus (P) are the primary yield-creating factors. Therefore, N and P balances are the key agri-environmental indicators. Due to the broad range of data covering various aspects of N and P flows and the necessity to make reliable comparisons at the European level, Eurostat decided that N and P balances will be calculated with the use of the Capri JRC model. Thus, it has become necessary to increase the availability of data to be used in the model at the national and regional level, and a detailed analysis of animal keeping systems, animal feeding and the use of various fodder types.

Release coefficients are broadly used for reporting data required under various policies and conventions (UNFCCC, ND). The lack of a common methodology makes it impossible to provide international comparisons of release coefficients. The previous works associated with developing coefficients of nitrogen and phosphorus production by farm animals was aimed at developing a universal methodology of calculating N and P release coefficients calculation common for all countries.

An important element of the protection of the environment are permanent grassland. They regulate water relations (retain water in the soil), act as a barrier to flood low-lying areas), increase the humidity of air and oxygen, creating a favorable microclimate. They contribute to the accumulation of organic matter and soil organic carbon, limit the penetration of nutrients

and pesticides to surface and groundwater, increase the aesthetic value of landscape, are the habitat of many species (fauna and flora).

Grasslands constitute an integral and, at the same time, significant element of the Polish landscape. Their share varies in particular voivodships, ranging from around 9% to 40% in the structure of agricultural lands. Grasslands form a separate category of agricultural land, differing from arable land in terms of physiographic and habitat conditions, ground cover and other features that are of great organizational and productive, as well as agricultural and economical significance.

Grassland management in line with the principle of the sustainable development requires monitoring the changes occurring both in the humidity level of their habitats, and in the use and yield. At present, given the growing use of information technologies in the scientific domain, the ongoing development of satellite imagery and the availability of satellite photos, an opportunity has emerged to use satellite imagery methods in order to distinguish grasslands from other forms of land management, as well as to differentiate meadows and pastures with various levels of utility and humidity.

The identification of grasslands through satellite imagery is possible through interpreting secular reflection coming from the surface layer of plant communities, and other modifying factors. The intensity of specular reflection is connected with the viability of meadow communities, which is strongly influenced by trophicity, humidity of habitats and the pastoral agricultural practices applied. Humidity conditions, current fertility of habitats and the diversification of plant communities are the features that can be interpreted on the basis of satellite imagery information.

The project's objective was to improve the quality of statistical data submitted to Eurostat in the form of agri-environmental indicators and to improve grasslands statistics. Activities are being carried out to increase the availability of data, contributing to the improvement of its quality and methodological facilitation. The project results in the future should provide better possibilities for assessing the impact of agricultural activity on natural environment.

The establishing and active development of cooperation between the CSO, public administration units and research units will make it possible to implement tasks successively set by Eurostat within the developing subject of the agri-environmental indicators. Support for these entities in the area of refining terms, definitions and methodologies of developing indicators. The outcome of cooperation in this area will be a detailed analysis of the availability of data and information on indicators reported to international institutions and forming a basis for securing the role of the CSO as the coordinator of the process of creating a data collection system necessary to calculate agri-environmental indicators. With the use of the scientific potential of experts within the cooperation, it will be possible to ensure the coherence of data submitted to many international institutions and conventions (UNFCCC, CLTRAP, NVZ, WD, OECD, FAO), calculated mainly on the basis of the CSO data. The

harmonisation of activities related to the procedures of creating lists and processing data will make it possible to improve the reliability, accuracy and coherence of information on agri-environmental indicators. A coherent system of agri-environmental indicators should contribute to the understanding and monitoring of correlations between the applied agricultural practices and their positive or negative impact on the environment, and also for the global assessment of the sustainability processes in agriculture. Collecting information on the condition of the environment in rural areas scattered among various departments and institutions helps to eliminate double data collection and reporting to superior authorities at the level of the European Commission, where conditions of the environment in various countries are compared.

I. The particular objectives of the project.

Objective 1: Streamlining cooperation between the CSO and institutions dealing with agri-environmental reporting.

Objective 2: Improvement in methodology: estimating area, crop yield and harvest from grasslands, classification of crops and manners of use of harvest from grasslands.

Objective 3: Increasing the availability of data on nutrient flows.
Within the third objective, two tasks have been planned:

> **Task 1**. Carrying out an analysis and tests for implementing the methodology of the Capri JRC model for estimating elements of the gross nitrogen balance at the national and voivodship level.
>
> **Task 2**. Improving and updating the methodology of estimating of excretion coefficients of nitrogen and phosphorus release by farm animals.

II. The implementation of Objective 1. Streamlining cooperation between the CSO and institutions dealing with agri-environmental reporting.

II.1. Actions taken

Identification and taking the inventory of entities which report indicators related to agri-environmental matters to EU and world organisations. The focus was also on entities dealing with research work associated with agri-environmental indicators.

During the inventory the analysis covered 27 administrative units, scientific institutions and organisations, including their websites, their publications, charter activities, the legal basis of their activities, with an overview of the agri-environmental projects in which the units have participated or will participate.

In order to expand knowledge of the impact of agriculture on the environment and gain more information on the activity programme of entities that were chosen to cooperate, specialist literature was analyzed.

Within the project implementation, statisticians from Agriculture Department organised series of meetings with entities involved in agri-environmental and grasslands-related issues. Furthermore they attended study visits (domestic and foreign to Wageningen UR) in cooperating institutions, as well as they took part in several scientific conferences with subject of agri- agri-environmental dependencies.

At Agriculture Department the questionnaire "The list of agri-environmental indicators, data sets reported or under development" was prepared. The questionnaire was sent to entities participating in the meeting and selected after consultations. The questionnaire was sent to a total of twenty three institutions. Nine entities sent back completed questionnaires.

Attention should be paid to a relatively low (lower than 50%) response from Polish institutions to our questions concerning the calculated AEI. This forced the project team to seek valuable sources of information on its own. It was a lengthy and laborious process due to the number of organisations associated with agri-environmental surveys, the complex subject-matter and the necessity of telephone consultations with the responsible persons in the units being the authors. During this stage of the works, apart from browsing websites and participation in industry conferences, the following were analysed:

- the available scientific publications,
- national inventory reports (including those identified by entities which expressed their willingness to participate in the project involving the creation of an agri-environmental database),
- reports on the implementation of survey programmes,
- reports on the implementation of particular conventions,
- expert opinions commissioned by ministries.

After identifying and compiling the required data, we have established contacts with units being the authors with a request to evaluate the possibility of obtaining the required indicators and their use in the currently created database. Series of consultation (personal, emails, phone) were held with the selected units on chosen indicators in terms of tables with data and metadata. Below is the list of these institutions:

- The National Centre for Emissions Management
- The National Water Management Authority
- Department of Environmental Monitoring and Information of the Central Inspectorate for Environmental Protection.
- The Main Inspectorate of Plant Health and Seed Protection.

- The Ministry of Agriculture and Rural Development
- The Institute of Soil Science and Plant Cultivation

The consultations were implemented due to the unique knowledge and expert skills in calculating and reporting particular indicators required for the implementation of tasks within the project. It is crucial to mention the important role of the Ministry of Agriculture and Rural Development, which helped us gain the required information by coordinating and supervising the work of scientific institutions. Within the structure of the ministry, there is a special position for cooperation with the CSO, which facilitates contacts and coordination of activities.

Finally the list of available agri-environmental indicators has been developed., as well as metadata for the indicators and examples of numerical data tables (for selected indicators).

Within the analysis of the submitted AEI:

- Members of project group were familiarised with the methodology of calculating agri-environmental indicators in reporting entities, among others with regard to the use of the data by the CSO.
- Key indicators presenting the impact of agricultural activities on the environment were identified.
- The main sources of pollution generated by agricultural activities were specified.
- The methodological description of indicators was confronted with the needs of the newly established database concept.
- The criteria for assessing the usability of indicators were set, together with the required level of detail.
- Main definitions, notions related to the indicators and the classifications applied were analysed.
- Access to data for official statistics was analysed, including such aspects as data timeliness and the method of the possible data transfer. The advantage of indicators submitted by institutions cooperating with the Agriculture Department lies in their major part being calculated on the basis of input data obtained from CSO surveys, which ensures methodological coherence.

