1. Executive summary

Reinforcement of BioSense Centre – ICT for Sustainability and Eco-Innovation – INNOSENSE is an FP7 project funded under the FP7-REGPOT-2012-2013-1 programme (Contract No: 316191) whose major objective was to stimulate development of BioSense Centre, Novi Sad, Serbia and foster it to become **an institution recognizable for its research and results in the field of ICT applications in agriculture, ecology, environmental protection, and forestry**. The Project aimed to strengthen not only research capacities, in terms of human potential and research infrastructure, but also business and innovation potential of BioSense Centre, as well as to support knowledge transfer and collaboration with industry, future participation in Horizon 2020 programme, and ultimately to ensure sustainable development of BioSense.

BioSense Centre was established as an organizational unit at the University of Novi Sad, and during the Project execution it **evolved to** an independent institution **BioSense Institute - Research Institute for Information Technologies in Biosystems.** Namely, the Project and the achieved results represented a genuine quantum leap that had boosted BioSense's research and innovation potential and consequently paved the way for the project ANTARES that was granted to BioSense Centre within prestigious Horizon 2020 Teaming Programme, which ultimately led to foundation of a new institution.

Development of the BioSense has been achieved through seven strongly interrelated work packages, whose tasks were focused on **reinforcement of research capacities and innovation and business capacities, and dissemination and networking activities**.

Reinforcement of the research potential was primarily **performed through the employment of new experts and their secondments to partnering institutions, and equipment purchase**. Namely, **eleven experts were employed** within the Project, **8 of which become permanent staff of the BioSense**, covering all major scientific fields of the interest of the BioSense, namely nano and microelectronics, signal processing and knowledge discovery, remote sensing, and biosystems. Research capacity of the BioSense has been also strengthened through the secondments of the BioSense staff in which they were trained in complementary skills and exposed to advanced working environments in the EU.

Equipment purchase in amount of 950.000,00 EUR positioned the **BioSense laboratory as the leading laboratory of its kind in the region,** as it includes LTCC technology, photolithography processes with 1μm line resolution limit, thin-films technology, thick films technology, micromachining processes in silicon, glass and ceramic, nano-manufacturing processes, optical laboratory, optical inspection and spectroscopic analysis in UV, visible and NIR spectra, electron microscopy, in UV, visible and IR spectra, thin film characterization, semiconductor analysis and high frequency measurements. In addition, research infrastructure has been enhanced by the equipment aimed at soil parameters mapping including autonomous robots equipped with hyperspectral cameras and soil probes, as well as XRF analyzer.

Innovation and business capacity of the institute has been tremendously reinforced through the **establishing entrepreneurial spirit** among researchers and building of **a strong network of partners**, which resulted in a number of **successful project proposals, in particular 10 from H2020 calls**. Furthermore, the BioSense **established PA4ALL - Living Lab in Precision Agriculture, the first living lab in Serbia** that communicates with potential end-users of our solutions and introduce them to the potentials of the BioSense Institute.

Dissemination and networking activities ensured an extensive network of partners including academia, SME, industry, and policymaking partners and thus visibility of the BioSense work and activities. Moreover, those activities **ensured that the BioSense is widely recognized as an outstanding institution whose breakthrough and needs-driven research bring new solutions** improving quality of biosystems and their sustainable use, and consequently economy development on national and regional level.

2. Description of project context and objectives

Biosensing technology offers state-of-the-art multidisciplinary tools that enable both *in-situ* and remote, rapid and reliable acquisition, transmission and manipulation of the coordinated, comprehensive and sustained monitoring data, with the final goal to support management of natural resources and decision making in an increasingly complex and environmentally stressed world. It is of increasing importance in a wide variety of areas, including agriculture, food production and processing, forestry, disaster management, ecosystem and biodiversity monitoring, environmental protection.

On the more local scale, Serbia heavily relies on its agricultural production and exploitation of natural resources. Since the production methods and used techniques mainly employ traditional approaches there is plenty of room for improvement. This particularly holds for application of biosensing technology and state-of-the-art concepts backed up with ICT solutions such as wireless sensor networks, low cost sensing devices and remote sensing. The introduction of this framework in Serbia could lead to faster economic development, better and more intelligent utilization of the resources, high-quality food production and protection of the environment.

BioSense Center was established at the University of Novi Sad with the mission to coordinate, focus and advance research in biosensing through introduction and promotion of state-of-the-art ICT solutions in agriculture, ecology, environmental protection and forestry.

The vision of the BioSense Center was to become an internationally recognized multidisciplinary research center and a key provider of advanced ICT solutions for acquisition and processing of data for natural resource management. To that end, the BioSense formulated research agenda and 3-year development strategy, and performed gap analysis.

Based on them, **the BioSense proposed the project InnoSense whose main objective was to foster its future development. The project aimed to strengthen both the research and innovation capacities of the Center, to support the synergies within, and, in the end, to contribute to the reduction of the brain-drain, advance of the infrastructure (both research and management) and to increase the eco-innovation performance of the Center.** The identified strengths of the BioSense Center, combined with the reinforcement activities proposed in this Project, were foreseen to help in overcoming the identified weaknesses, exploit benefits from recognized opportunities and mitigate the threats.

The specific objectives of the Project were defined as follows:

- Reinforcement of the research potential of the BioSense,
- Reinforcement of the IPR, innovation and business capacity of the BioSense Institute,
- Promotion of closer S&T cooperation between Europe and WBC,
- Support to future participation in Horizon 2020 programme and in other research co-funded by industry or EU,
- Boost to prospective involvement in co-funded research from industry and EU,
- Dissemination of the Project results and influence on the governmental policies in agriculture, environmental protection, water management, disaster management, nature conservation and spatial planning,
- Sustainable development of the BioSense Institute.

In order to achieve the objectives, we designed the Action Plan based on seven strongly interrelated work packages (WP1-WP7) within a period of 42 months, namely:

1. Management of the Project
2. Employment of new experts
3. Equipment purchase
4. Intellectual Property and Innovation Capacity Building
5. Secondments
6. Dissemination and networking
7. Ex-post evaluation

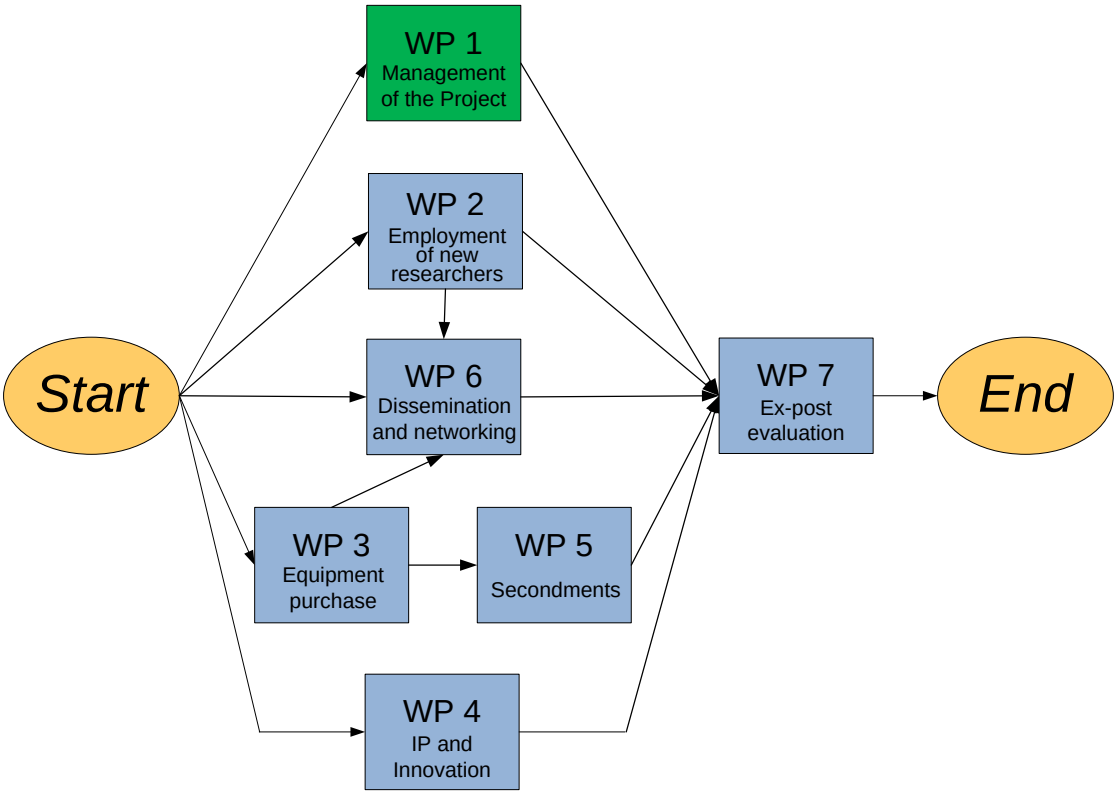


Fig. 1: InnoSense work packages

InnoSense was a mono-applicant proposal, i.e. the BioSense was the only beneficiary. However, the Project consortium gathered a strong team of EU partnering institutions carefully chosen to provide missing or strengthen existing research capacities of the BioSense. They took part in the trainings, placements, networking, and dissemination activities of the Project. Namely, the consortium comprised the following institutions:

Institute of Sensor and Actuator Systems, TU Vienna, Austria, was chosen since it presents one of the strongest European research centers for development and application of LTCC technology since it possesses a great expertise in the field of sensor design, as well as in integrated sensing and actuating devices, microfluidics, biochips and electronic packaging.

The collaboration with **Institute of Microwave Systems, Faculty of Electrical Engineering and Information Technology, Ruhr-University Bochum, Bochum, Germany** foreseen in the Project aimed at reinforcement of several research aspects of the BioSense, particularly in the design of

specific soil-moisture sensors for agricultural and environmental applications, that need to be compact in size, low-consumption and low-priced.

Agricultural University of Athens, Athens, Greece, (AUA) was carefully chosen due to its expertise in the application of modern technologies to agriculture and natural resources in the form of precision agriculture, which is one of the main focal points of BioSense.

Ghent University, Belgium, was included as the EU project partner for their vast experience in image processing, remote sensing, and geographic information systems as well as in the field of hyperspectral imaging.

One of the leading European institutions that encompasses both the technological and economic aspects of agro-industry and management of natural resources is the **Institute of Food and Resource Economics, Faculty of Life Sciences, University of Copenhagen, Copenhagen, Denmark**. The Institute possesses great experience in precision farming and development of new agro-industrial technologies and products, all of great interest to the BioSense.

GIS and Remote Sensing Laboratory (LAST) at Doñana Biological Station, Spain, is a multidisciplinary research institute with a strong focus on biodiversity and GIS and RS for automatized monitoring of natural processes, and thus it was chosen as EU partner.

During the second reporting period of the Project, the InnoSense consortium was expanded by five new partners - **Technical University Darmstadt, Germany, University of Perugia, Italy, South Westphalia University of Applied Sciences, Germany, National Center for Scientific Research "Demokritos", Greece, and University of Pavia, Italy**, which opened up possibilities for acquiring new knowledge and skills by the BioSense personnel. They were added to consortium with the aim to transfer the knowledge to the BioSense staff in the field of sensing technologies, in particular sensors based on nanostructures and sensors operating at microwave frequencies.

3. Description of the main S&T results/foregrounds

The project InnoSense represents a tremendous success, which boosted the development of the BioSense and marked it as an internationally recognized research institute. Besides **research excellence** in ICT applications in biosystems, the BioSense is recognized for a **wide range of services offering to stakeholders**, entrepreneurial culture which encourages realization **of market-oriented solutions**, **impressive network of partners**, and **participation in** a number of **projects**, particularly those **from H2020 calls**. Moreover, the BioSense has been recognized as **a major national player in the field of ICT applications in agriculture and related biosystems**.

The clear indicator of the Project success is the fact that during the Project execution **the BioSense evolved to an independent institution BioSense Institute - Research Institute for Information Technologies in Biosystems**. As stated previously, the Project and the achieved results represented a genuine quantum leap and consequently paved the way for the **project ANTARES that was granted to the BioSense Centre within prestigious Horizon 2020 Teaming Programme**, which ultimately led to foundation of a new institution. At the moment, the BioSense is taking part in phase II of the Teaming call as a candidate for European Centre of Excellence that will be funded by the European Commission.

Fig. 2 presents **Biosense's current situation** at a glance and shows its outstanding potential in research capacities, services offered to industry and government sector, its numerous international projects and wide network at national, regional, European level and beyond. The presented structure and accomplishments are at the same time **clear evidence of the success of InnoSense which actually made this progress possible**. We note that during the Project execution, the BioSense directed its vision and capacities more towards ICT applications in agrifood and related biosystems, which is illustrated in Fig. 3.

Since InnoSense is not scientific project per se, but a project from FP7-REGPOT call whose aim was to upgrade research potential by providing support in the form of investment, staff, networking or advice, we will present in the following the main results related to the reinforcement of the BioSense's capacities. The results will be presented in relation to the work packages of the Project.

3.1 Work package 2 – Employment of new experts

The main goal of the activities of WP2 was twofold - to employ researchers with high scientific expertise and to cover all major scientific fields of interest with their expertise. Through a careful and judicious selection process, **the BioSense was reinforced by 11 experts covering all scientific fields of the interest, namely nano and microelectronics, signal processing and knowledge discovery, remote sensing, and biosystems**, Fig. 4. In that manner, **the initial plan** to employ three experts and one technician was **outperformed to a significant degree**.

