Collaborative Project in Resource Monitoring Services

Project Title: **Services and CYBer infrastructurE for monitoring soiL humidity and watEr resources - CYBELE**

1. SUMMARY OF THE PROPOSAL

Protecting the environment is a fundamental goal of the survival of the human species. The latest technological advancements could have a positive impact over the environment, provided that the scientists are able to understand the specific problems and become actively involved in minimizing the negative effects of various environmental threats that can occur in the short or long term.

In this sense, Information Technology plays a crucial role by making available huge volumes of raw and / or processed data that scientists from related fields can use as a support for taking decisions and actions aimed at preserving the environment.

Two of the most important components of the environment are soil and water. Information about their quality is essential for ensuring vital human needs, thus influencing the quality of every day's life. This research proposal aims at creating an integrated service system for the continuous monitoring of the most important parameters that describe the quality of existing soil and water resources in a given area.

At world level, the scientific community still feels there is a lack of coordination in the way the complex components of the environment are treated isolated in various IT-based applications. That is why the idea of a correlated processing of the data related to soil and water resources is topical and will contribute to a larger opening towards the globalization of the research in all the environment-related areas. In order to ensure the collaboration with the European and international research community and to harmonize spatial information, full compatibility with the INSPIRE European Directive will be implemented.

The Cybele project aims at integrating advanced concepts from various fields of Information Technology (cloud architectures, services, artificial intelligence, Internet of Things, wireless sensors networks, mobile applications, etc.) and ensuring access to information for all interested users.

The system will be based on a cloud platform, to create a virtual space that will provide services based on data collected through a monitoring system from specific sensors for measuring key characteristics of soil and water (soil and air humidity and temperature, solar radiation, wind speed, precipitations amount, soil salinity etc.).

The system will process the data gathered by sensors, in specialized nodes of the sensor network or on mainframes that will be part of the system and then will dispatch them to the end-users (various entities which have interest in developing business in the field of agriculture and related areas, environment monitoring, local and central authorities etc.) in the form of decision support systems, data loggers, alerting systems etc. Data from third party systems, like meteorological platforms or water treatment stations, will be also included. The expectedly very large amount of data gathered will require use of the latest Big Data concepts and technologies.

To measure soil moisture, our team aims at developing a new soil humidity sensor based on some theoretical principles that are different from the existing ones, which will be sufficiently accurate and significantly cheaper than the ones available on the market nowadays.

The result of this research will be the experimental prototype of an integrated system having all the above-mentioned features, which will include the cloud framework together with its corresponding services, the measuring sensors, the wireless sensor network, the necessary equipment for transmitting data, and the mobile devices. The system will be connected to most devices that might already be in use in the areas that will be monitored.

2. TECHNICAL AND SCIENTIFIC DESCRIPTION OF THE PROJECT

2.1 THE PROJECT TOPIC AND ITS PRACTICAL RELEVANCE

Soil is an important component of a smart, supportive environment, mainly in rural areas. Its quality has a major impact on the entire ecosystem, thus influencing the inhabitants' quality of life. Among other parameters, humidity influences the soil quality, being dependent both on water resources (natural - ground water, river, lakes, springs, rain or human generated - water caption, artificial water accumulations) and on water consumers.

Soil and water ecosystems are governed by specific rules and require particular monitoring and control procedures, and for a long time they were treated separately. The project proposes the transition from the punctual processes approach, in which each process is treated in an isolated manner, to the integrated approach, which allows the unified management of all processes. Using new information and communication technologies, soil can be treated as a complex system, in which soil moisture (a decisive factor in plant growth) is correlated with other parameters (type of crop, soil type, season, geographical location), with water resources and with economic efficiency and the ergonomics of the farmer's workplace or the influences of other adjacent systems and phenomena (climatic, hydrological, access to expertise, legal regulations, etc.).

The overall objective of this proposal is to create an intelligent, integrated, cloud service-based framework, using advanced computer technology, automation and communications for monitoring and risk assessment of soil humidity and water resources, based on numerical data. In order to ensure the proper soil humidity, it is necessary to know all the available water resources and the rain forecast. Accurate predictions are based on real-time and historical data regarding existing water resources, and on meteorological information. The information regarding variation and quality of water resources in rural areas is in most cases incomplete or missing, so that a proper management of soil humidity is difficult.

Environmental monitoring applications (for water, air, soil, climate, etc.) collected, usually by means of sensors, a huge amount of data [1]. These data are delivered in real-time, in short time intervals, given the dynamic nature of the environment, as the physical, biological and chemical parameters can suddenly change their values. Usually, data acquisition generates data streams, delivered with a certain frequency.

To understand the phenomenon and to predict consequences, a very fast reaction is required; patterns in data streams must be identified, to ensure the right action [2].

A delayed decision, in critical cases (like floods, drinking water contamination, air pollution, etc.) can have tragic consequences. An environmental monitoring system may require handling parallel data from dozens or hundreds of streams, making correlation, and understanding the causal relationships. For this range of applications the key factors are throughput, latency and the complexity of processing algorithms.

Although, in recent years, large number of datasets regarding water quality and/or resources, as well as meteorological data, have been published as open or proprietary data, their use is not enough capitalized, due to their heterogeneity and due to the fact that they are not compliant to standards/regulations.

The project proposes the development of a cloud based framework for applications able to handle a large variety of data sources in a multi-platform way (Fig. 1).