Afterwards the indicators were divided into thematic groups and subgroups.

The length of the time series for the obtainable indicators was specified. The changes of some indicators in the years 1988-2014 were analysed. Subsequently a template of metadata specification for the reported indicators was developed.

Next the plan for implementing the AEI database on the STRATEG platform was discussed. STRATEG is a system created by the CSO for the purposes of programming and monitoring

the development policy. It contains indicators used for monitoring the implementation of strategies in force in Poland (at the national, supraregional and voivodship level) and in the European Union (the Europe 2020 strategy). Furthermore, the system provides access to statistical data of relevance to the implementation of the cohesion policy. Numerical data are supplemented with definitions of terms, methodological information and thematic reports and analyses. Along with an extensive set of databases, STRATEG offers functional tools enabling the analysis of phenomena in the form of figures and maps. AEI indicators could be included under the "Environmental protection" thematic area, in the part devoted to sustainable development resulting from the cohesion policy. The final localisation and visualisation of the AEI database will require consultations with the management of the Department responsible for the development and functioning of the database.

The analysis also covered the impact of the project on changes in collaboration between statistics and administration. We have obtained a number of contacts by organising meetings at the CSO and carrying out consultations with the employees of the cooperating offices and scientific institutes. The acquired trust and professional knowledge form a basis for further cooperation and involvement in joint projects. The possibilities of consultations with other units before Eurostat working groups' meetings will be expanded so that Poland could arrive at a dependable position of Poland at the international level. In the long-term perspective, the project outcomes will provide official statistics with a quicker and easier access to data from other sources, and also will make it possible to expand the range of indicators presented in our publications. It is planned to use the acquired experience in further activities within bilateral relationships with the cooperating entities.

II.2. Summary and conclusions

II.2.1. Conclusions

- During the implementation identified net of links between institutions involved in the agri-environmental reporting and cooperating in this regard with the Department of Agriculture.

- The needs of different environments - the recipients of the CSO data in terms of reporting obligations to the EU and international organizations have identified.

- Cooperation between statistics employees and other institutions reporting agri-environmental indicators contributed to a better understanding of the needs and problems in obtaining data sources to calculate indicators and information flow.

- Establishing cooperation in the framework of the task allowed the introduction, further development and strengthening the of information flow channels of the units participating directly (by the agreement) and indirectly (through consultations) in creating a AEI database.

- Frequent contacts contributed to some extent to consolidate the environment related to the agri-environmental matters. But underlines the lack of regulation, the legal basis necessary for the integration of this environment. You should mention the necessity of establishing a center for dealing with regular updating excretion coefficients or national consultative group composed of entities involved in the reporting of emissions.

- In the context of agri-environmental legislation, we should, together with other Member States, appeal to the European Commission to establish regulations on fertilizer statistics and statistics on the nutrients balances, like regulation on pesticides .

- The needs of Introduction of provisions in the Programme of statistical surveys of the public statistics is part of the formal and legal streamlining the flow of national systems and data processing. Detailed indication in the PBSSP of agri-environmental indicators and entities obliged to supply them provides the possibility of continuous and systematic evaluation of the impact of agriculture on the environment.

- Work on the project realized to institutions with which we made contact, the need to create a full database of agri-environmental indicators, which results from:
  - the need to fully identify of indicators
  - elimination of potential overlaps in the calculation of the of indicators
  - use for a specific purpose the same indicators for reliable comparisons
  - identifying indicators to develop.
  - use of the same data sources to develop indicators

- CSO has confirmed the role as coordinator of activities in the field of creation of a coherent base agri-environmental indicators.

- The result of the project is to bring together 87 agri-environmental indicators. Due to the area of influence of the environmental indicators divided into 6 groups. The work was attended by 27 administrative units and research units.

- Use the STRATEG platform for collecting and sharing indicators. Wider and faster access to the indicators after the creation of a common database.

- Experience and knowledge gained in the project will be used for continuous attention to the quality of data collected in surveys conducted by the Central Statistical Office due to the wide range of their use for the calculation of agri-environmental indicators and the

introduction of possible changes in the scope and level of collected characteristics in agricultural research or data estimation.

- In the current works of Agriculture Department, contacts established during the project are helpful in obtaining the information from the resources of cooperated institution.

II.2.2. Recommendations

- Continuation of the activities in future projects related to the agri-environmental subject in order to deepen knowledge in this field and improve information flow.
- The knowledge and experience gained by the participants of the project can be used for support to other Member States in the organization of base indicators, streamlining cooperation and solving issues related to data flows.
- Applying for other projects in the field of researches on broad impact of agriculture on the environment.
- Widening and deepening of cooperation with domestic and foreign entities in the agri-environmental area.
- Continuous exchange of information in the context of the growing demand for data indicator in order to achieve consistent and comparable information.
- Transmission to the experts from cooperating units conclusions and recommendations on the sessions of the working group "Agriculture and Environment" and the increased involvement of cooperating units in the preparation of opinions in the context of the work on the regulation SAIO (Statistic on Agricultural Input and Output).
- Strengthen the existing legal basis and the creation of new legal instruments sanctioning the data flows and the framework for cooperation between the institutions
- Use the acquired knowledge to broaden the scope of the information contained in the CSO' analytical collective studies.
- Implementation of the conclusions in the European Union level.
- The wider recognition of existing data from administrative sources. Possibilities to use administrative data for further development of AEI and as a consequence reduction of burden on respondents.

II.2.3. Future work to do in the Agriculture Department associated with the project

- Continuation of work associated with the identification of institutions dealing with issues of agri-environmental indicators and with the preparation of metadata to the indicators.
- Continuation of work on the technical side of the base in the field arrangements to place of agri-environmental indicators in the database STRATEG on the CSO website.
- After placing the indicators in the database further, continuous work on the updating of indicators, taking into account the dynamics of changes over the years, or changes in the methodology of calculation of indicators.
- The organization of further meetings with project participants in the development of concept of the AEI database.
- In the long-term planning is utilization of measurement resource and environmental monitoring carried out within the framework of the State Environmental Monitoring (Chief Inspectorate Of Environmental Protection and Ministry of Environment) under development work (with the support of satellite methods of and mathematical models) to combine these data with the CSO data in order to identify pollution coming from a particular field, affecting a particular watercourse. Such a system operates in the Netherlands.
- It is planned to establish contacts with the Polish Chamber of Chemical Industry (PiPCh) and the analysis reported to the European Fertilizer Manufacturer's Association (FE) data on the size of the doses of mineral fertilizers used in particular plants. We also intend to obtain information about the consumption of pure nitrogen under various crops in countries reporting data in this area to the International Fertilizer Industry Association (IFIA).
- After taking into account the informational requirements of institutions developing agri-environmental indicators carrying out the final arrangements and records in PBSSP and POS (in the research conducted by Agriculture Department) concerning the scheduled cooperation on the basis of methodological standards and principles for the development and procedures and forms of data transmission to the AEI database on CSO website.

II.2.4. Information on the project impact on the changes in the mode of cooperation between statisticians and representatives of other institutions reporting agri-environmental indicators.

- Cooperation in the project caused that the CSO began to be seen not only as a source of statistical data, but as a potential partner for government research institutions in future

agri-environmental projects, (the role of the CSO described in detail in the conclusions to the objective III. Task 2).

- Meetings and mutual relations have improved to some extent, communication between the experts involved in the collection and dissemination of agri-environmental information.

- Topics discussed at the meetings in the field of agricultural statistics, collection, processing, analysis and dissemination of statistical data characterizing the impact of farming on the environment influenced the dissemination of information about our research methods and ways of implementation of our researches among cooperators.

