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INNOVATIVE SOLUTIONS FROM EARTH OBSERVATION DATA FOR PRECISION FARMING

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Abstract

New Technologies developed for the agricultural sector in conjunction with the rapid evolution of ICT, Earth Observation Systems and Geographic Information Systems now offer enormous potential for the development and optimization of solutions for the distribution of accurate and georeferenced information to support precision farming.

The evolution of Earth Observation systems allows to acquire images with platforms increasingly lightest, from satellites with high spatial and spectral resolution sensors up to the UAV platform (down-sensing) and with costs ever more reduced, allowing to obtain images with high spatial resolution (up to a few cm/pixel).

The classification of remote sensed images has recently reached excellent levels of quality due to the rapid increase in spatial, spectral, and radiometric resolutions of sensors carried on aerial and satellite platforms and the parallel evolution of classifiers of the last generation.

In this work will be presented a case study near Venice using multispectral images and high resolution 3D data acquired by aerial platforms, and finally a specific solution with drones for the treatment plant protection in viticulture.

Key words

Remote Sensing, UAV, VHR images, 3D model, precision farming

Introduction

The initiative is part of the theme "Agrifood", where a strong technology push in recent years is derived from any segment of the "Precision Farming" which is a field of remote sensing carried out with different platforms (satellites, aircraft, drones) and is intended to monitor the quality and quantity of agricultural crops, with the aim to take action with targeted treatments on portions of crops in place to carry out the treatments in a large scale throughout the territory with consequences on environmental impact.

This is possible due to the rapid evolution of new technologies and systems for Earth Observation data acquisition, which offer tremendous opportunities for the field of precision farming with a view to improving the quality of the productions, the degree of environmental sustainability of agriculture and effectiveness in the use of natural resources. The evolution of Earth Observation systems allows to capture images and 3D models with increasingly lighter platforms (satellites at high spatial and spectral resolution, sensors aboard on aerial platforms up to the UAV platform (down-sensing) and cost more reduced allowing to obtain images with very high spatial resolution (up to a few cm/pixel).
The idea was born with the aim to create an innovative solution to perform phytosanitary treatment of crops, particularly in the wine sector (i.e., Prosecco hills in North-Italy) using the information derived from SkySat multispectral satellite data for monitoring of multi-temporal crop health and data with very high spatial resolution and 3D models obtained from aerial platforms and UAVs. In fact, until now in Italy, the treatments are performed with traditional helicopter and with strong environmental impact, and with spillage of chemical products even beyond the cultivated land (for instance gardens and private homes) and therefore not acceptable by the population and the general public.

Remote Sensing data utilization

The classification of multispectral data acquired by the satellites SkySat allows to build accurate vegetation indices (NDVI, SAVI, etc.), mapping of plant diseases in agriculture, and to monitor productivity and diseases in the oenological field. The main applications are made up of a full range of services geared to farmers and derived products generated by the Precision Farming (maps of vigor, plant diseases of crop water stress, fertilization, etc. targeted), and also to assess compliance "Greening" on the basis of the Common Agricultural Policy. The University IUAV of Venice (by its UniSky spin-off company) has recently acquired images from airborne platform with a resolution of 15 cm / pixel with which it was produced a point cloud 3D model with a density of 16 points per square meter using the recent technique of "Dense image matching". These data, in combination with multispectral images acquired from satellites SkySat, will be used to build an accurate flight plan for UAV drone that will perform targeted treatments along the viticultures (Figure 1). Also, the evolution of recent object-based classifiers allows to build accurate maps quickly integrating multispectral images and also 3D data in a meaningful way, to return to the farmers a series of maps easy to read for those who do not have high technological skills but who work every day in the countryside. It's necessary to acquire data SkySat at least every 15 days in correspondence with the phytosanitary treatments (usually in viticulture are carried out immediately after a rain).

![Figure 1: the remote sensing data acquisition workflow](image-url)
Aerial survey data utilization

Venice Province is the first examples, or probably the first one in Italy, of dense 3D point clouds generation with photogrammetric techniques over a large area for a public administration. Companies Terra Messflug GmbH and UniSky srl (a spin-off company of University IUAV of Venice), in fact, commissioned by the Province of Venice, performed in March 2014 aerial photogrammetric flights with Vexcel UltraCam Xp camera on the entire territory of the province of Venice (about 2,400 km2), collecting approximately 4,000 images with ground pixel size of 15cm. The goal was to extract 3D point clouds with advanced algorithms of dense image matching for different applications in urban and rural areas, to filter the digital terrain model and produce standard and true-orthophotos throughout the country, at a cost significantly lower than for LiDAR technologies.

In literature, the potential of aerial photogrammetry for 3D modeling is demonstrated in numerous publications (Haala and Rothermel, 2012, Irschara et al., 2012, Remondino et al., 2013). Image matching means for the identification of correspondences between primitives extracted in two or more images, and the estimate of the corresponding 3D coordinates with models of collinearity or projective. This process generates a density map in image space and a cloud of 3D points in object space. There are many algorithms for the automatic extraction of the primitive and the assignment of their correspondence (Gruen, 2012; Remondino et al., 2013). In aerial photogrammetry using algorithms based on a rea-based and feature-based matching to identify and recognize the primitives in a scattered manner, that is, for individual elements (eg points), and evaluate their correspondence with measures of correlation of intensity values pixels in a neighborhood, to which you can add geometric constraints and radiometric. Recent developments in the Image matching are directed to the improvement of algorithms based on dense reconstructions, no longer scattered, that are best suited to the modeling of irregular surfaces, just as the terrain and the objects on it. One of the main approaches is the one proposed by Hirschmüller (Hirschmüller, 2008), called semi-global matching (SGM), nowadays implemented in many commercial software for the extraction of digital surface models.

Figure 2: the dense 3D cloud point generated by Dense Image Matching
Specific multi-temporal use and Copernicus perspective of use

SkySat data are used for monitoring vegetation indexes during the growing season and for evaluating plant diseases thanks to the infrared band which is suitable for agricultural health monitoring. Pan-sharpening algorithms can generate sub-meter multispectral images with high radiometric resolution due to the ability of the sensors to 16 bit.

In the near future the Sentinel-2 satellite can be very useful for agricultural applications which will benefit greatly from the 13 spectral bands imagery. The short revisit time and geographical coverage will be especially useful for monitoring crops where growth and management practices mean that they are constantly changing.

UAV utilization

The prototype aims to employ a combination consisting of a drone aircraft RPAS (Remoted Piloted Air System) with an atomizer activated with electrical control (Figure 3), to be used with semi-automatic flight following a specific flight plan derived from 2D multispectral SkySat data and 3D model built from photogrammetry image data with “dense image matching” algorithms. The main advantages of this new method (currently not on the market), are greatly reduce the impact on the environment through the abatement of "drift effect" of the product currently used by helicopter or conventional atomizer on the ground, and greatly reduces the time spent with the current means on the ground (today, about 6 km/h).

In recent years, the RPAS have had a rapid development and thanks to the latest technology, have become safe, reliable and easy to use. With the ability to operate at low altitudes, even in situations where it would be impossible to do with other systems, are suitable for a multitude of operations, with a low environmental impact (they are all electric propulsion) and with a high level of operational ease.

The integration of an aircraft of this type with an atomizer (electric motor or combustion engine) equipped with integrated tank and sprayer arm is a practical, effective and innovative solution, especially for conditions that warrant a focused and precise action, soil conditions impracticable immediately after climatic events and in particular morphological conditions.
Figure 3: the aircraft RPAS with an atomizer to perform phytosanitary treatment

Conclusion

The project involves the construction of a new innovative service does not yet exist in the domestic market. It is an absolutely new market in Italy. Customers and users are the main producers of DOCG wines (quality brands of wine recognized by Italian law). At the international level is to report the presence of a similar solution produced by Yamaha but at very inaccessible costs to small and medium farmers that characterize almost the entire market segment in Italy. Given the strong connotation of the tourist areas of production of DOCG wines in Italy are expected benefits in terms of attracting new tourism flows on these territories will be able to offer new opportunities for enjoyment of the paths of consumption within the tradition food and wine.

The strong character of technological innovation and the environment in the project also generates a positive impact on priority "Innovation in the food chain" in that it allows the manufacturer to ensure a more secure and sustainable from the environmental point of view also generating positive effects of image against the the final consumer.
References


CHALLENGES RELATED WITH LINKING OF SPATIAL DATA ACROSS THE DOMAINS IN SLOVAKIA

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Geospatial data representing data with a direct or indirect reference to a specific location or geographical area represent significant part of information content nowadays. The level of demand from the re-user point of view confirms this kind of information belongs into a high-value datasets. Despite the potential spatial data bring by its nature, there is still a long way ahead in order to reduce mental fears and technological complexity this kind of data is often perceived and labeled. The effort to reduce barriers and create new evidences showing this potential is closely related to the deployment of spatial data within the various societal domains in close cooperation with relevant domain expertise as well as proper communication to wider audience of non-expert citizens. Although there was already done significant amount of work under various initiatives from global to local level, there is still limited amount of activities addressing possibilities to use spatial data across heterogenic domains, together with non-spatial data on minimal level of technological complexity. One of the possible approaches recently receiving attention is movement to the use of Semantic Web and Linked Data approach to address these expectations.

In Slovakia so far spatial data were mainly created and exchanged on the demand of public sector bodies addressing legal and societal requirements together with the private sector preferably fulfilling the needs of business use cases. To complete the picture, some spatial content also became available via Volunteered geographic information (VGI) activities. For last decade INSPIRE became significantly influencing awareness of the potential of exchange and re-use of spatial data. Despite its legally driven nature the fully functional spatial data infrastructure will still need some time before it will become fully operational. Together with the process of Open Government Partnership establishment demand for Open and Linked Data has become more visible, recently. Although, there are some initial examples showing the potential of opening data, there is still a lot to do to make them linked including the spatial data. Significant contribution in this field comes also from ongoing initiatives and related projects. This paper will provide information about the approach to address above mentioned challenges through linking spatial data from selected domains (environment, biodiversity, land cover, etc.) in Slovakia via SDI4Apps and SmartOpenData projects.

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10 http://geoknow.eu
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12 http://www.smartopendata.eu/
Community Co-design of a Geospatial Linked Open Data Platform for Environmental Management

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Abstract

SDI4Apps is an EU project that is building a cloud-based Geospatial Linked Open Data platform for data integration, to bridge from the top-down managed world of Geospatial Information to the bottom-up user-driven mobile world of Linked Open Data voluntary initiatives and micro SMEs developing applications using the information. To ensure its success, SDI4Apps requires the active participation of user communities in its co-design and validation through the implementation of 6 varied pilots involved in environmental management across Europe. Implementation of the SDI4Apps user communities’ participation and their social validation is described in this paper. The social validation includes criteria for measuring the platform’s success, methods for multi-stakeholder social participation, analysis for internal and external communities and also a set of indicators, which will be measured during the validation process based on structured pilot scenarios. It is envisaged that the robust stakeholders’ involvement, which is central to SDI4Apps, will not only generate sustainable economic returns through the interface between the users, SMEs, policy makers and scientific communities, but will guarantee a solid contribution to the knowledge-driven economy and environmental management across Europe.

Key words

Geospatial Information, Linked Open Data, Environmental Management, SDI4Apps, Social Validation, Community Co-design, European Project

Introduction

The potential of Geographic Information (GI) collected by various actors ranging from public administration to voluntary initiatives of citizens is not fully exploited. The advancements of Information and Communications Technologies (ICT) and the shift towards Linked Open Data (LOD) gives an excellent foundation for innovation based on the reuse of GI. The establishment of Spatial Data Infrastructures (SDI) has largely been driven by the “traditional” GI community and the national and European policies governing this sector. However now GI is no longer a separate information space but finds itself part of a larger European information space where the ultimate objective is the creation of value-added services based on use and reuse of public sector information as defined by the Public Sector Information (PSI) and Infrastructure for Spatial Information in the European Community (INSPIRE) Directives rather than exchange of “layers” between different GI software.

SDI4Apps (Uptake of open geographic information through innovative services based on linked data) [SDI4Apps Description of Work] is an EU Competitiveness and Innovation Programme (CIP) pilot action project that aims to bridge from the top-down managed world of INSPIRE, Copernicus and Global Earth Observation System of Systems (GEOSS) Geospatial Information (GI) to the bottom-up mobile world of LOD voluntary initiatives and
micro SMEs developing applications based on GI and LOD. SDI4Apps is adapting and integrating experience from previous projects and initiatives to build a cloud based LOD framework with an open Applications Programme Interface (API) for data integration, easy access and provision for further reuse.

Figure 1 SDI4Apps Platform [SDI4Apps Description of Work]

The SDI4Apps project will integrate a cloud-based platform for data reuse. On that platform, several user-driven applications (pilot apps) will be designed and implemented.

Figure 2 SDI4Apps Pilot Applications [SDI4Apps Description of Work]

To ensure its success, SDI4Apps requires the active participation of user communities in its co-design and validation through the implementation of 6 varied pilots involved in environmental management across Europe. These pilots include:

1. **Easy Data Access** - will support easy access to existing services and will integrate an API solution, which will support easy collection of information using smart phones and integrate this information into current SDIs.
2. **Open Smart Tourist Data** - will support related business issues such as easy integration of the SDI4Apps system into proprietary solutions (thanks to the implementation of standards), reusing and sharing existing information resources, channels and tools. Open Smart Tourist Data will integrate users’ data, free and open global data, SDI4Apps Team’s data, crowdsourced data and social media.

3. **Open Sensors Network** - will create an environment where different groups of volunteers (for example farmers) will be able to integrate low cost sensors (meteorological, quality of air, etc.) into local and regional web sensor networks.


5. **Open INSPIRE4Youth** - to generate local educational multilingual environmental and cultural heritage applications for students and youth.

6. **Ecosystem Services Evaluation** - will be focused on the sustainable support of tourism.

The SDI4Apps cloud infrastructure, which will be hosted in the national Centre CERIT-SC (CERIT Scientific Cloud) of the Masaryk University, will have the following architecture:

![SDI4Apps System Architecture and Operational Layers](image-url)

**Figure 3 SDI4Apps System Architecture and Operational Layers**

[SDI4Apps Description of Work]
The SDI4Apps platform and tools will be community co-designed and socially validated through the 6 deployed community pilot demonstrators that will be technically evaluated for:

1. the effectiveness of the approach for the Cloud, LOD and semantic services;
2. how well the proposed architecture can be adapted to different scenarios;
3. the limitations and benefits of the approach compared to existing technologies.

Community-based businesses foster trust, commitment, high-quality of products and services, accountability, social-environmental responsibility, business ethics, and “contagious commitment”. Thus in each of the 6 SDI4Apps pilots, the project will nurture the Service Provider and User concept and make them both integral to the community co-design and social validation participatory process so that it will become accepted as a necessary interchange and form part of an emerging business environment. It is envisaged that the robust stakeholder involvement central to SDI4Apps will not only generate sustainable economic returns through the interface between the business and the scientific community, but will guarantee a solid contribution to a knowledge-driven economy and environmental management in Europe. Then long-term sustainable implementation of the SDi4Apps platform will depend on three main pillars:

1. A large user community with strong commitment (based on involvement, trust and the benefits they receive from using the services).
2. A reliable supply of global SDI data content, guaranteed large scale of services.
3. A thriving private sector of small enterprises (individuals, SMEs and NGOs) that provide value-added services of mutual benefit to all involved.

Stakeholders and User Groups

SDI4Apps will build user communities that actively participate in the processes of design, integration, validation and uptake of the proposed SDI4Apps cloud platform. The specific operational objectives include:

- community building and management with a focus on pilot regions and potential external users and developers:
  - launch and maintain the SDI4Apps platform for the consolidation of its user communities and their structured participation in key project activities;
  - engage stakeholders involved in SDI4Apps pilot services on the one hand, and participants in the extensive thematic, global and trans-European networks represented by project partners on the other hand, for active participation in the SDI4Apps communities;
  - working with the SDI4Apps communities to develop user scenarios exploiting the availability of harmonised and interoperable data sets and services to access INSPIRE-related data by a large and extended community;
- define a validation methodology for internal and external validation of the platform
  - on the basis of the project results and especially the outcomes of the validation pilot services, assess the potential impact of scaled-up adoption of SDI4Apps metadata profiles, data models and SDI services on environment-related activities that they carry out in their daily work;
- support the social validation of the system by internal user groups and external communities, and provide feedback for the technical teams.
This building of a community around the SDI4Apps Cloud, will be based on a core community represented by the project partners. This community will be extended by other related communities and through organising sprint code workshops and developers’ contests, as follows:

![Learning Community Space](image)

**Figure 4 Learning Community Space [SDI4Apps Description of Work]**

While the stakeholder mapping emphasizes the institutional/market relationships between the stakeholders driving their transactions, it is also necessary to model the technical level at which the pilot is operating and the different layers of services involved.

The stakeholder and layered service models adopted in SDI4Apps have been developed from the ICT-ENSURE project [ICT-ENSURE project], which explored the broad dynamics of the contribution of ICT towards environmental sustainability, considering GI and LOD as important components.

![SDI4Apps stakeholder mapping](image)

**Figure 5 SDI4Apps stakeholder mapping [SDI4Apps Description of Work]**

The first SDI4Apps stakeholder mapping, based on ICT-ENSURE’s analysis of the environmental management problem space, is based on institutional, operational, and economic standpoints related to the environment, and the key roles are identified as follows:

- **Governments and policy-makers:** mainly as funders of environmental research, the initiators of top-down actions such as SISE and SEIS, and generally institutionally mandated for the implementation of INSPIRE and open data standards. In SDI4Apps, different levels of government are represented in all of the pilot communities.
- **Environmental experts**: experts in the field of the environment (generally universities or government bodies) applying GI and LOD to improve their capacity to monitor and predict; these actors generally assume an observational stance with respect to the environment, and are also present in several but not all of the SDI4Apps pilots.

