UCG
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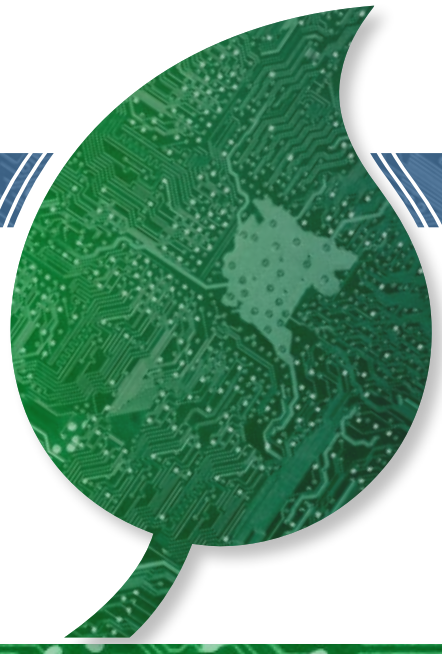
BIO-ICT

# BIO-ICT Best Essay Competition for Young People

## 2016 Award Winning Essays

CENTRE OF EXCELLENCE
IN BIOINFORMATICS



Faculty of Electrical Engineering

"Green house - Jovović"

IBM

cogimar

SRCES RAS
Saint-Petersburg, Russia

CTiF

World Bank loan

## Foreword

BIO-ICT Best Essay Competition for Young People in Montenegro 2016 is one of the programmes organised by the first Centre of Excellence in Bioinformatics.

As today's young people are crucial for the shaping of our future, it is imperative that they are enabled to develop ideas about the use of ICT in everyday life. BIO-ICT's objective is to help empower young people, reaching out to them, responding to their expectations and ideas, and fostering useful skills in order to support the creation of generations who will be aware of the importance of ICT, and especially bioinformatics, for the prosperous future of Montenegro.

This essay contest is organised in an effort to harness the energy, imagination and initiative of the Montenegrin youth in promoting analytical and creative thinking and principles of common good. It also aims to inspire society to learn from the young minds and to think about how each of us can make a difference if we started thinking about Montenegrin modern information society and "smart" future.

The themes of the 2016 BIO-ICT Best Essay Competition were focused on future of ICT in Montenegro, especially bioinformatics, the role of BIO-ICT Centre of Excellence in the development of digital agriculture, use of the advanced BIO-ICT solutions for improving quality of life in Montenegro, creation of prerequisites for opening of new jobs in the priority development areas in Montenegro, the role of knowledge and application of ICT skills in the development of the career in Montenegro and abroad.

14 essay entries were received from a wide and diverse spectrum of students from both secondary schools and universities from the whole of Montenegro. This publication contains First Prize, Second Prize and Third Prize winning essays.

We hope that by participating in this competition young Montenegrins have expanded their knowledge about the application and importance of ICT, especially bioinformatics. Considering the level of motivation and achievements of these young people, BIO-ICT Centre is open for future cooperation on the implementation of the proposed solutions using our infrastructure. BIO-ICT will continue with its mission to spread the importance of developing scientific research and application of bioinformatics in Montenegro, as well as to motivate young people to contemplate about the development of information and communication technologies necessary for the progress of Montenegrin society.

BIO-ICT Director

Professor Igor Radusinović

**1st Prize**

# Agro network – introducing Montenegrin agricultural potential

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The exponential growth of information and communication technologies in the world, as well as in Montenegro, is questionless. Bioinformatics, as a new arising branch of computer science and ICT, has opened the door to amazing new opportunities in the field of biology, medicine and agriculture. In this paper, we will focus on agriculture and the role of bioinformatics and ICT in this area.

## ICT in agriculture

Agriculture in Montenegro includes mostly huge number of households with arable lands who grow different crop plants for their personal use or for the market, while the number of big agricultural companies is rather small. There is a huge number of different factors that influence the quality and quantity of different types of crops as well as their manufacturing process (weather conditions, different crop diseases, characteristics of the market etc.), thus the realization of outcomes always comes with uncertainty. That is why software tools for examination, monitoring, data processing in the field of agriculture are becoming essential for its development. Until recently there was a problem in lack of reliable and accurate information, however, today, in the Internet era, we encounter an even bigger problem of too much information, and a lack of time for their processing and extracting the important and most accurate ones. On the other side, apart from the fact that information is easily accessible today, most rural areas of our country are still cut off of this privilege for various reasons: poor technological infrastructure, educational system, economical situation etc.