- Access to data held by the resources of other entities and metadata analysis had a significant impact on the expansion of knowledge of the staff involved in the project in terms of the impact of agriculture on the environment. Has been proven statistics openness to new experiences and challenges.

- Measures implemented under the project contributed to the development of the competence of the statistical services and to build a positive image of public statistics.

- A growing group of users of agricultural statistics concerning on agri-environmental dependencies and the growing importance of information in this area in decision-making processes increases the demands on the quality of data collected in the CSO researches.

- In our contractors opinions data used in the development of agri-environmental indicators originated from researches conducted in the CSO, show high quality and reliability, enable the timely realization of reporting obligations to the EU and international organizations.

- The international environment in which CSO operates, is the source of system solutions, standards and best practices. Through meetings and consultations conducted within the framework of the objectives of the grant, we had the opportunity to present our experiences, learned lessons and the nature of the international involvement of the CSO .

- Should be emphasized the possibility to present research topics conducted in the Agriculture Department in foreign centers like Wageningen UR and consultation on issues of common interest. Participation in these meetings is an opportunity to showcase CSO achievements and the performance in the field of agri-environmental statistics, which will certainly affect the perception of CSO as a reliable partner in future projects.

II.2.5. Coherence and comparability of reported agri-environmental indicators

Poland, as an EU member, is actively involved in the European Statistical System (ESS) and in accordance with the schedule reports determined the scope of national statistics. The CSO is the depositary of the original data reported to EUROSTAT, as well as the provider of input data to the basic agri-environmental indicators (balances of nutrients GNB, GPB, GHG emissions and other agricultural pollution). Statistics created on the basis of one of the main sources of data are consistent in the sense that the results of the particular research may be subject to a number of reliable combinations to produce results more complex. The data collected and processed by The CSO are moreover consistent with the requirements of Eurostat in terms of definitions, subject matter and reference periods, developed on the basis of common Eurostat methodology. Based on the Regulation of the President of The CSO on the measurement, evaluation, and monitoring the quality of statistical surveys in the services of official statistics authors' unit periodically draw up reports quality. Investigated is the comparability of the temporal, spatial and subject specific of data. Measures of to assess the quality of data in terms of all aspects of comparability are of length of comparable time series and the asymmetry in the comparable statistics. The subject of the coherence assessment in the research are: the consistency of the preliminary and final results, consistency of annual and short-term reserches coherence of research in the same field. The meter for measuring quality in terms of consistency of data is a measure of S1-number of studies showing consistent characteristics in terms of variables. In 2014, there was an overview of quality for research G04 - Report on trading in plant protection products. Review was to analyze the strengths and weaknesses of the study, the definition of good practices and the formulation of final recommendations. The proposed changes are now being gradually implemented.

To conclude, it should be pointed out, that cooperation between administration units in terms of observance of coherence and data quality is necessary. There exist a necessity of entering into projects expanding knowledge on this subject. Group of experts which action initiated this project could support such projects.

The CSO should be equipped in legal tools allowing to exert a greater influence on the on issues of quality and consistency of reported indicators.

III. The implementation of Objective 2 Improving the methodology: area estimation, volume of crops and harvests from grasslands, classification of crops and ways of using harvest from grasslands.

III.1. Identifying the method for estimating grassland production

Department of Agriculture of the Central Statistical Office uses two basic methods for estimating grassland production:

- Test mowing method - Method is very accurate and reliable and is based on mowing of dry green growth and weighing of the forage immediately after mowing. Then using the conversion factor, which makes it possible to calculate air dry mass (hay), crop yield per 1 hectare is counted.

- Estimation and measurement method - is an easy method, which involves estimating the crop yield on the meadow, without mowing and weighing the green growth – "as standing".

  The above method is based on the measurement of the two characteristic features of the green growth:
  — height of the principal mass of green growth
  — measurement (assessment) of grass-sod coverage
  After the measurement has been finished (e,g. during the day), the calculation of hay and forage crop yield from 1 ha starts.

III.2. Study visits

III.2.1. Biebrza

As part of the project three **visits in the Biebrza National Park** and its buffer zone were held (in April 2015, in May 2015, in May/June 2016). During visits participants acquainted with various types of meadows and pastures that are occure in the Biebrza National Park and its buffer zone.

The aims of the visits were:

- define the plots for further research using i.a. Land Parcel Information Systems (LPIS) and mark their coordinates using GPS devices,
- localization of sensors on IGiK plots, which are used for validation and calibration satellite images,
- discuss the work which were carried out and familiarize with the state of vegetation on the tested plots and typology of grasslands,

- identification and comparative analysis of vegetation occurring on permanent grasslands in different grassland sites, especially taking into account the areas on which were located parcels included in the study.

III.2.2. Norway

As part of the exchange of experiences with foreign scientific centres specialising in grassland survey, on 22-24 September 2015 a study **visit to the Norwegian Institute of Bioeconomy Research (NIBIO)** in Norway was held. The meeting offered the opportunity to compare grassland in different climatic conditions, to exchange experience on methodology to determine area and production from grasslands.

Conclusions and remarks regarding the visit:

- the meeting included the discussion on the possibilities of work out common methodology for grasslands,
- the result of the meeting was to exchange of experience in the field of using satellites and other modern technology for grassland examination,
- during the visit were noticed several similarities between Polish and Norwegian species growing on meadows, in spite of different climatic conditions,
- due to the large diversity of permanent grasslands cooperation should be expanded in order to identify the different types of habitats in Europe.

III.3. Summary of the pilot study "Development of the classification methodology of permanent and perennial grasslands in the Podlaskie Voivodship".

III.3.1. Actions taken

The „Grassland Term Definition" Work Team, in turn, established during the 24th General Meeting of the European Grassland Federation (EFG) on 3-7 June 2012 in Lublin (Poland), proposed a new classification of permanent grassland, under which permanent grassland in the EU territory were assigned to three main categories:

- Permanent grassland improved agriculturally
- Semi-natural and natural grassland
- Permanent grassland not used in production

The proposed classification of permanent grassland assumed that the main goal of European statistics is a coverage-based (area-based) approach, i.e. determining the area of turf, mown or pasture land or land not used in production. The problem of economic (utility) adjustment was deemed to be of secondary importance.

The permanent grassland classification proposed in the Pilot Programme is consistent with the EFG's proposal of 2012. Table 1 presents how the various classes are harmonized.

Table 1. Proposal for a uniform permanent grassland classification

Permanent grassland classification following the implementation of the Pilot Programme…		Permanent grassland classification according to the EFG
By habitat conditions	By the intensity of use	(Coverage-based) for the purposes of permanent-grassland statistics
Highest fertility	Improved intensive	Permanent grassland improved agriculturally (under meadow, pasture or mixed use)
Medium fertility	Improved medium intensive	
Low fertility	Natural and semi-natural extensive	Natural and semi-natural - regular meadows - extensive pastures (in various EU habitats)
Potential	Limited or no use	Potential permanent grassland, not used in production

The Pilot Programme was implemented in the Podlaskie Voivodship, within the Biebrzański National Park and its protection zone, where the majority of land is permanent grassland situated on post-wetland soils or light sand formation, used on a medium-intensive or extensive basis. Meadow and pasture habitats found in the territory of the EU are in turn characterised by substantial habitat-related diversity (ecological conditions).

Therefore, the permanent grassland classification, as proposed by the EFG (coverage-based), requires that further indoor and outdoor work be carried out with a view to assigning to each of the three main categories grassland areas that occur throughout the EU in habitat and climatic conditions that are different from those in Poland (e.g. Alpine meadows and a natural tundra below the tree line, Pannonian meadows – Hungary, Micronesian mesophiles, grassland of the Atlantic islands, steppes – Romania, Mediterranean xerothermic meadows, grassland on saline soils).