- **ICT and sector industries**: this includes in the broadest sense industrial activities with an effect on the environment, i.e. tourist organisations, agro-food multinationals, the construction industry, etc.; these stakeholders are present in several but not all of the SDI4Apps pilots. This category also includes the ICT industry and its potential interest (low so far, and of particular interest to SDI4Apps) in adopting and building its services on top of the SDI4Apps platform. A good number of SDI4Apps partners therefore fall into this category.

- **Multi-disciplinary research**: this groups socio-economic and ICT researchers into a multi-disciplinary perspective on the SDI4Apps problem space as a question of sustainable development including both the environment and human communities within it; this group drives some of the SDI4Apps pilots, particularly those with a stronger Living Lab approach.

- **Stakeholder communities**: these are the associations, local NGOs, etc. who represent those directly affected by environmental change; they are involved primarily in information management, dissemination and awareness activities; these actors can be said to be “inside” the environment rather than observing it and are often the “champions” within SDI4Apps pilot communities.

While the following table illustrates the layered mapping of stakeholders for ICT services such as those that will be enabled by the SDI4apps Platform:

<table>
<thead>
<tr>
<th>SOCIALISATION</th>
<th>Stances are formed, groups interact, decisions taken that influence others.</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTERACTION</td>
<td>Actors &amp; actions interact in causal linkages influencing process outcomes.</td>
</tr>
<tr>
<td>KNOWLEDGE</td>
<td>Information is contextualised into dynamic processes &amp; conditions of relevance</td>
</tr>
<tr>
<td>INFORMATION</td>
<td>Metadata &amp; harmonisation applying semantic models is applied &amp; information processed</td>
</tr>
<tr>
<td>DATA</td>
<td>Raw data is collected, stored &amp; made available for access.</td>
</tr>
</tbody>
</table>

**Figure 6 Layered model of ICT relevance**

This dimension of stakeholder mapping refers to the technical level of ICT relevance, which in the ICT-ENSURE project [ICT-ENSURE project], was developed as a layered model from the data level up to the social sphere where environmental information is used, as follows:

<table>
<thead>
<tr>
<th>SOCIALISATION</th>
<th>Network Analysis, eParticipation, Social Networks</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTERACTION</td>
<td>Cooperative Systems Simulation, Modelling Environments</td>
</tr>
<tr>
<td>Discourse Analysis Learning Environments</td>
<td></td>
</tr>
<tr>
<td>Personalised Information Artificial Intelligence</td>
<td></td>
</tr>
</tbody>
</table>
This model can be directly related to the different levels of social validation with respect to data modelling at one extreme and end-user services at the other. It is useful to see how each layer associates with the relevant ICT infrastructures, services, and research fields that can make a contribution to environmental management. Many of the technologies listed here are in fact adopted and/or explored by SDI4Apps pilots.

With specific relevance to the SDI4Apps project, the same layers can finally be developed as supporting different levels of the SDI4Apps platform-based community co-designed services, from the data access level to community and social networking services:

**Socialisation**
- SDI4Apps enabled Community Services

**Interaction**
- SDI4Apps enabled individual Apps.

**Knowledge**
- Publishing & Visualisation Tools

**Information**
- SDI4Apps enabled SDI/LOD Architecture

**Data**
- SDI4Apps enabled Open Data Models

Mapping of stakeholders and their interactions provides the basis for the analysis of the potential for market development of the different scenarios as thrown up by the pilots. Different pilots have their own dynamics in terms of the following elements:
- Their positioning with respect to the three impact scenarios of user engagement, user interaction and community co-design.
- The set of stakeholders involved in developing the pilot requirements and scenarios
- The role of the project partner responsible for the pilot within that stakeholder community

**Social Validation**
The SDI4Apps team combines partners covering the entire chain from data providers, technological developers and geospatial data experts to final end users. The consortium includes partners involved in Living Labs which will be part of the overall methodology for the platform integration and social validation. The Living Labs approach, as an essential building block of SDI4Apps, is aimed to structure wide-spread end-user participation in new technologies’ integration and adoption, and in research and new innovation activities.

The SDI4Apps methodology is not using the following standard sequence of actions of pilot projects:

User requirements ➔ Design ➔ Development ➔ Deployment ➔ Testing

Instead SDI4Apps is following a different approach, as:

1. The majority of EU projects are collecting new requirements which in most cases overlap,
2. There already exists many implementations of state of the art technologies, and user requirements collection is not leading to any progress,
3. Users are interested in getting results as soon as possible, and standard project methodologies do not deliver satisfying results in time.

For these reasons SDI4Apps is using the following very different user-driven approach:

(1) Deployment of SDI4Apps Cloud platform (state of art technologies, Open Tools) ➔ (2) User experimentation and social validation in real-world scenarios ➔ (3) Feedback from the SDI4Apps community ➔ (4) Redesign ➔ (5) Improvement of the SDI4Apps Cloud Framework ➔ (6) User experimentation and social validation in real-world contexts ➔ (2)

SDi4Apps is bringing together the demand-driven power of the market-oriented solutions and the institutional legitimacy of INSPIRE/OD/LOD, which places the public interest before commercial needs. The approach is based on social validation, a process which engages “those who will adopt” within institutionally framed pilot experiments in the 6 diverse pilots. The social validation will be provided by defining Use Cases in the User Scenarios of each pilot, according to a defined methodology and common structured description, based on:
Thus central to validation of the SDI4Apps pilots are user and community actions that aim to both build individual and collective assets by better understanding and potentially improving the effectiveness and transparency of the interaction amongst different organizational and institutional contexts which govern the use of these assets.

In particular, SDI4Apps is extending to the cloud, an environment with an open API based on Open Source components. This platform, which is an extension of the current INSPIRE architecture, incorporates the basic principles of neogeography [Neogeography] and Volunteered Geographic Information (VGI). These community-based techniques are being used as the main building blocks of the SDI4Apps social validation. It allows users and data providers to test existing technologies, customise solutions for their purposes and thereby generate further research tasks through user-driven processes.

The methodology for multi-stakeholder analysis adopted for implementation in the SDI4Apps social validation builds on the tradition of community-based participatory research [Francisco & Butterfoss, 2007], asking a number of evaluative questions to assess how involved end-users and more generally the overall population are affected by a given intervention, project or programme. A key methodological reference point is the Living Labs/SSRI (Social Spaces for Research and Innovation) [SSRI] approach to deal with the social, organisational and institutional dimensions of innovation in parallel with the technical aspects, and to engage in validation activities with all user groups, stakeholders, and content providers in an open and inclusive way, supported by the SDI4Apps platform and tools.

In the early evaluative rounds that will be carried out within the SDI4Apps project, social validation is related to the benefits associated with the deeper involvement of actual end-users in data access and service co-creation, according to the Living Labs user-centred open-innovation approach. In a conceptual definition of the social validation “space”, the focus of application for behavioural analysis is threefold, namely:

1. **The social significance of stated goals.**
   - Do the specific development objectives correspond to what users really want?
   - Are they fulfilling a need that is shared by the prospective end users?
   - Does the broader community in which the SDI4Apps infrastructure is located value the new services as important to them?

2. **The social appropriateness of followed procedures.**
   - Do the ends justify the means?
   - Do users feel that they have a voice in SDI4Apps infrastructure improvement?
   - How do they feel they are included in the development, implementation and assessment process?
   - Do users and/or local stakeholders consider the procedures for their involvement acceptable?
   - Do they recommend them in other situations?

3. **The social importance of obtained effects.**
   - Are end users satisfied with all of the results, including any unpredicted ones?
- Do domain experts value the effects and believe that they were indeed caused (or facilitated) by services developed using the SDI4Apps platform?
- Does the broader community appreciate the outcomes?
- Does it value them as something that should be extended to other domains?

Basically we look at what happened, and ask “Did it matter?”.

The objective of the SDI4Apps Social Validation is first of all to identify criteria and indicators of success according to the different standpoints of the actors represented in each usage scenario, as a framework for evaluating the added value of the services that conform to the standards proposed by SDI4Apps. This activity does not start from scratch, but takes into account the taxonomy of social validation approaches elaborated in the HABITATS project [Navarro & Saez, 2013], i.e.

- Validation driven by the prospect of user engagement
  In this case end-users are not yet directly involved in social validation, but the prospect of user engagement is already influencing institutional behaviour.
- Validation through direct user interaction with the open data access process
  With the direct participation of (expert/non expert) users in data access.
- Validation driven by the co-design of innovative “demand pull” services
  This is the most user-driven approach, as it actually involves final end-users in the co-design of services that use the SDI4Apps platform.

The indicator sets that are being defined will be matched with a composite list of evaluative questions to be used for the pragmatic assessment of impact generated by the Apps and services enabled by the SDI4Apps platform on each of the six pilot scenarios – and more broadly, on the environmental related activities in which users are involved.

The following table shows a broad initial estimate of the mapping of the 6 SDI4Apps Pilots from the structured descriptions of the User Scenarios:

<table>
<thead>
<tr>
<th>Pilot &amp; Validation approaches.</th>
<th>Validation driven by the prospect of user engagement</th>
<th>Validation through direct user interaction with the open data access process</th>
<th>Validation driven by the co-design of innovative “demand pull” services</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1. Easy Data Access</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>P2. Open Smart Tourist Data</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>P3. Open Sensor Network</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>P4. Open Land Use Map through VGI.</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>P5. Open INSPIRE4Youth/education</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>P6. Ecosystem Services Evaluation.</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

Table 1 SDI4Apps Pilots & Validation Approaches
[SDI4Apps Social Validation Methodology]

Success Criteria

The social validation includes criteria for measuring the SDI4Apps platform’s success, methods for multi-stakeholder social participation, analysis for internal and external communities and also a set of indicators, which will be measured during the validation process based on structured pilot scenarios.
These structured descriptions evolve as the project and social validation develops with the communities involved. From these structured descriptions of the 6 pilots (identified as P1 to P6 in Tables 1 and 2), the validation approach and initial mapping of each pilot’s metrics and criteria of success are identified, and the following initial mapping of each pilot’s own success criteria for the communities involved have been identified:

<table>
<thead>
<tr>
<th>Pilot &amp; Validation approaches</th>
<th>Each Pilot Community’s Criteria of Success</th>
<th>P1</th>
<th>P2</th>
<th>P3</th>
<th>P4</th>
<th>P5</th>
<th>P6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Validation driven by the prospect of user engagement</td>
<td>Usage level &amp; Social Validation of Services that use SDI4Apps</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Easy collection of information using smart phones &amp; LOD</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>More Young People using GI services</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sustainable support of tourism with ESS methodology &amp; datasets.</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Local youth educational environmental &amp; cultural heritage apps.</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Validation through direct user interaction with open data access processes</td>
<td>Integration of VGI into existing SDIs &amp; LOD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Integrate VGI with low cost sensors in local web sensor networks</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Increased access to harmonised &amp; interoperable GI, L/OD&amp; VGI data</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Integrate data from users’, OD, crowd-sourced &amp; social media.</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>VGI Open Land Use Mapping</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Availability of Valuation map of ecosystems with UI &amp; API</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Validation driven by co-design of innovative “demand pull” services</td>
<td>Reuse &amp; share tourist information resources, channels &amp; tools</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SMES, Students &amp; Researchers developing new Apps</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>New tourism activities, visitors &amp; jobs, and SME developed services.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

Table 2 Validation approach & Initial mapping of each Pilot’s Success Criteria
[SDI4Apps Social Validation Methodology]

Success Criteria for the SDI4Apps platform in each of the 6 User Scenarios has a number of issues:

1. In some cases it may be difficult to evaluate each scenario. There may be licensing issues of software components specific to certain scenarios.
2. There may be limited access to certain data - either not permitted or restricted – and the source data may need to be modified
3. One option is to use training materials that will be prepared to assess the usability and functionality scenarios.
4. For the initial external evaluation scenarios it will be necessary to prepare a set of criteria / questions that can be targeted at specific problems and scenarios.
5. Are the scenarios understandable for developers?

In addition, the initial set of required SDI4Apps platform’s Enabler functions that the pilots will require are grouped by its planned Basic and Extended Functionalities, as follows:
<table>
<thead>
<tr>
<th>SDI4Apps Functionality</th>
<th>SDI4Apps Enablers</th>
<th>P1 - Easy Data Access</th>
<th>P2 - Open Smart Tourism Data</th>
<th>P3 - Open Sensor Network</th>
<th>P4 - Open Land Use Map through VGI</th>
<th>P5 - Open INSPIRE4Youth Map</th>
<th>P6 - Ecosystem Services Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced visualisations</td>
<td>1. Advanced Visualisation framework &amp; API (of GI &amp; non-GI components)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Data harmonisation</td>
<td>2. Scalable GI to LOD transformation and harmonisation service, from many heterogeneous database sources, including HALE [HALE] support.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>3. Validation and integration tools</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>4. Scalable publishing of harmonised data sets.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Integration of mobile apps</td>
<td>5. Scalable crowdsourced/VGI real-time data collection with Open API.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Interoperability between local and global geospatial models.</td>
<td>6. Scalable Geo-focused Crawler for automatic collection of OGC services endpoints representing spatial content available via the deep web.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>7. Scalable intelligent deep-Web GI/LD Search &amp; discovery with Open API</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>8. Scalable Smart Sensor Networks and SensorML support, to extend the PPP FI ENVIROFY Specific Enablers [ENVIROFI]</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>9. Interoperable scalable access to sensors</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>10. Analytical and modelling toolset</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Linked Open Data</td>
<td>11. Scalable INSPIRE GI schema to LOD transformation and harmonisation service, with persistent URIs.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>12. Scalable RDF Triple Storage service for LD (such as Virtuoso)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>13. Semantic indexing infrastructure to transform GI to LOD</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Scalable execution of spatial models</td>
<td>14. Scalable fast PostGIS and concurrent PostgreSQL support, providing clustered real-time updates on all master databases.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>15. Scalable GeoServer implementation</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

Table 3 SDI4Apps Functionality Enablers required by the Pilots [SDI4Apps Social Validation Methodology]

These user required 9 functionalities and 15 Enablers provide input to and are now being implemented in the SDI4App platform [SDI4Apps Architecture].

Implementation of the Social Validation

Implementation of the SDI4Apps Social Validation methodology will be light and effective. It has been developed from the work and experience of other projects such as HABITATS, Plan4All, Plan4Bussiness and SmartOpenData. The methodology basically consists of iteratively presenting the best practice SDI4Apps platform to the various stakeholder communities and asking them what they want of it and how well it meets their needs, and then improving it. The methodology involves the SDI4Apps partners, users’ and developers’

28
communities, meetings, observations, surveys and other evaluation techniques to track progress against agreed indicators, as discussed above. The process consists of:

1. Identifying the stakeholder communities of:
   1. Users – represented by the 6 Pilots and operation of their user scenarios
   2. Developers –
      1. represented initially by the consortium’s internal partners, and
      2. later by the external developer communities that will be addressed through the activities to support External Developers

2. Asking the communities what they want in the context of what the SDI4Apps platform and tools can deliver, by:
   1. Providing the SDI4Apps infrastructure based on “best practice” architecture and tools from previous work
   2. Developing a coherent Social Validation Methodology, Plan and Indicators [SDI4Apps Social Validation Methodology].

3. Checking if the communities are satisfied, by:
   1. Internal validation of the pilots and their users.
   2. External validation of user and developer communities using the SDI4Apps Platform to enable services beyond the pilots.

The SDI4Apps Social Validation Methodology involves communities of stakeholders that the partners define who and where they are:

1. End Users – particularly in the pilots
2. Developers
   1. Internal – to provide the initial SDI4Apps Architecture and basic cloud functionality
   2. External – to take-up the open source SDI4Apps APIs and modules for new services.
3. Pilots – leveraging previous and existing work to define Scenarios in terms of
   1. Use Cases
   2. Datasets
   3. Applications and Services.

Evaluation of the SDI4Apps tools is based on community co-defined Use Cases in the User Scenarios of each pilot, in a structured format that describes the stories and context behind why a specific user or user group comes to a service or app. They note the goals and questions to be achieved and sometimes define the possibilities of how the user(s) can achieve them on the site. Scenarios are critical both for designing an interface and for usability testing.

The scenarios are carried out even before they are implemented. This is based on tabulated documentation of advance knowledge of the criteria and target evaluation scenarios, and as understood by developers. This will result in better implementation of the SDi4Apps platform’s tools.

Good scenarios are concise but answer the following key questions [Scenarios]:

- **Who is the user?** Using the personas that have been developed to reflect the real, major user groups coming to the service.
- **Why does the user come to the service?** Noting what motivates the user to come to the service and their expectations upon arrival, if any.
- **What goals does he/she have?** Through task analysis, we can better understand what the user wants of the service and therefore what it must have for them to leave satisfied.
- **How can the user achieve their goals using the service?** Defining how the user can achieve his/her goal on the service, identifying the various possibilities and any potential barriers.

Each evaluation criterion is not being evaluated by all evaluators but is being targeted at specific groups of evaluators. The potential user groups that are being addressed include:

- **SDI4Apps Integrators**: people who have to use heterogeneous GI to meet the requirements of their daily work (e.g., integration of LOD for complex analysis). They need the actual data and access this from different facilities potentially in different formats. They have to combine various data sources and harmonise them to make use of them for their own purposes. This group should understand the SDI4Apps platform as an efficient toolset to support the required data processing. They are mainly service providers.
- **SDI4Apps Users**: consist of a large group of people who want to solve a problem and decides to use LOD for their applications/purposes – they are not interested in the harmonization of data resources itself but only in its results. Two subgroups can be distinguished within this user role:
  - **SDI4Apps Development of LOD**: users who are directly working with or create LOD. They transform heterogeneous GI sources and create either LOD in an already harmonised form, or LOD that doesn’t need harmonisation or integration at all. They make further application modules using LOD for end users.
  - **SDI4Apps End-Users of Applications**: people who do not use LOD directly, they only use information arising from it (indirect use of LOD) or directly use applications. Most commonly they are users at a layman level, e.g., people using navigation systems, online routing services, etc.

