152nd EAAE SEMINAR

EMERGING TECHNOLOGIES AND THE DEVELOPMENT OF AGRICULTURE

THEMATIC PROCEEDINGS

August 30th - September 1st 2016
Novi Sad, Serbia

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Technology Transfer and Impact on Agricultural and Rural Development

PLENARY SESSION

Invited Paper

TECHNICAL CHANGE IN AGRICULTURAL DEVELOPMENT OF THE WESTERN BALKAN COUNTRIES

Koviljko Lovre[1]

Abstract

In the long run, the growth of agricultural production is carried out with the relative fixity of arable land and the labour extraction from agriculture, so the crucial extent of the output growth is achieved on the basis of the increased use of non-agricultural inputs, quality improvement of all production factors and their favourable combinations. From this empirically indisputable fact, it is deductible that the technical progress is one of the key generators of agricultural production and productivity factors. However, the efficiency and diffusion of technical and technological innovations in agriculture are much more complex than in other areas of material production. It is primarily due to the inherent characteristics of agricultural development, immense numbers of productive individuals and decision-makers, dispersed economic and social structure, the role of "traditionalism," agricultural transformation and accumulation of non-agricultural resources, and growing role of institutional factors in the development. At the international level, the pace of technical expansion is exceptionally unequal, even within the framework of a relatively homogeneous group of countries, such as the Western Balkans. The reason for this is primarily in the different levels of agricultural development, divergent institutional schemes, diverse approaches to methods of growth and operation of research and extension services, different levels of farmers' education and of overall economic development. From all the above stated, the objective of this work is a clear result: determining the technological progress pace and its contribution to the growth of agricultural production in the countries of the Western Balkans. The goal is to determine precisely the extent to which the technical progress has improved the agricultural competitiveness of the individual states. The research time span is primarily contingent by the efforts of these countries to become members of the European Union.

Keywords: *Growth and development of agriculture, technical change, productivity, the Western Balkans.*

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Introduction

Institutional and economic reforms have a dramatic impact on the organisation of agricultural production, production volume and agricultural efficiency of the Western Balkan countries. The initial productivity drop in agriculture is undisputedly associated with initial disruptions, as a result of land reforms, farm restructuring, privatisation of production capacities, soft budget constraints, lack of incentives and disorganisation of the food supply chains.

It is well known that the resource endowments is predominantly determined by the growth of agricultural productivity and the nature of agricultural technology. Most famously, Hayami, Y. and Ruttan, V. W (1970) showed how technical changes occur through a sequence of induced innovations in technology biased toward saving the limiting production factors.[2] Briefly, countries, in which the land is relatively scarce and the labour relatively abundant, generate technological innovations aimed at more efficient land use and vice versa, countries where thelabour is relatively scarce and the land relatively abundant production factor of technological innovation induce relatively more efficient use of labour .

Additionally, it is well known that the resource endowments defines the impact on agricultural productivity growth as well as the institutional reforms. However, the very nature of the transition process, the inherent policy, and institutional reforms interacting with the pre-reform distortions, make the resource endowments influence on productivity growth much more complex than it can be explained by Hayami-Ruttan model of induced innovation.[3]

Finally, the agricultural resource endowments plays a dominant role in the productivity growth during the transition process and, not less important, the resource endowments defines endogenous farm restructuring and the adjustment in factor proportions.

Materials and methods

The research database was completed using the available data sources: FAOSTAT, ILO, the National Statistics, as well as the World Bank database. The research time frame is from 2000 to 2013. The research units are the

[2]A very interesting critical evaluation and reinterpretation of Hayami-Ruttan model of induced innovation was made by Koppel, B. (1995).
[3]A detailed presentation of the impact of these factors in the transition countries can be found in the research by Swinnen, J., Van Herck, K., Vranken, L (2012).

Western Balkan countries, namely: Albania, Bosnia and Herzegovina, FYR Macedonia, Montenegro, Serbia (without Kosovo and Metohija). The aim of this study is to determine the technological progress pace and its contribution to the growth of agricultural production in these countries. The research interest stems from the Western Balkan aspirations to join the European Union. Accordingly, it is necessary to determine precisely the extent to which technological progress affects the agricultural competitiveness in these countries. The selected variables for the analysis were the following:

- The gross value of agricultural production in constant international $ (average 2004-2006) - FAOSTAT;
- Agricultural land – FAOSTAT;
- Labour force - active agricultural population; FAOSTAT, ILO and the National Statistics (for the years for which there are no statistical records,interpolation assessment was conducted);
- Mechanization - the number of tractors engaged in agricultural production – FAOSTAT;
- Livestock units - calculated certain categories of the livestock coefficients - FAOSTAT;
- Chemical agents - consumption of the active substances of mineral fertilisers - FAOSTAT.

The aggregated data for the Western Balkan countries are presented as the gross production indices calculated by weighting the indices of individual countries with their stakes in the total production, while the production factors are aggregated without weighting, and converted into indices.

Cobb-Douglas production function was used in the research as follows:

$$\mathbf{Y = A_0 \cdot X_1^{\beta 1} \cdot X_2^{\beta 2} \cdot X_3^{\beta 3} \cdot X_4^{\beta 4} \cdot X_5^{\beta 5 \cdot} e^{\gamma t}}$$

where:

Y – gross value indices in constant international $;
$\mathbf{X_1}$ – agricultural areas;
$\mathbf{X_2}$ – active agricultural population;
$\mathbf{X_3}$ – capital input (machinery);
$\mathbf{X_4}$ – livestock units;
$\mathbf{X_5}$ – consumption of active substances of mineral fertilisers;
T – time;
$\mathbf{A_0}$ **–** constant function;
$\boldsymbol{\beta_i}$ – estimated function parameters (elasticity of production in relation to the production factors);
$\boldsymbol{\gamma}$ – the rate of technical progress.

In order to show the development of the agricultural productivity of the Western Balkan countries, the research analysis was concentrated on three sets of productivity indicators: output per unit of labour, output per unit of land, and the aggregate total factor productivity (TFP).

Total Factor Productivity (TFP) is calculated as a measure of the input-output relations. The estimated production function parameters were used as weights for inputs[4]. After the TFP assessment, the technical progress rates were calculated in the resulting framework, reported on a gross basis. In addition, the contribution of technical progress and conventional inputs to production growth was estimated as well.

Results and discussion

Agriculture plays a significant role in the overall economy in the Western Balkans. This fact is indicated by the share of agriculture in GDP, employment and foreign trade (*Table 1*), which is extremely high in relation to the highly developed countries. The share of agriculture in GDP for the whole Western Balkan amounts to 11.8%, wherein it is the highest in Albania (22%), and the lowest in Bosnia and Herzegovina. The level of economic development and the share of agriculture in employment are closely correlated, with the range from 5.7% in Montenegro up to 44.6% in Albania. There are no employment data in Bosnia and Herzegovina, due to the inadequate national statistics. Agricultural and food products represent a very important segment in foreign trade exchange of the Western Balkan, which is indicated by the share of agriculture in the foreign trade.

Agriculture plays an important role in the overall economy of these countries, likewise, the key characteristics of agriculture in the Western Balkan is a very small average farm size, whereby, the average for the whole region is 2.51 hectare per farm. The lowest average farm size is characteristic of the Albanian agriculture (1.2 hectares per farm), while the highest average recorded is in Montenegro (4.5 hectares per farm) in the period. This structure of agricultural holdings indicates a high proportion of small, family farms, focusing on traditional manufacturing.

[4]Agricultural Total Factor Productivity is calculated using methodology described by Swinnen, J., Vranken, L. (2010). They used growth accounting method in which TFP growth is calculated as the difference between the growth in output and the aggregate growth in land, labour, fertilisers, machinery and livestock capital inputs. Input weights are the production elasticities estimated from a Cobb-Douglas production functions for each country and aggregated for the Western Balkan countries.

According to FAOSTAT estimates, the Western Balkan population is 19 million, almost half of which (49.19%) lives in rural areas. Broken down by country, 60.39% of the inhabitants in Bosnia and Herzegovina is classified as rural population, while the share is the lowest in Montenegro, amounting to 35.84% of the total population.

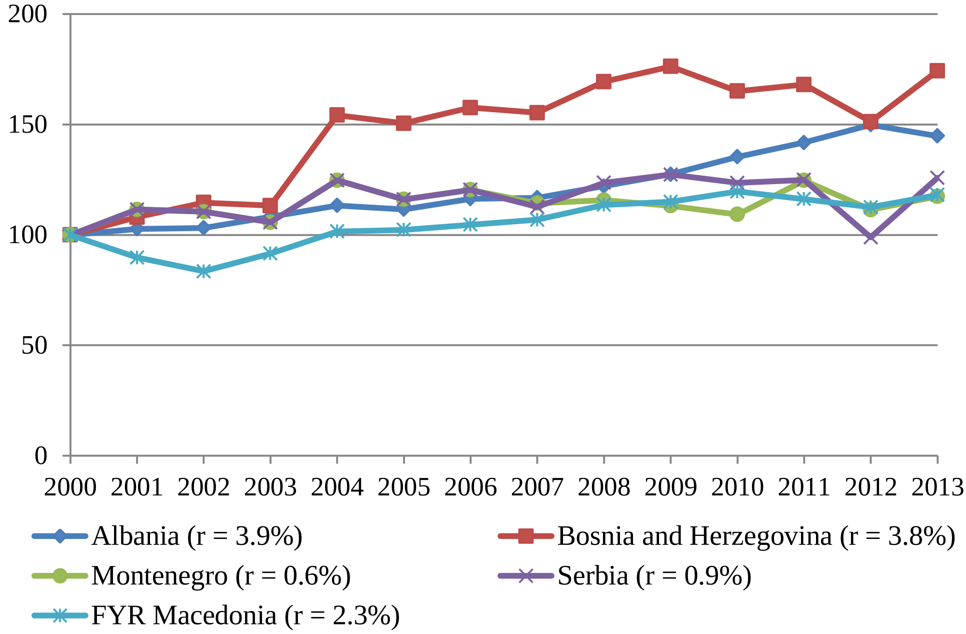
Table 1. ***General characteristics of agriculture of the Western Balkans countries***

	The share of agriculture in GDP (%)	**The share of agriculture in employment (%)**	**The share of rural population in the total (%)**	**The average farm size (ha)**	**The share of agriculture in exports (%)**	**The share of agriculture in imports (%)**	**The share of agri-culture in total foreign trade (%)**
ALB	22	44,6 (2013)	47.03	1.2	4.71	17.28	13.22
BiH	7.10	No data	60.39	2.0	8.65	18.41	14.94
MNE	10.20	5,7 (2012)	35.84	4.5	16.67	25.00	23.55
MKD	11.20	18,5 (2014)	43.55	2.5	15.52	35.72	22.69
SRB	9.50	21,3 (2013)	47.33	3.7	19.16	7.73	12.48
W.B.	11.80	-	49.19	2.5	15.14	14.23	14.60

Agricultural production in the Western Balkan countries is of extensive nature, exposed to the weather conditions. In addition to reducing development disparities in the most developed countries in the world, it is increasingly evident that the differences in agricultural productivity are primarily caused by agro-ecological conditions of agricultural production.

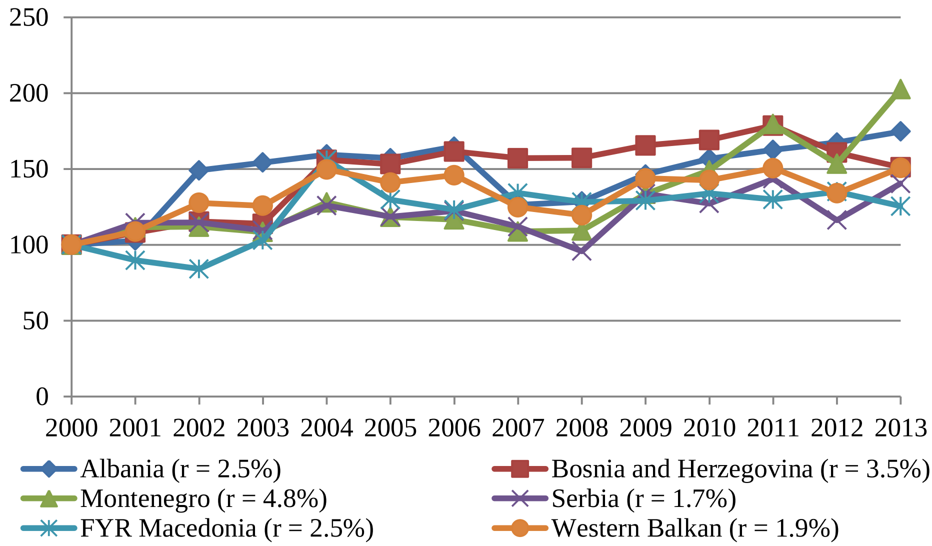
Figure 1 shows the indices of gross agricultural production, with the basisin the year 2000. In Albania, the highest production growth rate is recorded in the given period (3.9%), but due to the lower level of agricultural production at the beginning of the period. Bosnia and Herzegovina is next to Albania, with a rate of 3.8%, followed by Macedonia 2.3% and 0.9% in Serbia. The lowest agricultural production growth rate, which amounts to 0.6% is recorded in Montenegro.

Figure 1. ***The production indices***



Note: *r* - The growth rates of the total agricultural production (calculated from the linear trend)

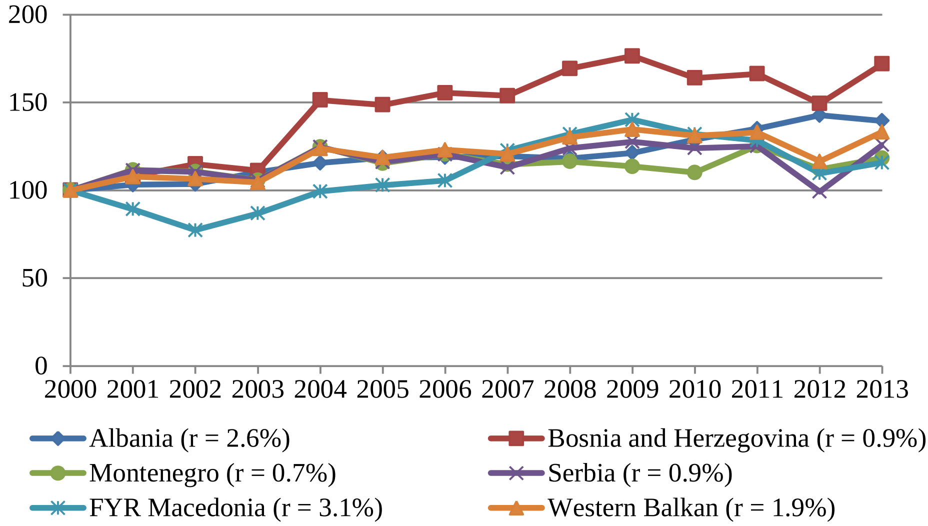
Figure 2. ***The indices of labour productivity***



Note: r - the growth rate of the total agricultural production (calculated from the linear trend)

Partial productivity is an important indicator of agricultural competitiveness. In addition, the productivity of labour and land are the best indicators of how much the Western Balkan countries lag behind European agriculture. Basic indices of productivity of labour and land are given in *Figure 2* and *Figure 3*. Speaking for the whole region, same as the total value of production, labour productivity grew at a rate of 1.9% (*Figure 2*). The highest rate of labour productivity was achieved in Montenegro (4.8%), followed by Bosnia and Herzegovina (3.5%), and Albania and Macedonia with a rate of 2.5%. On the other hand, the highest rate of land productivity growth is recorded in Macedonia (3.1%), followed by Albania (2.6%), Serbia, and Bosnia and Herzegovina with the rate of 0.9%, and Montenegro, with the lowestland productivity growth of 0.7% (*Figure 3*).

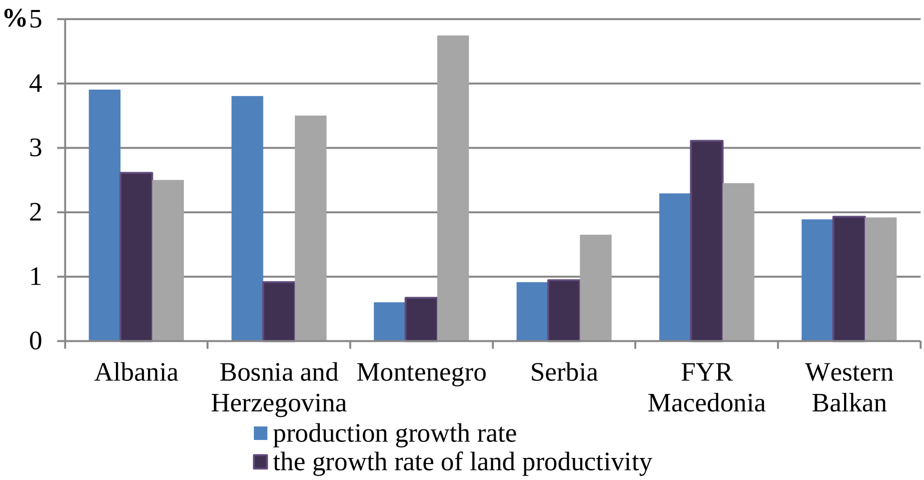
Figure 3. ***The indices of land productivity***



Note: r - the growth rates of the total agricultural production (calculated from the linear trend)

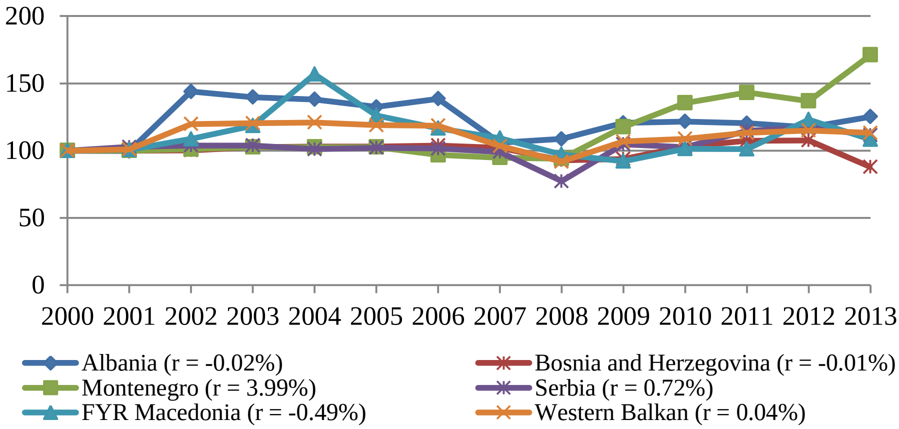
The growth rates of agricultural production and labour and land productivity are shown in *Figure 4*. In most countries of the Western Balkan, there is a noticeable higher growth rate of labour productivity than the land productivity. Such a growth rate of labour productivity is primarily the result of the outflow of labour from agriculture to other sectors. On the other hand, the intensification of agricultural production in the reporting period influenced the rate of land productivity to become higher than the rate of labour productivity in Albania and Macedonia.

Figure 4. ***Growth rates of production, and the land and labour productivity***



Defined by land/labour ratio, the resource structure in agricultureis the dominant factor in the selection of production technology (biochemical and/or mechanical technology) and determines the level of partial productivity. *Figure 5* shows the changes in land/labour ratio. Observed in the whole region, there were no significant changes in this ratio (r = 0.04%). A significant improvement in resource endowment was recorded only in Montenegro. Since the available land is relatively constant, the increased supply resource level is due to the outflow of people employed in agriculture into other sectors. Such a transfer of labour force leads to the labour substitution by capital inputs (use of mechanical technology).

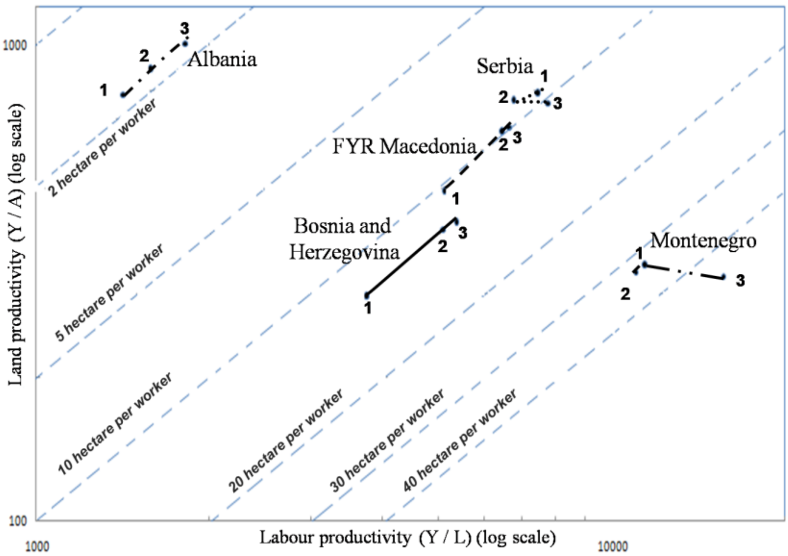
Figure 5. ***Changes in land/labour ratio***



Note: ***r*** - the growth rates of change in land/labour ratio (calculated from the linear trend)

In the reporting period, in Albania, Macedonia, and Bosnia and Herzegovina, there was an increase in land productivity and labour productivity at a relatively constant land/labour ratio (*Figure 6*).

Figure 6. ***Comparison of productivity of labour and land in the Western Balkans (in 2004-2006 const.int. $)***



1: 2000-2004. 2: 2005-2009. 3: 2010-2013.

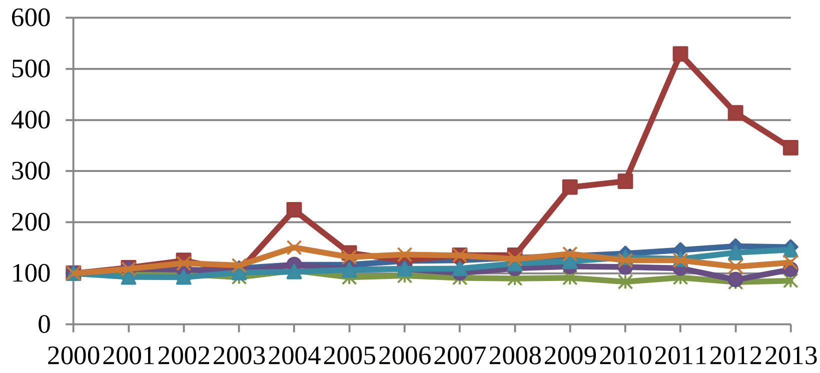
Productivity statistics compare changes in outputs to changes in inputs in order to assess the performance of a sector. Two types of productivity measures are partial and multifactor indexes. Partial productivity indexes relate output to a single input, such as labor or land. These measures are useful for indicating factor-saving biases in technical change but are likely to overstate the overall improvement in efficiency because they do not account for changes in other input use. For example, rising output per worker may follow from additions to the capital stock, and higher crop yield may be due to greater application of fertilizer. For this reason, a measure of TFP relating output to all of the inputs used in production gives a superior indicator of a sector's efficiency than do indexes of partial productivity.

To summarize, the theory underpinning the TFP productivity index assumes that producers maximize profits so that the elasticity of output with respect to each input is equal to its factor share. It also assumes that markets are in long-run competitive equilibrium (where technology exhibits constant returns to scale) so that total revenue equals total cost. If these conditions hold and the underlying production function is Cobb-Douglas, then this index provides an exact representation of Hicks-neutral technical change. Theoretically, production elasticity's and corresponding cost shares should be equal, so long as producers maximize profit and markets are in long-run competitive equilibrium. With growth rates in aggregate output and input thus constructed, we calculated indices of TFP and growth rates in agricultural TFP by country, and region as whole, for time period 2000 to 2013 (*Table 2 and Figure 7*).

Table 2. ***The Indices of Total Factor Productivity (TFP)***

	Albania	Bosnia and Herzego-vina	Montenegro	Serbia	FYR Macedonia	Western Balkan
2000.	100	100	100	100	100	100
2001.	103.3732	111.0008	100.9783	108.5526	92.59775	108.2537
2002.	105.0726	125.0855	98.59752	107.4142	92.39424	119.6166
2003.	109.8747	104.42	92.55665	103.02	101.4566	105.4164
2004.	116.6672	223.7645	105.3616	116.6871	103.1095	150.4096
2005.	116.9189	139.6556	92.5056	107.3073	106.4985	131.6887
2006.	124.3299	124.73	95.16836	108.5512	108.5913	136.7028
2007.	125.4622	135.2188	91.11546	100.6053	109.4029	134.9893
2008.	130.3324	135.1981	89.81177	109.6789	118.9714	128.2269
2009.	133.5138	268.2411	91.22459	113.4548	123.556	137.7752
2010.	138.7382	279.9139	83.28106	112.2206	131.0751	125.1614
2011.	145.5375	528.7894	91.85258	110.0732	127.7482	125.4064
2012.	153.2611	413.6226	82.69213	87.38864	140.327	113.2033
2013.	151.2022	345.421	85.44049	107.556	145.8728	121.0895
The growth rates of TFP (r)	**3.46**	**16.75**	**-1.42**	**-0.13**	**3.56**	**0.66**

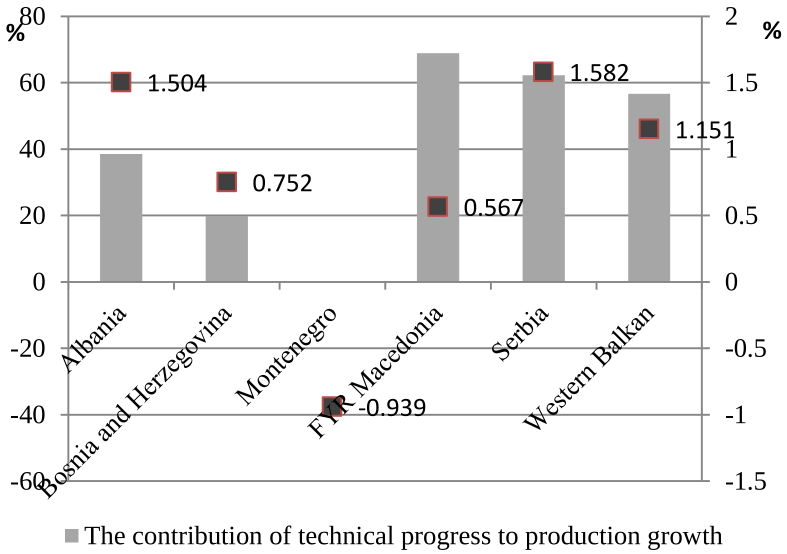
Figure 7. ***The indices of Total Factor Productivity (TFP)***



Note: r - the growth rate of Total Factor Productivity (calculated from the linear trend)

The highest growth rate of total factor productivity (TFP) was registered in Bosnia and Herzegovina (16.75%) as a result of the substantial intensification of agricultural production (the growth rate of the use of mineral fertilisers amounted to 18:22% in the reporting period). In Serbia and Montenegro, there was a decline in total factor productivity, which is primarily the result of the number of livestock reduction.

Figure 8. ***Rates of technical change and its contribution to the production growth***



Note: the contribution of technical change to the production growth- left scale; rate of technical change - right scale

Table 3. ***Contribution of technical progress and conventional inputs to the production growth***

	Contribution of technical progress	**Contribution of conventional inputs**
Albania	38.5%	61.5%
Bosnia and Herzegovina	19.8%	80.2%
Montenegro	0%	100%
Serbia	62.2%	37.8%
FYR Macedonia	68.9%	31.1%
Western Balkan	54.4%	45.6%

The rate of technical progress in the Western Balkans amounts to 1.15% (*Figure 8*). The highest rate of technical progress was achieved by Serbia and Albania, 1.58% and 1.5%, respectively. A negative rate of technical progress (-0.94%) was recorded in Montenegro. The contributions of technical progress and the use of conventional inputs to production growth in the Western Balkan countries amounts to 54.4% and 45.6%, respectively (*Table 3*). In Montenegro, the production growth is exclusively the result of the use of conventional inputs. The most significant contribution of technical progress to the production growth was recorded in Macedonia (68.9%) and Serbia (62.2%).

Conclusions

Increases in both agricultural output and productivity are important for two reasons. First, higher production and productivity are crucial to meet the growing demand for food and nonfood agricultural products in both domestic and foreign markets. Second, an increase in output and productivity drives up agricultural incomes and improves the competitiveness of the sector. In less economically advanced, such as Western Balkan countries, where a considerable proportion of the rural population still depends on agriculture as its primary source of income, an increase in competitiveness is crucial to enhance the viability of the rural areas and reduce the poverty gap between urban and rural populations.

Western Balkan countries had failed to establish adequate agricultural research and extension institutions and extend basic education to rural areas were stuck in low-productive agriculture and were falling further behind European Union. The results do show clear evidence of a slowdown in the growth in agricultural investment: the global agricultural resource base is still constant. These two trends—decelerating TFP growth and accelerating input growth—have largely offset each other to keep the real output of agriculture growing at slightly less than 2% per year between 2000 and 2013. This finding has important implications for the appropriate supply-side policy.

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ECONOMIC EFFECTS OF NEW TECHNOLOGIES APPLICATION IN VEGETABLE PRODUCTION[1]

Jonel Subić[2], Marko Jeločnik[3]

Abstract

Strengthening the competitiveness of national agriculture, imposes the need to increase the production of quality and safe food. Because of this, one of the basic tasks of farmer's education should be the advancement of knowledge in the field of new technologies application. Adapted to Serbian agro ecological conditions, new technologies are primarily applied in order to obtain higher quality and safe food, food whose production is socially acceptable, economically viable, and without any negative impact on the environment. Research described in paper was primarily focused on the economic analysis (cost-effectiveness) of the new technologies application (smart sensor networks, mobile robotized solar power generator) in vegetable production. Consequently, analysis was based on experimental measurements, in which were done parallel testing of energy efficiency and economic cost-effectiveness of use of four different pumping systems connected to different irrigation systems: electric pumps connected to the public electrical grid; pumps with gasoline engine; pumps with diesel engine; and electric pumps powered by solar power generator. The experiment was carried out on experimental plots under certain vegetable crops (cauliflower, tomatoes and lettuce) that were produced in the two production systems, on the open field and within the protected area (greenhouse), involving the use of irrigation (drip-drop and sprinkler system). Experimental plots are located in village Glogonj - Upper Danube region and village Veliko Selo - Central Danube region. After detailed analysis of results obtained within the one production cycle in vegetable crops production (analysis was done by use of analytical calculations based on variable costs), certain conclusions indicating economic justification of

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applied new technologies (mobile robotized solar power generator) have been made. Achieved economic effects are reflected through the reduction of fuel spent for irrigation (i.e., variable costs in cauliflower production were decreased for 486 EUR/ha; in tomato production for 554 EUR/ha; or in lettuce production for 340 EUR/ha).

Key words: *robot system, agriculture, economic effects, new technologies, vegetable production.*

Introduction

Stability and quality of yield in plant production lines can be significantly jeopardized under the impact of climatic changes, without wider use of agro-technical measure of irrigation. On the other hand, it is expected from the implementation of irrigation system to be adjusted with the costs and energy efficiency requirements, as well as the expressed orientation toward the environment protection.

Power-generating part of the irrigation system has been mostly relied on the consumption of fossil fuels (petrol and diesel) or to electric power supply from a public electric power grid. As a branch of strategic significance for the sustainable development of national economy, agriculture represents a great consumer of fossil fuels, which exploitation significantly degrades soil and water, while combustion releases gases with greenhouse effects. Of course, prices of agricultural products are highly dependable and sensitive to oscillations of fuel prices, before all, of fossil origin.

According to mentioned, the provision of renewable energy sources, which require minimum engagement of limited land and water resources and do not disturb their ecological status, becomes an important issue for future, not only domestic but also the world food production.

Scientific-research work has confirmed the possibilities of efficient replacement of energy from fossil fuels with the energy from renewable resources, primarily from solar and wind energy. It can be used in numerous activities which are conducted in contemporary, multifunctional agriculture, such are: starting of irrigation pumps, drying of cereals, oilseeds and fruits within the silos or dryers, in the production of artificial fertilizers and pesticides, in greenhouse production and fishery, and especially in organic production, cattle breeding organized on pasture and in agro-eco and eco-organic tourism on holdings in areas of high natural value and with underdeveloped energy infrastructure.

The costs of energy within the structure of total irrigation costs are a significant item, while the use of fossil fuels or the process of electrical energy production, most often directly or indirectly jeopardize environment. In accordance with the global recommendations, accepted by a national law and policy maker, in many strategic documents and legal acts is potentiated a wider application of renewable energy sources. Ultimately, in closer period set goals should lead to a share of renewable energy sources in final consumption of energy at the level of 20%.

In accordance with previously mentioned, science has been given a task to give its full attention in solving the issues of new technologies development regarding the use of renewable energy sources and pure technologies with the zero emission. Direct contribution of national science, by previously expressed global pretensions, reflects in the development of a prototype of mobile robotized solar electro-generator.

At the beginning of the 2015, a mobile robotized solar electro-generator was developed at the institute "Mihajlo Pupin" from Belgrade, the leading national research institution from the field of information-communication technologies (Stevanović et al., 2013). The mobile robotized solar electro-generator is an energy efficient ecological device for the production of electrical energy, by using of the sun light energy (Picture 1.).

Picture 1. ***Mobile robotized solar electro-generator***

Source: Author's archive.

This autonomous device, which doesn't connect to the electrical network and doesn't require any building or energy infrastructure (*stand-alone*), is primarily intended for smaller and medium energy consumers.

This is a new ecological product, unique on the Serbian and surrounding countries market. The product has a general purpose, but it is predominantly projected in order to improve agricultural production, regarding that it provides an intensive but economical irrigation of crops, without noise and pollution of environment. This device is also main nod of smart sensor network for collecting and process of data about soil conditions, soil moisture, soil and air temperature, wind speed at observed area, etc. All of this parameters could be included within the system for optimized irrigation at certain surface depending to soil conditions and short term weather forecast for observed area (Subić et al., 2016).

Main benefits of mobile robotic solar electric generator, which is a subject of present research analysis, in compare to power generator used in conventional irrigation system are as follows:

- Mobile and portable device, suitable for use on any ground;
- There is no requirement for special infrastructure, as well as for preparing the ground for the installation;
- Independent in operation and not connected to the public electrical network;
- Period of autonomy in work lasts for more hours while simultaneous recharging by use of solar energy;
- Easy to use (users friendly), does not require special training or education;
- Silent in operation and without negative impact on the environment;
- Highly automated device, which has the option of remote control;
- Easy and inexpensive to maintain;
- Working life of the device is more than 20 years, while the battery life is 1,000 to 5,000 cycles of charging (depending of level of battery discharging, from 0 to 60% of the full state).

Summarizing all previously presented, research in paper was directed to an analysis of solar energy profitability (use of mobile robotized solar electro-generator) in agriculture. In other words, the research of authors was focused on the assessment of economic effectiveness of new technology application in plant production (*vegetable growing*).

The analysis is based on experimental measuring, to which energy efficiency and economic profitability of using of four different pumping stations of the same power connected to the irrigation system were parallel tested:

- Electric pump connected to the city electro-network;
- Pump with gasoline engine;
- Pump with diesel engine;
- Electrical pump powered by the solar electro-generator.

The experiment was conducted on experimental plots under the certain vegetable crops (cauliflower, tomato and lettuce) in the production system in open field and within the protected area (*greenhouse*), which implies the application of irrigation.

Experimental plots are located at two selected locations:

- In the village Glogonj (at the territory of the Pančevo city, within the wider area of Upper Danube Zone);
- In the village Veliko Selo (at the territory of the Belgrade city, within the narrower area of Central Danube Zone).

All experimental measuring on specified locations was considered the identical project and production conditions.

Vegetable production most often requires a high level of intensity and technical equipment, use of organic and mineral fertilizers, plant care and protection, as well as certain level of attention in the process of harvesting, transportation and storing of fresh fruits. Contemporary vegetable production also considers the application of irrigation, since it provides the necessary conditions for plant growth and development, achievement of high yields, as well as economic viability of investment in other agricultural inputs (Svendsen, Turral, 2007). On the other hand, tendency for higher profitability in some cases led to neglecting of principle of food safety, and in relation to mentioned one of problems in vegetable production in Serbia is the excessive use and disrespect of the withdrawal period of used pesticides (Subić, Jeločnik, 2013).

Material and working methodology

Vegetable production is an important segment of agricultural production, where according to complexity of the applied technology and agro-technical solutions, this production has a relatively big impact on development of national agro-complex.

During period from September to October 2015, field researches were carried out on locality of villages of Glogonj and Veliko Selo, at selected family holdings predominantly oriented to the vegetable production. Mentioned researches, in addition to testing the functioning of mobile robotic solar electro generator, included development of analytical calculations based on variable costs for those vegetable varieties (in this case cauliflower, tomato and lettuce) for which production (within the activities of irrigation), among other things, the solar generator was tested.

Observing the single agricultural holding, for each production it does, it is necessary to create a individual calculation of production value and realized costs, in order to isolate those lines that carry a higher level of profitability. Therefore, calculative framework should provide simple, clear and easy applicable model for analyses of different types of plant and livestock production, which will enable comparison of achieved production results (Jeločnik et al., 2015).

Due to the relative methodological simplification and wideness of practical application, in practice of developed economies usually is used analytical calculations based on variable costs (contribution margin), as analytical base of the management of agricultural holding/enterprises, according to which they can efficiently to manage a costs, and deliver more correct business decisions. Mentioned calculations are particularly suitable for calculating costs on family holdings, which do not have bookkeeping, and therefore does not have all necessary data for development of analytical calculations of total costs (full cost price of the product), (Vasiljević, Subić, 2010/b).

In other words, in conditions of farm orientation to plant production, its complexity assumes analytical tool that would facilitate the current economic analysis of the present state of production at the farm (development of calculations with the elements of production value and costs), or simple analysis of the sustainability of adopted production technology and achieved production results (Subić et al., 2015).

Development of analytical calculation, based on variable costs, starts by determination of the market value of achieved production, which presents market prices of obtained products multiplied by their quantity. Then, by this value are deducted the variable costs of obtained products production.

Starting of new production cycle requires procurement of the necessary production assets, such as: seeds and seedlings, fertilizers, pesticides, energents (fuel) and lubricants, services of agricultural mechanization, labour (family labour and/or engaged workforce), etc. The costs of acquiring and use of almost all mentioned assets have the character of variable costs in agricultural production. Depending on working organization at the holding, labour costs can be observed as fixed or variable cost (included or excluded in a calculative procedure).

The final result of analytical calculations based on variable costs is contribution margin or gross financial result. It is defined as the difference between total production value (the value of the main product plus the value of by-products and subsidies[4]) and the proportional variable costs (Vasiljević, Subić, 2010/a).

Contribution margin could be presented as:

CM = PV – VC, where PV = (q x p) + s

Symbols meaning:

CM - Contribution margin;

PV - Totally achieved production value;

VC - Totally achieved variable costs;

q - Quantity of product per unit of production area;

p - Price of product per unit of measure;

p - Subsidies per unit of production area.

Contribution margin provides indications to the holder of a family agricultural holding (manager of the agricultural enterprises) how much, after covering of variable costs, financial assets remains for fixed costs covering, and achieving of positive financial result (profit). It can be an extremely important indicator in determination of optimal structure of production (using linear programming), or in determination of business risks (Subić et al., 2010/a).

Principally, in vegetable production, calculations based on variable costs allow direct comparison of the financial success of two different lines (or phases) of vegetable production with the same fixed costs, as well as a comparison of two or more different intensities of the same line or phase of vegetable production.

In the vegetable production, depending on the used land area, unit of measure can be adjusted to each entity individually. The obtained result (contribution margin), for each line of vegetable production, is multiplied by the number of hectares - ha (in case of production in the open field), or by the number of square meters - m2 (in case of production within the greenhouse):

TCM = CM x NMU

Where:

TCM - Total contribution margin;

[4] Incentives are usually referred to subsidies or premiums.

CM - Contribution margin;

NMU - Number of measure units (ha or m^2).

After summing of all contribution margins, as indicators of success of certain lines (phases) of production, can be obtained overall contribution margin for vegetable production organized in some agricultural enterprises (family holding). After deduction of total fixed costs from obtained value (costs of production capacities and various overheads) total profit (or loss) of entire vegetable production realized in observed entity in previously determined time period will be gained. Of course, in the case of allocation of fixed costs to certain lines (or phases) of production, mentioned calculation could be in function of obtaining of full cost price of certain vegetable products.

This way presentation of the obtained results, provides a quick and easy overview of business of agricultural holding in one production year (cycle), as well as the calculation of expected economic results in case of changing in production volume, or switching from one to another production (Subić et al., 2010/b).

In assessing the results of crop production, inability to predict future events (primarily incomes and expenses) significantly influence to investment viability, in other words reduce the real possibilities of management in the process of decision making. Accordingly, during the decision making, manager is facing a very complex problem which brings uncertainty, as well as in front of complex task to even slightly reduce the risk of potentially bad decision (Subić, 2010).

In addition to previously mentioned, the assessment of production results of crop production lines under uncertainty could be done by use of different methods and techniques. One of analytical methods is the determination of critical price, critical yield and critical variable costs. These indicators reflect the critical values of production under which the contribution margin (gross financial result) equates to zero (Nastić et al., 2014).

Mentioned indicators could be presented with next formulas:

Critical price: CP = (VC - S) / EY

Critical yield: CY = (VC - S) / EP

Critical variable costs: CVC = (EY x EP) + S

Meaning of symbols is:

- Expected yield (EY);

- Expected price (EP);
- Subsidies (S);
- Variable costs (VC).

As was previously mentioned, the experiment was considered field research, which was conducted during the September and October 2015. Besides the testing of mobile robotic solar electric generator in real conditions, research has implied the collection of data throughout the in-depth interview of members of selected family holdings predominantly oriented to the vegetable production.

Each surveyed household is specific by the application, to some extent, different production technology, different approach to the procurement of the necessary production materials and sale of produced vegetables. Selected holdings (including production areas) are located at the territory of the village Glogonj (2 holdings) and Veliko Selo (1 holdings). Analytical calculations were made only for the vegetable crops in which production cycle (within the application of irrigation) was tested solar electro generator. Observed vegetable crops were grown in the open field (cauliflower and lettuce), and in protected area – greenhouse (tomato).

For the purposes of this study, all calculations are done on the basis of the production value and variable costs, realized at the utilized agricultural (production) area at observed holdings. Then, in order to facilitate the comparison of achieved results and adopted production technology, all values are brought down to the area of 1 ha. In order to provide a wider comparison of achieved value indicators, all variable costs and production values are expressed both in national currency (RSD) and official currency of the European Union (EUR).

From the aspect of methodology, calculation principle of certain items within the calculation based on variable costs in crop production is identical, unless there are specific items of the production value or variable costs in certain lines of production.

Used model of calculation, in the production of selected vegetable crops, is based on the presentation of all indicators throughout several separate tables and charts. Previously all data and indicators are logically tested, or analysed by use of standard mathematical-statistical methods. The reason for such a presentation was found in accentuation of detailed calculation procedure and structure of contribution margin calculation based on variable costs.