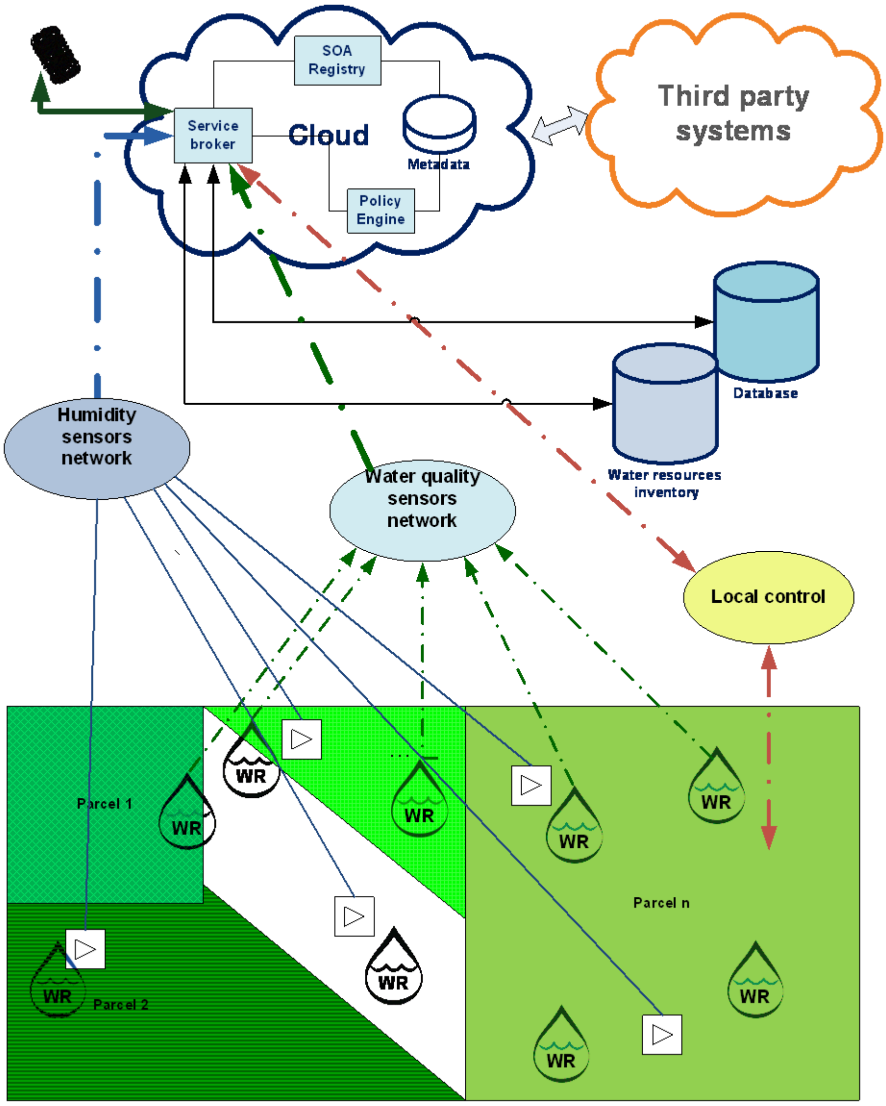

Fig.1. Cyber-infrastructure for Monitoring Services for soil humidity and water resources

The specific objective is to create an integrated monitoring system for soil quality and related water resources, using services available on mobile devices. The services also offer simple and cheap integration of the existing infrastructure in various types of companies involved in agriculture. The added value generated by the system results from the creation of a virtual space that can be shared by several categories of end-users (individuals and/or companies):

- Agricultural farms, greenhouses;
- Companies providing information and training services to farmers;
- Companies supplying equipment and agricultural materials, for modern technology-based advertising for agricultural products, seeds, tools, etc.;
- Associations of farmers, interested in a virtual environment for collaboration between farms / companies;
- Environmental authorities;
- Local/central authorities that have attributions in managing water resources.

The Cybele platform (Fig. 1) will determine the soil humidity using a widespread network of sensors and will predict its future values taking in account the existing water resources, present and historical meteorological phenomena, as well as other kinds of water consumers on the spot. The platform makes also available information regarding existing water resources (WR) in the area and their quality parameters. Through the e-services platform, the prediction of soil moisture will correlate not only measured values and meteorological forecasts, but also the crop type and/or other envisaged socio-economic activities. This way, the platform offers specialized decision support and contributes to development of farming business, by preserving a healthy environment. The system will be INSPIRE-compatible, thus improving the compliance with European, environmental legislation. The cyber-physical system will lead to sustainable management of soil and water resources. The framework allows use of information and services from various electronic sources, in different formats, by converting them into a homogeneous data model.

By offering decision support for proper soil humidity and water resources management the project outcomes contribute to increasing the quality of agricultural products by combining several advanced cloud services used on the entire value creation chain.

The primary chain services provide:

- real-time measurements of specific parameters (humidity, temperature, soil composition);
- a direct drive of watering equipment, depending on the specific culture of each lot.

The secondary chain services (support) provide:

- Setting up soil lots that can be treated individually and differentially, depending on the culture;
- Information / training of farmers on the most appropriate methods / tools / techniques for cultivation of various crops;
- Interoperability with platforms that monitor environmental conditions (meteorology, hydrology, pollution) to retrieve warning/alert messages. All services will be available on mobile platforms;
- Liaison with local / central government, by multi-level alerts dispatching, for rapid and efficient information of measures / regulations or situations of interest to farmers;
- Commercial advertising, for suppliers of specific equipment and materials (seeds, fertilizers, tools specifically destined to be used in farming).

By enabling environmental entities (soil, water resources) to communicate through a network of smart sensors, the topic aims to an Internet of Things (*IoT*) solution that uses extensive sets of real time and historical data, which requires a big data approach.

The experimental model of the integrated system includes the cloud platform hosting the services, the sensors network (the method of measuring the soil moisture is intended to be patented) and ensures the connectivity to third party systems that offer information about water resources and quality, that can influence the soil humidity, in particular, and its quality, in general. The open framework allows integration of future services, like automatic transmission of information to other platforms or to on site automation systems that control soil humidity.