Implementation of Social Validation in SDI4Apps involves the 3 dimensions of Social, Technical and Validation activities as illustrated in the following table over the 3 yearly periods of the project:

<table>
<thead>
<tr>
<th>SDI4Apps Dimension</th>
<th>Activity</th>
<th>Y1</th>
<th>Y2</th>
<th>Y3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social</td>
<td>Social Validation Methodology</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Community Building &amp; Support</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Technical</td>
<td>Basic Cloud Functionality</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Extended Functions &amp; Data transformation</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Validation</td>
<td>Internal Validation &amp; Pilots</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>External Validation &amp; OSS Communities</td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

**Table 4 SDI4Apps Social, Technical & Validation Activities**
[SDI4Apps Social Validation Methodology]

In year 1 the project is undertaking the following twin track parallel work:
1. Technical: Provide the SDI4Apps Architecture and Basic Functionality
2. Social: Build the Communities for Social Validation
Then in years 2 and 3 the project will focus on validation in the parallel tracks of:

1. Social: Undertake the Internal Community Validation and Pilots.
2. Social: Build external Communities & validation.
3. Technical: Add extended functionality.

These SDI4Apps activities aim to achieve the following major Social Validation Indicators (SVI) of the project:

<table>
<thead>
<tr>
<th>SDI4Apps Dimension</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical</td>
<td>Architecture &amp; Basic Functionality</td>
<td>Extended Functions.</td>
<td>Wider SDI4Apps Services.</td>
</tr>
<tr>
<td>Social</td>
<td>Build Communities</td>
<td>Internal Pilots, Internal Developers</td>
<td>Wider Communities, External Developers</td>
</tr>
<tr>
<td>Validation</td>
<td>Define methodologies.</td>
<td>Apps &amp; APIs</td>
<td>New service possibilities.</td>
</tr>
</tbody>
</table>

*Table 5 Major Aims of the SDI4Apps project [SDI4Apps Description of Work]*

To monitor progress of this plan the SDI4Apps the SVIs indicate how well the SDI4Apps Platform is meeting the needs of its stakeholder communities. The SVIs’ focus is very much on WHAT, not HOW the various users’ needs are being addressed, particularly in the pilots.

**Conclusions**

Any SDI/LOD platform should be seen as an evolving concept that sustains (or mediates) various perspectives or stakeholders’ views. Depending on the user’s interest and role within the broader community, its design and implementation (as well as the corresponding assessment process) gets reshaped by a continuous negotiation and re-negotiation with all involved actors. In addition, ‘space’ – or the ultimate object of any SDI/LOD Platform – is socially produced as well, which makes the validating role of socio-technical platforms such as that of the SDI4Apps social validation even more important.

It is envisaged that the robust stakeholder involvement central to SDI4Apps will not only generate sustainable economic returns through the interface between the users, SMEs and scientific communities, but will guarantee a solid contribution to the knowledge-driven economy and environmental management across Europe.

**References**


This catalogue also presents the ENVIROFI pilot scenarios - concrete examples of adopting a combination of ENVIROFI Specific Enablers and FI-Ware Generic Enablers for the agri/environmental domain specific tasks.


SDI4Apps Architecture, described in SDI4Apps deliverable D3.1 Architecture Concept, July 2014.


Views expressed in this document are those of the individuals, partners or the consortium and do not represent the opinion of the Community.

SDI4Apps Social Validation Methodology, described in SDi4Apps deliverable D2.2, Social Validation Methodology, September 2014.

Towards Farm-Oriented Open Data in Europe: the scope and pilots of the European project “FOODIE”

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Abstract

The different groups of stakeholders involved in the agricultural activities have to manage many different and heterogeneous sources of information that need to be combined in order to make economically and environmentally sound decisions, which include (among others) the definition of policies (subsidies, standardisation and regulation, national strategies for rural development, climate change), development of sustainable agriculture, crop recollection timing and pricing, plagues detection, etc. The European project called “Farm-Oriented Open Data in Europe” with abbreviation "FOODIE", funded between years 2014 and 2017 addresses the above mentioned issues. This paper describes the scope of the project with emphasis on its pilots. The Czech pilot is then analysed in detail including its three scenarios: Improving efficiency of transport in agriculture, Telematics of farm machinery and Monitoring of in-field variability for site specific crop management.

Key words
open data; agriculture; farming on cloud; telematics; strategic planning

1. Introduction

The agriculture sector is a unique sector due to its strategic importance around the world. It is crucial for both citizens (consumers) and economy (regional and global) which, ideally, should make the whole sector a network of interacting organizations. Rural areas are of particular importance with respect to the agri-food sector and should be specifically addressed within this scope. The different groups of stakeholders involved in the agricultural activities have to manage many different and heterogeneous sources of information that need to be combined in order to make economically and environmentally sound decisions, which include (among others) the definition of policies (subsidies, standardisation and regulation, national strategies for rural development, climate change), development of sustainable agriculture, crop recollection timing and pricing, plagues detection, etc.

In this context, future agriculture knowledge management systems have to support not only direct profitability of agriculture or environment protection, but also activities of individuals...
and groups allowing effective collaboration among groups in agri-food industry, consumers, public administrations and wider stakeholders communities, especially in rural domain.

The European project called “Farm-Oriented Open Data in Europe”, funded between years 2014 and 2017 addresses the above mentioned issues. The scope of this project, also known under the abbreviation FOODIE, is described in the following section. Afterwards, the pilots of the project are discussed separately depending on the country where the pilot is conducted. The Czech pilot is then analysed in detail including its three scenarios: Improving efficiency of transport in agriculture, Telematics of farm machinery and Monitoring of in-field variability for site specific crop management. At the end, benefits, opportunities and future development are mentioned.

2. State-of-the-art

An in-depth review of the different aspects is needed in order to design and implement the aforementioned service platform proposed by the FOODIE project. Such review must be considered to be in line with current initiatives and policies relevant in the environmental and agricultural domains as well as commonly and widely used standards, technologies, service oriented architectures and systems developed in other projects, together with the numerous data sources repositories available at local, national and European level that will enable the provision of new and added value agricultural services for the different stakeholders of the platform.

First of all, we have inspired by the existing international and European initiatives that aim at facilitating the exchange and access to a wealth of heterogeneous data sets related to the environmental and agricultural domains. We have also included references to the main European policies that are directly involved in the agriculture sector, such as Common Agricultural Policy or Water Framework Directive and that have to be taken into account in the decision making process of the stakeholders. In this sense, call for global data collection for agricultural monitoring is analysed by Sachs et al. (2010). Principles of common agricultural policy are provided by Donald et al. (2002). Influence of Water Framework Directive on agriculture is discussed by Bateman et al. (2006). See Řezník (2013) for information on Infrastructure for spatial data in Europe (INSPIRE) including the application schemas for agriculture and aquaculture. European nitrate directive and its influence on the farm performance was written by Ondersteijn (2002).

To sum up, the FOODIE project has a lot of similarities with the above mentioned initiatives. Data model and searching including metadata originates from INSPIRE. Parts of global initiatives called GEOSS (Global Earth Observation System of Systems) and COPERNICUS could be used and integrated as a part of FOODIE hub. It is important for the FOODIE implementation to establish link with GODAN (Global Open Data for Agriculture and Nutrition) initiative, which is trying to define world Wide standards for Agriculture Open Data and CGIAR (Consultative Group on International Agricultural Research), which is active in global scale on simmer area as FOODIE.

As the second, we have paid the attention to the standards commonly used in the geospatial and environmental domains to encode, visualize and access to the datasets, e.g. sensor information. We would also like to stress the specific standards used in the agriculture domain for exchanging information, such as agroXML and SoilML, as well as the standards necessary for semantic tagging and publishing the datasets contained in FOODIE platform.

As the third, the results from relevant projects provides us an overview of the different architectural approaches followed by various projects in the environmental and agricultural
domain which represent the basis for designing FOODIE architecture and specifying its building blocks. For instance, an architecture for soil data that may be re-used for FOODIE purposes is advertised by Douglas et al. (2008), Bröring et al. (2011), Feiden et al. (2011) and Kubiček et al. (2013). In addition, we also had a look at the results obtained by some projects in the areas of Big Data and Future Internet which are interesting from the point of view of the agriculture due the large volumes of data that can be generated over the time, e.g. sensor data from the in-situ sensors deployed on the farms, satellite imagery, its management, visualization and integration as well as in terms of new agriculture services that could be built/offered in the scope of the Future Internet architectures and paradigms respectively. Big data represent in agriculture especially the biological data as described by Howe et al. (2008). Future internet, as described Moreno-Vozmediano et al. (2013), significantly changes the generally accepted principles of internet usage for agricultural purposes that were recommended by Thysen (2000).

As the fourth, the data and knowledge sources compile an exhaustive list of openly available datasets and vocabularies that can be used in the scope of the project in order to improve the semantic tagging and publication of datasets within the platform repositories as well as by enabling the provision of improved tools and advisory services for the different stakeholders (by integrating and fusing these external data with the datasets stored in the FOODIE platform). Spatial data harmonization of these openly available databases are depicted by Čerba et al. (2012). See Šimek et al. (2013) who described the usage of AGROVOC for the data descriptions in the agrarian sector.

As the fifth, the existing technologies and software solutions focuses on the different available alternatives – many of the coming directly from the open source geospatial community that can be used as building blocks of the FOODIE service platform hub.

Finally, we have also included the analysis of the different sensors and communication protocols used to communicate with/among them and which will be of relevance for deciding which the best option in each pilot is.

3. Project scope

The “Farm-Oriented Open Data in Europe” (hereinafter FOODIE) project aims at the following aspects of the sector of agro-informatics:

- building an open and interoperable agricultural specialized platform hub on the cloud for the management of spatial and non-spatial data relevant for farming production;
- for discovery of spatial and non-spatial agriculture related data from heterogeneous sources;
- integration of existing and valuable European open datasets related to agriculture;
- data publication and data linking of external agriculture data sources contributed by different public and private stakeholders allowing to provide specific and high-value applications and services for the support in the planning and decision-making processes of different stakeholders groups related to the agricultural and environmental domains.

The FOODIE project is funded under the Competetiveness and innovation framework programme (CIP) 2007 – 2013 with the planned budget almost 6 million Euros from which almost 3 million Euros represents the contribution from the European Union (EU).
project consortium composes of 13 partners from 7 countries: Austria, Czech Republic, Italy, Latvia, Poland, Spain and Turkey. The leader of the project is the international IT company called “ATOS SPAIN SA”. The project consist of the following six work packages (WP) that are briefly described below as well as in the Figure 1.

- **WP1: Project Management** with the main objective to ensure the achievement of the project results through administrative coordination as well as to provide timely and efficient organisational and financial coordination meeting contractual commitments.

- **WP2: Service platform specification** focuses on producing – in an iterative and incremental manner - detailed functional and technical specifications of the FOODIE service platform hub, including aspects of hardware (mainly the cloud computing infrastructure), security, quality of services, and exposed APIs (Application Programming Interfaces).

- **WP3: Service platform integration and deployment in cloud infrastructure** provides the core services for the management of agricultural data, specified in WP2, as well as the integration of these services in a reference platform, to be deployed in a cloud infrastructure, that complies with the models and architecture defined in WP2.

- **WP4: Data analysis, modelling and synthesis** develops and publishes Cloud based services supporting scalable execution of spatial models, data visualization and analysis; develops a state of the art decision support and information tool for the agricultural sector; provides end user solutions for specialists, policy makers, stakeholders, farmers, and foresters.

Figure 1. Structure of the FOODIE project divided into six work packages (WP). The WP2 to 5 are the development work packages while WP1 and 6 support, among others, the administration and dissemination.
- **WP5: Pilots preparation, execution and evaluation** verifies in the selected pilot countries (Czech Republic, Germany and Spain) the first implementation of a set of innovative services for the agricultural sector which address real sector needs; it aims at adequate methodology and evaluation plan, which allow non-biased measurement and validation of the impact of deploying FOODIE services.

- **WP6: Dissemination, exploitation and sustainability** ensuring the communication and dissemination of the results of the FOODIE project throughout the life of the project to all stakeholders in the countries where FOODIE will work, as well as to international audiences.

4. **Pilot studies**

FOODIE concepts and objectives are realized by means of the resulting service platform hub, which is demonstrated in three different pilots’ scenarios across Europe, providing each of them a set of common and specific requirements:

- **Pilot 1: Precision Viticulture (Spain)** focuses on the appropriate management of the inherent variability of crops, an increase in economic benefits and a reduction of environmental impact.

- **Pilot 2: Open Data for Strategic and Tactical Planning (Czech Republic)** aims at improving future management of agricultural companies (farms) by introducing new tools and management methods, which follows the cost optimization path and reduction of environmental burden, improving the energy balance while maintaining the production level.

- **Pilot 3: Technology allows integration of logistics via service providers and farm management including traceability (Germany)**. This pilot focuses on integrating the German machinery cooperatives systems with existing farm management and logistic systems as well as to develop and enlarge existing cooperation and business models with the different chain partners to create win-win situations for all of them with the help of IT solutions.

**Description of Pilot 2 in Czech Republic**

The arable land of the Czech Republic in areas with high intensity of crop production has specific traits. Large areas of cultivated fields with combination of higher variability of topographical and geological factors result in visible heterogeneity of soil condition and crop yield. More than 54% of agriculture land in the Czech Republic is managed by farms with a size of over 1’000 ha (Ministry of Agriculture, 2010). Based on a statistical evaluation of the Land Parcel Information System (LPIS), over 40% of arable land lies in fields with an area larger than 20 ha. Crop management in these conditions requires advanced decision making. Therefore, there are increasingly applied approaches of site specific crop management. Site specific management, known as precision agriculture, takes into consideration the spatial variability within fields and optimizes production inputs, thus fulfilling the objectives of sustainable agriculture (Corwin and Plant, 2005). The aim of precision agriculture is an optimization of production inputs (fertilizers, pesticides, fuel, etc.) based on the local crop requirements and plants requirements. Crop management in this way should lead to the effective use of agrochemicals and avoid of environmental risks.
The Czech pilot is represented by one agricultural supply company MJM Litovel (hereinafter MJM) and two corporate farms - Farm Vajglov and Farm Tršice. MJM offers various products for farming industry in the Czech Republic, such as fertilizers, plant protection products, animal feed, seeds, and a large selection of grower equipment. Furthermore, they provide services for farmers, especially for precision agriculture under their proprietary system PREFARM® for efficient use of fertilizers, increased revenues, and stable production quality.

Table 1. Basic information about both pilot farms from LPIS database and climatic data

<table>
<thead>
<tr>
<th></th>
<th>Farm Tršice</th>
<th>Farm Vajglov</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geographic coordinates</td>
<td>49°32'14&quot;N</td>
<td>49°53'56&quot;N</td>
</tr>
<tr>
<td></td>
<td>17°23'45&quot;E</td>
<td>17°21'30&quot;E</td>
</tr>
<tr>
<td>Average elevation of fields</td>
<td>284 m</td>
<td>626 m</td>
</tr>
<tr>
<td>Average year temperature</td>
<td>8.9°C</td>
<td>5.8°C</td>
</tr>
<tr>
<td>Total amount of precipitation per year</td>
<td>570 mm</td>
<td>842 mm</td>
</tr>
<tr>
<td>Total area</td>
<td>1’291 ha</td>
<td>1’089 ha</td>
</tr>
<tr>
<td>Arable land</td>
<td>1’214 ha</td>
<td>-</td>
</tr>
<tr>
<td>Grassland</td>
<td>-</td>
<td>1’089 ha</td>
</tr>
<tr>
<td>Orchards</td>
<td>74 ha (hopfields)</td>
<td>-</td>
</tr>
<tr>
<td>Organic farming</td>
<td>NO</td>
<td>YES (all fields)</td>
</tr>
</tbody>
</table>

The first farm, Tršice, is located in the most productive region of Czech Republic, in the Central Moravia. The farm itself is focused on the intensive crop production in arable land (cereals, oil crops and other) and the production of hops. The second Farm, Vajglov, is located in the North Moravia region in the marginal mountain area. Most of the acreage of the farm falls within the Less Favourable Area (LFA), where is reflected the lower productivity of the land by supporting agricultural land use and preservation of sustainable agriculture in these areas. The farm is focused on livestock production (grazing beef cattle); agricultural land is therefore used in form of permanent grassland and is under organic farming regime. Basic data on both farms are listed in Table 1.

The improvement of future management of agricultural companies in the Czech pilot is divided into three scenarios:

- **Scenario A - Improving efficiency of transportation** of large service organization, which will support better logistics on different levels of agriculture services.

- **Scenario B - Telematics of farm machinery** for evaluation of the economic efficiency of field operations and improvement of the machinery management.

- **Scenario C - Optimization of crop management** practices by considering in-field variability for variable rate application of fertilizers.

**Scenario A – Improving efficiency of transport in agriculture**

In relation to farms, MJM acts as agriculture service organisation, trade partner and advisory organisation. MJM deals to both sided of the market, supply and demand side. On the market of inputs to agriculture, MJM plays the role of supply side by offering fertilizers, pesticides, and other materials to farms as the products or in form of providing complete services including application on fields. In connection with these supplies, MJM must fulfil their legal obligation to take back empty packing. On the market of crop product MJM act as demand
side purchasing products from farms. All these tasks meet demands for intelligent logistics system within the organisation.

The main purpose of this scenario is to implement a new system for optimization of transport in agriculture for a use case of MJM. This system should achieve better overview about transport related topics for purposes of MJM management, efficient information sharing between individual departments and between elements involved in the transport processes, and increased economic and energy efficiency of transport.

There are several possible steps to reach the desired optimization, which will be further analysed in the cooperation with MJM and involved into the Foodie platform:

- Creating transport schedules, which satisfy all constraints and minimizing transport costs.
- Creating schedules, which minimize deviation from requested times of loading/unloading (taking in account priorities) and satisfy other constraints. In this case, allowed costs of transport will be additional constraint defined by a user of the Foodie platform.
- Assigning costs to unsatisfied loading/unloading times and aggregating the costs with transportation costs. Furthermore, creating schedule respecting other constraints and minimizing the aggregated costs.
- Created schedules based on some of multi-criteria decision methods.