The study aims at improving the quality of agricultural and environmental statistics, in methodological terms, and at developing the statistics of lowland meadow grasslands.
The pilot studies provide for:

- developing the classification methodology of permanent grasslands (PG);

- distinguishing the PG generic groups on the basis of available materials (in situ surveys, agricultural maps, data sources from agricultural surveys);
- reviewing the PG classification in the pilot area using the classical methods based on field research of habitats and plant communities;
- conducting an analysis and preliminary synthesis of the field study results.

The application of satellite imagery methods is one of the ways to quickly assess the PG yield and use the results obtained in practice. Therefore, attempts have been made to establish the principles of a typological division of permanent grasslands meeting the needs of yield and use statistics, with a possibility to adjust them to the currently available satellite imagery methods.

The meadow communities located and described in the area of the Biebrza National Park (BPN) and its buffer zone are strongly diversified in terms of species, habitat fertility and use intensity. The permanent grassland yield depends on the use intensity and method, and on the PG type assigned in the typological division. In consequence, the new classification, in order to meet expectations, should take into account the PG division, both in terms of habitat fertility and use intensity of meadows and pastures, which entails the need to apply a double classification.

Obtained data demonstrates that the currently binding typological division of PG should be adjusted to agricultural statistics surveys, which is not in conflict with the classical division, but simply extends its practical application.

In the light of the above assumptions, it was proposed that various typological types of meadows displaying similar levels of moisture and trophicity, and a similar yield potential, be combined into generic groups, depending on:

- use intensity
- habitat conditions (soil trophicity),
- water conditions,
- prevailing species and their diversity.

Taking into account the above factors the following types of habitats were separated:

The most fertile habitats included: proper and dried marshy meadows, post-flooded oak-hornbeam forests and re-flooded moorshed meadow – in the new PG classification considered the most fertile;

Semi-fertile habitats included: dried marshy meadows, proper oak-hornbeam forests, proper and drying degraded moorshed meadow – in the new PG classification considered semi-fertile;

Poor habitats included: impoverished and waterlogged oak-hornbeam forests, degraded moorshed meadows – in the new PG classification considered moderately poor.

Potential habitats included: marshy meadows with stagnant and flooding water, swamped moorshed meadows and peatland meadows – potential PG.

Not all the generic groups and types of permanent grasslands, including their use intensity levels, which had been planned to be assessed, could be identified in the area selected for the studies.

As a result of work carried out, were separated following types of grasslands, which could be wide spread in EU:

- **Intensive PG**
  - Re-flooded moorshed meadows;
  - Impoverished dry meadows;
- **Semi-natural, semi-intensive PG**
  - Drying, proper and re-flooded moorshed meadows;
- **Semi-natural, extensive PG**
  - Proper, proper wet and drying moorshed meadows;
  - Impoverished dry meadows;
  - Flooded meadows with flowing water.

III.3.2. Lessons learned - Difficulties

- As far as the identification of grasslands through satellite imagery is concerned, the dates of taking photos are of utmost importance The analysis of photos taken in various periods is needed for the appropriate results interpretation in terms of the use intensity and method: in the spring (which marks the beginning of the vegetation period, and precedes grazing and cutting) and summer (which corresponds to the most severe water shortages). On the basis of the early spring satellite photos, it is difficult to distinguish humid plant communities with the delayed vegetation from extremely dried communities, referred to as impoverished dry meadows. Drawing a clear distinction is possible in the summer.
- Due to the areas selected to pilot studies, located in the Biebrza National Park and in its buffer zone, with dominated post-bog meadow habitats, pilot studies require implementation in other habitats in Poland or/and EU.

With post-bog meadow habitats prevailing in the areas selected to pilot studies, the following PG types were not described and require to be supplemented:

- Intensive PG
  - Degraded, drying and proper re-flooded moorshed meadows,
  - Proper, waterlogged and post-flooded dry meadows;

- Semi-natural, semi-intensive PG
  - Degraded re-flooded moorshed meadows;
  - Dry meadows: all types;
- Semi-natural, extensive PG
  - Degraded and drying re-flooded moorshed meadows;
  - Proper, waterlogged and post-flooded dry meadows
  - Dried flooded meadows.

III.3.3. Recommendations

- The surveyed area should be extended to include the grassland habitats located in lowlands outside valleys and in mountainous areas.
- Field studies of permanent meadows and pastures should take into account all types and generic groups, based on the classical typological division.
- The survey techniques employed in grassland statistics, including satellite techniques, should be based on, and supplemented with, field studies of meadow and pasture communities.
- pilot studies aimed at improving the quality of agricultural and environmental statistics, in methodological terms, and at developing grassland statistics, should be continued and improved.

III.4. Summary of the study concerning estimation of grassland production using information provided by drones based on the analysis of grassland on specific plots in the Podlaskie Voivodeship.

III.4.1. Actions taken

During implementation of the project, to obtain hyperspectral imaging from low altitude an unmanned measurement platform (drone) was used in the form of multicopter with six rotors. Hyperspectral camera - imaging within the range of 480-890 nanometers, was suspended under the drone.

Imaging from drone took place in the course of two field campaigns conducted on 25-26 May and 07-10 June 2015 and were supplemented with data from Landsat 8 satellite for fragments of plots for which acquisition of data from drone was not possible due to adverse weather conditions, or mowing performed before drone flight.

In addition, simultaneously with conducted flights the ground measurements were performed (74 points on the area of the analysed plots) using specialist apparatus being in the possession

of the Institute of Geodesy and Cartography, offering information about LAI (Leaf Area Index, ratio of projection area of leaves), humidity of soil and temperature of plants' surface.

The collected data described above allowed for analysis and calculation of the production from the grasslands by assigning to each indicated plot an estimated value of fresh biomass and biomass with regard to one hectare. A starting point for such analysis was a comprehensive set of data collected by IGiK over a period of few decades, enabling use of already generated and for many years used by the Institute models describing correlation of biomass with LAI - obtained for the surveyed area in the ground measurements points.

III.4.2. Conclusions and remarks - advantages and disadvantages of the decision to use drones to acquire remote sensing data to, consciously and rationally use them for later analysis.

Advantages:

- the possibility of taking pictures at low heights, as low as a few dozen meters, as well as smooth selection of height in vertical profile (which is impossible in the case of an aircraft or a satellite). Thus, such pictures are characterised by high spatial resolution, impossible to obtain by satellite images. Spatial resolution at the flight ceiling of 200 m. is approx. 12 cm. Such level of detail is necessary for precise determination of models, as well as for modification (detailing) of mathematical models used for image analyses, e.g. satellite images with greater data generalization, covering significantly larger areas.
- mobility, flexibility and relatively small cost of conduct of a single flight that can be carried out with a possibly short preparation time.
- the need to maintain eye contact with the device by the drone operator provides a chance for good recognition of the imaged areas from the ground level and execution of additional measurements, which positively affects the accuracy of analyses.

Disadvantages:

- the time of a single flight amounting to ca. fifteen minutes,
- high dependence on weather conditions, fairly low threshold conditions for wind power, during which flights cannot be performed for safety reasons (but also due to image quality),
- the need to maintain eye contact with the drone limiting the scope of the survey.

Those factors result in the fact that the use of a drone in the case of analyses of large surfaces becomes difficult and ineffective.
An additional problem also appears:

- a way of imaging by fixed under the drone camera, as though with optimum atmospheric conditions camera with sliding channels, performing imaging for each channel mode one by

one, offers a convenient flexibility to adjust to the current needs of specific spectral bands. But stronger winds means that even when using advanced stabilization, the individual channels can be spatially offset in relation to each other, which raises the need to use the compilation of time-consuming algorithms automatically adjust to each channel, or very time-consuming - even manual geometry corrections. This need not occur when we could use the muli-lens camera recording the appropriate channels at the same time (which of course increases the weight of the camera).