For a household in rural area that lives from agriculture, information can be substantial for success of the business. This information includes: weather forecast, prices and resources available, advice on farming different types of crops in their different stages of life cycle, agrotechnical measures in different circumstances etc. Even though statistics indicate that the number of computer and Internet users is getting higher in the rural areas, the usage of substantial information that these technologies offer is still low and reality is that farmers are not aware of the opportunities that technology offers them for their area of business.

## Software solutions in the field of agriculture

With development of ICT, the number of software companies which produce IT solutions for different areas of business grows rapidly. However, reality is that there are no such companies in Montenegro which would deal with production of software solutions for agricultural purposes, while ICT solutions from other countries are not adjusted to current needs of our agriculture, nor they follow its characteristics. World trends are directed to automatic machines for agronomy, contemporary systems for irrigation, modern technologies for land examination, genetically modified products, proper nutrition of the cattle etc. However, since we are still far behind the world standards, not all of these trends can be applied in the domestic market.

**Development of agriculture with the use of ICT**

Montenegro is a land with great agricultural potential and a lot of unused resources. Therefore, we consider that with the use of modern technologies, there are models which could be used to boost development of this area of industry. In that sense, we consider BIO-ICT centre of excellence is a great foundation for further improvement. Considering that Centre of excellence is currently working on research in the field of bioinformatics, we see the possibility to expand this research centre by employing more scientists from the respective field that would strive to follow latest technological achievements, and also put accent on improving communication with Montenegrin farmers and make all the collected information available to them, with a goal to help them with their business. To be more precise, we propose that existing centre transforms into a unique, new Advisory centre for agriculture.

By exploring the existing ICT systems in Montenegro in the field of agriculture, we came across website of "Savjetodavna služba u biljnoj proizvodnji", which was founded in 2003 and supported by Agricultural marketing information system. We were interested in how familiar the farmers actually are with existence of this service and through research we came with not so satisfactory results. As it seems, huge number of small households that are involved in agricultural business are either not familiar with existence of this service, or they do not know where it is situated. Also, another problem is that farmers who have heard of these services avoid to use them because of their high prices. Another thing that we spotted is that websites of Agricultural marketing information system and "Savjetodavna služba u biljnoj proizvodnji" haven't been updated for a very long time, except from a page with weekly market prices of products, which is not easily accessible. On the other side, a small progress was made by making "Agro portal", which, to some extent, covers up-to-date information from this area, but in most cases farmers still impatiently anticipate Sundays show "Agro saznanje", searching for updates. Essentially, poor information access for target group is what we see as a serious problem to tackle, for agriculture as well as for the entire society.

In our research, students have also been a valuable source of information. From talking to students of biology and biotechnology, we found out that not many of them know of the existing ICT services for agriculture, even though the Advisory service centre is placed in their faculty's building. We point out all of these facts to indicate the poor work of this service centre, for which we concluded that its main goal is keeping agro society informed about relevant topics from this field of economy.

**The role of Advisory centre for agricultural development**

As already mentioned, we see the structure of Advisory centre through already existing BIO-ICT centre of excellence. The Centre would gather and employ primarily specialists in the field of bioinformatics. In this way, this rather new and very popular branch of science would be popularized in our society, as it has the tendency to get significantly involved in our daily lives. The Centre would follow the latest technological trends with a goal to adjust and implement them in our country.