Intention was primarily found in marking of the costs of different energy sources used within the process of irrigation during the production of selected vegetable crops, which can be substituted and reduced by use of solar energy. In other words, there was a need for pointing out to the agricultural producers the size of energy costs and their share within the structure of total variable costs in the vegetable production.

According to overall importance of selected vegetable crops, closeness of the market, tradition of growing, adopted technological approach, following research activities were conducted:

- Analytical calculations based on variable costs (contribution margin) were done;
- Detailed structure of total variable costs were determined;
- Critical price, critical yield and critical variable costs for each line of vegetable production were determined (evaluation of production results in conditions of uncertainty).

Theoretical and material basis were taken from the available scientific and technical literature focused on the researched issue, as well as from in-depth interviews with the members of selected family agricultural holdings. Most of obtained data is directly related to the current production year (2015), while some are producers’ estimations or scientifically verified standard for some line of vegetable production.

Research results

Vegetable production (in this case: cauliflower, tomato and lettuce) is important segment of agriculture, as a meter of fact, a significant factor of national agro-economy competitiveness.

Considering the fact that a numerous of family holdings are dealing with vegetable production, the results of research can be of great importance, not only for members of those family holdings, but also for managers of agricultural enterprises, which production structure include vegetables. Those reasons are enough for choosing of calculations based on variable costs for mentioned crops, in order to see the influence of costs of energy related to irrigation on the economic results of production.

Testing of mobile robotic solar electric generator was carried out on fields under vegetable crops cultivated in production system which includes irrigation, considering that this production system significantly affects the stability and yield (vegetable crops require significant amount of water). On the other hand, the assumption is that incomes from the valorisation of cultivated vegetables cover all production costs (both variable and fixed), and provide enough financial assets for return of the investment in purchase/implementation of irrigation system.

According to methodology used, the irrigation costs have the character of variable costs, and such as are related to:

- Covering the costs of fuel and lubricants (i.e. covering the costs of energetics and variable costs of irrigation system);
- Paying of liabilities related to irrigation (i.e. reimbursement for water used for irrigation, reimbursement for water facilities used as a part of irrigation systems, fees for usage of regional irrigation systems and other water facilities, etc.).

In this study, mitigating circumstance is the fact that selected holdings have their own wells (water intakes). From previous experience, expectations are that the contribution of irrigation is that growth of incomes at holding exceed the growth of variable costs caused by irrigation use, as that cash outflows for the implementation of mentioned agro-technical measure (by which is compensated natural deficit of required amount of water of plants) are not significantly present within the structure of total variable costs.

1) Calculation of cauliflower production in open field

Table 1. ***Baselines***

Territory: Upper Danube Region (Glogonj)	Type of soil: good
Period: 1 production cycle (2015)	Area of production plot: 0,14 ha
1,00 EUR = 120,00 RSD	Space between plants: 60x50 cm

Source: *Group of authors (2015): Techno – economic aspects of use of renewable energy sources and mobile robotized solar electro-generators in agriculture, Study, IAE Belgrade, IMP Belgrade and PSSS Padinska Skela, Belgrade.*

Table 2. ***Contribution margin in cauliflower production in open field***

Element	Quantity	UM	Price per UM (in RSD)	Total RSD/ 0,14 ha	Total EUR/ 0,14 ha	Total EUR/ha
Incomes: A						
Cauliflower	5.875,00	kg	-	-	-	-
I class (95%)	5.580,00	kg	45,00	251.100,00	2.092,50	-
Spoilage (5%)	295,00	kg	-	-	-	-
Subsidies	14,00	ar	120,00	1.680,00	14,00	-
Total				**252.780,00**	**2.106,50**	**15.046,43**
Variable costs: B						

Seedlings	4.700,00	pcs	7,00	32.900,00	274,17	1.958,36
Fertilizers	-	-	-	16.372,50	136,44	974,57
Pesticides	-	-	-	7.505,40	62,54	446,71
Land tenure	-	-	-	-	-	-
Insurance	-	-	-	-	-	-
Ploughing (30 cm)	14,00	ar	90,00	1.260,00	10,50	75,00
Dispersal of manure	14,00	ar	112,5	1.575,00	13,12	93,71
Dispersal of mineral fertilizers	14,00	ar	15,00	210,00	1,75	12,50
Disking	14,00	ar	23,00	322,00	2,68	19,14
Pre-sowing treatment	14,00	ar	24,00	336,00	2,80	20,00
Planting (man.)	15,00	hour	200,00	3.000,00	25,00	178,57
Pesticide treatment (mec.)	5,00	treatment	350,00	1.750,00	14,58	104,14
Pesticide treatment and fertilizing (man.)	3,00	hour	200,00	600,00	5,00	35,71
Corrective hilling (mec.)	14,00	ar	17,00	238,00	1,98	14,14
Corrective hilling (man.)	8,00	hour	200,00	1.600,00	13,33	95,24
Harvesting (man.) with packaging, measuring, loading to lorry	72,00	hour	200,00	14.400,00	120,00	857,14
Packaging (carton box 20 kg)	300,00	pcs	50,00	15.000,00	125,00	892,86
Transportation	20,00	tour	600,00	12.000,00	100,00	714,29
Costs of stand tenure	-	-	-	7.100,00	59,17	422,64
Irrigation equipment	-	-	-	-	-	-
Preparation and presence of worker during irrigation	50,00	hour	200,00	10.000,00	83,33	595,21
Costs of water (irrigation)	-	-	-	-	-	-
Costs of fuel (diesel) for irrigation	60,00	l	136,00	8.160,00	68,00	485,71
Other costs	-	-	-	750,00	6,25	44,64
Total				**135.078,90**	**1.125,64**	**8.040,28**
Contribution margin: C = (A-B)				**117.701,10**	**980,86**	**7.006,15**

Source: *Group of authors (2015): Techno – economic aspects of use of renewable energy sources and mobile robotized solar electro-generators in agriculture, Study, IAE Belgrade, IMP Belgrade and PSSS Padinska Skela, Belgrade.*

Note: Value of mechanized operation was determined according to prices given by guide of Cooperative Union of AP Vojvodina, 2013.

Table 3. ***Structure of variable costs in cauliflower production in open field***

Element	Total RSD/ha	Total EUR/ha	Share in total variable costs (%)
Seedlings	235.003,20	1.958,36	24,36
Fertilizers	116.948,40	974,57	12,12
Pesticides	53.605,20	446,71	5,55
Carton boxes	107.143,20	892,86	11,10
Mechanized operations	126.350,40	1.052,92	13,10
Costs of energy (irrigation)	58.285,20	485,71	6,04
Engaged labour	211.424,40	1.761,87	21,91
Other costs	56.073,60	467,28	5,82
Variable costs (total)	**964.833,60**	**8.040,28**	**100,00**

Source: *Group of authors (2015): Techno – economic aspects of use of renewable energy sources and mobile robotized solar electro-generators in agriculture, Study, IAE Belgrade, IMP Belgrade and PSSS Padinska Skela, Belgrade.*

Table 4. ***Critical values of production***

Description	RSD(kg)/ha	EUR(kg)/ha
Expected yield (EY)	41.965,00	41.965,00
Expected price (EP)	45,00	0,375
Subsidies (S)	12.000,00	100,00
Variable costs (VC)	964.833,60	8.040,28
Critical price: CP = (VC - S) / EY	**22,75**	**0,19**
Critical yield: CY = (VC - S) / EP	**21.174,00**	**21.174,00**
Critical variable costs: CVC = (EY x EP) + S	**1.900.425,00**	**15.836,87**

Source: *Group of authors (2015): Techno – economic aspects of use of renewable energy sources and mobile robotized solar electro-generators in agriculture, Study, IAE Belgrade, IMP Belgrade and PSSS Padinska Skela, Belgrade.*

Gained results in the production of cauliflower in the open field with the use of irrigation (Tables 1-4.) suggest the following:

- In presented case of cauliflower production on observed holding, positive contribution margin was achieved (around 7.006,15 EUR/ha);
- Achieved incomes in cauliflower production are almost doubled in compare to generated variable costs of production;
- In the structure of variable costs, the cost of fuel (diesel) required for the process of irrigation, have a relatively modest share (i.e., around 6,04%);
- In the structure of variable costs dominate the costs of seedlings and engaged labour (with the share of 24,36%, or 21,91%);
- Critical values of production (values when contribution margin equates to zero) have the following values:
    - Critical price is 0,19 EUR/kg;
    - Critical yield is 21.174,00 kg/ha;

- Critical variable costs are 15.836,87 EUR/ha.

From the given case of achieved contribution margin in the production of cauliflower at the observed holding, it can be state with considerable degree of certainty that the contribution margin leaves enough space that after covering of all variable costs, the remaining assets for covering of fixed costs and achieving of positive financial result.

Although within the structure of variable costs, the cost of irrigation (in this case costs of energy - diesel) have relatively modest value, absolutely expressed (485,71 EUR/ha) it points to the possibility of their reduction or conversion of used energy source with cheaper and environmentally more desirable solution (solar energy).

2) Calculation of tomato production in greenhouse

Table 5. ***Baselines***

Territory: Upper Danube Region (Glogonj)	Type of soil: good
Period: 1 production cycle, 5 months (during 2015)	Size of greenhouse: 200 m^2
1,00 EUR = 120,00 RSD	Planting density: 2,5 plants per m^2 (4 rows x 35 m)

Source: *Group of authors (2015): Techno – economic aspects of use of renewable energy sources and mobile robotized solar electro-generators in agriculture, Study, IAE Belgrade, IMP Belgrade and PSSS Padinska Skela, Belgrade.*

Table 6. ***Contribution margin in tomato production in greenhouse***

Element	Quantity	UM	Price per UM (in RSD)	Total RSD/ 200 m^2	Total EUR/ 200 m^2	Total EUR/ha
A: Incomes						
Tomato	4.000,00	kg	-	-	-	-
I class (75%)	3.000,00	kg	35,00	105.000,00	875,00	-
II class (20%)	800,00	kg	30,00	24.000,00	200,00	-
Spoilage (5%)	200,00	kg	-	-	-	-
Subsidies	-	-	-	-	-	-
Total				**129.000,00**	**1.075,00**	**53.750,00**
B: Variable costs						
Seedlings	500,00	pcs	35,00	17.500,00	145,83	7.291,50
Fertilizers	-	-	-	16.900,00	140,83	7.041,50
Pesticides	-	-	-	4.655,20	38,80	1.940,00
Dispersal of manure	12,00	hour	200,00	2.400,00	20,00	1.000,00
Strings	2,00	hank	500,00	1.000,00	8,34	417,00
Mulch foil (stripes)	140,00	m	8,00	1.120,00	9,33	466,50
Foil (UV, anti-drop, anti-insect)	1/4	set	60.000,00	15.000,00	125,00	6.250,00
Shading net (3,60x50 m)	1/4	pcs	4.500,00	1.125,00	9,37	468,50
Packaging (used wooden box, 10 kg)	400,00	pcs	15,00	6.000,00	50,00	2.500,00

Stripe drips	140,00	m	5,20	728,00	6,07	303,50
Planting	6,00	hour	200,00	1.200,00	10,00	500,00
Binding	8,00	hour	200,00	1.600,00	13,34	667,00
Costs of laterals nipping	6,00	hour	200,00	1.200,00	10,00	500,00
Pesticide treatment	8,00	hour	200,00	1.600,00	13,33	666,50
Soil milling by moto cultivator	2,00	hour	500,00	1.000,00	8,34	417,00
Fruits picking, sorting and packaging	72,00	hour	200,00	14.400,00	120,00	6.000,00
Transportation	8,00	tour	1.000,00	8.000,00	66,67	3.333,50
Costs of stand tenure	-	-	-	7.100,00	59,17	2.958,50
Insurance of greenhouse	-	-	-	-	-	-
Costs of greenhouse heating	-	-	-	-	-	-
Costs of water (irrigation)	-	-	-	-	-	-
Costs of electric power (irrigation)	180,00	KWh	7,386	1.329,48	11,08	554,00
Other costs	-	-	-	750,00	6,25	312,50
Total				**104.607,68**	**871,75**	**43.587,50**
Contribution margin: C = (A-B)				**24.392,32**	**203,25**	**10.162,50**

Source: *Group of authors (2015): Techno – economic aspects of use of renewable energy sources and mobile robotized solar electro-generators in agriculture, Study, IAE Belgrade, IMP Belgrade and PSSS Padinska Skela, Belgrade.*

Note: Value of mechanized operation was determined according to prices given by guide of Cooperative Union of AP Vojvodina, 2013.

Table 7. ***Structure of variable costs in tomato production in greenhouse***

Element	Total RSD/ha	Total EUR/ha	Share in total variable costs (%)
Seedlings	874.980,00	7.291,50	16,73
Fertilizers	844.980,00	7.041,50	16,15
Pesticides	232.800,00	1.940,00	4,45
Wooden boxes	300.000,00	2.500,00	5,73
Mechanized operations	400.020,00	3.333,50	7,65
Equipment	948.660,00	7.905,50	18,14
Costs of energy (irrigation)	66.480,00	554,00	1,27
Engaged labour	1.170.060,00	9.750,50	22,37
Other costs	392.520,00	3.271,00	7,51
Variable costs (total)	**5.230.500,00**	**43.587,50**	**100,00**

Source: *Group of authors (2015): Techno – economic aspects of use of renewable energy sources and mobile robotized solar electro-generators in agriculture, Study, IAE Belgrade, IMP Belgrade and PSSS Padinska Skela, Belgrade.*

Table 8. ***Critical values of production***

Description	RSD (kg)/ha	EUR (kg)/ha
Expected yield (EY)	200.000,00	200.000,00
Expected price (EP)[1]	33,95	0,28
Subsidies (S)	-	-
Variable costs (VC)	5.230.500,00	43.587,50
Critical price: CP = (VC - S) / EY	**26,15**	**0,22**
Critical yield: CY = (VC - S) / EP	**154.064,80**	**154.064,80**
Critical variable costs: CVC = (EY x EP) + S	**6.790.000,00**	**56.583,33**

Note: [1] as holdings usually class the tomato, so expected price represents average price of sold kilogram of product.

Source: *Group of authors (2015): Techno – economic aspects of use of renewable energy sources and mobile robotized solar electro-generators in agriculture, Study, IAE Belgrade, IMP Belgrade and PSSS Padinska Skela, Belgrade.*

Achieved results in tomato production in greenhouse by use of irrigation (Table 5-8.), lead to next conclusions:

- In presented production line at observed holding, positive contribution margin was achieved (around 10.162,50 EUR/ha);
- Achieved incomes in tomato production are for 1,2 times higher than generated variable costs of production;
- Costs of energy (electric power) required for the process of irrigation have a relatively small share (i.e., around 1,27%) within the structure of total variable costs;
- In the structure of variable costs dominate the costs of engaged labour (with the share of 22,37%);
- Critical values of production (values when contribution margin equates to zero) have the following values:
    - Critical price is 0,22 EUR/kg;
    - Critical yield is 154.064,80 kg/ha;
    - Critical variable costs are 56.583,33 EUR/ha.

Cover margin obtained in the production of tomatoes in greenhouse at the observed holding should be sufficient to cover all fixed costs and gain the profit. Similar to the previous case, although the costs of irrigation (energy source is electricity) have a relatively low share in the structure of variable costs, in absolute amount (554,00 EUR/ha) leave enough space for finding of cheaper alternatives.

3) Calculation of lettuce production in open field

Table 9. ***Baselines***

Territory: Continental – Belgrade Region	Type of soil: good
Period: 1 production cycle from seedlings, 45 days (during 2015), lettuce Kristal	Production are: 5ar/0,05 ha
1,00 EUR = 120,00 RSD	Planting density: 35x25 cm

Source: *Group of authors (2015): Techno – economic aspects of use of renewable energy sources and mobile robotized solar electro-generators in agriculture, Study, IAE Belgrade, IMP Belgrade and PSSS Padinska Skela, Belgrade.*

Table 10. ***Contribution margin in lettuce production in open field***

Element	**Quantity**	**UM**	**Price per UM (in RSD)**	**Total RSD/5 ar**	**Total EUR/5ar**	**Total EUR/ha**
A: Incomes						
Lettuce	10.000,00	pcs	-	-	-	-
I class (90%)	9.000,00	pcs	22,00	198,000,00	1.650,00	-
II class (8%)	800,00	pcs	17,00	13.600,00	113,33	-
Spoilage (2%)	200,00	pcs	-	-	-	-
Subsidies	-	-	-	-	-	-
Total				**211.600,00**	**1.763,33**	**35.266,60**
B: Variable costs						
Seedlings	10.000,00	pcs	7,50	75.000,00	625,00	12.500,00
Fertilizers	-	-	-	4.491,00	37,42	748,40
Pesticides	-	-	-	4.493,60	37,45	749,00
Fertilizers dispersal (man)	2,00	hour	200,00	400,00	3,33	66,60
Mulch foil (stripes)	-	-	-	-	-	-
Packaging (carton box)	500,00	pcs	35,00	17.500,00	145,83	2.916,60
Irrigation equipment	-	-	-	-	-	-
Planting	70,00	hour	200,00	14.000,00	116,67	2.333,40
Pesticide treatment (man)	8,00	hour	200,00	1.600,00	13,33	266,60
Ploughing (25 cm)	5,00	ar	80,00	400,00	3,33	66,60
Tractor milling (15 cm)	5,00	ar	54,00	270,00	2,25	45,00
Soil milling by moto cultivator	1,00	hour	500,00	500,00	4,17	83,40
Harvesting and lettuce packaging	150,00	hour	200,00	30.000,00	250,00	5.000,00
Transportation	30,00	tour	150,00	4.500,00	37,50	750,00
Costs of water (irrigation)	-	-	-	-	-	-
Costs of fuel (gasoline) for irrigation	15,00	l	136,00	2.040,00	17,00	340,00
Other costs (fees, etc.)	-	-	-	350,00	2,92	58,40
Total				**155.544,60**	**1.296,20**	**25.924,00**
Contribution margin: C = (A-B)				**56.055,40**	**467,13**	**9.342,60**

Source: *Group of authors (2015): Techno – economic aspects of use of renewable energy sources and mobile robotized solar electro-generators in agriculture, Study, IAE Belgrade, IMP Belgrade and PSSS Padinska Skela, Belgrade.*

Note: Value of mechanized operation was determined according to prices given by guide of Cooperative Union of AP Vojvodina, 2013.

Table 11. ***Structure of variable costs in lettuce production in open field***

Element	Total RSD/ha	Total EUR/ha	Share in total variable costs (%)
Seedlings	1.500.000,00	12.500,00	48,22
Fertilizers	89.808,00	748,40	2,89
Pesticides	89.880,00	749,00	2,90
Carton boxes	349.992,00	2.916,60	11,25
Mechanized operations	113.400	945,00	3,64
Costs of energy (irrigation)	40.800,00	340,00	1,31
Engaged labour	919.992,00	7.666,60	29,57
Other costs	7.008,00	58,40	0,22
Variable costs (total)	**3.110.880,00**	**25.924,00**	**100,00**

Source: Group of authors (2015): Techno – economic aspects of use of renewable energy sources and mobile robotized solar electro-generators in agriculture, Study, IAE Belgrade, IMP Belgrade and PSSS Padinska Skela, Belgrade.

Table 12. ***Critical values of production***

Description	RSD (pcs)/ha	EUR (pcs)/ha
Expected yield (EY)	200.000,00	200.000,00
Expected price (EP)[1]	21,59	0,18
Subsidies (S)	-	-
Variable costs (VC)	3.110.880,00	25.924,00
Critical price: CP = (VC - S) / EY	**15,55**	**0,13**
Critical yield: CY = (VC - S) / EP	**144.088,93**	**144.088,93**
Critical variable costs: CVC = (EY x EP) + S	**4.318.000,00**	**36.000,00**

Note: [1] as lettuce is classed at the holding, expected price represents average price of sold head of lettuce.

Source: Group of authors (2015): Techno – economic aspects of use of renewable energy sources and mobile robotized solar electro-generators in agriculture, Study, IAE Belgrade, IMP Belgrade and PSSS Padinska Skela, Belgrade.

Achieved results in lettuce production in open field by use of irrigation (Table 10-12.), lead to next conclusions:

- In presented production line at observed holding, positive contribution margin was achieved (around 9.342,60 EUR/ha);
- Achieved incomes in lettuce production in open field are for 1,36 times higher than generated variable costs of production;
- Costs of energy (gasoline) required for the process of irrigation have a relatively small share (i.e., around 1,31%) within the structure of total variable costs;
- In the structure of variable costs dominate the costs of seedlings (with the share of 48,22%);
- Critical values of production (values when contribution margin equates to zero) have the following values:

- Critical price is 0,13 EUR/kg;
- Critical yield is 144.088,93 kg/ha;
- Critical variable costs are 36.000,00 EUR/ha.

According to presented contribution margin achieved in the production of lettuce in open field at the observed holding, it can be said with considerable degree of certainty that it leaves enough space for covering of fixed costs and profit gaining. Although within the structure of variable costs, the costs of irrigation (costs of spent gasoline) have a relatively small value, absolutely expressed (340,00 EUR/ha) point out to the issue of their possible reduction or substitution of used energy into the cheaper and environmentally more friendly solution (solar energy).

Conclusion

The results of field testing of mobile solar electric generator in vegetable production (cauliflower, tomatoes and lettuce) in open field and greenhouse, with usage of irrigation system on selected farms in the village Glogonj and Veliko Selo, are created by analytic calculations based on variable costs.

The analysis showed that all observed production lines achieved positive contribution margin, giving the conclusion that all farms over mastered technological process of vegetable production. In the structure of variable costs, by individual vegetable production lines, the costs of seedlings or labour costs are dominant. On the other hand, the irrigations costs (used petrol, diesel or electricity for activity of irrigation) were relatively low (varying in the range of 1,27% to 6,04%). However, the value of these costs expressed in absolute value per hectare of production area, was in range from 340,00 up to 554,00 EUR/ha. These results impose the need that some of holdings for certain vegetable production lines, have to find cheaper and from aspect of environment much cleaner energy alternatives. Application of solar energy, by using mobile solar electro-generators, is identified as ideal solutions for this issue.

Potential limit to the system is recognized in the fact that, despite the cheap energy, smart sensor networks and solar irrigation system, per one day it can be irrigated up to the half of hectare for three working hours. After that, system must be left to the charge, either by using of solar energy, or by connection to the public electrical network. Therefore, the daily capacity of the irrigation by tested device is maximum half of hectare.

On the other hand, next can be assumed: expected price of device in the base package of equipment could be range around 7.000,00 EUR; Ministry of Agriculture and Environmental Protection of the Republic of Serbia would be subsidized 40% of the device value (50% in marginal areas); Vegetable Association/family holding disposes with three hectares of production area under vegetables, whereby during one calendar year may be carried out two production cycles of certain vegetable crops (spring and summer planting); the average cost of energy used for irrigation of vegetable crops during one production cycle were around 459,90 EUR/ha.

According to presented, with a great degree of certainty can be expected that the period of return of assets invested in mentioned device, throughout the savings in costs of energy, will be under the three years of device exploitation.

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SESSION ONE

The Role of Technology in Sustainable Agriculture and Food Security

TECHNO-ECONOMIC FEASIBILITY USE OF PORTABLE SOLAR IRRIGATION SYSTEMS[1]

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Abstract

Stable production in the Republic of Serbia is limited by rainfall, which is on the one hand insufficient and on the other hand unevenly distributed throughout the growing season. Therefore, the introduction of irrigation in agricultural production is of great importance because it contributes to the increase in production volume, it improves the quality of crop yields and the economic effects of investments in production. Depending on climatic conditions and the conditions for production, up to 100% higher yields can be obtained by irrigation, while in very dry years up to two or three times higher.

Serbia is a member of the Energy community with international obligations regarding the use of renewable energy sources (pursuant to Directive 2009/28/EC on the promotion of the use of electricity from renewable sources). In accordance with that Directive and the Decision of the Council of Ministers of the Energy Community in 2012 (D/2012/04/ MS - ENZ) and National Renewable Energy Action Plan of the Republic of Serbia („Official Gazette of the Republic of Serbia“, No. 53/13) a very ambitious and binding target was set for Serbia of 27% gross final energy consumption from renewable sources by 2020. A number of national legislative and policy documents point out that increased use of renewable energy sources is a main need and aim in order to improve agriculture and economic development of Serbia.

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The implementation of solar panels that convert sunlight into electricity is recommended in order to use irrigation systems at affordable prices and save energy, that is, to start and operate the water pump at lower cost. This is particularly important for those areas that are suitable for agricultural production (which can not be intense in the true sense of the word without irrigation), where there is no electric grid, and there are water resources: wells, groundwater, streams, canals, rivers or lakes. Due to low operating costs during use, the solar pump units prove to be more cost-effective than the petrol engine only after the second year of use.

Keywords: *Renewable energy sources, portable solar irrigation systems, energetically, environmentally and economically sustainable agricultural production.*

Introduction

The limiting factor for the intensification of agricultural production is seasonal change in climate parameters, especially the schedule and amount of rainfall during the growing season. The only long-term way to combat drought is the introduction of irrigation in agricultural practices, as well as regular and mandatory measures. Occasional irrigation, limited to smaller areas in private hands, gave results in terms of high and uniform yields of quality fruit, which can easily be placed on the market. These positive individual experiences should be extended to the territory of entire Serbia, and thus improve the situation in agriculture, as well as the overall economic situation.

In order to use irrigation systems at affordable prices and save energy, that is, to start and operate water pumps at low cost, the authors recommend the use of solar panels, which convert sunlight into electricity. Accordingly, the paper discusses the use of renewable energy sources and mobile robotized solar power generators as new technologies in the implementation of irrigation in agricultural production in the Republic of Serbia through the techno-economic analysis of these devices, the capacity of devices and through the examples of their use in experimental fields in several localities where their efficiency and cost-effectiveness can be seen.

Starting and operating of irrigation systems based on the use of renewable energy sources is in line with international obligations regarding the use of renewable energy sources that Serbia, as a member of the Energy Community, took over („Official Gazette of the Republic of Serbia", No. 62/06). Namely, in accordance with EU Directive (2009/28/Ezo promotion of the use of electricity from renewable energy sources) and the Decision of the Council of Ministers of the Energy Community in 2012 (D /2012/04/MS

- ENZ), and National Renewable Energy Action Plan of the Republic of Serbia ("Official Gazette of the Republic of Serbia", No. 53/13), a very ambitious and binding target was set for Serbia of 27% gross final energy consumption from renewable sources by 2020.

The basic characteristics of irrigation measures applied in Serbian agriculture

Irrigation can be widely applied and used for different purposes. In addition to its basic use that involves adding water to the soil in order to compensate for the amount of water required for normal growth and development of agricultural crops in conditions of insufficient rainfall or their unfavourable schedule during the vegetation period, it is also used for fertigation, prevention of frost damage, phytosanitary protection, soil desalination etc. (N. Kljajić, 2012).

Worldwide, irrigation has experienced strong development over the last century and irrigated land has increased from 50 to 250 million hectares, so that irrigated land accounts for about 40% of the world's food. 60% of the world food production in the future is projected to be done with the use of irrigation systems (S. Petković, 2003).

Irrigated agricultural production allows a wider variety of crops during the growing season, especially early vegetables and two harvests during the growing season per unit area. By using irrigation it is possible to obtain higher yields, crop stubble and intercrop, it has an effect on the structure of agricultural production, deadlines and norms of sowing, soil tillage, plant nutrition and intensification of livestock production. In this way safe and stable agricultural production, which excludes large variation, is ensured (N. Kljajić et all, 2011).

The Republic of Serbia has favourable climate, land and water resources for intensive agricultural production. However, stable production is limited by rainfall, which is either insufficient, or unevenly distributed throughout the growing season. Therefore, the introduction of irrigation in agricultural production is of great importance, and depending on climate conditions and the conditions for production, up to 100% higher yields can be obtained by irrigation, while in very dry years up to two or three times higher.

According to (Kljajić, 2014; Cvijanović et al., 2012), irrigation in the Republic of Serbia is below the real needs and real possibilities and does not meet the needs of stable and efficient agricultural production. If the state of irrigation in our country is observed through the total number of irrigation systems, and the area on which they are built and used, the conclusion is that neither its extent, its technical equipment, nor the level of use of irrigation systems are satisfactory (Potkonjak, Mačkić, 2010).

According to *Census of Agriculture in the Republic of Serbia (2012)*, farms (legal entities, entrepreneurs, family farms) irrigated 2,9% of utilized agricultural land in the Republic of Serbia, and 3,6% in Vojvodina region (Table 1). The dominant irrigation method in the Republic of Serbia is surface method (60,6%), and in Vojvodina region surface irrigation (38,7%) and drip irrigation (36,2%) are approximately equally represented. The dominant source of water used for irrigation in the Republic of Serbia is groundwater found in household wells (51,6%), followed by surface water outside the households (31,0%), while in the region of Vojvodina these two sources of water are equally represented. In the Republic of Serbia and the region of Vojvodina fields and gardens are predominantly irrigated, approximately 85% in the Republic of Serbia and 91% in Vojvodina.

Table 1. ***Irrigated area in the Republic of Serbia, Vojvodina region i Srem, agricultural 2011/2012 year***

	Number of farms	Irrigated area, ha	Utilized agricultural land (KP), ha	Irrigation percentage compared to KPZ (%)
The Republic of Serbia	71.947	99.773	3.437.423	2,9
Vojvodina region	7.385	58.251	1.608.896	3,6

Source: *Census of Agriculture 2012, Agriculture in the Republic of Serbia, book 1, Statistical office of the Republic of Serbia, 2013.*

Irrigation in Serbia has the following characteristics (Kljajić, 2014; Cvijanović et al., 2012):
- mainly applied to small areas, and therefore has little impact on the volume of agricultural production;
- It is used very extensively, since it is mostly treated as a supplementary measure in the stabilization of agricultural production (in terms of neutralizing the negative effects of drought);
- the basic conditions for the use of irrigation in terms of land consolidation and land reallotment etc. are not fulfilled.

Restrictions for greater use of irrigation in the Republic of Serbia are the following:
- The lack of organized infrastructure to solve the problem of water intake and provide water for crop irrigation;
- Due to the very poor maintenance of irrigation systems built in the past, a number of irrigation systems are neglected. Specifically, the liquidation (bankruptcy) of many agricultural conglomerates and agricultural enterprises

led to the destruction of their irrigation systems. Another problem is the failure of the privatization process in the agricultural sector, disordered and unresolved property relations and the like;

- The existing canal network (network of amelioration channels) cannot be used for both irrigation and drainage[5];
- Agricultural holdings lack funds for the purchase of proper equipment and irrigation devices.

In addition to addressing all of the above irrigation restrictions in Serbia, it is important to introduce the concept of „water users association" (abbreviated WUA) in the future construction of regional water supply systems and irrigation systems, considering the fact that it is precisely this association that should play a key role (responsibility, competence, ownership) in the maintenance and use of water supply system and irrigation. These associations work on a non-commercial and non-profitable basis and efficiently perform their tasks, such as irrigation system maintenance, drainage system management, maintenance of flood protection system, waste water disposal and treatment, supplying the population with water and the like. A large number of countries around the world are currently transmitting water management tasks from state agencies to participatory, independent, financially self-sustaining water users associations (Zorica Srđević, Bojan Srđević, 2008, p. 69). The trend is especially prevalent in the irrigation sector, where the responsibility for the effective operation and maintenance of the system transfers (delegates) to the association of farmers, as well as water users (Ibidem, p. 69). This approach is especially prevalent in the countries of Eastern Europe and Central Asia, where such associations previously responsible for irrigation and drainage system management, are now disbanded agricultural cooperatives.

Currently in Serbia there is no organized problem solving of some important issues that are a prerequisite for the formation of WUA, in terms of how it's done in a number of countries in the world (setting the institutional and legal framework of WUA; addressing issues related to measuring the amount of water consumed, if farmers will pay based on the amount of water used,

[5]The former dual use of parts of canal network Hydrosystem DTD for both irrigation and drainage, as well as some other channels outside the basic system, showed that there is an evident potential of this concept of water management related to the growth in agricultural production (Zorica Srđević, Bojan Srđević, 2008, p.70). Summary data for Vojvodina showed that according to the situation as of May 2003, about 83,000 ha of land can be irrigated from the drainage canals, with an investment of only 1,000 dinars / ha (Ibidem, p. 72). Dual systems require that the existing drainage canal network become fully functional (cleaning, reconstruction of existing channels, construction of canals and other activities in order to make the existing canal network effective).

defining the tariffs and subsidies; determining the ability and willingness of farmers to pay tariffs, etc.).

In order to use irrigation systems at affordable prices and save energy, and in order to respect the principles of sustainable development and energy efficiency in the future, great attention should be devoted to ***exploitation of solar panels and other renewable energy sources in the development of irrigation systems***. This is particularly important for those areas that are suitable for intensive agricultural production, in rural areas where there is no electrical grid, and there are water sources in the environment and favourable conditions for the development of agriculture, rural development, diversification of economic activities of farms and the like.Therefore, the rest of this paper deals with the use of renewable energy sources and mobile robotized solar power generators as new technologies in the implementation of irrigation in agricultural production in Serbia.

Legal and strategic framework for the use of renewable energy sources in Serbia and EU

By adopting the „Law on ratification of the Treaty establishing Energy Community between the European Community and the Republic of Albania, Republic of Bulgaria, Bosnia and Herzegovina, Republic of Croatia, Former Yugoslav Republic of Macedonia, Republic of Montenegro, Romania, the Republic of Serbia and the United Nation Interim Administration Mission on Kosovo" („Official Gazette of the Republic of Serbia", No. 62/06), Serbia became a member of the Energy community and accepted international commitment regarding the use of renewable energy sources (according to Directive 2009/28 / EC on the promotion of the use of electricity from renewable sources).

In accordance with the Directive 2009/28 / EC and the Decision of the Council of Ministers of the Energy Community in 2012 (D / 2012/04 / MS - ENZ), National Renewable Energy Action Plan of the Republic of Serbia for the period 2013-2015 („Official Gazette of the Republic of Serbia", No. 53/13), a very ambitious binding target was set for Serbia, amounting to 27% of renewable energy sources in its gross final energy consumption in 2020.

National Renewable Energy Action Plan of the Republic of Serbia („Official Gazette of the Republic of Serbia", No. 53/13), among other things, points out to the most important existing legislation relating to renewable energy sources, as well as the regulations that need to be adopted in the coming period, in accordance with Directive 2009/28 / EC. Important national legislation, which regulates and promotes the increased use of renewable energy sources and energy efficiency, is the following (listed chronologically):

- ***Law on Integrated Environmental Pollution Prevention and Control*** (Official Gazette of the Republic of Serbia No. 135/04);
- ***Law on Strategic Environmental Impact Assessment*** (Official Gazette of the Republic of Serbia, No. 135/04 and 88/10);
- ***Energy Strategy of the Republic of Serbia by 2015*** (Official Gazette of the Republic of Serbia number 44/05);
- ***Law on ratification of the Treaty establishing Energy Community between the European Community and the Republic of Albania, Republic of Bulgaria, Bosnia and Herzegovina, Republic of Croatian, Former Yugoslav Republic of Macedonia, Republic of Montenegro, Romania, Republic of Serbia and the UN Interim Administration Mission on Kosovo*** („The Official Gazette Republic of Serbia“, No. 62/06);
- ***Law on Ratification of the Kyoto Protocol*** („Official Gazette of the Republic of Serbia“ No. 88/07 and No. 38/09). The Kyoto Protocol, among other things, sets binding targets for the reduction of greenhouse gas emissions;
- ***National Sustainable Development Strategy*** („Official Gazette of the Republic of Serbia“, No. 57/08);
- ***Introduction of Cleaner Production Strategy in the Republic of Serbia*** („Official Gazette of the Republic of Serbia“ No. 17/2009), which defines "clean production" as a comprehensive preventive environmental strategy applied in production process, products and services, in order to increase overall efficiency and reduce risks to human health and the environment;
- ***Law on Nature Protection*** („Official Gazette of the Republic of Serbia“, No. 36/09 and No. 88/10), which regulates the protection and conservation of nature, biological, geological and landscape diversity;
- ***National Strategy on the Inclusion of Republic of Serbia into Clean Development Mechanism of the Kyoto Protocol for the Waste Management Sectors, Agriculture and Forestry*** („Official Gazette of the Republic of Serbia“, No. 8/2010);
- ***National Programme of Environmental Protection*** („Official Gazette of the Republic of Serbia“, No. 12/2010);
- ***Strategy on Science and Technological Development of the Republic of Serbia in period 2010-2015: focus and partnership*** („Official Gazette of the Republic of Serbia“ No. 13/2010). The Strategy points out that, among other things, the development of new technologies using

renewable energy sources and clean technologies with zero emission is one of the priority research topics in energetics and energy efficiency;

- ***The Energy Law*** („Official Gazette of the Republic of Serbia", No. 57/11, 80/11-correction, 93/12 and 124/12), which defines the objectives of energy policy; targets for use of renewable energy sources; manner, conditions and incentives for energy production from renewable sources and the like.
- ***National Strategy for Sustainable Development and Action Plan for period 2011- 2017*** („Official Gazette of the Republic of Serbia" No. 62/2011);
- ***Law on Public-Private Partnership and Concessions*** („Official Gazette of the Republic of Serbia", No. 88/11);
- ***National Strategy for Sustainable Use of Natural Resources and Goods*** („Official Gazette of the Republic of Serbia", No. 33/12), which among other things aims at "providing the conditions for sustainable use of natural resources and goods; reducing negative impacts of resource use on the economy and the environment; directing development towards sustainable production and the like."
- ***Law on Efficient Use of Energy*** („Official Gazette of the Republic of Serbia", No. 25/2013);
- ***Draft Energy Development Strategy of the Republic of Serbia until 2025 with indications until 2030.*** According to this document, the strategic development of energetics is based on establishing a balance between the production of energy from available sources, consumption of energy socially sustainable within the market and more efficient production and use of „cleaner" energy from renewable sources. In order to improve the energy system, among other things, 27% share of renewable energy sources in gross final energy consumption is planned. In order to preserve the environment, global energy tendency is to increasingly rely on renewable sources and less on exhaustible resources (principle of „cleaner" and more fuel-efficient energy production).

The use of renewable energy sources in irrigation and agricultural production in Serbia is in accordance with appropriate national legislation in the field of ***promotion and support of greater use of renewable energy sources in the agriculture sector.*** Important national documents in this field are the following:

- ***Law on Incentives in Agriculture and Rural Development*** („Official Gazette of the Republic of Serbia", No. 10/13). Support to investments in renewable energy sources is among the incentives and measures to enhance rural development, and programs for sustainable rural development which are implemented in order to improve and protect the environment.

- ***Strategy of Agriculture and Rural Development of the Republic of Serbia for period 2014-2024.*** („Official Gazette of the Republic of Serbia“, No. 85/2014). The strategy envisages that in 2024 Serbian agriculture becomes a sector the development of which is based on knowledge, modern technologies and standards, as well as that natural resources, environment and cultural heritage of rural areas are managed in accordance with the principles of sustainable development.

-***The Republic of Serbia IPARD Program for 2014-2020*** („Official Gazette of the Republic of Serbia“ No. 30/2016). Investments in renewable energy production will be supported through the following IPARD measures: (1) Investments in physical assets of agricultural holdings (quantified targets: the number of farms that implement modernization projects; the number of farms that invest in renewable energy production); (2) Investments in physical assets in processing and marketing of agricultural and fishery products (quantified targets: the number of companies that implement modernization projects; the number of companies that invest in renewable energy production); (3) Diversification of farms and business development (quantified target: the number of users who invest in renewable energy). In addition, investments in facilities for energy production from renewable sources will be supported only for personal energy consumption (the sale of electricity to the network is allowed within the limits of personal consumption). Bearing in mind the potential beneficiaries of IPARD II Fund of EU and the principle of co-financing measures (projects), it can be expected that it is precisely the interest to use these funds in the future that will encourage the consolidation and association of domestic producers in the agri-food sector through cooperative organizations. Implementation of IPARD II program will start after the completion of the accreditation process of IPARD II operational structure.

The concept of renewable energy sources and "green economy" (in sectors such as agriculture, fishery, forestry, construction, energy supply, industry, tourism, transport, waste and water management) is integrated in the legislative and strategic framework of the EU, where significant documents are the following:

- ***Directive 2009/28 / EC*** of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and repealing Directives 2001/77/EC and 2003/30/EC. In accordance with Directive 2009/28/EC binding targets are set for Member States of at least 20% share of renewable energy sources in gross final energy consumption by 2020 at the EU level. As part of the fulfillment of the defined share of renewable energy sources in gross final energy consumption, each Member State is required to ensure that the share of energy from renewable energy sources in all forms of transport in 2020 is at least 10% of the gross final energy consumption. Also, the improvement of energy efficiency is a key objective of the European Community, and the aim is to achieve 20% improvement in energy efficiency by 2020 (Directive 2009/28/EC, page 17).

- ***EUROPE 2020: A strategy for smart, sustainable and inclusive growth***, COM (2010) 2020 final, EC. The strategy, among other things, emphasizes smart and sustainable growth (developing economy based on knowledge and innovation and promoting a more resource efficient, greener and more competitive economy), as well as the principle of „Resource efficient Europe". This principle involves the separation of economic growth from resource use, supporting the transition to low-carbon dioxide emissions, increasing the use of renewable energy sources, promoting energy efficiency and the like.

- ***EC Press Release, A resource-efficient Europe - Flagship initiative under the Europe 2020 Strategy*** (COM (2011) 21);

- ***The Roadmap to a Resource Efficient Europe*** COM (2011) 571, outlines how economies can be transformed into sustainable ones by 2050. It proposes ways to increase resource productivity and decouple economic growth from resource use and its environmental impact.

- ***EU biodiversity strategy to 2020*** (Our life insurance, our natural capital: an EU biodiversity strategy to 2020, the EC, Brussels, 3.5.2011, COM (2011) 244 final).

As for the use of renewable energy sources in agricultural production in the EU, it is important to note that the support of „green economy" in the ***Common Agricultural Policy*** (CAP) implies the targeted assistance to rural development measures which promote environmentally sustainable agricultural practices, such as agro-environmental schemes, and improve compliance with environmental protection laws. Reformed Common Agricultural Policy for the period 2014-2020 for 28 EU member states[6], among other things, focuses on improving the competitiveness of agriculture by promoting innovation; environmental protection; sustainable management of natural resources; climate changes. The achievement of the objectives of

[6]The legal framework consists of four regulations that cover the sectors of rural development; horizontal issues, such as financing and control; direct payments to farmers and market measures (EU Regulation No.1305 / 13, 1306/13, 1307/1, 1308/13).

rural development is realized through six priorities of the Union, and support to renewable energy use is available through the fourth and fifth priority of the EU Rural Development (EU Regulation No.1305 / 13), which are „Restoring, preserving and enhancing ecosystems dependent on agriculture and forestry „(fourth priority) and“ Promotion of resource efficiency“(fifth priority).

Techno-economic analysis of mobile robotized solar power generators

Techno-economic feasibility and sustainability study of renewable energy in agriculture, with special emphasis on the use of portable (mobile) solar systems for energy production, is related to the exploitation of solar energy in the irrigation of agricultural crops in order to improve agricultural productivity and competitiveness, in both domestic and foreign markets (A. Rodić et all, 2016).