III.4.3. Lessons learned and perspectives plans for implementing the result in practice

Trying to simulate the performance of imagery from drone on a scale of Podlaskie province with an area of 20180 km 2, where being a potential interest to agricultural land is 10741 km 2 (CSO, 2013) and based on framework price list of one of the companies carrying out flights by drones in 2015, we come to the values shown for clarity in the table below. Total, multimillion cost and the huge amount of time needed for the execution of such a large area of the project make use of established technology, it is impossible to predict.

The estimated costs to cover the data from the drone of agricultural land in Podlaskie voivodeship.

Area of the region of Podlaskie	**20 180** km^2
Agriculture area	**10 741** km^2
Expected area of flight by day	**4** km^2
Cost of working day (delegations)	**120** €
Daily cost of measuring ground control	**96** €
Cost of 1 km^2 made photo product	**314** €

Estimated number of working days	**2 685** days
Estimated cost by day (delegations + ground	**216** €
Cost field work (without the cost of transport)	**578 870** €

Cost made of photo product	**3 370 311** €

ESTIMATED TOTAL COST OF DATA (without transport costs)	**3 949 181** €

In conducting similar simulation for an air flight, price of obtaining imagery of course significantly reduces, but still exceeds 240 000 € (1 euro = 4,1749 PLN). Sample offer for acquisition and preparation for further analyzes imagery with ground resolution of 30 cm and using a camcorder recording visible radiation and the range of near-infrared (RGB and NIR), even taking into account the large discount associated with the scale of development, price fluctuates around 240 000 € of flight costs and additional 84 000 € for the development of orthophotos of the acquired data.

Accomplishment of imagery from drone on a scale of Podlasie province would generate significant financial burdens (estimated by subcontractor) and would be time consuming. Therefore, use of this technology in order to estimate the production of grassland seems irrational.

III.4.4. Recommendations

With the analysis of agricultural production with the use of remote sensing techniques, the first step should be to align the source of the obtained data for the planned scale of the study and the needs related to spatial resolution. While in the case of single plots, imaging from the level of a drone can provide valuable material for the purpose of conducting detailed analysis of production from grasslands, as well as provide possible additional significant data for verification of models used for analysis of image content. In the case of gminas or poviats (NTS 5 level), it may be more reasonable to use data from small airplane flights, with the use of the same equipment as the one used in drone studies, or even data from satellite (e.g. data from satellites Landsat 8 or Sentinel missions, which may enable analysis in the scale of a voivodeship, districts or the whole country.

III.5. Summary of the study concerning development of new methodologies with regard to data collection and grassland classification using modern satellite techniques in the Podlaskie Voivodship.

III.5.1. Actions taken

Work utilising the methodology for the classification of grassland was divided into two phases:

- the preparatory phase - the collection and processing of satellite images from the Landsat 8 optical and Sentinel-1 microwave satellites, covering the growing season of meadow plants (from April to August 2015).

- the crucial phase - the diversity of distinguish ability of three types of grassland was analysed – productive meadows, natural meadows and marsh areas – with the use of Landsat 8 optical images and Sentinel-1 radar images.

On the basis of the results of this analysis, a supervised classification of grassland for the entire Podlaskie Voivodship was carried out, utilising a synergic set of satellite images (Landsat 8 and Sentinel-1). The results of the classification were subjected to the analysis of accuracy. At the final stage of work, the areas of grassland classes identified in the classification process were calculated.

III.5.2. Conclusions and remarks - advantages and disadvantages

Advantages:

- satellite images give the possibility of global application,
- allow the measurement and analysis of large areas,
- make it possible to automate some processes of measurement,
- enable repeatable imaging in defined time series,
- retain archival value,
- give the possibility of repeated analyzes, measurements or supplement them,
- provide stable data flow,
- cost per unit area are lower than in the case of data collected by drones.

Disadvantages:

- long process of data flow, required dedicated software (specialist facilities for processing)
- limited capacity for data storage and processing rules
- calibration by in-situ surveys is required
- also main difficulty is the ability to perform optical satellite images on a cloudless day at the start of hay-making. Especially during the first cut on permanent grassland there is increased evaporation from the land surface (vegetation, water) and simultaneously high air temperatures conducive to increased humidity and entrusts the accumulation of water vapor in the form of clouds.

III.5.3. Lessons learned and perspectives plans for implementing the result in practice

Comparison of the results with the data recognized as valid (based on test cuts) shows the desirability of the proposed approach and methodological solutions for estimating yields and harvest of permanent grasslands using information obtained by the help of satellite remote sensing.

III.5.4. Recommendations

Using satellite images to assess area and production from grasslands requires:

- In situ data for calibration
- Further work on methodology for estimating yields and production, taking into account:
  - recognition of daily growth of biomass, different in various grassland sites,
  - knowledge of the share of production and non-production biomass of the total biomass, which is also not the same for meadow plants in various grassland sites,
  - conducting systematic research on the identification of meadow habitats on the basis of high resolution satellite images,
  - determination of the botanical composition on permanent grassland based on remote sensing satellite images,
- The development of statistics on estimates related to grassland in order to use these data for related topics such as emissions assessment or the balance of carbon dioxide.

The work done to date shows that further analyses of distinguish ability of the various types of grassland using satellites should be conducted with the use of both Sentinel-1 and Sentinel-2 satellite data.

III.6. Summary and conclusions

As a result of the implementation of „The pilot study designed to methodologically improve agri-environmental statistics and the development of grassland", the subject of which was „The preparation of a methodology for the classification of permanent and multi-year grassland in the Podlaskie Voivodship, with the use of standard and advanced satellite techniques", a classification of permanent grassland was proposed, with the economic functions of meadows and pastures taken as a basis, according to a typological division.
As a result of the pilot study the following grassland classification was obtained:

- Intensive PG
- Semi-natural, semi-intensive PG
- Semi-natural, extensive PG

In respect of agricultural statistics pertaining to the use of land, and the sowing, yield and crop area, the production approach was adopted, i.e. in addition to the assessment of coverage, account was also taken of the production of biomass per area unit. Such an approach to agricultural statistics is comprehensive in that it includes all information on the production and state of meadow vegetation as well as on its growth conditions. The production-based

approach can be determined on the basis of remote-sensing data obtained from satellite images.

Determining the volume of production is of vital importance as regards appropriate economic decisions.

The knowledge of habitat condition, i.e. the typological division of grassland, is necessary in order to improve the method and specify the forecast estimates of yield and crop of biomass from PG. To determine the area of permanent grassland and the productiveness of biomass, satellite images should be analysed from spring to autumn, so that they can be properly interpreted.

The highest diversity in land coverage captured in satellite images is visible in photos taken in summer and early autumn, whereas the lowest diversity occurs in spring when the vegetation, undergoing fast growth, is largely monocoloured. This allows the identification of not only individual plant species, but even the various types of plant communities.

The results of interpretation of satellite images were verified in outdoor conditions by scientists researching permanent grassland areas and the vegetation growing there.

The classification applied in statistical analyses should be universal enough to be used in both surveys and satellite studies.
The classification used in surveys on the use of land and plant production should be unambigous and understandable for the respondent. All these conditions are met by the production-based approach. The table below presents the possible uses of each type of classification.

Table 1. The possible uses of permanent grassland classification in the production- and average-based approaches.

Approach / Use	Production-based (by the manner of use)	Area-based (by land coverage)
Surveys	+	-
Satellite images	+	+
Experts' estimates on land use surveys	+	-
Administrative data	+	+
Emission balance	+ -	+
Assessment of ecological and environmental hazards	+ -	+

Based on data from the Agency for Restructuring and Modernisation of Agriculture (ARMA) and from the Head Office of Geodesy and Cartography (GUGiK) ie.:

- vector layers fields of management;
- applications for direct payments to farms
- layer of parcels

has been created map of grassland for podlaskie province. Then overcharged surfaces for districts (NTS 4) and municipalities (NTS 5). This resulting material will be treated incidentally by the department of agriculture at estimates of areas and yields of permanent grassland. Unfortunately, we could not get access to the soil maps for the study area, which could expand the possibilities of matching permanent grassland to the relevant types of soil.