Problems to be addressed

Romania has an extended agricultural soil with important impact on the entire environment. Still,

- irrational use of land;
- lack of proper information on water resources;
- lack of correlation between the effects of natural phenomena;
- lack of correlation between long and short time necessities;
- destruction of (extended) irrigation systems,

lead to degradation / poor soil recovery. Extended regions suffer from inappropriate water humidity (desertification, swamp, uncontrolled humidity, lack of water supply), mainly due to bad / lack of management of water supplies.

The Cybele project will offer electronic services, available also on a large scale of mobile devices, to link and process information for decision support systems focused on controlling soil parameters (mainly humidity and ground water quality) by:

- collating information on water resources available in a given area;
- measuring the quality parameters from different water sources;
- measuring the soil moisture;

- retrieving data from third party sources (records, weather forecasts, specialized sites);
- developing predictions regarding moisture, based on the processed information;
- developing predictions on the necessary water in the soil, depending on the desired use of the land;
- developing strategies for using the available water, depending on resources and needs.

Data and services will be available on a pilot cloud platform (Fig. 2), INSPIRE compliant, accessible on mobile platforms. INSPIRE is an EU initiative to establish an infrastructure for spatial information in Europe that will help to make spatial or geographical information more accessible and interoperable for a wide range of purposes supporting sustainable development [3].

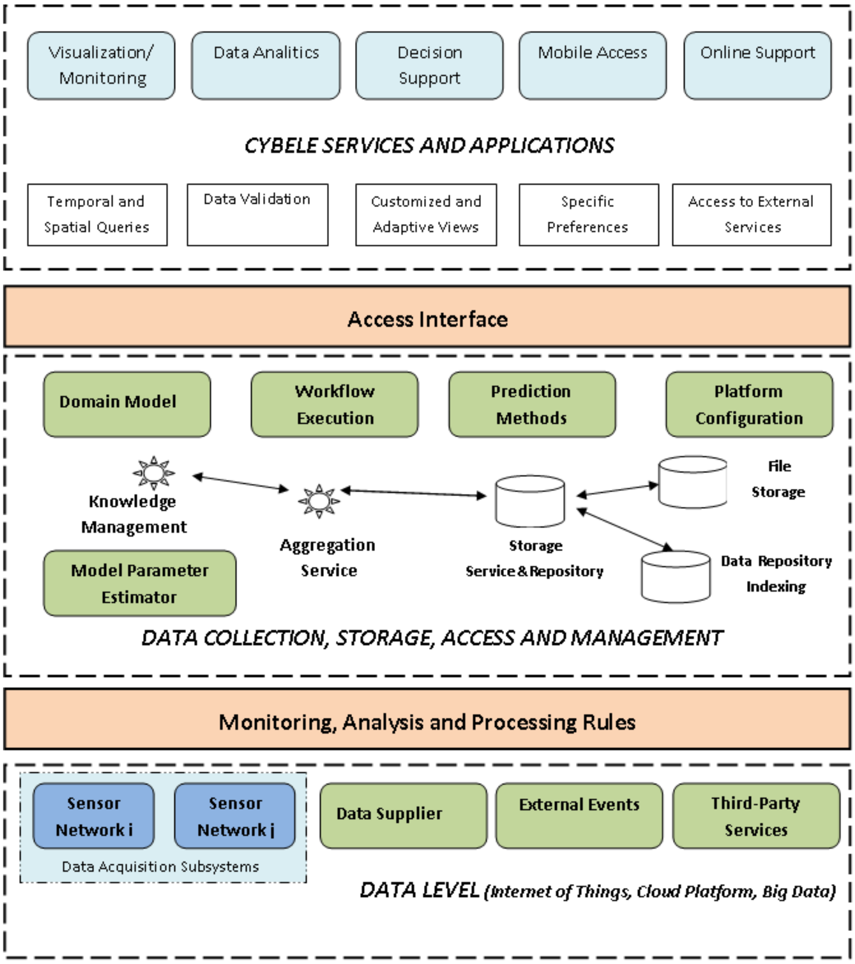

Fig.2. Framework architecture

An important component of the system is the acquisition subsystem, consisting of layers of sensor networks (for soil humidity - based on an original sensor solution, for the other water quality parameters), that communicate with the system.

The humidity sensors utilized at the moment are divided into two categories: sensors based on conductometry and sensors based on the absorption of electromagnetic field. The sensors in the former category have the advantage that they are cheap and the disadvantage of a strong dependence of the delivered signal on the soil composition, salt content and other substances or fertilizers applied on the crop. The sensors in the latter category, though more stable, are more expensive and the delivered signal is strongly nonlinear. The sensor proposed for study and implementation in this project is situated on the middle: reasonable price and acceptable linearity on a wide range of humidity (Fig. 3). As a main disadvantage we could enumerate an energetic consumption bigger than for the other sensors, but considering that the humidity of the soil is a parameter that varies slowly, this fact can be amended by doing the measurements at reasonable periods of time.

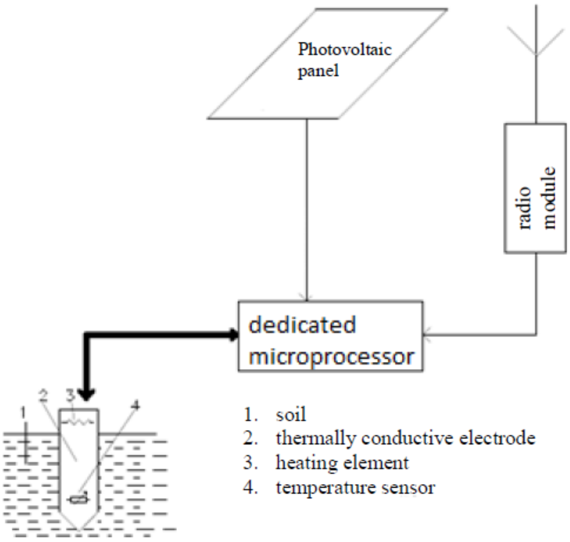

Fig.3. The humidity sensor in remote connection

An intermediate output of the project consists in defining the domain model by modeling the workflows. As an example, figure 4 presents the workflow for decision support, using the components of the framework. Based on the define ontology and the framework architecture, the workflows for typical case studies will be developed.