Water pumping for irrigation purposes on family farms in our country is mainly done by engine pumps and petrol or diesel driven generators. Very popular and widely used devices are DMB and Tomos diesel engine pumps. Also, Honda and Villager petrol engine pumps of different forces, mostly from 5-7 kW (3.7 to 5.5 KW), are quite often used.

Of all renewable energy sources, *stationary solar photovoltaic systems* are mainly used for agricultural purposes.They are placed in sunny locations and next to the agricultural area (gardens, fields, greenhouses, etc.). Windmills are used for irrigation to a lesser extent, and mostly in Banat and areas where there is constant air flow during the year.

Regarding the fact that in the Republic of Serbia family farms (they are in majority) possess arable land sometimes many kilometers away one from the other, stationary solar systems are not cost-effective solutions for this category of agriculture producers. For this reason, farmers prefer to opt for the purchase of motor units for irrigation compared to solar irrigation systems.

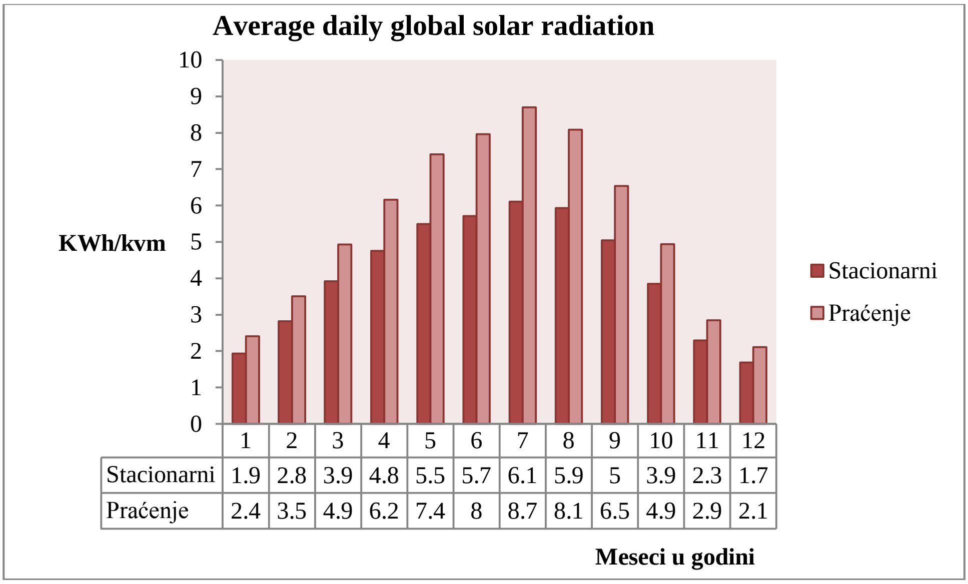
The solution to the above-mentioned problem are the so-called portable, mobile (cell) solar systems for energy production, which can relatively easily and quickly be transferred from place to place with no special ground preparations. Solar photovoltaic devices are made in two variants:

- with a constant angle of inclination;
- with a system for tracking the sun on the horizon.

Its main characteristics that distinguish it from conventional irrigation systems are as follows: It is movable and portable, so it is suitable for use on any ground; It does not require special infrastructure nor ground preparation for the installation; It works independently and isn't connected to the electrical grid; The operating time is several hours with simoultaneous recharging using solar energy; Easy to use and requires no special training or education; Silent in operation, and harmless to the environment; Highly automated with the possibility of remote control; Easy and inexpensive to maintain; The working life of the device is over 20 years; Battery operating life of 1000-5000 charge/discharge cycles can be achieved and depending on the discharge rate the battery is at 20-60% state-of-charge (A. Rodic et all, 2014).

This system is not intended for typhoon irrigation, since it hasn't got sufficient power. It is designed for small and medium-sized family farms, which have up to several hectares of arable land, in one piece or scattered. It has a higher degree of solar energy utilization but it is even up to 30% more expensive to implement. is given in graph 1.

Graph 1. ***Comparative graphical overview of the energy efficiency of these two types of solar power generating systems***



Source: *Study: ,, Techno-economic aspects of renewable energy and mobile robotized solar power generators use in agriculture. " Project of the Ministry of Agriculture and Environmental Protection of the Republic of Serbia, 2016.*

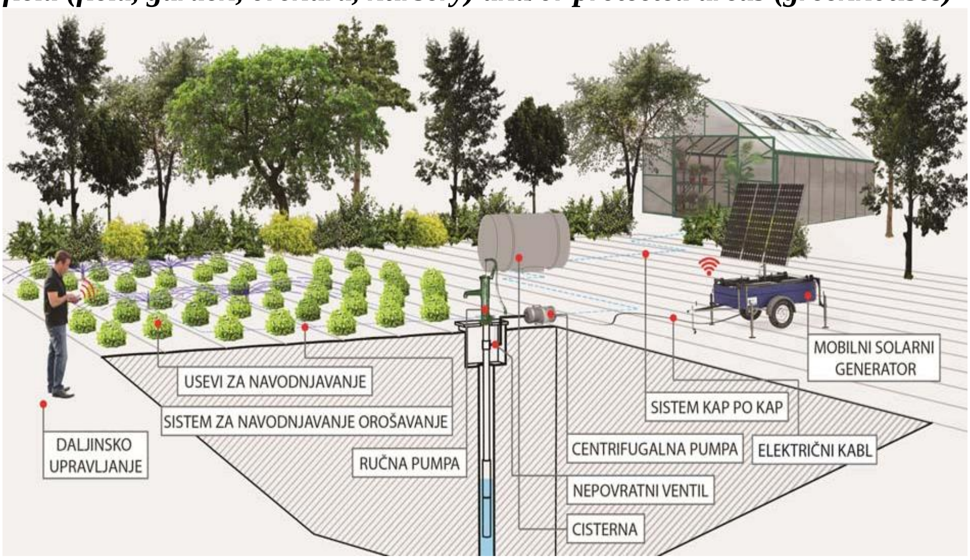
Comparative advantages of using stationary devices with fixed inclination of the panel (blue bars) and mobile solar systems with a solar tracking device (red bars) during the season. The optimum position of the stationary solar system is defined by azimuth angle of $\alpha = 1°$ facing south and elevation angle of $\beta = 34°$

Graph 1 presents average monthly and daily global solar radiation in kilowatt-hours per unit area of a photovoltaic panel. It is observed that in the summer months of June, July and August, when irrigation of agricultural land is needed mostly, the level of solar radiation per square metre is the largest. In our region, we get the greatest amount of energy from the sun in July and it is 4 times higher than in December or January. This can be beneficial for irrigation of arable and fruit crops, in a way that photovoltaic systems use solar energy to produce electric power (electricity) required to run the water pumps (single-phase or three-phase).

If we analyze the amount of energy that is obtained by using stationary (with fixed inclination of the panel) and mobile (with a solar tracking device) solar systems, it is evident that mobile devices have the advantage. They are on average 33% more efficient than the corresponding (the same panel sizes) stationary systems. The difference in energy efficiency is greatest in July and amounts to 42% in favour of mobile devices. The smallest difference in the efficiency is in the winter, when the difference between stationary and mobile solar systems is reduced to 25%.

The principle of using solar power generator for irrigation is shown in Figure 1. In order to irrigate in this way it is necessary to have a water source for irrigation (artesian well, classical water well, canal, pond, river, lake); pump facility, 1-4 KW; pipeline and appropriate irrigation system - sprinklers (ie. guns), drip irrigation system, water cannons for irrigation, etc.

Figure 1. ***Scheme of solar power generators used for irrigation in the open field (field, garden, orchard, nursery) and/or protected areas (greenhouses)***



Source: *Study: „ Techno-economic aspects of renewable energy and mobile robotized solar power generators use in agriculture. " Project of the Ministry of Agriculture and Environmental Protection of the Republic of Serbia, 2016.*

The main goal of mobile robotized solar power generator study is to determine its technical features and the appropriate economic indicators of the profitability of its application.

In order to analyse techno-economic aspects of mobile solar power generators use in irrigation of crops the test setting was used at 4 different locations, namely:
- In the village of Glogonj-at three locations (Municipality of Pancevo - Pancevo), and
- In the village of Veliko Selo-at one location (municipality of Palilula - Belgrade).

In Glogonj the device has been tested for irrigation in the open field using the sprinkler system (cabbage and cauliflower gardens: location-1 and location-3) and greenhouse drip system (greenhouse tomato production: location-2).

At locations 1 and 3 (open field), the following pumps were used:
- Single-phase vacuum pump 2.200 W;
- Villager petrol engine pump WP 35, 3.700 W;
- SLAP800 diesel engine pump, 7.300W.

At location - 2 (protected area - a greenhouse), a weaker, 1.500 W garden pump was used.

In the village of Veliko Selo the device has been tested for irrigation in the open field using the sprinkler system and 12 mm water cannon (lettuce and leek garden: location-4) and greenhouse sprinkler system (greenhouse lettuce production: location-4).

At location 4 a single-phase vacuum pump of 2.200 W was used.

The research studies have attempted to provide answers to the following questions:

- What is the power consumption of this device?
- How effective is this device in exploitation?
- How many hours of continuous operation can it accomplish?
- How many acres can be irrigated over the course of one day?
- What amount of water can be pumped daily?
- What is the capacity of the unit on a daily, weekly, monthly, seasonal or annual basis?
- What is the lifetime of the device, with different dynamics of use? - What is the term of return on investments through energy savings?
- What are the potential advantages of this device, compared to using conventional petrol or diesel engine pumps?

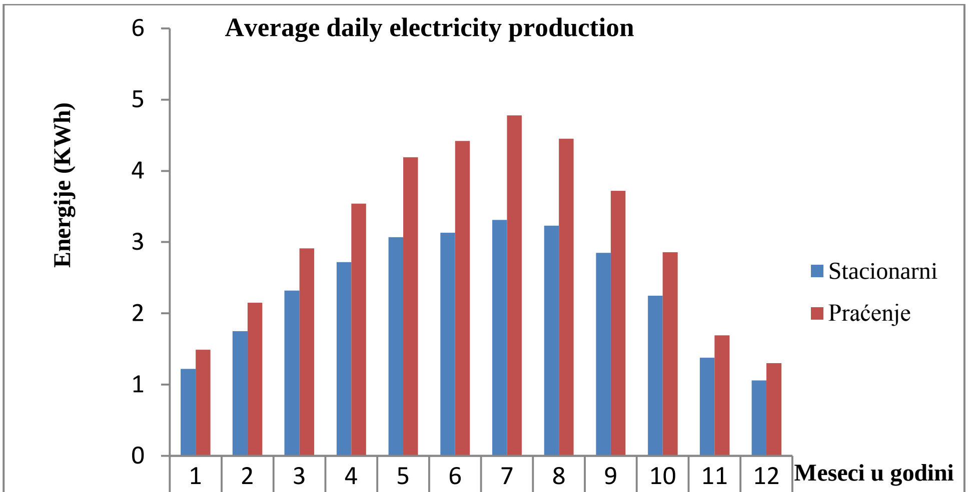
- Answers to the questions above were obtained by putting into operation the system in real conditions of exploitation and the corresponding measurements on the device.

Capacity of the device

The capacity of the mobile solar generator is determined by the battery storage capacity and the amount of daily sunlight. Battery capacity is 480 Ampere-hours and 24 volts. Available energy stored in a battery is calculated by multiplying these two data. Energy derived from photovoltaic panels is added to this stored energy. The amount of solar energy changes throughout the year.

Graph 2 shows the average daily energy production depending on the season. It is the highest in July and the lowest in December. Mobile robotized solar power generator, the tested device, possesses the solar tracking system (STS). It provides maximum utilization of solar energy (red bars on the graph). If the STS deactivated and panels were set up in a fixed position the effects of stored energy would be lower (blue bars).

Graph 2. ***The average daily electricity production depending on the season***



	1	2	3	4	5	6	7	8	9	10	11	12
Stacionarni	1.22	1.75	2.32	2.72	3.07	3.13	3.31	3.23	2.85	2.25	1.38	1.06
Praćenje	1.49	2.15	2.91	3.54	4.19	4.42	4.78	4.45	3.72	2.86	1.69	1.3

Source: *Study: „Techno-economic aspects of renewable energy and mobile robotized solar power generators use in agriculture". Project of the Ministry of Agriculture and Environmental Protection of the Republic of Serbia, 2016.*

Electricity generated by photovoltaic panels, along with the energy from batteries can be used to start water pumps of various power.

From experience, batteries should not be discharged to more than 60% state-of-charge, because their lifespan can be shortened due to intensive charging and discharging.

The number of charge and discharge cycles (CD) in the lifespan of a battery is changeable. At 100% depth of discharge, the lifespan is 400 CD cycles, at 60% depth of discharge its lifespan is 1.000 CD cycles, and at 20% depth of discharge its lifespan is 3.600 cycles.

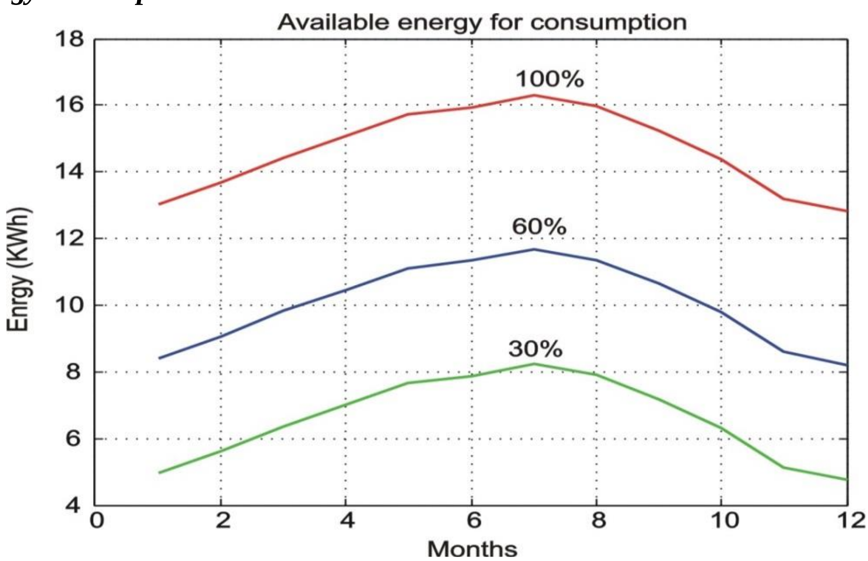
The device will not be damaged if it is completely discharged but the depth of discharge should be taken care of in order to prolong the battery lifespan.

The time needed to fully recharge the system (100%) by using solar energy is about 18 hours of charging, which is achieved in less than two days. At 60% depth of discharge one day is needed in order to fully recharge the system.

The system has an intelligent energy management system which optimizes the work and its use. This is automatic operation mode.

Graph 3 shows the estimated amount of energy that can be used. For example, in July, when solar radiation is the strongest, the device has a supply of 15 kilowatt hours of energy.

Graph 3. ***Available energy supplied by the device at different intensities of battery energy consumption***



Source: *Study: „Techno-economic aspects of renewable energy and mobile robotized solar power generators use in agriculture". Project of the Ministry of Agriculture and Environmental Protection of the Republic of Serbia, 2016.*

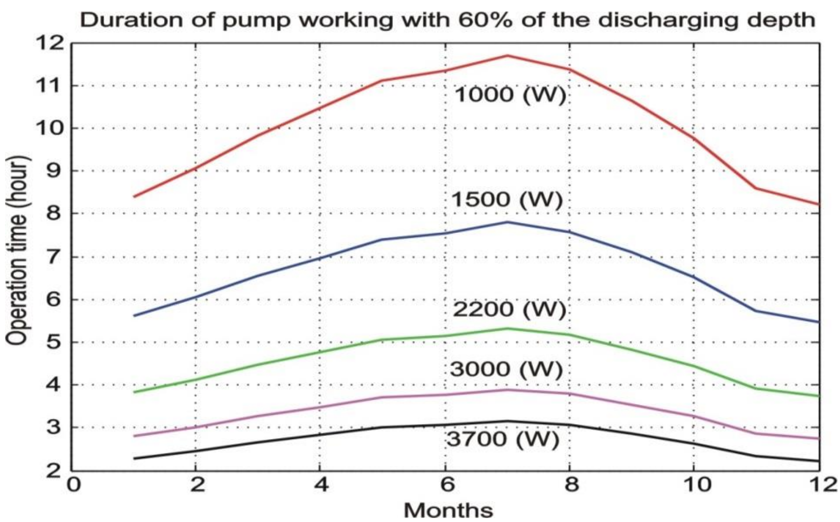
If the intention is not to discharge the batteries beyond 60%, then you can use a little less than 12 kilowatt hours. At moderate consumption of 30% of the battery about 8 kilowatt hours can be used.

The available energy, provided by the mobile solar power generator, can effectively be used to start the water pumps.

If the recommendation not to discharge the battery beyond 60% is adopted, then we can calculate the number of hours of continuous operation.

So, for example, if you use a weaker garden pump, eg. 1.500 watt pump, it can continuously operate for 11,5 hours. Single-phase 2.200 watt pump, that was used in the experiments, can continuously operate for 5,5 hours (*Graph 4*).

Graph 4. Estimated time of continuous operation of the pump at maximum power and at 60% depth of discharge of the battery



Source: Study: „ Techno-economic aspects of renewable energy and mobile robotized solar power generators use in agriculture. " Project of the Ministry of Agriculture and Environmental Protection of the Republic of Serbia, 2016.

If we know the height of the suction pump (in Glogonj, it is already at 2-3 metres), the elevation difference the pump has to overcome and the flow through the pump, then we can relatively reliably calculate the amount of water to be brought to a certain agricultural land for irrigation. Approximately 30 litres per square metre is abundant watering, while 10 litres is enough to refresh the crops.

Conclusion

Technical characteristics and capacity of the mobile robotized solar power generator are determined by testing its operation in irrigation of different vegetable crops and in the application of different methods of irrigation: sprinkler irrigation, drip irrigation and 12 mm water cannon irrigation.

Bearing in mind the established capacity of mobile solar power generator, the ideal solution to solar powered irrigation would include the following:

- The capacity of the solar generator is quite sufficient to meet normal customer requirements and remove from use the „dirty“ conventional gasoline and diesel generators for irrigation;
- Single-stage or multistage centrifugal pumps, single-phase or three-phase pumps from 3.000 to 4.000 W with appropriate frequency converter that regulates the impeller speed, and thus the flow and pressure at the outlet, are the most optimal to use. The pump that was used to test the device is slightly weaker than the real user needs demand. However, solar power generator enables 2 weaker pumps to be connected in a line (when the pressure doubles) or in parallel (when the flow doubles). Mobile solar generator allows different connection of the existing power inverters (3 appropriate with 1.600 W), which enables the user to optionally use either single-phase or three-phase pump, depending on their own needs. Three-phase pumps have larger motor power from 3 to 4 KW, while the single-phase pumps have up to 3.000 W;
- Mobile solar generator, being portable, enables farmers to irrigate their crops in several remote locations in the course of one day relatively easily.

In the context of the above, we start from the results shown in the picture above. If we accept, for example, that a single stage centrifugal pump, type PEDROLLO FG2 32/200 AH (or optional F 32/200 AH) http://www.pumpe.rs/katalog2011/katalog_pedrollo_FG_pumpi.pdf, in terms of power and other parameters (p = 4 KW, Q = 100-320 lit / min, p = 4,4 to 5,5 bar), optimally matches the capacity of mobile robotized solar power generator, then the following table should be used for assessing the economic effects of this irrigation system.

Table 2. ***Calculation of energy consumed from the solar generator using the recommended Pedroli water pumps for irrigation of usable agricultural area (intensive irrigation, moderate watering and refreshment of crops)***

Pump type	Hours of operation	Energy (KWh)	Flow (litres)	Extremely soaked-saturated area (ares)	Normally soaked area (ares)	„Refreshed“ area (ares)
FG2 32/200 AH	1	3,7	19.200	5.82	9,60	19,20
	2	7,4	38.400	11,64	19,20	38,40
	3	11,1	57.600	17,46	28,80	57,60

Source: *Study: „Techno-economic aspects of renewable energy and mobile robotized solar power generators use in agriculture“. Project of the Ministry of Agriculture and Environmental Protection of the Republic of Serbia, 2016.*

33 l/m^2 is spent for intensive watering, 20 l/m^2 for moderate watering and 10 l/m^2 for „refreshment of crops“.

The analysis of the results given in Table 2, shows that in moderate irrigation surface area of about 30 ares is irrigated in 3 hours of operation of mobile robotized solar generator. Thereby it consumes 11,1 kilowatt-hours of energy, which at the current electricity price of 9 dinars per kilowatt / hour means that 1 ha of agricultural land can be irrigated at the price of 350 dinars. 15-20 litres of diesel fuel are used to irrigate the same area of 1 ha, which costs about 2.500-3.000 dinars. If we leave out the initial investment for the purchase of solar generator and water pump (not small), irrigation using energy from the solar generator is almost ten times more cost-effective.

The disadvantage of this system relates to the fact that, despite cheap energy, solar irrigation system can daily irrigate up to 50 ares of surface area in 3 hours of operation. After that, the system must be left to „recharge“, either by using solar energy, or connecting to the electrical grid (in case of necessity). Thus, the maximum daily irrigation capacity of the tested device is up to half a hectare.

On the other hand, it can be assumed that: - the estimated cost of the device with the basic equipment is around € 7.000,00; - The Ministry of Agriculture and Environmental Protection would subsidize 40% of the purchase price of the device (50% in marginal farming areas); - association of vegetable growers/family household has 3 hectares of production area under vegetables (open field and greenhouse production), whereby two production cycles of a vegetable crop (spring and summer sowing/planting) may be carried out during one calendar year; - the average cost of energy consumed in the process of irrigation of the observed vegetable crops during one production cycle ranged from around 400 EUR (the village of Glogonj), up to about 950 EUR (Veliko Selo).

It can be expected with a high degree of certainty that the period of return on investment in these devices, through energy savings, would be less than 3 years.

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THE MODERN USE OF RENEWABLE ENERGY SOURCES

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Abstract

Last two years were extraordinary for renewable energy use in the world. Estimated 147 gigawatts (GW) of renewable power capacity was added in 2015,which was the largest annual increase ever, while heat capacity increased by around 38 gigawatts-thermal (GWth). Wind and solar photovoltaic (PV) recorded additions for the second consecutive year, accounting for about 77% of new installations. For the first time in history, total investment in the renewable power and fuels in developing countries in 2015 exceeded that in developed economies. At the same time, employment in the renewable energy sector increased to 8 million jobs. Solar PV and biofuels provided the largest numbers of renewable energy jobs. Considering all renewable energy technologies, the leading employers were China, Brazil, the United States and India. Renewables are now cost-competitive with fossil fuels in many countries and are established around the world as mainstream sources of energy. Cities, communities and companies are leading the rapidly expanding 100% renewable movement.

Key words*: renewable energy sources, use, investment, employment.*

Introduction

The worldwide need for renewable energy sources rose steadily during last years. Primarily, the application of clean renewable energy sources was encouraged for ecological reasons instead of harmful fossil fuels use. Thus the dependence on oil and gas imports was reduced, while employment increased. In developing countries this process was achieved with the help of international financial institutions that financed the use of renewable energy sources for electricity production. During 2014, worldwide net investments for the use of renewable energy sources were $ 242.5 billion, which was almost twice as much as net investment for those of fossil fuels.[2] However, the noticeable fossil fuels price drop caused by global economic and political crisis has significantly delayed the previous growth. At the same time, the

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[2] *Renewables 2015 – Global Status Report,* available at: www.ren21.net/content/upload/2015/07/ren12-gsr-2015_onlinebook_low1.pdf

"epidemic" of limited wars in North Africa and Near and Middle East was an aggravating factor. Ending the war in the Middle East and stabilizing the global energy market would result in petroleum products and natural gas reaching their real prices. This would certainly strongly encourage new acceleration of renewable sources use. Contrary to this, if the war flames expand to the territory of Turkey or Russia, the previous statement will be highly questionable.

The use of renewable energy sources in 2014

During 2014, global gross investments for the use of renewable energy sources reached $310 billion, which resulted in the newly built capacity for electricity production with the total power of 134.4 gigawatts (GW)[3], Table 1.

Table 1. ***Worldwide installed power capacity of renewable energy for grid connected generation and estimated annual generation in 2014.***

Energy Type	New installed capacity in 2014 (GW)	Cumulated installed capacity in 2014 (GW)	Estimated electricity generation in 2014 (TWh)
Hydropower	39.0	1,058.3	3,814/8
Wind power	50.2	368.5	705.7
Solar (PV)	39.4	168.1	223.5
Solar CSP	0.7	4.5	8.3
Biomass	4.4	93.0	263-651
Geothermal	0.6	12.6	73.7
World Total:	**134.4**	**1,705.0**	**5,089-5,477**

Source: Klainedam, P., Dorr, J. (2015) Renewable power generation 2015, Renewable Energy Focus, December 2015, p.160

Geographically speaking, the market has moved to fast-growing countries of Asia, Africa and South America. For this reason, the share of North America and Europe in the total number of world plants for the use of renewable energy sources has been reduced from 46% to 42%, whereas the share of Asia and South America has increased from 50% to 54%.

Concerning different types of energy sources, hydropower still remains the most applied type of renewable energy sources with almost three times the installed power of the second in line source - wind energy. However, this difference is slowly decreasing given that new installations for electricity production from wind of 50 GW have outgrown the rival hydropower plants

[3] Kleinedam, P., Dorr, J. (2015): *Renewable power generation 2015. The latest World-market status*, Renewable Energy Focus, Vol. 16, No. 5-6, December, 2015, p. 160

whose newly added power of 39 GW was the same as of solar power plants. Of course, it is not about the typical market competition. On the contrary, these three types of power plants (hydropower, wind power and solar power plants) in fact ideally fit seasonally and their parallel use is desirable in every country.

However, unlike the previous three impermanent sources that are supplemented with other fuel, during 2014 biomass and geothermal energy as stable sources achieved a steady growth rate of 4,400 MW and 600 MW of new power capacity, respectively. Finally, the amount of electricity produced from all renewable sources together in 2014 was estimated to average 5.3 PWh, which is 22.5% of the total global electricity production![4]

Hydropower

As the global major renewable source, hydropower helps many countries (including Serbia) to achieve the goals of increased renewable sources use in domestic energy production. However, given that this requires considerable investments due to the aforementioned global financial crisis, many well-planned projects had to be postponed. As a result, newly installed hydroelectric power in 2014 of 39.0 GW was slightly lower than the one achieved in the previous year. Furthermore, it should be noted that three quarters of this value were achieved in one country - China (29.9 GW)! It is followed by India (16 GW) and Russia (6.4 GW).[5]

Table 2. ***Summary of the global hydropower market in 2014.***

World Region	**New installed capacity in 2014 (GW)**	**Cumulated installed capacity in 2014 (GW)**	**Estimated electricity generation in 2014 (TWh)**
Europe	1.0	186	576.8
North America	0.9	173.4	708.7
South America	1.4	147.9	675.8
Asia	35.5	509.6	1,694.1
Oceania	0.0	13.4	37.4
Africa	0.2	28.0	122.5
World Total:	**39.0**	**1,059.0**	**3,815**

Source: Vorobyev, P., Metzger, B. (2015) Hidropower maintaining itssupremacy in 2014, Renewable Energy Focus, Vol. 16, No. 5-6, December, 2015, p.136

Alongside the aforesaid three leading countries in 2014, new hydropower plants started operating in Canada (725 MW), Kampuchea (418 MW), Turkey

[4] Kleinedam, P., Dorr, J, *Ibidem,* p. 163

[5] All three countries, besides Brazil and South Africa, were members of the International Economic Organization BRIC.

(279 MW), Pakistan (226 MW) and in Colombia, Brazil, Uganda, Norway, Iceland, Switzerland and Slovenia. Apart from these already completed hydropower plants, a large number of new ones was being built in different places, for example, in Vietnam (1,200 MW), Laos (2,300 MW), Myanmar (2,000 MW), Pakistan (3,000 MW).[6] Serbia is not on this list although new hydropower plants are to be constructed on the Drina, the Lim, the Ibar as well as on some other domestic rivers.

When it comes to **reversible** hydropower plants, their total power at the end of 2014 was 132 GW, representing 12% of the total power of all hydropower plants on the planet. Asia has most of reversible hydropower plants - 55 GW, of which 26.5 GW is in Japan and 18.8 GW in China. Europe holds the second place with 51 GW (mostly in Germany, Austria and Switzerland). [7] Finally, when it comes to **small** hydropower plants China will be mentioned again, whose potential of 128 GW, together with India (15.5 GW) and Brazil (15.0 GW) puts the countries of BRICS in the first plan in the near time perspective.

Wind Energy

The use of wind energy in the world has increased unabated. At the end of 2014 the cumulative power of all wind power plants in the world was 368.5 GW with achieved annual growth rate of 16%. This was an improvement of 13% compared to the growth from the previous year. This recovery happened owing to a strong increase of 44% in **Asia**, primarily in China and India in whose territories more than half of the world wind power plants are established. Among other Asian countries, South Korea, Japan and Pakistan have a significant share. The fast growth of wind energy use is also present in **North and South America**. At the end of 2014 the USA quadrupled the power of newly installed wind power plants per year, while Brazil, Chile, Peru and Uruguay increased their wind power plants capacity for around 4 GW in total. Similarly, a noticeable development was achieved in South Africa and Australia with about half a gigawatt each. Europe as a whole was stagnating, except for Germany where 5 GW of new plants was installed during 2014, as well as Sweden and Great Britain where 1 GW was installed per country. Other countries recorded slow growth, while some, such as Italy and Spain were in a serious crisis.

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[6] As well as in Ethiopia, Cameroon, Rwanda, Brazil, Venezuela, Colombia, Mexico, Canada, Austria, Albania, Belarus.

[7] New reversible hydropower plants are now being built in China, Spain, Indonesia, India and South Africa.

Table 3. ***Summary of the global wind power market in 2014.***

World Region	New Installed capacity in 2014 (GW)	Cumulated Installed capacity in 2014. (GW)	Estimated electricity generation in 2014 (TWh)
Europe	11.9	133	260.3
North America	7.5	78.7	203
South America	3.3	7.8	17.7
Asia	26	142	206.5
Oceania	0.6	4.4	11.5
Africa	0.9	2.5	6.7
World Total:	**50.2**	**368.5**	**706**

Source: Kleinedam, P., Courtet, G., Dorr, J., (2015) Wind energy still going strong with two Asian leaders, Renewable Energy Focus, Vol. 16, No. 5-6, December, 2015, p.165

Analyzing foreign offers of wind energy devices, it can be concluded that major producers retained their place on the global market. Danish *Vestas* is leading, whose 6 GW of new windmills in 2014 was installed and connected to the electrical grids around the world. The aforementioned Danish company is followed by German *Siemens*, American *General Electric* and Chinese *Goldwind*, with 5 GW per company of newly installed wind turbines in the same year, respectively. When it comes to the largest projects for onshore wind energy use, the American wind farm Sierra Madre in Wyoming should be mentioned, whose first phase of 1.5 GW is now being installed. Australia is also worth mentioning with its Ceres project of 600 MW near the city of Adelaide, as well as Egypt with the project to install wind turbines of 350 MW on the coast of the Red Sea. Speaking of the projects for offshore wind energy use, although windmills of individual power of 3-4 MW dominate, recently it has been experimented with the platforms that have a turbine power of 5-8 MW.[8]

Photovoltaic Solar Cells

The reduction of feed-in tariffs in 2014 across developed markets has considerably decreased the use of solar cells, especially in Europe. At the end of 2014 newly installed plants for electricity production from solar cells in the world reached the power of 39 GW, which was only 8% more than in the previous year. It should also be emphasized that Asia took the lead with 58% of newly installed capacity. The second was the European market (19%), followed by North America (17%) and Oceania (2%).[9]

[8] The most famous are Danish Vestas (8 MW), Japanese Mitsubishi (7 MW), Korean Samsung (7 MW), Chinese MinYang (6.5 MW) and German Siemens (6 MW).

[9] Unlike these saturated markets, in 2014 Africa recorded 7 times increased use, while South America expanded its capacities 20-fold.

Table 4. ***Summary of the global Photovoltaic power market in 2014***

World Region	New installed capacity in 2014 (GW)	Cumulated installed capacity in 2014 (GW)	Estimated electricity generation in 2014 (TWh)
Europe	7.61	85.45	90.79
North America	6.78	19.42	34.52
South America	0.42	0.65	1.28
Asia	22.87	57.43	86.12
Oceania	0.90	4.10	8.73
Africa	0.81	1.08	2.04
World Total:	**39.38**	**168.15**	**223.49**

Source: Topmo, A., Klinge, T. (2015) Photovoltaic growth slow despite new opportunities in emerging markets, Renewable Energy Focus, Vol. 16, No. 5-6, December, 2015, p.168

In the territory of **Asia** during 2014, China and Japan were true leaders with 10.6 GW and 9.6 GW respectively, followed by South Korea (0.92 GW) and India (0.79 GW). Leading countries in Europe were Great Britain (2.44 GW), Germany (1.9 GW), France (0.98 GW), Romania (0.46 GW) and Italy (0.39 GW). In **North America** these were the USA (6.2 GW) and Canada (0.5 GW). As for **Oceania** and **Africa**, Australia (0.88 GW) and South Africa (0.77 GW) stood out.

Concerning the countries with developed application of solar cells, **Germany** considerably reduced its development, having the power of newly installed plants in 2014 compared to the previous year. The reason why is a significant reduction of incentive purchase tariffs.[10] Similarly, a decreased solar cells application in **Italy** was recorded.[11] Unlike Germany and Italy, in 2014 solar market in **France** recorded an increase of 45% compared to 2013. The reason for this lies in the fact that France began to apply tariff incentives later and has not yet reached market saturation point like its eastern neighbors. Contrary to this, **Romania** as the fourth largest solar cells market in Europe recorded a slight growth slowdown

[10] From 0,1158 €/kWh for power plants with power up to 1 MWp, i.e. 0,0947€/kWh for power plants with power up to MWp, to considerably lower 0,1095 €/kWh, i.e. 0,0872 €/kWh, respectively.

[11] In fact, during June 2014, Italian parliamentarians passed a law to reduce incentives for plants with nominal power over 200 KW by 8%, as well as to lower these tariffs from 17% to 25% due to the contract extension of four years. On the other hand, the elimination of further incentives for new plants was announced due to large budget deficit that exceeded 6.7 billion euros! Topmo, A., Klinge, T. (2015) *Photovoltaic growth slow despite new opportunities in emerging markets*, Renewable Energy Focus, Vol. 16, No. 5-6, December, 2015, p.169

also because of incentives reduction.[12] The most difficult situation was in **Greece** where 10-fold decrease was recorded - from high 1 GW in 2013, to only 13 MW in 2014! Like in the previous year, the leading national solar cells market was **China** with 10.6 GW of newly installed plants in 2014. Such a strong development was accomplished by the application of incentive purchase prices of one Chinese yuan (0.117 euros) per kilowatt-hour. Since the planned power of cumulative plants for 2015 of 35 GW was achieved much earlier, the Chinese plan to reach 100 GW of functional solar cells in their territory by 2020. However, despite this, due to the very rapid growth of consumption, solar electricity in China meets only 1% of domestic needs for electricity of the most populous and the fastest-growing economy in the world. Japan takes the second place regarding the power of newly installed solar cells in the Asian territory. After the disaster at Fukushima nuclear power plant and the introduction of very high incentive purchase prices, newly installed power of solar cells in the Japanese territory has been increasing impressively. At the end of 2014 Japanese cumulative capacities were 23 GW, of which 70% belonged to the commercial sector and 30% to the household sector. Concerning other Asian countries, South Korea has undergone rapid development, surpassing India. The Koreans achieved this by obliging electricity distribution companies to produce one part of electricity from renewable sources. Besides, the long-term national program "One Million Green Homes until 2020" is being realized in South Korea.[13]

Thanks to the application of incentive programs for independent electricity producers from renewable sources, in 2014 **South Africa** in its territory installed 775 MW of new solar cells plants, which was an increase ten times bigger compared to the previous year. Taking into account the possibility of using investment funds of BRICS Development Bank in the following years, the continuation of the initiated process of intense solarization is expected. On the other side of the Atlantic Ocean, Chile became the leading country of South America by installing new 359 MW in 2014. Although in Chile no special incentive tariffs were introduced, the amount of insolation of the northern, desert area of this coastal Pacific country encouraged investors to install relatively large

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[12] Namely, the Romanian system to incentivize the application of solar cells is based on the application of quotas and Green Certificates for every megawatt of electricity produced in the period of 15 years. During 2014, the number of Green Certificats issued in Romania was halved compared with the previous year.

[13] Within the program, ending with 2015, more than 100,000 standard solar cell roof systems were installed, of individual power of 3 KW.

photovoltaic power plants. As far as Serbia is concerned, there has been a rapid growth in the use of solar cells. Besides numerous systems of low power - up to 10 KW (cottages, boats, mobile phone chargers etc.), as well as several large systems of 500 KW or more (Kladovo, Merdare, Leskovac), the most common solar cells systems of medium power (from 20 to 50 KW) are being applied, mainly in the private sector.[14]

Three largest global projects for solar cells application were carried out in the USA. During 2015 *Topaz Solar Farm* power plants in California with power of 550 MWp and *Agua Caliente* power plant in Arizona with power of 290 MWp were finished. Both power plants have innovative cadmium telluride solar cells. The expected annual electricity generation from these two solar projects was 1,100 GWh and 620 GWh (gigawatt-hours), respectively. Unlike the previous two, the third project *Mount Signal Solar* in California with peak power of 266 MW was based on standard solar cells made from silicon crystals. Among the other major world projects, *Welspun Solar* in **India** with power of 151 MWp, *Amanecer Solar* in **Chile** with power of 100 MWp and *Jasper Solar* project in **South Africa** with power of 96 MWp will be mentioned. These projects are also based on the application of verified silicon crystals solar cells.

Since 2013, solar cells market prices have been at a standstill, production costs have decreased, while the efficiency of converting solar energy to electricity has increased. Even eight of ten major world producers are from China and Japan! It is similar to inverter market (direct current-DC to alternating current-AC inverter), where Chinese and Japanese companies also dominate. Only at CPV- concentrated photovoltaic market that is still not developed enough, German companies have a leading role.[15] According to the data from the renowned Fraunhofer Institute from Freiburg, the record efficiency of concentrated photovoltaic cells amounts to 36.7% for modules and 46% for individual cells![16]

Solar Thermal Power

Unlike thin and light solar cells, solar thermal power plants are quite bulky and their installation is limited to sparsely populated and very sunny places.

[14] Djukanovic, S., Djukic, P., (2014) *The Spreading of Solar Cells Application in Serbia,* Grand Renewable Energy 2014., Proceeedings, July 27-August 1, Tokyo, Japan. Theme: Policy & Integrated Concept, pp.74-78

[15] Pilot projects of the application of these expensive, but more efficient solar cells are currently being conducted in Portugal, Saudi Arabia, South Africa and the USA.

[16] Topmo, A., Klinge, T. (2015) *Photovoltaic growth slow despite new opportunities in emerging markets,* Renewable Energy Focus, Vol. 16, No. 5-6, December, 2015, p.169

In regard to successful 2013 when 1.2 GW of new solar thermal power plants were installed, during 2014 newly installed power was halved (0.7 GW), reaching cumulative power of only 4.5 GW. This obvious deceleration of solar thermal power plants development can be explained by reduced costs of competitive solar cells whose application, as it can be seen, recorded a very fast growth. The most important markets for solar thermal power plants in the world were **Morocco**, South Africa, India and the USA. The realization of *Noor Solar Complex* project of anticipated electrical power of 460 MW started in Morocco. In **South Africa** under the auspices of *REIPPPP – Renewable Energy Independent Power Producer Procurement Program*, 200 MW of solar thermal power plants are installed. In **India** (Rajasthan area) the experimental solar power plant based on linear Fresnel reflector with the power of 100 MW is being built. Finally, in the **USA** that is currently the leading country in this field of solar energetics, except for the largest solar thermal power plant *Ivanpah* (power of 392 MW), *Mojave* (280 MW) and *Genesis* (250 MW) are also put into operation. After all, the installation of the solar thermal power plant *Cerro Dominador Solar* in **Chile** with power of 110 MW is announced for the coming years. This is supposed to be the largest and the most modern power plant of the kind in South America with the anticipated utilization factor of 80% thanks to thermal storage that will enable seven-day storage of the collected sun heat. [17]

In the next table (*Table 5*), a great number of zeroes on the left of the decimal point can be noticed, which confirms the fact about the delayed global use of solar thermal power plants.

Table 5. ***Summary of the global solar thermal power market in 2014***

World Region	New installed capacity in 2014 (GW)	Cumulated installed capacity in 2014 (GW)	Estimated electricity generation in 2014 (TWh)
Europe	0.0	2.3	4.2
North America	0.6	1.8	3.6
South America	0.0	0.0	0.0
Asia	0.2	0.4	0.5
Oceania	0.0	0.0	0.0
Africa	0.0	0.1	0.1
World Total:	**0.8**	**4.5**	**8.3**

Source: Herrera, L., Klinge, T. (2015) *Uncertain future for Solar Thermal Power,* Renewable Energy Focus, Vol. 16, No. 5-6, December, 2015, p.172

[17] Herrera, L., Klinge, T. (2015) *Uncertain future for Solar Thermal Power,* Renewable Energy Focus, Vol. 16, No. 5-6, December, 2015, p.172

Speaking of the types of applied technologies in all existing capacities the share of low-cost **parabolic trough** solar thermal power plants (85%) still prevails, although a trend of increased share of **power tower** solar thermal power plants can be noticed, due to their potential for more efficient storage of the collected heat. One of the perspectives for the application of solar thermal power plants in northern countries with less sunlight is their hybridization (parallel use) with conventional thermal coal or biomass power plants. Serbia is one of these countries. The hybrid use of solar energy and biomass, the dependence of this country on former and present exclusive use of energy (poor domestic lignite) will be reduced in the long run.

Biomass Power

Living organic matter, known as biomass can be used to obtain solid, gaseous or liquid fuels. These different forms of secondary fuels can be further used for the production of electricity, heat or to fuel motor vehicles. At the end of 2014 the installed world capacity for electricity generation from biomass was estimated at between 75 GW and 93 GW. The countries that have stood out in the recent years in this field are China, Germany, Brazil and Japan. In **China**, newly installed plants of 1.5 GW at the end of 2014 resulted in the total power of 10 GW with the estimated electricity generation between 35 and 70 terawatt-hours (TWh). Similarly, in Japan in the same year new 0.9 GW of biomass power plants were added, reaching a cumulative power of 4.7 GW and the possibility of annual electricity generation between 16 and 33 TWh! Unlike China and Japan that in recent years have been developing rapidly, in **Europe** this process began much earlier, so in recent years it has been slower. Strictly speaking, during 2014 most of new biomass power plants was put into operation in **Great Britain** (0.5 GW) and Germany (0.4 GW), while the total European capacity amounted to 36.5 GW with annual electricity production between 128 and 256 terawatt-hours.

