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IRSES Mid-Term Report

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Warszawa 2012

**SYSTEMS RESEARCH INSTITUTE
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IRSES MID-TERM REPORT

A summary of two year research within the EU 7th Framework Programme Marie Curie action IRSES "Geoinformation Technologies, Spatio-Temporal Approaches, and Full Carbon Account for Improving Accuracy of GHG Inventories"

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Warsaw 2012

ANNEX 1: MID-TERM REPORT

Marie Curie Actions – International Fellowships

Project n°: 247645

Project Acronym: GESAPU

Project Full Name: Geoinformation Technologies, Spatio-Temporal Approaches, and Full Carbon Account for Improving Accuracy of GHG Inventories

Marie Curie Actions

IRSES Mid-Term Report

Period covered: from 24 June 2010 to 23 June 2012

Period number: 1

Start date of project: 24 June 2012

Project coordinator name: Zbigniew Nahorski

Project coordinator organisation name: Systems Research Institute of the Polish Academy of Sciences

Date of preparation: _____

Date of submission (SESAM): _____

Duration: 4 years

Version: _____

1. GENERAL PROGRESS OF THE PROJECT

Please indicate if the project:

- a) has fully achieved its objectives and technical goals for the period;
- b) has achieved most of its objectives and technical goals for the period with relatively minor deviations;
- c) has failed to achieve critical objectives and/or is not at all on schedule.

If you answered b) or c) please include a detailed description of the modifications in the report

Qualitative indicators of progress and success in line with workplan and milestones
(description of progress towards the milestones and deliverables)

Work Package 1: Spatially resolved greenhouse gas inventory for Poland

Milestone no. 2: A spatial inventory of GHG emission for Poland

Task 1.1. *Study of specificity and availability of national spatially resolved statistical data in Poland. Checking through the parameters required to conduct inventory in the following key IPCC sectors: "Energy", "Industry", and "Agriculture". These are: fuel statistics, statistical data on industrial production, land use statistics, national net calorific values, emission factors etc. Finally, adjustment of these data to IPCC inventory methodologies.*

Task 1.2. *Collecting information and digital maps (available for Poland) for territorial resolution of activity data (if possible, similar to the ones used to conduct inventory in Ukraine).*

Task 1.3. *Modification of corresponding methods and algorithms developed for spatial distribution of activity data for Ukraine (taking into account Polish parameters: sectors specificity; available statistical data, and other information obtained from reference books, scientific investigations etc.; available digital maps with spatially resolved information etc.).*

Task 1.4. *Building appropriate datasets' templates for activity data information input. Filling up the datasets with information for a year under investigation.*

Task 1.5. *Application of the obtained methods to greenhouse gas inventory in Poland for each subcategory of the general sectors: "Energy", "Industry" and "Agriculture". The spatial resolution of 2 x 2 km, 5 x 5 km, and 10 x 10 km is planned. The results are to be presented in the form of digital maps and corresponding georeferenced databases.*

Deliverable 1.1. *Digital maps for Poland with spatial information on greenhouse gas emissions for the following IPCC sectors: "Energy", "Industry", and "Agriculture" (temporal resolution – 1 year) (attached).*

The data collected by LPNU and SRI researchers have been entered into a GIS database, according to the IPCC sectors mentioned, and with a reference to more detailed source categories. To prepare the databases, a series of technical works was required, including preprocessing of the data. The results are presented either for the year 2009 or 2010, depending on availability of input data. The point data are associated with their geographic coordinates, while for the linear and

areal data the basic space resolution is 2 km. The activities within the Deliverable 1.1 result in the emission data presented graphically in the form of maps.

Task 1.6. *Creating information technology to distribute greenhouse gases inventory based on geoinformation systems and IPCC methods.*

Deliverable 1.2. *Analysis of emissions' territorial distribution for individual subcategories and greenhouse gases (attached).*

This deliverable was scheduled to be ready after 28 months since the start of the project, but slight acceleration of the works turned out to be possible. The data on emissions entered into the GIS database were used to produce emission summaries of various profiles, like economic sectors and administrative units. They are presented in 31 figures and 12 tables.

A number of papers has been published in conference materials, as well as in Ukrainian and international journals.