III.6.1. Activities planned to be conducted upon completion of the project work

- Use of gained experience to estimate production from grasslands on voivodeship and national level.
- Transfer of knowledge to experts estimating yields from grasslands.
- Estimating the area of grassland and the use of modern methods of satellite remote sensing - in order to fully implement this action considerable financial resources are needed, involvement and better cooperation of other institutions of the agricultural sector with experience in the field of phenology of vegetation meadows and pastures.
- Dissemination of crop production statistics during working groups meetings.
- The use of the experience gained during the pilot study during national conferences.
- The use of existing data from administrative sources for mapping.
- Implementation of the conclusions in the European Union level.

IV. The implementation of Objective 3, Task 1: Carrying out an analysis and tests for implementing the methodology of the Capri JRC model for estimating elements of the gross nitrogen balance at the national and voivodeship level.

IV.1. Actions taken

The identification of potential experts who could undertake to perform this task, using their experience and knowledge was performed. The review of specialist literature concerning the CAPRI JRC model.

The selection of subcontractors to perform the subject matter of the contract – carrying out the analysis and tests concerning the implementation of the Capri JRC model methodology for estimating the gross nitrogen balance at the national and voivodeship level – was compliant with the public procurement procedure.

The inventory of batch data and the identification of missing data for the gross nitrogen balance in the CAPRI model was done. It included a detailed description of particular streams of nitrogen taken into account in the gross nitrogen balance ("the land balance"). For each item the source of data for the model was identified.

IV.2. Summary and conclusions

IV.2.1. The summary information on the data provided by the CSO to the balance sheet and missing data.

Poland, as an EU member state, actively participates in the European Statistical System (ESS) and reports a range of national statistics as scheduled. Each member state designates a national statistical office to serve as the contact point for Eurostat on statistical matters. In Poland this function is served by the Central Statistical Office. This creates a comfortable situation in which CSO is the depositary of primary data (reported later to EUROSTAT), including the necessary data to determine gross nitrogen balance in the CAPRI model.

CSO collects and administrates the following data used to calculated GNB in the CAPRI model:

- number of cattle by category of use and data on animal production volume (animals for slaughter, milk, eggs) − determining the amount of nitrogen from natural fertilisers;
- production volume of organic fertilisers − determining the amount of nitrogen from organic fertilisers;
- production volume of mineral fertilisers − determining the amount of nitrogen from mineral fertilisers;
- area and crops of cultivated leguminous plants − determining the amount of biologically fixed nitrogen;
- area and crops of arable land − determining the amount of nitrogen output from major crop products;
- area and crops of permanent grassland − determining the amount of nitrogen output from yields of permanent grassland.

Data that are necessary to calculate GNB in the CAPRI model, and which (according to IUNG experts) may be incomplete or not recorded at all, include:

- trade in natural fertilisers (type of fertiliser, volume of trade, balance of imports/exports) between individual voivodships and the volume of international trade, the amount and type of produced natural fertilisers − data needed to determine the amount of nitrogen from natural fertilisers;

- the use of side-line crops − data necessary to determine the amount of side-line crops used as fodder or litter material, used to determine the volume of nitrogen input in natural fertilisers;
- the amount of seeds and planting stock used − data needed to determine the amount of nitrogen input on fields.

IV.2.2. Final conclusions. Analysis of the possibility of introducing the model CAPRI in Poland.

The perspective of implementation in Poland GNB calculation using the model CAPRI in the context of the availability of data, needs further works on validation of the model. Starting of simulation calculation of nitrogen balance in the model CAPRI requires the delivery of large amounts of detailed input data. In Poland, there is a lack of certain data or some of required data are not fully evidenced. However, it does not prejudge the possibilities of implement the model in Polish conditions.
It should be pointed the following **problematic areas** in terms of the availability of the data needed to use the model Capri:

- Statistics of natural fertilizers (manure, liquid manure, slurry). The deficit data applies to records of trade at regional and national levels (a type of fertilizer, the size of the turnover, the balance of import / export), production volumes, data on systems of keeping and feeding the livestock. In terms of estimating nitrogen content in different types of natural fertilizers, important here, can be application of nitrogen excretion coefficients developed within this project, within the implementation of the second task of third goal of our project. Uniform coefficients of excretion should be used in both the calculation GNB, as well as greenhouse gas emissions. Information can be extended to a certain extent on the data collected in this year's FSS survey. The results of this research will indicate, among others, trends and general information about the turnover of natural fertilizers.
- Identification of the source data for sowing materials and seed-potatoes in the model CAPRI. Data are available only for the sale of certified seed (representing a small portion of the material used seed) registered by the Agricultural Market Agency, and other data in this field are estimates.
- The amount of nitrogen from atmospheric deposition. In our opinion, more reliable than mathematical calculations recommended by the EMEP/EEA guidebook, are the data of the State Environmental Monitoring compiled by Chief Inspectorate of Environmental Protection.
- Lack of precise data defining the direction of the use of by-products of specific crops, when CAPRI requires on the input side of balance, data on the use of animal feed and for bedding.

- There is a high degree of uncertainty as to the amount of biomass of grassland used for animal feed, as well as the estimated nitrogen content in used for consumption the bulky feed.
- In the model CAPRI on the revenue side does not take into account the nitrogen from external sources of organic matter used in agriculture, such as sewage sludge (industrial and municipal) and compost (in currently used the balance sheet are included). It was necessary to consider the inclusion of that element in balancing the model Capri.
- Currently, there are no accurate data on the consumption of fodder by the different technology groups of livestock, however, this parameter, according to our knowledge, it would be possible to estimate

IV.2.3. Recommendations

- The Capri model could be recommended to estimate GNB in Poland only after the thorough validation.
- The validation should include certain simplifying assumptions of the model consisting primarily at limiting the amount of the data entering model, which have no significant impact on the final result. It is also possible to estimate the majority of the missing data.
- On the issue of missing data on trade in natural fertilizers, there is no detailed statistics, but for the validation purposes we can assume that, in Polish conditions it is not so important. In Poland, there is no large-scale phenomenon of over-fertilization of soils (outside the identified hot-spots). Rather, due to poor soil quality and low humus content, it is advisable to increase fertilization, mainly using natural fertilizers. Currently, it is assumed that the entire quantity produced natural fertilizer remains in the region. If grazing is either directly deposited on grasslands for grazing animals or lost as a result of loss of surface, penetrate deeper into the soil profile or in the form of gaseous compounds of nitrogen volatilization into the atmosphere.
- It should be noted that the Polish part of the Baltic Sea catchment basin is formed by two major rivers basins: the Vistula (54% of the country) and Odra (34%). For this reason, natural fertilizers trade between provinces within the same catchment area could be neglected.
- Due to the minor importance of nitrogen from the in the balance sheet, this element should be considered in the calculation to skip it (especially in the case of the lack of precise determination the amount of consumed seed seed-potatoes). The arable area under potatoes in Poland since years shows a downward trend. Currently, the share of potato area is just over 2% of the total sown area.
- It should be noted that the model CAPRI JRC may not include some of the regional natural, organizational and economic conditions. Some coefficients may not be sufficiently adapted to local conditions (soil, climate, farming systems, feeding systems, stable conditions, feeding measures). So it’s indicated a thorough comparative analysis of the coefficients and parameters used in the model CAPRI, so as to be able to properly give

local variation. In our opinion, both in the model Capri, as well as currently model determining components of the GNB used in Poland, at the regional level variation is not covered sufficiently. There is therefore a need for further studies and improvements, as well as development work on the same Capri model.