Table 6. ***Summary of global biomass to electricity market in 2014***

Form of biomass	**Cumulated installed capacity in 2014 (GW)**	**Growth rate 2014 to 2013 (%)**	**Estimated electricity generation in 2014 (TWh)**
Solid biomass	64	4.5	161-445
Biogas	16	7.5	56-112
Municipal solid waste	11	5.5	39-78
Liquid biofuels	2	0.0	7-14
Total biomass:	**93**	**5.0**	**263-651**

Source: Kaltschmitt, M., Janczik, S. (2015) *Biomass to power is on their rise globally,* Renewable Energy Focus, Vol. 16, No. 5-6, December, 2015, p. 176

From the technological point of view, regarding available types of biomass use, the use of **solid biomass** with the share of 70% prevails. Purposes of this application are different - heating, electricity generation or their cogeneration. Similarly, co-firing of biomass with coal in hybrid thermal power plants is being more and more applied in Great Britain, the Netherlands, Belgium, Finland and Poland.[18]

The global cumulative power of solid biomass power plants at the end of 2014 amounted to 64 GW[19]. Only in Europe the total power of solid biomass power plants in the same year was estimated to around 29 GW. European countries that in this regard made the furthest progress are Germany, Finland, Sweden, Austria and Poland. At the same time, on the other side of the Atlantic Ocean, in Brazil, for instance, during 2014 new biomass power plants with power of 1.7 GW were put into operation, which enabled electricity production between 6 and 11.9 TWh. Apart from electricity generation, these power plants also produce heat that is usually distributed in the form of district heating. The evaluation of the global amount of energy produced in this way is between 388 and 450 petajoules (PJ).

Unlike solid biomass that is usually used for combustion, in the process of anaerobic fermantation, i.e. fermantation without oxygen, biogas is obtained and it is used for electricity and heat production. At the end of 2014, global installed power of all biogas power plants was 16.1 GW with electricity generation between 56 and 112 TWh.

The growth rate of the expansion of these plants in the last years was about 7.5%, where Europe had the lead. The leading country was Germany, followed by Italy, Poland, France and the Czech Republic. Serbia, as a predominantly agricultural country, has a good opportunity to gain substantial economic and environmental benefits from the application of biogas energy in the following years.[20]

Since approximately a half of municipal solid waste contains organic material, it can also be used to obtain biogas. The combustion of inorganic material

[18] Speaking of the biomass gasification projects for electricity generation at the end of 2014 only three projects were being developed: *Gussing* and *Oberwart* in Austria, *Ulm* in Germany and *Gothenburg* in Sweden.

[19] With the efficiency of the used capacity of 40 to 80%, this installed power is sufficient for producing between 161 and 445 terawatt-hours of electricity.

[20] See: Tesic, M., Sakalas Z., Kis, F., (2012) *Biogas Plants and Regulation of Energy Production from Biogas in Southeastern Europe*, the first International Scientific Conference "Renewable and Available Energy Sources", Fruska Gora, Andrevlje, October 2012, Collected Works, pp. 200-205 (in Serbian)

(incineration) is usually controlled with the aim to obtain heat or electricity. According to estimation, in 2014 in this way in combustion plants with power of 11 GW, between 39 and 78 TWh of electricity was produced around the world, which was 5.5% more than in 2013.

Regarding the amount of energy produced from municipal solid waste, the leading country in the world is China. The USA, Japan, Germany, Italy, France and the Netherlands follow. Serbia is, unfortunately, still far away from the modern use of waste energy, although the progress made in the field of collecting and recycling certain types of useful waste provides hope that the useless residue will be used for energy purposes.

Liquid biofuels can be produced from plants that contain large amounts of starch or sugar (bioethanol), or oil (biodiesel). The main characteristic of liquid biofuels is that they are principally used in the field of transport, for starting internal combustion engines. It also means that liquid biofuels are negligibly used for obtaining electricity.

Although liquid biofuel power plants exist only in Italy, Germany, Brazil and Argentina, their share in the total electricity production is stagnating or even declining. Most of these plants work on the principle of cogeneration, so that waste heat could be adequately used.

Wood pellets are an example of the growing supply of biomass. Pellets have the advantage as compared to other lower density biomass feedstock, that they can easily be hauled for long distances. Over the last 10 years, from 2004, to 2014, global pellet production grew by 21% annually. In 2014, the main producing regions are Europe, with 16,2 million tones, and North America with 8 million tones. It can be expected that the global pellets production will surpass 50 million tones within the next 15 years.[21] All in all, cumulative production of biomass power plants of 263 to 651 terawatt-hours during 2014 contributed to global electricity production with 1.1% up to 2.8%. For the following years a rapid growth of the application of biogas energy obtained from organic waste is predicted. Thus both electricity and heat would be produced efficiently, with the simultaneous treatment of wastewater problems.

Geothermal Power

During 2014 more than 500 megawatts of new geothermal power plants was installed around the world - 340 MW in Kenya, 110 MW in Turkey, 60 MW in Indonesia and 50 MW in the Philippines.

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[21] World Bioenergy Association (2016) *The role of Bioenergy in European cities*, Stockholm, Sweden, p.8

Since the intensive use of geothermal energy is possible in the areas with increased volcanic activity, around 70% of global geothermal power plants is situated in the territory of five Pacific countries around the so-called Pacific Ring of Fire. These countries are the USA (3.5 GW), the Philippines (1.9 GW), Indonesia (1.3 GW), Mexico (1.0 GW) and New Zealand (1.3 GW). Italy (0.9 GW), Iceland (0.7 GW) and Japan (0.5 GW) follow.

Table 7. ***Summary of global geothermal power market in 2014.***

World Region	New installed capacity in 2014 (GW)	Cumulated installed capacity in 2014 (GW)	Estimated electricity generation in 2014 (TWh)
Europe	0.04	1.7	11.3
North America	0.004	5.1	26.4
South America	0.0	0.0	0.0
Asia	0.22	4.1	25.2
Oceania	0.0	1.1	7.4
Africa	0.34	0.6	2.9
World Total:	**0.61**	**12.6**	**74**

Source: Janczik, S., Kaltschmidt, M. (2015) *After a major drive, geothermal power is growing rapidly,* Renewable Enegy Focus, Vol. 16, No. 5-6, December, 2015, p.178

The table above shows that in Europe at the end of 2014 the installed power of the plants for electricity generation from geothermal energy was 1.7 GW. Along with abovementioned Italy and Iceland, there are also Germany (33 MW), Portugal (29 MW) and France (16 MW). Apart from them, another 13 European countries are developing projects for intensive use of geothermal energy. Serbia, unfortunately, is not one of them.

On the other side of the Atlantic Ocean, in addition to the USA and Mexico, Salvador (205 MW), Costa Rica (207 MW), Nicaragua (160 MW) and Guatemala (52 MW) are worth mentioning.

Unlike these Latin American countries, their "brethren" from continental South American countries have not yet built any geothermal power plant. The main reasons for this are high costs of drilling, political instability, as well as risks connected with the development of new form of energy.

Contrary to this, 630 geothermal projects are currently being developed in more than 80 countries. In Africa these countries are Kenya, Ethiopia, Rwanda, Uganda and Tanzania. In Asia, besides the Philippines, Indonesia and Japan, Turkey (0.4 GW) and Russia (82 MW) are interesting to mention.

The use of renewable energy sources in 2015

During 2015, the value of new investments for the use of renewable sources in the world reached $285.9 billion.[22] As a result, the power of the plants for electricity generation from renewable sources increased by 152 gigawatts, i.e. 8.3%. The capacities of wind turbines (63 GW, i.e. 17%) expanded fastest, encouraged by reducing the costs of onshore wind farms installation.

Next in line were the plants for solar energy use (47 GW, i.e. 21%) as a result of cost reduction of solar cells. Hydropower plants increased by 35 GW, whereas the biomass energy and the energy of the Earth's heat (geothermal) increased its capacities for electricity generation by 5% (5 GW and 1 GW, respectively).

Table 8. ***Summary of world renewable power market in 2015.***

World Region	New installed capacity in 2015 (GW)	Cumulated capacity in 2015 (GW)	Estimated electr. generation in 2015 (TWh)
Europe*	24	497	25
Euroasia**	4.0	89	4
North America	20	330	17
Central America	1.5	12	1
South America	9.1	180	9
Asia	88	797	40
Mead East	1.3	17	1
Australia and Oceania	1.4	26	1
Africa	2.2	37	2
World Total:	**152**	**1,985**	**100**

*European countries and Ukraine **Russia, Belarus, Caucasian and Turkey
Source: *Renewable capacity highlights, April, 6, 2016, available at www.irena.org*

In the table above it can be seen that over 80% of world plants for electro-energetic use of renewable sources is located in Asia, Europe and North America. More precisely, at the end of 2015 in Asia was 58% of all new world capacities, reaching cumulative electric power of almost 800 GW! In this way Asia recorded the most rapid growth of renewable sources use of 12.4%, while the main competitors, Europe and North America, were developing at a considerably slower rate, of 5.2% and 6.3%, respectively.

Accordingly, at the end of 2015 the total power of all world plants for electricity generation from renewable sources amounted to 1,985 gigawatts (GW). **Hydropower** with installed 1,209 GW still represents the majority of it

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[22] *Renewables 2016 Global Status Report,* www.ren21.net/wp-content/upoloads/2016/06/gsr_2-6_KeyFindings1.pdf

(61%).[23] **Wind** (22%) and **solar energy** (11%) follow with installed electric power of 432 GW and 227 GW, respectively. The remaining 6% are **biomass** (104 GW)[24], **geothermal** (13 GW) and **sea** and **ocean energy** (500 MW).

Overall, the power of plants for electricity generation from renewable sources in the last five years increased by one third. Most of this growth was owed to the use of wind and solar energy, which became significantly cheaper in the monitored year.

Costs of wind and solar energy use as opposed to coal and natural gas

According to the research of the specialized company Bloomberg New Energy Finance (BNEF), based on the data of a great number of projects around the world, it was concluded that onshore wind mills and silicon solar cells (as two mainly used technologies for the application of renewable sources) recorded the reduction of their costs during 2015, thus becoming the competitors to coal and natural gas thermal power plants.

Thus, according to BNEF, the average Levelized Costs of Electricity - LCOE for **onshore wind turbines** were reduced from 85 USD/MWh in the first half of 2015 to 83 USD/MWh in the second half of 2015. At the same time, the cost of the use of silicon **solar cells** was reduced from 129 USD/MWh to 122 USD/MWh.[25]

The application of better technologies and lower financial costs enabled the cost reduction of wind and solar energy use. Contrary to this, the reduction of efficiency degree and higher ecological taxes resulted in increased costs of coal and natural gas. It should be emphasized that levelized cost does not take into account only cost of electricity, but also costs of investments and development, ownership and debt, as well as operating and maintenance costs.

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[23] Hydropower plants make three quarters of this value, with individual power greater than 10 MW.

[24] In 2015, 133 million litres of biofuels were produced. 62% of all biofuel produced in the form of bioethanol, 24% as biodiesel and the rest as advanced biofuels. See World Bioenergy Association, available at: www.worldbioenergy.org/content/wba-launches-global-bioenergy-statistics-2016

[25] Contrary to this, LCOE for coal thermal power plants in the USA increased from 66 USD/MWh in the first half of the same year, to 75 USD/MWh in the second half of 2015. Similarly, only significantly sharper was in Europe - from 82 USD/MWh to 105 USD/MWh! Natural gas power plants increased the cost of electricity from 76 to 82 USD/MWh in the USA during the same period, while the increase in Europe was from 103 to 118 USD/MWh! *Wind and Solar as competitive as fossil fuels*, News Digest, ISES / Renewable energy focus, December 2015. p. 101

Speaking of other low-carbon energy technologies, **offshore wind farms** have decreased costs from 176 to 174 USD/MWh, which are still considerably higher than solar cells, onshore wind, coal and natural gas costs, while **solid biomass** power plants have retained stable LCOE of 134 USD/MWh. **Nuclear power plants**, however, have very different heights of LCOE, depending on the part of the world they are located in - from 158 USD/MWh in Africa and Near East, to 261 USD/MWh in North America and Europe. After the disaster in Fukushima, Japanese nuclear power plants have been closed waiting for better days to come. Meanwhile, in the Land of the Rising Sun, thanks to strong government incentive, the applications of wind, solar, sea, biomass, Earth's heat and hydrogen energy are resurrecting.[26]

Finally, the announcement of considerable cost increase of coal in China represents a good sign, with the aim of faster transition to using renewable sources and reducing enormous air pollution in industrial parks of the most populous country in the world. [27]

«Solar Impulse» flying halfway around the world

After 12 years of dedicated research and development, on the 9th of March, 2015, the solar-powered aircraft named *Solar Impulse*, operated by experienced Swiss pilots B. Piccarde and A. Borschberg began its flight around the world without the use of fossil fuels.

The first part from Abu Dhabi (Emirates) to Muscat (Oman) 772 kilometers long was finished in 13 hours. After 11-hour long maintenance in Oman, *Solar Impulse* continued its "flight around the world without fuel". **The second part** of the flight, from Muscat to Ahmedabad in India broke the former world record of the longest flight by solar plane. Flying at an average speed of 104 km/h, the pilot Bertnard Piccarde covered the distance of 1,593 km in 15 hours and 20 minutes, while enjoying the view of the meanders of the river Ind from the height of 8,874 meters.[28]

The third part took place on March the 18th, on the route from Ahmedabad to Benares. Flying across the vast Indian land, the pilots covered the distance of 1,170 km in 13 hours and 15 minutes, landing in the old city Benares, the spiritual capital of India. On the same day, they began **the fourth flight**, firstly across the Ganges Delta, then over the beautiful Bay of Bengal. Spurred by scorching Indian sun, *Solar Impulse* broke its own speed record, reaching 216

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[26] See: Djukanovic, S. (2014): *Ecological Energetics*, AGM Knjiga, Belgrade, p. 56-77
[27] Visit You Tube: Chai Jing (2014): *Under the Dome - Investigating China`s Smog*
[28] Visit: www.solarimpulse.com

km/h. After 13 and a half hours and 1,536 kilometes, it landed in the city of Mandalay (Myanmar) around noon of the following day, where the pilots were welcomed cheerfully with music and diverse colourfulness that are characteristic of the hospitality of Burmese people.

After ten-day rest in pleasant Mandalay, the pilots were ready for **the fifth flight** to the Chinese city Chongqing. The longest part so far of 1,636 km was a real challenge. The flight over the mountains of Burma and Yunnan Plateau in China was accompanied by clouds and strong wind. Pilot Bertrand Piccarde was especially happy because he finally managed to achieve what he already unsuccessfully tried in 1998.[29] This time, flying substantially upgraded aircraft, bad weather was successfully defeated. Landing in Chongqing, the pilots wished their hosts a quick solution to their environmental problems, using clean technologies such as *Solar Impulse*.[30]

Picture 1. Solar Impulse above Japan. The volcanic cone of Mount Fuji rises above clouds

The sixth flight between Chinese cities Chongqing and Nanking, although not too long (only 1,384 km) was considered crucial, because it represented the introduction and preparation for the most difficult part of the trip - flying

[29] Namely, flying in an experimental hot-air balloon, he was forced to stop the flight on the same part due to adverse weather conditions.

[30] Solar Impulse is made of carbon fibre, three times lighter than paper. 17,248 solar cells of monocristalic silicium are located on this unusual aircraft's wings with the range of 72 metres as well as on its tail, and during the day they charge accumulator, enabling the flight even during the night hours. The total weight of this aircraft is only 2.3 tons, of which 633kg litium-ion batteries weigh, responsible for initiating and maintaining the operation of four electric motors of 17.5 horsepower each.

across the Pacific Ocean. This shorter part was finished in 17 hours and 22 minutes of slow flight because of huge clouds above the Yangtze River.

For the next **seventh flight** of *Solar Impulse* the original intention was to fly continuously for five days and five nights in order to reach Hawaii. Unfortunately, extremely miserable weather conditions in the Pacific forced pilot Andre Borschberg to suspend the flight on the second day (June the 1st) and make emergency landing at the city of Nagoya in Japan. There they had to wait for weather conditions in the Pacific to stabilize in order to continue their trip to Hawaii. It took almost one month for the flight to be finally continued. They took off from Nagoya on June the 28th and after four days, 21 hours and 52 minutes of incessant flight and 8,924 km covered, *Solar Impulse* landed at the much desired land of Hawaiian islands.[31] After such an exhausting effort (five days and nights), recharcheable batteries were seriously damaged due to overheating. This situation definitely postponed until next spring the second half of the "flight around the world without fuel" of the most modern solar-powered aircraft in the world.

World Solar Challenge 2015

At the end of the previous year for the twelfth time Australia was a successful host of the informal Planet solar car competition, called World Solar Challenge. As before (starting from 1987, and taking place every third, then every second year) the competition pathway was the same - from Darwin in the north to Adelaide in the south of Australia. Following 3,000 km long sun trail, the road winding through rocky desert and mangrove shrubs, in the last days of October 2015, 43 solar vehicles "sailed" across the island continent.

All participants of the race were sorted out in three competition classes - Challenger[32], Cruiser[33] and Adventurer.[34] Solar cars were allowed to move

[31] On the third day of the flight Andres Borschberg, broke his own record (set the previous month), and during two following days surpassed his colleague Steve Foset's 2006 record of 76 hours and 45 minutes of flight.

[32] The *Challenger* class involved light solar-electric vehicles with four wheels, one seat, 4.5 m of maximal length, 1.8 m of width and 2.2 m of height. The allowed surface of solar cells is 6 m^2, while the mass of rechargeable batteries used should not exceed 20 kg. Accumulator had to be charged with solar power exclusively, using solar cells.

[33] The *Cruiser* class was similar to the Challenger class with regard to dimensions and solar cells surface. The only difference is that Cruisers were intended to transport two or more passengers. This is why Cruisers had rechargeable batteries of mass three times larger (up to 60 kg) and at the end of the first half of the racing track they were allowed to charge the accumulator from street power grid.

[34] The third *Adventurer* class was made of the most robust solar cars, 5 m long, intended for the transport of a driver and three passengers

from 8 am to 5 pm. Outside this period the vehicles had to be at a standstill, but as long as there was sunlight, it could be used for battery recharging. After five days of competition, the order of the highest ranked vehicles from the Challenger class at the end of the pathway in the city of Adelaide was as follows:

Table 9. *The final rank of the five fastest solar vehicles in the Challenger class at World Solar Challenge in Australia in 2015.*

Name of vehicle	Country	Rising time
Nuna 8	The Netherlands	37 hours 56 minutes
Red One	The Netherlands	38 h 04 min
Tокаi Challenger	Japan	38 h 50 min
Aurим	The USA	38 h 54 min
Punch One	Belgium	39 h 19 min

Source: www.wsc.au.org

In the Cruiser class, representing the transition from experimental to market vehicles, besides convincing Japanese and Dutch, other four competitors finished the race as well - Sun Riser (Germany), EVE (Australia), EOS (the USA) and Widya Wahnan (Indonesia) with driving time between 55 and 58 hours.

The winning Cruiser, Japanese vehicle sunbathing next to the ocean

The other five participants from this class unfortunately did not succeed in reaching finish line. Similarly, in the Adventurer class, none of three participants (two from the USA and one from Australia) reached finish line.[35]

[35] See: Djukanovic, S. (2016): *With the Sun's Help,* "Planet", Magazine for Science, Research and Discoveries No 73, April/June 2016, "Belmedia" ltd, Belgrade, pp. 38-39

However, the failure of some participants under no circumtances should upset them. On the contrary, it should be a powerful motivation to apply all new knowledge acquired at World Solar Challenge and to further improve their environmentally-friendly vehicles.

Conclusion

This paper is devoted to the review of the development of renewable sources use for electricity production in the world during 2014 and 2015. Geographically speaking, Asia predominates on whose territory more than a half world capacities was installed in the monitored period.

The value of net investments for the application of renewable energy sources in the same period increased from $242.5 to $285.9 billion. These investments were two times larger than investments made in new coal and natural gas plants. The main reason for this is very unstable political situation that strongly affected price increase of the application of imported fossil fuels, with the simultaneous necessity to encourage the application of domestic renewable sources.

Consequently, the use of renewable sources in global electricity production increased from 6% to 6.7%.[36] Taking into account many different types of the application, it was concluded that wind (432 GW) and sun energy (227 GW) recorded the fastest growth, gradually approaching leading hydropower (1,209 GW). It was also emphasized that employment in the field of renewable energy sources use increased by 5%, reaching 8.1 million of direct and indirect jobs.[37]

At the end of the paper a brief overview of attractive modern application of solar energy to power aircraft (*Solar Impulse*) and cars (*World Solar Challenge*) was provided.

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BIO-REFINING AGRICULTURAL CROP PRODUCTS INTO HIGH-VALUE MATERIALS – ECONOMIC IMPACTS ON THE AGRICULTURAL SECTOR

Jørgen Dejgård Jensen[1]

Abstract

This paper examines the economic consequences of scenarios, where technological solutions for conversion (bio-refining) of agriculturally supplied biomass are implemented on a large scale in Denmark. The technological scenarios are analysed in a partial equilibrium model of the Danish farm sector, which enables assessment of distributional effects between different farm types (crop, cattle, pig farming, full-time versus part-time farms, organic versus conventional farming, etc.), based on cost minimization theory. Two alternative biorefining scenarios have been analysed:

- *extraction of high-value protein from green biomass to be used for e.g. pig feeding*
- *extraction of high-value components of the biomass for industrial processing*

The analysis suggests some variation across farm types in terms of their adoption of biomass production for industrial purposes, e.g. depending on their reliance on on-farm feed production. But the analyses also suggest that the economic gains from involving in biomass production seem to be relatively large on part-time farms.

Key words: *Bio-refining, high-value protein, high-value bio-based industrial components, agricultural sector mode*

Introduction

Worldwide, it is increasingly acknowledged that there is need for changes in the approach to production, consumption, processing, storage, recycling and disposal of biological resources. In 2012, the European Commission launched its strategy for the biobased economy: "Innovating for Sustainable Growth: A Bioeconomy for Europe" (European Commission, 2012), with the vision to create economic growth and jobs in rural areas, reduce fossil fuel dependence

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and improve the economic and environmental sustainability of primary production and processing industries via better utilization of bio-resources, including bio-resources produced in agriculture and forestry.

At the same time, the agricultural sector is also looking for opportunities for further value creation, and strategies towards production of feedstock for non-food bio-products, such as biomaterials, "green" chemical products or biofuels might be promising (OECD, 2008). Utilizing new biotechnology may however also boost value creation in the food supply chain, for example by enhancing the nutrient accessibility in crops for feeding, thus enabling the utilization of high-yielding crops for feeding to non-ruminants.

Implementing the vision of a bio-based economy requires the development of technological solutions to convert biomass into high-value materials for use in modern production systems. In Denmark, the BioValue research and innovation project (www.biovalue.dk) has been established to contribute to such technological solutions within conversion of agricultural and forestry products into materials for industrial processing and high-protein feed for animals via different forms of biorefining.

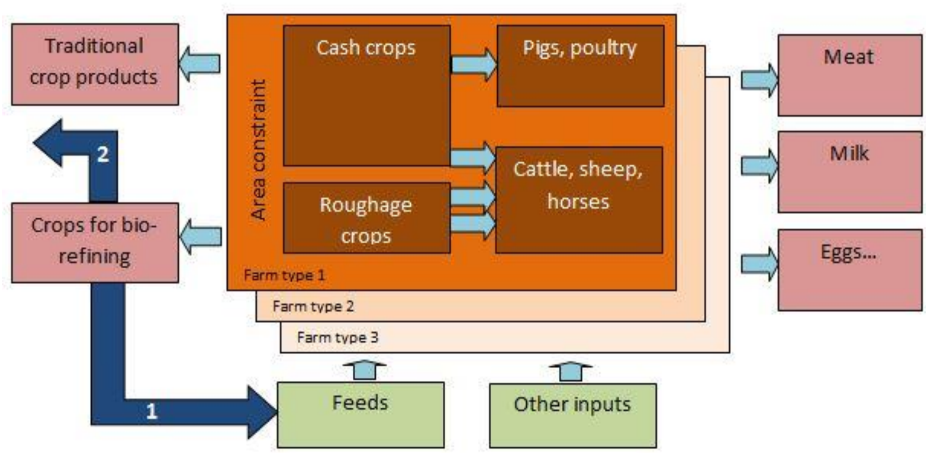
Cherubini et al. (2009) provide a useful framework for describing biorefinery systems, outlining four main features of such systems: platforms, products, feedstock and processes. The *platform* (e.g. sugars, lignin, organic juice, etc.) is the intermediate, which links *feedstock* (crops, wood, organic material or residues and side-streams from other production processes) and final *products* (e.g. bioethanol, animal feed, chemicals etc.) utilizing *processes* (including chemical or mechanical/physical processes) that are needed to transform the feedstock biomass into the desired platform and further to the final products. From an agricultural economic perspective, interest is mainly focused on the feedstock and product features. The feedstock feature is interesting because the farming sector can be a key actor here, and the product feature can be interesting, if the products from bio-refining can either be utilized in farming activities or if they may act as substitutes for "traditional" farm products. On the other hand, the relevance of the platform and process features for the farming sector is of a more indirect nature.

In this paper, we aim to examine the agricultural economic consequences of scenarios, where technological solutions for this conversion of agriculturally supplied biomass is successfully implemented on a large scale in Denmark, where high-protein feed replaces imported soya, or where new bio-based materials replace current (mainly fossil-based) materials in different industries.

Methodology

The technological scenarios are analysed in a partial equilibrium model of the Danish farm sector. The model determines output, use of variable inputs, livestock, labour, capital and land in 36 lines of agricultural production, including 25 crops and 11 livestock sectors at the farm type level, combined with an aggregation routine to aggregate farm-level results to desired aggregates (e.g. national, regional, farm-type, farm-size level, etc.). An outline of the model is given in Figure 1.

Figure 1. The agricultural sector economic model



Due to extensive engagement in international trade with most agricultural products, Danish farmers are in general assumed to be price takers. One exception is however roughage for cattle, sheep and horses, where there is assumed to be equilibrium between domestic supply and demand. The production technology in each line of production is described by nested CES technologies, where elasticities of substitution σ between inputs have been estimated from econometric analyses of farm accountancy (FADN) data or derived from agronomic data, such as field experiments. Based on the initial cost structure and the elasticities of substitution, the demanded composition of inputs in the respective lines of production can be determined from the response to changes in relative "effective" prices (where relative "effective" prices incorporate effects of market price, taxes, subsidies and shadow prices representing bindingness of quantitative restrictions etc.)

(1) $$\dot{x}_i - \dot{x}_j = \sigma_{ij} \cdot \left(\dot{w}_j - \dot{w}_i \right)$$

The supply of individual products can be determined from zero profit conditions (price = marginal cost) in the respective lines of production.

(2) $$\dot{p}_a = \sum_i s_i^a \cdot \dot{w}_i$$

(where s_i^a represents input i's share of costs in production line a).

A number of constraints determine the interactions between different lines of agricultural production, and these constraints define the model closure, which is scenario specific. One (technical) constraint is an area constraint, stating that the areas for individual land uses should add up to the total area on each farm type. Combined with an equilibrium condition stating that the shadow price of land (reflecting the marginal returns to land) should be equal in all uses, this constraint determines the allocation of land to agricultural uses within the farm type. Another technical constraint is the mentioned supply-demand balance for roughage. Constraints can also be determined by policy, e.g. quota on output or input use or requirements on livestock density. Each such constraint is associated with a "shadow price", which represents the extent to which this constraint is binding. An overview of the model can be obtained from Jensen & Ørum (2012). The current analysis addresses the distributional effects within the Danish agricultural sector, as represented by 15 different farm types (Table 1).

Table 1. ***Farm typology***

Type code	Type	Approximate number, 2011	Area per farm (ha)
111	Small conventional crop full time farm, clay soil	1302	134
112	Large conventional crop full time farm, clay soil	153	377
121	Small organic crop full time farm, clay soil	7	141
122	Large organic crop full time farm, clay soil	6	433
211	Small conventional crop full time farm, sandy soil	5422	111
212	Large conventional crop full time farm, sandy soil	10	334
221	Small organic crop full time farm, sandy soil	6	134
222	Large organic crop full time farm, sandy soil	8	425
311	Conventional cattle full time farm	3252	117
321	Organic cattle full time farm	463	181
411	Small conventional pig (+other) full time farm	4772	85
412	Large conventional pig (+other) full time farm	10	317
421	Small organic pig (+other) full time farm	88	114
511	Conventional part time farm	23138	36
521	Organic part time farm	2022	38

Large farm: > 200 ha

Source: Danish Farm Accountancy Data (Statistics Denmark)

Two alternative types of scenarios have been analysed and compared (static-comparatively) with a baseline scenario (the observed situation in 2011):

1. A scenario with extraction of high-value protein from green biomass (grass etc.) to be used for pig and poultry feeding and use of the residual component for cattle feeding

2. A scenario with extraction of high-value components of the biomass for non-food industrial processing, e.g. as a substitute for petrochemical raw materials

Whereas the technology has been more or less developed for bio-ethanol production (which can be considered as a special case of scenario 2), other realizations of scenario two – as well as scenario 1 - still rely on technologies to be developed and matured. In order to enable comparisons, the two scenarios are scaled equally in the sense that the biomass area for the considered high-value production is assumed to be the same in both scenarios. In particular, the biomass area is determined as the area needed to increase the self-sufficiency by one third in order to replace current protein feed import (mainly soya) with proteins extracted from green biomass (scenario 1).

Data to represent production costs of biomass are adopted from other studies (Bojesen et al. 2016, Jacobsen & Dubgaard 2010).

Scenario 1. High-value protein from green biomass

In scenario 1, it is assumed that the bio-refining of green biomass (grass, clower, etc.) to extract proteins can be done at a cost (at the current unit cost of grass production) that enables the sale of the extracted proteins to (pig) farmers at a price that is equivalent to the price of imported soya protein. Furthermore, it is assumed that the extracted protein is a perfect substitute for the soya protein.
In the scenario, 40 per cent of the protein demand for livestock production is assumed to be covered by domestic sources, including bio-refined green biomass (as compared with the baseline level of around 30 per cent). This assumption is implemented in the economic model in terms of the model closure equation

(3) $$(\alpha - 0.30)\cdot \sum_{h=farmtype} b_h \cdot \sum_{i \in livestock} v_i \cdot a_{h,i} = \sum_{h=farmtype} b_h \cdot \sum_{c \in biomass\_crops} v_c \cdot a_{h,c}$$

The difference between the target share α (40 per cent) and the current share (30 per cent) of total protein demand from the livestock production should be supplied by domestic production at the national level from green biomass (where v_i is protein per unit of activity in sector i, $a_{h,i}$ is the level of activity in this sector on farm type h and b_h is the number of farms in type h). For the scenario, the existing range of crops in the model is expanded with a 'green biomass' crop (grass), which supplies feedstock for processing to high-value protein feed. The price of the green biomass is endogenously determined in order to secure equilibrium between demand and supply of domestically produced protein.

An α-value of 1 would imply perfect self-sufficiency, whereas a value less than 1 implies some net import of protein feed. Hence, in the model analysis, the α-value can be varied to assess the sector economic consequences of alternative levels of ambition as regards self-sufficiency, but 40 per cent is chosen as the level of ambition in this study.

Estimates of the protein coefficients v have been obtained on the basis of data from Handbook for Farm Management (2012) and Kristensen & Jørgensen (2012) and are shown in Table 2.

Table 2. ***Protein and dry-matter coefficient***

Crops	Crop yield (kg/ha)	Dry matter content (%)	Protein content (% of dry matter)	Protein content (% of product weight	Dry matter yield (kg/ha)	Protein yield (kg/ha)
Wheat	6530	85	10.6	9		588
Barley	5340	85	10.6	9		481
Rye	5110	85	10.6	9		460
Oats	4810	85	10.6	9		433
Other grains	4810	85	10.6	9		433
Field peas	3410	85	23.9	20.3		693
Rapeseed	3380	91.4	21.8	19.9		673
Biomass grass	46900	20	18	3.6	9380	1688
Biomass wheat	11630				9335	
Willow	12000				12000	
Livestock						**Protein (kg/animal/ year)**
Dairy cows						853
Suckling cows						145
Heifers						302
Calves						156
Sows (incl. piglets)						172
Finishers						44
Layer hens						4
Chicken						0.3
Horses						131
Sheep						22
Mink						88

Source: Handbook for Farm Management (2012), Kristensen & Jørgensen (2012)

The fact that one hectare of biomass grass yields around three times as much raw protein as ordinary grains (wheat, barley, etc.) illustrates the protein potential of bio-refining green biomass. Due to low digestability of grass for non-ruminants, this protein is not directly accessible for pigs and poultry, but extraction of the high-value proteins from the grass via bio-refining makes these proteins accessible to these animals.

Scenario 2: Bio-based components for industrial processing

In scenario 2, it is assumed that an area equivalent to that in scenario 1 is allocated to biomass production as feedstock for bio-refining. However, instead of imposing the restriction that the biomass should be utilized to increase self-sufficiency in protein feeds, the biomass may in scenario 2 be used for other types of refining, possibly with higher potential value than as protein feed. Hence, in this scenario, the model closing condition takes the shape of a constraint on the total national area $\bar{A}$ allocated to 'industrial biomass', which may be grains, grass or willow dedicated to bio-refining.

(4) $$\sum_{h=farmtype} b_h \cdot \sum_{c \in bio\_crops} a_{h,c} = \bar{A}$$

The 'industrial biomass' area is allocated between these three crops according to the relative marginal economic return to land in the respective biomass crops. The 'shadow price' of constraint (4) represents the bindingness of the constraint, which again reflects the minimum value of the bio-refined products (after coverage of processing and distribution costs), if the biomass area $\bar{A}$ should be market-driven.

Results

Using the partial equilibrium sector model outlined above, economic effects for the Danish agricultural sector, including impacts of the scenarios on agricultural production and its composition, agricultural income and employment have been assessed, both at an aggregate sector level and for different farm types within the agricultural sector.

Sector level

Table 3 displays the calculated economic impacts of the two scenarios at the agricultural sector level.

Table 3. ***Estimated agricultural sector economic impacts of biomass scenarios***

		Baseline	Scenario 1	Scenario 2
Biomass area	1000 ha	2	810	810
Trad. cash crop area	1000 ha	1894	1099	1086
Roughage area	1000 ha	592	573	590
Dairy cows	1000 hds	458	470	458
Sows	1000 hds	962	984	962
Produced finishers	1000 hds	20412	19244	20412
Crop output	Mill. €	3424	3482	3782
Livestock output	Mill. €	4012	4003	4215
Feed costs	Mill. €	1325	1368	1380
Other variable costs	Mill. €	2782	2780	2583
Gross factor income	Mill. €	2581	2675	3425
Sector profit	Mill. €	542	743	1333
Sector employment	1000 full-time equiv.	41.6	40.6	40.4

Increasing the Danish self-sufficiency of protein feeds with one third to 40 per cent (scenario 1) by means of green biomass for bio-refining requires a biomass area of 810,000 ha. The increase in green biomass area occurs primarily at the cost of traditional cash crops, especially ordinary grain production (spring barley and wheat). Agricultural sector income increases around €0.1 billion, mainly due to an increase the value of crop production.

In the scenario where a corresponding biomass area is grown for refining into industrial raw materials (scenario 2), the expansion of biomass area mainly takes place for bio-refinery wheat and willow (which provide a higher economic return per hectare than grass), predominantly at the cost of spring barley and wheat, whereas production remains unchanged in the most important livestock sectors. The value of crop output increases by 10 per cent, and the agricultural income increases by around €0.8 bill.

It should be noted that the income figures are calculated under the assumption that the biomass price adjusts to ensure market clearing for the biomass. Considering the scenario-specific production goals as the demand side, this implies that the biomass price will have to be adjusted upwards to ensure that supply meets this demand, compared to the baseline. In scenario 1, this means a biomass price increase of 4 eurocents per kg biomass (43 per cent). For scenario 2, it means a price increase of 8 eurocents per kg biomass (84 per cent). If the biomass production is valued at the baseline prices instead of these equilibrium prices, the calculated sector income gains would be reversed to a €0.23 billion loss in scenario 1, and reduced to a gain of around €0.23 billion in scenario 2.

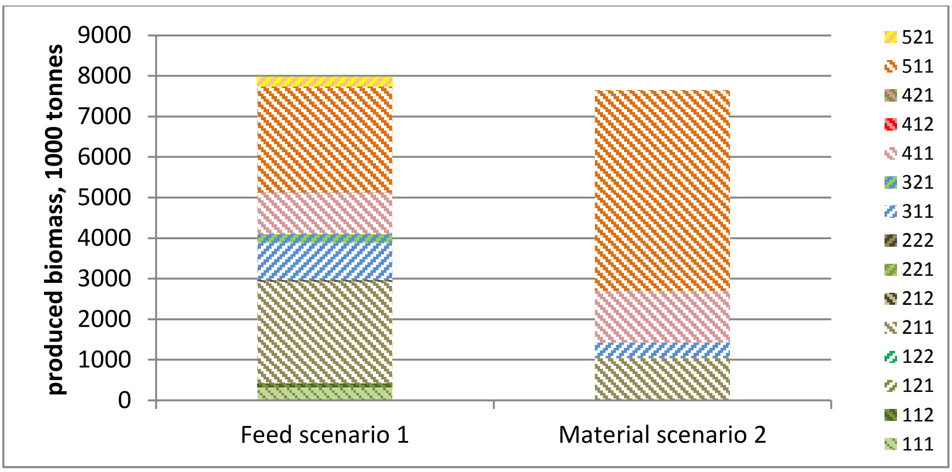
Farm level

As mentioned previously, the present study considers 15 farm types, distinguished according to main production, farm size, soil type, organic status and full-time/part-time status. Figure 2 illustrates how the biomass production is distributed on the 15 farm types in the two scenarios.

The analysis suggests some variation across these farm types in terms of their adoption of biomass production for industrial purposes. In particular, conventional part-time farms (511) represent around one third of the biomass production in the protein feed scenario and more than half in the materials scenario. Other major contributors to the biomass production include conventional crop farms on sandy soils (211), conventional pig farms (411), and to some extent conventional cattle farms (311).

Note that the two scenarios have been scaled equivalently according to the total biomass area. In scenario 1, the total biomass (dry + wet matter) production amounts to about 8 million tonnes, whereas it is slightly less (7.7 million tonnes) in scenario 2. The difference is explained by the fact that the total biomass yield per hectare is higher for grass than for the two other biomass crops considered.

Figure 2. ***Distribution of biomass production between farm types in the scenarios***

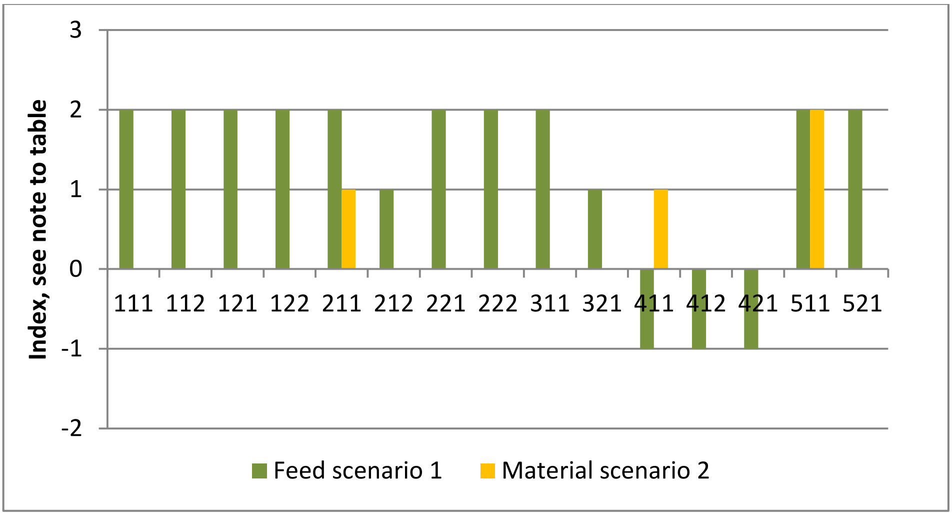


One key explanation for the relatively large effect for conventional part-time farms is that the economic rate of return on agricultural land was relatively low on these farms in the baseline, mainly due to relatively low productivity. This should be viewed from the perspective that many of these part-time farmers conduct their farming activities either as a hobby or (often) as a minor supplement to their total household income. For full-time crop farms on sandy soil (211), grass production has a comparative advantage vis-à-vis cash crops – and as the value of grass increases due to the possibility for bio-refining, this comparative advantage is activated to a higher degree than for crop farms on clay soil. The baseline crop composition on "small" full-time pig farms is strongly based on grains with relatively low economic returns, and hence feedstock grass becomes more competitive on these farms than on farms growing more special crops with higher value.

The economic impacts of the scenarios are also unevenly distributed across farm types, as illustrated in Figure 3, where these impacts are illustrated, based on average net profit (including profit from livestock activities) per hectare for the respective farm types. The figure categorizes farm types in three categories according to the scenarios' effects on average profit per hectare:

- Average profit per hectare affected negatively (index -1)
- Average profit per hectare affected positively but below average (index +1)
- Average profit per hectare affected positively and above average (index +2)

Figure 3. ***Distribution of economic impacts per hectare by farm types***



Note: +2: Above average, +1: Positive, but below average, -1: Negative

Two overall observations can be made from Figure 3. First, net returns are generally positive in scenario 2 for those farms engaging in biomass production, whereas scenario 1 leads to economic redistribution from livestock farms to crop-based farms. The negative effect for livestock farms occurs because feed prices increase in the protein feed scenario. As mentioned, it is assumed that at the baseline unit cost of grass production, the price of protein feed from refined biomass is equivalent to the baseline price of protein. But in order to encourage an increase in the production of biomass grass to the level determined by the self-sufficiency condition (3), the equilibrium price of biomass grass becomes higher than the baseline unit cost – and this spills over to the feed price. Second, conventional part-time farms tend to be winners in both scenarios (in relative terms).

Discussion

The work with analysing economic impacts of biomass production for bio-refining is a field in progress, given that the development of biomass processing technologies for high-value purposes is still at its infancy. As a natural consequence, results of quantitative economic analyses of such technologies will also be a somewhat uncertain predictor of actual economic outcomes, once the scenarios have become reality. Nevertheless, economic model tools and analyses are deemed useful to identify some of the critical assumptions for the economic viability of alternative technologies within the field of biomass refining and hence for the economic sustainability of the bio-based economy.

Having considered economic sustainability with regard to biorefining technologies, it is also of importance to consider aspects related to the environmental sustainability of these technologies. Whereas conversion of green biomass to high-value protein feed has implications for the import of soya from e.g. South America (with associated environmental consequences), the production of biobased materials may have other environmental impacts. Parajuli et al (2015) review some of the pathways for sustainable biorefinery value chains and their assessment.