Work Package 2: *Methodology, modeling network and information background of verified full carbon account of forest ecosystems: Adaptation for Ukraine.*

Milestone no 3: *An estimation of the productivity of Ukraine forest.*

Task 2.3. *Updating existing IIASA's and Ukrainian databases on biological productivity of forests and adjusting semi-empirical models of forest productivity for Ukrainian conditions.*

Deliverable 2.1. *The database containing forest live biomass measurements in situ and their description (attached).*

Ukrainian and IIASA's researchers have collected the most representative database on live biomass measurements in Ukraine and neighbour countries. The database contains results of measurements on 541 sample plots in Ukrainian forests that completely reflect all main types of forests, and 212 more sample plots in surrounding countries. This database is used (1) to model fractional structure of forest phytomass in Ukraine, based on data of forest inventory (State Forest Account), and (2) to develop the models and tables of dynamics of biological productivity of forests.

Deliverable 2.2. *Set of semi-empirical models for assessing dynamics of live forest biomass and Net Primary Production (attached).*

NULESU and IIASA have developed and partially modified a spatially distributed set of models for assessing dynamics of live forest biomass and Net Primary Production. The models cover the whole territory of Ukraine and all main types of forests.

Task 2.1. *Modifying and adapting methodology, schemes and models of the spatially and temporally explicit verified full carbon account of forest ecosystems (FCA).*

The project partners have been working on adaptation of methodology of FCA for Ukraine. IIASA's method of FCA, elaborated initially for Russia, was modified and adjusted for Ukrainian conditions. The methodology as well as modeling schemes have been improved due to the specifics of the information background of FCA for the country. The results obtained have been shown in the Deliverable 2.2. Future work on this task is connected with spatial distribution of FCA parameters and uncertainties' estimation.

Task 2.2. *Developing a hybrid forest map for Ukraine based on on-ground inventories and multi-sensor remote sensing concept*

Deliverable 2.3. *Hybrid forest cover for Ukraine with spatially distributed major indicators of the FCA. Deliverable date: 30.11.2012.*

Qualitative indicators of progress and success.

- Analysis of available spatial datasets covering Ukraine (remote sensing datasets, GIS datasets) has been done.
- As a basis for development of the Ukrainian forests digital map the next remote sensing products have been chosen:
 - Global Land Cover (GLC2000) with resolution 1km;
 - GlobCover 2009 with resolution 300m;
 - MODIS Land Cover with resolution 500m;
 - MODIS vegetation continuous field (VCF) with resolution 500m;
 - ENVISAT ASAR with resolution 150m.
- The remote sensing products GLC2000, GlobCover 2009, MODIS Land Cover were compared using fuzzy logic methodology and experts knowledge.
- The GIS-based forest enterprise map (polygons) for the years 2002 and 2010 has been created. It covers the entire territory of the Ukraine.
- Developing a forest/non-forest map for Ukraine based on global land cover products:
 - The results achieved show that three products exactly identified 50 % of the forest land of Ukraine.
- The developed forest/non-forest map has been compared with regional data on the State Forest Account, and auxiliary information by natural zones (forest zone, forest-steppe zone, steppe zone, Carpathians, Mountain Crimea).

Analysis of the validation points to determine the land cover type, where the remote sensing products (GLC2000, GlobCover 2009, MODIS) disagree, and the cross-check of forest land areas in the developed map has been conducted (this map was put online: regional.geo-wiki.org).

Work Package 3: Improving accuracy of inventories by means of spatio-temporal statistical methods

Task 3.1. *Collecting the GHG related activity data for 17 territorial regions in Poland.*

Task 3.2. *Collecting and adjusting data from a land use map and a map of line emission sources (e.g. roads) for the territory of Poland. Information contained in these maps needs to be summarized in a regular grid.*

Milestone no. 1: *Spatially detailed data on GHG related activities in Poland*

Deliverable 3.1. *A detailed map of GHG related activity data in Poland, ready for use in Work Package 1 (attached).*

Activities of WP 3 focused on collecting GHG activity data from territorial regions (voivodships) in Poland. SRI and LPNU partners have collected data on GHG emissions from the IPCC sectors: Energy, Industry, and Agriculture. Most of the data were acquired from the statistical yearbooks, from the Internet search, but some could only be obtained addressing various agencies, through personal communication or had to be bought. Final results are presented in maps, figures, and tables included in the Deliverable 3.1.