- It should take steps to improve the methodology of developing estimates and where possible to expand the range of data for use from other sources. Further work related to the validation of the model CAPRI should be conducted in cooperation with all entities involved (CSO, The Chief Inspectorate of Environmental Protection, The National Centre for Emissions Management, the Institute of Soil Science and Plant Cultivation, The National Research Institute of Animal Production) to ensure the access to current data and ongoing monitoring of parameters used in the balance, that due to changes in techniques and the level of agricultural production would be correct.
- Making arrangements directly with the creators and custodians of the CAPRI model in respect of the rules for use of the model by the Polish party, should be prioritised.
- At the scenarios of the proceeding for implementation of the model Capri could affect the possible legislative changes and the introduction of a recommendation to use the model Capri in EU legislation. Release of new regulations and a commitment to their implementation could be a basis for further work by the Central Statistical Office in cooperation with other entities administration and Institute of Soil Science and Plant Cultivation.
- The possible further work on nutrient flows could be continued within the framework of the Annual Work Programme of Eurostat for 2017. Priority area 08 – Strategy for agricultural statistics towards 2020 and Beyond: Improve methodological aspects for AEI assessing the impact of nutrient flows.

V. The implementation of Objective 3 Task 2: Improving the methodology of estimating of excretion coefficients, as an important element of estimating nitrogen and phosphorus flows in agriculture.

V.1. Actions taken

Searching for potential experts in animal production with extensive knowledge of and experience in studying agricultural and environmental indicators, who would be able to support the Agriculture Department with their expertise, to implement the task.

A study visit to the National Research Institute of Animal Production in Kraków-Balice, and the presentation of the project's principles, objectives, work schedule and general rules for cooperation with subcontractors was organized. Becoming acquainted with professional literature in the field of broadly defined natural fertilisers

The selection of the subcontractor to perform the contract subject: "Improving the methodology of estimating of excretion coefficients, as an important element of estimating nitrogen and phosphorus flows in agriculture" was consistent with the public procurement procedure. At this point, we should stress the high quality of cooperation with the subcontractor.

In order to evaluate the progress of work conducted by the subcontractor, the National Research Institute of Animal Production in Kraków-Balice was visited on 2-3 December 2015. Among the discussed topics were the work accomplished to date, the methods of dissemination of the project results and the work completion plan. An observation was made that the calculated indices of nitrogen and phosphorus released by livestock should be updated every 10 years due to changes to the feeding and animal keeping systems.

The summary of updated coefficients was compiled using the most representative database compatible with officially used quantities in terms of environmental protection standards, as well as scale delimitation and production concentration.

The Nutrient Flow Balance used in developed countries was adopted as the basis for calculations. The scale sets the amount of nutrients in animal nutrition against the use of these substances in products and natural fertilisers. The excretion coefficient calculation methodology at the NTS 0 level, the methodology for preparing balances of biogenic compounds of nitrogen and phosphorus in livestock breeding, as well as LSU conversion factors methodology The study also made use of data included in DEFRA, 2013, Guidance on complying with the rules for Nitrate Vulnerable Zones in England for 2013 to 2016. The aforementioned sources are either official guidelines (OECD/EUROSTAT) or regulations used in production practice by the Ministries of Agriculture of France (CORPEN), Germany (KTLB), and the United Kingdom (DEFRA). These sources were selected due to their being frequently quoted in other studies, especially in EC, Best Available Techniques (BAT) Reference Document for the Intensive Rearing of Poultry and Pigs, Draft 2 - August 2013.

The elaboration was conducted in relation to the keeping systems used throughout the country, average animal productivity and taking into consideration the most common values of loss in the form of emission or leaching.

The obtained results indicate a significant discrepancy between indicators, depending on the species, type and age group and animal keeping system. Such a state is confirmed by data presented in the literature and the results of direct chemical analyses. The obtained release coefficients are certainly among the most complementary and representative analyses in the field of the environmental impact of animal breeding.

The comparison of concentration coefficients of phosphorus and nitrogen compounds in natural fertilisers with data included in foreign literature:

- OECD and EUROSTAT, 2007. Gross Phosphorus Balances Handbook
- CORPEN, (Comite d'orientation pour la reduction de la pollution des eaux par les nitrates, les phosphates et les produits phytosanitaires provenant des activites agricoles), 2013. Estimation des rejets d'azote – phosphore - potassium calcium - cuivre – et zinc par les élevages avicoles ITAVI/Corpen
- CORPEN, 2003. Estimation des rejets d'azote - phosphore - potassium - cuivre et zinc des porcs. Influence de la conduite alimentaire et du mode de logement des animaux sur la nature et la gestion des déjections produites.
- CORPEN, 2001. Estimation des flux d'azote, de phosphore et de potassium associés aux bovins allaitants et aux bovins en croissance ou à l'engrais, issus des troupeaux allaitants et laitiers, et à leur système fourrager.
- CORPEN, 1999. Estimation des rejets d'azote et de phosphore par les élevages cunicoles.
- Kuratorium für Technik und Bauwesen in der Landwirtschaft e.V. (KTBL) 2009. Faustalen fur die Landwirtschaft. 14 Auflage. Bartningstraße 49, 64289 Darmstadt.
- KTBLU. Schultheiß, H. Döhler, M. Bach, 2011. Festmistaußenlagerung. 1 überarbeitete Auflage.

The cooperation between members of the team implementing the project and the subcontractor was conducted both by direct consultations (e.g. visits of the Agriculture Department staff at the National Research Institute of Animal Production in Balice), and by phone and e-mail. Moreover, the subcontractor provided assistance and expert knowledge in other aspects related to the Agriculture Department's work. Among other things, he gave a lecture at the annual conference summarising the results of the Agriculture Department surveys. This project has certainly contributed to the strengthening and consolidating of mutual relations, which is very important in the context of further cooperation.

A set of calculated N and P excretion coefficients and unit productions of natural fertilisers, divided into animal keeping systems for particular technological groups of the basic species of farm animals, along with a methodological description and results interpretation, constitutes the outcome of the subcontractor's work. The Nutrient Flow Balance was used as a method commonly used in industrialised countries, which balances the amount of nutrient compounds in animal nutrition on the one side, and the distribution of these substances in natural products and fertilisers on the other side.

The study was prepared in relation to the keeping systems used in the country and the average production of animals, as well as taking into account the most frequent volumes of losses through emissions or washing-out.

V.2. Summary and conclusions

V.2.1. Analysis of the results.

- The findings established so far with regard to the volume of production of natural fertilisers in various systems, and for various animal species, have revealed that this volume is decreasing in comparison to recent decades. A similar conclusion can be drawn in respect of N and P concentrations in natural fertilisers. When this area is compared with the official standards being currently in force in other EU Member States, lower values are clearly visible in Poland.
- On the other hand, the technological advancement in agriculture, following our country's accession to the EU, has resulted in the optimisation of feed and a number of modifications to the keeping systems.
- Also of significance is the unification of the animal breeds and hybrids utilised in Poland – most of them are the same as those in other EU countries. These animals, however, are not backed by technological advances so much as to meet the highest EU productivity levels. This contributes to lower feed rations and, ultimately, reduced N and P content in natural fertilisers.
- Still to be determined is the level of emissions of nitrogen compounds from animal breeding, which should eventually be added to the amounts of nitrogen obtained in fertilisers as a comprehensive outflow of this biogene. Responsibility for this state of affairs lies largely with the animal keeping systems and we are witnessing a rapid drop in the share of litter-based solutions in this regard. This change has been the consequence of reducing the production costs in commercial farms which increase the concentration of production, or in extensive farms which change their operating profiles to that of commercial farms.
- After all, the animal welfare legislation alone as well as the incorporation of EU Directives into national law through legislative acts and regulations have made it necessary to reduce the stock per the building area; this, in turn, has resulted in lower nitrogen concentrations in natural fertilisers.
- A turning point for large-scale livestock breeding also came from enhancements to feeding methods. As the genetic sciences and market competition progressed, farmers faced the requirement to follow feeding standards with regard to increasing the productivity and lowering the costs of production, over 70% of which is comprised by feed expenditures. As farmers broadened their knowledge in this area, the protein and energy levels in feed rations could be balanced more accurately, which led to reduced losses of the nitrogen released to the environment.
- When discussing the breeding of dairy cattle, we should also address the problem of substantial differences between animal productivity levels, which is still clearly visible. Inasmuch as the breeding value of poultry and pigs is fairly balanced across the entire country, the domestic livestock of dairy cattle comprises several breeds that are largely

varied when it comes to their milking capacity. In consequence of high genetic potential, feeding should be adjusted to animals' physiological needs. Therefore, animals characterised by higher productivity consume more fodder and water, while also generating proportionately more excrements. This differentiation is depicted in the tables containing data on cattle.