Scenario B – Telematics of farm machinery

Operation of agricultural machinery significantly influences the economic profitability of the crop management. First of all, it applies to the fuel consumption, machines and operators’ workload, control of performed treatments and the environmental effects such as reducing the risk of deterioration of soil physical properties. Verification of the monitoring system will be done at both pilot farms by an evaluation of tractors’ work during basic operation such as soil tillage, fertilization, sowing, crop protection as well as harvest and grass management. Similar monitoring will be tested at the enterprise which offers services for farmers (MJM Litovel) for assessing the quality of work for customers.

Main purposes of these scenario are:

- Evaluation of the economic efficiency of machinery operations within the fields.
- Precise records of crop management treatments (mainly for fertilizers, pesticides).
- Improved management of machinery operations and planning of crop management treatments.
- Control of quality of field operations, such as pass-to-pass errors and overlaps, coverage of maintained area, recommended work speed.
- Control of applied input material in comparison to prescribed rates.
- Compliance of agro-environmental limits (Nitrate Directive, Good Agricultural and Environmental Conditions - GAEC, protection of water resources, etc.).

From the technical point of view, the monitoring system involves tracking of the vehicles position using GPS combined with acquisition of information from on-board terminal (CAN-BUS) and their online/offline transfer to GIS environment for spatial analysis and visualization.
Scenario C – Monitoring of in-field variability for site specific crop management

Site specific crop management requires information about the within-field variability of soil condition and crop stand. The use of remote sensing is a key step in obtaining whole-area data to support agronomical treatments during the vegetation season. The aim is to develop a stable monitoring system for effective identification of spatio-temporal variability of crops and to use this information for optimization of the crop management practices.

The monitoring system includes three types of observation to provide information about crop variability at different spatial and temporal level:

1. **Operative aerial remote sensing** for whole-area mapping of the fields at high spatial resolution but with low frequency – temporal resolution. The aim is to prepare the prescription maps for variable applications of fertilizers and pesticides, estimated by the spectral measurement of crop parameters. The frequency of the survey depends on the crop type, agronomical operations, crop management intensity and weather conditions. Aerial imaging will be carried out using multispectral camera by an external provider of photogrammetric services. Within the Foodie project, a workflow will be developed for pre-processing of acquired images (radiometric and geometric corrections) and their analysis and classification according to the MJM interpretation algorithms.

2. **Periodic satellite remote sensing** for wide-ranging identification of spatial variability and simultaneously capturing the dynamics of vegetation growth, both at medium level of spatial resolution (30 metres per pixel, once per 14 days). Suggested satellite survey is based on the free available data of Landsat 8 or in 2015 launched Sentinel-2. The main information is the vegetation index NDVI determined from R (red) and NIR (near infra-red) bands. The absolute values of NDVI, their relative to mean value of the field and change detection will be implemented for assessment of crop stands and delineating of management zones.

3. **Meteorological monitoring** at farm level to capture detailed dynamics of weather conditions on the ground. Weather data will be recorded at the specific localities in high frequency (between 10 and 15 minutes). The main goal is to obtain data for modelling of crop growth and to support decision making by agronomist for plant protection (prediction of the plant pests and diseases infestation), plant nutrition (crop growth and nutrient supply), soil tillage (soil moisture regime) and irrigation (soil moisture).

5. **Conclusions and future development**

The discussed Foodie platform represents a new approach to the precision agriculture domain. It uses observing and measuring tools, like remote sensing techniques, similarly to the advanced precision agriculture/farming systems. Moreover, the Foodie platform offers the complex set of tasks in order to enhance the “traditional” view on the precision agriculture/farming. To be more specific, the Foodie platform deals with the issues of telematics to/from the field, fleet management, reduction of environmental impacts, improving the energy balance, etc. that are mostly beyond the advanced precision agriculture/farming systems.
One of the greatest differences is the openness of the Foodie platform when using the cloud computing. As such, it enables the agricultural data interoperability. Pan European activities like INSPIRE, COPERNICUS and/or GODAN may be integrated as a part of the Foodie hub. On the technological level, for instance, any Web service respecting the standards in the geospatial domain may be connected to the system. Examples in this direction may be found in the Open Geospatial Consortium’s Web Map Services (WMS), Web Feature Services (WFS), RESTful APIs, etc. As the result, the Foodie platform is significantly customizable and scalable.

One of the main open issues lies in the area that affects big data in all its forms. Farmers usually distrust the companies aggregating data. Farmers afraid, that their sensitive detailed data may be misused. Future development would therefore be on the technological level as well as on the personal level to ensure the usefulness of the Foodie platform in daily life.

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References


Open Land Use Map

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Abstract

OPEN LAND USE MAP is an initiative that has been started by the Plan4business project and that will be extended as part of the SDI4Apps project in the future. This service aims to create an improved worldwide land use map. The initial map will be prepared using the CORINE Land Cover, Global Cover dataset and Open Street Map. Contributors, mainly volunteers, are able to change the geometry and assign up-to-date land use according to the HILUCS specification. For certain regions more detailed datasets, if available, will be used as an update of the Open Land Use Map. The product is treated as Open Data and users will be able to download the data in a specified format and for a selected area. The paper introduces the developments that will support this initiative, namely in the Plan4business and SDI4Apps project.

Key words

data integration, land use, open data, business model, sustainability, INSPIRE

Introduction

Land use and land management practices have a major impact on natural resources including water, soil, nutrients, plants and animals. Land use information can be used to develop solutions for natural resource management issues such as salinity and water quality. For instance, water bodies in a region that has been deforested or having erosion will have different water quality than those in areas that are forested. Forest gardening, a plant-based food production system, is believed to be the oldest form of land use in the world.

The term land cover is often mistakenly used instead of the term land use. However, their actual meanings are quite distinct. Land cover refers to the surface cover on the ground. The INSPIRE Directive [1] defines land cover as “physical and biological cover of the earth's surface including artificial surfaces, agricultural areas, forests, (semi-)natural areas, wetlands, water bodies.” [2] Land use is defined as “territory characterised according to its current and future planned functional dimension or socio-economic purpose (e.g. residential, industrial, commercial, agricultural, forestry, recreational).” [2]

On the one side, there are global mapping initiatives for land cover mapping (e.g. CORINE Land Cover, Africa Cover, Global Cover) and voluntary initiatives such as Geo-WIKI for updating global Land Cover Maps. On the other hand, there are no global initiatives for land use mapping. The only sources of land use are heterogeneous and scattered data from local and regional levels. This problem of land use data heterogeneity was the main challenge for
the Plan4business project. This EU co-funded project aimed at harmonising and integrating spatial planning data sets so they can be used for cross-border information and analysis services.

The Plan4business project developed a platform that can serve to users as a catalogue of land use and planning data such as transport infrastructure, regional plans, urban plans and zoning plans. The platform represents not only a central access point for integrated, harmonised and thus ready-to-use formatted data, it moreover offers rich analysis and visualisation services via an Application Programming Interface (API) and an interactive web frontend [3]. As a result, a large data pool of integrated land use and open data was created.

The Plan4business platform offers not only data but also tools and apps for different user groups:

- data providers - planning authorities, engineering bureaus and researchers who provide data into the platform using the Plan4business tools,
- data curators - who perform integration and quality assurance,
- clients and data brokers - who will be hosting and exploiting the Plan4business platform and its apps.

The Plan4business platform is twofold. On the one side, there is an Open Data Platform which is accessible for free and contains mainly open data. On the other side, in order to keep the platforms sustainable, there will be a Commercial Platform which revenue will be generated via on-demand and subscription services to different customer groups ranging from environmental and planning authorities and companies to banks and real estate companies and developers.

The Plan4business developments and results serve as a basis for another EU co-funded project Uptake of Open Geographic Information Through Innovative Services Based on Linked Data (SDI4Apps). SDI4Apps will exploit the integration tools and the Open Data Platform developed in Plan4business for one of its pilot applications – Open Land Use Map. This application is focused on land use data collection through voluntary participation, data integration, harmonisation and visualisation.

**Objectives**

Land use data, urban and regional planning data sets were not aggregated so far, and thus it was very laborious to use them for any other purpose than for printing or simple publishing by the authorities that collected them. Creating time series or comparative analyses on these data sets was not yet possible; researchers, spatial planners and professionals from the real estate world and other disciplines, such as insurance industry, investors, or market-relevant activities related to urban development have a growing stake in such capabilities.

There is neither global nor European initiative for mapping land use on local and regional levels. The INSPIRE land use represents scattered resources of various quality and with limited coverage in Europe. The CORINE Land Cover (CLC) is land cover map, not land use map. Moreover, the map is too generalised for regional and local purposes. The Urban Atlas is only for major European cities and does not cover rural areas and remote suburbs of cities.

The needs for a European land use map were expressed during the collection of requirements within the Plan4business project. The voluntary approach is the only way how to perform the collection of data with minimising the costs. The intention of Open Land Use Map is to start
support voluntary initiative for open land use mapping. The initial work was already done in Plan4business and the initiative currently continues under the SDI4Apps project.

3. Methodology

The work is divided into the next steps:

- Define data model for land use mapping based on the Hierarchical INSPIRE Land Use Classification System (HILUCS).
- Transfer existing data and build initial land use map as a combination of different sources:
  - Land use from Open Street Map,
  - Land cover datasets (CORINE Land Cover, Global Cover) which include information on land use,
  - National information sources such as cadastral data in the Czech Republic.
- Make Open Land Use Map publicly available.
- Deploy SDI4Apps mobile and desktop interface for updating of Open Land Use Map.
- Deploy harmonisation tools for updating of Open Land Use Map using existing available open data.

The Open Land Use Map will become freely available for download and accessible through OGC interfaces, but also through Application Programming Interfaces (API) developed within SDI4Apps.

The Open Land Use Map will use the following available global data sources:

- European and global land use and land cover data including CORINE Land Cover, Urban Atlas, Global Cover, Africa Cover;
- Land Use Data from Plan4business and other projects;
- Regional, local, spatial and urban plans of the SDI4Apps partners;
- Publicly available land use data.

**Sustainability of the Open Land Use Map**

The main aspect of all emerging initiatives is to secure their sustainability. The idea is not only to build an open data set for land use but also to offer a set of added value commercial services. From the business model point of view, there will be two main platforms with the following pricing:

**Open Data Platform (ODP)** – a data hub containing open data, management and harmonising tools, open applications (e.g. Open Land Use Map). All the services will be available for free with no restrictions. Any party can access the data pool and make commercial or non-commercial apps based on these data. The use of the data must be in line with data licences.

The non-profit ODP will have the following sources of financing in order to keep it sustainable:
− In-kind contributions - sponsorships of companies contributing to the system maintenance, server infrastructure, update and upgrade.

− Future project contributions – there is a number of future projects (e.g. Smart Open Data, SDI4Apps, Open Transport Net, FOODIE) for which the portal can serve for their purposes. The projects would not only use the data but they would also feed the platform with new data. These projects could contribute to the system maintenance, server (cloud) infrastructure and new tools development.

− Advertisement - the hub will offer space for advertising.

− Public funding from the side of organisations who don’t want to build their own infrastructure or who would like to support the Open Data Platform.

− Other contributions.

Commercial Platform (CP) – a data hub containing restricted data and commercial apps and tools. The restricted data hub includes all data that cannot be included in the ODP. The CP will be used for commercial applications and in line with data licences. Restricted data will be either not available for download or there will be a possibility to download the data only for a certain group under given conditions and in line with data licences. The incomes will be composed of:

− Advertisement with the focus on concrete user groups (e.g. real estate businesses).

− Data hosting for public and private bodies who don’t want to make data freely available, but they need to publish their data.

− Profits from the commercial apps.

− Payments from the project partners for the infrastructure utilisation.

− Payments from third parties accessing the CP or offering the commercial apps in other counties and regions.

Figure 1 shows these two platforms, associated apps and tools and the potential users.
Technology Description

The Plan4business system is realised through a composition of three engine layers, namely the integration layer (1), the storage layer (2) and the analysis layer (3) (Figure 2). The layer’s tasks are either to harmonise (1), store and provide (2), or visualise and analyse (3) data related to urban plans [4].

The integration engine’s task is to transform spatial data sets based on a set of schema mapping instructions. Examples for mapping instructions are reclassifications of land use nomenclatures, spatial coordinate transformation and assigning object types from the source data to a target schema. The integration engine has been realized as a web service based on the Humboldt Alignment Editor (HALE) software stack. HALE provides the functionality to perform interactive mapping of geospatial schemata. HALE’s user interface has been adopted in order to allow for performing the mapping process online. Therefore, a step-by-step wizard guides the user through the mapping process and asks to map the source entity types to a predetermined target schema. The latter is a simplified subset of the INSPIRE Data Specification.
on Land Use. Besides spatial coordinate transformation and retyping of entities and attributes, re-classification of land use categories is one of the core aspects in the land use domain (Figure 3). Re-classification can be realized through mapping-tables connecting a source classification to one or more classification categories of HILUCS.

Figure 3 - Exemplary mappings for spatial, temporal and thematic attributes. The bold attribute names belong to the target schema INSPIRE Data Specification on Land Use.

Once the schema mapping is finished it may be executed, published and shared with other users.

Applying the mapping instructions to the source data uploads the resulting transformed data to the storage engine. The latter is a combination of two separated data bases following the relational paradigm on the one hand and the graph paradigm on the other. The main component of the storage engine is the relational data base. Although the relational paradigm has been carried out successfully for many years, it lacks in performance when it comes to more complex queries that require a lot of table joins. Thus, we have supplemented it with a graph data base that runs particular use cases. Both, the relational data base and the graph data base, can be managed via the web portal. This allows for storing, deleting or updating transformed data sets. The data is either accessible as INSPIRE compliant files (e.g. Geography Markup Language) or via SQL.

The analysis engine encapsulates data access and represents a base for an extensible collection of analysis and visualisation applications (apps) [5].

**Spatial Apps on Top of the Plan4business Platform**

This section presents the end-user apps built on top of the analysis engine, such as Brownfields (an app for brownfield advertisement), Embed Map (embedding an interactive map window with user defined maps into user’s website) and Advert (placing an advert for selling real estates). The Plan4business platform and the apps are available at www.whatstheplan.eu. The apps combine the data harmonized through the integration engine with open data available from various sources. As an example the Thematic Map Viewer and the Location Evaluator apps are described in more detail.

The Thematic Map Viewer (Figure 4) enables to navigate through thematic maps and results of predefined analyses from local to European level. Based on the level of zoom in a certain area a list of thematic maps is dynamically offered to the user. The user can then select one of the thematic maps, display it in the map viewer and analyse it in an interactive manner.
The Location Evaluator is an app for user friendly access to data from various sources including statistical, analytical and cadastral information. User can generate a comprehensive report about a region in Europe (Figure 5), a municipality or a point of interest in selected countries through navigation in a map.

Another app that will be enhanced within the SDI4Apps project is the already mentioned Open Land Use Map.

**Conclusions and Future Perspectives**

The current situation with data availability and compliance to commonly used standards differ from country to country. But in general, most data from the public sector are not published in a standardised and machine readable form. This makes collection, integration and update of data rather difficult.
The Plan4business project developed a solution that can help to overcome this situation and enable effortless land use and other data integration. The solution is fully Open Source and can be extended to any region in the world including African countries.

The results of the Plan4business project offer the first complete solution for users. The solution will be extended with additional data sets as well as further functionalities and applications to support different user communities. The SDI4Apps project will build on top of the Plan4business achievements and extend the platform with additional apps and tools including the Open Land Use Map.

The authors presented the technological solution for data integration, how to make the system sustainable in the future and the methodology for setting up the Open Land Use Map built on top of this platform.

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References


Cloud architecture for spatial data infrastructure

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Abstract

This paper presents a cloud infrastructure developed in the SDI4Apps project, which should enable easy creation of applications providing geographic information obtained from spatial data infrastructures. Its architecture is based on analysis of application requirements from previous projects, which has shown that spatial data applications have 3 main phases of data processing with differing scalability requirements. Thus the architecture has 3 Platform-as-a-Service clouds fulfilling the needs of the 3 main phases of data processing, and a data storage that fulfills all the scalability requirements. The data storage will provide scalable PostGIS, which can be obtained using Postgres-XL clustering.

Key words

Cloud infrastructure, spatial data infrastructure, applications

Introduction

In this paper, we present the results obtained so far in the early phase of the SDI4Apps project that aims to design a cloud based infrastructure enabling easy creation of applications providing geographic information obtained from spatial data infrastructures.

We have performed analysis of requirement of applications working with spatial data, and its results lead us to a proposal of an architecture that is depicted in the Picture 1 and described in the surrounding text.

The main findings are that spatial data applications have 3 main phases of data processing, where each phase has different requirements for scalability of data access. The requirements can be satisfied by a data storage which may have separate reading and writing parts, and scales them independently.

Another important finding is the importance of the PostGIS extension of the PostgreSQL database, which can be scaled using clustering techniques described in this article, namely using the Postgres-XL extension.

The SDI4Apps project

The main target of the SDI4Apps project is to build a cloud based framework with open API for geographic data integration, easy access and provision for further use. The aim of the framework is to bridge two separate worlds – the world of government-related top-down managed spatial data infrastructures (SDI), and the world of voluntary individuals, initiatives, and small and medium enterprises developing applications (Apps) based on geographic information – hence the name SDI-for-Apps.
Cloud infrastructure

Cloud computing is a general term for anything that involves delivering hosted services over the Internet. Its precise definition can be found in the NIST publication [1]. For further discussion it is important to realize that cloud has three rather different service models:

- **Software-as-a-Service** (SaaS) model provides on-demand access to software, either as downloadable code or markup text executed on client computers, or through remote calls to code executed on servers.
- **Platform-as-a-Service** (PaaS) model provides on-demand software environment for deploying applications. The environment includes concrete programming languages, their specific libraries, and additional services like SQL and no-SQL storage. PaaS cloud is usually used as a layer under SaaS cloud services.
- **Infrastructure-as-a-Service** (IaaS) model provides on-demand resources from a virtual data center, like virtual machines, disk images and networking services. The resources can be used directly or as a layer under PaaS or SaaS cloud services.