Task 3.3. *Designing a disaggregation model for the regional activity data, taking advantage of the gridded information on land use and line emission sources. Basically, the relevant statistical tool is based on a conditionally autoregressive structure, however, some further details are to be determined.*

Task 3.4. Carrying out numerical experiments and choosing appropriate algorithms for parameter estimation in the model.

The project partners have been working on the development of a statistical approach for spatial disaggregation of emission inventory data and a novel method has been elaborated. Estimates of values in a fine grid have been obtained by a model based prediction. The formulas for the predictions and their errors have been derived. The method has been validated on ammonia inventory in Poland (agriculture sector). The method and the results obtained have been presented in the paper submitted to the journal *Climatic Change*. Preliminary steps were also taken for application of the method to the developed GHG inventory in Poland. The plausible sectors include agriculture, and fossil fuel consumption in the residential sector. The results will be presented in the **Deliverable 3.2. Methodology for spatial scaling of GHG activity data.**
Delivery date: 31.05.2013.

2. PROJECT ACHIEVEMENTS

Scientific highlights and research achievements

Work Package 1: Spatially resolved greenhouse gas inventory for Poland:

- Methods and algorithms have been developed for spatial allocation of activity data in Poland. They take into account numerous features such as sectors specificity, available statistical data, other information obtained from reference books, scientific investigations, as well as available digital maps with spatially resolved information etc.;
- The databases with parameters required to conduct inventory in sectors: “Energy”, “Industry”, and “Agriculture” (fuel statistics, statistical data on industrial processes, land use statistics, national net calorific values, emission factors etc.) have been built and filled up with information for the years 2009-2010;
- Georeferenced databases of emissions in the IPCC sectors Energy, Industry, and Agriculture with resolution of 2 km has been prepared, and the corresponding digital maps have been built.

Work Package 2: Methodology, modeling network and information background of verified full carbon account of forest ecosystems: Adaptation for Ukraine:

- The most comprehensive database on live biomass measurements has been collected;
- Set of semi-empirical models for assessing dynamics of live forest biomass and Net Primary Production which cover the whole territory of Ukraine and by all main forest types was developed;
- The methodology to compare together several land cover products using fuzzy logic was improved;
- Comparison of GLC2000, GlobCover 2009, MODIS v.5 with focus on Ukraine (the accuracy of land cover maps spatially varied for regions and for different land cover types): fuzzy agreement of these products for the territory of Ukraine is about 65%;

Developed initial version of digital forest/non-forest map for Ukraine (resolution 300m) based on information derived from land cover products that has been made more accurate by using the validation points.

Work Package 3: Improving accuracy of inventories by means of spatio-temporal statistical methods:

- The database on GHG related activity data at the level of administrative units has been

collected;

- The georeferenced datasets of GHG related parameters based on a land use map and maps of line emission sources (e.g. roads, railways) for the territory of Poland have been adjusted;
- The disaggregation model for the regional GHG related activity data has been designed. It takes advantage of the gridded information on land use and line emission sources;
- Digital maps of GHG related activity data in Poland have been created and used in the Work Package1 for spatial analysis of emissions.

Teaching and Training activities (workshops...)

Seminars

- 9 June 2011: "Spatial inventory of GHGs for Poland: Energy sector. Input datasets" (M. Lesiv), Systems Research Institute of the Polish Academy of Sciences, Warsaw, Poland
- 10 June 2011: "Spatial inventory of GHGs for Poland: Industry, Agriculture, and Waste. Input datasets" (O. Yaremchyn), Systems Research Institute of the Polish Academy of Sciences, Warsaw, Poland
- 10-11 November 2011: the International Workshop on "Spatial inventories of GHG emission/absorption processes" has been organized at the Lviv Polytechnic National University (LPNU), in Lviv, Ukraine, with participation of scientists from the International Institute for Applied Systems Analysis (IIASA, Laxenburg, Austria), Lviv Polytechnic National University, National University of Life and Environmental Sciences (NULESU, Kiev, Ukraine), National University of Forestry and Wood Technology (Lviv, Ukraine), the State Natural Reserve "Roztochya" (Ukraine); and online participation of scientists from the Systems Research Institute of the Polish Academy of Sciences (SRI, Warsaw, Poland), and the AGH University of Science and Technology (Kraków, Poland).