We see further development of the Advisory centre through the following steps. As a foundation, it is needed to empower and reconstruct internal structure of the centre, as well as to continue the current work, which is without doubt headed in the good direction. Then, it is substantial to engage new forces, engineers and scientists ready to give their contribution to development of bioinformatics in Montenegro. Existence of laboratories inside the centre which would be meant for commercial use instead of just scientific research, are also very important. By these labs, we mean service centres for different kind of tests for land, crops, seeds that individual farmers use, and that they would bring for examination. We believe this kind of customer oriented activities in the Centre would additionally motivate young people to engage in studying this area of science. The question is, why is all this important in the first place? The reasons are simple: advanced examination of agricultural resources, automation of systems for agricultural production, modern agricultural mechanization etc. Also, including individual farmers in all of this can only be beneficial and can encourage development of agricultural industry in the country and founding of new companies. With all of this, we would lower unemployment in rural areas and tackle the problem of constant abandoning of rural areas of Montenegro. From the economical point of view, with development of domestic agricultural industry, eventually, there would be a lower need of import of agricultural goods and increased possibilities of export of domestic brands.

How do we achieve all of this? Researches and examinations in the centre are not justified if we don't use them in solving real problems. Therefore, our idea is to create a comprehensive website of Advisory centre. Website would facilitate the search of huge amount of information significant to farmers, some of them being: the work of Advisory centre, services that it offers (different tests, examinations with modern ICT technologies, free simulation of these technologies in concrete households, information of market prices of different products, information about agriculture throughout the world as well as in the country, advice on farming, medical care of domestic animals, law regulations, agro forecast, calendar of events and trade fairs etc.). We also emphasize the role of the Advisory centre in presenting modern agricultural ICT technologies to farmers and other utmost users. We consider organizing seminars and other similar events with proper media attention substantial for this. Through these kind of events, we would also significantly enhance the network of farmers, expanding and sharing the knowledge, as well as getting to know and following the market conditions. Another very significant feature of the website, which we believe would open countless opportunities, is opening the space for online selling of the agricultural goods. This would attract an even larger number of farmers as well as big companies and additionally motivate them to invest in their business and modern technologies as they would have to fight for competence on the market. It is very important to have the awareness that the Advisory centre for agriculture should have several representations in different cities of the country so that people could access it more easily.

The use of informational content through ICT becomes a dominant way of obtaining and sharing information. Rural households, instead of the fact that acceptance of digital technologies is running slower than in urban areas, have the same tendencies. Predictions say that by 2017 every part of the planet will be covered with internet connection. Additionally, prices of internet connection are getting lower and lower, indicating that possibilities of expanding and enhancing technological infrastructure in our country will be more than real. However, due to the problem of language barrier that inhabitants of rural areas usually encounter while searching for information online, there is a need for richer information base on our own language, which additionally justifies and supports the idea of the local agricultural website. From financial aspect, it is important to emphasize that there are a lot of European funds which offer loans to farmers and agricultural industry and some municipalities grant free mechanization for some particular agricultural activities. All of this is an encouragement for domestic farmers as well as already existing agricultural companies to further invest in development of their business and in that way contribute to development of Montenegrin agriculture in general.

Through thinking about future of agriculture in Montenegro along with development of technology, we come to prediction of development of bioinformatics as academic field of study in our country. We strongly believe that this area of science is yet to become significant and that experts from this field will be highly needed, not only in area of agriculture, but also in the area of medicine, biology, ecology, etc. That is why we consider that resources should be invested to introduce this field of study in the academic world of Montenegro and motivate young people to specialize in this area.

In the end, with the world improving so fast in the field of bioinformatics, Montenegro will inevitably be affected by this fever sooner or later. It is only up to us to decide when will it be. Anyhow, it is important for us to be aware that it is better for our society that these changes come more quickly. Apart from lowering unemployment, offering new scientific perspectives in our domestic terrain, these changes would eventually help in creation of new, internationally recognized brands of Montenegro and would enrich our culture, touristic offer, and show the agricultural potential of the country to the fullest.

**2nd Prize**

# Bioinformatics in Montenegro: Current education perspectives and future directions

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## 1. Introduction

Bioinformatics is a relatively new discipline, gaining importance across the: biomedical research, healthcare and agriculture sectors due to their importance in helping to improve the timeliness and accuracy of disease diagnosis, prognosis and treatment, as well as enhancing crop yield. While scientifically-advanced countries in North America and Europe have been major leaders in this field, many developing countries have been making progress in bioinformatics training and applications. Bioinformatics is a dynamic field, so its research areas increase exponentially day by day. Recently established Centre of Excellence in Bioinformatics in Montenegro shows strong interest in development and future progress within this field. However, it is important to design bioinformatics study policy with the integration of biology and computer science to keep pace with the world.