According to their expertise the hired people have been evenly distributed among major research groups. Namely, four hired experts have been affiliated to Nano and microelectronics group and four to Signal processing and knowledge discovery group, and two experts to Remote sensing and GIS (geographic information system) group. In addition, the human capacity has been enhanced by an expert in the field of biological sciences.

Besides their research activities, the hired people have invested a significant effort to support full exploitation of the new equipment, in particular through the organization of the relevant trainings and introduction of new methods and practices in the laboratory.

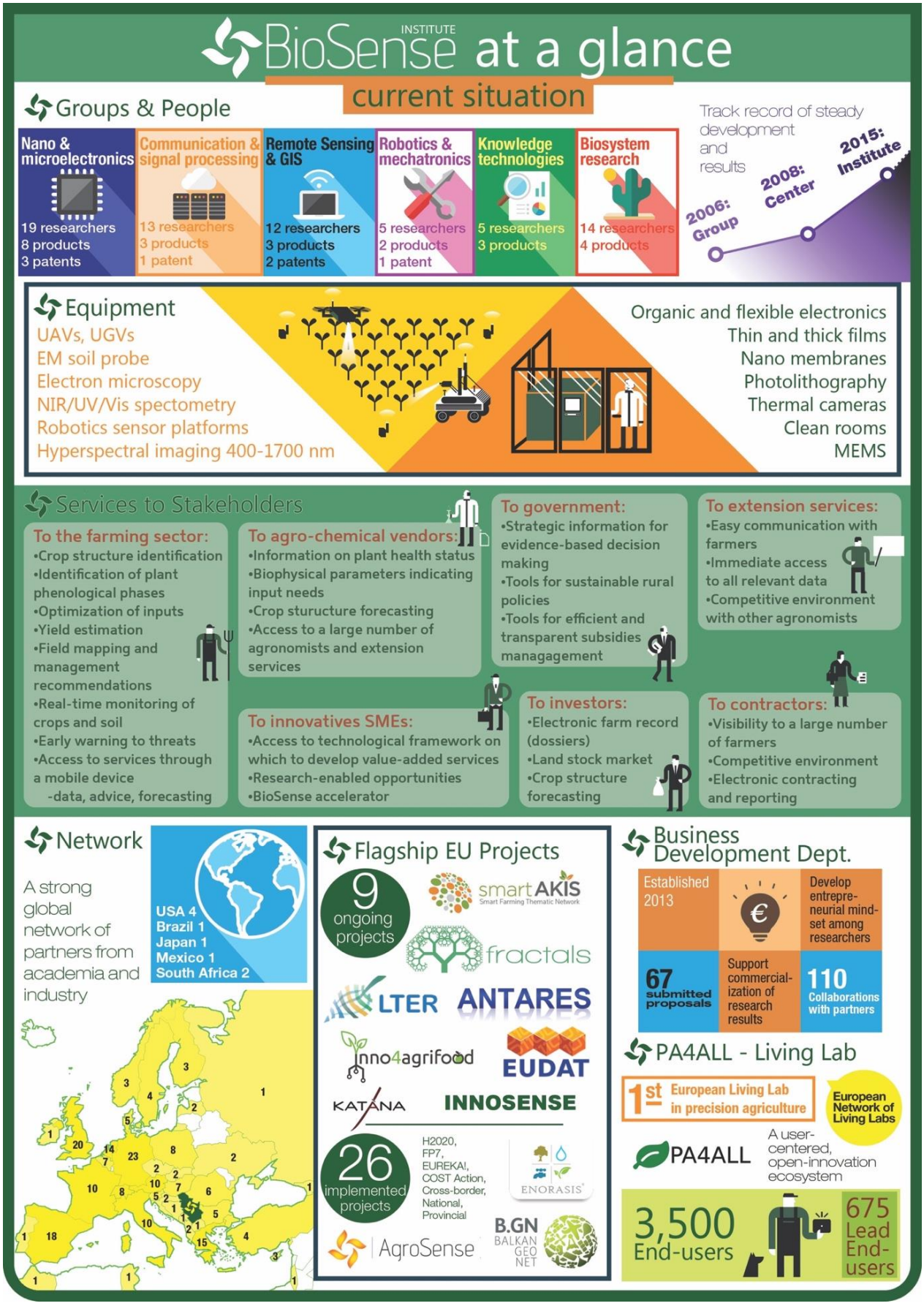


Fig. 2: BioSense Institute – current situation.

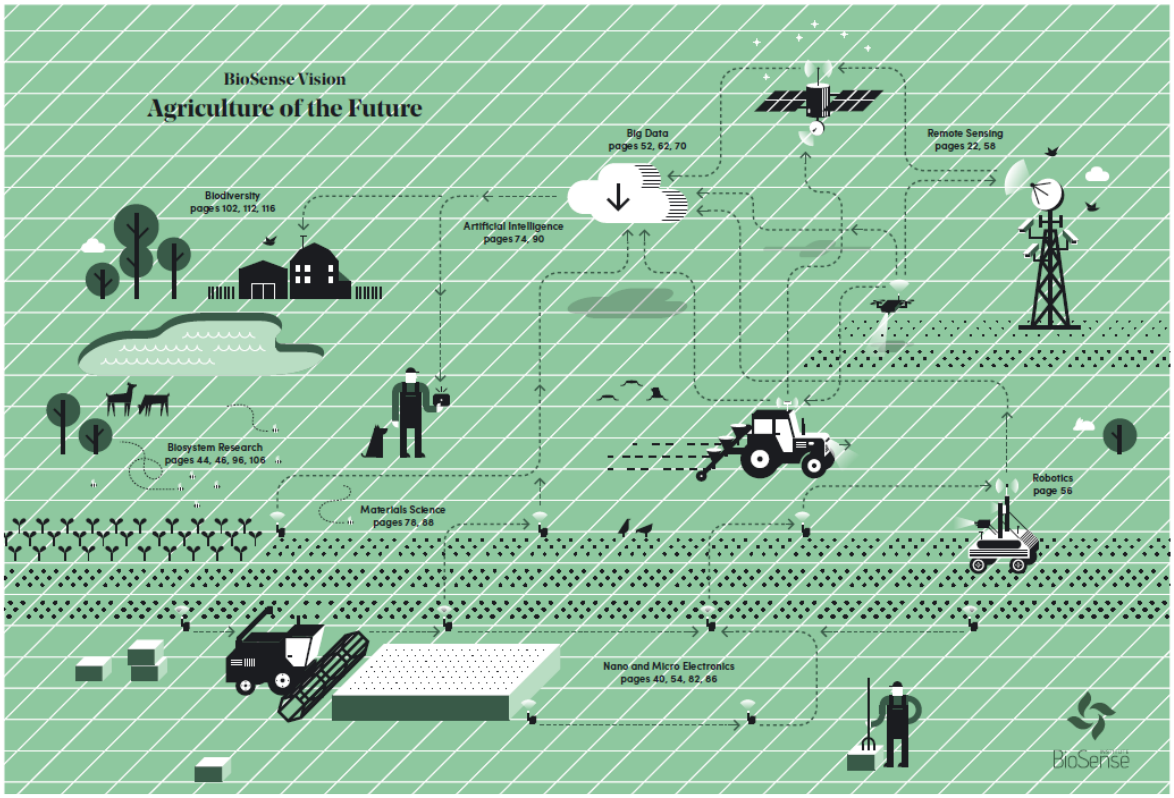


Fig. 3: BioSense vision for the agriculture of the future.

	Nano and Microelectonics	Signal Processing and Knowledge Discovery	Remote Sensing and GIS	Ecology
PhD	Jovan Matović Georges Dubourg Georgios Niarchos	Dragana Bajović Dušan Jakovetić Mališa Marijan	Dimitrios Fotakis Dušan Sakulski	Antonio Ricarte Sabater
MSc	Goran Kitić	Vladan Minić		

Fig. 4: The experts hired through the project InnoSense

Also, the experts have transferred knowledge to other personnel of the BioSense Institute, and particularly important is their support to young researchers. Finally, they have disseminated the excellence of the BioSense Institute at various occasions and have contributed to the business development facility through participation in the project proposals preparation.

Therefore, WP2 activities have provided a strong multidisciplinary research team whose capabilities and expertise gave a strong stimulus to the research potential of the institute.

As a particular success of BioSense beyond the lifetime of the project, we emphasize that **8 out of 11 people hired through InnoSense project, remained at BioSense after their contracts within InnoSense project were concluded**. Due to their significant scientific results, they have become a members of the permanent staff at BioSense and take part in different projects including those funded from the national, provincial and H2020 calls, thus contributing to the research potential of the Institute.

In the following, a short presentation of the hired people will be given.

Jovan Matović is a principal scientist at the BioSense with a strong expertise in micro- and nano-technology and over 20 years of experience. He gained work experience in Institute of Nuclear Sciences, Belgrade, Serbia and the Institute for Chemistry, Technology and Metallurgy, Dep. of Microelectronic Technologies and Single Crystals, Serbia where he conducted research in design of MEMS devices. He conducted research in nano/microsystem technologies, mechatronics and biophysics as a research fellow at Integrated Microsystems Austria GmbH, Austria from 2004 to 2007. Before he joined the BioSense he did research in self-organized, biomimetic, and 2-D nanostructures for application in photonics, energy harvesting, and nanomedicine at Vienna University of Technology, Institute for Sensors and Actuators Systems, Austria. Dr Matović has published over 50 journal and conference papers as well as chapters in three scientific books. He holds two patent applications for MEMS devices for spacecraft thermal control and he won award in biomedical sensors at Cleveland Clinic, USA, 2012. From 2010 he has served as EU Expert-evaluator in the field of sensors and nano-technology. He has supervised PhD students and has vast experience in laboratory management and therefore he strongly contributes to the development of the BioSense.

Georgios Niarchos joined the BioSense in September 2014 as a researcher with expertise in sensor design. He received his B.Sc (2006) from the Physics Department and his M.Sc (2008) and Ph.D (2013) from the Department of Informatics and Telecommunications of the National & Kapodistrian University of Athens, Greece. His research focused on Piezoelectric Energy harvesting from vibrations, combining both solid and flexible substrates to create novel MEMS microgenerators for powering up small sensors. Dr Niarchos has publised over 10 scientific papers related to different fields of micro- and nano-electronics. His research interests include, but are not limited to: energy harvesting, ZnO nanostructured materials, MEMS, sensors. In addition, dr Niarchos has experience in different fabrication technology which contributes to development of the BioSense Laboratory and full exploitation of new equipment.

Georges Dubourg joined the BioSense in September 2014 as a researcher with expertise in sensor design. He received the engineer degree in electronics and PhD degree in microelectronincs from the University of Sciences and Technologies in Bordeaux in 2009 and 2012, respectively. His PhD studies included the fabrication of organic microcantilevers, their characterization and their potential application for bio/chemical sensors. Also, he introduced a new activity in the laboratory concerning organic MEMS for biosensing applications and acquired a strong background in organic MEMS fabrication. His research interests are in the bio/chemical research application area and in development of wireless and user-friendly innovative sensing microdevices for agriculture and environmental applications. He has published more than 10 scientific papers mostly related to sensor development. Dr Dubourg has very strong technical skills and experience in clean room processes such as photolithography, DRIE, RIE, wafer-bonding process, spray-coating, shadow-masking process, metal deposition and patterning processes.

Goran Kitić received MSc degree from the University of Novi Sad in 2008 in the field of MEMS (microelectromechanical systems) devices and joined the BioSense in November 2013. His tasks are to cooperate with researchers on development of different sensors and devices, to further advance the equipment capabilities of the BioSense as well as to ensure necessary support for the full exploitation of new equipment. His research includes design of sensors including microwave soil moisture sensors, milk quality sensors, and nitrogen

sensors. Because of the nature of his research work Goran Kitić developed experience in the field of different fabrication technologies like LTCC, PCB, microfabrication, thin and thick film technology. Thus, he possesses excellent abilities to provide the link between full capabilities of the technological process and circuit-design efforts of the researchers.

Dušan Jakovetić has been with the BioSense since October 2013 at the position of researcher with the expertise in signal processing. He obtained a dipl. ing. degree from the School of Electrical Engineering, University of Belgrade, Serbia, in August 2007, and the Ph.D. degree in electrical and computer engineering (ECE) from Carnegie Mellon University, Pittsburgh, PA, and Instituto de Sistemas e Robótica (ISR), Instituto Superior Técnico (IST), Lisbon, Portugal, in May 2013. From June to September 2013, he was a postdoctoral researcher at IST. Dr. Jakovetić's research interests and expertise include convex optimization, statistical inference, and distributed algorithms for networked systems. He has published 10 journal papers in the IEEE Transactions on Signal Processing/Automatic Control, and 17 papers in international conferences. His main role is to produce research on wireless sensor networks and wireless access networks, targeting applications in environmental monitoring and protection, as well as in precision agriculture. More specifically, he works on distributed in-network processing and distributed storage for wireless sensor networks, as well as on distributed protocols for wireless access and machine-to-machine communications.