Teaching

September-December 2011, at the Lviv Polytechnic National University a new lecture courses have been developed and introduced for master-students:

- „Mathematical modeling and spatial analysis of GHG emissions and sinks” (lecturer: Prof. R. Bun);
- „Mathematical and computer modeling of GHG emissions in energy sector: Case studies for Poland and Ukraine” (lecturer: PhD M. Lesiv).

Dissemination of results (conferences, publications...)

Publications

- Shvidenko A.Z., Buksha I.F., Dubin V.G., Lakida P. (2012) *Forests of the Ukraine in a changing world*. Chapter 6.5 in *Earth Systems Change over Eastern Europe*, edited by P.Ya.Groisman and V.I.Lyalko, Kuiv, Akademperiodyka, pp. 239-256
- Horabik J., Nahorski Z. (2010) *Improving resolution of spatial inventory with a statistical inference approach*, In: Proc. 3rd Int. Workshop on Uncertainty in Greenhouse Gas Inventories, LPNU [revised and extended version submitted for *Climatic Change*]
- Boychuk Kh., Bun R. (2010) *Regional spatial cadastres of GHG emissions in Energy sector: Accounting for uncertainty*, In: Proc. 3rd Int. Workshop on Uncertainty in Greenhouse Gas Inventories, LPNU [revised and extended version submitted for *Climatic Change*]
- Lesiv M., Bun A., Jonas M. (2010) *Analysis of change in total uncertainty in GHG emissions for the EU-15 countries*, In: Proc. 3rd Int. Workshop on Uncertainty in Greenhouse Gas Inventories, LPNU [revised and extended version submitted for *Climatic Change*]

Forthcoming publications

Lesiv M., Schepaschenko D., Shvidenko A., Bun R.: *Forest digital map of Ukraine based on global land cover data*, Journal of National University of Forestry and Wood Technology, Ukraine.

Shvidenko A., Lakyda P., Schepaschenko D., Vasylyshin R., Marchuk Yu.: *Carbon, climate and land-use in Ukraine: forest sector*. A monograph. Kyiv.

Lesiv M. *Comparison of global land cover digital maps for territory of Ukraine using fuzzy logic*, Journal of Geodesy, Cartography and Aerial Photography, LPNU.

The following publications have been prepared within the GESAPU project but miss the appropriate annotation:

Lesiv M., Bun R., Shpak N., Danylo O., Topylko P. (2012) *Spatial analysis of GHG emissions in Eastern Polish regions: energy production and residential sector*, Ekontechmod, Vol. 1, N. 2, pp. 17-23.

Bun R., Boychuk Kh., Bun A., Lesiv M. (2012) *Information technologies for spatial inventory of greenhouse gases in energy sector and uncertainty analysis*, Lviv: PP Soroka T, 464 p. (in Ukrainian)

Danylo O., Lesiv M. (2012) *Geoinformation technology for spatial GHG inventory in residential sector for Eastern Polish regions*, Recent Achievements in Geodetic Science and Industry, Lviv, №23, pp. 216-219. (in Ukrainian)

Lesiv M., Bun R. (2011) *Geoinformation technologies and spatial analysis of GHG emissions in Polish regions bordering Ukraine*, Artificial Intelligence (Iskusstvennyy intellekt, Donieck, Ukraine), No.4, pp. 342-349.

Lesiv M., Bun A., Hamal Kh., Jonas M. (2011): *Preparatory Signal Detection for the EU-27 Member States Under EU Burden Sharing Advanced Monitoring Including Uncertainty (1990–2007)*. Interim Report, IIASA IR-11-005, International Institute for Applied Systems Analysis, Laxenburg, Austria, 55 p.

Lubinski B., Bun R. (2011) *Specialized software for geographical analysis and inventory of greenhouse gases*, Modeling and Information Technologies, N. 59, pp. 129-135. (in Ukrainian)

Lesiv M., Bun R. (2010) *Geoinformation technologies and spatial analysis of carbon dioxide transport through border line*, Artificial Intelligence (Iskusstvennyy intellekt, Donieck, Ukraine), N. 4, pp. 322-329.