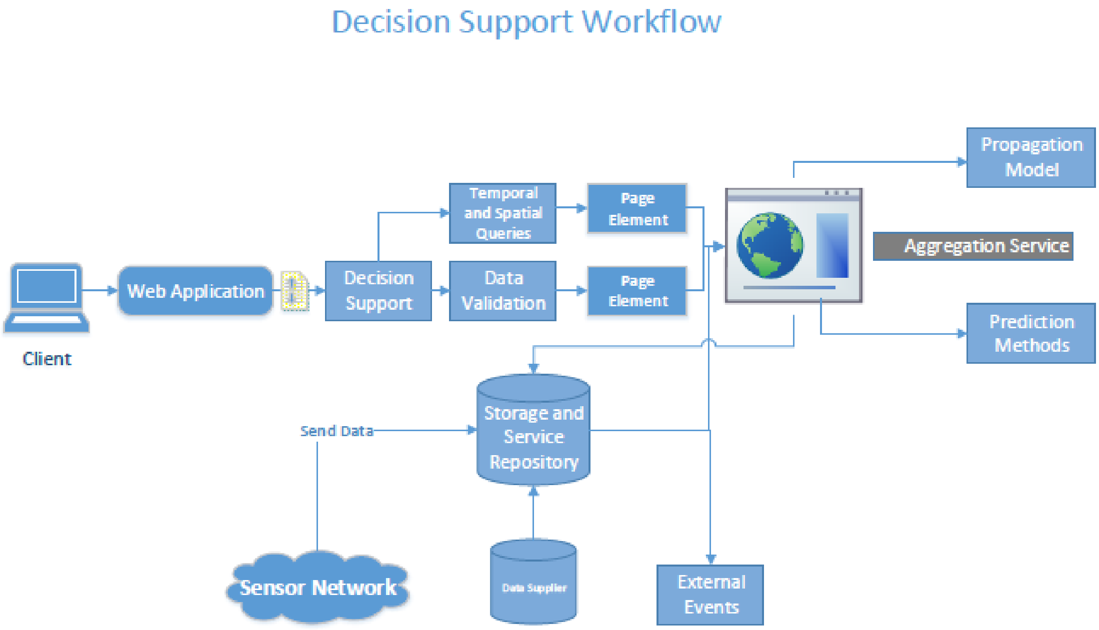

Fig.4. Decision Support Workflow

2.2 PROJECT CONTRIBUTION BEYOND THE STATE OF THE ART

Soil is a dynamic resource that supports vegetal life on Earth. It is made up of organic matter, differently sized mineral particles (sand, silt, clay, etc.), and numerous species of living organisms. Thus, soil has biological, chemical, and physical properties, which are dynamic (they can change in response to how the soil is managed). Soil quality has been defined as "the capacity of a specific kind of soil to function with its surroundings, sustain plant and animal productivity, maintain or enhance soil, water and air quality and support human health and habitation" [4]. Changes in the soil's functional capacities are reflected in soil properties, which are changing in response to management or climate changes. Effective management policies that enhance soil quality will be highly beneficial to cropland, rangeland, and woodland productivity. Enhanced soil quality can help reducing the costs of soil erosion, improve water and nutrient use efficiency, and ensure that the resource is sustained for future use. It also benefits water quality, air quality, human life and wildlife habitat. Soil quality is evaluated using specific quality indicators that reflect changes in the capacity of the soil to function. Useful indicators are those that are sensitive to change, and change in response to management. The type and number of indicators used depends on the scale of the evaluation (i.e., field, farm, watershed, or region) and the soil functions of interest. For example, infiltration rate and aggregate stability indicate the capacity of the soil to perform water absorption and resist to runoff and erosion. Changes in soil organic matter can indicate changes in productivity. Measurements of indicators can be made with simple to complex field tests, or sophisticated (and time consuming) laboratory analyses. To evaluate soil quality, indicators can be assessed at one point in time or monitored over time to establish trends.

An **assessment** provides information about the current functional status or quality of the soil. The assessment must start with an understanding of the standard value (or reference value) used for comparison. Assessments can be made to help identify areas where problems occur, to identify areas of special interest, or to compare fields under different management systems. Land managers can use this information, along with data from soil surveys, fertility tests, and other resource inventory and monitoring data, to make management decisions.

Monitoring soil quality indicators over time identifies changes or trends in the functional status or quality of the soil. Monitoring can be used to determine the success of management practices or the need for additional management changes or adjustments. Evaluating soil quality can improve the response to many resource concerns, including those listed below:

- Loss of soil by erosion;
- Deposition of sediments by wind or floodwaters;
- Compaction of layers near the surface;
- Degradation of soil aggregates or soil structure;
- Reduced infiltration and increased runoff;
- Crusting of the soil surface;
- Nutrient loss or imbalance;
- Pesticide carryover;
- Build-up of salts;
- An unfavourable change in pH;
- Loss of organic matter;
- Reduced biological activity;
- Poor residue breakdown;
- Infestation by weeds or pathogens;
- Excessive wetness;
- Increased water-repellence of soils due to fire;
- Reduced water quality;
- Greenhouse gas emissions.

Tests for air and water quality monitoring have been standardized and widely adopted internationally [5]. However, although an estimated 65% of the land area worldwide is degraded [6], no standardized SQ tests exist currently [7]. The World Soils Agenda developed by the International Union of Soil Scientists lists as the first two agenda items: 1) assessment of status and trends of soil degradation at the global scale, and 2) definition of impact indicators and tools for monitoring and evaluation [8]. There is a need for international standards to measure SQ. These could be useful for agricultural research and extension agencies, non-governmental organizations, governments and farmers to better understand, implement and monitor sustainable soil management practices [9].