The SDI4Apps infrastructure aims to provide SaaS for services that will not be hosted directly on the infrastructure, and PaaS for applications and services that will be hosted directly on it. Both the SaaS and PaaS services need to be layered on top of IaaS services.

While the SaaS and PaaS layers will be specific for spatial data infrastructure, the IaaS layer should be independent. To achieve this separation from a specific cloud implementation, a layer wrapping the underlying IaaS layer should be created. The wrapper may be based on a proposed standard such as OCCI (Open Cloud Computing Interface) or CIMI (Cloud Infrastructure Management Interface). The wrapper would play a similar role as JDBC plays in the world of relational databases by providing a unified interface for applications that are shielded from differences among implementations. The OCCI standard proposed by Open Grid Forum seems very promising in this regard, as it provides a unified API for managing IaaS clouds, and it has already implementations for clouds with Amazon AWS, OpenNebula and OpenStack APIs, and implementations for Google Compute Engine, Microsoft Azure and VMware are planned for near future. Thus it will cover all the main APIs used by cloud providers.

Results of spatial data applications requirements analysis

The analysis is based on experience of previous projects like Plan4Business.

All spatial data processing can be always assigned into one of 3 main use cases:

- **data collection** – using crawlers, sensors, crowdsourcing
- **batch data transformation**
- **data provision** which can be further divided into
  - provision of transformed data without further processing
  - answering queries - **interactive data transformation**

The requirements for **scalability** of the three data use cases (collection, batch transformation, provision) are not related – all combinations are possible, e.g. an easy data collection may be followed by a very computationally intensive transformation and that may be followed by provision of data to a moderate, but not negligible, number of simultaneous users.
Data collection, batch data transformation and provision of data without processing are not time-constrained, however the use case of answering queries is limited by the time a user is willing to wait for an answer to his or her query. There can be two types of scaling to reduce the time:

- scaling to more concurrent users
- scaling to process more data in a single query

The data collection can be performed in one of two ways – push or pull. Data pull would be performed by downlosders or crawlers copying data from outside sources. Data push would be performed by hardware sensors pushing their measured data into a data storage, or by humans creating data using crowdsourcing which can be considered as just using human sensors instead of hardware sensors. In either way, the requirements for scalability of data collection are only for concurrent data writing.

During data provision no spatial data are written, so the scalability requirements are just for concurrent data reading.

During the batch data transformation, raw collected data are read, and transformed data are written, thus both scalability for data reading and data writing are required, however the transformed data do not have to be written to the same data storage system from where raw collected data are read, so it is possible to scale reading and writing independently by using two separate spatial data storage systems, one for reading and the other for writing.

During the interactive data transformation performed when answering queries, scaling to more concurrent users requires just scaling of data reading, as in that case data are not written back to the spatial data storage, thus this case is the same as for the provision of transformed data without further processing.

The most difficult case is interactive data transformation that needs to process more data in a single query. This case cannot be solved by simple horizontal scaling (adding more computers), because there is only a single query, and it cannot be solved by vertical scaling (using more powerful computers) because there is a low limit on vertical scaling. The only solution seems to be a radical application redesign, perhaps using the map-reduce technique which maps parts of a single processing onto many computers and then reduces their partial results into a single final result. But this depends on the particular query and cannot be solved in a general case.

Many existing spatial data software tools rely on the PostGIS extension of the PostgreSQL relational database management system, which adds new data types (geometry, geography, raster and others), functions, operators and index enhancements that apply to these spatial types. Thus to ease the transition of the current generation of spatial data applications to the cloud architecture, this must be taken into account.

The requirements can be summarized as:

- there are 3 main phases of data processing – collection, batch transformation and provision – with independent scaling requirements
- scalable concurrent reading and writing are needed, but the source and destination storages may be separate, and at least the reading side should be compatible with PostGIS

**Proposed architecture**

The proposed architecture as shown on picture 1 provides 3 PaaS clouds targeted to data collection, data transformation and data provision respectively, and a scalable spatial data
storage, which should have a part that scales for writing, and a part that scales for reading. The reading part would be PostGIS-compatible.

The scalable spatial data storage may be implemented as a single scalable database system, or it can be implemented as two separate systems, where data written to the write-only part are transferred after some delay to the read-only part.

We expect the use of clustered Postgres XC or Postgres XL databases with PostGIS extension, however if that solution appears not to scale well, the write-only part may be implemented using other technologies than relational databases, trading their properties like transactional integrity for higher scalability.

The 3 PaaS clouds would provide 3 platforms tailored for the 3 data uses cases – collection, transformation and provision. They may be implemented using a single platform providing features needed for all of them, or they may be implemented separately.

The PaaS will provide API (Application Programming Interface) for the following areas:

- workflow management (e.g. data transformation after collection, incremental updates)
- management of degree of parallelism (how many workers should be allocated to a task, using rules or direct API calls)
- events (finished transformation, partial update of collected data, etc.)

The current best practice is to base APIs on the REST (Representational State Transfer) architectural style.

![Picture 1: The proposed architecture for cloud infrastructure suitable for spatial data applications](image-url)
PostGIS clustering techniques

The proposed SDI4Apps platform should be able to accommodate large numbers of sensors (both hardware and human) on one side and large numbers of consumers on the other. We learned from the previous projects, that one of their foundations is the PostgreSQL database with PostGIS extension support. While with current number of users its performance of single instance of database on single virtual machine is satisfactory, with increasing numbers of sensors and consumers, database performance could be a bottleneck for the whole system.

That’s where the cloud comes in handy. If we were able to cluster the database, we would be able to take advantage of the key feature of cloud platform – its ability to provision vast numbers of resources on demand. There are many SQL database implementations and most of the major ones have spatial data support (PostgreSQL PostGIS, Oracle Spatial, MS SQL Server, MySQL …). These spatial extensions are not mutually compatible. SDI4Apps should follow up other projects that use PostGIS. Rewriting all code from old projects would be costly, so we reduced our research to PostgreSQL clustered solutions that supports PostGIS extension.

Native PostgreSQL supports two types of clustering:
- hot standby – asynchronous replication, standbys are read-only
- warm standby – used for high availability, standbys cannot be queried

Native PostgreSQL clustering could be used for consumers - read operations could be load balanced on top of standbys and thus scale well, on the other hand this solution is not very useful for concurrent writing, because writes can only go to a single node.

From all the available third party clustering extensions of PostgreSQL, only two support PostGIS out of the box - Postgres-XL and Stado. We plan to use Postgres-XL, which is more actively developed, but it could be replaced by another solution, if it doesn't prove to be suitable for the SDI4Apps platform.

Postgres-XL is an open source SQL database solution closely based on older Postgres-XC project. Postgres-XL is a very fresh project – its first release candidate version was released on 14 May 2014.

Postgres-XL key features are:
- write-scalable PostgreSQL cluster – it was observed 3x speedup with five nodes compared with native PostgreSQL
- synchronous multi-master compared with asynchronous master-slave native PostgreSQL
- table location transparent – no change in transaction handling
- tables can be replicated among all nodes for read scalability, or distributed for write scalability
- same API to Apps as native PostgreSQL
- PostGIS is not supported natively. Postgres-XC sources need to be patched before compilation.

Postgres-XL key features compared with Postgres-XC are:
- MPP query support
- performance improvements
- multi-tenant security
- native PostGIS support

Conclusion
The paper has presented the SDI4Apps project and the architecture of its cloud infrastructure based on analysis of requirements of spatial data applications. It also described techniques for scaling performance of PostGIS extension of the PostgreSQL database management system.

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References
SUPPORTING A REGIONAL AGRICULTURAL SECTOR
WITH GEO&MAINSTREAM ICT – A CASE STUDY OF
SPACE4AGRI

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Abstract

Agriculture is a global issue nowadays. At the European level, it is a sector, in which we are investing a lot of resources. In particular, the Agri-Food sector plays a central role in the policies of the European Commission and the Horizon 2020 research and innovation program, as well as being the main theme of Expo 2015 - Feeding the planet energy for life, which will be held in Milan, Lombardy. In the Lombardy region, the farmers represent 2% of the entire population, cultivating about 80% of the agricultural land. The needs to develop a common body of knowledge shared at the regional level capable to effectively monitor cropping systems, water stress and impacts of climate changes affecting more frequently the territory, have been increased.

In this context, the project Space4Agri intends to support the regional and national needs in terms of management of the agriculture sector. The aim is to design and develop an information knowledge platform based on geospatial and mainstream information and communication technologies (Geo&Mainstream ICT). These platforms are based on data workflows integrating i) spatial data, ii) observations and non-spatial information available from existing systems, iii) data collected in the field by farmers or by enthusiasts using mobile applications, iv) data collected by unnamed areal sensors, and/or data produced by applying scientific analysis on high quality remote sensing data.

Foreseen outputs of the Space4Agri and from other similar ongoing research activities may significantly spur the socio-economic development of Europe and create new growth opportunities for companies, public administrations and citizens.

Key words

Agriculture, Geo & Mainstream ICT, Space4Agri, Lombardy
Wireless sensor technology for precision farming and forestry applications in Latvia

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Today’s agriculture and forestry faces new challenges such as global and local climate changes, global society changes.

Global grain crop production has doubled in the past 40 years. Increased yields mainly are resulting from greater inputs of fertilizer, water and pesticides. Huge increase in global food demand is forecasted for the next 20 - 30 years. It poses immense challenges for the sustainability both of food production and terrestrial and aquatic ecosystems and services provided to society. Challenges for agricultural producers are food security and product quality.

The only way to raise productiveness and food security of agriculture is adoption of new ICT technologies like precision farming methods in rural community. Effective implementation of precision agriculture methods require both development of farm management systems (for instance PROGis software) providing site specific management of agriculture production and real time data of soil, crop, and climate monitoring.

Wireless Sensor networks (WSN) can provide data in real time. Real time data is required for risk forecasts necessary for crop protection. Implementation of Early warning and risk management systems is crucial for both agriculture and forestry.

For forestry it is necessary to use precision monitoring technologies to cope with main threats: pest control and forest fires.

Institute of Mathematics and Computer Science of the University of Latvia (IMCS) in framework of current researches has developed and implemented long range 868 M Hz frequency band wireless sensor network (WSN) and gateway platform with extended sensor and network interfaces and solar energy harvesting feature for precision agriculture and forestry.

WSN platform includes originally developed IMCS WSN node based on IMCS WSN technology together with modified WSN gateway technology developed by Czech Centre for Science and Society (CCSS).

The research was performed in two directions. The first - development of new long range Wireless Sensor Network (WSN) nodes providing radio link in long distances (more than 300m) with built in atmospheric sensors and battery charging by solar energy. The second is development of energy efficient WSN operating system (FarmOS) for large scale WSNs with main focus on long term robust easy to use agricultural applications.

IMCS WSN platform features:
- long range communication;
- vented enclosure for weather-safe operation;
- robust operation;
- sensors - full range of sensors for environment monitoring;
• interfaces – GPIO, ADC, UART, SDI-12, 2-wire JTAG, 1-Wire, I2C;
• power - energy harvesting;
• standard sensor interface extensions according to application requirements;
• buffers for sensor connection over long cables;
• input multiplexer for chemical element measurement.

Using WSN technology developed by IMCS comprehensive meteorological data measurements are available for practically all phenomena making impact on agriculture.

IMCS has performed several field trials in real cranberry farm. The network was based on IMCS WSN platform for gathering meteorological data for:
• radiation frost early warning and prevention using large volume fog generator device;
• cranberry overheating, frost protection and precision fertilizing using sprinkler system.

The field trials proved that technology of new WSN platform is viable for wide range of agricultural and forestry applications. It provided stable unattended functionality for more than full growing season. WSN nodes based on IMCS WSN technology retained full functionality even during winter season. Due to long range working nodes WSN can cover large planted area within reasonable costs. Effective radio communication between nodes can guaranty communication even in forests where trees make natural barriers for radio coverage.
Traffic Volumes Described on Examples in the Open Transport Net Project Pilot Regions

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Abstract
The article describes the goals of the OpenTransportNet project in the pilot regions as well as motivation behind using traffic volumes in solving certain tasks needed to accomplish those goals. In the introduction the short background of the OpenTransportNet project is provided. It is followed by the description of the problems that the project will try to solve in the pilots and the discussion of using traffic volumes for achieving good quality results. Further the basics of traffic volumes as well as their visualization are described and demonstrated with brief examples.

Key words
traffic volume, transport network, OpenTransportNet, INSPIRE

Introduction
Transport is one of the key issues addressed by EU policy. Europe’s population and visitors are reliable on transport and its efficient operation. In order to make it efficient, safe, trusted and sustainable, thorough planning must take place. This is true for example while constructing a new motorway, modifying a road junction, adding an extra connection to a bus line or integrating a train schedule with an online tourist portal. A necessary precondition for such planning is the ability to analyse information from the past, combine it with dynamic data coming from sensors such as mobile phones, and to use the generated knowledge for real-time applications and future planning.

The EU co-funded project Open Transport Net (OTN), which started in February 2014, aims to support the use of transport data for public good. The main issues that are addressed by this project include:
- supporting the reuse of spatial data in the transport domain,
- combining spatial and non-spatial data from various sources,
- publishing data to enable easy access and data integration with other applications,
- analysing aggregated data and providing new services and visualisations through web interfaces.

The project tackles some technical challenges with data integration and aligning data and services to existing standards. In addition, the involvement of end users and stakeholders is intensive; social validation makes a valuable contribution to the sustainability of the final results. These results should include:
- a data hub for transport data integration and sharing,
OTN focuses on open data that are freely provided by public administration and other organisations. The project started by modelling and visualising traffic volume data that should support transport applications in the OTN pilot areas: Liberec Region in the Czech Republic, Antwerp in Belgium, Birmingham in the UK and Issy les Moulineaux in France. This paper contains the description of user requirements from the pilot regions and a detailed overview of the traffic volume modelling and visualisation process.

User Requirements from the Pilots

The OTN project identified the main problems and goals of the OTN pilots through co-design workshops.

- **Antwerp**
  In Antwerp, there will be major roadworks carried out between 2014 and 2022. Many roads will be closed. Therefore, there is a need to take some measures that would alleviate the impact of the temporally imposed restrictions (road closures) on transport infrastructure. Such measures can include improvement of public transportation: establishing new public transport links/changing the route of existing links and reducing the time interval between connections. The logic behind is quite simple: the capacity of the public transportation vehicle is generally bigger than the private transportation vehicle, so by making more frequent public transport connections that have reasonably big coverage to bring people where they need, there will be no need for people to use their private transport and thus it will help to prevent transport congestions on roads (because in a public transportation vehicle the ratio of its area and number of passengers that can fit in it is smaller than in a private transportation vehicle).
  Together with re-planning public transport some additional measurements could be taken. The number of parking spaces at the edges of the city could be increased. Many people who are commuting to work from other settlements by their private transport and wish later to switch to the public transport should have enough space to park the vehicle when they enter the city. Also infrastructure for cycling could be improved. This can be done through extending the bicycle track networks and creating more places where people could borrow bicycles (this can be classical bike renting places but also some bike sharing systems).
  The main OTN project objective in Antwerp will be thus to provide all necessary analytical tools to accomplish these planning tasks.
  There will be some additional minor tasks such as to provide pilot city with visualisation of traffic flows, ongoing roadworks on the map, to create routing web service that will take into account some deduced information from the city traffic model as well as live information collected from platform’s users’ mobile phones or from some external APIs (live information about weather conditions), to create intermodal journey planner that will compute the optimal route from one point to another using the traffic means selected by user.

- **Birmingham**
  In Birmingham, the main objective is to identify accident-prone segments on motorways. In the future, there can be some steps taken towards decreasing the number of accidents on those segments; for example by setting a new speed limit for cars, put additional traffic lights or restrict the number of parking places. In identifying those segments statistical datasets about traffic accidents from governmental agencies as well as live data from sensors and VGI (volunteered geographical information) will be used. All data about traffic accidents will be merged together and combined with other related datasets; for instance with data about parking lots, speed limits on motorways, traffic volumes (eventually congestions).
motorways. The combination of data will enable deeper analysis. This database of traffic accidents in the city and related data will be maintained by the OTN project and will be available for anyone interested for download.

Furthermore, certain functions such as routing, geocoding, reverse geocoding, finding closest amenity of the certain type will be available for use through restful API. The same basic functions will be available for all the pilots and will use the data stored in the project database. These data can be of a great help to those who want to develop web-applications on top of the OTN data hub.

**Issy-les-Moulineaux**

The next pilot region is Issy-les-Moulineaux – south-west suburb of Paris. An average person who commutes from Issy-les-Moulineaux to Paris is losing about 77 hours per year in traffic jams, while the national average for France is only 35 hours per year. The city government is naturally trying to take some steps to reduce the number of hours its citizens are wasting in traffic jams. For now the city has quite rich public transport network. In addition, there have been established 11 Velib’ and 12 Autolib’ docks for bicycle and electric-car sharing correspondingly. The role of the OTN in improving the transport situation is mainly relying in launching application that would help users to make more efficient journey plan based on the real-time data about the traffic situation on the motorways as well as some additional information related to traffic such as current weather conditions. This real-time data can be acquired from data volunteers or from the public and private data providers. In cases when real-time data is missing traffic modeling based on statistical data can be performed in order to estimate the traffic volume at different road segments and take this information in consideration while computing journey plan or routing.

Furthermore, to make transportation of the Issy-les-Moulineaux citizens more efficient the journey plan can include some extra information except just the public transportation routes such as the information about parking lots and Velib’/Autolib’ docks. So the user can see for example opportunities to go certain portion of the trip by car then park car in a certain place where there are free parking slots and switch to public transport or for instance go by public transport to certain place and then switch to bicycle in the place of Velib’ dock through the intermodal journey planner.