Dragana Bajović joined the BioSense in October 2013 as an expert in signal and information processing in wireless sensor networks. She obtained her engineering degree from the School of Electrical Engineering, University of Belgrade, Serbia, in August 2007, and the Ph.D. degree in electrical and computer engineering (ECE) from Carnegie Mellon University, Pittsburgh, PA, and Instituto de Sistemas e Robótica (ISR), Instituto Superior Técnico (IST), Lisbon, Portugal, in May 2013. From June to September 2013, she was a postdoctoral researcher at IST. Dr. Bajović's research interests are in the general area of distributed inference, and her expertise includes distributed detection and estimation algorithms, products of random matrices, and large deviations analysis. She has published four journal papers in the IEEE Transactions on Signal Processing, and eleven papers in international conferences. Dr. Bajović works on information processing algorithms in sensor networks, with an emphasis on large-scale systems and distributed solutions.

Vladan Minic joined the BioSense in March 2015 as an expert in the field of Wireless Sensor Networks and image processing. He received MSc degree from the Faculty of Technical Sciences, University of Novi Sad. His activities include data collection and maintenance of Wireless Sensor Networks and meteorological stations, as well as maintenance of BioSense GIS server and other services necessary for operation at BioSense.

Mališa Marijan received the Dipl. Ing. degree in electrical engineering from the University of Belgrade, Serbia, and the M.S. and Ph.D. degrees in electrical engineering from University of Rochester, NY in 2005, 2008, and 2012, respectively. He was a postdoctoral research associate under the Lady Davis Fellowship at Technion, Haifa in 2012. In October 2013, he joined the BioSense as an expert in coding theory. His research is in the area of data acquisition (A/D converters, image sensors, and sensor networks) and related signal processing and reconstruction techniques (compressed sensing, mathematical optimization, and error-correction). As a part of BioSense

research team, his work has been toward improving accuracy and reliability of measurements from sensors involving sigma-delta (ΣΔ) type analog to digital converters (ADCs).

Dimitrios Fotakis has been working at the Biosense since January 2014 as an experienced researcher in the field of geoinformatics with specific expertize in natural resources management. He holds an interdisciplinary PhD degree combining Natural resources and Operational research. After obtaining a Bachelor degree on Forestry in 2000 he was working in various projects as practitioner and forest manager in Greece until 2103 combining research and working experience. He received his MSc in Geoinformatics with emphasis on hydrology modelling in 2003, and his PhD in 2009 from the Faculty of Engineering, Aristotle University of Thessaloniki (AUTH). He has 10 publications in International Journals (h-index: 5), he is a member of journal editorial boards, a reviewer in several international journals and a member of various European networks. His current research interests are: natural resources management and ICTs in a variety of interrelated areas.

Dusan Sakulski joined the BioSense in December 2014 as an expert in the field of environmental/water/disaster risk management, data mining and data processing, and integrated information systems design and development. He received PhD thesis in the field of Environmental and Disaster Risk, from University of the Witwatersrand (WITS), Faculty of Engineering, Johannesburg, South Africa. His research activities include enhancement of spatial and temporal data monitoring, integration, and management, and development of application strategies based on data processing for various BIO-fields scenarios.

Antonio Ricarte Sabater was with the BioSense since March 2014 to December 2014 as an expert in the field of insect biodiversity and conservation of habitats. Dr Ricarte received his PhD degree from the University of Alicante, Spain in 2008. Dr Ricarte has participated in 16 research projects and been awarded 2 research grants within the EU infrastructure project ExpeER. He has authored over 40 publications and undertook research in institutions from different countries such as Serbia, the UK and Mexico. Dr Ricarte's role in the BioSense was also to provide biological advice, especially in projects concerning agricultural systems and nature protection.

The published scientific results represent the most tangible evidence of the research excellence and in that sense the hired experts have had a **very successful publication rate**. Namely, Table 1 shows the list of the published papers and it can be seen that the total number of the published papers equals 36, 18 of which are journal papers, 15 conference papers, and 3 invited talks. Taken into consideration that the average duration of the employment was 22,6 months within the Project, the publication rate represents a clear indicator of the success. We note that Table 1 lists only the papers published by the hired people, and not all papers which resulted from InnoSense project.

Another important marker of the research excellence is the citation of the papers. Although the papers have been recently published, in 2014 and 2015, and thus their impact might not be properly estimated, some of the papers have received a considerable attention. **The total number of the citations for the all papers exceeds 110,** which indicates that the published results have **a strong impact** on the academic society.

To further illustrate the success of the research activities of the hired people and their contribution to the BioSense Institute, we present some of the devices developed by them. Fig. 5a shows two prototypes, one analogue and another digital, of the **device for somatic cell count in the cow milk**.

Namely, the increased number of somatic cells indicates presence of mastitis which represents the largest cost to the dairy industry since contaminated milk has to be instantly poured out and infected cows medically treated.

Table 1: List of publication realized by the hired people

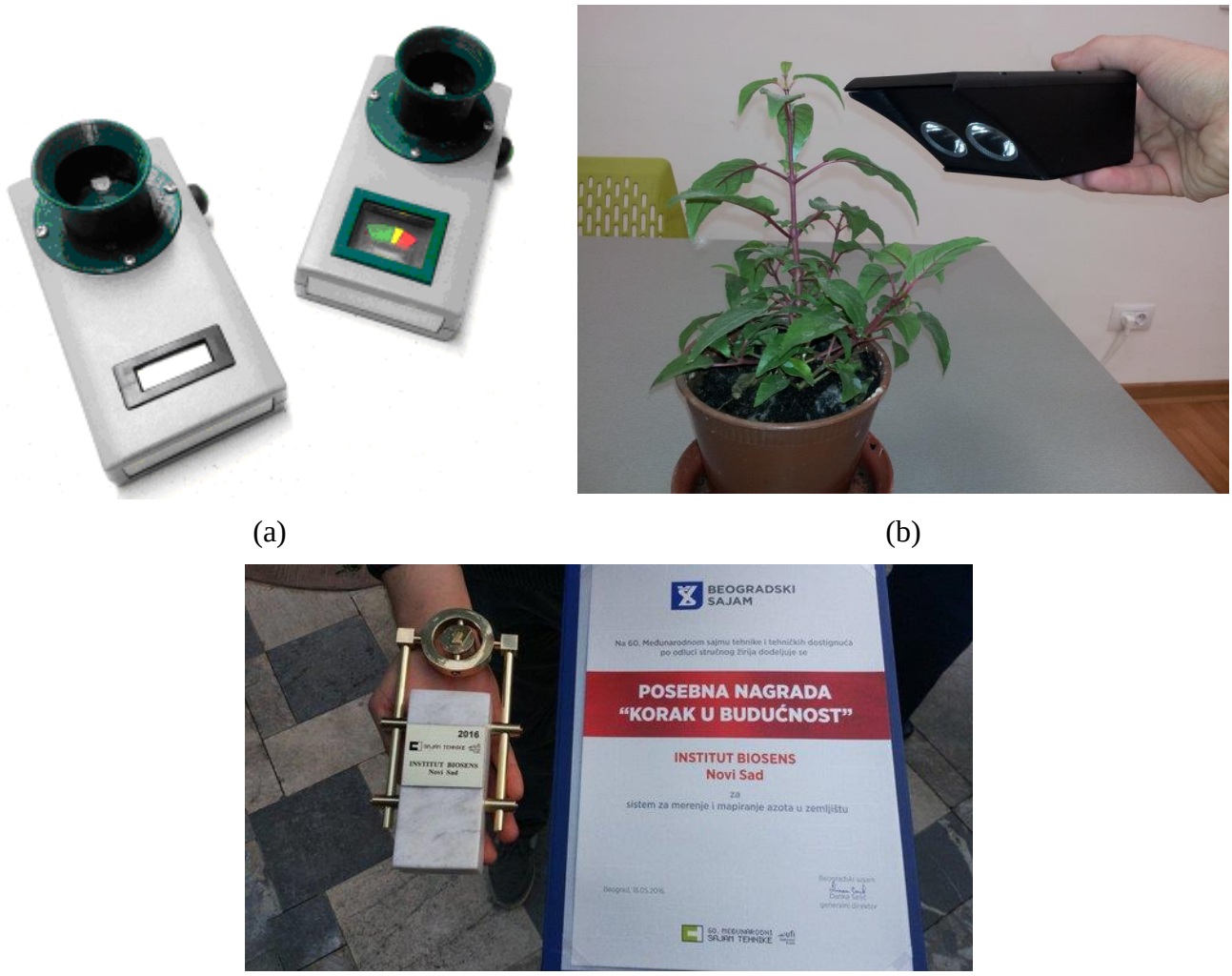
Journal papers
1. Nikola Bednar, Jovan Matović, Goran Stojanović, Properties of surface dielectric barrier discharge plasma generator for fabrication of nanomaterials, Journal of Electrostatics, Volume 71, Issue 6, pp. 1068–1075 December 2013
2. Michael Kellner, Philip Radovanovic, Jovan Matovic, Robert Liska, Novel cross-linkers for asymmetric poly-AMPS-based proton exchange membranes for fuel cells, Designed Monomers and Polymers, Volume 17, Issue 4, pp. 372-379, 2014.
3. Jakovetić D.: Convergence Rates of Distributed Nesterov-like Gradient Methods on Random Networks, IEEE Transactions on Signal Processing, 2014, Vol. 62, No 4, pp. 868-882.
4. Ricarte A, Rotheray G, Lyszkowski R, Hancock E, Hewitt S, Watt K, Horsfield D, Macgowan I, The syrphids of Serra do Courel, Northern Spain and description of a new Cheilosia Meigen species (Diptera: Syrphidae), Zootaxa, 2014 May 1;3793:401-22.
5. Jakovetić D.: Fast distributed gradient methods, IEEE Transactions on Automatic Control, 2014, Vol. 59, No 5, pp. 1131-1146.
6. Fotakis, D., Sidiropoulos, E., Loukas, A, Integration of a Hydrological Model within a Geographical Information System: Application to a Forest Watershed, Water 2014, 6(3), 500-516.
7. Myronidis D., Fotakis D, Utilizing 3D solid modeling tools for simplified designing of a small concrete Gravity Dam, International Journal of Sustainable Agricultural Management and Informatics, Vol. 1, No. 4, pp. 351-357, 2015.
8. E. Sidiropoulos, D. Fotakis, Spatial optimization: An indispensable tool for development, South-Eastern European Journal of Earth Observation and Geomatics, vol. 4 pp. 81-91, 2015.
9. Nedeljković Z., Ačanski J., Đan M., Obreht D., Ricarte A. and Vujić A: An integrated approach to delimiting species borders in the Syrphidae (Diptera), with description of two species of Chrysotoxum Meigen. Contributions to Zoology, 84 (4) 285-304, 2015.
10. Jakovetić D.: Linear Convergence Rate of a Class of Distributed Augmented Lagrangian Algorithms , IEEE Transactions on Automatic Control, 2015, Vol. 60, No 4, pp. 922-936.
11. Jakovetić D., Bajović D., Vukobratović D., Crnojević V.: Cooperative Slotted ALOHA for Multi Base Station Systems, IEEE Transactions on Communications, 2015, Vol. 63, No 4, pp. 1443-1456.
12. Antić B., Minić V., Tsioukas V.: Activities to Promote Earth Observation in the Balkan States, South-Eastern European Journal of Earth Observation and Geomatics, 2015, Vol. 4, No 1, pp. 17-24
13. Dimitrios Fotakis, Multi-objective spatial forest planning using self-organization, Ecological Informatics, Volume 29, Part 1, pp. 1–5, September 2015.
14. Kazana V., Kazaklis A., Stamatiou C., Koutsona P., Boutsimea A., Fotakis D, SWOT analysis for sustainable forest policy and management: a Greek case study, Int. J. Information and Decision Sciences, Vol. 7, No. 1, pp. 32-50, 2015.
15. Markovic V., Vasiljevic Dj., Jovanovic T., Lukic T., Vujicic M., Kovacevic M., Ristic Z., Markovic S., Ristanovic B., Sakulski D, The Effect of Natural and Human-Induced Habitat Conditions on Number of Roe Deer - Case Study of Vojvodina Serbia, Acta Geographica Slovenica, January 2016.
16. Janković N., Niarchos G., Crnojević-Bengin V.: Compact UWB bandpass filter based on grounded square patch resonator, Electronics Letters, 2016, Vol. 52, No 5, pp. 372-374.
17. Markov Z, Nedeljković Z, Ricarte A, Vujić A, Jovičić S, Józan Z, Mudri-Stojnić S, Radenković S, Ćetković A, Bee (Hymenoptera: Apoidea) and hoverfly (Diptera: Syrphidae) pollinators in Pannonian habitats of Serbia, with a description of a new Eumerus Meigen species (Syrphidae), Zootaxa. 2016 Aug 18;4154(1):27-50.
18. Lukic T., Maric P., Hrnjak I., Gavrilov M., Mladjan D., Zorn M., Komac B., Milosevic Z., Markovic S., Sakulski D., Jordaan A., Djordjevic J., Pavic D., Stojsavljevic R, Forest Fire Analysis and Classification - Based on Serbian Case Study, Acta Geographica Slovenica, 57(1):51–63, January 2017.
19.