Bioinformatics is not integral in the national education curriculum, which implies a lack of standards, of common and recommended learning materials and of assessment tools.

## 2. Bioinformatics and computional biology

The term bioinformatics arose in the beginning of the 1990s, when large amounts of experimental data were produced by sequencing projects, particularly the Human Genome Computational Biology/Bioinformatics is the application of computer sciences and associated technologies to answer the questions of Molecular Biology. Bioinformatics refers to the creation and advancement of algorithms, computational and statistical techniques, and theory to solve formal and practical problems arising from the management and analysis of biological data.

## 3. Bioinformatics in Montenegro

Montenegro is a young and prospective country on biological research spatially on bioinformatics. We are all aware of the fact that Montenegrin life science research is not as advanced as it is in the leading countries. However, given the Montenegrin circumstances and rather limited resources, bioinformatics is easier to develop in such an environment than fundamental research in life sciences. Life sciences including modern biology, molecular biology, biochemistry, biotechnology research are increasingly becoming dependent on new technologies. Research and development in bioinformatics do not require setting up world class laboratories and research institutes. Results of fundamental research done worldwide are available and could be combined with bioinformatical approach in Montenegro for research purposes itself and development of this discipline but also for improvement of everyday life. In my opinion Montenegrin development of bioinformatics has two major challenges:

1. Identify Montenegrin institutions leading research and teaching in the discipline
2. Identify research areas in which bioinformatics applications have been focuses

### 3.1 Montenegrin leading research institutions – focus on education on all levels

The progress of bioinformatics in Montenegro, in my opinion, is fully dependent on investments of the physical and intellectual capacity to promote the discipline. Collaborative research and teaching network is vital for success. Therefore, education should take place on all levels: starting with basics in primary school, continuing with in high-school and advancing at the University. Bioinformatics' teaching in Montenegro is not yet integrated into high school teaching and learning programs, playing almost no role in preparing the next generation of information-oriented citizens. Moreover, no university in Montenegro has well developed multidisciplinary bioinformatics course.

Notable among these is the recently established Centre of Excellence in Bioinformatics which I, myself, recognize as a leading institution which may help capacity-building of on strengthening the scientific and teaching capacity. Montenegro needs to form a national research and teaching council, which will promote bioinformatics.

#### 3.1.1 Integration into high-school programmes

While bioinformatics is increasingly important in modern life sciences, it plays almost no role in high-school science classes. Bringing the complex and contemporary science of bioinformatics to the high school classroom is quite challenging, concerning the fact that bioinformatics is not taught at the highest levels of education in Montenegro.

Teaching bioinformatics inherently requires computational infrastructure, including, for example, computers, internet access, appropriate bioinformatics tools, the availability of which is not trivial. In addition, most high schools do not provide support policies or the qualified and knowledgeable personnel required for teaching bioinformatics. Currently, teachers often lack any prior experience in bioinformatics and have only little (if any) background in associated disciplines, such as computation and statistics.

To successfully implement and broadly incorporate bioinformatics into high school science, in my opinion, an essential preliminary step is to determine a policy that bioinformatics should be integrated as an elective or obligatory topic in the national science standards and curriculum. This would necessitate the definition of practical educational goals, which are consistent with the target population, the time frame, the available resources and the national standards. In addition, minimal technical and computational requirements should be characterized and provided to schools. Obviously, the rules and recommendations for development of learning materials and teaching bioinformatics, as described before, should be implemented. Support, to both students and teachers, is another key issue. Long and continuing professional development programs and short training courses for teachers in bioinformatics, which combine knowledge, skills and pedagogy in technology-rich environments, are needed. Teachers can serve as an appropriate means of linking and integrating contemporary and pioneering materials into existing teaching curricula. Assuming that, additional courses, training school, education would be provided for current high-school

teachers through organizes, well-structured education leaded by highest University institutions, integration of bioinformatics into Montenegrin high-school programmes would be feasible.