The solution will rely a lot on VGI as well on developing some ways to effectively and promptly share the information between the users of the platform. One such way can be sending to user an SMS notification if there is a traffic accident on the route he has selected in intermodal journey planner. Also all major accidents inputted by users can be twitted through Twitter social network.

**Liberec Region**

Liberec Region will try to utilise the OTN project mostly for routing rescuers during the emergency situations such as flooding. At first, the road network should be extended by field and forest tracks. Then some sources of real time data related to traffic will be connected to the project database. Possible sources of real time data can include:

- the Czech Hydrometeorological Institute about weather and hydrological conditions at various hydrometeorological stations throughout the country,
- the Road and Motorway Directorate of Czech Republic that provides the actual data about the traffic conditions (ongoing road-works, traffic accidents, traffic jams etc.),
- VGI from data volunteers of the platform.

All these factors need to be taken into account to provide rescuers with as precise routing as possible. The cost of delay in an emergency situation can be high.

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1 OTN D2.4 Co-Design Workshop Reports. OTN Consortium 2014.
Traffic Volumes

There is one computation which metaphorically speaking stands behind and not so obvious however needs to be performed as a part of many ordinary tasks such as routing to improve the quality of the results. That is estimating of the traffic volumes. In Antwerp where there is a need to take some measures (which were already mentioned such as change in public transport, arrange more parking lots, improve cycling infrastructure) against the traffic jams that could happen as a result of multiple road closures due to planned roadworks, there is a strong need to assess traffic volumes and their redistribution over the network in a result of roads closure. In Birmingham, there is a need to analyse factors influencing the location of traffic accidents. An example of such factor can be high traffic volumes at certain road segments. In Issy-les-Moulineaux and Liberec the need of the traffic modelling is not so obvious because the pilots are mainly dealing with real time data. However, the traffic volumes models can be used to assess the situation on the transport network and to improve quality of the routing service.

In order to compute traffic volumes there is need to have well described traffic network. Such a traffic network has to be topologically clean and with correctly described edges and turns in junctions – to allow routing (see for example the INSPIRE Data Specification on Transport Network2). Good to know the traffic volumes is particularly true in densely populated areas with big traffic. It is a parameter of a road network, which describes an amount of vehicles which go through a network segment in a period of time. Together with an information about the maximum capacity of network segments, it can be forecasted where the volume of traffic is going to cause traffic disruptions and traffic jams. We can distinguish three types of traffic volumes:

- daily traffic volume (different for each week day, from Monday to Sunday),
- annual average of daily traffic volume,
- peak traffic volume – in the busiest hour of the day.

A long term predictions can be made, calculating the traffic volumes 10, 20 or even 30 years into the future.

• Input data and parameters

In general, there are three basic types of data necessary for traffic volume calculation:

- Traffic generators - demographic data about places (usually represented as points). These points can be cities, city districts or building blocks - it depends on the granularity of the data and desired detail. These data are used for estimation of traffic flows in the network. Distinguishing between different types of places (living, industrial, service or shopping place) is useful for estimation of traffic flows directions changes in time.
- Road network - well defined and topologically correct road network is the fundamental constraining graph structure, which describes the allowed movements between different places.
- Calibration measurements - physical measurements of traffic volumes (traffic censes) at particular spots of the traffic network are then used for calibration of calculated volumes.

• **Process of traffic volume calculation**

There exist several tools for traffic modelling. For example EMME, CUBE, PTV VISUM, SATURN, TRANSCAD or OmniTrans. All of them are based on similar principles:

− First of all, the road network topology has to be checked (deleting pseudonodes, cleaning gaps and overlaps). Then junctions are computed and turns defined.
− Then, as the places do not have to lie exactly on a network segment, a connector from each place to the nearest network part (junction or segment) is created. The defined crossing with the network represents a point, in which the people enter the network and generate the traffic.

The two above described points are usually realised in a geographic information system (GIS). The following steps are calculated in a transport engineering software:

− Using the demographic data about traffic generators, various types of traffic volumes are calculated (see for example 3 for more details). This step produces relative volumes – it can be seen which road segment has higher traffic volume than the other.
− Afterwards, those relative volumes are calibrated on absolute values from traffic censes.
− The final step is an export from a transportation software to a GIS, where the data can be visualised or used together with the rest of geographic data.

**Traffic Volumes in OTN**

Above described peak and daily traffic volumes are useful for crisis management (Liberec Region), ordinary routing (Issy-les-Moulineaux), road safety analysis (Birmingham) and redirecting of traffic flows (Anwerpen). Furthermore, city network reconstructions as well as urban planning can take advantage of long term traffic volume predictions. Therefore, various types of traffic volumes are going to be calculated in the OTN project, as it is a unifying theme which naturally interconnects all four pilots. As the project is still in an early phase (started in February 2014), only a demonstration of traffic volume calculation was prepared.

• **Traffic network ready for traffic volume calculation**

Basic settlement units (source ArcČR 5004) and a road network from the Road Databank of the Czech Republic were used for the demonstration. The road network is topologically correct with well-defined junctions. First of all, the connectors were calculated (see Figure A).

• **Traffic volumes calculated on the road network**

The prepared data were imported into the OmniTrans software. Then the annual and daily volumes were calculated. See Figure B for comparison of volumes for different week days as an example of time variability of the volumes.

The difference of the traffic volume in an average day hour and a peak hour can be portrayed to see, which road segments are heavily affected by traffic peaks (Figure C).

Other visualisations can be created. For example a visualisation comparing calculated traffic volumes with the maximum traffic capacity of each segment can detect potential traffic delays and traffic jams. Using long term traffic volumes predictions in in urban planning can dramatically improve the quality of live in a city or a region.

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Figure A: Road network (black lines), places (black triangles) and connectors (red lines).

Figure B: Saturday (yellow), regular working day (green), Friday (blue) traffic volumes displayed using the line segment width.
Conclusion

In the article it has been described the main goals of OTN project in the pilot cities and basics of using traffic volumes. Including traffic volumes into computations could significantly improve quality of the results of certain operations (routing computation, modeling traffic redirection for instance) as well as help to get deeper understanding of events related to traffic (for instance traffic accidents). The article will be followed by the practical work on reaching the goals put by the pilots. Based on the achieved results it will be possible to do the real assessment of benefits using the traffic volumes in such computations.

Attribution

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WinGIS SDK – GIS Software for ICT Developers

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Abstract

PROGIS Software GmbH enables ICT developers to link the Geospatial Engine WinGIS, in combination with the embedded Bing Maps module to any database application based on the ActiveX developer component AXWinGIS. WinGIS provides a wide range of GIS functionalities, modules (thematic maps, ISO module, GPS modules, geocoding module) and interfaces (import / export / GPS / WMS). This is a unique solution, bringing together the advantages of an easy to use, cost efficient and versatile GIS software - WinGIS - and the outstanding potential of Microsoft products and online services like Bing Maps.

WinGIS – Geographic Information System

The GIS software WinGIS is the core product of PROGIS GmbH and central part of all PROGIS applications. Due to the integration of MS BING maps online data as embedded module, the access to geographic content like satellite- and high-resolution aerial images, road and terrain maps and services like address conversion (geocoding of addresses also for entire databases in a single step) is part of the software.

The ortho-images are area-wide available for the USA und Western Europe with a resolution of 30 cm per pixel. The acquisition of new images in other regions can be done on project basis. This type of images is certified by the EU-JRC for agricultural use. In addition, MS Bing Maps provides worldwide available satellite images with a resolution up to 1-2 m per pixel and road/terrain maps from Nokia (former NAVTEQ maps).

The access to online data in WinGIS is not only limited to MS Bing Maps. There is also the possibility to integrate map content via Web Map Services (WMS). Vector data interfaces allows the exchange with other GIS and CAD systems (e.g. ESRI ArcView SHP files or AutoCAD DXF files). Building up and editing vector data like LPIS (Land Parcel Information System) or cadastre maps can be done in several ways: Digitizing on the basis of ortho-images, import of existing spatial data or via interfaces to GPS, GLONASS, Galileo devices.

The creation and editing of maps can also be done in the multi-user mode. Attribute data are either stored in the WinGIS Internal Database (IDB) or in external databases like MS Access or MS SQL Server.

Modules for thematic maps and ISO-models give extended visualisation and interpretation of data.

Further, WinGIS maps can be published in different ways on web platforms: Overlay of vector maps with MS Bing Maps web control or export of maps in KML format to combine them with Google Maps/Earth.
The Bing Maps online address database enables the WinGIS integrated Geocoder module to convert an address information (e.g. city, street, street number) to the corresponding coordinate (address search). The Bing Maps DB-Geocoder module converts addresses of entire database tables to the corresponding coordinates. After selection of the database (e.g. MS Access .mdb file), the table and the query fields (e.g. street, city, country), for every record an online transaction converts the address to a coordinate and adds X and Y fields to the table. Therefore you get an easy and efficient possibility to locate and visualize your personal database content (e.g. customer databases).

AXWinGIS – Developer Component

The WinGIS SDK gives software developers the possibility to link and integrate the geographic component to their existing applications via ActiveX and COM interfaces.

PROGIS enables ICT developers to link the GIS software WinGIS, in combination with the embedded Bing Maps module to any database application based on the ActiveX developer component AXWinGIS. WinGIS provides a wide range of GIS functionalities, modules (thematic maps, ISO module, GPS modules, geocoding module) and interfaces (import / export / GPS). This is a worldwide unique solution, bringing together the advantages of an easy to use, cost efficient and versatile GIS software - WinGIS - and the outstanding potential of Microsoft (database) products and online services like Bing Maps.

The ActiveX component AXWinGIS enables the communication between an application and WinGIS. The whole function set and every menu entry can be called directly from the application. The communication works bidirectional. Events in WinGIS (e.g. the selection of an area) are sent to the application and can be related to the corresponding database entries (attribute information).
WinGIS Canvas – Direct integration of a WinGIS map in the user interface of an application

WinGIS can run as an independent program with the full available user interface (menus, toolbars) beside the application, but also as an embedded map control („Canvas“). In the user interface of the application a region or window control (e.g. panel) is reserved for the map. By calling the according AXWinGIS function, the visualization of the map takes place on the defined region of the application window.

Products and Projects

- AGROOffice DokuPlant
- LoGIStics
- PipeGIS
- EnvirOffice
- BAU-MATIC
- TREE-MATIC
- Z-GIS Land Consolidation
- OIS – Object Information System for fire brigades
• PROGIS MapServer
• GeoINFOtainment und geo marketing projects
• and many more
• WHERE IS YOUR APPLICATION?
ICTs Improving Family Farming

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Abstract

At the recent Agrifuture Days 2014 Conference held at Villach, Austria 130 participants from 35 countries discussed “Information and Communications Technologies Improving Family Farming”.

They considered the directions family farming across the world was evolving, the development in Information and Communications Technologies (ICTs), the impact these trends are having on farming and agriculture and the ICT related needs especially of resource poor family farmers. The participants recommended the following for ICTs to improve family farming:

• Policies promoting and enabling aggregation of family farmers and farming systems such as through cooperatives, producer organizations, farmer organizations etc.

ICTs can contribute to “virtual” aggregation of farms, synchronization of farm inputs, processes, outputs and logistics to participate in markets.

• New Forms of advisory and support systems for knowledge, skills and technology.

ICTs can enable access to just-in-time information for decision support and action.

• Trust Centers with Data and Information Agreements, Treaties with regulatory and enforcement mechanisms to share data at various levels and among multiple categories of users from plot, farm, farming system, region, national to global agricultural and related systems.

With the emergence of big data, cloud computing and advanced analytics, new issues and concerns on privacy, security, intellectual and property rights, values, ethics etc. are emerging in data and information management related to agriculture and farming. This will need transforming existing and developing new Institutional arrangements at various levels for data and information.

• New business-models that integrate governments, farmers and banks, insurance, market intermediaries, cooperatives etc. for participation in markets

• Inclusive governance of flow of data, information, knowledge, skills and technology

• Inclusive development of standards

• Open Technologies – Open data, information, knowledge, learning
• Increased democratization of science, learning and support to exponential innovation
• Lower cost of Hardware, infrastructure and connectivity

This paper presents the discussions that resulted in the above recommendations at the Agrifuture Days 2014 Conference.

Introduction

At the recent Agrifuture Days 2014 Conference held at Villach, Austria, 130 participants from 35 countries discussed “Information and Communications Technologies Improving Family Farming” as a topic through expression of their research findings and collective, experiences, opinions and knowledge on trends and disruptions influencing:

• Family farming in different parts of the world which in general reflected trends globally
• Development of information and communications technologies, especially those influencing agriculture
• Family farming in the future that can be improved by the developments in information and communications technologies

From this, they considered issues that are and would emerge for policy, Institutions, organizations, use of technology, in particular Information and Communications Technologies (ICTs), and the participation by agricultural and related communities in improving family farming.

Current status of family farming

Family farming of the present was under severe threat. Incomes from family farming are on decline. The youth from farming families are reluctant to take up farming as a vocation. Family farmers faced difficulties and are challenged in their ability to participate in markets, by change in climate and severe weather aberrations, loss, degradation and difficult access to land, water and other inputs for farming and loss of biodiversity which affected their livelihoods. Their access to new information, knowledge, skills and technology that was useful to their farming was being continuously eroded and reduced increasing their isolation from economic, social, political and technological change. In general, family farmers across the world are abandoning their traditional livelihoods and their numbers are diminishing rapidly. However, even with the current decreases, family farming will remain a livelihood for a majority of rural people for the foreseeable future till 2030 and after.

Though family farming has many commonalities across the world, when scrutinized they face heterogeneous and different conditions such as in crops grown, size of farms, government policies, access to new knowledge and technology etc., in each region, country and community. This entails that the applications of ICTs will need to be adopted and adapted for local conditions and their effective use.
The trends in family farming were:

• Aggregation of farmers / Further disaggregation (Breakdown of traditional communities and families)

• Increased market participation but also isolation from markets

• More complex food chains / Reemergence of simple food chains

• Access to massive data/information with capacities to process and use but also can cause new forms of inequities and information conflicts/Lack of capacities to learn and use information effectively and to adopt/adapt to change

• Increased more equal availability and access to affordable, safe, high quality, nutritious, healthy food but also reduced availability and access to adequate, wholesome, nutritious food for some individuals, households and communities.

• Agriculture as a polluter, major extractor of natural resources, contributor to greenhouse gases causing climate change and environmental degradation but also as a means, mitigating directly and indirectly climate change, for environmental protection and its rejuvenation.

• Greater recognition of farmer and farming services for protecting environment, heritage and quality of life

The future of family farming

There are several scenarios that may happen, with current trends, for family farming in the future. Family farming could end up into:

1. Rural poles of farms and farming linked to complex agri-food chains,

2. Continuum of rural-urban multifunctional systems of activities linked to local markets of diversified products,

3. Agro-industrial systems of activity linked to global markets of standardised products

4. Marginalized family farms in abandoned rural areas.

One or several of these scenarios (Bourgeois and Ferrand 2014) may exist or co-exist in a country or region depending upon policies implemented by governments.
Application of ICTs could influence the emergence and the function of underlying systems that support the above scenarios. Vice-versa the emergence of these scenarios could influence the application and use of ICTs. For example, rural poles with complex agri-food chains for agricultural commodities used as industrial and manufacturing feedstock and food would benefit from ICTs automation, robotics, integrated farm management systems and traceability systems and this scenario may drive the emergence and rapid development of these ICTs. Rural-urban systems could benefit significantly from information systems that enable educating producers and consumers on linkages between production and consumption in terms of resources used, wastage, ecosystem conservation and community participation. Similarly, large agro-industrial systems would greatly benefit from ICTs that can monitor and support decision making at various levels as also automate many human labour intensive farming functions.

An important question is whether ICTs can contribute to reducing marginalization of family farming and abandonment of rural areas by these farmers. These farmers also play a vital role in preserving cultural heritage and ecosystems that enhance the quality of life of urban areas, a role that is not yet fully recognized by society and such marginalization and abandonment of family farming could have disastrous consequences for the society.
**Trends in ICTs**

The trends in ICT were identified by participants as:

- Exponential increase in computing power, memory, storage, capability (Moore’s Law) with lowering of costs
- Near-ubiquity of mobile computing
- Spread of broadband connectivity
- More big/open/real-time data
- More Cloud for data and apps
- Content Co-Generation
- Predictive Analytics and decision support systems
- Semantic Web
- Wearable Computers
- Internet of Things
- Telematics, Geographic information Systems with location services and more precise, real time earth observations
- Use of field sensors/embedded computing
- More and new social media
- More crowd-sourcing models
- 3D printing
- Visualization
- Automation, Linked Tools and Processes, Robotics
- Drones
- More smart phones and tablets
**ICTs that are currently impacting agriculture**

The ICTs currently impacting agriculture were identified by participants as:

- Automation, Robotics, Autonomous, Linked Tools, Equipment and Process Monitoring,
- Wearable Computing
- Controller Area Networking/Sensor Networks/Grid Computing
- Big data at different scales from field, farm to global
- Farm Management Information System
- Global Positioning System – Multi satellite
- Drones and Low cost Satellites/Micro satellites
- More precise geo-spatial data and 3D maps with elevation information
- Humidity, Ambient Environment and Soil Nutrient sensors
- Photometry
- Visualization and Integrated Display
- Social Media, MOOCs, Online Learning
- Rural access to online financial services
- Traceability systems using low cost RFIDs, NFC and other new technologies
- Telematics
- Variable rate Irrigation/Fertigation and prescriptive planting
- Weed, Biodiversity and Pest Management through Integrated systems

The current centrality of the Smartphone with mobile connectivity and access to cloud based data and applications are bringing to new and innovative knowledge based services to rural communities.