OECD (2007) discusses a range of potential measures to support the development of the bioenergy sector, and several of these measures – as well as the potentials and challenges associated with them - also apply to the biomass uses in the present analysis. In relation to biomass production, such measures might include traditional agricultural policy instruments, such as subsidies or quotas. Biomass conversion may be supported by improved market infrastructures, reduced R&D costs, reduced production costs or guaranteed price or market access for the refined products. As with "traditional" agricultural support, it should however be considered, whether such support measures do not cause unintended economic distortions – in the biomass sector as well as in other sectors.

Conclusion

The present study has assessed the agricultural economic impacts of extensive implementation of biorefining technology to increase value-added in agricultural production, including the distributional effects within the farming sector, using Denmark as an example. Two alternative strategies were assessed: pursuit of increased self-sufficiency strategy for protein feeds, and – as an alternative – allocation of a similar agricultural area to the production of biomass for production of biobased materials.
Both scenarios suggest positive economic effects for the Danish agricultural sector, but the two scenarios differ in terms of their redistributional effects, assuming that the biomass can be sold at its marginal cost. In particular, the protein feed scenario implies some redistribution from livestock farms to crop farms (especially part-time farms), whereas the effects tend to be more evenly distributed for biomass production for non-food materials.

Acknowledgement

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IMPROVING INFORMATION TECHNOLOGY FOR FOOD SAFETY IN SERBIA

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Abstract

Regarding complexity of the food supply chain, the application of up-to-date information technologies (IT) is becoming very important for production and trade of safe food. Moreover, consumers demand to know "who, what, when, where and how" of products they purchase. This article describes general food safety situation in Serbia structure of food safety and control system, risk management and risk communication of certain disease as well as forthcoming challenges in implementation of the acquis. Special emphases is given to the establishment and functioning of the Rapid Alert System for food and feed (RAFSS). The paper gives a spreadsheet presentation of more than 100 notifications originating in Serbia, recorded in RAFFS system for the period from 2005 to 2015 and classified as information, alert, and information for attention, border rejection or information for follow-up. The paper concludes that Serbia is moderately prepared for EU integration in the area of food safety, veterinary and phytosanitary policy. There is a need for adopting a national monitoring and control programme for food and feed safety needs as well as a programme for upgrading agri-food establishments. The general assessment is that Serbia should introduce, develop and improve the IT that serve as a tool for improving transparency in the food supply chain.

Key words: *food safety, IT, transparency, Serbia*

Introduction

Public concern about food safety, most directly on pesticide residues, grew markedly during the 1980s, while scientists concern focused on the risks of illness associated with microbiological contamination of food. Thanks to increased knowledge of linkages between diet and health dietary recommendation emerged in the late 1980s (Caswel, J, 2012). In the following decades consumer confidence in the healthiness of food products has generally decreased because of incidents such as bacterial

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outbreaks, bovine spongiform encephalopathy (BSE), and possible risks associated with genetically modified organisms (GMOs) in food (Yeung, 2001). Restoring confidence in food presents a considerable commercial challenge to the food industry (Jardine, 1999; Gregoriadis, 1999).

Safe foods a precondition for the protection and promotion of health, can be defined as food contain nothing that is hazardous or injurious (Hasanpour, 2006). Many international organizations are involved in the efforts to mitigate the effects of foodborne illnesses on public health. The most important is World Health Organization (WHO), particularly its Department of Food Safety and Zoonoses (FOS) which provides leadership in the efforts to lower the burden of diseases from food and animals across the globe. In order to address food safety issues along the entire food chain WHO works closely with many organizations, especially with the Food and Agriculture Organization of the United Nations (FAO UN) and WHO for Animal Health (OIE).

Risk assessment is the scientific evaluation of known or potential adverse health effects resulting from human exposure to foodborne hazards. The process begins with the identification of food hazards which can be: microbiological, chemical and technological. The microbiological hazards are hazards caused by bacteria most often by *Salmonella*, *Campylobacter coli*, *Listeria monocytogenes*, and *Escherichia coli* (FSAC, 1993). Chemical hazards are associated with the chemical usage: agri-chemicals, growth control hormone, feed conversion enhancers and anti-biotic treatments. Pesticide residues in fruits and vegetables are a major concern to consumers due to their negative health effects. Fetuses, infants, growing children, pregnant and nursing mothers, and women of childbearing age are most at risk for adverse health outcomes from exposure to pesticides. Chronic, lower dose exposure to pesticides is associated with respiratory problems, memory disorders, skin conditions, depression, miscarriage, birth defects, cancer and neurological conditions such as Parkinson's disease [3] .U.S. study with nationally representative sample showed that organophosphate exposure, at levels common among US children, increasing odds of attention-deficit/hyperactivity disorder for 8-15 year olds (Bouchard, 2010). The Environmental Working Group (EWG) publishes the Shopper's Guide to Pesticides in Produce that identifies that apples, celery, sweet bell peppers, peaches, strawberries, nectarines, grapes, spinach, lettuce, cucumbers, blueberries and potatoes are most likely to be contaminated with pesticides. Key finding suggest that 98 percent of strawberry samples, peaches,

[3] https://depts.washington.edu/ceeh/downloads/FF_Pesticides.pdf

nectarines, and apples tested positive for at least one pesticide residue[4]. Similarly, concerns regarding the safety of livestock products rising due to use of antibiotics, growth hormones, and antihelminths used for disease control and growth promotion of livestock animals. Antibiotic residues in food of animal origin might be potential threat to direct toxicity in human or might result in alternation of microflora and cause failure of antibiotic therapy due to development of resistant strains (Nisha, 2008). Estradiol-17β, progesterone, testosterone, zeranol, trenbolone, and melengestrol acetate hormones impact on human health is still under debate (Jeong et al., 2010). Finally, technological hazards refer to the possible negative consequences of technological advancements in food products, such as food irradiation and genetic modification of food (Yeung et al., 2001).

Regarding complexity of risk assessment, growing public concern over the food safety as well as complexity of the food supply chain as a hole, the application of up-to-date information technologies (IT) is becoming very important for production and trade of safe food.

IT and food safety management systems

Consumers of our time demand to know "who, what, when, where and how" of products they purchase. In fact, access to information influence decision making process and willingness to purchase the products. The IT concerned with data capture, storage, analysis and retrieval are the cornerstone of the modern food safety management systems. IT with proper databases has the role to assist decision making in a short time frame, potentially allowing decisions to be made and practices to be actioned in real time. As described by McMeekin such databases find application in: 1) National surveillance programs (identifying pathogens in food at the species level or bellow them); 2) International web based searchable database (predictive modelling software, such as the Pathogen Modeling Program and Growth Predictor); 3) Expert systems databases (microbial characteristics, food composition and processing information); 4) Computer software packages (to establishing and modifying food safety management practices- practical application of HACCP and risk assessment); 5) Websites aimed to disseminate rapidly information on foodborne disease outbreaks (include the reasons for and consequences of disease incidents); 6) Active surveillance networks for rapid dissemination of information between public health agencies to detect foodborne outbreaks and limit the spread of human disease; 7) Traceability of individual animals or crops from (or before) conception or germination to

[4]https://www.ewg.org/foodnews/summary.php

the consumer as an integral part of food supply chain management; 8) Online educational packages to food industry personnel (McMeekin et al., 2006).

Serbia legislation regarding food safety

The Republic of Serbia has granted the status of candidate country of the European Union on 1 March 2012. In order to become compliant with EU standards, Serbia needs to adopt EU legislation and ensure its full implementation. To facilitate the process, the Serbian Parliament adopted the National Plan for the Adoption of the Acquis 2014-2018 (NPAA)[5]. According to the Plan producer as food and feed business operators are responsible for safety of their products and implementation of the self-control system based on the HACCP principles or on the hazard analysis and risk management in their own production. Monitoring of the food and feed hygiene regulation implementation, aligned with the EU hygiene package (Regulations EC 852/2004, 853/2004, 854/2004 and 183/2005) which is applied as of June 2011 is subject of official control.

In the EU, food safety, veterinary and phytosanitary policies are managed by The European Commission's Directorate General for Health and Consumer Protection (DG SANCO)[6] which was established in 1999 and in its structure includes European Food Safety Authority (EFSA). In the Member States and in the candidate countries different sections covered by this policy area are usually divided among various Ministries. Such situation is in Serbia also. Two principal organizations are involved in food safety: Ministry of Agriculture and Environmental Protection and the Ministry of Health including the Secretariat for Health in the autonomous Province of Vojvodina. The Ministry of Agriculture and Environmental Protection supervises the legality of work through its four directorates: Veterinary Directorate, Plant Protection Directorate, General Directorate and the Directorate for National Reference Laboratories. Authorized public and private laboratories and institutes accredited to ISO 17025 are conducting analytical studies and monitoring. For the accreditation of certifying bodies is responsibility of the Accreditation Body of Serbia. The most important legislation regarding food safety is the Law on Food Safety (Official Gazette RS no.41/09), which reflects the requirements of the EU General Food Law Regulation 178/2002. The Low respects the principles of risk analysis, precautionary principle,

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5 http://www.seio.gov.rs/upload/documents/nacionalna_dokumenta/npaa/npaa_eng__2014_2018.pdf

6 http://ec.europa.eu/dgs/health_food-safety/index_en.htm

principle of protection of consumers' interests and principles of transparency. According to Article 12 the duties related to food safety are divided as presented in Table (1).

Table 1. ***Areas of responsibility***

MINISTRY OF AGRICULTURE AND ENVIRONMENTAL PROTECTION	
In the primary production stage	(1) of food of animal origin – veterinary inspection (2) of food of plant origin – phytosanitary inspection
	(1) of feed of animal origin – veterinary inspection (2) of feed of plant origin – phytosanitary inspection
In the production, processing and wholesale stage	(1) of food of animal origin – veterinary inspection (2) of food of plant origin and non-alcoholic beverages – agricultural inspection (3) of mixed food – veterinary and agricultural inspections
	(1) Feed- veterinary inspection
In the import and transit stage	(1) of food of animal origin - border veterinary inspection (2) of food of plant origin – phytosanitary inspection (3) of mixed food – border veterinary and phytosanitary inspection
	(1) of feed of animal origin and mixed feed – veterinary inspection (2) of feed of plant origin – phytosanitary inspection
In the export stage	(1) of food of animal origin – veterinary inspection (2) of food of plant origin – phytosanitary inspection (3) of mixed food – veterinary and agricultural inspection (4) of wines and spirits – agricultural inspection
In the retail stage	(1) retail of fresh meat, milk, eggs, honey, fish and wild animals in specialized facilities (butcheries, fisheries and similar)-veterinary inspection (2) wine and alcoholic beverages- agricultural inspection
Genetically modified organisams	(1) All stages of production, processing and circulation of GM food- phytosanitary inspection (2) All stages of production, processing and circulation of GM feed- veterinary inspection
MINISTRY OF HEALTH	
Sanitary inspection	(1)Control of novel food (2) dietetic supplements (3) food for babies – supplements for mothers milk (4) dietetic supplements and salts for human ingestion (5)production of additives, aromatics, enzymatic preparations of other than animal origin and accessories of other than animal origin (6) drinking water in original packing (table water, mineral water and spring water) (7) water for public supply of drinking water in all stages of production, processing and circulation (wholesale, retail, imports on customs points and exports)

Source: http://faolex.fao.org/docs/pdf/srb100429.pdf

Serbia is bordered by a number of countries and there are 71 border crossings on its territory: international (60), inter-state (2), local cross-border (8), exceptional (1), of which 36 road, railway 11, river 10 and air 3 (European Parliament, 2013).Veterinary, phytosanitary and agricultural inspections are carried out in both domestic and foreign (border inspection) trade. The Law on Food Safety (Article 18 and 19) states that National Reference Laboratories shall perform activities in the field of food safety, animal health, plant health, health of agricultural and decorative plants seeding material, residues, milk and plant genes bank. Table 2 indices the main predicted laboratory activities.

Table 2. ***Some activities of National Reference Laboratory***

(1) The establishment of uniform criteria and methods and implementation of standards for the operation of authorized laboratories
(2) Exchanging of information from national laboratories of other countries to the Ministry and authorized laboratories
(3) Implementation and/or development of testing methods based on international standards, with mandatory validation
(4) Establishment of quality control system for both authorized laboratories and its own use
(5) Providing and implementation of statistically developed control and results monitoring within the authorized laboratories
(6) Preparation of national guidelines for sampling and handling of samples for the purposes of execution of reliable diagnosis
(7) Training of authorized laboratories staff
(8) Exchange of information on official diagnostic activities and cooperation with laboratories of other countries
(9) Preparing of risk analysis programs on occurrence and spreading of harmful organisms
(10) Organization of certification by the procedure of expert control of production
(11) Keeping of seeding material collection
(12) Exchange of samples with other gene banks in the world
(13) Implementation and organization of activities connected to the procedure on protection of rights of breeders

Source: http://faolex.fao.org/docs/pdf/srb100429.pdf

Although the National Reference Laboratories Directorate was established in 2009, and National Reference Laboratory was officially opened in March, 2015 the Laboratory still is understaffed and unable to perform its full duties. In order to renovate it, build the capacity of and equip a number of project have been undertaken (European Parliament, 2013). As a donation from the EU the value amounts to nearly 8 million Euros[7], the phytosanitary laboratory was only of the national reference laboratories to be opened. Further efforts are needed to put other laboratories into operation, such as the Laboratory for quality control of raw milk (EC, 2015). This issue has created a heated debate in the media and the great dissatisfaction of the National Association for Consumer Protection[8] who claim that the laboratory does not own the necessary accreditation and looking for a response from the relevant Ministry who and what are the criteria to decide about examination of the foods that will be tested, "one day when the laboratory practically becomes operational."

Animal and plant health

The most important regulations covering feed and animal by-products, animal health protection and animal welfare, international trade, certification and veterinary control are: the Law on Veterinary Matters (Official Gazette of RS 91/2005, 30/2010 and 93/2012), the Law on Food Safety (Official Gazette 41/2009) and the Law on Animal Welfare (Official Gazette 41/2009).

Following the request by the Ministry of Agriculture on 2 March 2011 to DG SANCO to approve Serbia for the import of certain live animals (cattle and

[7] http://www.prviprvinaskali.com/clanci/potrosaci/zastita-potrosaca/nacionalna-referentna-laboratorija-pocela-sa-radom.html

[8] http://www.danas.rs/danasrs/ekonomija/nacionalna_referentna_laboratorija__neakreditovana.4.html?news_id=298629

poultry) into the EU, the Food Veterinary Office (FVO) undertook two concurrent audits[9]. Although overall conclusion states that the animal health situation appears to be favorable, competent authorities could not provide adequate guarantees for the import of live cattle into the EU due to “(1) implementation of the new on-farm register is in progress (2) not granted herds the status of herds officially free from TB, BB and EBL (3) contingency instructions are still to be developed or finalized (4) National Reference Laboratories have not yet been designated for all relevant diseases and national ring testing has not been initiated for some tests (5) laboratory reports may omit the identity or incorrectly identify animals subject to official testing”. The FVO mission carried out in order to evaluate the operation of official public health controls over the production and processing of milk and milk-based products destined for export to the EU, as well as their certification procedures in 2010 have shown “the competent authority could not demonstrate that all criteria for certification of heat-treated dairy products from Serbia into the EU can be met: the principles for certification are not yet fully respected and deficiencies were identified regarding the hygiene on the dairy holdings. The competent authority could not demonstrate that the milk and milk-based products intended for export to the EU satisfy the relevant microbiological criteria for foodstuffs sets out in Regulation (EC) No 2073/2005”[10]. The outcome of a Food and Veterinary Office (FVO) audit in Serbia, carried out from 15 to 19 April 2013, on the monitoring of residues in live animals and animal products concludes that most of the national requirements are broadly equivalent to EU legislation, but “lack of traceability between animal health certificates makes it difficult for the competent authority to ensure that exported equate have not been treated with substances which would exclude them from human consumption”[11].

According to these audits the process of upgrading of establishments producing food clearly emerged as a critical issue. Only one poultry slaughterhouse and cutting plant, one meat preparation plant, and eight meat processing plants have received export approval to the EU (Tomasevic, 2013). Lack of adequate control and authorized establishment is the reason to ban milk and animal export. The implementation of HACCP is of particular importance for the sector. All animal products and animal feed related business are obliged to implement HACCP system from 1 January 2009, while for production, processing and trade of food from plant origin HACCP is mandatory from June 2011. One study in meat processing and retail establishments in Serbia has shown strong positive effect of

[9]ec.europa.eu/food/fvo/act_getPDF.cfm?PDF_ID=9123
[10]ec.europa.eu/food/fvo/act_getPDF.cfm?PDF_ID=8133
[11]ec.europa.eu/food/**fvo**/act_getPDF.cfm?PDF_ID=10626

mandatory HACCP implementation on process hygiene indicators in meat establishments (Tomasevic et al., 2016), but the main obstacles in implementation is the inability of companies to recoup costs related to the implementation/operation of HACCP system (Tomasevic, 2013). The number of slaughterhouses, dairy units cooling stores that have implemented HACCP is still far below the total establishment that has been implemented for production (Van Berkum&Bogdanov, 2012).

According to EC Report (EC, 2015) the Law on Plant Protection Products is not implemented in relation to registration, for which the previous non-EU compliant procedure is still applicable. In order to assess controls on pesticide residues in food of plant origin intended for export to the European Union (EU) an FVO audit was carried out in 2012[12] and conclusion was that control system on pesticide and pesticide residues provide sufficient guarantees that fruit and vegetables exported to the EU comply with the EU requirements. As an important obstacles report states national programme for pesticide residues and limited scope of official laboratory due to lack of financial resources. Pesticides are regulated in "Ordinance on maximum permitted amounts of residues of pesticides in food and feed and food and feed, which establishes the maximum allowable amount of residues of pesticides" (Official gazette Republic of Serbia, No. 25/10") and is harmonized with Regulation 396/2005/EC, but a few years more will pass to get system in place, with regards to plant health and phytosanitary standards (Van Berkum, 2012).

Information sources, database construction and IT in Serbia

As a member of the World Organisation for Animal Health (OIE), Serbia had taken international obligations for the notification of animal diseases. It also undertakes notifications to the European Animal Disease Notification System (ADNS). Also, Serbia has joined the system for tracking the movement of animals and products of animal origin (TRACES)[13] which main objective is to digitize the entire certification process and linked procedures, and is in line with the declaration of the Digital Agenda for Europe. TRACES is an efficient tool to ensure: traceability (monitoring movements, both within the EU and from non-EU countries); information exchange (enabling trade partners and competent authorities to easily obtain information on the movements of their consignments, and speeding up administrative procedures); risk management (reacting rapidly to health threats by tracing the movements of consignments

[12]ec.europa.eu/food/fvo/act_getPDF.cfm?PDF_ID=10133
[13] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=URISERV%3Af84009

and facilitating the risk management of rejected consignments. Anyway, TRACES establishment in Serbia is not without the problems, some cross border points missing this important tool (Radovic, 2014).

In line with the Food Safety Low Central registry of the Ministry of Agriculture with listed operators of food and feed in stages of production, processing and transport food was established by Agricultural Inspection Division. The registration obligation had been fulfilled as of June 2011. In 2008 there was an initiative to create an information system to support the Internal Trade Control of the Agricultural Inspection Division. Although a number of activities have been carried out however the envisaged database has not yet been established. Also, if the European Commission Progress report for 2012 stated that HACCP and risk analyses, risk communication, publication of guidelines, recommendations for food safety education and trainings along with associated IT systems needed to be upgraded (European Parlament, 2013) the activities in this field are still far below expectations. The obligation to establish Rapid alert system has not been completed although it has been introduced in the Food Safety Law (Smigic et al., 2015).

RASFF system and transnational role

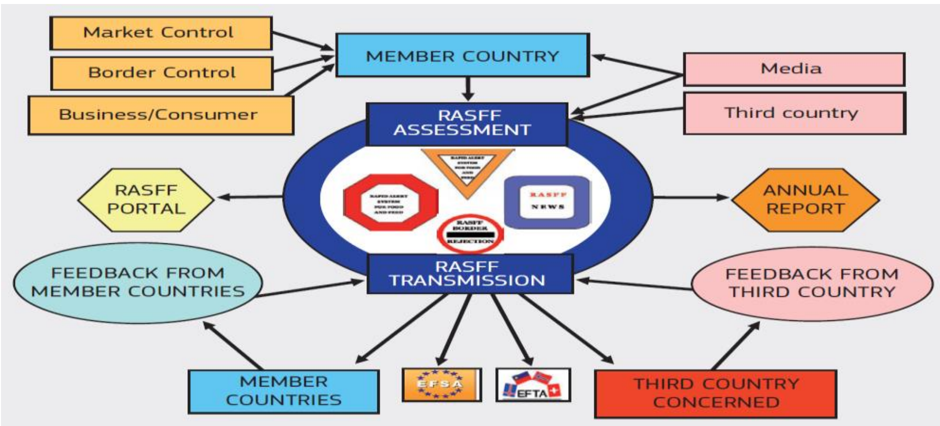
Rapid Alert System for Food and Feed (RASFF) has been established in 2002 within Article 50 of Regulation (EC) No 178/2002. The scope of RASFF covers different risks, either direct or indirect, to human health. Those risks could be derived from food or feed. The RASFF represent very effective system of communication between Member States and their contact points, some national authorities and Commission about risks from food and feed. Key elements of RASFF codification are structured in: types of notifications, different duties of the members, requirements for notification transmitting, specific tasks from Commission’s contact point’s and exchange information with other Member States of with third countries. Those key elements are codified by members experience during long period of time in specific the European Commission’s RASFF contact point (ECCP). Using RASFF, many Member States which detected food safety risks have prevent it before it could harm any consumers.

For exchanging information with third countries Commission has obligation for establishing contact with designed contact point of RASFF in any country. During 2011, above 3,800 original notifications were exchanged through RASFF. Most of notifications were caused by border controls of imported country, and most of other notifications were triggered by EU control centers. Third countries are also well informed about food and feed products exported to them which show that whole system ensuring food safety worldwide. Figure

1 shows that every Member States and especially third countries play significant role in functioning of RASFF system. On such way RASFF system developed a transnational dimension.

Firstly, every notification in RASFF system needs to be sent to the Commission. Secondly, Commission doing verification and adjustment of received information and documents and instantly forward it to all Member States and set on RASFF Portal. That case shows two role of the Commission within RASFF, one role is managing role, and other is member role. Because of that dual function European Court of Justice clarified that Commission's role as equal member of system takes precedence over managing role. Nowadays Commission publishes RASFF annual reports in which emphasize reject notifications only in agreement after consultation with Member State and third country which notified food safety problem. On such way RASFF network shows non-hierarchical nature of whole system.

Figure 1.*Shematic representation of the information flow of the RASFF*



Source: *RASFF Annual Report 2014*

RASFF Model on the Global Level

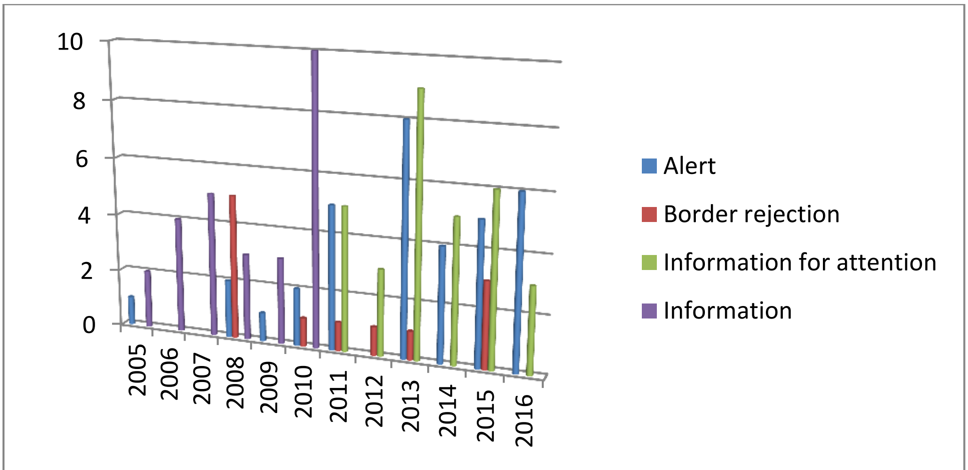
Very interesting example of extension of RASFF system on the global level represent cooperation with the International Food Safety Authorities Network (INFOSAN), which is unique system of alerting of the WHO. The main goal of INFOSAN is strengthening food safety systems. It is implemented with continuously communication between countries, across sectors and disseminating important food safety information of global relevance. INFOSAN as system constantly grow and develop. It creates strong connections with regional food safety networks and initiatives building a strong reputation in food safety emergency response around the world. Although membership to INFOSAN is voluntary, it is restricted to representatives from national government authorities and it should be officially designated. At the national level INFOSAN membership is characterized by a single INFOSAN Emergency Contact Point. Also additional INFOSAN Focal Points has been involved in food safety from each of the various government sectors. Since its launch in 2004, 186 Member States have joined INFOSAN. In addition, some Associate Member States and overseas areas/territories of Member States have also designated INFOSAN members. Sustained efforts at the Secretariat are ongoing to encourage existing members to remain active and engaged, and to advocate for all 194 members of WHO and FAO to join INFOSAN.

RASFF in case of Serbia

Serbia had published the Rulebook on the establishment and organization of the rapid alert system for food and feed (Official Gazette 62/13)[14]. Serbian organizations involved in the RASFF system are Ministry of Agriculture, Ministry of Health, Expert Council on Food Safety and Directorate for national Reference Laboratory.

Products from Serbia have been the subject of a number of notifications under the European RASFF system as presented in Graph 1.Total number of all notifications was 110 as of June 2012 of which 91 food cases, 14 feed and 5 food contact material (Figure 2).

Figure 2. ***Serbia notification by type and class***



Source: *Author's calculation based on RAFSS portal*

[14] http://www.mpzzs.gov.rs/download/Pravilnici/4827013.0062.49-1.pdf

Total number of alerts in the period 2005-2016 was 34. The maximum number of alerts was in 2013 and 2015 (8). The most important notifications was due to presence of: 1) fragment of bones of land animals in sugar beet pulp; 2) *Sallmonela spp.* in live snails, in collagen casings and in spice mix; 3) *Citorbacter spp*. in organic pumpkin seed batter; 4) Norovirus in frozen raspberries; 5) *Listeria monocytogenes* in frozen red and green peppers; 6) Aflatoxin in maize; 7) hepatitis A virus in frozen berry mix; 8) too high content of ragweed's (*Ambrosia spp*) seeds in soybean. Total number of border rejection was 12 due to: 1) deoxynivalenol (DON) in popcorn; 2) acetamipirid in green tea; 3) absence of health certificate and absence of common entry documents for hazelnut butter almonds; 4) poor hygienic state of shell dry peppers for paprika infested with moulds and with insects; 5) norovirus in frozen blackberries; 6) altered organoleptic characteristics of mushrooms in brine; 7) aflatoxin in peanuts. Notifications named as information (all type) were related to: 1) *Staphylococcus* in soft cheese in brine; 2) undeclared gluten in spice red pepper powder; 3) *Salmonell*a in spice mix or in processed feed for dogs and cats or in ice cream or in mach mallows; 4) Ochratoxin in crackers or in soft rolls with fig filling; 5) *Listeria* in smoked salmon fillets; 5) irradiation of dried mashrooms; 6) pyrimethanil, azoxystrobin and boscalid and procymidone in frozen organic raspberries; 7) dioxins in sunflower fatty acid; 8) norovirus in frozen fruit mix; 9) cadmium in baby food; 10) hepatitis A in mix of frozen berries; 11) foreign bodies (nail, wire) in rice and corn wafer; 12) aflatoxin in white maize dunst and maize; 13) dichlorvos in maize; 14) metal particles in crystal sugar.

The products from Serbia have been the subject of notifications of the RASFF system, particularly related to fruit and vegetables and most recently (2013) related to norovirus contamination of frozen raspberries and aflatoxin contamination of maize. The most public attention drew aflatoxin contamination. Until March 2013, maximum permissible concentrations of total aflatoxins (B1, B2, G1 and G2) in cereals and cereal-based products in Serbia were regulated by the Regulation on maximum residue levels of pesticides in food and feed (Official Gazette of RS, no. 25/2010 and 28/2011, Annex 5, paragraph 2.1) is in accordance with the EU regulations (Commission regulation (EU) No. 165/2010 amending Regulation (EC) No. 1881/2006). After the occurrence of aflatoxin, the Serbia adopted Amendments on Regulation on maximum residue levels of pesticides in food and feed (Official Gazette of RS, no. 20/13) and determined the maximum volume of aflatoxin M1 in raw milk, heat-treated milk and milk for production of dairy products of 0,5 µg/kg. In fact, the maximal permitted level increased 10 times, and previous regulation that was in force until 2010 was returned into the power. At that point the measure made sense because it protected domestic production (Brankov, et al, 2013). It was impossible to reach EU aflatoxin milk if Regulation on the quality of the feed (Official Gazette of RS, no. 4/2010, Article 99) is not in line with the EU regulation. Also, the incidents have showed the need to HACCP application for processes control and not just the final products. During 2014 permitted aflatoxin level was once again returned to the 0.05µg/kg. By the current law regulation (Serbian Regulation, 2015) adopted in 2015, permitted level of aflatoxin M1 in milk is 0.25 µg/kg. Recent work suggests regular monitoring to avoid the elevated level of aflatoxin M1 in milk and states huge differences in the occurrence of aflatoxin M1 in milk between the large and small producers. Big farms have a better quality control system of feeds than individual producers which have less economic ability to control feed ingredients (Polovinski et al., 2016).

Serious threat to Serbian producers of raspberries and other berries is also norovirus in frozen small fruits. Between 2009 and 2013, ten notifications relating to noroviruses in raspberries from Serbia were issued through the RASFF. Bearing in mind the importance of Serbia as world exporter of raspberries this problem requires special attention. The price of carelessness can be very high. Only one shipment of infected fruit can cause even stricter measures than the ones valid now, i.e. the control of 1 out of 10 trucks on the EU borders[15]. Without introducing strict hygienic measures, especially in cooling facilities, raspberry producers in Serbia will not be able to meet the high standards that the EU is imposing. An FVO audit was carried out in Serbia from 8 to 17 May 2013 to assess the systems in place to control microbiological contamination of raspberries intended for export to EU[16]. The conclusion stated ineffectiveness of the system by the limited monitoring of norovirus contamination of raspberries and ineffectiveness of the officially designated laboratories for norovirus analyses to provide adequate guarantees on the validity of the results. INMES Institute in Belgrade has recently received international accreditation for the detection of norovirus and hepatitis A in berries, and became the first accredited institution of its kind in the Balkans. This brings benefits to domestic exporters and producers who will now have the opportunity to test the samples at much lower prices compared to the costs of testing laboratories in Europe[17]. However, there is a need to check a certain minimum sample quantity for viruses and bacteria (was not the case

[15]http://www.ninamedia.rs/en/clipping/news/2016/05/04/norovirus-mo%C5%BEe-skupo-da-nas-ko%C5%A1ta/
[16]ec.europa.eu/food/fvo/act_getPDF.cfm?PDF_ID=10567
[17] http://www.agroservis.rs/norovirus-moze-skupo-da-nas-kosta

in previous years) and to ensure traceability from the side of cold storage plants. Until now primary source of fruits often was unknown.

Way of communication with consumers in Serbia

The good examples to describe communication with consumers in Serbia regarding disease incidence is aflatoxin. Many different points of view expressed. The Minister of Agriculture said in the course of the affair that the recent discovery of elevated aflatoxin concentration in milk stunned his ministry (Radovic, 2014), that affair had been opened in order to cause the damage for farmers and with aim to import GMOs[18] and advised consumer to buy milk without any fear. Contrary, Vojvodina agriculture secretary stated that milk in Serbia is "catastrophic"[19] and: "If you ask me whether to buy milk, the answer is no"[20]! Asked whether the milk is safe one ex-minister of agriculture says he does not buy domestic milk and cheese[21]. Director of the City Institute of Public Health recommended purchase of yogurt but not sour cream and cheese[22]. A toxicologist said the problem is that for years we drink milk with aflatoxin[23]. Consumer Association of Serbia (APOS) announced it supports the commitment of the Ministry of Agriculture to increase the allowed level of aflatoxin at 0.25 µg/kg[24]. Institute for Public Health (Batut) supported this decision[25]. A statement of the former Vojvodina agriculture secretary was: "I do not understand why they would do so"[26]. New decision about permitted level of aflatoxin in milk (0.25 µg/kg) is followed by the affirmative statements of policy makers such as: "The new level is two times more rigorous than the internationally recognized standard of 0.5 micrograms, which applies to three-quarters of the world and countries like the US, China, Russia, most of the countries of Latin America and Asia. Milk with the new levelof aflatoxin is absolutely health-safe"[27]. Suddenly, according to newspapers 0.25 µg/kg becomes rigorous standard although it is five times higher than in the EU. Aflatoxin affair showed how policy-makers, when they want, give up on the goals drawn on EU path and how consumers right to information is denied in

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[18] http://www.kurir.rs/knezevic-lobisti-nas-nece-baciti-na-kolena-clanak-668959
[19] http://www.stetoskop.info/Jesic-Mleko-katastrofalno-lose-5118-c4-content.htm?b7
[20] http://www.021.rs/story/Info/Srbija/56543/Ministar-Mleko-u-Srbiji-bezbedno-APOS-trazi-ostavke-ministara.html
[21] http://arhiva.24sata.rs/vesti/aktuelno/vest/aflatoksin-bi-u-srbiji-trebalo-da-bude-nula/78109.phtml
[22] http://www.b92.net/info/vesti/index.php?yyyy=2013&mm=02&dd=24&nav_id=689758
[23] http://www.b92.net/info/vesti/index.php?yyyy=2013&mm=02&dd=24&nav_id=689758
[24] http://mondo.rs/a837090/Info/Drustvo/Aflatoksin-APOS-podrzava-povecanje-dozvoljene-kolicine-na-0-25.html
[25] http://www.telegraf.rs/vesti/1787185-granica-za-aflatoksin-u-mleku-spustena-na-025-mikrograma
[26] http://www.021.rs/story/Info/Srbija/119415/Jesic-Zasto-dizu-nivo-aflatoksina.html
[27] http://www.telegraf.rs/vesti/1787185-granica-za-aflatoksin-u-mleku-spustena-na-025-mikrograma

Serbia. As exposed to different opinions and frequent changes about rules of such important issue Serbian consumers feel confused. If the initial decision to increase the level of aflatoxin in 2013 could be attributed to an attempt to protect domestic producers (Brankov, 2013), recent changes can be explained as inability of competent ministry to solve the problem at its source and to resist pressures from dairy industry (Smigic, 2015).

Events surrounding aflatoxin clearly demonstrated weakness of the food safety system: unfamiliarity of Serbian policy makers with the way of adequate risk communication, obvious interweaving of policy-making with inspection and the lack of transparency and professionalism (Radovic et al., 2014).

Conclusion

Serbia as well as other candidate countries must accept and fully implement EU legislation in the area of food safety by the time of accession. All products will have to meet certain standards of hygiene in order for a significant level of consumer protection to be reached. 2015 EU progress report as main obstacles in the area of food safety stated: inability of National Reference Laboratory to perform its duties, absence of reliable system for milk quality control, maximum level of allowed aflatoxin in feed and milk, animal welfare in slaughterhouses and transport, absence of national monitoring and control programme for food and feed safety as well as programme for upgrading agri-food establishments and absence of the safety food council, improper legislation on separation and treatment of animal waste, not implementation of the Law on Plant Protection Products in relation to registration [28] . In addition, recent research pointed out lack of: transparency in inspectional services work; analysis in terms of food safety trends, hygiene process indicators and food safety outbreaks; risk assessment, risk communication, publication of guidelines, recommendations for food safety education and trainings (deal of Food Safety Agency); coherent and consistent public communication about the recall or withdrawal of pasteurized milk or dairy products (Smigic, 2015).

Generally, IT development regarding food safety is insufficient. Serbian consumers are not provided with information “who, what, when, where and how” of products they purchase and they are very often exposed to different opinions about the same subject. In order to properly communicate with public it is necessary to establish unique consumer portal that would advise consumers in the event of any food incidents.

[28] http://ec.europa.eu/enlargement/pdf/key_documents/2015/20151110_report_serbia.pdf

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DETERMINANTS OF CHANGES IN SALE OF RENEWABLE ENERGY TECHNOLOGIES (RETS) IN NIGERIA AND KENYA

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Abstract

This study analysed determinants of changes in sale of Renewable Energy Technologies (RETs) in Nigeria and Kenya. A total of 22 and 41 RETs marketers were purposively selected through a snowballing and interviewed in Nigeria and Kenya respectively in 2013. Data were analysed with both descriptive and inferential statistics. Fullness of RETs package was found as a common determinant of changes in sale in the study areas. In addition, while the level of research in RETs and number collaborators had positive and significant effect on sale in Nigeria, degree of standardization influenced sale in Kenya. Provisions of financial support and advisory services to clients by marketers however have significant negative effect in Kenya against degree of domestic knowledge in Nigeria. Increase in sale in Nigeria therefore calls for more sensitization of people on the domestic uses by the marketers, while increases in number of technology collaborators, provision of both advisory and financial support to clients are imperative in Kenya.

Keywords: *Growth, energy efficiency, clean energy, energy demand, sustainability, Africa*

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Introduction

Access to energy is a prerequisite for economic and social development (Bergasse, 2013). Renewable energy generated from sunlight, wind, rain, tides, and geothermal heat, which can be replenished naturally hold great promise for meeting the energy and development needs of countries throughout the world (Ottinger and Williams, 2002). Over the last few years, investment in renewable energy technologies has steadily increased both in developed and developing countries (Wustenhagen and (Menichetti, 2012) due probably to the impact of emissions from the combustion of fossil fuels, the hazards of extracting, transporting, and refining (Benecke, 2008). This form of energy has an important role at providing energy with sustainability to the vast populations in developing countries who have no access to clean energy (Painuly, 2001). RET is considered as one of the strong contenders to improve plight of many people living in rural areas, without access to modern forms of energy (World Bank, 1999). It is one of the fastest growing components of the energy industry (Perry, 2012) because the global drives for future sustainable development require low cost, clean and renewable sources of energy (Tahvonen and Salo, 2001). But, negative perceptions about the benefits of RE sources, higher prices and distrust in accreditation processes, for example, make traditional product marketing for RE more difficult (Bloom and Novelli, 1981). Companies that invest in RETs are often seen as the riskiest types of companies (Perry, 2012). The interaction between demand and supply involving current and future prices would determine how a given remaining stock would be allocated over time. It is therefore necessary to have a good understanding of the determinants of sale growth of these technologies. This paper determines the factors affecting sales growth of renewable energy technologies (RETs) in Nigeria and Kenya.

Literature Review

Development in technology has brought about increasing demand for energy services (Orhewere, 2013). Energy security in the Economic Community of West African States (ECOWAS) region is threatened by various factors including poor system reliability, limited infrastructure, fuel import dependence, and heavy reliance on fossil fuels, hydropower, and traditional biomass resource (Renewable Energy and Energy Efficiency Status Report, 2014). Renewable energy is a key strategy to reduce greenhouse gas emissions (IPCC, 2014; Moomaw *et al.,* 2011). Renewable energy sources can provide a number of intangible benefits, such as greater energy security, lower carbon dioxide (CO_2) emissions (relative to fossil fuels) and continual innovation (IPPC, 2014; Wei *et al.,* 2010). Studies however have shown that many customers purchase renewable energy technologies even if their costs are somewhat more than conventional energy (Barbara and Ashley, 1996). Some of the barriers to the development and penetration of RETs include: high investment cost for technology development compared to other power generation modes (Fredric and Eric, 2004; Woo-Jin *et al.*, 2015); market barriers, institutional barriers, and technical barriers (Painuly, 2001).

Materials and Methods

Study area

The study was conducted in Nigeria and Kenya. Nigeria is a federal republic with 36 States and a Federal Capital Territory (FCT), which serves as the seat of the Federal Government. The country is the 12th largest oil producing country in the world and sixth in the Organisation of Petroleum Exporting Countries (OPEC), thereby making her economy to be crude oil based. The country has an estimated population of 167 million (National Population Commission, 2011) which is about 15% of the continent's population, making it the most populous country in Africa and the 10th most populous country in the world. The grid is powered by hydropower and thermal, which itself is composed of fossil fuels. The country is blessed with other resources yet un-utilized. Nigeria is endowed with an annual daily sunshine that is averagely 6.25 hours, which is ranging between about 3.5 hours at the coastal areas of the northern boundary of the nations. Nigeria also receives about 4909.212 kWh of energy from the sun which is equivalent to about 1.082 million tonnes of oil. The country also has large rivers and a few natural falls. Small rivers and streams also exist within the present split of the country into eleven River Basin Authorities, some of which maintain minimum discharges all the year round. Hydropower currently accounts for about 29% of the total electrical power supply.

Kenya has a population of 41 million (2011), 70% of whom live in rural areas and the remaining 30% in urban centres. Kenya has an area of 587,000 sq. km in total size of which 11,000 sq. km is waters bodies. In more dry zones, livestock rearing is practiced by pastoralists keeping huge herds of animals for subsistence use and with little technological inputs. The zones have immense opportunities for technology applications to develop innovative solutions to perennial draughts, nutrition for livestock, pests and disease control, installation of irrigation infrastructure, marketing of produce and introduction of draught resistant varieties of food. The survey study focused on both large and medium-small processing firms situated in Nairobi, Mombasa and other cities situated in the maize producing region such as Nakuru, Kitale, Kisumu and Eldoret. Distributors of processing equipment both local and foreign were identified and included in the survey in order to understand adoption process. Importers, distributors and local manufacturers of renewable energy equipment who are concentrated in Nairobi and its surrounding areas were also identified and surveyed.

Sources of data and methods of data collection

The field survey was undertaken between May and June, 2013. Data for the study were collected from primary source. Primary data were obtained from a cross-sectional survey of RETs suppliers and marketers using semi-structured questionnaire.

Sampling procedure

A two-stage sampling technique was used to select the respondents (RETs suppliers/marketers in Nigeria and in Kenya). In the first stage, Nigeria in West Africa and Kenya in East Africa were purposively selected based on the limited resources for the study. In the second stage in Nigeria, Lagos State was purposively selected for the survey based on the concentration of RETs marketers/suppliers in the state. In the second stage, the list of the RETs marketing/supplying firms were compiled mainly through extensive literature search, the use of internet, and snowballing. The findings revealed that over 80 percent of RET marketers/suppliers in Nigeria and Kenya are located in Lagos State and Nairobi respectively being the main industrial centre of the countries. We therefore selected Lagos State in Nigeria and Nairobi in Kenya. The suppliers were first contacted through telephone calls before the interview but while some agreed to be interviewed others refused. In all, a total of 22 RETs suppliers/marketers were interviewed in Nigeria and 41 in Kenya.

Methods of data analysis

In order to address the objectives of this study, descriptive and inferential analytical tools were employed within the innovation system framework. Descriptive statistics such as line graph, percentages, frequency distribution tables were used where necessary in order to provide insight into the distribution of RETs. Ordinary Least Square regression model was also used to determine factors affecting RETs sale growth.