I, being a junior high-school student would expect that bioinformatics teaching means that fundamental concepts and ideas as well as practices of each discipline (biology, computer sciences, mathematics, etc.) should be connected and integrated, rather than presented as separate discipline-specific units.

Teaching bioinformatics in secondary schools may come in following forms:

1. bioinformatics-based lessons and curricular elements should been developed
2. bioinformatics-based online resources
3. learning modules and outreach programs at University of Montenegro offered to high school students.

Incorporation of bioinformatics into high school curricula offers great opportunities and major challenges. Students today are digital 'natives', that is to say they have grown up with computers, internet and technology, and they therefore possess natural proficiency and technological competence. Today high-school students have a different approach to learning, one which is concerned with speed of access and multitasking abilities. Therefore, bioinformatics naturally fit computer-based learning approach current technologies in real-world problem-solving contexts while using 21st century skills. It fits with active learning and 'less traditional' learning styles.

Having bioinformatics in high school education would be beneficial for many reasons:

1. to learn about bioinformatics as a new discipline needed for purposes of computer-based life in 21st century
2. to understand all benefits which bioinformatics may help for our own society
3. to help high school students to become aware of careers in science, technology, engineering, and math (STEM).

High-tech jobs being more and more popular demand a highly educated workforce familiarized at an early age with advancements in math and science. Continued growth of bioinformatics made me think that an effort to introduce high school students to this emerging field and hopefully inspire some to pursue studies would be beneficial for our country.

### 3.2 Bioinformatics – Benefits for Montenegrin society

Bioinformatics is an integral part of modern life sciences. It has revolutionized and redefined how research is carried out and has had an enormous impact on biotechnology, medicine, agriculture and related areas. From my perspective, bioinformatics represent a great discipline which may attract interests of young talented students to undertake studies of bioinformatics at University of Montenegro within structured programme which will involve all national institutions of bioinformatics network. Additionally, many scientists which are placed in various prestigious institutions almost all over the world, originating from Montenegro could help to develop world

class bioinformatics studies in Montenegro. Collaboration with world-wide known institutes also may facilitate development of bioinformatics in Montenegro. In his way our highest educational system might train hundreds of students with high tech cutting-edge technologies virtually from anywhere of the world with a minimum cost. Great research and education, in turn results with secured grants and funding which allows long term survival. Additionally, this contributes to development of various tools which allows application of bioinformatics useful for our every-day life. Academic, commercial and non-profit organizations in Montenegro that have bioinformatics and genomics resources and expertise may:

1. provide infrastructure and tools for training, mentorship and research in bioinformatics and genomics data analysis
2. develop a network of scientists with expertise in biotechnology and *omics* technologies
3. train more scientists in Montenegro in bioinformatics skills through capacity-building courses and efforts to introduce bioinformatics modules into existing university curricula
4. develop national competence in the development and application of bioinformatics tools and techniques to provide biotechnology-driven solutions to biological problems in Montenegro.

Lastly, Montenegrin governments, policymakers, educational authorities and funding agencies should improve their support for science research and education, especially those that apply bioinformatics. Although bioinformatics have been integrated into biomedical and agricultural research in Montenegro in some extent, training and education in these areas need to be strategically expanded in order to better propagate the disciplines. Judging from my interests so far, I am more than prepare to use all my capacities to contribute to development of bioinformatics in Montenegro and first step needed would be to enrol such BSc programme which I hope, will be available at the University of Montenegro in few years.

**3rd Prize**

# ICT farmer in Montenegro

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Faculty of Mathematics and Natural Sciences and Faculty of Political Sciences– University of Montenegro

Digital agriculture

**'Digital agriculture' includes activities such as the development, testing and deployment of information and communication technologies (including informatics) for agricultural research, development and delivery.**

Scientific and technological advances are opening up new possibilities for farmers around the world. The networked digital farm of the future is already making the agriculture more efficient and sustainable today.