Soil quality includes an inherent and a dynamic component [10]. The inherent component is an expression of the soil forming factors, documented by soil surveys as expressed by land capability classification. Dynamic SQ, however, refers to the condition of soil that is changeable in a short period of time largely due to human impact and management [10]. The SQ concept encompasses the chemical, physical and biological soil characteristics needed to support healthy plant growth, maintain environmental quality, and promote human and other animal health [11].

The indicators' suitability can be judged by several criteria, such as relevance, accessibility to users, and measurability [12]. Criteria and thresholds for relevant indicators must then be set by which to assess performance level relative to a standard [13].

SQ cannot be measured directly, but soil properties that are sensitive to changes in management can be used as indicators [14]. Methods for measuring individual indicators and minimum data sets [15] and for calculating indices from groups of indicators [16] are being developed for SQ monitoring over time and for evaluating the integrated sustainability of agricultural management practices. However, such tests must be inexpensive and dependent on minimal infrastructure if they are to be widely adopted beyond the research domain and especially in the developing regions.

Limited experience exists with the use of such methods, other than for standard agricultural soil tests. Such tests have provided farmers and consultants around the world with relevant information for nutrient and lime management. In a more holistic SQ paradigm, integrative assessment of the three SQ domains (physical, biological and chemical) would be accomplished by SQ indicators that represent soil processes relevant to soil functions and provide information that is useful for practical soil management.

Soil management is a long-term goal. The ways that humans use soils affect their quality. Soil erosion can strip away fertile soils and leave the soil less hospitable to plants. Heavy farm machinery can compact the soil and impede its capacity to accept and store water. Loss of organic matter because of erosion or poor cropping practices can seriously impede the soil's ability to filter out potential pollutants.

The relative importance of the components of soil quality and the relative importance of the processes of soil degradation vary from area to area. Soil quality varies dramatically from soil to soil. Certain soils are more vulnerable to the loss of one or the other components of soil quality and vary in their resistance to different soil degradation processes.

The value that society assigns to the three components of soil quality also varies. Setting soil quality as the long-term goal of soil management has implications for national-level assessments of soil resources, for the design of programs to conserve soil resources, and for analyses of sustainable farming systems.

Soil and water quality are linked, because soil degradation results in both direct and indirect degradation of surface water and groundwater quality. Protecting or improving soil quality is a fundamental step toward improving the environmental performance of agricultural ecosystems. Changes in farming systems that attempt to address the loss of nutrients, pesticides, salts, or other pollutants will not be as effective unless soil quality is also protected or improved.

Soil quality improvement alone, however, will not be sufficient to address all water quality problems unless other elements of the agricultural system are addressed. Soil quality improvement alone, for example, will not solve the problem of nitrate contamination of surface water and groundwater if excessive nitrogen is applied to the cropping system.

The soil monitoring systems reported in the scientific literature are not very numerous. In [17], a CDMA-based soil monitoring system developed by a team from China Agricultural University is described. The monitored values are relative humidity, environmental temperature, soil temperature, and soil water content.

Most applications are only monitoring a subset of the parameters of interest. For instance, in [18] Giordano and Liersch present a fuzzy GIS-based system for monitoring soil salinity. In [19], is presented an in-field soil property wireless sensor network for monitoring soil parameters, but no groundwater information is acquired (only soil volumetric water content). In [20], the authors present a real time web-based drought broadcasting system that is designed for „assisting decision-makers in assessing current drought conditions, thereby allowing for informed drought management decisions".

Parts of a similar system are in use (installed and functioning) in Canada from 1994 (see http://agrienvarchive.ca/nscp/download/SQEP_summary.pdf). The soil monitoring systems are integrated with GIS systems to provide a quality and comprehensive interface between the end users and the monitored soils.

Australia has also implemented such soil monitoring systems as part of a national soil management plan (see http://soilquality.org.au/about). The objectives of this plan are to establish benchmarked sites to identify and highlight the nature and extent of soil biological, chemical and physical constraints to production systems and to provide the basis of an on-going soil quality monitoring and education program. It is remarkable that *education* is a major component of this plan and, in our opinion, the development of educational applications as a side effect of the main soil monitoring system should probably be integrated in all future research projects in this field.

In Romania, a few attempts on creating soil monitoring systems have been done, but they are limited to periodical chemical analysis done on soil samples [21].

Soil and water monitoring applications can be implemented in various technologies. There are no standard or commercial solutions, but only instruments that can be used by application developers or even by scientists without advanced programming skills.

The **project contribution to the progress beyond the state of the art** will be found in following directions:

- For soil humidity and water resources management, the Cybele framework will ensure an integrated approach, based on an ontology that will be defined during the project;
- From the ICT point of view, the expected solution of the framework combines Internet of Things architecture with "big data" methods. By the statement "enabling water resources to communicate" we actually mean that the platform belongs to the Internet of Things field. By intensive processing of data, the applications fall into the "big data" category. Most existing systems save the acquired data in a database (in the majority of cases, on disk), performing *afterwards* queries to extract the interesting information. This approach is slow if the data volume is big and/or the interrogations are complex. In-memory databases offer a better performance for the queries, but are not optimized to give real-time information by data-stream analysis, as required by the business logic;
- The project will also contribute to development of INSPIRE compliant solutions, based on the ISO 19156 standard on Observations and Measurements (O&M) and SOS (Sensor Observation Service), SES (Sensor Event Service), SAS (Sensor Alert Service);
- Besides introducing an integrated chain of services, the current project will also create a basic framework for other types of environmental monitoring and services;
- The project aims at developing a sensor for humidity, based on an original principle, that will be patented;
- Last but not least, the framework will offer the possibility to conduct further researches, mainly in the field of prediction and setting up correlations between related phenomena, based on the available information.