Invited talks

1. Bajović D., Jakovetić D., Vukobratović D., Crnojević V.: Slotted ALOHA for Networked Base Stations: Algorithms and Performance, 20. European Wireless Conference, Barcelona, Spain, 14-16 May, 2014.
2. D. Jakovetic, Distributed optimization in multi-agent systems, LARSYS Summer School, Instituto Superior Tecnico, Lisbon, Portugal, 2014.
3. J. Matovic, "Nanotechnology in sensors for environmental monitoring", invited talk IBSC conference 2014 Phuket, Thailand

Conference papers

1. B. Will, V. Crnojević Bengin, G. Kitić: „Microwave Soil Moisture Sensors," Proceedings of the 43rd European Microwave Conference EuMA 2013, Nuremberg, Germany, 7-10. October 2013.
2. Bajović D., Jakovetić D., Vukobratović D., Crnojević V.: Slotted ALOHA for Networked Base Stations, 14. IEEE International Conference on Communications (ICC), Sydney: IEEE, 10-14 June, 2014.
3. Jakovetić D., Bajović D., Vukobratović D., Crnojević V.: Slotted ALOHA for Networked Base Stations with Spatial and Temporal Diversity, 4. IEEE International Symposium on Information Theory ISIT, Honolulu: IEEE, 29 June -4 July, 2014
4. Dubourg G., Žlebič Č., Matović J., Crnojević-Bengin V.: One-Step Patterning of a Flexible Piezoresistive MEMS Sensor by 3D Direct Laser Writing, IEEE-NEMS, Xi'an: IEEE, 7-11 April, 2015, pp. 553-556
5. Jakovetić D., Minja A., Bajović D., Vukobratović D.: Distributed Storage Allocation for Neighborhoodbased Data Access, IEEE Information Theory Workshop, ITW Jerusalem 2015, April 26 – May 1, 2015.
6. Jakovetić D., Bajović D., Vukobratović D.: Distributed Estimation of Sparse User Activity for Multi-base Station On-Off Random Access, 2015 IEEE International Conference on Communication Workshop (ICCW), 8-12 June 2015, DOI: 10.1109/ICCW.2015.7247488
7. Dubourg G., Marjanović S., Žlebič Č., Matović J., Crnojević-Bengin V.: 3D laser writing in-line process for the rapid fabrication of flexible electronic devices, 10. TechConnect World Innovation Conference, Washington, DC, 2015, pp. 131-134
8. Jakovetić D., Bajović D., Krejić N., Krklec Jerinkić N.: Distributed Gradient Methods with Variable Number of Working Nodes, 22nd International Symposium on Mathematical Programming, Pittsburg USA, July 2015.
9. Krejić N., Jakovetić D., Bajović D., Krklec Jerinkić N.: A Newton-Like Method for Distributed Optimization, 22nd International Symposium on Mathematical Programming, Pittsburg USA, July 2015.
10. Krklec Jerinkić N., Krejić N., Bajović D., Jakovetić D.: Variable Sample Line Search Method for Distributed Optimization, 22nd International Symposium on Mathematical Programming, Pittsburg USA, July 2015.
11. Niarchos G., Dubourg G., Afroudakis G., Tsouti V., Makarona E., Matovic J., Crnojević-Bengin V., Tsamis C.: Low-cost paper-based humidity sensor based on ZnO nanoparticles, 29. Eurosensors, Freiburg, Germany, 2015
12. Dubourg G., Kojić S., Matović J., Crnojević-Bengin V.: Rapid fabrication of paperbased MEMS strain sensor using a laser micromachining process, 12. Micro and Nano Engineering, Hague, 2015
13. Myronidis D., Fotakis D., Sgouropoulou K., Stathis, D, Checking a culvert suitability for flood wave routing within the framework of the EU flood directive, 7th International Conference on Information and Communication Technologies in Agriculture, Food and Environment, 2015.
14. S. Marjanović, G. Kitić, J. Matović, N. Cselyuszka, V. Crnojević Benign: „Towards a New Generation of Microfluidic Devices Without Microfluidic Channels," *12th International Conference on Advanced Technologies, Systems and Services in Telecommunications TELSIKS 2015*, Niš, Serbia, 14-17. October 2015.
15. Dubourg G., Savić S., Niarchos G., Kitić G., Ivetić T., Doumbia M., Janković N., Crnojević-Bengin V., Radović M.: Characterisation of Screen-printed TiO2 Nanoparticles on Flexible Substrate for Humidity Sensing, 1. The International Bioscience Conference and the 6th International PSU – UNS Bioscience Conference IBSC 2016, Novi Sad, 19-21 September, 2016



(a) (b)

(c)

Fig. 5: Some of the devices developed by the hired people: (a) Milk quality monitoring device, (b) NDVI device for plants' health monitoring, (c) device (b) awarded at the 60th International Fair of Technical Achievements.

Fig. 5b shows the prototype of the **NDVI (Normalized Difference Vegetation Index) device that is used for plant's health monitoring.** By analysis of plants spectra one can determine if the plant suffers from the lack of water, nutrients, photosynthetically active radiation and much more parameters that are important for proper growth and development of the plant. This device also won Special award "Step into the future" at the 60th International Fair of Technical Achievements in Belgrade, Serbia, Fig. 5c.

As stated previously, the hired people contributed to the BioSense in other means including full support to exploitation of the new equipment, organization of the relevant trainings, introduction of new methods and practices in the laboratory, dissemination, project proposals preparation, and knowledge-transfer.

3.2 Work package 3 - Equipment purchase

Further improvement of the research capacities has been achieved through the equipment purchase. The purchased equipment is used to complement and upgrade the existing equipment at the

BioSense. Investments were primarily directed towards Nano and microelectronics laboratory and an investment was made into **LTCC facility which is emerging and highly promising new technology in environmental sensor design**. Since LTCC equipment needed to be placed in a clean room, within the Project a purchase and installation of the **clean room facility** of the appropriate size and class was also foreseen. Additional pieces of equipment aimed at characterization of the micro- and nanoelectronics circuits were purchased. The list of these equipment is given in Table 2, whilst the clean room with LTCC and other facilities is shown in Fig. 6a.

The importance of this sophisticated and unique in the region laboratory, with the potential to produce novel scientific results, was also **recognized by the authorities** and Fig. 6b shows the moments from the opening ceremony of the laboratory with the **Provincial Prime Minister** Bojan Pajtic.

The fabrication capabilities of Nano and microelectronics laboratory of the BioSense Institute now include:

- Infrastructure:
  - Clean room 1 – photolithography, nano and MEMS, class ISO 5 / ISO 7 (ISO 146441), DI water Grade 1 (ISO 3696), nitrogen, argon and air class ISO 5, vacuum;
  - Clean room 2 – thin and thick films Class ISO 5 / ISO 7, DI water Grade 3 (technical water), nitrogen and air class ISO 5, vacuum;
  - Clean room 3 – nano and micro manufacturing, characterization & measurement, optical laboratory, class ISO 8, nitrogen and air class ISO 5, vacuum;
- LTCC (Low Temperature Cofired Ceramics) technology with complete prototyping line including laser cutting.
- Photolithography processes with 1μm line resolution limit.
- Thin films technologies: thermal evaporation of inorganic and organic layers; e-gun evaporation in neutral or reactive environment; Layer-by-Layer deposition of polyelectrolytes; electrodepositing.
- Thick films technologies: screen printing; spin coating of films.
- Micromachining processes in silicon, glass and ceramics.
- Micro-electro-mechanical systems (MEMS) which can be fabricated using thin/thick film deposition, photolithography, electroplating, laser machining, and inkjet printing.
- Nano-manufacturing processes, particularly connected to bionics and self-organized nanostructures.
- Chemical and electrochemical section.
- Optical laboratory section with optical tables and accessories.
- Electronic and mechanical workshop serve as units for assembling sensor prototypes, microwave circuits and supporting electronics, and manufacturing of a special experimental apparatus, acoustic devices, and housing for sensors.

The characterization capabilities now include:

- Optical inspection in UV, visible and NIR spectra and dimension control up to 1 μm level
- Electron microscopy, with included EDX analysis and surface analysis
- Spectroscopic analysis in UV, visible and IR spectra
- Thin film characterization with contact and contactless methods

- Semiconductor analysis and Hall measurements with installed wafer probe station
- RF and microwave measurements
- X-ray fluorescence
- Mass spectroscopy
- Electrochemical impedance spectroscopy

Research facilities and equipment have been further upgraded with **autonomous robots and all-terrain vehicle equipped with hyperspectral cameras and soil probes as well as XRF analyser that provides fast, non-destructive elemental analysis of the soil**. The new facilities enable a detailed soil mapping in terms of its parameters providing a wide range of soil condition data, which can be further processed so as to provide a valuable information for end-users.

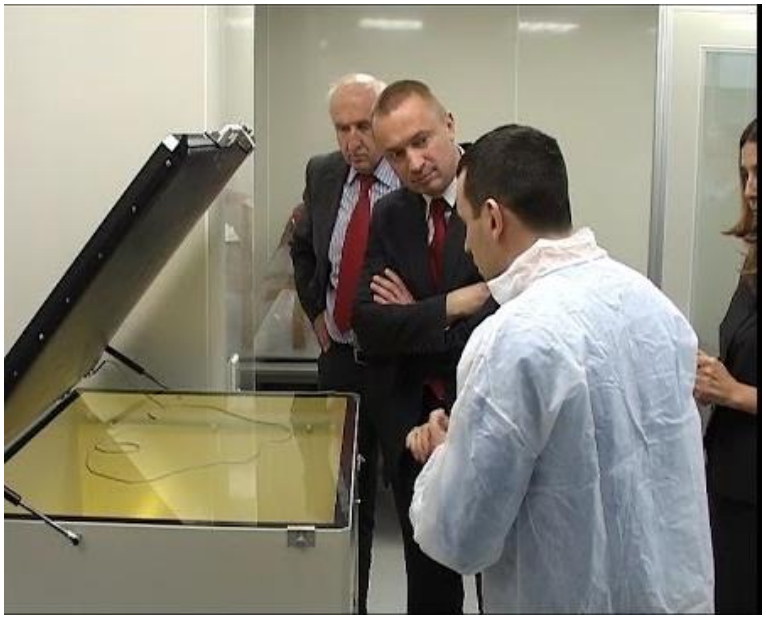
In this manner, the BioSense Institute is set as a multidisciplinary research institute with the highest potential to produce novel scientific results for application in agriculture and environmental monitoring.

Fig. 7 shows some pieces of the equipment, whilst the list is given in Table 3.

Table 2: List of purchased equipment related to LTCC fabrication facility and characterization

LTCC fabrication facility
LTCC conductor screen printer EKRA M2H with MOPS with accessories: Spin coater Laurel WS-650Mz-23NPP, UV exposition and calibration VARIOCOP S 67 x 77 cm - S 1500, Linear CNC mill SyiL X5 PLUS, CNC machine Bernardo Proficentre 700 BQV, and Mask Cleaner Sonorex Super Ultrasonic Bath RK 514 BH
LTCC sheet dryers Memmert UN300, 32 litre, 2 pieces
General purpose high-accuracy (5 μm) Mask Alignment & Exposure System MDA-400M, MIDAS SYSTEM CO. Ltd
LTCC uniaxial laminator CARVER Auto Series Autofour/20-NE press
Clean room for LTCC facility (designed according to specifications)
LTCC furnace for firing in the argon and nitrogen atmosphere Nabatherm L 9/11/SKM with controller P330 and accessories
Laser marking system Rofin-Sinar CombiLine advanced WT and Powerline D-100
Characterization equipment for micro- and nanoelectronics
Hitachi Tabletop Electron Microscope TM 3030 with modules for profilometry and chemical analysis
Vector Network Analyser Agilent E5071C-280 with a standard mechanical calibraiton kit and accessories
UV/VIS spectrometer with 2 beams
Fast Fourier transform infrared spectrometer

(a)



(b)

Fig. 6: Upgraded BioSense laboratory and equipment: (a) Clean room with LTCC and other facilities, (b) Provincial PM Bojan Pajtic in the Biosense laboratory.

(a)

(b)

(c)

(d)

Fig. 7: (a) Hyperspectral imaging cameras MQ022HG-IM-SM5x5-NIR, (b) XRF- X-ray DP-2000-CX-E-EN-EN-AP, (c) all-terrain vehicle (ATV) BRP-CAN AM equipped with soil probe, (d) unmanned ground vehicle CLEARPATH Husky.

Table 3: List of the purchased equipment for non-destructive analysis of the soil.

Hyperspectral imaging system including field spectrometer and line hyperspectral camera
Hyperspectral line imaging cameras SP-HS-CL-30-V10E-Std 400-1000 nm and SP-NIR-VLNIR-CL-100-N17E 700-1900 nm
Hyperspectral matrix imaging camera MQ022HG-IM-SM5x5-NIR
Server Lenovo X3850X6 Intel XEON E7-4820
Storage NETAPP E2700-R6
Unmanned ground vehicle for agricultural sensing
Unmanned ground vehicle CLEARPATH Husky A200™ UGV Robot 2 pieces
XRF- X-ray fluorescence spectroscopy for UGV DP-2000-CX-E-EN-EN-AP
fabrication and characterization equipment for micro- and nanocircuits
Soil probe system
Soil probe EM-38 MK2 Geomatrix
All-terrain vehicle (ATV) BRP-CAN AM for soil probe
Accessories for ATV BRP-CAN AM

3.3 Work package 4 - Intellectual Property and Innovation Capacity Building

In order to fully exploit the research results of the BioSense, work package 4 was implemented with the aim to establish a framework for the effective protection and management of IPR, to develop a structured approach towards greater involvement of key stakeholders, to alter the mindset of the researchers with respect to innovation and entrepreneurship, and to contribute to the diversification of the income base of the BioSense.