Digital agriculture is the new branch of industry which is combining large data sources with advanced crop and environment to provide actionable on-farm decision. The main goal in agriculture is to make the best management decisions each year to meet economic, social, and environmental goals. Every producer enters spring with the best plan for their farm, based on the information they have available. The goal of digital agriculture is to help producers to accelerate the adoption of new cultural practices and technology for yield value and added benefits to the farming operation.

Digital agriculture is focused on increasing farmer's ability as growers to make the best farm decisions. It is unlikely that Digital Agriculture will replace the traditional sources of agronomic advice although it will certainly provide a new and potentially very beneficial tool set to help enhance the advice and provide a broader understanding of farming environment.

The potential of BIO-ICT centre is to support the access and exchange of information for smallholder farmers. A rich discussion centred on examples of current pilots and processes expected to bring beneficial results. For example, BIO-ICT centre can offer farmers apply sensor systems that can cheaply and accurately monitor the state of plants, animals and soils. The data generated from such a system would assist a farmer to precisely manage their inputs in order to maximize production in the most cost effective and sustainable way. It must be noted, however, that there continues to be a challenge in finding examples that have moved beyond the pilot stage, reaching scale in a sustainable manner.

Through improved communication, BIO-ICT is known to enhance or expand human networks. Mobile technology is seen as having a particularly positive impact in this area, fostering networks of farmers and agribusiness, so that they can support each other. Specialized applications are being developed to further extend this impact.

Real facts about digital agriculture in Montenegro

In Montenegro there are smallholder farmers which follow traditional farming practices because they lack access to knowledge about current practices. Living in village area, struggling to nurture crops on tiny plots of poor land, they overuse macro fertilizers and miss the benefits they could gain from micro-fertilizers appropriate for their crops and soil. They also lack a scientific understanding of pest life cycles, and thus often experience crop failure when a preventable infection or infestation arises.

Everyone knows that Montenegro have a wild beauty nature and many possibilities for rural and agricultural development. In the central region there are fertile plains: Zeta and Bjelopavlići and also we have Skadar Lake – the paradise for birds. Then there is a wreath of mountain ranges over 2,000 meters high. Apart from the peaks, they are adorned by woods, spacious pastures, many lakes, impetuous and clean rivers, deep and mysterious canyons. The worlds of beauty are under water and underground - in many caves whose exploration has only begun.

**Do you believe that ICT would increase the progress in Agriculture?**

Yes! We believe in this kind of progress, because BIO-ICT centre will inform farmers about digital agriculture as well as about how to use modern ICT solutions and thus achieve the:

- Increasing the productivity and income of small and medium-sized farms
- Agricultural market becomes more efficient and transparent
- Connects isolated farmers with city, regional and global markets

Precision agriculture (GPS, GIS) & Mobile applications in agriculture

Improving yield is an age-old challenge for farms and always will be. However, for the first time in a generation, digital technologies enable farmers to achieve a quantum leap forward in their performance. While improving yield is good for a firm’s profitability, it’s also increasingly critical to addressing he growing demand for food.

BIO-ICT with "Precision Agriculture" will research and address key challenges in a range of farming systems, including viticulture, dairy farming. BIO ICT with other institutions will work on development tools to assess, monitor and redress environmental and economic risks associated with agricultural practices.

Using GPS and GIS (geographic information system) collects the information necessary for the improvement of land and water. In the past, it was difficult for farmers to correlate production techniques and crop yields with land variability.

From the standpoint of agriculture the GIS system will work processing of information which will include: where does it work (when we mean on location) and about what and when did the work happened (about time, parcels, crops, est.)? Practically, this is not much different than keeping notebooks what agronomists practiced for decades. However, the essential difference is about the data, which are is now entered into the information system that provides the necessary processing of such data. This processing cannot disturb new data or folders, and it is important to note is that all

the entered data remains which entered forever remain available for further research. GIS in itself must contain at least the entry, modification and handling of data, the storage and downloading of data.

Many of the new innovations rely on the integration of on-board computers, data collection sensors, and GPS. Many believe that this system is only used on large farms with large capital investments and experience with information technology. This in reality is not the case. There are cheaper and simpler methods and techniques that farmers can used.