The uses of these ICTs individually and with other ICTs in systems are resulting in complex applications to improve productivity, resource use, reduce time and drudgery such as for farm management, forecasting, marketing, logistics and quality assurance. ICTs are increasingly improving access to information, knowledge, skills and technology for farmers and their communities, improving farm productivity and ability to participate in markets and in
contributing to increased sustainability and resilience of farming systems while transforming them to meet new challenges.

There are fresh trends not only in digital ICTs but in all ICTs such as print media and in learning. There were also trends such as in the democratization of science and education that enabled increasing flow of new information and learning to family farmers. This could be harnessed and lead to an exponential increase in innovation and capacity to adopt and adapt new ideas, skills and technologies to improve family farming.

**Key ICT drivers currently influencing Agriculture**

A range of ICT drivers impact on a wide array of agricultural finance, credit, market, weather, aging population, cultural changes, energy cost, risk management, quality and safety assurance and other services for agriculture that are delivered by public, private and community organizations. These bring new forms and types of services. The key drivers are:

- Pervasive Computing
- Low Cost Connectivity
- Massive Processing Power through “Cloud” based computing
- Shareable tools, applications and intelligently linked content and data
- Mobile devices with multi-sensory inputs and outputs
- Ability to collect, analyze and reuse massive, distributed collections of data
- Ability of individuals and “amateurs” to create, manage and draw inferences from sophisticated information and learn
- Interactions of ICTs with biology, biotechnology, nanotechnology, space technology and materials science. These interactions are leading to development of high quality information from diverse entities and sources leading to new perspectives, concepts and innovation. The interactions and the information emerging from them is many a times self-organizing.

Pervasive computing, low cost connectivity along agri-food chains through a wide range of devices and platforms to access and use data, information and knowledge already contribute to increasingly knowledge-rich environments for agri-food chains. The use of mobile phones and other mobile devices as interfaces to connecting in these environments is now well documented. In future, multiple connectivity paths using devices different from those seen today will provide not only more but different connectivity than we see today.

Sensor sharing data and linked to Decision Support Systems and Geographical Information systems now enable monitor soils, weather, market and crop/livestock conditions and digital signatures and labels to track inputs and products from producer to consumer. In future, applications will come in many new shapes and sizes to suit even the most specialized needs.
Increasingly accessible data and information from public institutions, communities and individuals are becoming visible, publicly accessible and re-useable at the click of a device, many a times which is mobile, removing the constraints of location and bringing greater inclusion in their use. This is leading to need for and development of intermediary skills and applications to enable effective harvesting, making sense and adds value from this data and information for agricultural systems.

Increasingly interconnected knowledge bases and diverse sets of tools and applications available through digital clouds and as mentioned earlier made accessible and useable across different devices from any location are enabling collaboration across boundaries as never before. Different communities are starting to connect and share their knowledge with each other, along value chains and across disciplines in new forms of innovation chains with wider actors including farmers, processors, traders and politicians enhancing innovation processes and their rapid spread.

As a result, pervasive computing, low-cost connectivity, massive computing power accessible through cloud computing with shareable tools, applications and intelligently linked content and data will provide individuals and communities ability to create and manage sophisticated information and knowledge. This “democratization” of science will draw actual farmers/producers and other agri-food chain actors into agricultural research, innovation and development processes. This could transform the entire structure of agricultural research and innovation systems and lead to an exponential increase in innovation (Maru 2014).

Indeed, much of the data in future will be generated and shared by communities. For farming and agriculture, this will be by agricultural communities who contribute to agricultural commodity chains from input, farming, processing, marketing to consumption. Fields and farms and all the processes in between will generate huge sets of data, “big” data that will need to be processed many a times instantaneously.

ICTs together with bio and nanotechnology, space technology and materials sciences are now defining the core direction of agricultural science, research, innovation, technology and development and opening hitherto unexplored new directions. This will intensify in the foreseeable future till replaced by new approaches and disciplines.

**ICTs impacts on agriculture**

How these drivers will develop and combine in the future will have an impact on agriculture. More investigation is needed but among expected impacts the following are highlighted:

- **Lower Food and Agricultural Commodity Prices**
  - Through lowered input, throughput and harvesting costs through more efficient supply chains and reduced wastage
  - Improved Farmer and Farm Information System
  - Sensors and equipment linked to GPS systems linked through sensor networks and Internet of Things enabling more precise decision support systems, modeling and simulation for planning, monitoring, optimization and forecasting and automation
• Safe Foods
  o Labeling, Traceability and Identity preservation
  o Safer handling, processing and transport of agricultural products, especially food
  o Monitoring of Food Production in Farms for safety
  o Reduction in Human interventions and possible contamination through robotics and automation

• Decreasing energy and chemical consumption
  o Improving farm, processing and marketing logistics
  o Optimization of labor and machinery use
  o Optimizing utilization of energy, fertilizers, pesticides, herbicides, water and packaging

• Healthy and Nutritious Foods
  o Farm information Systems for monitoring good agricultural practices including those for inputs, crop management and harvesting
  o Monitoring of quality and safety during transport, processing and storage
  o Enabling logistics for “Just-in-Time” delivery of foods to consumers

• Socio-political and Cultural
  o Taxation and Subsidies
  o Policies, Legislation and Regulations for cost, quality and safety of foods
  o Cultural preferences, authenticity assurance and reduction in waste
  o Animal welfare and ethically produced food
  o Environment/Ecology and pollution
  o Trade, local, national and international
Possible disruptions to trends

The possible disruption to the trends in farming and use of ICTs include:

- Health scares (food, environment)
- Trade disruptions and exclusions (Non-tariff, tariff, political, market failures)
- Political upheavals
- Information conflicts
- Other Resource conflicts (water, land)
- Developments in other technologies such as Nanotechnologies, Materials, Biotechnology, Space Technology
- Emergence of alternative socio-economic values to short-term profit and productivity
- Counter Movements such as for privacy and against intellectual property rights

Needs of Family Farmers for improving their Farming Systems through ICTs

The various trends (and possible disruptions) in family farming and ICTs, their possible scenarios and the key driving forces, equitable participation in fair and just markets and the need for learning to learn and effectively use knowledge, skills and technology for continuously adapting and improving family farming to emerging challenges indicate that family farmers for improving their farming systems through ICTs need:

- Policies promoting and enabling aggregation of family farmers and farming systems such as through cooperatives, producer organizations, farmer organizations etc.
  
  ICTs can contribute to “virtual” aggregation of farms, synchronization of farm inputs, processes, outputs and logistics to participate in markets.
- New Forms of advisory and support systems for knowledge, skills and technology.
  
  ICTs can enable access to just-in-time information for decision support and action.
- Trust Centers with Data and Information Agreements, Treaties with regulatory and enforcement mechanisms to share data at various levels and among multiple categories of users from plot, farm, farming system, region, national to global agricultural and related systems.

With the emergence of big data, cloud computing and advanced analytics, new issues and concerns on privacy, security, intellectual and property rights, values, ethics etc. are emerging in data and information management related to agriculture and farming. This will need
transforming existing and developing new Institutional arrangements at various levels for data and information.

- New business-models that integrate governments, farmers and banks, insurance, market intermediaries, cooperatives etc. for participation in markets
- Inclusive governance of flow of data, information, knowledge, skills and technology
- Inclusive development of standards
- Open Technologies – Open data, information, knowledge, learning
- Increased democratization of science, learning and support to exponential innovation
- Lower cost of Hardware, infrastructure and connectivity

There are several dimensions in fulfilling these needs such as for investment through public, private, crowd and community, infrastructure such as for data, applications, analytics, hardware, software and connectivity, content, integration of data, information, information systems and applications and governance.

These needs have to be considered together and actions taken to be holistically addressed to yield benefits to family farmers. They cautioned that action on only one or two items, as it usually happens, may not have beneficial results.

**Summary**

To contribute to improving smallholder family farming, ICTs should make agriculture more knowledge driven and:

1. Enable family farmers to participate equitably and as entrepreneurs in markets that are just and fair.
2. Reduce transaction costs, wastage, improve quality, save time and decrease drudgery.
3. Enable and involve the private sector, especially small, medium entrepreneurs and public sector agricultural research and extension services in partnership to provide knowledge based services for these farmers.
4. Enable gender and youth to access and share information and participate and engage effectively in all aspects of decision making in their farming and related livelihoods.
5. Enable and support small holder farmers to aggregate into cooperatives, producer companies and organizations with similar functions
6. Support these farmers to continuously innovate their farming and participate in research
7. Help formulate policies, change Institutions, their structures and work processes to effectively generate, manage and use information and ICTs in farming.
References


Sustainable intensification, integrated technology support, cooperation of stakeholders – the way forward – but how?

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Abstract

1926 Austrian’s economist Schumpeter explained “Creative Destruction” - based on innovation. Don’t we have today a situation where we know that methods beloved by structures do not work or better do not work sustainable? Nevertheless we keep on doing it! GFAR’s, the Global Forum of Agricultural Research of the United Nations’, senior foresight expert Robin Bourgeois created 2013 the word “Destructive Creation” as a more soft method – like the difference between revolution and evolution. Europeans RISE foundation told about large scale ecosystem destruction the last 150 years – sorry, we are just sitting here after such a comment and nobody cries out loudly - and about the urgent need of sustainable intensification to improve productivity and environment management parallel. All these facts show, a fast change is a must and it supports all since years told, developed, installed and verified PROGIS’ concepts: (1) integrate latest technologies, (2) cooperation of all chain-stakeholders, (3) public-private-partnership-models supporting infrastructures as orthoimages or access to weather-data for all stakeholders, (4) support creativity and power of farmers as entrepreneurs and (5) accept private ownership of ground and of information of this land, (6) cooperate with experts and setup of competitive advisory services, (7) trust centers as neutral support to hold needed data in a trustful manner and no data-grabbing, …. When in their latest findings experts tell, we need “more knowledge per ha” or the agro-chair of SAP tells at our last conference, ICT means “Intelligent Cooperative Technology”, we at PROGIS feel the need now to explain based on all findings of the last decade, supported by our ICT concepts and accepted by a growing number of users and accompanying experts, not only that in the future sustainable intensification models for economic, environmental and social targets are needed but also how they can be implemented. Important as one of the fundamentals – one must respect local farmer’s knowledge in the same manner as that of local experts and experts from International organizations, NGOs or Universities. If more knowledge per ha is requested, we need all sides. Top down knowledge must be made easily access-able and made available also for farmers, supported by latest technologies and farmers know how must not be collected under “information is power” targets to create monopoles – we need diversity, bio-diversity! Farmers need entrepreneurial freedom to use it to the best of the farm. Parallel we have to create a model of social responsibility of farmers for a sustainable development and value and compensate the work. In many cases collaborative and cooperative working will be needed. For implementation, governments have to set legal frameworks protecting farmers that outside influences do not disturb their sustainable work and assure also sustainable developments in all sectors – not only on farms. If not, farmers will find them in a Sisyphus work being responsible for sustainability of big parts of the Earth but get crossfire by negative immision arriving from outside. The farmers are able to do the job, need holistic advise separated clearly from the sales process and supported by a hierarchy of higher expertise. ICT will be THE supportive and integrating, technology to overcome guessing from the past or the saying “take a little more, fertilizer, feed, pesticide” and move it to precise, knowledge based answers. How to implement this in a way that economic, ecologic and social targets are supported? I will try to show it on the next pages!
Since years PROGIS developed technology for farmers, foresters, for environment- and risk-management and always tried to have a long term target instead of short term success in mind that supports beside further development of our own technologies also the integration of different technologies as well as also integrated a deep understanding of stakeholder’s needs and their processes.

WinGIS

Starting with one of the first object oriented GIS (Geographical Information System) systems, fast, powerful and easy to use with an internal database and with an SDK (Software Development Kit) that allows every database developer to link via AX his database application, SQL, Access or any other to our spatial engine “WinGIS” and make a GIS out of it. The basic idea at this time was easy: We have many more database developers on the world and want to enable them to use “geography” as on form of information beside many others. First we struggled for years. We simply had, not technologically but in organizational manner, no data available. The owners of geo-data kept their monopoles alive! Microsoft did in the meantime a Western Europe- and US-wide EC/JRC certified 30cm orthoimage-map. The rest of the globe contains 1-2m satellite images; also Google or Russian Yandex maps or any other WMS (Web Map Service) based map can be used. Users can start immediately to work as the GIS comes with a globe. If elsewhere better images or also vector-data are available they can be imported via shapes, DXF or other formats or accessed as WMS-service. The answer of EC-countries was different. Some, like SF, gave free access to their images, others created 25cm images to keep their monopoles alive. A GIS with an easy user-interface - WinGIS - is used by educated farmers or advisors to set a first step: To import/digitize LPIS – Land Parcel Information System – to know the field, the polygon and its size is owned or rented by whom. In some countries cadaster data can be imported. Beside fields available soil- or geological-maps, weather-data etc. can be implemented too. If not available it should be developed to allow better decisions, e.g.: On which soil and at which climate which crop should be grown with which crop rotation? It can tell moisture and weather forecast for irrigation needs? Easy access- and distribute-able satellite chlorophyll-maps can tell where how much to fertilize? Farmers need this information on their smart-phone. Some of these we can’t do small to get reasonable priced information!

THE ECONOMIC ELEMENT OF MANAGING RURAL AREAS

DokuPlant – a farm management and advisory service tool:

After this first step, PROGIS developed around 20 applications as well as integrated a complete new concept within, that allows the typical GIS functionalities like ‘geography, vector or raster and database to link as well as linked a time- and activity-planning module and an expert module that allows to integrate local expert data in cooperation with local experts from institutes, Universities etc.
Fig 1: Expert data provided from local experts supported by DokuPlant Admin

These (1) expert data are (1/1) all agriculture machines and their performances (we cooperated with the German KTBL – 2500 machines), (1/2) organic- and inorganic fertilizer incl. their nutrients (we cooperated within a 2 years project with a German scientific institute that supported the project with data also of all organic deposits on the field and their nutrient contents – 2500 fertilizer), (1/3) further we managed to integrate 850 in Germany allowed pesticides with their chemical substances and (1/4) all the 25,000 seeds and varieties accredited in Germany. In total this were around 30,000 datasets. Based on this primary datasets we (2) organized also with experts datasets of growth models that (2/1) plan all the activities and the used resources from the expert data and later after planning (2/2) enter – either via key-board or via interface also from a machine – the execution. Naturally every difference between plan and realization is protocolled. Today our expert model for Germany/Austria contains around 400 crops and methods.
Fig 2: DokuPlant manages where, what, when and expert data (agro, forest, environment, natural risks)

All the datasets integrate (1) all needed and time related costs and with their help automatically a cost calculation can be done without entering any number. Important is the sustainable upgrade of the datasets by the expert team(s), but this is needed only once within a country and can be distributed very easy via internet. Beside the costs for a field or a farm an advisory module allows to manage hundreds of farms within one DokuPlant summarize the data via specific modules for regions and/or even countries. I a country e.g. has 10.000 advisors that are managing each 500 smallholder farms in total 500.000 farms with all their data are summarized available.

We have to understand that only such a bottom up approach allows to get the data in a right manner as at the begin of a season or year only the farmer knows where – on which field - to grow what. Beside the general easy to use technology with the expert model we have one giant advantage: We can plan with one click resp. drag and drop: Here – on this field I grow that – a crop from the database. For a farmer with ten fields ten clicks – everything is planned if the field polygons are once digitized within 5 minutes.

DokuPlant – a subsidy management tool:

When we have the data available as mentioned above we have many more possibilities to work with this data; e.g. (1) to link a subsidy module that tells when farmers are growing a specific crop the get a specific subsidy/ha. It can be automatically done and sent to a Ministry server. The subsidy module has to be programmed according the local needs as well and can be integrated. Programming can be done by a local software team.
**DokuPlant – a nutrient balance tool:**

(2) As beside costs also the nutrients are managed for N, P, K, Ca, and Mg a nutrient balance is easy to be planned and or protocolled as every step automatically with the expert data behind is calculated and as result a nutrient balance shows up; again – for every field, a group of fields, a farm, a group of farms in a specific geographic region or even for a country if the data will be summarized on a server. Also this expert data set can be used and by local experts modified.

**DokuPlant regional – managing complete regions:**

(3) Is a tool where advisors or group of advisors are able to make regional statistics selecting across all mentioned parameters in the database and/or in the geography and get the output beside numbers also in form of business diagrams.

**DokuPlant – a carbon- and/or energy management tool:**

(4) At the moment we work on a carbon module that will allow document the whole carbon situation. The fundamental concept for a country covering solution is simple: Take ICT software as our Doku-Plant for agriculture and every flow of work is pre-calculated at the planning stage and later on protocolled and controlled. This is in any case necessary for business planning and controlling, for a calculation regarding costs and returns, for nutrient-balances, for humus-balances or also for quality certification. Every work has influence on carbon! Tractor and other agricultural machines have an emission from the production in relation to the life-long-working hours or also per fuel consumption, further a manure distribution enters carbon into the soil, afforestation or thinning brings measurable more cubic-meter per ha etc. For all these single parameters data are available and have to be collected – thousands of data - if missing, the parameters can be surveyed. PROGIS has science partners who are able to do this in detail and they also have collected many of these data during the last decades. Together with a German partner, a scientific institute - we did already years ago the nutrient balances for N, P, K and Mg; they have experience for 20 years in agricultural carbon balances as well as a forest consulting-office is also able to develop growth tables for specific tree sorts together with local experts if such tables are not available.
Fig 3: Carbon balance, nutrient balance, cost calculation, subsidies, ..... – a one stop shop

With these input parameters suddenly everything is calculate-able – for a field, a meadow, a forest department etc., naturally also for a farm in total as well as via farmers or advisors or any combination of it for a complete country. If not the overall country is covered this is only valid for the farmers taking part in such a project. CO2 buffering becomes visible, can be planned and calculated, can be linked to subsidies – and all this without big amount of additional work.