2.3 PROJECT OBJECTIVES AND OUTCOMES

The project aims at obtaining research results, disseminating them by publishing scientific works, exploiting them in submitted patent applications, and engaging a number of PhD students in different project work packages.

The project contributes to the overall objectives of the Environmental protection and management thematic area:

- development and implementation of modern technologies for environmental monitoring and risk assessment;
- prediction of the regional impact of natural phenomena, climate changes or human actions, based on numerical data;
- improvement of compliance with environmental legislation (INSPIRE directive);
- development of sustainable management of the nature resources;
- increase the applicability of research results in planning and control of the environment, and adaptation to climate change.

The overarching goal of the proposal is the creation of an innovative and intelligent system based on Cloud services and advanced computational, automation and communication technologies to improve the soil quality and the management of water resources, thus contributing to a smart environment and to sustainable development of businesses in the domain of agricultural farms.

The specific objectives are:

- conducting research studies regarding development of solutions for soil humidity monitoring and water management, based on advanced ICT technologies;
- implementing a pilot platform, where information comes from a network of sensors of type Internet of Things and a variety of heterogeneous electronic sources;
- using methods and technologies for collecting and processing large volumes of unstructured data ("big data") and providing users with correlated, easy to interpret results;
- ensuring access to services and information for broad categories of users by means of various equipment, including mobile devices;
- ensuring compliance of data structure and services with INSPIRE Directive;
- increase knowledge sharing through joint research, organization of scientific events (seminars, workshops, conferences);
- involve young PhD students in doctoral research;
- Supporting SMEs in using research results in creating innovative products and services.

2.4 ORIGINAL AND INNOVATIVE CONTRIBUTIONS OF THE PROJECT

The originality consists in the implementation of an intelligent information system, accessible using mobile devices, designed to assist multiple processes linked to monitoring soil humidity and water resources management.

The system will ensure the acquisition of the measured values from sensors, for specific physical magnitudes. Soil humidity, an essential factor in agricultural production, will be measured using an original sensor, developed during the project, based on the correlation between the humidity and the observed temperature.

Another original aspect is represented by the flexibility of the system which will allow differentiated operation at the plot scale, according to the defined ontology for the growing of a certain species of plants. The system allows different treatment of the plots depending on the harvest type and climatic factors both *in situ* and remotely through web services. It also offers the possibility to integrate new services, for instance to extend the scope of the pilot platform with services that control existing equipment in farms.

A service hosted on Cloud platform allows the configuration of the parcels as an augmented map and the planning of the crops. This service is actually a support for planning of activities, in the field. The cloud based framework will create a collaborative environment for farmers and other business categories interested in the development of activities in farms. The web services available on Cloud platform are addressing all activity types on the primary and secondary value chain. The framework combines the Internet of Things architecture with "big data" methods.

2.5 INTER-, MULTI-, OR TRANS- DISCIPLINARY CHARACTERISTICS

The project uses a multidisciplinary approach because it requires experience and knowledge from several domains: Computer Science, Computer Engineering, Services Science, Electronics, Automated Systems and, last but not least, the organization of agricultural activities, Pedology (soil study), water resources management.

For the development of the Cloud platform deep skills in the Computer Science and Engineering are required. Service definition and orchestration requires competences both in the services science and in domains where these are used, such as: organizing activities on farm lands, managing water resources, economical activities, marketing and maintenance of the platform. For the implementation of the acquisition subsystem, competences in

Electronics and Automated Systems are decisive. The project teams of the four partners are built up in such a way to complete each other to solution together the challenges and problems raised by the project.

3. IMPACT AND DISSEMINATION OF THE PROJECT RESULTS

3.1 DISSEMINATION AND EXPLOITATION OF THE PROJECT RESULTS

The research results of the project will be presented at national and international conferences and in prestigious journals in the field.

We propose a total of at least 9 scientific papers. The articles / papers will be focused on the specificities of each partner and will reflect the obtained innovative results.

Dissemination will be made through the Internet, using the portal that will be developed in the project. The services, published on the cloud platform can be accessed for free, and the publicity for the platform will be made on the project website as well as on the partners' websites.

Also in the project a number of workshops will take place, where will be invited companies in agriculture - farms, local government representatives and other companies interested in cooperation with farmers, to popularize the system and attract its prospective customers.

The project results will be disseminated by testing and validating the system actual operating conditions, in farms for which partner P3 has already developed some control systems.

3.2 POSSIBLE APPLICATIONS WITH MARKET POTENTIAL

The developed system can be used in various configurations.

The **complete configuration** consists of the sensor networks subsystem of physical parameters in the field, as well as of the e-services accessible on the portal developed in this project, through licenses.

- The system can be extended also with a **local control module**, providing intervention in the system directly from the site.
- The **humidity sensor**, based on an original concept, can be harnessed as an individual component, or incorporated in the configurations mentioned above.
- The system provides the ability **to connect existing monitoring and control equipment** via an adapter that allows access to the equipment, through an e-service from the cloud platform.
- The e-Services, available on the cloud platform, can be harnessed by licenses / subscription.
- The system has a high potential commercial value and because of the possibility of offering **advertising / information space** for companies or clients, that are in the reach of such an assembly.
- **The portal** itself can be harnessed by adapting services for similar applications in agriculture or environmental monitoring.

<u>Activities supported by the e-service system</u>:

1. *Agricultural activities* – through monitoring and control of physical parameters (like humidity, temperature, ventilation, etc.);
2. *Farmers' information* (regarding best practices in cultivating different types of cultures / plants);
3. *Collaboration between companies* / farms enabled by the creation of a virtual environment;
4. *Advertising* based on modern technologies for agricultural products, seeds, tools, etc.;
5. *Services* – there is the possibility to extend the scope of services, for example by identifying the most appropriate crops on soil composition identified by the sensors.