Model specification

In order to analyse factors influencing sales growth RETs in Nigeria and Kenya, the study employed the ordinary least square multiple regression analysis. This was achieved by regressing the average percentage annual change in sales of RETs in the last 2 years (a proxy to sales growth) against 8 variables. The model is explicitly stated below:

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7 + b_8X_8$$

Where

$\boldsymbol{b_1}$ ------------------------ b_8 are the parameters to be estimated. The other variables are defined in Table 1

Table 1: ***Description of specified variables in the regression model for RETs***

Variables	Definition of variables	Types of measure	A priori expectation
Y	The average percent annual increase / decrease in sales in the last 2 years (sales growth of RETs)	percentage	
a	Constant term		
X_1	The fullness of a package being offered	dummy: 1 = yes; 0 otherwise)	+
X_2	The degree of domestic knowledge in RETs technology	index: 1= based on foreign technology only; 2 = involves domestic technology to a small degree; 3 = involves domestic technology to a large degree; 4 = primarily based on domestic technology	+
X_3	The degree to which the technology is standardized	index: 1 = very much standardized; 2 = great deals of customization; 3 = highly customized to individual	+
X_4	The number of technology collaborators	number	±
X_5	The degree to which the company engages in research to improve the product	percentage of sale spent on product improvement	+
X_6	The number of company actor types contributing to the development of RET	number	+
X_7	Whether or not the company offers financial support in terms of allowing instalment payment	Dummy (1 = yes, otherwise 0)	+
X_8	Whether or not company advice clients on how to obtain financial support from financial institutions or government	Dummy (1 = yes, otherwise 0)	+

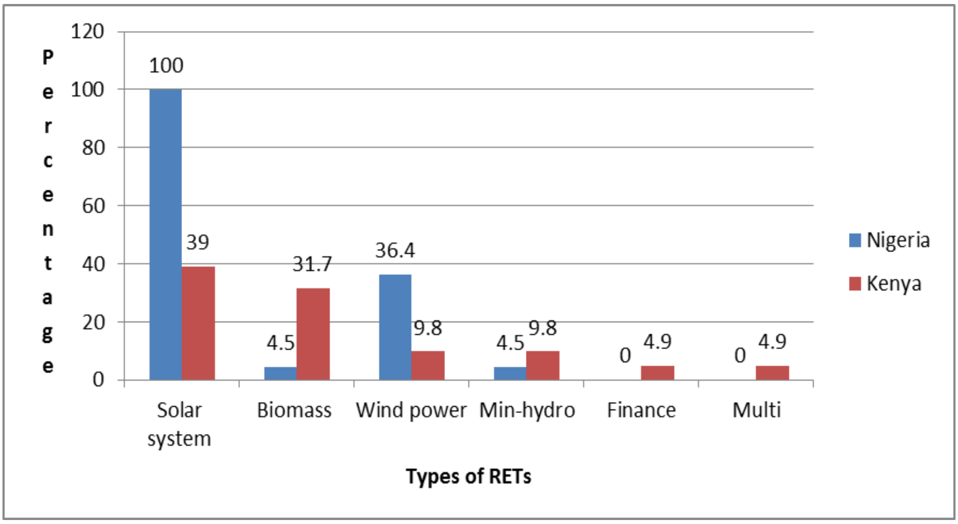
Source: Authors a priori expectation

Results and Discussion

Distribution of RETs marketers by types of products sold

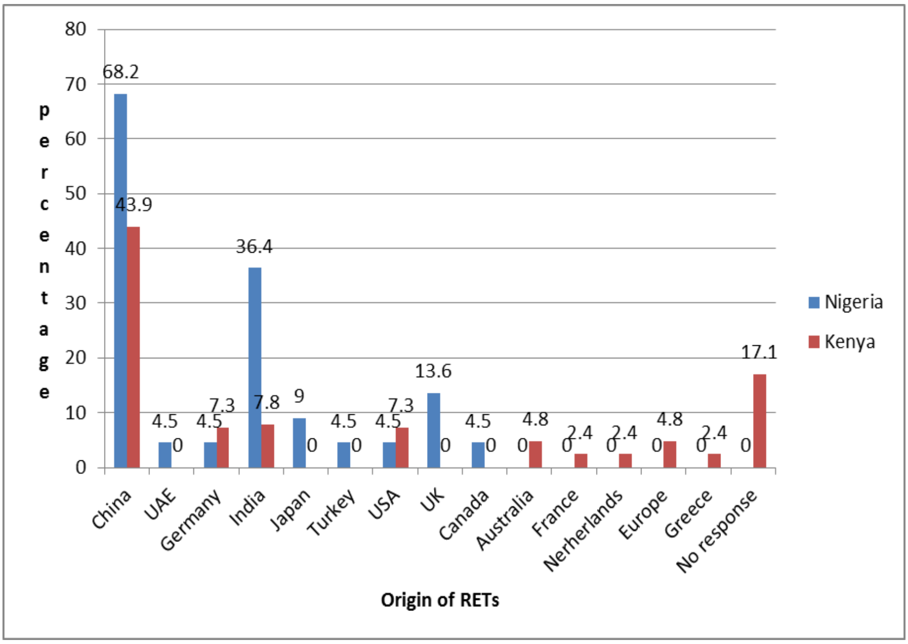
This study set out with the aim of assessing the significant factors which influence the growth in the sale of renewable energy technologies. In the process of achieving this goal, the study also identified certain trends related with respect to the location of major sales outlets, major types of RETs and countries of origin to Nigeria and Kenya. The descriptive statistics reveal a very interesting finding in terms of the location and origin of RETs marketers and importers. The majority (95.5%) of RETs marketers are located in Lagos State, Nigeria with about 54.5% of the sampled marketers found at "Alaba" International market, located in Lagos, Nigeria. Some of the suppliers/marketers have up to three outlets within the market. The concentration of the marketers in Lagos might be due to the closeness of the area to the sea port and economic agglomeration in Lagos as the Nigerian business and commercial capital. All the RET marketers surveyed are involved in sales of solar systems such as solar inverter, solar controller, solar batteries, solar panel, solar bulb/solar street lightening, solar lantern, solar fridge, solar pump, solar lantern. About 36.4% however sell both solar power equipment and wind power facilities, while the sales of biomass and mini-hydro has only 4.5% (only one respondent) (Fig.1). The sellers could not ascertain the type of buyers of these RETs owing to the fact that they only sell their products without further probe to the destination of the products. In Kenya RET distribution was more developed with more types of technologies being sold. Still, solar emerged the most popular with 39% share of firms interviewed distributing it. Also popular was biomass and in particular small biogas systems distributed by 32% of the sampled firms. Sugarcane (bagasse) provided two firms with feed stocks for energy generation and one firm with material for developing ethanol gel for use by households.

Figure 1: ***Distribution of RET markets in the research sample***



Source: Data from field survey, 2013

Figure 2: ***Origin of RETs Sold in the selected areas***



Source: Data from field survey, 2013

Determinants of sale growth of renewable energy technology in the study areas

The R^2 (the coefficient of determination) value of 0.953 in Table 2 indicates that 95 percent of the variation in RET sales growth in Nigeria was explained by variability in the specified independent variables. Common factor having a positive and significant effect ($P<0.01$) on the rate growth in the sale RETs in both Kenya and Nigeria was the fullness of RETs package offered. This is an indication that the completeness of RETs products sold determines the rate of purchase and growth rate of the technology. In addition to this, the number of technology collaborators and degree to which the company engages in research to improve RET products also have direct and significant effects on the growth in the sale of RETs in Nigeria. In Kenya, the degree to which the RETs is standardized, number and types of actors contributing to the development of RETs have positive and significant ($P<0.01$) effect on sales growth. This implied that as these variables increase the rate of growth of RETs also increases and it shows that in Kenya people really considered the quality of RETs products before purchase possibly because of the long experience of Kenyan on RETS. Lack of evidence on standards, testing and certification of RETs can lead to a decrease in sale of these technologies.

Table 2: ***Determinants of RETs sale growth in Nigeria and Kenya***

Variables	RET firms in Nigeria			RET firms in Kenya		
	Coefficients	Standard Error	t-stat	Coefficients	Standard Error	t-stat
	β	SE	t-value	β	SE	t-value
Constant	3.381	68.737	.049	-18.214	17.575	-1.036
Fullness of a package offered (X_1)	71.373***	27.728	2.574	27.717***	7.011	3.953
Degree of domestic knowledge (X_2)	-22.392*	13.193	-1.697	-2.749	2.427	-1.133
Degree of standardization (X_3)	-12.159	20.818	-.584	21.123***	2.416	8.744
No of technology collaborators (X_4)	32.779*	19.204	1.707	-3.428***	1.162	-2.951
Degree to which the company research to improve the product (X_5)	1.517***	.317	4.784	-.276	.173	-1.601
Types and number of company actor contributing to RET (X_6)	.475	5.564	.085	22.372***	3.779	5.920
Provision of financial support to clients (X_7)	-58.128	15.917	-3.652	-17.177***	4.020	-4.273
Provision of advisory services to clients (X_8)	-36.072	23.676	-1.524	-12.257***	3.923	-3.125
Diagnostic statistics						
R- squared	0.976			0.947		
Adjusted R- squared	0.953			0.985		
F-stat	5.040			25.472		
Prob. > F	0.176			0.011***		

Note: Dependent Variable: RET sale growth rate, *** Significant at P<0.01, * significant at P<0.1

On the other hands, variables such as the number of RETs collaborators, provision of financial supports to clients by RETs firm/marketers as well as advisory services to clients have a negative and significant ($P<0.01$) influenced on RETs sales growth in Kenya while in Nigeria, the degree of domestic knowledge in RETs had similar effect ($P<0.1$). This implied that these variable still decrease the sale growth of RETs in the two countries instead of increasing it as expected.

Conclusion and Recommendations

This study examined the factors underlying the growth in the sale of renewable energy technologies in Nigeria and Kenya. The evidence from this study suggests that the most prominent type of RETs in use in both counties is solar technologies mainly source from China. The common factors having positive and significant effects on RETs sale growth in the two countries was also found to be the fullness of a package being offered by RETs firms/marketers. The finding suggests in order to enhance increase the rate of sales of RETs in the two countries the types of RETs must be the one that will be a complete package saving the buyer the stress and cost of looking for other accessories before enjoying the benefits. Provision of financial support by firm to clients in terms of allowing part or instalment payment on products bought and advisory services to clients by firm on how to obtain financial support from financial institutions or government are imperative in order to increase RETs sale growth in Kenya, while in Nigeria, degree of domestic knowledge in RETs has to be strengthened by both the RET marketers/ firms and government through sensitization on the various benefits that can be derived from the use of RETs is to be increased.

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SESSION TWO

New Technologies and Changes in Supply Chain Organization and Performance

NEW TECHNOLOGIES IN PRECISE AGRICULTURE AND POSSIBILITIES OF APPLICATION IN SERBIA

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Abstract

The constant growth of the world population increases the need for food. Price level of food has a long-term growth on the world market. This has a direct effect on the number of malnutrition people in the world. Therefore, there are greater demands set upon the sustainable agriculture in terms of optimization and lower production costs, increase of yield and improving the quality of agricultural products, but also the protection of the environment and human health.

Under certain condition application of new technologies (autonomous machines, robots, drones and nanotechnology) in the system of precise agriculture could respond to these requests. Innovations in agriculture can achieve goals without the need for genetic modification of seeds and application of total herbicides which are harmful to the health of both farmers and consumers.

In Serbia, the development of precision farming based on the application of new technologies is in the stage of "pioneer" venture of certain agribusiness companies.

Key words: *precision agriculture, new technologies (autonomous machines, robots, drones and nanotechnology), the efficiency of agricultural production, Serbia.*

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Introduction

Innovation as a result of multidisciplinary skills is becoming a key factor in the competitiveness of agriculture in the XXI century.

The objective of this paper is to get acquainted with new technologies in precision agriculture and their existing or potential application in Serbia.

The paper is based on research opportunities to improve precision farming using drones, autonomous agricultural machinery, robots and nanotechnology.

Since this is a review paper a descriptive method is used. The material used in this writing consists of the research and work of domestic and foreign authors published in scientific publications and other journals.

About precision agriculture

In the past few decades, agricultural production has experienced serious changes. In the late 20th and early 21st century, we have witnessed revolutionary discoveries, and some of them are still waiting for their full implementation. Today's agricultural production is transformed into a high-tech enterprise which many farmers of the first half of the 20th century would not able to recognize. (Thomasson, 2015)

In the decade ahead, the automation of agricultural machinery will play an extremely important role in the agricultural revolution. (Li, et al., 2015);

"The technology based on a computerized information system and global positioning, transforms commercial agriculture around the world. This technology, often referred to as "precision agriculture" gives a new life to an old idea of management at the specific location by reduction of costs: obtaining information about crops and variable costs of inputs."(Bongiovanni, et al., 2011)

Today's technology allows the production of precise navigation systems that can help farmers to properly allocate the fertilizer and chemicals needed to the soil. (J. F. McLellan et al., 1996)

To solve the problems of traditional precision farming, such as obtaining information in real time, a small area that can be covered, work-intensive production and similarly, a system of wireless sensor networks can be applied. This system allows you to collect a variety of data on the capacity of the land, climate conditions, the need for water, nutrients and that they transmitted in real time via GPS to the farmers computer. (Xia, et al., 2011)

In modern agriculture, farmers are high-tech operators because they use GIS software for planning, GPS to monitor operations in the agricultural area and the automatic guidance system for the tractors. (Brown, 2013)

The pictures obtained by drones are used as a supplement to satellite imagery, ground imaging and soil testing. The usefulness of the obtained images is increased and the need for frequent soil testing is reduced by linking the soil test results and imagery obtained by drones which enables more effective and more frequent oversight. In this way, it is faster to reach the required information for agrarian managers action. (Walthall, 2011)

In cattle breeding, drones can be used to monitor cattle grazing, control area of grazing and verification of basic health conditions (such as fever) (Mladenović, 2016).

There has been breakthrough of automated machines in the process of milking cows. Instead of using conventional milking highly specialized robots for milking are now applied. An autonomous system of milking also been designed where cows come up to milking machines (expecting a reward - food), without the presence of man, and robots based on the principles of sensors detect the udder and connect the milking machines on it (Brouček, 2015).

Nanotechnology brings innovations in the field of animal health, control and improvement of the quality of livestock products.

In recent years, application of nanotechnology in agriculture has increasingly been attracting attention. Nano materials under development offer the possibility of more efficient, less harmful manipulation and application of pesticides, herbicides and additives precisely controlling when and where they will be omitted. (Kuzma et al., 2006).

In 2016 the European Commission adopted a Strategic approach to investment in agricultural research and innovation in the European Union, separating five strategic areas that are divided into two segments, one of them is related to the increase of innovation and modernization in the rural sector (European Commission, 2016). How Plewa (2016) points out, this document will serve as a basis for the Horizon program 2018 to 2020.

Research results

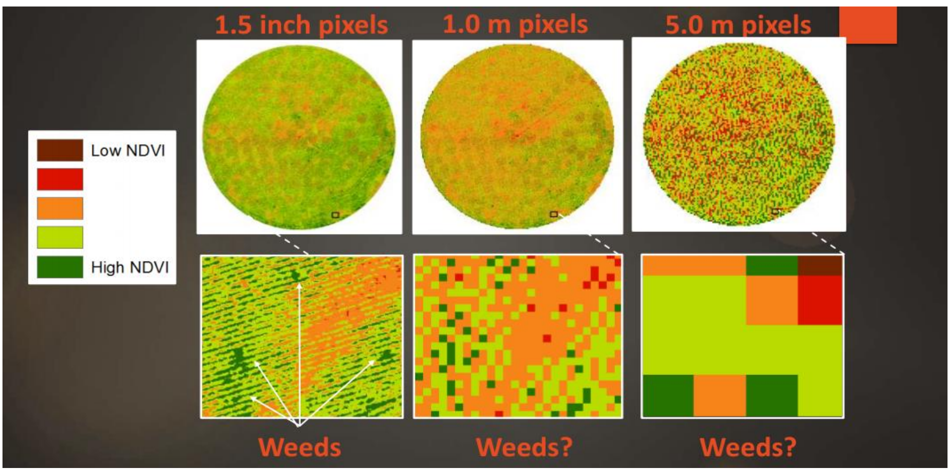
To achieve a higher level of precision and efficiency in the production process it is necessary to make a clear distinction between precision agriculture and the introduction of new technologies. In addition to precision farming, drones are already used to facilitate the process of surface mapping for easy guidance of self-propelled tractors and other agricultural machinery, and facilitate the process of crop monitoring and locating the necessary interventions over them, and reduce the cost of frequent testing area. Using records obtained by drones, software and global positioning system (GPS) precision command to entirely autonomous machine can be specified, which can perform a work processes without the human factor. Last but not the least, nanotechnology could facilitate the additional crop control and care completely.

The paper focuses on four new technologies that can bring precision farming to an entirely new and more efficient level. For precision farming it is necessary a software solution for planning a circled process of agricultural production, from soil preparation to harvest. These softwares already exist, it is only necessary to further develop and capture new tasks placed before them by innovative development and apply the new technologies in agricultural production.

Drones

Although they may have a multiple use in agricultural production, we consider drones in this paper as an additional tool in precision agriculture. In relation to satellite imagery, one of the advantages of drones is quality photos that can be recorded with cameras that are attached to them. Based on Figure 1, we can notice a change in the quality of photos taken from different distances, or via drone, aircraft and satellites. These differences are reflected in the resolution of images. You can see, from left to right, that we have less precise shots that show us the Normalized Difference Vegetation Index (NDVI - Normalized Difference Vegetation Index).

Figure 1. ***Differences in image quality depending on the type of aircraft used***



Source: *Price, 2014*

Current research is oriented towards achieving higher quality records that can generate additional information. VVT Technical Research Centre in Finland has developed a Fabry-Perot Interferometer (FPI) based on Hyperspectral camera that is compatible with low capacity of drones. (Sarri, et al., 2011)

If we observe a full automation of processes, records obtained by drones can be directly transferred via GPRS technology in software that farmers use for planning. Independently software process the obtained photos and turn them into information necessary for action. With the development of the GPS technology and technology management drones, with the help of satellites a desired area can be mapped for a drone to fly over so that the need for a human factor can be further reduced.

The records obtained by drones with the use of an appropriate software can be converted into information that are priceless. Information by drones farmers can use obtained to improve the production planning process given by precision agriculture. (Honkavarra, et al., 2012)

"By uploading different types of crops records, obtained by the use of drones we can obtain precise information on the composition and quality of the land, the state of the crops, how to plan the harvest and harvesting crops, which should be the first walkthrough of the machines, which amount of the fertilizer is necessary to apply in a certain part of the parcel and the like."(Mladenović, 2016)

Records obtained from the drone can contribute to a more precise mapping walkthrough of the agricultural machines, which lead to higher levels of efficiency in agricultural production.

It is necessary to point out the shortcomings of the implementation of drones, among which it is of particular importance that no autonomous drones have yet benn commercialized, and those that are on sale are not easy to use. In addition the drone shots of lower quality due to windy weather should be omitted.

As far as Serbia is concerned, we should point out the small average size of a family farm - only 4.56 ha (Census of Agriculture 2012), and a drone capacity is 60-120 ha of agricultural land per day. Also, by the Rule Book of unmanned aircraft (Official gazette of RS, number 108/2015) in Serbia import the drones and their use for any purpose is limited.

Autonomous agricultural machinery and robots in agriculture

Precision agriculture is directed to the use of agricultural machinery that will completely autonomously, carry out the processing of land and all the processes important for the efficient cultivation of agricultural crops, without people who directly manage it.

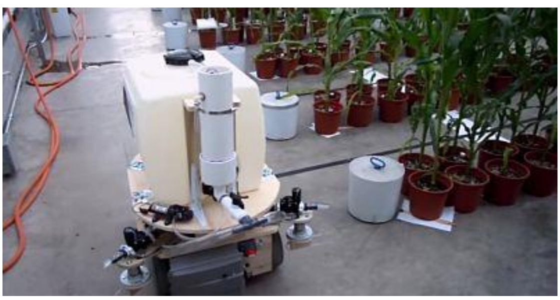
Some manufacturers of agricultural machinery have included in their offer machines that incorporate an automatic guidance system, and these devices can be installed into existing tractors. Work on these machines means a certain amount of human labor. Namely, the man must be in the machine during its operation to turn the machine at the end of each row, checking the path and whether processes are working properly.

Today, precision farming involves the use of automated agricultural machines, but if you go one step ahead soon it could include autonomous machines. This types of machines are capable to perform all work processes completely independently without the presence of people in the machine, like a robot programmed to do a specific task. This allows the comfort from your armchair on your phone, tablet, computer or TV watching the machine perform its work processes on the land all on its own.

Research in the field of robotics brings more and more new types of robots that can be used in the agricultural production. The largest number of robots is applied to enclosed (indoor) systems. It opens the possibility of robots performing sowing and monitoring crops (taking care of health of crops, removing the weed, taking care of the fertilization and irrigation of plants,) and selectively collect only ripe fruit. (Pedersen et al., 2008). The analysis has shown that the application of robots in agriculture may lead to a reduction of the necessary investment in agricultural production, the size of the tractor and the surface of the application (in terms of the precise application of fertilizers, pesticides and water only to areas needed instead of on the entire surface). For example, investing in a tractor could be reduced by about 60%, and the cost of annual maintenance of tractors and machines for about 65%. (Pedersen et al., 2006).

In this paper, we present a few interesting examples of the application of robots in practice. Aquarius is a robot that is used for accurate and efficient watering the plants in a greenhouse, wearing a tank capacity of 30 gallons.

Figure 2. Aquarius



Source: *Introbotics, 2015*

Rowbot is used in the cultivation of maize for checking the state of the crop, but also for the application of nitrogen as needed. It is shown in Figure 3.

Figure 3. *Rowbot*

Source: *Tobe, 2014*

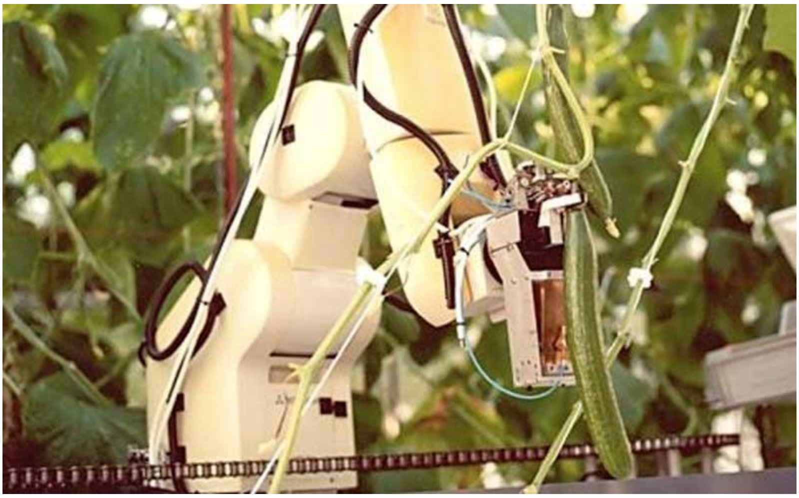
Hortibot , shown in Figure 4 , is successfully identifies , and removes up to 25 different species of weeds.

Figure 4. *Hortibot*

Source: *Introbotics, 2015*

Robot for harvest cucumber is shown in figure 5.

Figure 5. Wageningen UR cucumber harvesting robot



Source: *Tobe*, *2014*

Nanotechnology

"Nanotechnology is a field of researching and innovations with the aim of building "stuff "- in general, materials and devices - at the level of atoms and molecules. A nanometer is the billionth part of a meter: diameter ten times larger than an atom of hydrogen. Diameter of a human hair on average is 80,000 nanometers. On this scale, a school known rules of physics and chemistry are not applicable. For example, material properties, such as their color, the ability of the material as a conductor and reactivity, can vary significantly at the nano and macro scale. Nano tubes made of carbon are 100 times stronger than steel, but six times lighter." (Brahic et al., 2005)

The ability to manipulate a mater at the nano level can contribute to a better understanding of the processes and the creation of improved materials, structures, devices and systems that with new features will improve their performance and efficiency in the exploitation (Sastry, et al., 2010).

The application of nanotechnology can greatly assist the sustainable development of agriculture. For almost a decade a discussions has been opened on application of nanotechnology in the food industry, but also in agriculture. Questions of influence of nanotechnology on health, biodiversity and ecology are sharing scientific community . (Pocket K No. 39, 2011) However, benefits that nanotechnology can offer are gaining more supporters in the scientific community. In favor of this fact tells a marked increase of scientific papers and patents in the field of nanotechnology, where the number of patents have increased 10 times in the past two decades (Brand, 2011). We should be carefull with the society's attitude as a whole to a new technology, because it can affect the speed of diffusion (Kuzma et al, 2006).

In agriculture, nanotechnology may enable reduction of pollution entering the controlled environment of pesticides, which will operate on the nano level in areas where the infection is located. Also, the system of "smart" delivery of active ingredients can influence a reduced amount of dietary supplements plants. Certainly, in this way we can optimize plants requirements for water, as well as perform the process of water purification. (Brahic, et al., 2005). Along with all the above mentioned, import of certain nano particles in the soil can also contribute to increasion of crop yield. (Jurjevic, et al., 2015/2016). Can nano fertilizers and pesticides contribute to precision farming? The systems of "smart" delivery of necessary fertilizers, pesticides, water, control and monitoring via touch sensors can raise precision farming to a whole new level. Of course, we should be careful with any new technology. It is necessary to do additional testing to detect previously mentioned potential risks of nanotechnology applications. As one of the major obstacles for the application of nanotechnology in agriculture, particularly in the econimacally poorer countries emphasize the the amount of the costs of research and its application in practice. In agriculture, the initial investment in the application of nanotechnology, are extremely high, and for now can they only be cost-effective for large agricultural areas. (Paris et al., 2014). Application possibilities of nanotechnology and the fields of research in agricultural production are shown in Table 1.

Table 1. ***Relevant applications in agricultural nanotechnology and examples of successfull applications at small scale or R&D stage.***

	Definition	**Example**	**Source**
Crop production			
Plant protection products	Nanocapsules, nanoparticles, nanoemulsions and viral capsids as smart delivery systems of active ingredients for disease and pest control in plants	Neem oil (Azadirachta indica) nanoemulsion as larvicidal agent (VIT University, IN)	C.H. Anjali, Y. Sharma, A. Mukherjee, N., Chandrasekaran, Pest Manage. Sci. 68 (2012) 158—163

Fertilizers	Nanocapsules, nanoparticles and viral capsids for the enhancement of nutrients absorption by plants and the delivery of nutrients to specific sites	Macronutrient Fertilizers Coated with Zinc Oxide Nanoparticles (University of Adelaide, AU CSIRO Land and Water, AU Kansas State University, US)	N. Milani, et al., J. Agric. Food Chem. 60 (2012) 3991—3998
Soil improvement			
Water\liquid retention	Nanomaterials, e.g. zeolites and retention nano-clays, for water or liquid agrochemicals in the soil for their slow release to the plants	Soil-enhancer product, based on a nano-clay component, for water retention and release (Geohumus-Frankfurt, DE)	http://www.geohumus.com/us/products.html
Water purification			
Water purification and pollutant remediation	Nanomaterials, e.g. nano-clays, filtering binding to a variety of and toxic substances, including pesticides, to be removed from the environment	Filters coated with TiO2 nanoparticles for the photocatalytic degradation of agrochemicals in contaminated waters (University of Ulster, UK)	T.A. McMurray, P.S.M. Dunlop, J.A. Byrne, J.Photochem. Photobiol. A-Chem. 182 (2006) 43—51
Diagnostic			
Nanosensors and diagnostic devices	Nanomaterials and nanostructures and (e.g. electrochemically active carbon nanotubes, nanofibers fullerenes) that are highly sensitive bio-chemical sensors to closely monitor environmental conditions, plant health and growth	Pesticide detection with a liposome-based nano-biosensor (University of Crete, GR)	V. Vamvakaki, N.A. Chaniotakis, Biosens. Bioelectronics 22 (2007) 2848—2853.

Plant breeding			
Plant genetic modification	Nanoparticles carrying DNA or RNA to be delivered to plant cells for their genetic transformation or to trigger defence responses, activated by pathogens.	Mesoporus silica nanoparticles transporting DNA to transform plant cells (Iowa State university, US)	F. Torney, B.G. Trewyn, V.S.Y. Lin, K. Wang, Nat. Nanotechnol. 2 (2007) 295—300.
Nanomaterials from plants			
Nanoparticle s from plants	Production of nanomaterials through the use of engineered plants or microbes and through the processing of waste agricultural products	Nanofibres from wheat straw and soy hulls for bio-nanocomposite production (Canadian Universities and Ontario Ministry of Agriculture, Food and Rural Affairs, CA)	A. Alemdar, M. Sain, Bioresour. Technol. 99 (2008) 1664-1671.

Source: *Parici et al., 2014*

New technologies in agriculture of Serbia: state and development opportunities

Is precision agriculture present in Serbia? There are a few examples of application of new technologies in the form of computerized agricultural machines in agricultural production in large agrcultural companies (MK Group, Delta agrar, Al Rawafed Serbia, Agri Business Partner, Mirotin Group, Almex, ...) and on a larger family farms, and a robot for milking cows in just one farm (“Fotos” in Crepaja, in company “Almex” Pančevo).

Figure 6. ***Robot for milking cows on farm in Crepaji – Almex, Pančevo***

Figure 7. ***John Deere Air Seeder on an Al Rawafed Serbia farm***

In Serbia, still there is no application of drone and nano technology in agriculture. Are we ready for the wider development of precision agriculture and what are the limits for its application in Serbia? Serbia is characterized by a dual model of agriculture. According to the Agricultural List in 2012, on one side, there are 3,000 legal entities of different organizational forms (agribusiness companies, agricultural companies, cooperatives and entrepreneurs), and on the other side, there are 628,522 family farms. (Ševarlić M., 2014)

In the following period there are possibilities of application of new technologies in a small number of capital-intensive agribusiness companies oriented to achieving greater competitiveness in production with sales of agri-food products in the international market, such as the MK Group, Delta Agrar, ...

However, the application of precision agriculture on family farms (PPG) is quite limited due to the fragmentation of their land (with an average of only 4.56 ha of agricultural owned), a very unfavorable economic situation (subsidies for plant production were reduced in 2015 from 100 to only 20 ha or five times, and in 2016 with 100 euros to 33 euros per hectare or three times). Exceptionally, the application of new technology could be available to a larger joint family farms who controlled over 100 ha - which, according to the Agricultural List in 2012 was 1,364, or 0.22% of total 628,522 PPG, but they are disposed of 227,065 ha or 8, 04% of the 2,825,068 ha of total agricultural land PPG. (Ševarlić M., 2015)

In particular, the limit for the application of new technologies on family farms is insufficient education and age structure of farmers. It must be added that the number of advisers in Serbia decreased from 713 in 1997 to only 261 in 2012. adviser or 63.4%, which indicates that we do not have enough expertise for transfer of new technologies on family farms. (Ševarlić M., 2003)

The previous statement is confirmed by a comparative analysis of number of advisors for family farms in Serbia and two ex Yugoslav republics - Slovenia and Croatia, which are now members of the European Union. Namely, in order to increase the number of advisors increase to the level of ex republics in Yugoslavia, Serbia needs to increase the number from the current 261 experts:

- "*number of advisors according to the surface of agricultural land*: 453 advisors or to hire an additional 192 advisers to the level of development of advisory services in Croatia, or even 1,075 advisors or hire another 814 advisors to be at the level of advisory services in Slovenia; and
- *number of advisors according to the number of family farms*: 660 advisors or to hire 399 advisors that would be at the level of development of advisory services in Croatia, or even the 2,770 advisors or to hire an additional 2,509 advisors that would be at the level of advisory services in Slovenia. " (Nastić R., 2016: 58)

Besides increasing the number of agricultural advisors in Serbia, it is necessary to pay more attention to a new approach of permanent education for sustainable development farmers and especially agricultural experts, which is based on “interdisciplinary learning, new knowledge, skills and attitudes, creative thinking, innovation and a long- term perspective.” (EC, 2016 b: 13)

Conclusion

The application of new technologies in agriculture is hurridly taking place together with the processes of globalization of production and the enlargement of land and livestock farms, especially in countries with industrialized agriculture.

The end of the 20th and the beginning of the 21st century have brought new technologies in agriculture, among which the most important ones are precision farming, the use of unmanned spacecraft and robots in agriculture, while the use of nano technology in agriculture is yet to show their unimagined possibilities in the coming years - with solving a mystery in terms of environmental sustainability applying nano technology.

In Serbia, the application of precision agricultural machines is present - mainly in large agribusiness companies, with nice land holdings and large family farms, while the use of the robots significantly less frequent - in just one cows milking farm and in experiments for irrigation and recharge of vegetables in greenhouses. Because of the complicated legal procedures the applications of drones and other unmanned spacecraft is not yet represented in the Serbian agriculture, but it would be important for the establishment especially in the very unsecured agricultural advisory service, while the application of nanotechnology today is only spoken of at scientific meetings but is not present in the production practice.

A particular problem for the application of new technologies in agriculture is insufficient education of farmers and the fragmentation of family farms that have investment potential for the application of new technologies.

Finally, for new technologies in agriculture to be applied we should supply answers given by multidisciplinary scientific research on major economic, social and environmental dilemmas, such as:

- Do new technologies in agriculture reduce the number of jobs and the economic viability of farmers and workers in agriculture?
- Does the application of new technologies in addition to increasing productivity in agricultural production worsens the impact on the environment and accelerates demographic devastation of agricultural areas?

- Do new technologies in agriculture reduce social cohesion of farmers and agricultural workers as well as numerous participants in the chain "from farm to fork"?
- Do new technologies in agriculture contribute more to the economic welfare of producers of new technologies in the industry rather than the welfare of farm owners, or whether farms are becoming more and more just "water heater" for the transfer of capital from agriculture to industry of new technologies?
- Should farmers, due to the application of new technologies, give up the direct physical contact with their fields and plants, barns and livestock, with nature and other participants in the process of agricultural production?

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FARM ACCOUNTANCY DATA NETWORK AS A TOOL FOR MEASURING EFFICIENCY OF APPLIED NEW TECHNOLOGIES IN AGRICULTURE

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Abstract

The aim of the paper is to determine potential use of Farm Accountancy Data Network (FADN) as a tool for measuring efficiency of new technologies in agribusiness sector in EU and Serbia.

The paper provides a broader context for understanding the concept of new technologies as a Precision Agriculture and Smart Agriculture. Effective system for measuring results of applied new technologies in agriculture is analyzed in this paper both at the level of individual farms and agrarian policy.

FADN is the accountancy system uniform for all EU countries. As the FADN has same methodology in collecting and processing data for all EU countries, results are comparable for all EU countries and candidate countries. Serbia has started with FADN introduction in 2011 and an efficient system has been established so far.

Results of the paper are showing that FADN can be excellent tool for measuring effects of the new technologies' application. The FADN data as e.g. the used working unit (AWU), fixed capital, variable expense, yields per hectare, profit margin can be used as indicators for effectiveness of the new applied technologies. In this paper there are suggested some new indicators which could be included within the FADN.

Keywords: *Precision Agriculture, Smart Agriculture, FADN, Efficiency of new technologies.*

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Introduction

The Food and Agriculture Organization (FAO) estimates that there will be 9 billion people in the world by 2050. It will be needed 70% increase in food production compared to 2005 level to feed the aforementioned people. Thus we have to grow, harvest, distribute and consume our food more efficiently. Considering the fact that we are not gaining additional resources such as land or water, the only solution lies in introducing new technologies in agriculture (FAO, 2002).

One of the new technologies in agriculture the international scene has paid great attention to is the Precision Agriculture. Applications of precision agriculture include auto-guiding systems and variable-rate technology that allow for precise tillage, seeding, fertilization, irrigation, herbicide and pesticide application, harvesting and animal husbandry. Crop management and aspects of animal rearing are optimized thanks to the use of information collected from sensors mounted on-board agricultural machinery (soil properties, leaf area, animal internal temperature) or derived from high resolution remotely sensed data (plant physiological status). The benefits to be obtained include increased yields and profitability (mainly for arable farmers), increased animal welfare, and improvement of various aspects of environmental management (EU Directorate general for internal policies, 2014).

It is important for all countries to monitor the situation in the field of application of modern technologies in agriculture with aim that subsidies in new technologies be conceived to deliver optimal effects. Measuring of new technologies efficiency beside importance for the agrarian policy is important for farmers in order to measure efficiency of new technologies implemented at the farm level (Vasiljevic et al., 2012).

FADN is an important instrument in measuring the efficacy of new technology in agriculture in the EU and candidate countries with established FADN (Vasiljević, 2012).

The Farm Accountancy Data Network (FADN) is an instrument for evaluating the income of agricultural holdings and the impacts of the Common Agricultural Policy and national agricultural policies. The concept of the FADN was launched in 1965 when Council Regulation 79/65 established the legal basis for the organization of the network. It consists of an annual survey carried out by the Member States of the European Union. The services responsible in the Union for the operation of the FADN collect every year accountancy data from a sample of the agricultural holdings in the European

Union. Derived from national surveys, the FADN is the only source of microeconomic data that is harmonized, i.e. the bookkeeping principles are the same in all countries. Holdings are selected to take part in the survey on the basis of sampling plans established at the level of each region in the Union. The survey does not cover all the agricultural holdings in the Union but only those which due to their size are considered commercial. The applied methodology aims to provide representative data along three dimensions: region, economic size and type of farming. While the European Commission is the primary user of analyses based on FADN data, the aggregated data can be found in the Standard Results database (Regulation (EC) No 1166/2008).

The aim of the network is to gather accountancy data from farms for the determination of incomes and business analysis of agricultural holdings. Currently, the annual sample covers approximately 80,000 holdings. They represent a population of about 5,000,000 farms in the EU, which covers approximately 90% of the total utilized agricultural area (UAA) and account for about 90% of the total agricultural production. The information collected, for each sample farm, concerns approximately 1,000 variables.

It is important to note that the collecting and processing methodology is the same for all EU countries thus the FADN data are comparable between them.

FADN data can be used for monitoring of the situation in the fields of modern technologies in agriculture, as well as the effects of agricultural policy at the macro level. The farmers included in the FADN sample can use FADN Feedback form to monitor the effects of the applied new technologies on the farm.

FADN as a tool for measuring efficiency of applied new technologies in agriculture – macro level

At the macro level, the FADN allows EU member states to compare results of applied new technologies in agriculture. At the national level it measures the efficiency of agricultural policy (primarily subsidies) in the field of new technologies in agricultural production.

In this part of the paper there are presented indicators that have been already available within the FADN, as well as indicators that can be calculated from existing data.

Table 1: ***Labor data as indicators of new technologies efficiency - FADN 2013***

Country	Labor input (SE011*)	Total Utilized Ag. Area (SE025)	Labor input in hours/ha	L (Labor input/avg labor input)	$K_{Labor\ input}$
Belgium	4962.52	49.3	100.66	0.65	34.99%
Bulgaria	4575.53	35.22	129.91	0.84	16.10%
Cyprus	2935.91	9.12	321.92	2.08	-107.90%
Czech Republic	13597.69	232.93	58.38	0.38	62.30%
Denmark	3399.23	96.84	35.10	0.23	77.33%
Germany	4942.63	86.63	57.05	0.37	63.15%
Greece	2539.51	9.31	272.77	1.76	-76.16%
Spain	2615.21	39.31	66.53	0.43	57.03%
Estonia	4393.76	128.27	34.25	0.22	77.88%
France	3300.64	85.87	38.44	0.25	75.18%
Croatia	3354.27	14.59	229.90	1.48	-48.48%
Hungary	3426.51	45.02	76.11	0.49	50.85%
Ireland	2576.97	51.36	50.17	0.32	67.60%
Italy	2685.14	15.55	172.68	1.12	-11.52%
Lithuania	3945.71	50.31	78.43	0.51	49.35%
Luxembourg	3899.02	78.5	49.67	0.32	67.92%
Latvia	4037.04	69.16	58.37	0.38	62.30%
Malta	3135.4	2.57	1,220.00	7.88	-687.91%
Netherlands	5842.43	34.61	168.81	1.09	-9.02%
Austria	3264.55	32.39	100.79	0.65	34.91%
Poland	3831.58	19.11	200.50	1.29	-29.49%
Portugal	3022.15	25.53	118.38	0.76	23.55%
Romania	3097.14	9.9	312.84	2.02	-102.04%
Finland	2595.9	55.53	46.75	0.30	69.81%
Sweden	3049.2	102.45	29.76	0.19	80.78%
Slovakia	27758.5	594.82	46.67	0.30	69.86%
Slovenia	2611.27	11.38	229.46	1.48	-48.19%
United Kingdom	5180.02	166.15	31.18	0.20	79.87%

Source: *FADN, Labor input in hours/ha, L (Labor input/avg labor input) and* $K_{Labor\ input}$ *author's calculation based on FADN data.*
*Additional information on SE data can be found on FADN web page: http://ec.europa.eu/agriculture/rica/concept_en.cfm.

Information related to labor can be used as an indicator for new technologies application with assumption that new technologies will have lower labor input[4].

First it is calculated Labor input in hours/ha, than for each country average labor input compared to EU. $K_{\text{Labor input}}$ is calculated as:

$K_{\text{Labor input}}$ = (1- Labor input/avg labor input)*100%

According to the table 1 more efficient technologies and lower labor hours/ha has Denmark with only 29.76 hours/ha, Labor input/avg labor input 0.19 (almost five times lower use of labor hours/ha compared to EU average) and $K_{\text{Labor input}}$ 80.78%. Malta has most hours/ha and more extensive production with 1,220 labor hours/ha.

Table 2: ***Production data as indicators of new technologies efficiency - FADN 2013***

Country	Yield of wheat (SE110)	D_{wheat}	Yield of maize (SE115)	D_{corn}	Milk yield (SE125)	D_{milk}
Belgium	90.38	71.14%	128.21	55.58%	6998.21	7.74%
Bulgaria	42.75	-19.05%	68.86	-16.44%	3160.46	-51.34%
Cyprus	3.97	-92.48%	67.7	-17.85%	7481.36	15.18%
Czech Republic	57.62	9.11%	72.21	-12.38%	7348.07	13.13%
Denmark	72.59	37.46%	79.52	-3.51%	8858.33	36.38%
Germany	78.25	48.17%	81.25	-1.41%	7696.43	18.49%
Greece	31.13	-41.05%	123.88	50.32%	6043.39	-6.96%
Spain	33.92	-35.77%	116.08	40.86%	7073.13	8.89%
Estonia	35.66	-32.47%	/	/	7961.83	22.58%
France	73.45	39.08%	81.15	-1.53%	6890.09	6.08%
Croatia	48.05	-9.01%	69.34	-15.86%	4051.33	-37.63%
Hungary	47.49	-10.07%	57.43	-30.31%	6496.71	0.02%
Ireland	85.65	62.19%	/	/	5362.06	-17.45%
Italy	54.53	3.26%	97.08	17.80%	5797.92	-10.74%
Lithuania	47.02	-10.96%	/	/	5561.06	-14.39%
Luxembourg	63.64	20.51%	58.81	-28.64%	7025.11	8.15%
Latvia	38.89	-26.36%	/		5713.18	-12.04%
Malta	/	/	/		6516.82	0.33%
Netherlands	88.11	66.84%	117.76	42.90%	7901.28	21.64%

[4] Information on labor hours/ha and K coefficient should be analyzed with data from the table 3 output/ha.