To that end, the **Innovation and Business Development Facility (IBD) was established within InnoSense and 3 people were hired**, namely:

Grigorios Chatzikostas has been employed as Innovation and Business Development Manager. He has over 10 years of international experience in fostering successful win-win research collaborations and partnerships between industrial players, government organizations and leading academic institutions to increase the rate of innovation and technology. His experience includes writing successful proposals, carrying out contract negotiations and acting as coordinator on a number of projects in the fields of Environmental Technologies and Introduction of Advanced ICTs in agricultural clusters.

Maja Radisic has been employed as Innovation and Business Development Assistant. She graduated at University of Novi Sad, Faculty of Sciences, Department of Geography. Previously, she was working for several years in tourism industry, with main duties in event organization and administration. Currently, her main responsibilities within BioSense Institute are: business administration assistance for the activities of WP4 including organization of trainings, market research, organization of promotional activities, contribution in the preparation of reports, proposal writing etc.

Milica Trajkovic has been employed as an Innovation and Business Development Assistant. She graduated at the University of Novi Sad, Faculty of Technical Sciences and obtained her M.Sc. degree in the area of Industrial Engineering and Management. During her studies, she was active member of student organization, where she was project leader of an international project and Vice President for Public Relations. Currently, her main responsibilities within the BioSense Institute are business administration assistance, organization of trainings and other types of events, writing project proposals and project management assistance.

IBD facility, established owing to the project InnoSense, **makes the BioSense a unique research institution in the region**. Moreover, **Innovation and Business Development Facility has been enlarged with 2 new staff members and matured into the Business Development Department (BDD) of the BioSense Institute.**

The BDD team has achieved a number of results and set a strong basis for further commercial exploitation of the research results and transfer of the knowledge to the market.

Firstly, BDD invested a great effort to **expand the existing network of partners and their networking activities were successfully promoting the capacities of BioSense Institute to both governmental as well as industrial partners**, so the capacities for contracted research and strategic advisory service. Business Development Facility has developed a user-friendly data base which incorporates all important information about contacted partners, Fig. 8.

Therefore, research and innovation at BioSense is developed in a close interaction with farmers and the agrifood sector, government bodies, entrepreneurs and business community, international researchers, and citizens. We work together to create a new generation of open innovations which

will be readily used and which will bring benefits across the entire value-chain. As a meeting place for all relevant stakeholders, **we have established PA4ALL – the Living lab for precision agriculture. This is the first living laboratory in Serbia and the first one in Europe to focus on precision agriculture.** PA4ALL takes full advantage of inter-sectoral cross-fertilization of ideas and offers possibilities to test ideas and prototypes in the real-world setting. The range of services that are offered to stakeholders are summarized at the BioSense web presentation, whose corresponding screenshot is shown in Fig. 9.

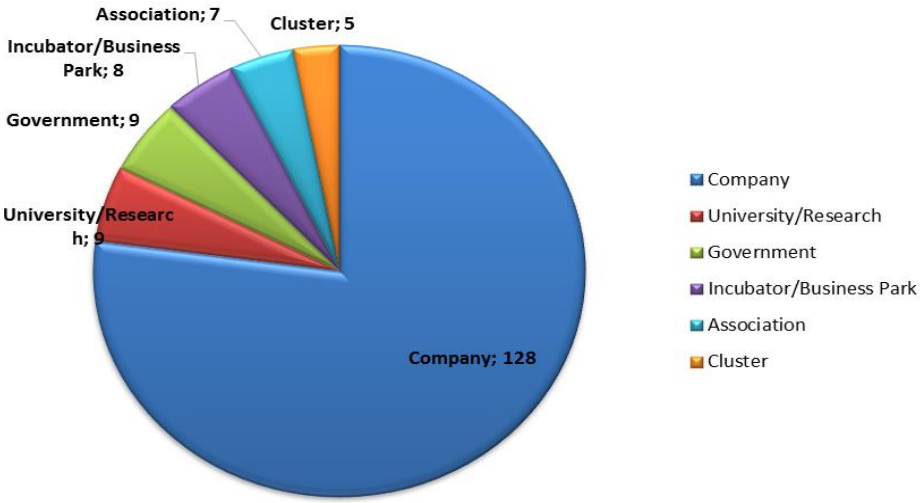


Fig. 8: Partner's field of work

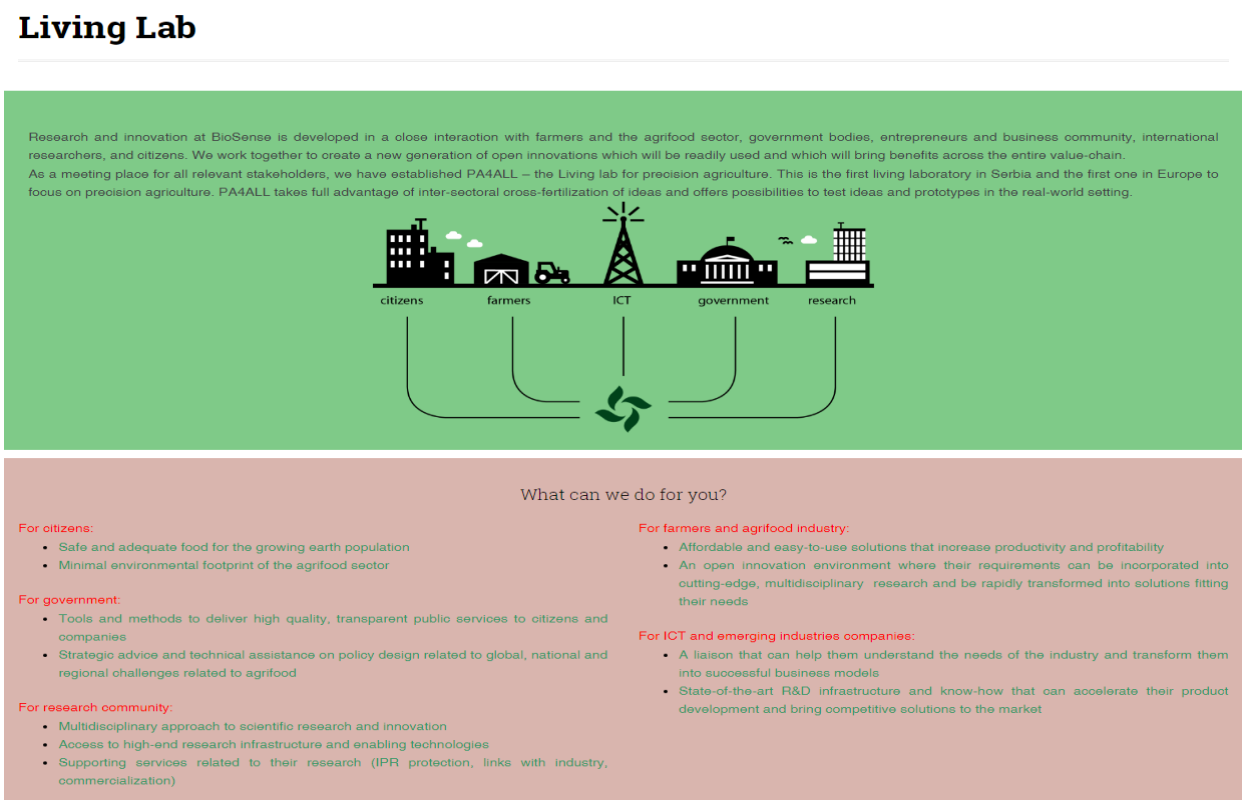


Fig. 9: Screenshot of the web presentation of the BioSense Living Lab.

Starting from August 2013, PA4ALL is a member of ENoLL, European Network of Living Labs. We managed to attract a nucleus of stakeholders as members of PA4ALL including the regional government, a huge agricultural company with state-of-the-art facilities and the region cluster of ICT companies. PA4ALL was further enforced by our participation in the FRACTALS project, in the course of which we recruited 300 end-users to validate ICT solutions from the agricultural sector.

The efforts of BDD team were also directed towards **organization of the trainings with the aim to encourage entrepreneurial spirit among researchers** and shift their research work to be more market and user-driven. Another significant aim of conducted trainings was **to introduce all the researchers with the Horizon2020 programme as well as with the importance of the Intellectual Property protection** and the benefits that this activity can provide.

Working closely with the BioSense researchers on the project proposal preparation, BDD has significantly intensified participation of the BioSense staff in EU-funded calls, in particular in those from H2020 programme. **One of the flagship outcomes of the Project are 10 successful H2020 project proposals**, with a 25% success rate. Table 4 gives a full list of the projects together with their short description.

The project ANTARES represents an outstanding success of the BioSense which is a direct outcome of the project InnoSense. Namely, **the BioSense Institute has been tremendously reinforced through the InnoSense, and as such has a huge potential to become a European leader in research in ICT** for agrifood and related biosystems. **This has been confirmed through ANTARES**, which was granted to the BioSense in the prestigious **H2020 Teaming call whose aim is transformation of research institutions into European centres of excellence**. At the moment, the BioSense is participating in in phase II of the Teaming call as a candidate for European Centre of Excellence that will be funded by European Commission. We note a specific contribution of BDD in the preparation of the business plan of BioSense for the next 7 years, executed within ANTARES.

Table 4: List of H2020 projects granted to the BioSense

Project acronym	Project name	Shot description
ANTARES	Centre of Excellence for Advanced Technologies in Sustainable Agriculture and Food Security, H2020-WIDESPREAD-2014 Teaming	ANTARES aims to evolve BioSense Institute, Novi Sad, Serbia, into a European Centre of Excellence (CoE) for advanced technologies in sustainable agriculture and food security. This endeavor is supported by the participation of the Serbian Ministry of Education, Science and Technological Development (MESTD), the national research authority who will provide both institutional and legislative expertise as well as co-financing of 14 mil Euro. The participation of DLO, the Netherlands, the leading European research institute for applied and market-driven research in agriculture and food security, currently involved in 250 FP7 projects, will secure that the know-how and experience of highest European standards are transplanted to Serbia.
SmartAKIS	European Agricultural Knowledge and Innovation Systems (AKIS) towards innovation-driven research in Smart Machines and Systems	The main objective of the Smart-AKIS Thematic Network is to foster the effective exchange between all relevant actors in the value chain, communicate and disseminate direct applicable solutions to close the research and innovation divide for the use of Smart Machines and Systems (SFTs) in crop, livestock and forestry production in Europe. Smart-AKIS will use a “Multi Actor Approach”, including in the partnership researchers, extension services, farmer organizations and industrial partners. Through covering a wide range of the European AKIS typologies, Smart-AKIS will leverage on their differences in order to better capture their innovation capacities and processes in the field of SFTs.

KATANA	Emerging industries as key enablers for the adoption of advanced technologies in the agrifood sector	KATANA supports European SMEs in the agrifood value chain to simultaneously access knowledge, technology, capital and markets in order to respond to the global competitive environment. KATANA aims to provide this access to companies by leveraging upon the multiplier potential of cross-border/cross-sectoral collaboration and the systemic approach which homogenizes services towards the overall aim to place new products/ services in the market.
INNO-4-AGRIFOOD	Capitalising the full potential of on-line collaboration for SMEs innovation support in the Agri-Food ecosystem	INNO-4-AGRIFOOD will deliver a new generation of innovation support services that will assist European SMEs across the vast Agri-food ecosystem to create value from on-line collaboration for innovation, access a broader range of potential innovation partners beyond their national and sectoral borders and timely mobilise them to seize opportunities to launch concrete innovation projects. INNO-4-AGRIFOOD services will be provided by properly qualified and well-trained innovation support specialists and appropriately escalate to respond to the diverse needs and characteristics of agri-food SMEs. They will be platform-independent and supported by a suite of smart ICT tools based on well-established and mainstream web technologies.
IoF2020	Internet of Food and Farm 2020	For the first time, DG Connect and DG Agri jointly finance the 30mEuros IoF2020 H2020 project (Internet of Things in the Agrifood Domain), where BioSense is a core partner and WP Leader, while our strategic partner DLO, the Netherlands, is the coordinator. IoF2020 is dedicated to accelerate adoption of IoT for securing sufficient, safe and healthy food and to strengthen competitiveness of farming and food chains in Europe. It will consolidate Europe's leading position in the global IoT industry by fostering a symbiotic ecosystem of farmers, food industry, technology providers and research institutes. The IoF2020 brings tgoether a consortium of 73 European partners includung multinational companies like Philips and ST Microelectronics.
SKIN	Short supply chain Knowledge and Innovation Network	SKIN is an initiative of 20 partners in 14 countries in the area of Short Food Supply Chains (SFSCs), which will systematise and bring knowledge to practitioners, promote collaboration within a demand-driven innovation logic and provide inputs to policymaking through links to the EIP-AGRI. SKIN will build and animate a community of about 500 stakeholders, with the strategic objective of setting up, at the conclusion of the project, a European association permanently working for the improvement of SFSCs efficiency and for the benefit of stakeholders and growth in the sector.
AgriDemo F2F	Building an interactive AgriDemo-Hub community: enhancing farmer to farmer learning	The overall aim of AgriDemo-F2F is to enhance peer-to-peer learning within the commercial farming community. The project will utilize the experience of different actors and involve practitioner partners throughout the project to deepen understanding of effective on farm demonstration activities (multi-actor approach).
eLTER	European Long-Term Ecosystem and socio-ecological Research Infrastructure	A collective effort is needed to create the environmental research infrastructure for answering pressing questions in a world of rapid social, economic and environmental change. The overall aim of the eLTER project is to advance the European network of Long-Term Ecosystem Research sites and socio-ecological research platforms to provide highest quality services for multiple use of a distributed

		research infrastructure.
Advance_eLTER	Advancing the European Long-Term Ecosystem, critical zone and socio-ecological Research Infrastructure towards ESFRI	Advance_eLTER marks an important step in building the distributed European Research Infrastructure of Long-Term Ecosystem Research sites and socio-ecological research platforms (eLTER RI) to provide highest quality data and services complementary to the European and global environmental RIs. Building upon the partnership between BioSense and ILTER, the project will conduct important conceptual work and preparatory steps towards enabling European-scale investigation of the "Critical Zone", major ecosystems and socioecological systems, targeted at supporting knowledge-based decision making at various levels concerning ecosystem services and biodiversity.
EUDAT	EUDAT2020	EUDAT2020 brings together a unique consortium of e-infrastructure providers, research infrastructure operators, and researchers from a wide range of scientific disciplines under several of the ESFRI themes, working together to address the new data challenge. In most research communities, there is a growing awareness that the "rising tide of data" will require new approaches to data management and that data preservation, access and sharing should be supported in a much better way. Data, and a fortiori Big Data, is a cross-cutting issue touching all research infrastructures. EUDAT2020's vision is to enable European researchers and practitioners from any research discipline to preserve, find, access, and process data in a trusted environment, as part of a Collaborative Data Infrastructure (CDI) conceived as a network of collaborating, cooperating centers, combining the richness of numerous community-specific data repositories with the permanence and persistence of some of Europe's largest scientific data centers