Another possibility results from patenting the humidity sensor. Partner P3 will benefit from the patent rights.

The interoperability of the cloud platform with others in the industry makes it to act as a bridge between different entities: farmers, local government, suppliers of materials and farm equipment, training companies.

3.3 ESTIMATED IMPROVEMENTS IN THE QUALITY OF LIFE, WITH RESPECT TO CURRENT PERFORMANCE OF PRODUCTS, TECHNOLOGIES AND/OR SERVICES

Quality of life is determined by how each person's needs are met. We can say that the proposed system helps to meet the needs of all levels of Maslow's hierarchy of needs.
Thus:

- by monitoring and controling the parameters, the quality of delivered agricultural products, is ensured, thus satisfying the need for food (level of physiological needs).
- the permanent control of the work procedures, the stability of the farm and stable employment are protected from risks proviced by the external environment, thus ensuring personal safety and security needs (a guaranteed minimum income, job security leading wellbeing, necessary for the efficient functioning). Reducing the response time in case of undesirable phenomena, the reduce of physical effort of workers also contribute to increasing personal safety.
- the collaborative environment creates the opportunity to enter into relations with others, to fit the extended social groups, to inform and instruct, is thereby covering social needs of belonging. Increasing the speed of information on a wide range of issues adjacent to greenhouse activities, contribute greatly to enhancing the feeling of belonging to the community. Furthermore, the possibility to express their views on the problems of labor, leads to increased self-confidence, self-esteem, helping to meet the need of social recognition.
- the posibility to configure parcels, to decide which are the optimal strategies for the success of the activity, and to propose creative solutions, based on the gathered information, leads self- actualization and personal development.

Cloud platform provides support for quality of life, just by facilitating communication between persons in different forms that are accessible for all the involved stakeholders. In addition, it provides an environment in which the manual labour is reduced, thus contributing to the health of the workers.

3.4 PROJECT INTEGRATION IN THE DEVELOPMENT STRATEGY OF PARTNER COMPANIES

The mission of the **University “Politehnica” from Bucharest** was conceived as a combination of education, research and innovation, which is the key to a knowledge economy and society. Creating knowledge primarily through scientific research, spreading through education and training, its dissemination and use of information technology, technological innovation are elements that define the distinctiveness of the university. The proposed project is part of the UPB strategy, primarily because it is developing an innovative solution, based on up to date information and communication technologies. UPB’s interest in this project lies in the fact that the outcome of this project is a tool for education and information, as well as for research, which are part of the primary mission of the university.

The **SINTEF Group** (Stiftelsen SINTEF) is the largest independent research organization in Scandinavia. SINTEF acts as an incubator for new industrial companies. In 2011, it was involved in the commercialization of eight different SINTEF technologies, through licensing agreements and the establishment of new companies. About 40% of the international turnover comes from the EU’s research programs, in which SINTEF is a leading participant. European Union projects are given high priority, because of its strategic decision to participate in multinational knowledge-generation efforts, and to join networks. A target of SINTEF is to grow in the international R & D market, and for this reason, it invests in areas in which it is particularly strong: oil and gas, energy and the environment, materials technology, maritime and bio marine technology, ICT, building research and medical technology.

The **Technical University of Cluj-Napoca (TUCN)**, one of the 12 universities of “advanced research and education" in Romania, aims at engaging itself in producing outstanding scientific results and approaching interdisciplinary and multidisciplinary subjects. Furthermore, it strives to integrate the research results in the exchange of national and international values, to increase its national and international visibility, and also attract and create highly skilled human resources. Achieving these goals must strengthen its already established position as a university of "advanced research and education", and the recognition of TUCN as a center of excellence in scientific research with a high impact on the social and economic environment.

Due to both its geographic position and its historical background, the city of Cluj-Napoca is considered the capital of Transylvania region and needs to support the overall development of this region by the know-how provided by its worldwide recognized academic community. Agriculture and environment protection are major fields of interest both for the Romanian and European governments; that is why such projects as the present proposal (CYBELE) benefit from a high level of support from the local communities and governors.
From a scientific point of view, the interdisciplinary character of the present proposal (CYBELE) can bring a very important added value in high interest fields as Computer Science, Computer Engineering, Mobile Communications, etc.

The **CBM Electronics** development strategy is the creation of new and competitive products. Application of automation and electronics technologies in various industries offers a possibility to diversify the range of products. A strategic objective of CBM Electronics is to maintain a close connection with universities, by participating at common researches and providing them laboratory equipment, and this way, being close to the latest achievements in the field.

3.5 INTELLECTUAL PROPERTY PROTECTION

Intellectual property rights resulting from the project will be distributed among the partners with respect to each partner's contribution.
Protecting intellectual property rights shall be approached in accordance with the law and its specific regulations, by each partner. At project level partners are required to comply with the minimum protection of copyright, imposed by the coordinator.

Before signing the partnership agreement, that will be part of the ultimate research contract the input and output data at the project level will be discussed in a project meeting, in order to identify, classify and determine the rights of intellectual property, according to the following types: a) pre-existing this contract, within teams and / or partner institutions, b) resulting from activities related to the research project, which is part of the objectives of the project, c) resulting from activities related to the research project, but not part of the project objectives.

For each stage, the outputs and outcomes will be analysed, in terms of their originality. Each team will decide who is entitled to claim for protection rights or to decide upon the priority in submitting, the commonly elaborated papers. If the result of the work will be embodied in patents or software products registered with ORDA (Romanian Copyright Office), each Party shall give the other party the exclusive license with no obligations throughout the term of protection, the right to use the object, and the single use protection only for further research in the direction of the current project and without the possibility of passing on, regardless of the modality of this right.
At the request of the Contracting Authority, the partners will draw up reports that will be edited into a publishable form so as to not affect or prejudice the intellectual property rights of the parties in the contract or performing services under the contract.