Austria	51.35	-2.76%	93.65	13.64%	6493.81	-0.03%
Poland	52.74	-0.13%	79.78	-3.19%	5107.38	-21.37%
Portugal	20.86	-60.50%	77.2	-6.32%	7044.79	8.46%
Romania	39.14	-25.89%	51.39	-37.64%	3357.34	-48.31%
Finland	40.35	-23.59%	/	/	8665.06	33.40%
Sweden	57.87	9.58%	65.01	-21.11%	8560.02	31.78%
Slovakia	46.4	-12.14%	54.49	-33.88%	6260.45	-3.62%
Slovenia	47.19	-10.64%	73.01	-11.41%	5122.35	-21.14%
U. Kingdom	76.99	45.79%	99.3	20.50%	7324.62	12.77%
EU Average	52.81		82.41		6495.45	

Source: *FADN*, D_{wheat}, D_{corn}, D_{milk}, *author's calculation based on FADN data*.

Assumption is that new technologies will lead to higher yield[5]. D_{wheat}, D_{corn}, D_{milk} are calculated:

D_{yield} = (Country yield/EU average yield-1)*100%

According to the table 2 the highest efficiency in applied technologies has Belgium for wheat and corn, while Denmark has the highest D coefficient for milk - 36.38%, and best technologies in milk production. Bulgaria and Romania are countries with the lowest D coefficients and the lowest technologies applied in agricultural production.

Table 3: ***Production output as an indicator of new technologies efficiency - FADN 2013***

Country	Total output (SE131)	Total output/ha	Total output / Total input (SE132)	Total crops output / ha (SE136)	Total livestock output / LU (SE207)
Belgium	265975	5395.03	1.15	2008.89	1175.98
Bulgaria	38872	1103.69	0.96	782.4	927.14
Cyprus	40769	4470.28	1.18	1713.24	1773.62
Czech Republic	344709	1479.88	0.89	830.5	1230.44
Denmark	484484	5002.93	1.06	1526.62	1678.69
Germany	266707	3078.69	1.06	1261.14	1530.15

[5] This indicator has to be followed with analysis on climate, soil fertility and water supply in compared countries.

Greece	21783	2339.74	1.27	1697.27	1022.16
Spain	52181	1327.42	1.3	874.74	866.66
Estonia	111296	867.66	0.9	460.57	1296.95
France	195887	2281.20	1.01	1247.46	1107.24
Croatia	23200	1590.13	1.06	913.53	904.23
Hungary	65507	1455.06	1.02	925.2	1157.25
Ireland	69754	1358.13	1.05	252.79	930.58
Italy	52951	3405.20	1.41	2450.03	1085.53
Lithuania	42555	845.85	1.08	499.75	1205.48
Luxembourg	192653	2454.17	0.93	572.94	1182.49
Latvia	56694	819.75	0.94	463.06	1047.94
Malta	39675	15437.74	1.25	6640.77	1627.18
Netherlands	490248	14164.92	1.12	5931.48	1768.38
Austria	75255	2323.40	1.1	642.31	1506.46
Poland	31390	1642.59	1.15	828.75	1127.12
Portugal	29499	1155.46	1.24	801.51	800.97
Romania	12967	1309.79	1.49	754.35	796.86
Finland	106543	1918.65	0.77	945.75	1740.2
Sweden	199885	1951.04	0.89	905.75	1302.46
Slovakia	609681	1024.98	0.78	621.55	865.1
Slovenia	25047	2200.96	0.9	1039.37	826.05
United Kingdom	257008	1546.84	1.02	685.09	1035.18

Source: *FADN, Total output/ha is author's calculation based on FADN data*.

It is assumed that efficient new technologies will lead to the high Total output/ha, Total crops output / ha, and Total livestock output / LU. According to the table 3 Malta and Netherlands have the highest level of applied new efficient technologies with 15,437.74 and 14,164.92 €/ha, while Netherlands and Denmark are leading countries in applied new technologies in livestock production.

Table 4: ***Production inputs as indicators of new technologies efficiency -FADN 2013***

Country	Total Utilized Agricultural Area (SE025)	Total Inputs (SE270)	Total inputs/ha
Belgium	49.3	231400	4693.71
Bulgaria	35.22	40647	1154.09
Cyprus	9.12	34576	3791.23

Czech Republic	232.93	387348	1662.94
Denmark	96.84	458104	4730.52
Germany	86.63	250848	2895.63
Greece	9.31	17171	1844.36
Spain	39.31	40213	1022.97
Estonia	128.27	123493	962.76
France	85.87	193424	2252.52
Croatia	14.59	21969	1505.76
Hungary	45.02	64056	1422.83
Ireland	51.36	66417	1293.17
Italy	15.55	37524	2413.12
Lithuania	50.31	39554	786.21
Luxembourg	78.5	206081	2625.24
Latvia	69.16	60233	870.92
Malta	2.57	31767	12360.70
Netherlands	34.61	436823	12621.29
Austria	32.39	68585	2117.47
Poland	19.11	27207	1423.70
Portugal	25.53	23860	934.59
Romania	9.9	8698	878.59
Finland	55.53	139104	2505.02
Sweden	102.45	223814	2184.62
Slovakia	594.82	780671	1312.45
Slovenia	11.38	27813	2444.02
United Kingdom	166.15	253070	1523.14

Source: *FADN.*

The highest output with higher level of technologies applied is followed by higher inputs.

Modern technologies are characterized by higher fixed costs and lover variable costs per production area.

According to the table 4, Malta and Netherlands have the highest implemented technologies with the highest inputs/ha, due to the large percentage of indoor production in these two countries.

Table 5: ***Farm value and income as indicators of new technologies efficiency - FADN 2013***

Country	Gross Farm Income (SE410)	Gross Farm Income/ha	Farm Net Value Added (SE415)	Farm Net Value Added (SE415)	Farm Net Income (SE420)	Farm Net Income/ha
Belgium	119795	2429.92	86559	1755.76	57678	1169.94
Bulgaria	24353	691.45	19483	553.18	8866	251.73
Cyprus	19462	2133.99	15876	1740.79	11248	1233.33
Czech R.	178006	764.20	138603	595.04	53979	231.74
Denmark	205377	2120.79	162003	1672.89	59011	609.37
Germany	127625	1473.22	95768	1105.48	49958	576.68
Greece	16413	1762.94	12811	1376.05	10487	1126.42
Spain	32019	814.53	28623	728.14	22059	561.15
Estonia	48373	377.12	32218	251.17	16716	130.32
France	95917	1117.00	62665	729.77	31580	367.77
Croatia	11436	783.82	7212	494.31	4702	322.28
Hungary	34911	775.46	28848	640.78	17083	379.45
Ireland	37256	725.39	28281	550.64	22172	431.70
Italy	33638	2163.22	26707	1717.49	20757	1334.86
Lithuania	24230	481.61	16404	326.06	14081	279.88
Luxembourg	120485	1534.84	65291	831.73	44908	572.08
Latvia	25630	370.59	16725	241.83	9861	142.58
Malta	15490	6027.24	12947	5037.74	11140	4334.63
Netherlands	199540	5765.39	147865	4272.32	66820	1930.66
Austria	47556	1468.23	30012	926.58	25402	784.25
Poland	16678	872.74	11951	625.38	9835	514.65
Portugal	19457	762.12	15765	617.51	13432	526.13
Romania	8564	865.05	7293	736.67	6133	619.49
Finland	55510	999.64	31387	565.23	17857	321.57
Sweden	79532	776.30	52615	513.57	16286	158.97
Slovakia	268247	450.97	176076	296.02	-8683	-14.60
Slovenia	13863	1218.19	5905	518.89	5711	501.85
United K.	116256	699.71	83846	504.64	46465	279.66

Source: *FADN, Gross Farm Income/ha ad Farm Net Income/ha is author's calculation based on FADN data*;

Farm value and income can be indicators of new technologies efficiency. As the new modern technologies are costly higher, the farm value will indicate higher level of applied technologies. Income indicators are important in measuring new technologies efficiency as it is expected that applied technologies will lead to the higher farm income. According to the Gross Farm Income/ha indicator, Malta and Netherlands have the highest level and efficiency of implemented new technologies with 6,027.24 and 5,765.39 €/ha.

Table 6: ***Assets as indicators of new technologies efficiency - FADN 2013***

Country	Total fixed ;ets (SE441)	Total fixed assets/ha	Machinery (SE455)	Worth of Machinery/ha
Belgium	631212	12803.49	75305	1527.48
Bulgaria	46593	1322.91	20265	575.38
Cyprus	144176	15808.77	16734	1834.87
Czech Republic	742030	3185.64	258559	1110.03
Denmark	2125149	21944.95	192081	1983.49
Germany	748454	8639.66	119312	1377.26
Greece	103258	11091.08	21978	2360.69
Spain	199955	5086.62	16116	409.97
Estonia	193372	1507.54	69636	542.89
France	260265	3030.92	84340	982.18
Croatia	141972	9730.77	19639	1346.06
Hungary	105732	2348.56	28650	636.38
Ireland	866954	16879.95	34403	669.84
Italy	281063	18074.79	24829	1596.72
Lithuania	78835	1566.98	36274	721.01
Luxembourg	976202	12435.69	212516	2707.21
Latvia	98350	1422.06	30757	444.72
Malta	180331	70167.70	25439	9898.44
Netherlands	1976903	57119.42	151498	4377.29
Austria	357816	11047.11	78046	2409.57
Poland	145669	7622.66	25372	1327.68
Portugal	81982	3211.20	14917	584.29
Romania	29546	2984.44	5555	561.11
Finland	358794	6461.26	70872	1276.28
Sweden	704736	6878.83	135415	1321.77
Slovakia	576034	968.42	136476	229.44
Slovenia	185353	16287.61	32132	2823.55
United Kingdom	1635705	9844.75	122426	736.84

Source: *FADN, Total fixed assets/ha and Worth of Machinery/ha is author's calculation based on FADN data.*

Data on average farm assets as indicators of new technologies efficiency are based on the fact that new technology is costly and higher value of asset is indicator of higher level of technologies applied. Higher worth of machinery is indicating higher level of technologies on farms. According to the Worth of machinery, Malta has the highest level of applied technology and it is followed by Netherlands.

Table 7: ***Investments as indicators of new technologies efficiency - FADN2013***

Country	Net worth (SE501)	Change in net worth (SE506)	Gross Investment (SE516)	Net Investment (SE521)
Belgium	530896	39163	47048	13812
Bulgaria	61353	6116	9304	4434
Cyprus	170636	-12951	1199	-2387
Czech Republic	763875	56140	68257	28855
Denmark	1053465	19517	72751	29376
Germany	708037	13165	49729	17871
Greece	107616	-3084	581	-3021
Spain	254967	-905	2099	-1297
Estonia	179773	9000	37300	21145
France	266556	1065	30805	-2447
Croatia	150990	-597	1644	-2580
Hungary	143837	8395	7791	1729
Ireland	903112	28628	13432	4457
Italy	387049	21408	3030	-3902
Lithuania	103859	4573	12015	4188
Luxembourg	883727	25083	98160	42967
Latvia	103032	8622	18182	9277
Malta	187048	-763	1977	-566
Netherlands	1512948	72781	69777	18102
Austria	402305	1534	23615	6070
Poland	156299	1697	4073	-653
Portugal	104417	3551	5665	1972
Romania	38989	2426	697	-574
Finland	319519	7235	26498	2376
Sweden	597376	-44693	33952	7035
Slovakia	898147	-60500	106346	14174
Slovenia	195437	3112	8953	996
United Kingdom	1629095	91813	47303	14894
EU Average	272905	8147	9838	677

Source: *FADN.*

Investments as indicators of new technologies efficiency are based on the fact that for new technologies investments are needed. Higher investment is needed for the higher level of technologies.

For agrarian policy related to new technologies it is important to analyze gross investment, net investment, net worth, as well as changes related to these indicators.

FADN as a tool for measuring efficiency of applied new technologies in agriculture on farms

Farmers can use FADN in measuring efficiency of applied new technologies on farms. There are two possibilities.

First, farmers included in the FADN are receiving on the annual level FADN Feedback form.

Feedback form contains farmer's data compared with the average data for producers within the same line of production.

Second possibility for farmers not involved in the FADN is to use FADN public reports and compared with their own data.

Feedback form is not conditioned by the EU, thus each EU Member State decides on the Feedback forms.

Farmers not involved within the FADN can use FADN reports and FADN public database and compare their own data with FADN averages.

FADN indicators are giving to the farmers the answers to questions such as:

1. What are the effects of the application of new technologies on the farm?

2. Is there improvement in average operating result after applying the new technology?

3. Is the new technology improving the average operating results on farm compared to all the farmers involved in the same line of work in its own country and compared to other EU countries?

Table 8: ***An example of a Feedback form within the FADN system in Serbia***

		Farm data	Group average
General indicators			
	Total utilised agricultural area (UAA) - ha	70,00	91,00
	of which rented land - ha	50,00	65,00
	Labour input - AWU	2,5	3,3
	of which paid labour input - AWU	1,6	2,1
	Wages of paid labour per hour - RSD/h	45,00	58,50
	UAA per labour - ha/AWU	6,0	7,8
	Yield of wheat - kg/ha	5 678	7 381
	Milk production per cow - kg/cow	6 756	8 783
Financial indicators (RSD)			
+	Total output	7 000	9 100
	Crop production	4 000	5 200
	Livestock production	5 000	6 500
	Other production	2 000	2 600
-	Total intermediate consumption	5 000	6 500
	Specific costs	3 000	3 900
	Farming overheads	2 000	2 600
+	Balance current subsidies & taxes	1 500	1 950
=	Gross Farm Income	3 500	4 550
-	Depreciation	600	780
=	Farm Net Value Added	2 900	3 770
+	Balance subsidies & taxes on investments	200	260
-	Total external factors	1 900	2 470
	Wages paid	1 000	1 300
	Rent paid	400	520
	Interest paid	500	650
=	Family Farm Income	1 200	1 560

Source: *FADN Serbia.*

In addition to the mandatory information required by the European Commission, each national FADN system may include information that is intended for use at national level. So it can be recommended an inclusion in the collection procedure, processing and Feedback form the direct data on application of new modern technologies. For example, it can be recommended to include the following:

- Data on the use of alternative energy sources, solar, wind and biomass;
- Data on irrigation;
- Information about using technologies like sensor automatic irrigation and fertilization, the use of satellite-guided machinery, etc.

Conclusion

According to the survey analyzed in this paper, it could be concluded based on the indicators used, that the highest level of applied technology in agricultural production have Malta and Netherlands, while the lowest level have Bulgaria and Romania (in 2013).

Given the growing importance of increase in average yields and environmental protection caused primarily by constant increase in the number of inhabitants in the world, application of new technologies are getting more and more important.

The tendency of governments is to create incentives aimed at development and application of new technologies. One of the basic conditions for a successful national agricultural policy as well as application of new technologies on the farm is to establish an effective system for monitoring the results of the new technologies' application at the macro and micro level.

Analyses in this paper show that the FADN system can be useful for analyzing the efficiency of application of new technologies on the farm through the Feedback form and/or the public FADN database.

The recommendation could be given to the inclusion of information related to the application of new technologies within the national FADN.

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PRODUCTION OF HARD CHEESE FOR THE RUSSIAN MARKET

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Abstract

Given that the production of milk and dairy products in Serbia is to some extent compromised, because there is already an influx of cheap dairy products from the EU, all to the detriment of domestic producers, and it also don't benefit consumers because they do are not able buy cheaper products, it is necessary to look for other solutions. The Russian market is interesting because good prices can be achieved and large quantities of products sold. Hard cheese is particularly interesting because it is known for its quality and long shelf life. The problem of our dairies is that almost no dairy produces hard cheese for cutting and grating from cow's milk, mainly hard cheeses of pasta filata type, and smaller amounts of hard cheese are made from sheep's milk. The group of hard cheeses includes large number of varieties of cheese which are divided into extra-hard, hard with holes and hard without holes. They are characterized by: low moisture content, which is achieved by size of particles during the cutting of the cheese curd and using the high temperature processing of the curd; clean rind, or not having rind at all in the case that it is packed into some sort of foil and a method of ripening under the influence of an enzymes originating from a starter culture, non-starter bacteria and rennet. This is hard cheese, that goes through a series of physical-chemical and microbiological changes during the ripening period, affecting the sensory characteristics. Below the rind is straw-colored dough, without any cracks, which melts in the mouth. The flavor is delicate, mildly sharp, but not too narrow and complete despite a low fat content.

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Hard cheeses have a long ripening period, and thus have greater digestibility, higher concentration of free amino acids and a higher concentration of short and medium chain free fatty acids. The high concentration of calcium in cheese has significant impact on the formation and protection of teeth and bones, prevention of osteoporosis and hypertension. Thanks to its high sensory and nutritional properties, and also long shelf life, hard cheese Čarnok has a high commercial value.

Čarnok cheese is mainly sold in whole sheave or cut to pieces on the spot in shops or packaged into ¼ kg pieces.

This paper describes the technological process of making hard cheese called Čarnok produced in Dana dairy plant in Vrbas. This is a new type of hard cheese in Livno cheese type that is produced in Serbia, which is already on the domestic market and will soon be exported to the Russian market.

Key words: *hard cheese, Russian market, ripening, Čarnok*

Introduction

Given that the production of milk and dairy products in Serbia is to some extent compromised, because there is already an influx of cheap dairy products from the EU, all to the detriment of domestic producers, and it also don't benefit consumers because they do are not able buy cheaper products, it is necessary to look for other solutions. The Russian market is interesting because good prices can be achieved and large quantities of products sold. Hard cheese is particularly interesting because it is known for its quality and long shelf life (Ottavio, 2001). The problem of our dairies is that almost no dairy produces hard cheese for cutting and grating from cow's milk, mainly hard cheeses of pasta filata type, and smaller amounts of hard cheese are made from sheep's milk.

Cheese has always been an important food in the diet of people, and now has a wider significance as a cultural and traditional treasures of the country. In Serbia extra hard cheese made from whole milk which can be used for cutting and scrubbing is hardly producing, so that in our market this type of cheese is mostly imported. Traditionally, hard cheeses are produced without the addition of starter cultures from raw sheep's milk, less than goat or cow milk. Today, the majority of hard cheeses are made from pasteurized milk (mainly cow, less sheep and goat milk) with addition of thermophilic starter culture. During production, curd is drying at high temperatures (40-52 °C), which is important step for the formation of hard consistency.

The group of hard cheeses includes large number of varieties of cheese (Slanovec and Kervina, 1982) which are divided into extra-hard, hard with holes and hard without holes (Kammerlehner, 1989). They are characterized by: low moisture content, which is achieved by size of particles during the cutting of the cheese curd and using the high temperature processing of the curd; clean rind, or not having rind at all in the case that it is packed into some sort of foil and a method of ripening under the influence of an enzymes originating from a starter culture, non-starter bacteria and rennet (Kutle, 1996; Kirin et al., 2003).

This paper describes the technological process of making hard cheese called Čarnok which is a new product in Serbia that is already placed on the market and will soon be exported to the Russian market.

Materials and methods

Production of Čarnok cheese was introduced in dairy "Dana" in Vrbas, part of the Mirotin company. The dairy is modern and well equipped, and got approval of the Veterinary Administration for export to Russia. The first quantities are agreed and cheese is produced every day, and after the completion of the ripening process deliveries to the Russian market will begin. Physical-chemical analysis of cheese was done in Faculty of Agriculture, Novi Sad, using standard methods.

For production of cheese, milk from their own dairy farm "Sava Kovačević" is used, whose quality is in the accordance with the Technical regulations on milk and milk products of the Russian Federation (2008).

In terms of safety of cheese and other milk products, followed are the regulations drawn up in accordance with the Agreement on common principles and rules of technical regulation in the Republic of Belarus, the Republic of Kazakhstan and the Russian Federation of 18 November 2010.

Results and discussion

Basic technological stages of making hard cheese are shown on Figure 1, pasteurisation (Figure 2), horizontal device for coagulation of milk (Figure 3), transport of curd into molds (Figure 4), cheese molds (Figure 5), horizontal press (Figure 6), cross section after pressing (Figure 7), cheese put in brine (Figure 8), control of pH level during brining (Figure 9), dying of cheese (Figure 10), ripening of cheese (Figure 11), and packaging (Figures 12 and 13).

Figure 1. ***Technological process of production of hard cheese***

Milk	Full fat or partially skimmed
Adding $CaCl_2$ and	10-15 minutes before adding the culture
Adding the culture	During production from raw milk culture is not added, in the production from pasteurized milk thermophilic and mesophilic are added
Adding the rennet	Rennet powder (previously dissolved in a little water) is added after the addition of the culture after about 20 min. After adding rennet, milk is mixed thoroughly and mixer is turned off
Coagulation	Coagulation time is 40-45 minutes
Cutting the curd	Very fine cutting and grinding of curd 15-20 minutes
Heating and drying	Heating is done gradually to during 15-20 minutes to a temperature of 41-43 °C and at this temperature drying of curd grains is performed in the course of 30-40 minutes
Take out the cheese curd	Removing the cheese curd and placing into molds (molding). Some manufacturers allow a cheese curd to connect and form a lump at the bottom of the boiler or the tub, and then coarsely cut and transfer into molds, and the others tranfer the grain directly into molds and is compressed manually
Pressing	In the press at a pressure that is lower in the beginning and then gradually increases (2-4-6 bar)
Acidification	It takes place as needed and in a cool room (12-13 °C) after pressing to pH 5.20 to 5.30
Salting	Dry salting / In brine (with 20 % sat at 10-12 °C)
Ripening and packaging	Ripening is from 3 months to 2 years. In the first 30 days it is turned every day, and in the later period once a week. Upon completion of the maturation, next steps are washing, drying, coating, drying, labeling and packaging

Source: *Author view (Popović-Vranješ, 2015)*

Figure 2. ***Pasteurisation***

Source: Author archives

Figure 3. ***Horizontal device for cheese production***

Source: *Author archives*

Figure 4. ***Cheese ready for moulding***

Source: Author archives

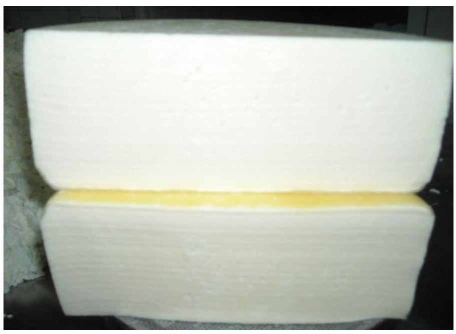
Figure 5. ***Cheese moulds***

Source: Author archives

Figure 6. ***Horizontal press***

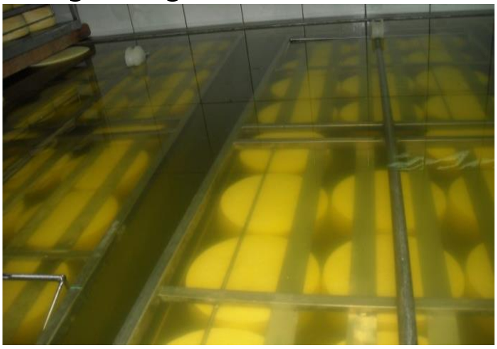
Source: *Author archives*

Figure 7. ***Appearance after pressing***



Source: *Author archives*

Figure 8. ***Cheese in brine during brining***



Source: *Author archives*

Figure 9. ***Control of pH level***

Source: *Author archives*

Figure 10. ***Drying of cheese***

Source: *Author archives*

Figure 11. ***Cheese ripening***

Source: *Author archives*

Figure 12. ***Packaging of cheese***

Source: *Author archives*

Figure 13. ***Packed cheese***

Source: Author archives

The quality of milk and the processing conditions that are used for making cheese should be standardised so that consistent quality products are made each time. This involves control of factors in the process that affect the quality or safety of the product. These are known as ‘control points’ and are the points at which checks and measurements should be made. Hard cheese making involves a number of main stages that are common to most types of cheese. The cheese milk, full fat or partially skimmed is pre-treated, after addition of a bacteria culture appropriate to the type of cheese, and mixed with rennet. During production of hard cheese from raw milk culture is not added, in the production from pasteurized milk thermophilic and mesophilic cultures are added. 0.02% of calcium chloride is normally enough to achieve a constant coagulation time and result in sufficient firmness of the coagulum. Excessive addition of calcium chloride may make the coagulum so hard that it is difficult to cut.

The enzyme activity of the rennet causes the milk to coagulate to a solid gel known as coagulum or curd. This is cut with special cutting tools into small cubes of the desired size – in the first place to facilitate expulsion of whey. During the rest of the curd making process the bacteria grow and form lactic acid, and the curd grains are subjected to mechanical treatment with stirring tools, while at the same time the curd is heated according to a preset programme (Kosikowski and Mistry, 1997).

The combined effect of these three actions – growth of bacteria, mechanical treatment and heat treatment – results in syneresis, i.e. separation of whey from the curd grains. The finished curd is placed in cheese moulds, which determine the shape of the finished cheese.

The cheese is pressed by applying pressure to the moulds. Treatment during curd making and pressing determines the characteristics of the cheese. The actual flavour of the cheese is determined during the ripening of the cheese.

The following control points affect the safety and quality (flavour and texture) of hard cheese (Practical Action Handbook, 2008):

- The temperature and time of heating and cooling the milk. Over-heating and slow cooling causes changes to flavour, colour and nutritional value; under-heating may result in inadequate destruction of enzymes and micro-organisms leading to spoilage or food poisoning.
- Correct amount of rennet and starter culture added, which affects the firmness of the curd.
- Incubation temperature to allow rapid production of lactic acid by the inoculated bacteria. If the temperature is too high the bacteria and rennet will be inactivated, if it is too low there may be insufficient acid production.
- Adequate cutting and draining of the curd to remove most of the whey.
- Correct time and temperature of cooking the curd to firm it sufficiently.

- Correct amount of salt added.
- Correct time and pressure during pressing the curd to give the required texture in the final product.
- Correct time of ripening and ripening conditions, which affect the flavour and texture.

Reasons for imperfect cheese:

- Sour acid flavour is due to too much lactic acid produced by the fermentation, or too much whey retained in the curd.
- Yeasty or sweet flavours indicate that yeasts, moulds or bacteria were introduced into the cheese by unclean utensils or a contaminated starter culture, or that the milk was not properly pasteurised.
- Soft, wet curd is due to too much moisture in the cheese, the development of too much acid during the fermentation, heating the curd at too high or too low a temperature.
- Tough, dry curd results from insufficient acid development in the curd before it is cut, cutting the curd too finely, heating to a temperature that is too high, or holding the curd for too long after cooking.

Čarnok cheese is mainly sold in whole sheave or cut to pieces on the spot in shops or packaged into ¼ kg pieces.

Commercial Čarnok cheese assortment includes selling cheese ripened for certain periods (barring the "young", also pieces aged 8, 12, 14, 18 or more months are sold).

Cheese Čarnok during the ripening period goes through a series of changes, physical-chemical and microbiological, affecting the sensory characteristics. Changes during ripening must be controlled in order to be an indicator of current maturity and therefore the quality of the cheese (Popović-Vranješ et al., 2013).

Table 1. ***Nutritive value of Čarnok cheese (100 g)***

Milk fat (%)	32,25-33,41
Milk protein (%)	25,36-26,08
Dry matter (%)	64,70-67,42
Salt (%)	2,20-2,45
Water (%)	32,58-35,30
pH	5,33-5,43

Source: *Author archives*

Figure 14. ***The final product - Čarnok cheese***

Source: *Dairy Dana, Vrbas*

Table 2. ***Quality control of Čarnok cheese during ripening***

Structure the dough	The thickness of the crust, flavor and fat of the dough	„Incision“ with knife
Elasticity of the mixture which must be as in fresh cheese. Cheese which resembles leafiness shows segments that easily break, and the mixture is fragile and easily crumbles.	Hardness and thickness of the crust (matured cheese with less fat or cheese with a hard rind, openning is a little more difficult)	Structure must be homogeneous, without holes or with very small holes scattered, fine granularity, with large granularity indicates processing at elevated acidity
Structure must be homogeneous, without cracks, no leafing, no excessive granulation	The smell of dough, which should be neither acidic nor sulphurous	The color should be of hay or white, unchanged on the air (cheeses obtained from milk with antibiotics often change color in the air) and the right taste, not too spicy
Sensory properties, the corresponding smell and taste, absence of decaying, and uncharacteristic smell and taste	Fatness of dough: less fat cheese makes a hard dough, fat cheese makes a softer dough	Aroma which must be full in case of the mature cheese; Lack of defects (cracks, bloating, leafiness ...) which can be observed visually

Source: *Faculty of Agriculture Novi Sad, Department of Animal Science*

According to the realized import of cheese, in 10th place in the world is the Russian Federation, with imports of 328 thousand tons, accounting for 5.9% of total world imports, with a tendency to decrease slightly (2011-2015.). The average value of imports of cheese in value of 1.549 billion USD. These imports come from 45 countries of the world (Ferrantino, 2016). In *Graph 1*. an obvious decline in imports of cheese to the Russian Federation, with 295.000 tons in the 2010, to 200.000 in 2015. Maximum import was in 2013. when it stood at over 350.000 tonnes.

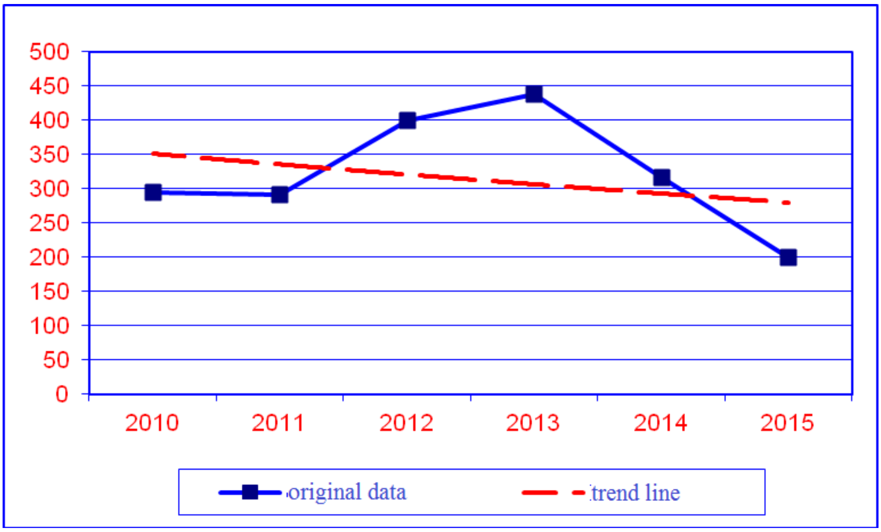
The largest import is realized from Belarus, the average of 120 thousand tons, with a tendency to very significant growth. In 2015, imports from the said country has reached 160 thousand tons and accounted for 80% of total imports of cheese in the Russian Federation. This is followed by Argentina with 10 thousand tons. The Republic of Serbia is in third place in the Russian imports with the average amount of just over five thousand tons per year. In 2015, this amount rises to nearly 9 thousand tons, representing 4% of total imports of cheese. The average value of imports of cheese from the Republic of Serbia amounted to 17.8 million USD. Largest import by total value was in 2014 and amounted to 28 million USD. The average import price of cheese from the Republic of Serbia amounted to 4.03 USD per kilogram. The Russian Federation is the most important market for exports of cheese from the Republic of Serbia, which absorbs two-thirds of total exports of cheese.

Figure 8. ***Hard cheese as a specialty***

Source: *Author archives*

If it could be done to get semi-hard and hard cheeses rid of tariffs and restrictions on exports to the Eurasian Union, the export value of these types of high-quality dairy products could reach an additional five million dollars a year. Several domestic companies at the moment export cheeses, among them the "Dairy" Šabac, "Imlek" and "Kuč", while several smaller manufacturers received permits and start with the sale of dairy products in these markets. "Imlek" exports on the market of the Russian Federation about 300 tons of white cheese per month. It would be important that specific types of cheeses are liberated of costs of about 15%, which is the customs, so they would become competitive in the market. The signing of the Eurasian Trade Agreement, besides the Russian Federation, opens new markets of Belarus, Kazakhstan, Armenia and Kyrgyzstan. Customs Union of Russia, Belarus and Kazakhstan is a market of over 180 million consumers, and the Republic of Serbia has privileged trading conditions.

Graph 1. ***Import of cheese in Russian Federation (2010-2015.), in 000 tons***



Source: *Intracen statistics: http://www.intracen.org/*

Table 3: ***Structure of cheese export from Republic of Serbia (2010-2015.)***

Country	Average value (t)	Structure (%)
Russian Federation	4.413	52,5
Montenegro	1.764	20,9
Macedonia	777	9,2
Bosnia and Herzegovina	697	8,3
Croatia	281	3,3
Other	472	5,8
Total	***8.404***	***100,0***

Source: *Intracen statistics: http://www.intracen.org/*

This is a good opportunity for manufacturers of special types of cheeses which have not been competitive in the Russian market, but are accepted well among their consumers. It is possible to increase exports of cheese to increase competitiveness provided that sanctions against EU continues to remain in force. Therefore, all the benefits that are now available on the market of the Russian Federation should be utilized (Ferrantino et al., 2016). Serbia has not used the full opportunity for the export of white cheese to the Russian market, which is very appealing. However, that type of production should be standardized and the same quality provided, because in this way the manufacturers more easily found buyers.

Many authors advocate the formation of clusters of which would have a direct link with markets that sell goods.

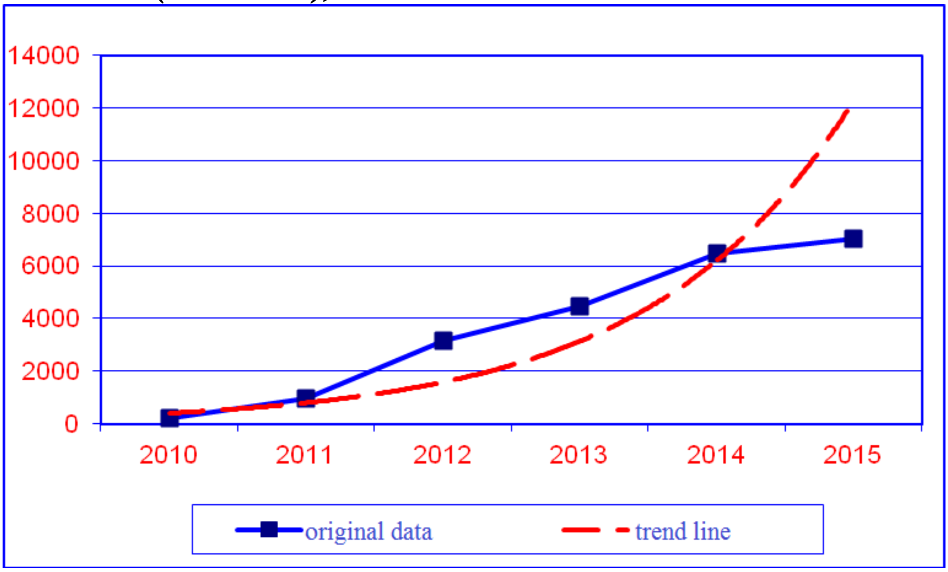
In addition to these countries, a major import is realized from Armenia, Uruguay and Switzerland. All of these countries dominate the structure of imports with a share of over 90% (2015).

Countries that have previously dominated the Russian imports (Sedik et al., 2003): Ukraine, imports fell from 56.000 tons in 2012, to only about three thousand tons in 2015. This is due, among other things, the political conflict between these countries (McCarthy and Berry, 2015). Imports from Germany amounted to 73.000 tonnes (2012), decreases to only 23 tons in 2015. Imports from Lithuania amounted to 40.000 tonnes (2012), falling to just over a thousand tons in 2015. Imports from the Netherlands amounted to 36.000 tonnes (2012) drops to only 20 tons in 2015. Imports from Finland was down from 32.000 tons (2012) to several dozen tons in the last year analyzed. Polish exports was down from 21 thousand (202) to several dozen tons.

It is evident that there is a significant change in the import of cheese of the Russian Federation, and it shold be expected that the Republic of Serbia with its quality cheeses should position well in the Russian market in the future.

With the achieved consumption of eight kilograms per capita, Russia is far behind the European average. Starting 2012. there was a significant expansion of consumption of cheese. The resultant is the increase of knowledge about the types of cheese and gourmet qualities of different types of cheese, increase in culture of wine consumption and therefore the consumption of cheese. Also, the growing diversity of cheese in the largest retail chains. Hard cheese has the highest demand in the Russian Federation, unlike other types of cheeses that are sold only in special situations (cheeses with molds, etc.). Competition in each of the categories of cheeses in the Russian market is different.

Graph 2. ***Export of cheese from Republic of Serbia to Russian Federation (2010-2015.), 000 tons***



Source: *http://webrzs.stat.gov.rs/*

Previous large suppliers were the following companies: "Arla Foods" (Denmark), "Flechard SA" (France), "the Hochland", "Kaserei Champignon Hofmeister GmbH & Co.KG" (Germany), "Lactalis Group" (France) and concern "Unilever" (United Kingdom - the Netherlands), and all of them are losing their position in this market. In the category of hard cheeses, currently the main rivals are not established brands, but a large number of unbranded cheese. Many foreign suppliers - including companies from former Soviet republics (Kazakhstan, Moldova, etc.) compete in this segment.

Conclusions

Hard cheese Čarnok has a slow and prolonged ripening, low water content, and therefore can be kept for a long time. Below the rind is straw-colored dough, without any cracks, which melts in the mouth. The flavor is delicate, mildly sharp, but not too narrow and complete despite a low fat content. Hard cheeses have a long ripening period, and thus have greater digestibility, higher concentration of free amino acids and a higher concentration of short and medium chain free fatty acids. The high concentration of calcium in cheese has significant impact on the formation and protection of teeth and bones, prevention of osteoporosis and hypertension.

In the cheese market in the Russian Federation there is a problem that manifests itself in the declining raw material base, which is caused by the reduction of cattle population and production of raw milk, as well as the lack of norms and standards of milk quality, which often reduces the quality of the cheese. This showes that in the coming period, the Russian Federation will continue to be an important cheese importer of different cheese varieties. The Republic of Serbia should use the current situation on the Russian market, in order to position itself better in this market, especially with hard cheeses such as cheese Čarnok, which are characterized by high quality and long shelf life.

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ICT PLATFORM TO IMPROVE FARMERS CAPABILITIES

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Abstract

The main objective of the new agricultural sector is to improve the productivity in a sustainable way. To face this challenge the new CAP (Common Agriculture Policy) includes a set of fundings to increase the skills of all agricultural operators through professional trainings. The Information and Communication Technology may represent a useful tool for knowledge transfer in this field. The creation of online platforms dedicated to vocational education allows farmers, in particular for digital connected enterprises, to access to valuable information related to good agronomical practices, newest regulations and all technical specifications approved by European Union. According to this, the purpose of our research is to adopt the e-learning approach in agriculture and to implement a platform that enables operators to get information on their main agronomical activities and crops business, such as organic production, irrigation, fertilization, application of integrated pest management and related aspects.

Key words: *Information and Communication Technology (ICT), Agricultural sector, Information needs, Training course, Knowledge transfer*

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Introduction

The quality and productivity of labor services that a person provides, so called human capital stock, derive from personal attributes, such as physical strength, innate ability, health, education, vocational training and work experience (Antonelli and Guidetti, 2008).

Economics and, in particular literature, assign to human capital the role of engine of growth, which is mainly attributed to the virtuous circle that endogenously feeds the growth process. In these models, the development process is considered as a result of multiple and interrelated endogenous forces, operating within an economic system. Among these forces, human capital plays a major role through the spillover effects on the productivity of the resources used in the production process.

Schultz (1961) was the first to highlight the contribution of human capital to the growth and economic development. Subsequently, from the seminal contributions of Lucas (1988; 1993), human capital, related the production process that's accumulated in the formal educational process, is described as an endogenous source of technical progress, whether it is implemented intentionally by businesses or unintentionally caused by externalities (Carillo and Zazzaro, 2001; Carillo et al. 2008).

More specifically, human capital produces two effects: one inside, the increase in labor productivity, resulting from increased skills and efficiency of the more educated workers; the second one is an externality that improve the average productivity of all workers involved in production. This indirect effect of spillovers makes everyone else more productive employees, a result of accumulation of human capital that an individual uses in the production. The aforementioned effect leads to an increase in the average level of the existing human capital and is not deliberate in the sense that depends on the way in which the educated worker interacts with those that operate around. The spillover is stronger the greater the difference of human capital between educated workers and those he interacts with (Weir and Knight, 2000). In the aggregate, these synergies give rise to increasing returns to scale (Lucas, 1988) and generate an endogenous growth process.

The agricultural and rural scenery is going through a period of major restructuring and adjustment in relation to rapid market developments and policy, which require the enterprises themselves a greater competitiveness and the achievement of higher quality and production standards. Furthermore, the primary sector is led to new functions and types of activities:

Agriculture, in fact, is not only called to provide diversified products, but also services targeted at different types of stakeholders:

- To end consumers (requiring: quality, safety, food safety);
- To users in rural areas (interested in obtaining: hospitality, culture, pleasure and leisure);
- To the same customers present in the local systems (which is intended to ensure: services for land management, strengthening local identity).

According to this, it is prefigured a new "agricultural model" based on multifunctionality of agriculture, to respond to the needs of communities not only in production but also in social and environmental requirements.

It is clear that a similar change in the attitudes of agriculture must be accompanied and supported by investment operations on knowledge of human capital. Focusing on the enhancement of such assets, it would be possible to realize the preconditions to ensure the creation of new market opportunities in the area of traditional activities, as well as in innovative sectors. This way of proceeding allows more to consider training as a decisive factor in expanding the levels of employability of social working force. In order to respond training requirements within the agricultural and rural scenery, it is here described our research experience at European level.

Literature review

The complexity of agricultural sector and the severe changes of its dynamics impose to agricultural firms a seamless process of skills and experiences' upgrade. Achieving a certain degree of competitiveness, throughout a knowledge enhancement, is one of the solutions to deal with the huge challenges that agricultural sector faces (Lamonaca *et al*., 2015a; Kale *et al.*, 2015; Pignatti *et al.*, 2015; Wolfert, 2010; Bunte *et al.*, 2009).

In accordance with the strategies of Europe 2020 and the rural development policies, a way to support a smart and sustainable development of farms is to rely on knowledge transfer (European Parliament of the Council, 2013). The accumulation and distribution of knowledge hold a relevant role in the agricultural sector. In reality, knowledge is frequently seen as a success factor for the competitive advantage of farms and its strategic management contributes to support creation, evaluation, and sharing of intellectual assets within a firm (Santovito *et al*., 2016; Boohene *et al.*, 2015; Lamonaca *et al*., 2015a; Lamonaca *et al*., 2015b; Rullani, 2004; Davenport and Prusak, 1998).