Expansion and diversification of the network of partners and significant results provided an increased interest of industry for the BioSense research and activities. Beside leading national agricultural companies including MK group and Delta Agrar, **world leading companies such as Syngenta has shown interest in our activities and therefore we are intensively working on the ideas for joint projects.**

Namely, Syngenta's global competition Syngenta Crop Challenge, in which the BioSense team won 4th place, **drew a specific attention to us.** In November 2015, Syngenta released the call for Crop Challenge. It had a **huge dataset at the disposal**, which included weather, yield and soil characteristics at its farms in the US. The company decided to share the data with the community and get the answer to the question of seed selection. **Competitors needed to develop an algorithm for choosing 5 out of 180 soybean varieties that should be planted on the Evaluation Farm to maximize yield and minimize risk.**

The BioSense offered a solution that is based on voting and Portfolio Optimization Theory, i.e. yield at the Evaluation farm was predicted for each seed variety based on votes of the farms from the training dataset and afterwards processed using Portfolio Optimization Theory.

Out of 500 applications and 30 teams that successfully submitted the solution, BioSense managed to get into the finals along with 5 other **teams from MIT, Stanford and other universities and companies. In this extremely competitive contest, the BioSense team comprising our young researchers won 4th place.**

Also, the BioSense Institute has remained a strong partner to the local and provincial government in the realization of their strategies and policies. Namely, the Provincial Government

recognized the reinforced potential of the BioSense and recently **commissioned the following research projects to the BioSense:**

- **Aflatoxin – farm-to-table, aflatoxin monitoring through the whole food production chain,**
- **Prototype development of the device for somatic cells count of raw milk**
- **Development of low-cost microfluidics sensor to monitor algae chlorophyll in surface waters**
- **Development of device for mapping and measurement of nitrogen as the most important parameter for sustainable agriculture**
- **Sensing technologies for integrating monitoring of agricultural production**

The aim of the projects is to develop low-cost and reliable devices and systems for the control of food, environment, soil, and agricultural production.

These projects confirm the raising importance of the BioSense not only to provincial decision-making, but also to overall progress of the agricultural production and environmental protection on the national and regional level.

3.4 Work package 5 – Secondments

The third pillar of the BioSense research capacity reinforcement were secondments to the EU partnering institutions. The secondments ensured knowledge transfer to staff from the BioSense Institute in areas of expertise of the EU Project partners with emphasis on interdisciplinary approach, adoption of best practices concerning deployment and utilization of ICT systems, exposure of the BioSense staff to advanced working environments in the EU, and their training in complementary skills.

The secondment activities were classified as:

- Long-term secondments of duration of more than 10 days and usually of duration between one and three months, and
- Short-term secondments of duration less than 10 days.

Both long-term and short-term secondments involve visits in both directions between BioSense Institute and EU partnering institutions. The main purpose of long-term secondments of the BioSense Institute staff at EU partnering institutions is to foster the transfer of the know-how, to acquire deep understanding and expert knowledge on a subject, to gain access to resources existing in the EU and to facilitate coordination of future joint research. Short-term secondments are primarily used to transfer knowledge by experts from EU partner institutions to BioSense staff. e.g., for EU partners performing trainings in Serbia.

In total numbers over the entire project, there were 90 secondments, 51 of which were long-term, whilst 39 were short-term secondments, Fig. 10. More precisely, 38 outgoing and 13 incoming long-term secondments, and 19 outgoing and 20 incoming short-term secondments were realized.

Overall, secondment activity was one of the crucial factors of increase of the BioSense Institute staff skills, research expertise and networking capacity during the last three years. All the secondments were carefully planned during the course of the project execution so as to maximize the impact on BioSense Institute development and in this sense, the WP5 success was one of the strong factors in overall realization of InnoSense project and successful reinforcement of BioSense Institute.

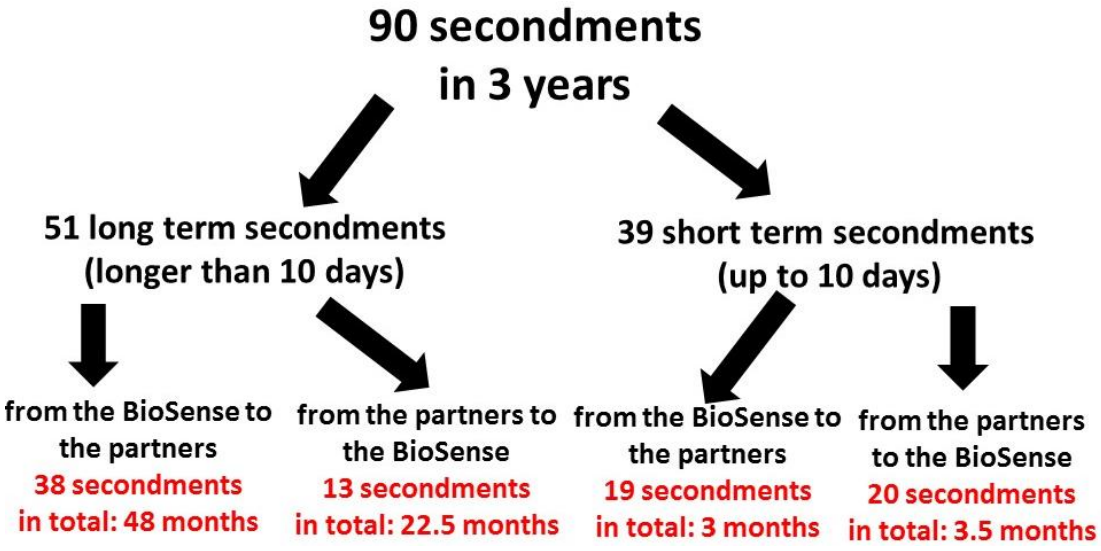


Fig. 10: Secondments realized within InnoSense project.

3.5 Work package 6 - Dissemination and networking

Dissemination was performed on provincial, national, regional (WBC) and EU levels, and it targeted the whole ecosystem of stakeholders including scientific community, provincial and national policy-making bodies, SMEs, companies in agrifood, farmers, student and general population.

Besides raising awareness about the scientific results, one of the objectives of InnoSense was to increase visibility of BioSense among general public to increase understanding of the importance of ICT applications in biosystems and our activities and to offer a wide range of services to stakeholders.

The networking was performed through the secondments and meetings at various occasions including those with researchers from other institutions, as well as meetings with governmental, industry, and SME representatives.

To that end, the BioSense performed an exhaustive dissemination plan that included high impact conferences, networking meetings, workshops, media appearances, trainings, publications, as well as promotional material and web presentation.

The intensive dissemination and networking activities resulted in an impressive network of partners, gathering a wide range of stakeholders, primarily those residing in European countries, but also those from Asia, Africa, and North and South America, Fig. 11.

Table 5 gives an overview of some of dissemination and networking activities in which the BioSense staff participated.

Besides a number of scientific publications and participation in high-impact conferences, a significant effort was invested in promotional, networking, and training activities.

Moreover, **the activities of the BioSense attracted a great attention of media, which is a clear evidence of raising awareness of the BioSense and the importance of its work whose results affects not only research community, but also business world and society as a whole.**

The media appearances were particularly intensified after the project ANTARES was commissioned to the BioSense, which is a direct outcome of the InnoSense and the BioSense reinforcement. Fig. 12 shows excerpts of some media releases.

More details about dissemination activities are given in the following section.

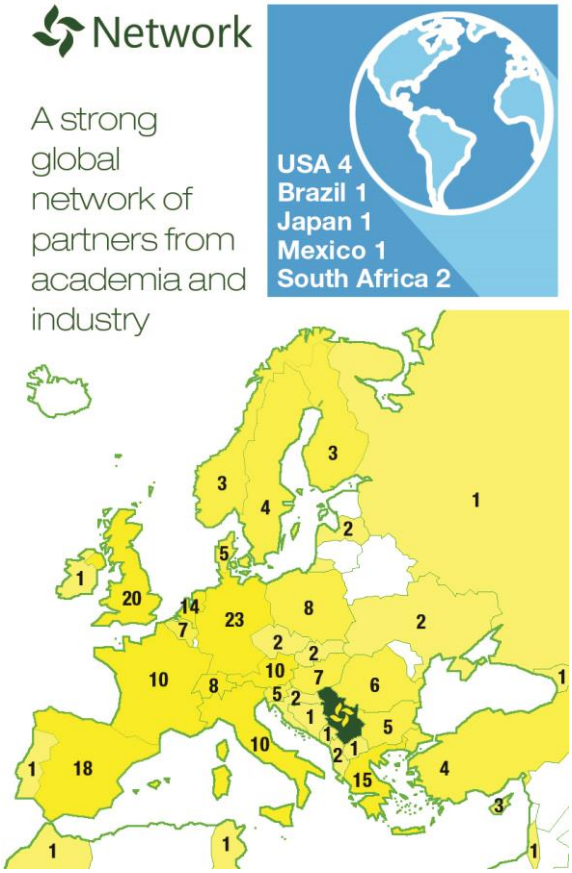


Fig. 11: Network of partners of the BioSense.

Table 5: Dissemination and networking activities in which the BioSense staff participated

Type of dissemination and networking activity		**Number/pieces**
Media appearances	TV and radio reports	16
	Article reports in daily newspapers in print	10
	Article reports published electronically	35
High-impact conferences		31
National and international promotional activities (open days, presentations to a wider public, fairs..)		50
Networking activities (official meetings with academia, industry, governmental representatives…)		56
Training activities Hard (laboratory equipment, workshops related to scientific knowledge) and soft skills (organizational, managerial, communication skills etc.)		20
Publications	Books	1
	Book chapters	5
	Journal papers	73

Promotional content	BioSense branded folder	3260
	Project leaflet	150
	BioSense brochure	1100
	BioSense T-shirts	800
	BioSense mug	1340
	BioSense notepad	3100
	BioSense pen	2420
	BioSense promotional book “Make Sense”	1500
	BioSense umbrella	100
	BioSense bag	200

Evropska podrška srpskom naučnom poduhvatu

Тридесет милиона евра за будући научни центар

VELIKO PRIZNANJE NOVOSADSKIM NAUČNICIMA

Pola miliona evra iz Evrope

Fig. 12: Excerpts from media releases.

4. The potential impact, the main dissemination activities and exploitation of results

4.1 Potential impact

The BioSense has been significantly **reinforced** within InnoSense in various aspects including **research capacities, infrastructure, business activities, and networking**. The results presented in the previous section clearly confirms that the **visibility and awareness of the BioSense has remarkable been increased** in the last three years, Namely, the BioSense gathers a strong community of researchers from different fields whose multidisciplinary work delivers novel ICT solutions for application in biosystems. As such, the BioSense represents a **role model at national and regional levels in terms of research, business, and institutional capacities.**

Strong research capacity and forefront research in the emerging scientific fields will bring **scientific breakthroughs across a range of topics.** Our research groups - Nano and microelectronics, Communication and signal processing, Remote sensing and GIS, Robotics, Knowledge discovery, and biosystem research – will synergistically act and provide a large scientific impact in all field of research. Some of the expected scientific results are:

- new materials, principles, fabrication technologies and devices for ultra-sensitive and highly-selective detection and sensing of parameters previously non detectable or monitored only by complex apparatus;
- technologies for optimal delivery of external inputs to crops;
- artificial structures for a full control of electromagnetic, acoustic and phononic waves for sensing and actuation applications;
- understanding of genotype-phenotype connections;
- new algorithms for multi-parameter optimisation;
- microbial metagenomic mapping etc.