Basically, it is intended that the SME - partner P3, which will develop the humidity sensor, will benefit from the patent rights.

3.6 SOCIAL AWARENESS

The proposed project is highly technical, as it aims to create a framework for monitoring environmental resources using information and communication technologies. Nevertheless, the issue of social awareness is a key to project success. It is based on awareness of the role and responsibility that each person / organization has, by treating soil and water resources as a common good, even when they are privately owned. By allowing the placement of sensors, in public or private areas, and to enable the provision and processing of information about the property, the civic action linked to environment protection is strengthened.

4. CONSORTIUM STRUCTURE

CO - University POLITEHNICA from Bucharest (UPB) is the most important engineering university in Romania. *UPBs role in the project is to provide the information and communication infrastructure and to coordinate the entire project*.

P1 – The **SINTEF Group** (Stiftelsen SINTEF) is the largest independent research organization in Scandinavia. SINTEF division represented in this project is Information and Communication Technology (SINTEF ICT) through the department for Networked Systems and Services (NSS). NSS provides research-based expertise in Internet of Services and Internet of Things technologies, cloud computing, semantic Web, model-driven development, quality and security technology, and user-centred development. *The role of SINTEF in the project is the integration of data in cloud services.*

P2 – The **Technical University Cluj-Napoca,** Romania (TUCN) is a higher education institution created in 1920. *The main tasks attributed to the TUCN research team are: development of a framework structure for the Cybele platform, design and implementation of the platform, integration of old/new functionalities in the composite application, dissemination of results.*

P3 - CBM Electronics SRL, Cluj-Napoca, (http://www.cbm.ro/), has a product range including: proximity sensor; timers; universal indicator; counter with display; thermostats; level measuring systems; PLC Systems with peripherals. *The role of CBM in the project is to design and construct the humidity sensor, to design and construct the control module for the soil parameters and to participate at the system integration and validation.*

5. PROJECT MANAGEMENT

The consortium consists of two Romanian universities, a Norwegian research institute and a Romanian SME. During the project life, the project leaders of all partners will constitute the Steering Committee (SC) of the project, that will be the main decision making body of the consortium, in relation to the overall management of the project. It will be the first instance for settlement disputes between the partners related to the execution of this project. The SC will be led by the principal investigator that has the role of project manager.

A Scientific Board (SB) will be constituted by representatives of all partners in the project and will be in charge of the scientific and technical coordination of the activities in order to achieve the coals set in the work plan. It will monitor technical/scientific performances and promote, with the help of all partners, the technical part of the project. The SB will play also the major role in the dissemination of results.

5.1 WORK PLAN, DELIVERABLES AND LOAD BALANCING

WORK PACKAGE LIST

Work package No[1]	Work package title	Work package leader[2]	Person/month[3]	Start month[4]	End month[5]
1	Requirements specification for soil humidity and water resources management systems	UPB	43	1	6
2	Framework design	UPB	40,37	7	18
3	Sensors network design	TUCN	41,34	7	18
4	System implementation	UPB	82,1	19	30
5	Experimentation and demonstration of system functionality	CBM	54,6	31	36
6	Dissemination of results	TUCN	30,2	2	36
7	*Project management*	*UPB*	*30*	*1*	*36*
	TOTAL		**291,61**		

The work breakdown structure of the project is based on the decomposition of the work packages in tasks. For each task, a task leader is designated.

5.2. List of deliverables

The table summarizing all the project deliverables is provided below.

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1 Work package number: WP 1 – WP n.
2 Number of the partner leading the work in the WP
3 The total number of person-months allocated to each work package.
4 Relative start date for the work in the specific work packages, month 1 marking the start date of the project, and all other start dates being relative to this start date.
5 Relative end date, month 1 marking the start date of the project, and all end dates being relative to this start date.

LIST OF DELIVERABLES					
Del. no. [6]	**Deliverable name**	**WP no.**	**WP leader**	**Dissemination level** [7]	**Delivery date**[8]
1	Research study on the use of advanced technologies for information systems for monitoring soil humidity and water resources	1	UPB	PP	
2	Research study regarding national and international regulations for monitoring soil humidity and water resources	1	UPB	PP	
3	Conceptual model of risks related to improper use of information	1	UPB/ CBM	PP	
4	Conceptual model of risks related to improper use of information	1	UPB	PP	
5	Technical design of the cloud based platform architecture	2	UPB	RE	
6	Research study on ontology definition and data model	2	UPB	RE	
7	Technical paper regarding INSPIRE compliance requirements	2	TUCN	RE	
8	Research study on the conceptual model of the sensors network	3	TUCN	RE	
9	Research study on the conceptual model of the humidity sensor	3	TUCN/ CBM	RE	
10	Experimental model of the framework	4	UPB	RE	
10	Open data management platform	4	SINTEF	RE	
11	Software application, based on real use-cases	4	UPB	RE	
12	Patent documentation submitted	4	UPB/ CBM	PU	
13	Validation report of trial results	5	CBM	RE	
14	Scientific report on performance evaluation	5	UPB	PU	
15	9 conference papers	6	UPB/ SINTEF/ TUCN	PU	
16	3 international workshops	6	UPB/ TUCN	PU	
17	3 articles submitted in ISI journals	6	UPB/ SINTEF/ TUCN	PU	
18	Technical and financial report for the 4 phases	7	UPB	PU	

[6] Deliverable numbers in order of delivery dates: D1 – Dn

[7] Please indicate the dissemination level using one of the following codes:
PU = Public
PP = Restricted to other programme participants (including the Contracting Authority)
RE = Restricted to a group specified by the consortium (including the Contracting Authority)
CO = Confidential, only for members of the consortium (including the Contracting Authority)

[8] Month in which the deliverables will be available. Month 1 marking the start date of the project, and all delivery dates being relative to this start date.

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