Lesiv M. (2010) *Analysis of change in uncertainty of results of GHG inventories in fossil fuel stationary combustion*, Modeling and Informational Technologies, N. 58, pp.180-186. (in Ukrainian)

Lesiv M., Bun R., Sorochych P. (2010) *Informational technologies for spatial analysis of nitrous oxide transport through border line*, Journal of Lviv State University of Life Protection, N. 4, pp. 30-35. (in Ukrainian)

Conferences

The 3rd International Workshop on *Uncertainty in Greenhouse Gas Inventories* took place in Lviv, Ukraine, on 22-24 September, 2010. This Workshop was jointly organized by the Lviv Polytechnic National University (LPNU), one of the partner organizations, and the beneficiaries of the project - the International Institute for Applied Systems Analysis (IIASA), and the Systems Research Institute of the Polish Academy of Sciences (SRI). It covered state-of-the-art research

and developments in accounting, verifying and trading GHG emissions and provided a multidisciplinary forum for international experts to address the methodological uncertainties underlying these activities. The topics of interest were centered around national GHG emission inventories, bottom-up versus top-down emission analyses, signal processing and detection, verification and compliance, and emission trading schemes. A collection of 33 papers presented at the Workshop has been published in the Proceedings, and extended versions of the papers have been submitted for *Climatic Change* Special Issue. More information is available at: <http://ghg.org.ua/workshop.html>

Following an invitation from the European Commission, the GESAPU project was presented at the Eastern Dimension of Mobility Conference, held in Warsaw on 6-7 July 2011. The conference was co-organized by the Polish Presidency of the Council of the EU and the European Commission. The objective of the event was to reinforce mobility flows of students, researchers, youth, sport and cultural actors between the European Union and the Eastern Partnership countries. The GESAPU project was presented by J. Horabik and J. Jarnicka. More information is available at: http://nubip.edu.ua/sites/default/files/u72/IRSES_prezentacja_Jarnicka_Horabik.pdf.

3. PROJECT MANAGEMENT

Overview of the activities carried out by the partnership, identification of problems encountered and corrective action taken.

The project is coordinated by the Management Committee (MC). The 1st, kick-off meeting took place on 21st September 2010 in Lviv. The meeting date was connected with the 3rd International Workshop on *Uncertainty in Greenhouse Gas Inventory* organized in Lviv. The meeting was open, thus, besides the MC members, many other participants of the project took part in it. In particular there were some researchers from LPNU, SRI, and IIASA, but also a few other participants of the Workshop. The coordinator presented the aims of the project, its structure, and obligations, and described results expected. A good discussion followed.

The 2nd meeting of the Management Committee was held on 10th November 2011 in Lviv, and it was attended by participants from LPNU, IIASA, and NULESU. Participants from SRI took part in the meeting via Skype. The meeting was scheduled in coordination with the International Workshop on "Spatial inventories of GHG emission/absorption processes". The seminar was organized this time in Lviv, and again, many non-MC-members could participate in the meeting. Participants presented advancement of research carried out within each Work Package. A discussion followed, and in conclusion, proper advancement of the works has been found.

The 3rd meeting was organized in June 2012, using e-mail facility. The aim of the meeting was to summarize the state of the project after 2 years of its execution. Joint research of the project is based on the staff exchange among the partner institutions. In general, the secondments roughly follow the schedule indicated in the Gantt chart of Annex I. Existing discrepancies from the schedule were thoroughly discussed by the Management Committee, and the resulting Position Statement was agreed upon by the MC members. It has been agreed that approximately half a year shift in payment with respect to the fixed start date considerably shortened the effective period for financing the secondments. It was also observed that the scientific results achieved in the Work Package 2 desire extension of its planned contents.

4. ADDITIONAL INFORMATION

Please indicate any additional information, which may be considered useful to

assess the work done during the reporting period. The socio-economic aspects of the project may be addressed in this section.

Following the successful series of Workshops on *Uncertainty in Greenhouse Gas Inventories*, initial steps were already taken to organize the 4th Workshop, next year probably.

Attachments:

**Person in charge of the project for
the beneficiary/consortium**

Name

Zbigniew Nahorski

Date

Signature