Research and innovation at the BioSense will also lead to a **number of results with a high impact not only for the scientific community and the general level of human knowledge but also for the society as a whole** and quality of life, since it will provide answers to a broad range of stakeholders' needs across the agrifood value chain, as summarized in Fig. 13.

Namely, the growing world population has resulted in rising demand for agricultural and food products: according to the Food and Agriculture Organization of the UN, world population is expected to grow by over a third, or 2.3 billion people, between 2009 and 2050; **food production presents on of the major, if not the major challenge for agriculture**. Furthermore, other barriers represented by, among others, the limited availability of land and the disruptive effects of climate change, have a strong impact on the farmers' supply capability. **Precision agriculture is an effective tool to tackle these challenges and increase productivity and efficiency by employing technologies** that make the farming process smarter, more connected, and data-driven.

The BioSense research agenda as well as research and institutional capacities have been proven to perfectly meet the abovementioned challenges. In other words, the BioSense **has a strong impact on development of precision agriculture concepts, in particular on national and regional levels**. More importantly, the food production is a global problem and therefore the **impact of the BioSense on the overall society is more prominent.** The BioSense vision of the future agriculture was shown in Fig. 3.

BioSense Institute has an established strong national-wide network in the domains of agrifood and ICT. In its function as a living lab for precision agriculture (PA4ALL) and beyond, it cooperates closely with a range of stakeholders including 675 lead end-users from the agricultural production

community, Vojvodina ICT cluster which brings together 30 high-tech SMEs, the Provincial Secretariat for Agriculture, Water and Forestry of Vojvodina, water management authority Vode Vojvodine, various NGOs, large international agri-input companies (Syngenta, Pioneer, Victoria…), large regional agrifood groups (Delta Agrar, MK Group, Matijevic…) etc. This strong network and our dedication to excellent research and innovation guarantee that the BioSense will significantly boost the **end-user driven innovation and generate large economic impact**.

Owing to the BDD and strong dedication to the development of the entrepreneurial spirit of the researchers, **the potential of the BioSense to participate in Horizon 2020 projects and other industry- or EU-co-funded research has been remarkably improved**. Namely, the BioSense is participating in 10 H2020 projects, among which the most prestigious is ANTARES from Teaming call. Also, we have established collaboration with leading agricultural companies such as MK group, Delta Agrar, and Syngenta, which indicates our strong potential to strengthen and diversify our income base.

Taking into consideration its overall potential, the BioSense is considered as a fruitful research environment which attracts young Serbian researchers and encourages the return of scientists from diaspora. In that manner, the BioSense actively work to reduce the brain drain, one of the main problems of Serbian economy.

Although strong, the influence of the BioSense on national government and public sector bodies is expected to become even more prominent in the years to come. Namely, **leading position of the BioSense in ICT application in biosystems, at national and regional levels, has set the BioSense as a key player in providing information relevant for policy and strategy formulation.**

The proposed Project also created an **impact at the European level.** Recently **H2020 projects** granted to the BioSense undoubtedly confirm that the reinforced **BioSense Institute has imposed itself as a strong scientific and business partner** not only on the national and regional levels, but also on the European level. In that manner, the BioSense has been strongly integrated into ERA supporting high-quality research and ensuring technology and knowledge transfer.

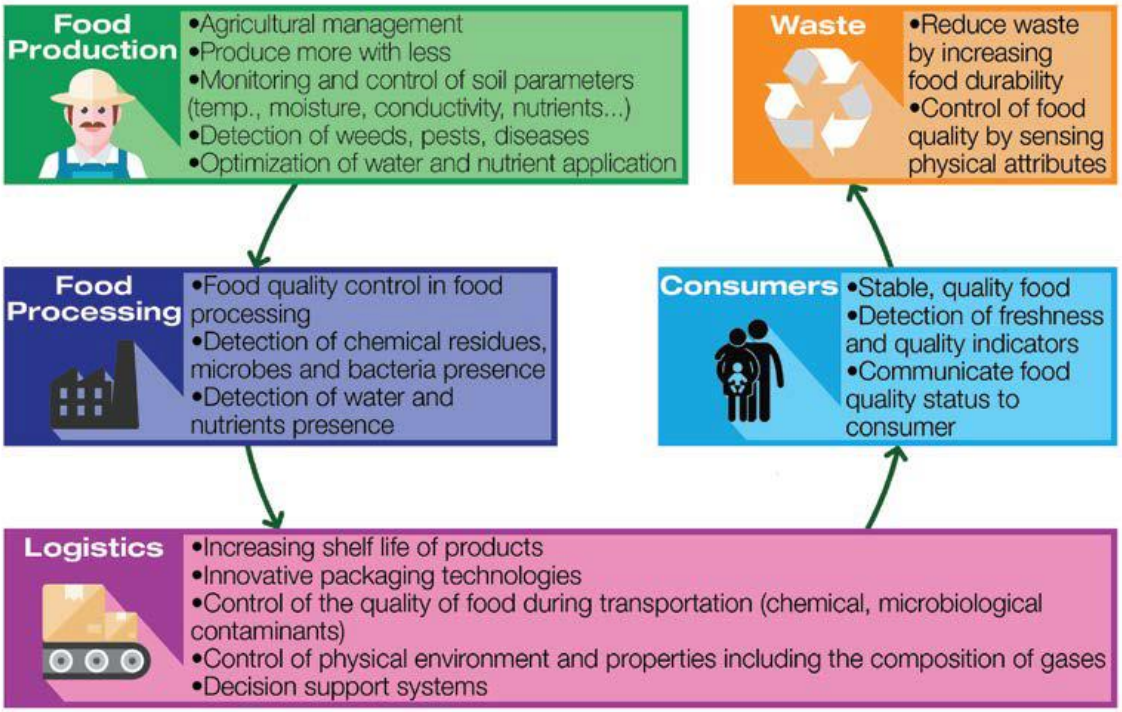


Fig. 13: Main impacts of BioSense research in the agrifood value chain.

Although Serbia has marked some important improvements in research and innovation in the past decade, a **significant effort is required to catch up to European standards** and some neighboring countries. Weaknesses are predominantly rooted in lack of an innovation culture to follow research. The BioSense, with human and infrastructure reinforcement within InnoSense, has installed **the spirit of global excellence and competitiveness** which helps generating high-level results in R&I. Our concept, which is now widely recognized on national and regional level, will serve as a **replicable role model for other institutions in the region, and in that manner spread the excellence in WBC region.** Furthermore, we have initiated **BioSense Regional concept** that will **bring together research institutions located in WB countries (Croatia, Serbia, Bosnia and Herzegovina, FYR Macedonia, and Montenegro)** and provide fertile grounds for a strong scientific collaboration, knowledge transfer, and idea exchange between the selected individual centers/research groups/institutions recognized as leading in their regions.

Recently won H2020 grants, the success of our Phase II H2020 Teaming proposal (where we have entered the short list of the selected proposals, while the final outcome is still unknown at this moment), new industrial partners, expanded partnering network, and a close collaboration with the provincial and national governments, represent only some of the achievements that **ensure further fast development and sustainability of the Institute.**

4.2 Main dissemination activities

In order to achieve the project objectives and strong impact, we designed a detailed dissemination plan. Dissemination activities were performed with the aim to promote and present our activities and increase our visibility within a whole stakeholder ecosystem.

The dissemination activities were performed on several levels and they targeted scientific community, provincial and national policy-making bodies, SMEs, companies in agrifood, farmers, student and general population. The dissemination means included web presentation, promotional material, media appearances, publications, whilst the dissemination channels included mass media, conferences, workshops etc.

Dissemination and networking activities in which the BioSense staff participated were summarized in the previous section, and here we present highlights of the dissemination activities.

Namely, during the course of the Project, two workshops were organized in which InnoSense and the BioSense as a whole were presented to a number of stakeholders as well as to media, Fig. 14 and 15.

First BioSense Scientific Workshop **(18-20.02.2015)** gathered around 100 experts from the three on going FP7 projects (InnoSense, EOPOWER and ADVANTAGE) and researchers and industry representatives from all over the world. The workshop covered the topics from sensor design, machine-to-machine communications and remote sensing applications. The workshop demonstrated the BioSense Institute as a regional leader in interdisciplinary and multidisciplinary research involving ICT, agriculture, ecology, environmental engineering and forestry. 38 speakers/experts from EU and WBC not involved in the InnoSense Project were invited.

Second International BioSense Workshop (10-12.02.2016) gathered EC and Serbian Government representatives, researchers, and industry representatives from all over the world, altogether around 200 experts. The Workshop was joint event of three ongoing projects: InnoSense, ANTARES and FRACTALS.

As stated previously, **the activities of the BioSense attracted a great attention of media, which is a clear evidence of raising awareness of the BioSense and the importance of its work whose results affects not only research community, but also business world and society as a whole.**

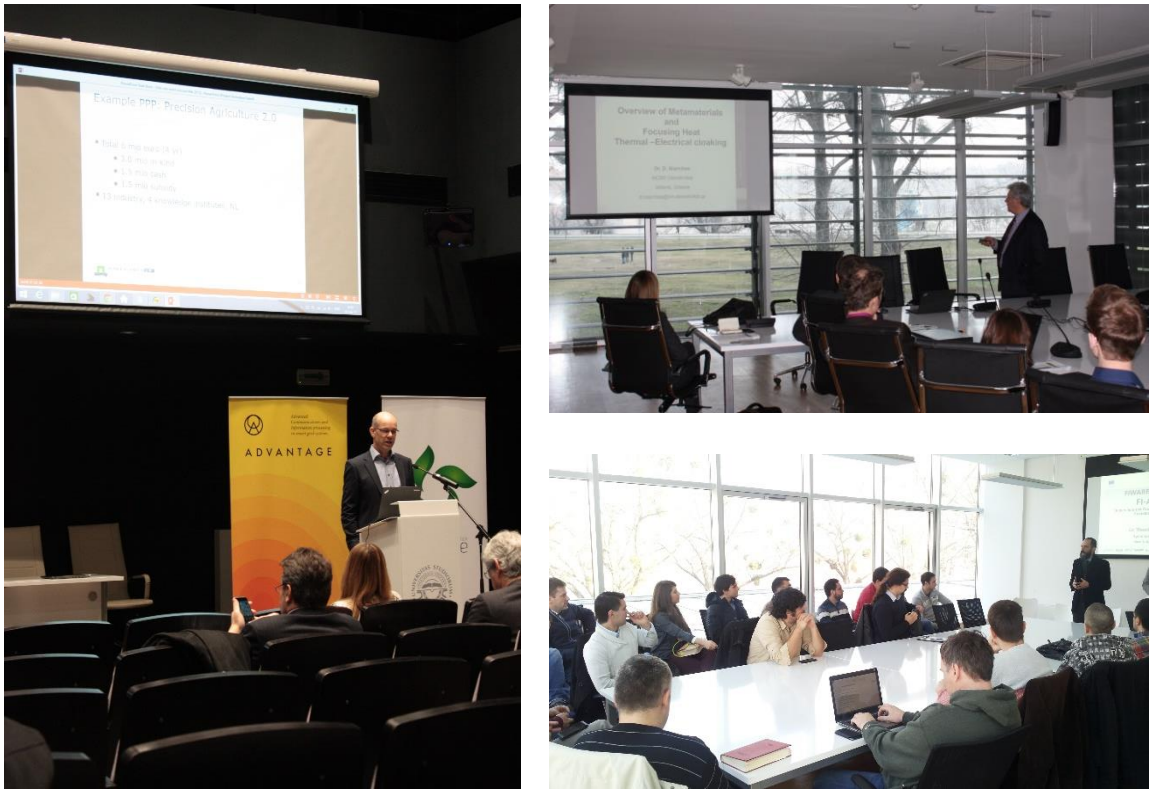


Fig. 14: Moments from the First BioSense Scientific Workshop.

Fig. 15: Moments from Second International BioSense Workshop.

A number of media appearances also indicates that the BioSense Institute has been recognized as a resource that can boost national economic growth and overall wellbeing. For instance, the **H2020 project IoF2020 was jointly presented to media by the Prime Minister of the Province of Vojvodina Igor Mirovic and the director of the BioSense Institute Vladimir Crnojevic,** which undoubtedly confirms that the BioSense has become the national major player in application of ICT in biosystems, Fig. 16.

We note that the efforts of the BioSense to disseminate Project results have continued beyond the lifetime of the project. Namely, **the BioSense has continued to take part in various events including participation at workshops and conferences, events organized by the European Commission, industrial partners, or governmental bodies. Thus, the awareness of our activities is being raised constantly over a wide circle of audiences, ranging from scientific, through industrial to governmental (decision-making).** This has resulted in BioSense being widely recognized for its research excellence and services offering to stakeholders. For example, currently the system of research funding in the Province of Vojvodina is being redesigned, and BioSense researchers have been invited as key experts to suggest how the transformation of the funding policies should be made to enable more tangible results and a higher rate of the transfer of research results into the industry. At the same time, the advice of BioSense researchers is sought after in re-shaping the governmental policies in the field of agriculture, both on the provincial and the national levels.

In addition, the **BioSense staff are often invited to deliver plenary talks at the events organized by various governmental bodies**, which bears a strong evidence that the results and vision of BioSense have been recognized widely as very important for development not only of academic community but also for the national industry and society as a whole.