- Production volume of manure calculated in accordance with the new coefficients of excretion do not differ from the previously calculated. In a very simplified method of calculating the production of manure, mostly for analytical purposes, used in previous years, they are not taken into account livestock keeping systems and production was counted with the use of indicators for the basic technological groups of livestock. The division into technological groups of livestock was significantly broader (less detailed) than in the elaboration made during the project. On account of visible process of technological progress in Polish agriculture should take notice of the lack current data concerning on livestock keeping systems. Recent data from this scope in 2010 concerning on the number of places in stanchion-tied and loose housing stalls and piggeries including solid and slatted floor. On the new information on livestock keeping systems for use in the calculation of the production of manure, we have to wait until 2020.

V.2.2. Lessons learned in terms of the methodological difficulties encountered when estimating the excretion coefficients.

Estimating the excretion coefficients of livestock poses under national conditions some difficulties.

- **The first** of these, which is also the basic premise for this study is **the lack of an official, national, dedicated system** to collect representative information about the applied technologies of feeding and animal husbandry, together with an assessment of their usability and storage of natural fertilizers. Databases on the basis of which the final report was created, use although a number of other systems, however, are supplemented only on specific orders, not giving continuity changes in animal husbandry, and only the current state. Sporadic estimation require at the same time a significant amount of work and time. Lack of an official system and the periodicity of obtaining information, are also the reason why some authors' teams attempt to adapt estimation methodologies from other countries. The main disadvantage of these studies is the complete lack of knowledge of farming conditions and the lack of representative output data. In other EU countries, function commissioned by the relevant ministries, permanent activities of monitoring of excretion coefficients, but also the related emissions (eg .Denmark - University Aarhaus, Germany - KTLB, France - Corpen, UK - Defra).

- **The second** difficulty with estimation is a significant national **divergence in the underlying technology, methods of nutrition and utilized races**. As you know, the

extreme values, strongly impinge on the size of the arithmetic mean and the weighted average relative to the population, will not give the state the average farm. Poland has one of the largest in the EU the number of farms, which steadily declined over the consecutive decades, but is still a reason for the diversity of applied technologies and obtained productivity of animals. This problem is particularly evident in the proposed separation of dairy cattle in three different categories of production, between which there are several dozen differences in milk yield. This solution is dictated by what the actual dissection and diversity. In this context, by least another decade, we can not directly equate excretion coefficients with the European average.

- Unresolved problems remain **excretion coefficients for chickens for fattening** in its present form common to the extensive and intensive farming. Certainly in intensive farming should be lower and the extensive higher, mainly due to the use of other races, standards of nutrition and technological solutions (eg. pre-drying manure).

V.2.3. The conclusions on comparability of the estimated excretion coefficients with other countries

Calculated national indicators of excretion vary slightly from those of the countries with a higher level of animal husbandry. The reason is the lower productivity of the national races and nutrition into just such lower demand. In small and medium-sized farms exist also different ways of feeding, than in highly industrialized farms, not only the EU-15, but also countries such as the Czech Republic, and Lithuania. For example, Poland still shows a very high share of grazing of dairy cattle (approx. 60% of the population), which in industrial plants do not take place, as affects the concentration and amount of produced natural fertilizers. Not without significance is also higher emissions of volatile nitrogen compounds with less equipped domestic breeding, deprived of official emission standards, especially concerns ammonia. This situation will be improved due to the ongoing processes of concentration domestic livestock production, as well as changes in legislation. Basically, in the context of the development of traditional products and high quality (eg. ecology) should be provided for the need to differentiate indicators of the intensity of farming. However, at this stage of development in relations and in international fora, should emphasize the causes of discrepancies occurring indicators, as knowledge of local characteristics even at professionals, is negligible.

It needs to be highlighted a necessity of regular revision and updating of the calculated within this project excretion coefficients, mainly due to changes in farm animal feeding and keeping systems. It is suggested to make such review every 10 years.

V.2.4. Conclusion on the perspectives of cooperation between the CSO, ministries, and research institutes, in terms of the monitoring of animal production and its environmental impacts.

- Setting up an efficient national centre for the purpose of estimating production indicators, including release coefficients, seems to constitute the major challenge to be faced by the entities managing the agri-environmental animal production reporting. It also comprises the issues of continuation and improvement of the methodology included in the report. As was mentioned before, only continual monitoring and frequent reporting can ensure the reliability of the indicators applied. Such an ongoing character of work will also let us determine the trends of the occurring changes.
- In the context of the establishment of the center, but also any other work related to the monitoring of animal production and its environmental impact, the emphasis should be put on close cooperation organizations such agencies as the Ministry of Agriculture and Rural Development, CSO and research and development institutes. To the extent that only the latter, unlike the universities, are able to constantly examine issues of quality (digestibility, emissions, concentration, etc.) while the issues of quantification (used breeds, types and length of processes, productivity, systems used, etc.) remain domain of CSO, The Agency for Restructuring and Modernisation of Agriculture (ARMA) or National Veterinary Research Institute. As already mentioned, the research units need constant work orders, with the well-known, widely accepted methodology (Nutrient Mass Flow Budget).
- Organizations collecting quantitative data require, however, not only unify, but expanding research methodologies, and from the point of view of the size of the actions, their task division. Much of the data collected by the statute of ARMA and National Veterinary Research Institute, because of its small imprecision can not be used by the CSO and The National Research Institute of Animal Production for estimating production indicators.
- The leading role in the search for cooperation opportunities and changes and harmonization of methodologies, must be attributed to the recent CSO. This is not an easy operation, because it faces to ossified structures and permanent lack of synergy and horizontal co-operation of these units. Therefore, it is advisable to further continue the made efforts and the projects, the more that the ultimate goal will be very attractive to many domestic and foreign customers.
- In the context of this objective it should be noted the necessity of closing balances, so the concentration of nutrients in fertilizers and nitrogen emissions of gaseous compounds from manure storage and greenhouse gases. The difference in average 30% of the nitrogen contained in natural fertilizers as compared to the original concentration in the faeces means that exactly the same of the element, is emitted in the form of NH3, NOx, or N2. On the other hand emissions of NOx estimated as greenhouse gases, should be equal to the difference between the total emission, and share of the NH3 and N2, which do not belong to GHG. Currently, no unit offers this balancing.

- In the end, it must be noted that the suggested resort and the associated system of estimation will be forced to gradually modify indicators and data resulting from further transformation of domestic agriculture, including livestock production. These actions will be needed so long until you become aligned to the level of intensity of domestic production. Even then, however, they remain issues of data processing for the purpose of demonstrating the reduction of negative impacts on the environment, public health and climate change.
- Currently, in the Ministry of Agriculture and Rural Development and Ministry of Environment is being discussed the implementation of possible the reduction solutions to in the production practice. Their introduction does not close the measures imposed by the EU directives. Necessary in fact, is also constant reporting of effects achieved to the European Commission. Operating in The National Centre for Emissions Management (KOBiZE) methodology, only allow the estimation of the overall risks and do not have algorithms enabling the demonstration of reduction effect. Based on the superiority of the quantitative features, they can not give qualitative changes of the generally accepted techniques (systems, feeding, breeding). It seems that the Central Statistical Office, equipped with all the necessary tools and developing a network of cooperation between all concerned units will remain an important link in the common reporting system of indicators in the field of environmental impacts of livestock production in Poland.