BIO-ICT centre need to help farmers to use GPS-derived products to enhance operations in their farming businesses. BIO-ICT with GPS equipment manufacturers can develop and apply a several tools that help farmers and agribusinesses to become more productive and efficient in their farming activities. With GPS is collected receivers information about the locations also it is useful for mapping field boundaries, roads, irrigation systems, and also to notice problematic areas in crops such as weeds or disease. The accuracy of GPS allows farmers to create farm maps with precise acreage for field areas, road locations and distances between points of interest. GPS allows farmers to accurately collect soil samples or monitor crop conditions.

In this way BIO-ICT centre will collect the main information about farm maps, soil samples, crop condition and everything that is valuable in agriculture. Then, for the best results BIO-ICT center should inform and work with Ministry of Agriculture about collected information which would be the main substance of future development in Montenegrin agriculture.

One example of a precision agriculture practice is to evaluate the natural soil variability of a field. If the soil in one area holds water better, crops can be planted more densely and irrigation can be sparing. Or, if the plot is used for grazing, more cattle can graze than a similar area of poorer quality soil.

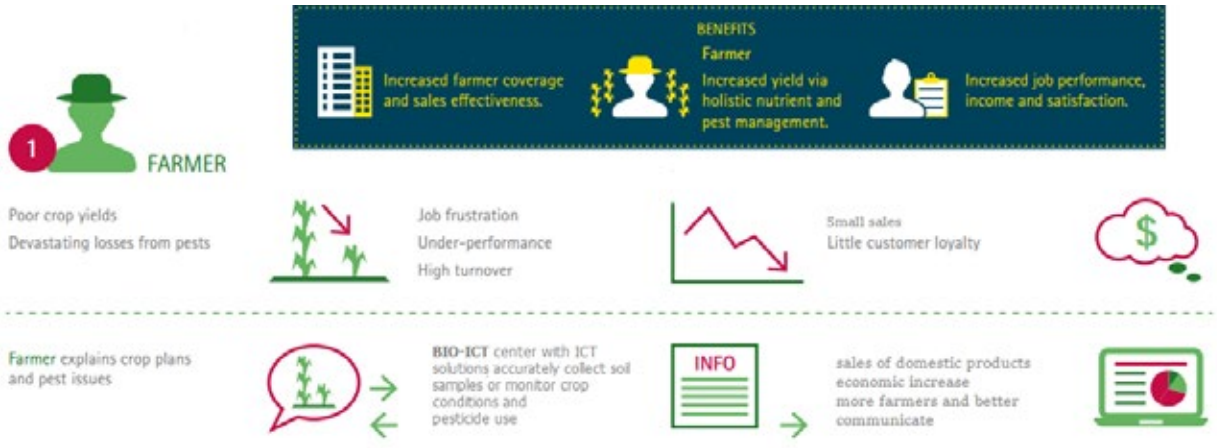


*Figure 1- Challenges for smallholder farmers*

**Technology is dramatically increasing the amount of land each farmer can work effectively. Using the GPS vocational device and sensors in the field, farmers can harvest, along with their crops, detailed digital maps of their fields. Precise applications reduce waste and improves yield.**

Mobile applications for agriculture are a real boom in the market. There are more and more tools that farmers used around the world and they only need to have a smart phone. In Montenegro almost 50% of farmers don't have a smart phone. The role of BIO-ICT in this segment is to secure the cheapest smart phones, of course in cooperation with Ministry of Agriculture, and to secure a free course for farmers thought which will introduce and inform farmers how to use apps that are designed for the agriculture. There are a number of quality apps available for Android, iOS and other operating systems.

For example:

- Landini Digital Library – with this applications farmers can get all information on the tractor, they are interested in and read their favourite magazine with additional contents: audio, videos.
- Farm forum app – agriculture news: this application helps farmers to find equipment for sale based on make, model and location, than to get classifieds from the farm forum (updated daily), and to see current commodity, and market prices, also to find weather data that is important for farmers like: wind speeds, crop moisture index, field drying forecasts and more.
- Career paths: this app is design to be a dictionary for farmers who want to learn English words which are used in communication in agriculture. There are 3 levels of: reading, listening, speaking and writing. Topics include: soil preparation, seeding methods, farm equipment, organic farming.