We have also established a comprehensive web presentation of the BioSense Institute which can be found at http://biosens.rs/?page_id=6597&lang=en. The presentation provides a detailed insight into BioSense work and activities and it enables efficient information delivery, high quality presentation and quick search through all the organizational units. Screenshot of the homepage can be viewed in Fig. 17.

Fig. 16: Joint presentation of H2020 project IoF2020 by PM of the Province of Vojvodina Igor Mirovic and the director of the BioSense Institute Vladimir Crnojevic.

Table 5 in the previous section indicates that various promotional material was realized within the Project. Fig. 18 shows the BioSense promotional material, among which one should note the BioSense promotional book “Make Sense”, Fig. 19.

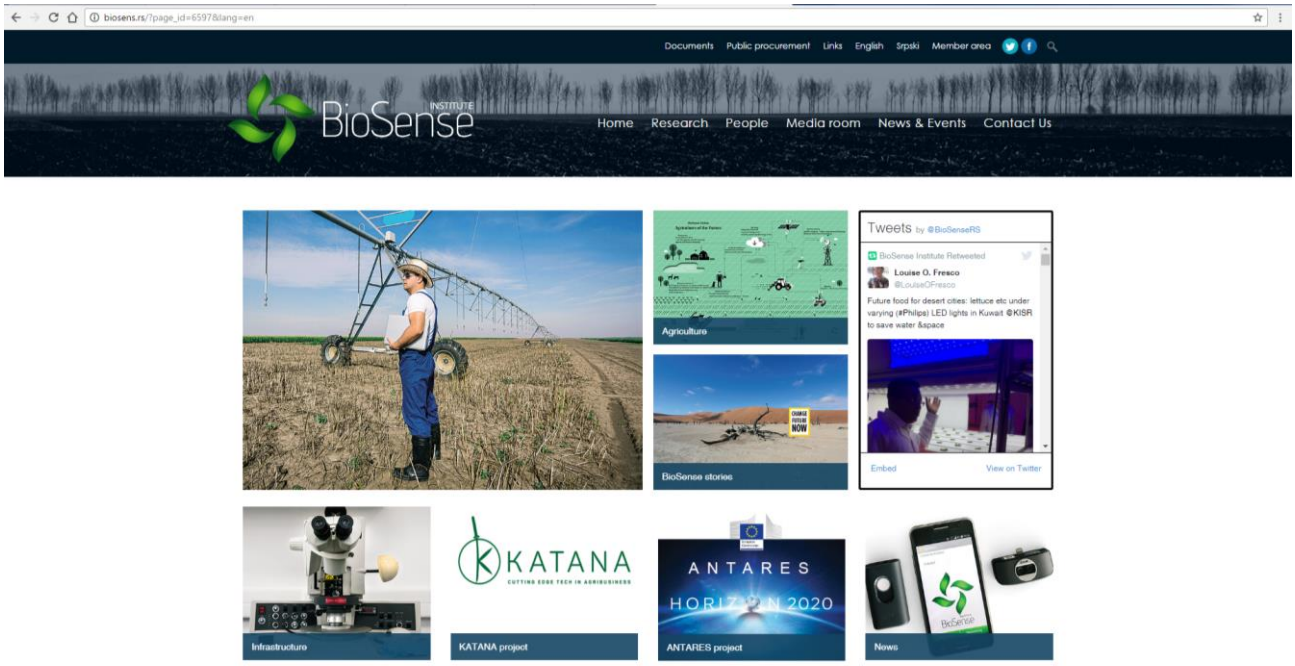


Fig. 17: Screenshot of the homepage of the BioSense Institute web presentation.

Fig. 18: BioSense promotional material.

Namely, the BioSense Institute brochure "Make Sense" is designed for a wide target group: farmers, decision makers, scientific community and in general diversely specialized stakeholders in the agri-food sector. Each segment of the brochure is conceived to intrigue the reader and awakes its interest in the whole story. The BioSense mission, vision, stories, facts and effective images are combined to deliver more general picture of its activities and challenges they respond, and not some fast outdating content.

The brochure promotes the newly founded BioSense Institute emphasizing its core activity: ICT application in agriculture, and the research excellence in this needs-driven research. The brochure stresses the pivotal role of ICT application in ensuring sustainable, smart and inclusive growth of agriculture, and promotes the BioSense's multidisciplinary research scope: from nanoelectronics to robotics focused on enabling technology.

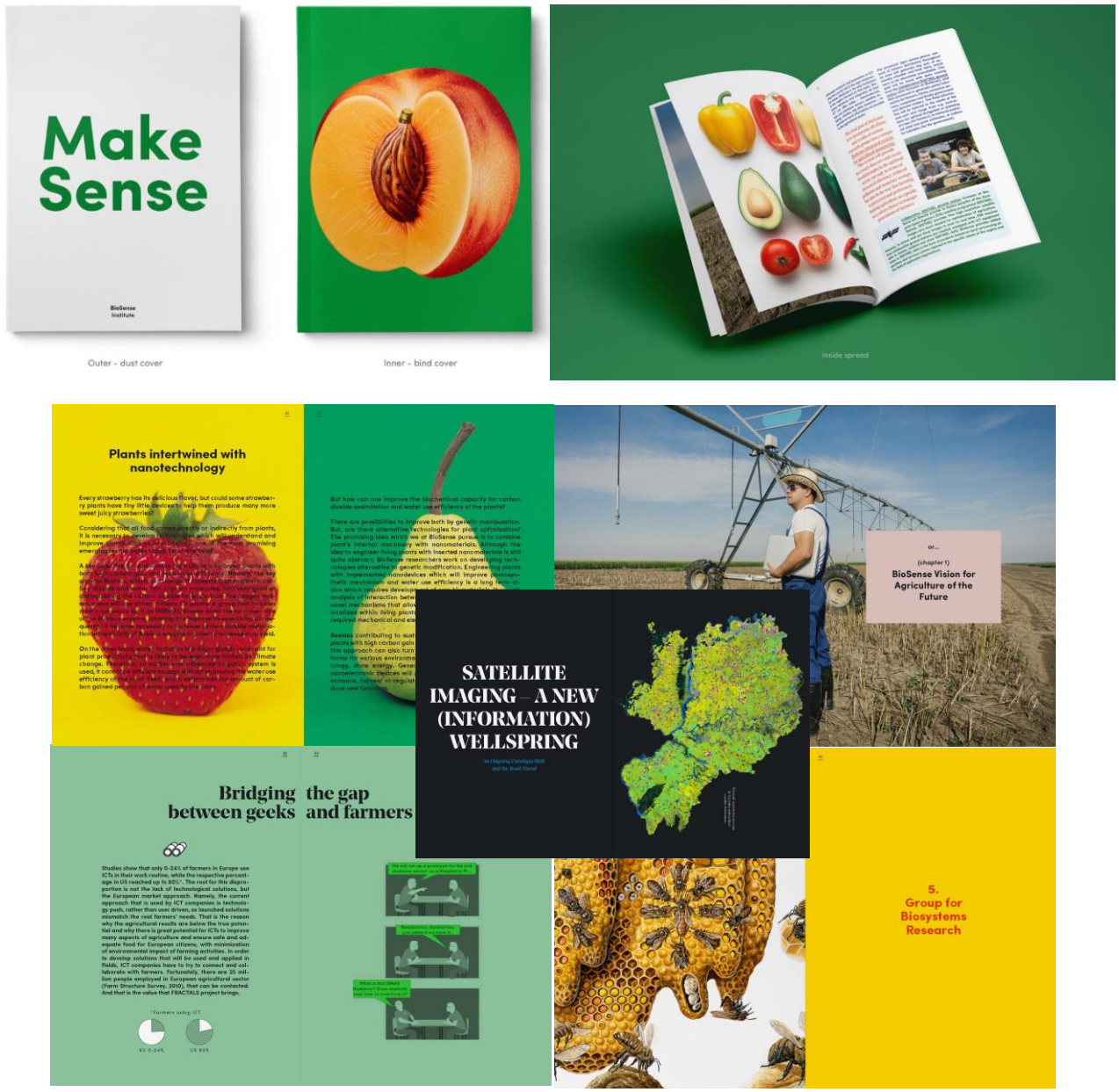


Fig. 19: Excerpts from the BioSense promotional book "Make Sense".

The aim of the brochure is not only to present the BioSense Institute organizational structure, and its equipment, but as well to convey some motivational messages, to report some successful stories, and to present research groups, directions, and projects. This approach offers straightforward recognition of the BioSense Institute as a pillar supporting the regional development of sustainable agriculture and creating a positive impact to the lives of people.

The broshure is divided into three parts. The first introductory part contains foreword - condensed information on our mission, BioSense vision for agriculture of the future, and Q-Helix. The central part presents some successfull scientific stories, images with motivational messages, and our work on promotion of the research among children. The final part provides information on organizational structure, available equipment, research groups, references and projects.

4.3 Exploitation of the results

The BioSense has been marked as a prominent research institution for its excellent human resources and research infrastructure, and consequently for the research results in the field of ICT applications in biosystems and their high potential to be commercialized.

One of the most tangible results of the project represent **hired people** that have a range of skills in the field of interest of the BioSense. Since most of the hired people had come from international institutions, they have also brought and applied new research concepts and upgraded competitive spirit in the BioSense. The hired **people published 36 papers during the project execution, which significantly increased the visibility of the BioSense in the relevant communities.** Moreover, **knowledge transfer** from the hired people to the BioSense staff **built up the knowledge base of the researchers** which will be exploited for generation of new results.

During the project execution, the BioSense organized trainings with the aim to encourage **entrepreneurial spirit** among researchers, to introduce all the researchers with the **Horizon2020 programme** as well as with the importance of the **Intellectual Property protection**, as well as to improve **soft skills** of the researchers in terms of managerial, organizational, and business skills. **The improved skills and significantly upgraded knowledge allow researchers to participate in the rigorous H2020 calls**, and in collaboration with BDD to **obtain funds in 10 H2020 project**s so far. Moreover, **5 projects strongly related to agrifood sector, have been commissioned to the BioSense by the Provincial Government.**

Another important project result is the **upgraded BioSense laboratory**. Form the very beginning of its installation, the equipment has been exploited and contributed to accelerated and improved scientific results. In other words, the purchased equipment enabled **research diversification and creation of new research paths** in the BioSense. Furthermore, we aim to establish a **Shared Research Facility** which will allow **access to our equipment to external users, who will only be charged for the time of use, under a not-for-profit pricing scheme.** Apart from the broad impact to external stakeholders, the Shared Research Facility will also provide cross-fertilization benefits to BioSense researchers.

Hired BDD team members have paved the way to the adoption of novel concepts in the work of the BioSense, primarily in terms of shifting the research towards market and commercialization.

Extensive dissemination and networking activities enabled establishing of **a diverse network of over 150 partners including academia, industry, SME, government, and public sector. Such a strong network enabled the BioSense to apply improved research concept – the one that takes into consideration the needs and input form a wide range of stakeholders**. Namely, **we have established PA4ALL – the Living lab** for precision agriculture enabling that research and innovation at BioSense is developed in a close interaction with farmers and the agrifood sector,

government bodies, entrepreneurs and business community, international researchers, and citizens. We plan to upgrade the Living Lab so it will serve as an open air show-room where innovative solutions from and for BioSense ecosystem can be actively implemented. For instance, farmers will be able to see solutions of interest to them implemented in real-world settings, while scientists from BioSense and other collaborating institutions will be able to run experiments and test prototypes in the operational environment. Demonstration farm will also be a place for regional stakeholders to meet, attend trainings and participate in co-development workshops.

In addition, **the novel concepts, accumulated knowledge and achieved results opened up the perspective for transfer of knowledge to the market.** The BioSense and BDD strongly supports the contracted research, i.e. the **collaboration with the industry** in order to accelerate potential commercialization of an idea. Such contracts provide an excellent opportunity for researchers to become familiar with the mentality and the requirements of the corporate world. As stated previously, beside **leading national agricultural companies including MK group and Delta Agrar**, **world leading companies such as Syngenta** has shown interest in our activities and therefore we are intensively working on the ideas for joint projects.

Also, we support technology transfer to industry, which implies that the BioSense has patented the results and requires specific targeted actions on behalf of BDD to attract the right industrial player. In addition, the BioSense gives a support for foundation of spin-offs, which are another way of producing the proof-of-principle of inventions, and of valorizing the results of research. They can be hosted by business incubators offering infrastructure and services.

Moreover, **we continued our collaboration with WBC partners in Croatia and Montenegro, and established collaboration with partners in Bosnia and Herzegovina, and FYR Macedonia**, with the aim to foster the development of the BioSense Regional concept. BioSense Regional will provide fertile grounds for a strong scientific collaboration, knowledge transfer, and idea exchange between the selected individual centers/research groups/institutions recognized as leading in their regions, thus contributing to de-fragmentation of the regional research space, academia-to-industry transfer of knowledge and focusing on the common goals related to sustainable development.

5. Website address and relevant contact details

The website of the BioSense Institute is http://biosens.rs/?page_id=6597&lang=en

The website of the InnoSense project is http://biosens.rs/?page_id=8953&lang=en

The address of the coordinating institution:
BioSense Institute
Dr. Zorana Djindjica 1
21000 Novi Sad
Serbia

The contact of the project coordinator prof. Vesna Crnojevic-Bengin is bengin@uns.ac.rs