DokuPlant – a forest management tool – Forest-Office:

4: Forest inventory & forest management
At the moment we have with Forest-Office also a forest-inventory, forest-planning and forest-management tool that has as expert model tree-growth tables integrated that tell in form of absolute yield power (Absolut-Bonität) that shows at natural growth conditions like specific sites depending on geology, soil, climate etc. at which age which height is reached and followed how many m³/ha can grow as well as the growth rate for the next decade. With the help of this tables and height measurements as well as Relaskop measurements that tell the difference between standpoint and tables, the data can be gathered with statistical samplings very fast and precise calculated. If data resp. tables for the different species are available we can integrate them, if not such tables have to be developed together with local forest experts. Beside yearly cutting assessment also detailed harvest planning incl. all calculations or even a carbon balance are possible.

DokuPlant - the fundament for digital contracting:

As within DokuPlant all single activities are planned also digital contracts can be send to partners within the chain, e.g. to a service company where, on which field incl. GIS plan, has to be done what. When the receiver has a so called mobGIS he can receive the dataset and the sender gets later automatically a protocol when the machine is working on his field incl. at the end a bill of the work incl. the also GIS based protocol (more details see at our logistic module).

THE ECOLOGIC ELEMENT OF MANAGING RURAL AREAS

Beside the production of crops and/or logs, farmers produce also any amount of services where the farmer but also we all benefit from. Under the economic pressure during the last decades farmers and we all forgot that these services do not come all automatically, many of them have to be managed as well. Again, experts are able to define them together with farmers – they have from a big pot of existing ecological elements that can be optimized to be defined with local targets. I is clear that we want to have a green globe but the way how we achieve the target will be region for region different, and the priorities and the values of importance when and which targets should be reached have to be calculated. When the reader reminds that with DokuPlant every activity for a specific crop has to be managed and every activity has to have a specific value, for e.g. carbon- or for an environmental- or even for a risk-management target. The main environmental goals will be related to soil erosion, soil organic matter (carbon!), nitrogen balance, leaching or runoff of pesticides or of N/P/K, soil cover, air emissions, energy balance, GHG emissions, landscape elements, water use, farmland birds and bees and other animals; locally there might be additional targets beside the above mentioned.

These expert modules again have to be implemented and if beside the standard crop management additional activities have to be done than a specific activity is defined with its impact – and this is again automatically calculated. Later on it can be verified by experts and farmers can be paid for their work for environmental caretaking or risk-management.

GENERAL NEEDED TECHNOLOGIES

The DokuPlant Admin version

In general it can be told that for all these expert data sets an own Admin version is available that allows to define them define also rules for them as well as symbols how they are displayed later on etc. Experts get these tools for the definition of the expert models.
The Trust Center

When managing with farmers data we have to take into consideration that in many cases we manage data from a private entity; although of there a social responsibility of a private ground exists that does not mean that the data belong to everybody. If we start to split between private ownership of ground and private ownership of data in relation to this piece of land we start to shake on the private ownership in general. In the same manner as Facebook works with the users data to make business many organizations, public and private wants to gather these data, also to make business! There is one way out – a trust center where the farmer is able to define exactly whom he will give the data; if the Ministry wants to have data this has to be regulated with the help of legislation, all other cases can be managed bilaterally.

Trust centers can work out statistically data for other stakeholders, anonymously and if data have to be shared – please bilaterally or legally. The benefit for all of us would be enormous if we are able to implement such trust center structures.

Data rape as partially seen today – although if the sufferer is not aware of it – is something that is not the way forward; it is seen from the public as well as from the private side and shakes on principle democratic structures – the inviolability of private property.

THE STAKEHOLDER COOPERATION TOOLS OF MANAGING RURAL AREAS

LOGISTICS – central unit and mobGIS

Stakeholder cooperation we find in the sector logistics – which machine, also machines that are not the farmer’s one – has to do which job when and where. This module was developed together with the biggest food factory in Europe with 6 factories and 40,000 farmers with 100,000 fields linked to it and hundreds of machines – all guided by 45 logistics central units managed by service offices of the German Machine Cooperatives (250,000 members, 250 offices and 7,5 Mio ha) and hundreds of mobGIS implemented on laptops or palms on the different machines (harvesters, pickups, trucks etc.) - then in a second step it was opened to all other food/feed industries. The whole harvesting process was organized in a manner to optimize the route to the field, to guide the driver to the field and to protocol the work – how many kilometer and how many ha – on the field. This can be managed by a service office like in Germany with additional organizational services or implemented on a server where every mobGIS can be linked and gets the contract via the server without organizational support.
Fig 5: Step by step based on a countrywide infrastructure (ortho-images, weather-stations, advisory licenses) one can setup LPIS (Land Parcel Information System), farm- and/or forest- and/or advisory service management, logistics with stakeholder integration, precision farming with or without service providers and environment- and/or natural risk-management and on top land consolidation with the integration of public and private stakeholders.

PRECISION FARMING AND VIRTUAL FARMING:

With logistics we implemented in a country the communication from an office to mobile devices implemented on machines; as communication we used GPRS/UMTS or in other words the standard telephone line where we could arrange a reasonable priced flat rate for our customers so that the offices were updated all 30 seconds. This was the fundament for two elements: First a stakeholder-cooperation as the use of machinery together with service providers, with the industry with transport organizations and with farmers needs this cooperative model; beside technology also a business model was implemented that satisfied all stakeholders and was fully accepted by the drivers, the key deciders of the acceptance of a technology.

Second the communication between several partners that have been linked to the system: Dokuplant for a contract, a service provider for managing the contract, a machine and driver for fulfillment the contract and closing it at the end and send the finished contract back to the farmer’s Dokuplant. This is also the fundament for the next step – Precision Farming – a technology that allows managing a field site specific as not all the field needs the same treatment: different amount of nutrients here and there and different amount of pesticides and also of water here and there. The data of a precision farming contract can come from the local understanding of a field, from lab analysis of the soil with GPS supported sampling, satellite images with IR data, chlorophyll content data showing the growth or also data from the last harvesting results as well as crop rotation information from Dokuplant or the plan for the next year/season.
A qualified farmer and/or a service provider is able to produce such maps – he will be able to use WinGIS for his work with special functionalities like krigging (make out f point information iso-lines) and can send the map via DokuPlant to either the farmer or directly to a mobile device (mobGIS). This mobGIS either shows the farmer where to do what and he can manage this with an old machine or he has a new machine with a terminal and we transfer the map to the terminal and this triggers the e.g. the sprayer or the manure distributor and after the work done, documents the result back to DokuPlant and stores it for later use.

The key question for the future will be the service provider that really understands his job and is able to provide the farmer with a high quality precision farming map. To get this maps reasonable priced it will be necessary to do it big, otherwise the costs to do it for a few hectares become to high. This is only possible if the government or larger cooperatives are integrated into a business model.

Beside PF we will be able to use, I call it virtual farming, a method, developed by the German agriculture professor Auernhammer, where many farmers integrate their small or bad shaped fields into one field and with precision farming documentation we know where which costs and harvest results showed up and distribute the – increased - income. A virtual land-consolidation method!

ENVIRONMENT- AND/OR RISK-MANAGEMENT - COMPLETE REGIONS

In the chapter “The ecologic element of managing rural areas” we spoke about the method how a farmer also can manage ecological elements within rural regions. When we want now that groups of farmers together with experts and the general society define targets for a region this will have several important impacts:

1. The farmers and the general public come closer and it is understood that the farmers have lots of work to do to achieve targets that everybody needs
(2) The targets itself are together with experts defined and integration of the general public society, so the achieved results will be accepted from everybody and

(3) A payment for the farmers for the achieved targets will be easier possible and people start to understand that lots of work is behind and the payment is not a grant.

The nobel-price winner 2009, Elinor Ostrom found out rules how environmental targets are achieved of original inhabitants of virgin forests – they manage in contrary with us today their environment sustainable. She found out several rules and specified them: Precise defined borders, congruence between rules of acquisition and rules of allocation, local requirements, org-structures for collective decisions, control and penalty, conflict solving mechanism and a minimum organization structure. As she reported that she found similar structures also at cooperatives in Switzerland, I recognized – I am since many years beside my own farm and forest enterprise manager of a cooperative at our mountains with around 120 ha and five farms as owners - that we do the same since > 150 years within this cooperative together with a governmental organization that has the overall control but only interferes if problems occur.

Fig 7: Cooperatives will be THE solution for regional environment- and or risk-management

Now back to the regional targets; a – also virtual – cooperative that works together for one or several specific targets can be founded and many farmers together work then and expert attendance in the direction of these target(s) that had been defined with farmers, experts and general public participation. Something that in the field of land use planning is state of the art since many years.

At the end everybody will be satisfied – the farmers has a better sustainable land with a higher value, the Minister increases the value of his complete country, the experts and farmers get payments and the general public gets services that they expect from farmers to get and that they will need and respect.
Z-GIS – THE LAND CONSOLIDATION TOOL

Together with the Land Consolidation Authority of Lower Austria, the biggest province of Austria around Vienna, we developed Z-GIS, an integration of WinGIS with a several land consolidation applications. The whole process of land consolidation starting (1) from cadaster and ground-book integration, (2) soil quality investigations to verify detailed prices of the land depending on soil qualities, (3) meetings with farmers to show them variants of land consolidation and get their agreement with automatically sent these variants to all participants from a land consolidation project, (4) after feedback the planning of general landscape elements like roads, water, bushes etc. and (5) after the final ok to all needed geodetic measurements and enter the final data into the ground-book and the cadaster. More than 40 land consolidation experts are working since with their mobile and stationary devices to optimize the ownership of fields for the benefits of the farmers and for all of us.

THE SOCIAL ELEMENT OF MANAGING RURAL AREAS

Finally we will also implement also with all these steps a more social sustainability where

- farmers need to get better education with the help of ICT tools,
- due to better communication with the help of ICT tools with the general public more local sourced goods will be sold and
- linked to it working hours and income for farmers will also increase.
- Last but not least also the general public, independent if living in rural areas or living in nearby or far away cities will get lots of benefits like better environment, less risks, higher quality of food etc.
- Today it is also measurable that with closer exposure with the nature better health is supported as well as a much better common sense will suddenly occur again. My feeling is it gets lost today. Just imagine how many sensors are triggered when you are in the nature and how many when you are sitting in front of a TV! Farmers can give to the general population much more then only food, less risks, a nice environment or carbon neutral bioenergy! Also the social impact of a better cooperation as benefit for the overall social structure is deeply embedded into farming.

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Ground Water Monitoring – from EnviroGrids to Alice

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Abstract

EnviroGRIDS was an FP7 project that aims at building capacities in the Black Sea region to use new international standards to gather, store, distribute, analyse, visualise and disseminate crucial information on past, present and future states of the Black Sea region in order to assess its sustainability and vulnerability. To achieve its objectives, EnviroGRIDS built a modern SDI that became one of the components of the Global Earth Observation System of Systems (GEOSS), compatible with the INSPIRE Directive.

The objective of sensors part of EnviroGrids Black See project is to create a system, which would independently monitor the ground water level and thereby enable the optimisation of drawing the ground water from individual pump wells in order to comply with demand of consumers and at the same time ensure protection of the bottomland forest. The network was deployed and fully integrate with URM EnviroGrids portal, which currently become part of GEOS infrastructure. Implementation demonstrate full operational functionality of existing technologies. Network allows to monitor level of ground water and take action, in the case, if level is to low or too high.

The current project ALICE deals with the development of an alert system that warns of extreme groundwater-level declines or rises in areas that are directly dependent on steady-state groundwater level. This system will be based on sensing the signals from the individual measuring points – sensors located in boreholes in the area concerned, and on radio transmission of these signals to the pre-processing centre and then via the Internet to a central database, accessible only to authorized persons with power of decision. This alert system should be especially applicable in areas, whose sustainable development directly depends on steady-state groundwater level:

1) Protected areas: areas of floodplain forests and wetlands that are also used as source areas for the abstraction of drinking water or where there generally increases groundwater pumping for agricultural or industrial use. The quality and the existence of ecosystems in these areas directly depend on steady groundwater level and in the event of extreme groundwater-level decline a permanent damage to these ecosystems may occur. In the event of groundwater-level decline below the critical limit, water column contact with the root system of floodplain forests or wetlands will be interrupted, which will lead to dieback of (often protected) ecosystems and irreversible change in habitats. Alert system ALICE so will very effectively serve as the active protection of the protected areas of floodplain forests and wetlands, while allowing the maximum possible groundwater abstractions in the given area for drinking or non-drinking purposes.

2) Agricultural areas: vine growing areas. ALICE will be an effective tool of groundwater-level regulation also for large vine growing areas which are mostly situated in drier locations and extreme groundwater-level fluctuations may affect the quality of wine and/or may directly lead to the death of the root system. Vine growing areas are often irrigated, therefore, there is a need to monitor the groundwater level which may only occur within certain height limits; a higher decline of the water column leads to drying of vine, on the contrary, excessive
irrigation may lead to rotting of the root systems and again damage to crops. ALICE can also provide the maximum efficiency of water use for irrigation purposes and prevent water wasting, which will lead to significant savings for end users and the release of water for irrigation also in other agricultural areas.

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Geomatic Concepts in Agriculture Thesauri

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Abstract

The agriculture thesauri (e.g. AGROVOC or NAL Agriculture Thesaurus) represent very large and robust systems of formalized knowledge. They are primarily focused on information related to agriculture. But they also use fragment of geomatic information and knowledge in a form of concepts and their terms. These concepts includes general terms of all parts of geomatics as well as data instances (such as particular methods). Even though these concepts are not the main component of above-mentioned thesauri, the concepts from geomatic domain play very important role in a process of detail description of agricultural and other concepts (including processes of their measurement, observation or mapping) contained in thesauri.

This paper assess geomatic concepts in AGROVOC and NAL Agriculture Thesaurus from the view of geomatics (but with a respect to methodologies of thesauri development and maintenance). It means evaluation of the subset of concepts related to geomatics and close scientific disciplines such as cartography, fotogrammetry, GIS science or remote sensing. Authors look into definitions of concepts, their hierarchy, relations and links to other information resources. As the result there is a short list of recommendations how to improve and enrich above-mentioned thesauri from the view of concepts from geomatic domain. It can enhance the quality of thesauri and their information value.

The paper introduces the fundamental terminology (terms thesaurus, geomatics and concept) and related researches. Than a description of mapping of concepts in particular tools follows. The results of mapping are summarized in the part focused on the most frequent imperfections. The last section (with the exception of the final conclusion) presents the set of recommendations concerning using concepts from geomatic domain in agricultural thesauri.

Key words

geomatics, thesaurus, semantics, agriculture, concept

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Spatial data - collection and visualization in www environment

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EXTENDED ABSTRACT

The paper addresses the issue of spatial and activity data in the www environment (in a web application). The acquired knowledge and principles were used to evaluate the spatial activity of forest game in the selected regions of the Czech Republic (Europe). The data base for the analysis and processing consists of large data sets obtained on the basis of mutual co-operation among the Faculties of the Czech University of Life Sciences (CULS) and other external entities. The analytical and software solution was developed by the Department of Information Technologies of the Faculty of Economics and Management (CULS) that administers and operates the system.

Owing to the development of modern information technologies it is technologically relatively very easy and inexpensive to obtain spatial data and transmit them online for processing. Spatial data can be used in a number of industries, from security technologies and logistic systems to agriculture and environmental protection. Spatial data are also used in the research.

These principles and knowledge were used e.g. for the evaluation of the spatial activity of game in the Doupovské Mountains and the Šumava National Park in the Czech Republic. The whole solution is based on our web application, which processes validated spatial data kept in the database (data archive) and makes the outputs avail-able to users. This web application has been developed in the PHP 5 environment using libraries of the Nette framework. The application obtains data from the database server via the Dibi database layer. Google Maps mapping ser-vices developed by Google Inc. are used to display spatial and activity data of game animals. Communication with Google Maps is ensured by Google Maps JavaScript API V3. The information on the monitored game animals is dis-played by means of the client-side programming language (JavaScript) using the jQuery framework. The application is optimized for most widely used web browsers that run on various operating systems and devices, e.g. desktops, laptops as well as on mobile devices such as tablets or smartphones. The application runs on the Microsoft IIS (Internet Information Services) Internet server. Data from the application are further provided to other applications, namely for mobile devices.

At present (August 2014), we have already monitored four game species – red deer (Cervus elaphus), sika deer (Cervus nippon), wild boar (Sus scrofa) and most recently also the European bison (Bison bonasus). The designated animals are monitored via GPS, by means of a collar, which records the animal position with the accuracy of several meters; the location; records of the animal's GPC receiver; the date and time in programmed intervals (i.e. usually 1 hour). In addition, the sensor records the temperature and accuracy of measurements. Newer collars are equipped with GSM modules, which contain telephone SIM (subscriber identity module) cards al-low-ing for the transfer of data to the user's computer. Generally, it is useful to validate data and to store them in a database system for the subsequent processing and display.
The pilot processing and verification is run on the portal Zvěř (game) online (http://zver.agris.cz/).

REFERENCES


Electronic Regional Risk Portal

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Abstract

The paper presents the main technical features of the Electronic Regional Risk Portal (ERRA) as a geospatial information technology that will support emergency management in Armenia, Azerbaijan, Belarus, Georgia, Moldova and Ukraine. The portal prototype provides solid features for all phases of emergency management. ERRA should protect communities by coordinating and integrating all activities necessary to build, sustain, and improve the capability to mitigate against, prepare for, respond to, and recover from threatened or actual natural disasters, acts of terrorism, or other man-made disasters.

ERRA portal is built on national and regional nodes within Partner Countries. Every national or regional node consists of a portal publishing data through the OGC compliant services. Authorisation and authentication for portal, Geoserver and services is provided by central server. Non-public data are secured by the GeoShield solution which provides restricted access to services and masking of data according to defined filter (extent, polygon, layers etc.). Every node provides functionality for uploading spatial data, creating visualisations and publication of services. OGC standards are used to secure interoperability between nodes. Since ERRA will be used in cross-border scenarios, support of multiple languages is essential. Different nations using different languages will be involved in the operation of ERRA. This requires a multilingual solution where the user of ERRA can switch the geoportal into his/her preferable language.