Applications which will be used for communication are necessary for the transfer and exchange of knowledge and experience among farmers, in order to facilitate the dissemination of information from research and extension services for farmers. This flow of information is essential to the deficit of small producers, and has the potential to cover more farmers.

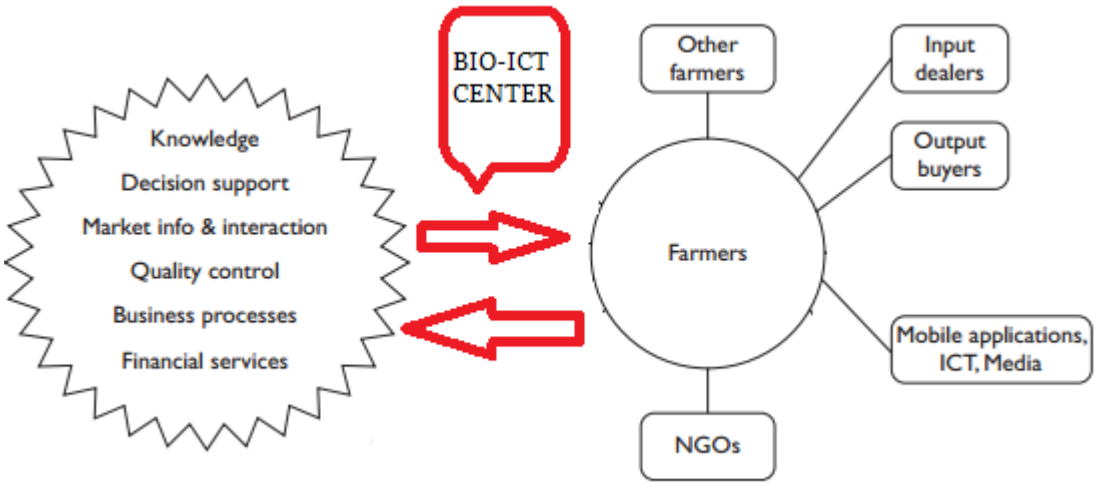


*Figure 2- Opportunities with BIO-ICT in agriculture*

In the end

Agriculture of the future will be digitally integrated at all stages of production, from understanding the crop genetics to transport logistics.

Through the facts that we specified earlier, we come to the conclusion that the BIO-ICT centre must have the cooperation of the Ministry of Agriculture, and with them affect the development of agriculture through the provision of digital technical-support develop. In this way there will be the enhancement of agricultural production as well as sales of domestic products to foreign markets and will also affect economic increase within a state and overall economic development.

BIO-ICT centre would even have a dual role. It would offer a certain kind of information arrangements for technical assistance for farmers, and improve communication and cooperation with other institutions (NGO, Ministry of agriculture, Ministry of science, Ministry of information technology…). With this public cooperation and investments BIO-ICT could achieve a certain level of constant profit. Unavoidably, young people will have even more opportunity to express their ideas and be motivated for the development of various ICT solutions.

Our idea is that the current situation in agriculture can improve, first with the investment in smart phones and the applications that will continue to provide multiple functions: help farmers to manage risks, improvement of land and manage natural resources, increase productivity and income of smallholder farms. Also, this kind of investment would rapidly improve communication and mutual cooperation between farmers that was the result of better marketing of domestic products. By encouraging, precision farming, through GPRS devices and GIS systems to agriculture, we would place agriculture on a higher level.

This way, we get a clear picture of the state of agriculture in Montenegro and also with precise information of data which offers ICT solutions we could make calculations for further investment as well as for the further development of our country closer to European standards in the field of agriculture.

> *"The over-all point is that new technology will not necessarily replace old technology, but it will date it. By definition. Eventually, it will replace it. It's like people who had black-and-white TVs when colour came out. They eventually decided whether or not the new technology was worth the investment."* Steve Jobs

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