An economic system, which is knowledge-based, may depend on "the production, distribution and use of knowledge and information" (OECD, 1996). In reality, a strand of literature is focused on the advent of a new economy, based on knowledge resources, which represent the basis of innovative processes. In such perspective, the innovative process could be seen as the result of the introduction and creation of new knowledge, in addition to the arrangement of the existing knowledge (Nonaka and Konno, 1998; Nonaka, 2007). According to this perspective, farms should invest in the dissemination and sharing of knowledge, to systemically increase the quality of their networks (European Commission, 2009).

In order to pursue this goal, a strategic choice for agricultural farms may be the implementation of technological innovations. Therefore, a smart adoption of the Information and Communication Technologies (ICTs) by agricultural firms may be a relevant solutions, because they allow to quickly create, store and disseminate knowledge (Santovito *et al.*, 2016; Kale *et al.*, 2015; Lamonaca *et al.*, 2015a; Boohene *et al.*, 2015; Lamonaca *et al.*, 2015b; Wolfert *et al.*, 2010; Galliano and Roux, 2003; Wilson, 1996; Jonassen, 1994). Moreover, their usage may generate income, share tasks and skills, increase productivity, accelerate communication, and so on (Pignatti *et al.*, 2015; Zaremohzzabieh *et al.*, 2015). This issue has been deeply investigated in literature. Eminent scholars studied the use of ICT for agricultural sector's needs in terms of knowledge improvement, and its impact on the agribusiness: actually, ICTs contribute to "socialize" competences and experiences of the producers, and in doing so they help the economic growth of an organization, due to the strong relationship between ICT and farm performance and is the positive correlation between the use of ICT and productivity (Spinelli, 2016; Boohene *et al.*, 2015; Pignatti *et al.*, 2015; Bunte *et al.*, 2009; OECD, 2003).

According to the Parliamentary Office of Science and Technology (2006), ICT is defined as electronic technologies, resources, and techniques, that allows to acquire, manage, communicate and transmit electronic data, information and knowledge. In agricultural sector, ICT tools are wildly used for the management of information and knowledge. This occurs essentially because, during the last years, farms tend to orient their activities towards the production of knowledge, rather than only to the typical production of goods (Santovito *et al.*, 2016; Boohene *et al.*, 2015; Pignatti *et al.*, 2015; Zaremohzzabieh *et al.*, 2015; Bunte *et al.*, 2009). This social aspect of ICT tools within the farmers, such as share, collaboration, communication, etc., could help to redefine the educational needs for the farms. The resulting accessibility of knowledge represent, therefore, a key factor for farms. (Bughin *et al*., 2012; Davidson and Goldberg, 2010; Toikka, 2007; OECD, 1996).

Methodological approach

In order to address the aim of this paper, namely creating the contents of online training activities for farmers and agricultural players, first of all the authors had performed the analysis of the existing literature on the issue. The purpose of this first analysis was to highlight what are the information needs of agricultural players, the use of ICT for knowledge transfer to the farmers, and the utilities of e-learning platforms in agriculture. In second instance, on the basis of the analysed literature and emerged players' needs, a set of possible contents for training courses have been defined, as listed in the next section (Table 1). A further step will be the characterization of different learning objects or modules for each course could be enabled. According to Schott *et al.* (2003), each module is a self-contained element that should become a continuous part of a learning package on a specific topic. Moreover, the focus of each module is on a particular sub-topic, which is of interest for a precise audience, for example filtered by geographical areas, crop types, and so on.

First findings

The eLearning approach in agriculture is addressed to every agricultural community around the world, involving a high number of farmers. In particular, it may represent a useful tool for young farmers as well as operators of developing countries, providing resources and knowledges otherwise not easy to access (Leary and Berge, 2006).

Even though the potential diffusion, there is still a significant gap on the quality of agricultural eLearning programs to solve. According to this, the objective of this work is to offer a range of courses covering different aspects of the agricultural sector. The courses are offered throughout videos according to the MOOC (Massive Open Online Courses) methodology, where knowledge is distributed across the Web and people's engagement with it constitutes learning (Blom *et al.*, 2013).

The high quality of the courses will be ensured by the knowledge and technical support from many university professors, technicians and professionals with expertise in the selected topics.

In addition, the presence of these figures, will warrant that the techniques and information provided will be constantly updated according to the evolutions in agricultural science and policies.

In order to facilitate farmers learning and motivate their participation, the course contents will be developed using simple and familiar language, providing appropriate documentation, proposing forums and blogs for the interaction between educators and learners. Moreover, in order to further improve educational contents, it will be foreseen a continuous evaluation and correction process of the provided courses and ways of transfer. For this reason, at the end of each course, a survey will be administered to a selected target group, asking their opinions and satisfaction level.

As in table 1, the identified topics of the single courses range between basic and advanced knowledges in agriculture. Each topic will contain a series of modules with instructional items, such as outline, content, summary, questions, case studies and links to outside resources.

The first topic will be aimed to the education in general of young farmers and at the same time to update operator' knowledge's, indeed it will contain modules with information on basic agronomical operations.

The second topic will be more focused on the important concept of the Integrated Pest Management (IPM), due to its mandatory adaptation for EU farmers, and to inform farmers from candidate countries to accession the EU. The corresponding modules, will be diversified according to the interested geographical areas and main crops of the selected zones.

The third one will be dedicated to the operators interested in the diversification of their productions, e.g. introducing organic crops or adapting their products to technical specifications to obtain quality labels.
In order to update farmers on latest regulations and reviews of agronomical laws, there will a specific course focused on these fundamental aspects.

Another course will be aimed at informing the farmers about public databases and websites, explaining how to use these instruments, in order to get important information and start e-commerce activities.

A specific course will be addressed to explain how the cooperation and other form of associations, as producer organizations, can help small farmers to reduce the production costs and increase income also throughout export activities.

The described course will be distributed through an innovative e-learning platform, especially developed, that will suit farmers' requisites and offers the essential tools to the educators.

***Table 1.* Identified training courses content**

Topic	Potential modules	Goals
Main agronomical activities and good agronomical practices	• Soil management; • Fertilization; • Irrigation; • Phytosanitary treatments; • Basic agronomical practices (harvesting, pruning, etc.); • Etc.	Providing young farmers with basic agronomical knowledges and improve agronomical competences of all farmers.
Integrated Pest Management (IPM)	• IPM Principles; • IPM on herbaceous crops; • IPM on tree crops; • Etc.	Providing farmers and agronomists with tools for a successful application of IPM programs in different environments and for diverse crops.
Technical specifications approved by European Union	• Organic production • European Designation of Quality Labels: Protected Designation of Origin (PDO) and Protected Geographical Indication (PGI); • Etc.	Aware farmers about the opportunities given by the application of these technical specifications on economical income and local development.
Newest Regulation	• Common Agriculture Policy (CAP); • National or Regional agri-food regulations.	Update farmers on latest regulations and reviews of agronomical laws in order to attain to specifications and be competitive
Online instruments	• Ways to access to public databases; • Web-Sites for e-commerce.	Providing farmers with knowledges on importance and opportunities related to these innovative resources
Crops business	• POs (producer organizations) • Crops export	Providing farmers with knowledges about the importance of cooperation related to income increasing, costs reduction, creating new market opportunities, etc.

Source: *Authors' elaboration.*

Concluding remarks

First, it should be emphasized that the availability of qualified and continuously trained personnel is a necessary requirement for companies, in order to operate in competitive contexts.

In this sense, it has a particular importance the processes of acquisition and the "knowledge management", as a basic resource to cope with change, manage the environmental complexities and develop innovations. In this regard, it should be highlighted the role played by ICT for development and knowledge sharing; there is a growing interest in e-learning as a useful tool for improving and expand the possibilities for learning and training.

An important aspect regards the level of flexibility and advantages that may be obtained by such a way of education, which are particularly interesting to encourage the development of training in farms, thus allowing to affect their competitiveness. However, the use of training activities by these types of companies is characterized by several problematic issues, especially cultural.

In particular, it is found that the “formal training” is not used as much and that the provision of training, often does not respond adequately to their real needs; in many cases, this approach is derived from unsatisfactory learning experiences. It is interesting to note that this occurs despite the support of several educational institutions offering quality services. On the other hand, more and more SMEs appreciate the benefits of e-learning, having the opportunity to make the training programs available continuously over time to their employees. Therefore, farms employees, could also benefit from the development of Virtual Communities of Practice, which favor processes of sharing knowledge, socialization and problem resolution. This requires new cultural approaches by the various involved parties and also a correct understanding of the technical and organizational arrangements.

The training activity should not be seen as an isolated event or necessary (when resulting from regulatory obligations), but as a component that continuously develop the intellectual capital of an organization, adding value substantially. This is the challenge that different types of users and different categories of training operators will gather in the coming years and in this perspective e-learning ranks as a useful system.

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STABILIZATION AND ASSOCIATION AGREEMENT IMPACT ON CORN SEED TRADE BETWEEN SERBIA AND EU

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Abstract

Aiming to track the implementation of the Stabilisation and Association Agreement with the European Union, there the mutual trade exchange of agro-industrial products was analysed, first of all the trade with seed corn, which fell in line with the most important agro-industrial products of Serbia in trade with the European Union. In order to track the relative changes in trade exchange value, an eleven-year-lasting period was analysed by using the comparative advantage model in international trade, while the absolute data values were shown through a prism of constant prices. There were used the official data of the European Union, as well as the official data of the Republic Statistical Office.

Key words: *revealed comparative advantage, agro-food trade, EU, Serbia, corn seed*

Introduction

As a strategic goal of Serbia, EU accession process significantly influences mutual trade, which therefore influences their comparative advantages. Historically, trade of agro-industrial products has always been a bottleneck in international trade liberalization process which required specific negotiation approach. Trade liberalization between Serbia and EU was defined in Stabilization and Association Agreement (SAA) (Official Gazette, 83/2008) with aim to provide full liberalization of trade relations with special emphasis on agro-industrial products[4]. For

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[4] Certain number of products were not subjected to SAA such as raw tobacco, raw and unrefined sugar and sunflower oil for human consumption which kept the same level of customs duties as before ITA implementation (Katić et al. 2008)

Serbia, as dominantly agricultural state, the importance of trade liberalization draws attention not only to agricultural producers, but also to the public and especially to policy makers.

Even though Serbia has positive records in trade of agro-industrial products with EU (Stegić, 2016), Serbia is import-dependent even though production potential exists which could substitute at least a part of imported goods. One of those products reflects to corn seed, SITC 04410 which belongs to the group of most significant agro-industrial trade products with EU.

Material and methods

The importance of monitoring changes in terms of relative export competitiveness, led to development of revealed comparative advantage model (Liesner 1958, Balassa 1965) established in the second half of the twentieth century. Even though Liesner can be considered as the first scientist that conducted researches in this field, popularization of comparative advantage model was brought by Balassa. Over the time the model evolved in order to solve identified weaknesses or to add more complexity to the model. Critics of the concept of "revealed comparative advantage" identified weaknesses in the theoretical and empirical sense ("Leromain and Orefice 2013";, "Yeats in 1985"; "Laursen 2015"; "Dalum et al 1998"; "Jambor 2013"; "Benedictis, Tamberi 2001"). Besides critics, Balassa index is still widely used model of identification of industry specialization in international trade and over the time became the basis of many future models (Bowen 1983, Lafay, 1992 (Sanidas and Shin 2010), Kanamori 1964, Vollrath 1991 (Vollrath 1991), Dalum et al 1998, Proudman and Redding 1998, Hoenand Osterhaven 2006, Yu et al. 2009, Michaely 1962/67, CEPI 1983, Grubel and Lloyd 1971, (Ballance et al.1987), Laursen2015). Implementation of the revealed comparative advantage model in agriculture was applied by Vollrath 1989, Utkul and Seyman 2004, Fertõ and Bojnec 2007, Qinetiet al. 2009, Bojnec and Fertõ 2012, Torok and Jambor 2012, Raičević et al., 2012, Ignjatijević et al. 2014 and others.

In order to monitor changes in relative comparative advantage at the level of two countries, Market Oriented Revealed Trade Advantage (MORTA) was developed and implemented in the field of agriculture (Kuzman, Stegić, Subić, 2016). This model will be used for the purpose of this research covering not only trade, but also import and export.

MORTA index represents difference between *Market Oriented Symmetric Revealed Comparative Advantage- MSXA* and *Market Oriented Symmetric Import Penetration Advantage - MSIA*:

$$MORTA = MSXA_a^{i,m} - MSIA_a^{i,m} \quad (1)$$

$$MSXA_a^{i,m} = \left(\frac{MXA_a^{i,m} - 1}{MXA_a^{i,m} + 1} \right) = \frac{\left(\left(\frac{X_a^{i,m}}{X_n^{i,m}} \right) - 1 \right)}{\left(\left(\frac{M_a^{w,m}}{M_n^{w,m}} \right) + 1 \right)} \quad (2)$$

$$MSIA_a^{i,m} = \left(\frac{MIA_a^{i,m} - 1}{MIA_a^{i,m} + 1} \right) = \frac{\left(\left(\frac{M_a^{i,m}}{M_n^{i,m}} \right) - 1 \right)}{\left(\left(\frac{X_a^{m,w}}{X_n^{m,w}} \right) + 1 \right)} \quad (3)$$

where *X* represents export, *M* represents import, *i* represents country, *m* represents observed market, *w* represents group of countries that has trade relations with observed market *m*, *a* represents observed product, *n* represents all products.

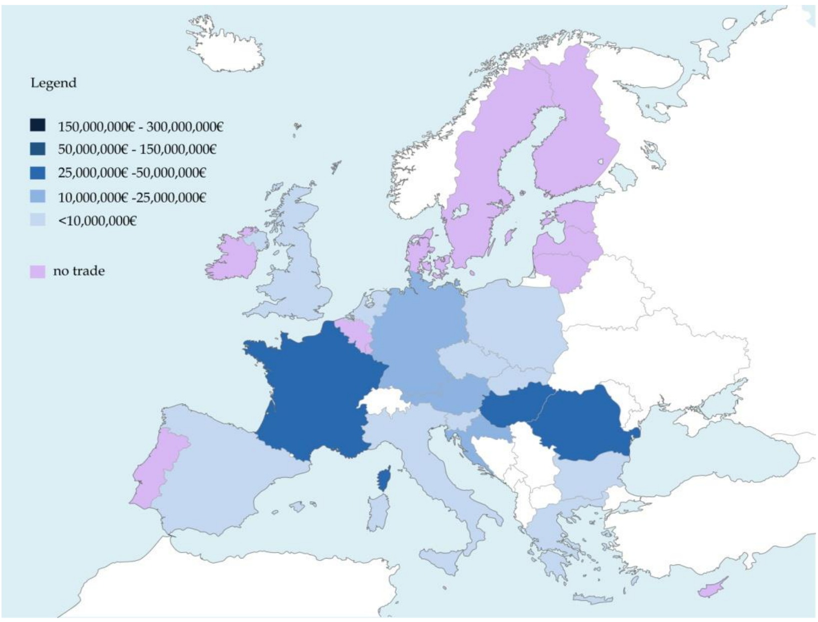
If *MSXA*>0, relative comparative advantage in export is revealed in relation to all exporters of an observed market *m*. If *MSIA*<0, relative penetration level of the product *a* from market *m* in country *i* is low. Comparing to *MSXA* and *MSIA* which gives values in the range -1 to +1, *MORTA* gives values ranging from -2 to +2. In cases where the *MORTA*> 0, relative comparative trade on observed market becomes a priority.

Results

Trade with seed corn in the European Union in observed period was realizing a value of 2.4 milliards EUR, where the EU countries were directed primarily to purchase within the EU. That is to say, 71.4% of trade is the result of turnover among the EU member countries, while 28.6% is the result of turnover with non-EU member countries. The importance of trade with seed corn in the European Union is at the level of 0.2% of share in total trade with overall agro-industrial products. The most important importers in EU are Germany, with import value of 2.1 milliard EUR and share in total import of 20.3% (share in import outside the EU amounts 5.3%, in internal 22.8%) and France, with import value of 1.7 milliards EUR and share of 16% in total import (share in import outside the EU amounts 28.5%, in internal 13.9%). On the other hand, the most significant exporters of seed corn in EU are France, with export value of 5 milliards EUR and share of 47.4% in total export (share in export outside the EU amounts 30.5%, in internal 52.6%) and Hungary, with export value of 1.5 milliards EUR and share of 13.8% in total export (share in export outside the EU amounts 26.3%, in internal 9.7%).

Trade with seed corn with non-EU-member-countries records a surplus of 626 million EUR, along with the coverage of import by export of 143%. The most important EU partners in import outside the EU are Chile, with export value of 485.7 million EUR in observed period and the share in EU import outside the EU of 33.1% (share in total EU import amounts 4.7%) and the U.S.A. with the realized export value of 410 million EUR and the share of 27.9% (share in total EU import amounts 4%). Chile, as the most significant EU trade partner outside the EU in import of seed corn, records the growth of export value by an average annual rate of 4.6% with relatively strong variability of 53.3%, while the USA export decreases by a significant average annual rate of 11.1% during the period, and a relatively high variability of 56.1%. Serbia, with export value of 112.3 million EUR is not specifically important trade partner of EU, having in mind that it makes only 1.1% of total EU import (7.7% is the share of Serbia in import of EU outside the EU borders).

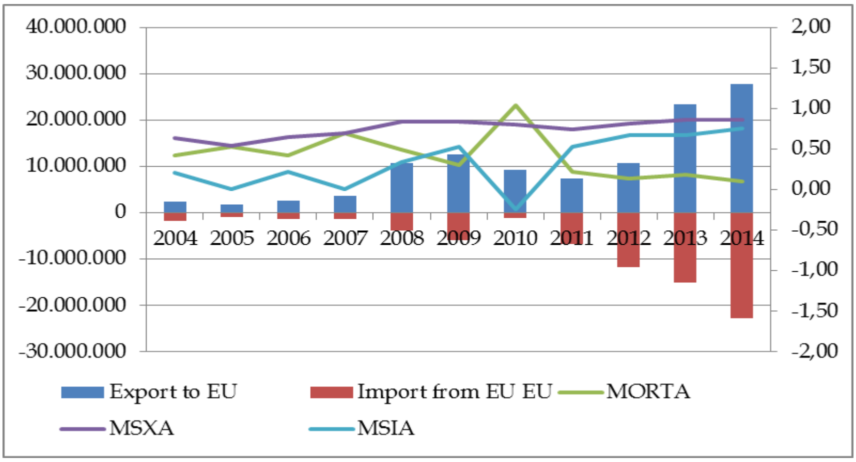
Figure 1 – *Description of trade exchange of SITC 04410 between Serbia and EU for the period 2004-2014, expressed in constant prices, in EUR*



Source: *Calculation of authors based on combined data of Eurostat and RSO*

Although Serbia is not a significant EU partner in trade with seed corn, it is about the product which is on the list of the most important agro-industrial products of Serbia in trade with the EU. In total exchange of agro-industrial products with the EU in observed period, trade with seed corn records a value of 184.8 million EUR expressed in constant prices, with the share in exchange of agro-industrial products of 1.4%. In mutual trade, the exchange was primarily based on seed corn export from Serbia to the EU (60.8% of trade volume was a result of Serbian export to the EU market), where the most significant partners were Germany, France, Austria and Croatia (*Figure 14*). The relative comparative trade advantage in the trade with the EU was noticed in all observed years, along with the noticed downward trend values of *MORTA* index during the period (*Graph 20*).

Graph 1 – *Volume of SITC trade 04410 between Serbia and EU in the period 2004-2014, expressed in constant prices with the belonging indices of comparative advantage*



Source: *Calculation of authors based on combined data of Eurostat and RSO*

The lowest recorded value of *MORTA* index was noticed in 2014 and it was amounted 0.11, while the highest value of *MORTA* index was recorded in 2010 (1.03). The relative comparative advantage of Serbia in export to the EU market is relatively high and it was recording an uptrend value of *MSXA* index during that period. The highest value of *MSXA* index was noticed in 2014, when it was amounted 0.87, and the lowest recorded values of *MSXA* index were noticed in the beginning of this period, in 2005 (value of 0.57). During the observed period, a value of Serbian export to the EU market was recording a significant increase by an average annual rate of 29.2% and strong variability of 79.8%. An increasing value of *MSXA* index points out to the increase of relative significance of Serbian export to the EU market. On the other hand, regarding trade between Serbia and the EU, Serbia records also relatively high penetration level from the EU markets, when it is about seed corn import, taking into consideration that values of *MSIA* index were positive during this period (except in 2010), with noticeable upward trend of index value. During this period, a value of seed corn import from the EU increases by an average annual rate of 33.9%, with strong variability of 103.1%, which appears as a consequence of significant increase in import value in the last observed years.

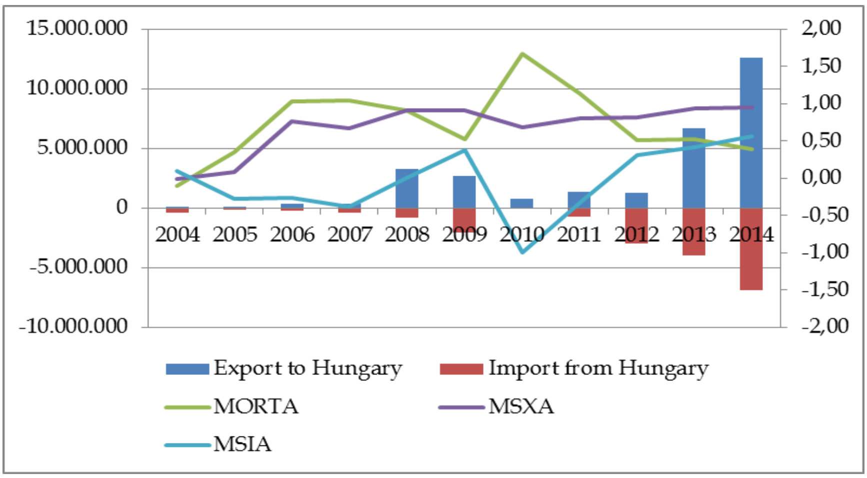
Implementation of SAA was contributed to a gradual reduction of customs duties on import of basic and other hybrids of seed corn to the complete cancellation in the last year of liberalization, except in case of double and “top cross” hybrids, as well as three-line hybrids, in which registers a gradual reduction of 30% in the last year of liberalization. Exactly during this period of SAA implementation, there has come to decrease of the relative level of comparative trade advantage of Serbia, primarily as a result of the relative penetration level increase in import.

Serbia, in trade with the EU countries, realizes prevalently the relative comparative trade advantage, as in the case with the states, which are the most significant in the SITC exchange 04410. A negative value of *MORTA* index was noticed only in trade with Slovakia and Italy, where only Italy records a significant share in mutual trade of 4.9%. Description of the relative comparative advantage of Serbia in regard to the most significant trade partners on the EU market in case of SITC 04410 is given below.

The most important trade partner of Serbia among the EU countries in trade with seed corn is Hungary with the realized trade value of 48.2 million EUR, which makes 26.1% of total trade with seed corn, of which 61.2% is a result of Serbian export. Except in the first observed year, during the whole period we can notice the relative comparative trade advantage with significant changes of *MORTA* index during the period (*Graph 2*). The highest values of *MORTA* index were recorded in the middle of the observed period, while in the last observed years this index value was decreased, and the lowest index value was noticed in 2014. The relative comparative advantage in Serbian export to the Hungarian market was noticed during the entire period, with the present upward tendency of index value. The highest index value was recorded in 2014 and it was amounted 0.96. Increase of *MSXA* index value was mainly a result of increasing value of seed corn export to the Hungarian market after a very significant average annual rate of 56.6%, with strong variability of 136.8%, as a consequence of a significant increase in export value in the last observed years. On the other hand, in trade between Serbia and Hungary, the relative penetration level varies during the observed period of time, so in some years there was noticed a relatively low penetration level, while in other was noticed a relatively high penetration level. The lowest value of *MSIA* index was recorded in 2010 and was amounted -0.99 as a consequence of the lowest recorded import value, while in 2014 there was recorded the highest index value of 0.56, when the highest import was noticed, too. A value of seed corn import from Hungary was increasing during the period after an average annual rate of 30.1%, with strong variability of 121.7% as a consequence of significant increase in import value in the last observed years.

Hungary is export-oriented country and 56.3% of export value realizes in trade with the EU member countries. Regarding import, Hungary is prevalently directed to import from the EU member countries, which make 78.4% of total import. Hungarian import increases by an average annual rate of 8.3% with the modest variability of 37.2%, considering that the decline of import value is noticeable in trade with non-EU member countries, along with significant fluctuations, while the increasing tendency is noticeable in case of importing from the EU member states[5].

Graph 2 – *Volume of SITC trade 04410 between Serbia and Hungary in the period 2004-2014, expressed in constant prices with the belonging indices of comparative advantage*



Source: *Calculation of authors based on combined data of Eurostat and RSO*

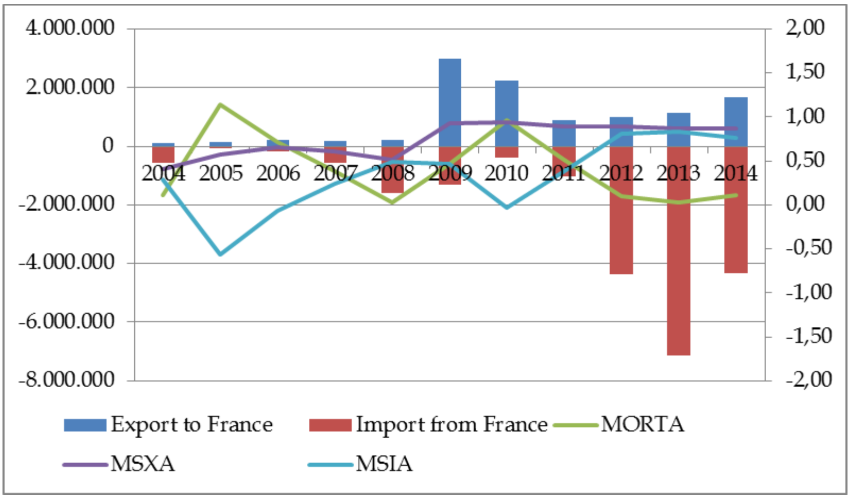
[5] The most important exporter to Hungarian market is France, with the realized export value of 209.5 million EUR, which makes 46% of total import of seed corn in Hungary, with an average annual export value growth rate of 13.9% and moderate variability of 41.2%. Besides France, a significant exporter to the Hungarian market is Romania with the realized export value of 80.7 million EUR, which makes 17.7% of total Hungarian seed corn import. Romanian export value increases by an average annual rate of 25%, with relatively strong variability of 66.8%.

France, with its trade value of 32.3 million EUR and the share in total trade with seed corn of 17.5%, is the second best trade partner of Serbia. However, unlike Hungary, trading with France is primarily import-oriented taking into consideration that import makes 66.6% of total mutual trade with seed corn. In all these observed years, we can notice the relative comparative trade advantage with some important changes in *MORTA* index value during the period (*Graph 3*). The highest values of *MORTA* index were noticed in 2005 and 2010, while the lowest values were recorded in the last observed years, contributing to downward trend of index value, during the period. On the export side, there was noticed the relative comparative advantage of Serbia on Hungarian market, along with noticeable upward trend of *MSXA* index value, which was also the highest in the second half of the observed period of time. The export value grows by an average annual rate of 33.1%, with strong variability of 94.2%. On the other hand, in trade between Serbia and France the relative penetration level varies during this period, with noticeable upward trend of *MSIA* index value. Relatively low penetration level was noticed in 2005, 2006 and 2010, while the highest relative penetration level was noticed in the last observed years, as a consequence of significant growth of seed corn import value on the Serbian market. The import value of seed corn from France, as the biggest exporter to the EU, records a significant increase during the observed period by an average annual rate of 41.6%, with strong variability of 111.9% as a consequence of significant increase in import value in the last observed years.

France is export-oriented country and 89% of its export value realizes in trade with the EU member countries. Speaking of import, France is predominantly oriented to import from the EU member countries, which make 74.7% of total import. French import was relatively stable during this period and it was increasing by an average annual rate of 2.2% and relatively weak variability of 28.2% considering that the import decrease was noticed in trade with non-EU-member countries, with significant fluctuations during this period, while considering the import from the EU member countries, there was present upward trend[6].

[6] France, as the second best importer of seed corn in the EU, has a wide range of importer partners. The most significant French partner in import is the Netherlands with realized export value of 281.5 million EUR and the share of France in total import of 17.1%. Right behind the Netherlands, with export value of 210.4 million EUR and the share in total import of 12.7%, Hungary is, at the same time, one of the most important exporters in the EU. Talking about the borders outside the EU, the most significant exporters are Chile with the realized export value of 171 million EUR with share of 10.4% and the U.S.A. with the realized export value of 129.4 million EUR and the

Graph 3 - *Volume of SITC trade 04410 between Serbia and France, expressed in constant prices with the belonging indices of comparative advantage (2004-2014)*



Source: *Calculation of authors based on combined data of Eurostat and RSO*

Neighbouring Romania is the third most significant partner of Serbia in trade with seed corn, with the realized trade value of 35.2 million EUR, which makes 19.1% of total trade with seed corn between Serbia and EU. Trading between Serbia and Romania is mainly import-oriented with the import share in total trade of 53.4%. Except in 2005, during the entire period there notices the relative comparative trade advantage in Serbian trade with Romania, with noticeable significant fluctuations of *MORTA* index value during this period. The last observed years recorded the lowest values of *MORTA* index, which significantly contributed to downward trend of index value during the observed period. The lowest index value was recorded in 2014 (*Graph 4*). The relative comparative advantage of Serbia in export to the Romanian market was noticed in all observed years, considering that the *MSXA* index value records downward trend during this period, and after a drastic decrease of export value in 2009, there was noticed increasing trend in the second half of the observed period. The highest recorded value of *MSXA* index was noticed in 2008 and was amounted 0.85 with the realized export value of Serbia of 2.6 million EUR. The value of Serbian export in the observed period increases after a significantly high average annual rate of 40.6% with strong variability of 87.8%, while Serbian share in total import of seed corn of Romania is at the level of 4.4%. On the other hand, in trade between Serbia and Romania, the

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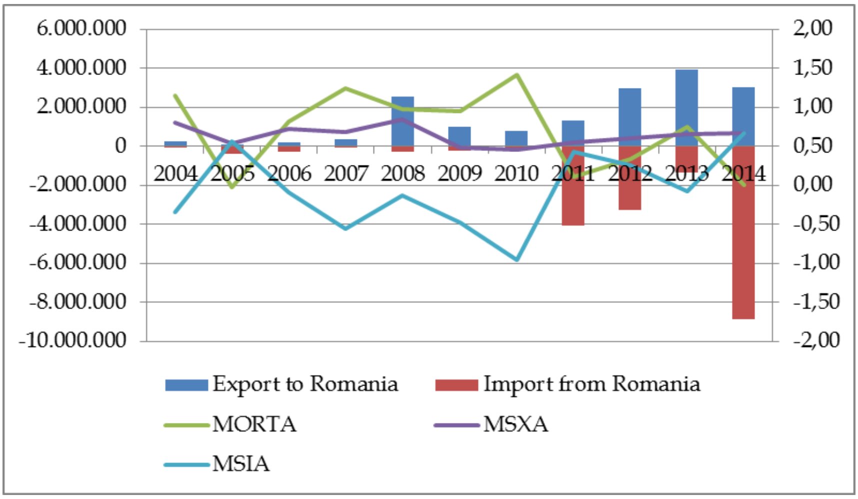
share of 7.8%. The import value of the most significant partners within the EU is growing, while import from the most significant partners outside the EU is declining.

relative penetration level varies during this period with noticeable upward trend of *MSIA* index value. Relatively low penetration level was noticed in all observed years, except in 2005, 2011, 2012 and 2014. Relatively high penetration level origins as a consequence of significant increasing import value in the last observed years. That is to say, the import value of seed corn from Romania records significant growth during this period after an average annual rate of 34.4% with strong variability of 153.7%. The highest import value was recorded in 2014 and was amounted 8.9 million EUR or 47.2% of total import from Romania in the whole observed period.

Graph 4 – *Volume of SITC trade 04410 between Serbia and Romania in the period 2004-2014, expressed in constant prices with the belonging indices of comparative advantage*



Source: *Calculation of authors based on combined data of Eurostat and RSO*

Romania is export-oriented country and 49% of export value realizes in trading with the EU member countries. Regarding import, Romania is prevalently oriented to import from the EU member countries, which make 86.5% of total import. Import of Romania is dynamic and grows after an average annual rate of 26.5% with relatively strong variability of 60.5%. Increase of import value is noticeable in trade with the EU member countries and non-EU-member countries, but it is evident that trading with the EU member countries almost completely dominates, with noticeable higher growth rate of import value[7]. Serbia, in trade with the EU

[7] The most important partners of Romania in import of seed corn are France and Hungary, which together make almost 2/3 of total Romanian import, and which are the biggest exporters to the EU at the same time. In the observed period, a value of corn import from France amounts 146.4 million EUR, which makes 38.8% of total import of Romanian seed corn. In the same period, a value of import from Hungary amounts 93.1 million EUR, or 24.7% of total seed corn import. There is especially important import of seed corn in Romania from

countries, realizes mainly the relative comparative trade advantage. Besides these mentioned trading partners, it is important to emphasize also the trade corporation with Austria and Croatia, which makes 10% and 9.8% of total trading of Serbian seed corn with EU, respectively. In case of Austria, Serbia records the relative comparative trade advantage in all observed years, with significant growth of the relative comparative advantage in export, but also with noticeable increasing trend of *MSIA* index value, which achieves positive values in the last observed years, as a consequence of import value increase (except in 2014). As a result of significant increase in import value we can find achieving almost maximum values of *MSXA* index in the last observed years. On the other hand, in case of Croatia, Serbia realizes the relative comparative advantage in all years except in 2004 and 2009, when there the highest values of *MSIA* index were recorded. As Serbia has a significant growth of export value to the Croatian market, the trend of *MSXA* index values increases gradually, reaching the highest recorded values in the last years of the observed period.

Conclusions

Description of a value of trade with seed corn between Serbia and the European Union in the observed period (2004-2014) was pointed out to a fact that there came to more significant increase of mutual trade exchange in time of SAA implementation, with simultaneous more significant changes of the relative level of comparative advantage. In other words, Serbia had ensured the growth of export value in the period of SAA implementation, but at the same time, the significant increase of import value, which had contributed to increase and the relative level of comparative advantage in export and increase of the relative level of penetration, as well. However, trend of changes of the relative level of Serbian trade advantage points out to a gradual decline, as a consequence of more significant impact of the relative penetration level in import.

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France, taking into consideration that import value increases after a significantly high average annual rate of 36.9%, with strong variability of 76.7%, while in case of import from Hungary, there was noticed significant, but slightly lower average annual growth rate of 14.4%, along with the modest variability of 43.4%.

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HOW TO IDENTIFY THE VALUE-BASED FOOD CHAINS: A SLOVENIAN CASE STUDY

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Abstract

Since 2011 one of the new types of food chains has been often described in scientific literature. It is called value-based food chains (VBFC) and referred to as the food chains with added values. The added values are usually expressed through three different ways such as i) high quality food products, ii) different protected designations and iii) fair business relationships among the actors in food chain. This paper discusses which the indicators for identifying the added values are and additionally unravels different social and economic interactions between actors among the supply chain, also recognized as the characteristics of VBFC.

***Key words**: Value-based food chains, added values, Planika dairy*

Introduction

The common use of "value-based food chain (VBFC)" terminology can be found in the recent European scientific literature (Pirog and Bregendhal, 2012; European Parliament, 2013). Vacas et al. (2014) explained positive direct and indirect socio-economic effects of VBFC in increasing the local economy and community, such as higher farmer´s income, lower unemployment rate and good relationships between the actors. Authors also argue that positive direct and indirect economic effect of value-based food chains are definitely lower compared to conventional food chains, because of higher production costs and investments in production and processing system.

The most commonly characteristics of VBFC are: i) producing and spreading the values equably to all partners, addressing producers, processors, retailers and consumers (according to Stevenson et al., 2011; Viitaharju et al., 2005) and ii) producing food products which are differentiated from similar food products based on product attributes such as food quality and safety.

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Values of VBFC based on an excellent cooperation and information flow between chain members during growth, aiming to provide transparency (Münchhausen et al., 2014).

The main difference between VBFC and other forms of food chains is in expression the (added) value ("Value" and/or "Value added") which could be expressed through three different ways (Stevenson and Pirog, 2008; Pirog and Bregendahl, 2012; European Parliament, 2013):

a) Through the agro-food products made from raw materials expressing the origin of the food and consequently reaching a higher price on the market;

b) Through the protected designations labels expressing geographic location, higher quality and/or food safety and

c) As a combination of correct business relationships and interactions between different actors in the food chain.

Stevenson and Pirog (2008), Pirog and Bregendahl (2012) and Stevenson (2013) explained the definition of food chain with added value according food chain actors relationships. These differences are the following:

a) Business relationships between strategic partners in the VBFC are built on common principles, which are primarily based and built through the trust component. The strategic partners contribute a large share to well organization and functionality of the chain. Strategic partners are commonly the companies or processors;

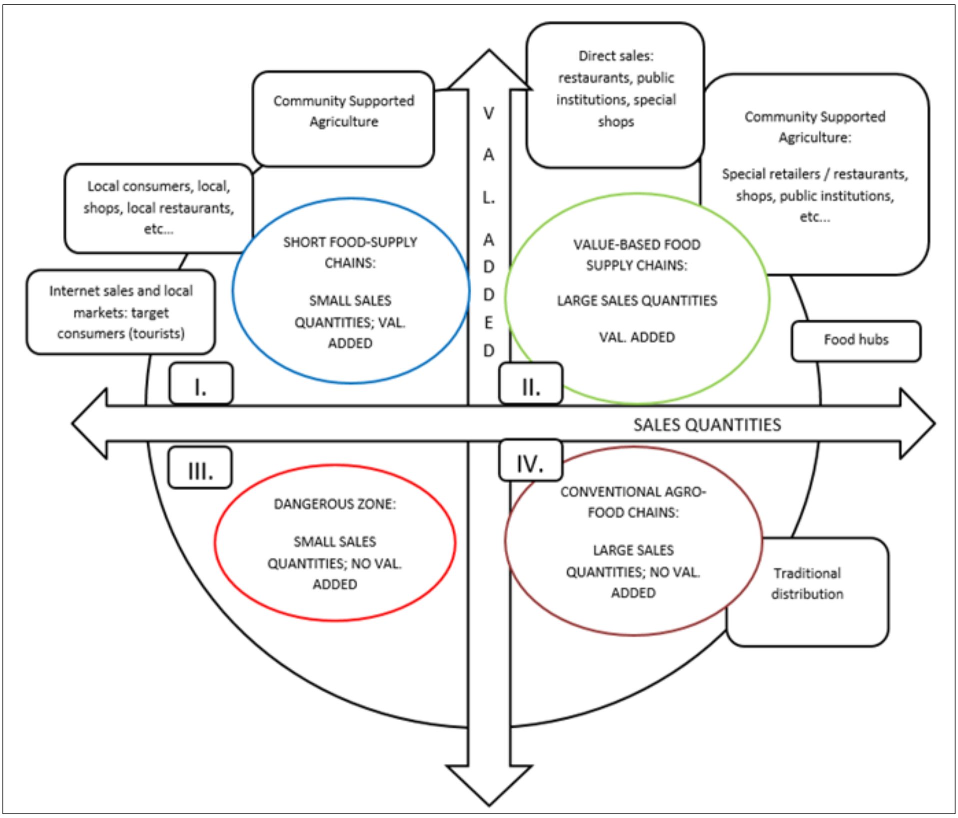
b) The producers/farmers are treated the same as the strategic partners in discussion about risk management and decision-making;

c) Obligations and rights in the chain are placed for improving the benefits of all actors and

d) Coordination of the actors is performed at the local, regional, national and/or international level.

The scheme of classification the agro-food chains according to two different ways of selling and marketing the agricultural and food products can be gleaned from Picture 1.

Picture 1: ***Classification of agro-food chains, given the components of agro-food chains system including different ways of selling and marketing the agricultural and food products***



Source: *(according to Low and Vogel, 2011; Barham et al., 2012)*

VBFC – EU case studies

Münchhausen et al. (2014) described some examples of VBFC in Germany. The agro-food chains Bohlsener Mühle GmbH & Co. KG and Rinklin Naturkost GmbH have been developed to large successful companies from local processing companies. In addition to the management efficiency of the agro-food chain, the main actors in the chains are important factors for the success of the dealing with values in agro-food chain. These values, such as "fair price", animal welfare, environmentally friendly farming manner and less use of plant protection products stand for the solidarity between the actors. Further, adapted from Furtschegger and Schermer (2014), these values can refer to the social and regional economic cooperation, with the clear aim to point at the importance of production and consumption of high quality food. Bio vom Berg and Biohof Achleitner are examples of value based agro-food chains from Austria. The names represent trademarks that combine various organic producers, while Bio vom Berg focused on buying raw materials only from mountain Austrian Tyrol areas. From the preliminary results of an international project Healthygrowth (Kvam and Bjørkhaug, 2014) it shows that both agro-food chains provide "fair price", solidarity among actors, preserve the environment, ensure animal welfare and the tradition of food processing. As described by Furtschegger and Schermer (2014), in both cases the communication between the actors about the values is well-established through different communication channels, such as websites, leaflets, brochures, social networks and quality product designations.

Material and methods

Following the criteria of value-based food chain a pilot case study has been identified – local dairy Planika (Prišenk, 2015). Selected value based agro-food chain includes components of value added, although it does not represent short agro-food chain. With purchasing milk from local producers it is integrated into the local area. Below there are specified some crucial indicators which should be indicated to confirm the added values in food supply chains.

Economic Benefit and Strategic Collaboration

Upstream and downstream partners in food value chains can derive significant economic benefits from value chain transactions in comparison to more conventional business arrangements. Value chains allow producers and buyers alike to participate in coordinated marketing and distribution activities that maximize product value through strategic responsiveness to buyer demand and consumer preferences and to enjoy the transportation savings associated with shorter supply chains (USDA, 2014). The economic benefits have been analyzed with econometric approach.

Farmers as strategic players

In food value chains, farmers are not anonymous, interchangeable suppliers of homogeneous ingredients and food, as they are in traditional commodity supply chains. Instead, they are strategic collaborators in the chains, which are deliberately designed to allow the farms, the distributors, and others involved to earn a profit (USDA, 2014). This value in Slovenian case study VBFC has been identified as a) a percent of local milk producers involved in Planika milk production in last 5 years and b) as the cooperation between the farmers with other actors in chain management and organization.

Open and ongoing communication with transparency component – clear principles

The strongest food value chains are those forged with a clear understanding of, and consistent communication about, their underlying values. A successful food value chain defines values clearly, integrates them throughout the chain, and communicates them to the customer.

The chain is built around participants that honour certain values and can work together to implement them, such as farms that follow agreed-upon values based production standards (USDA, 2014). Interviews with actors in different segments of supply chain management helped us to create networking analysis in identifying the open and ongoing communication with transparency component.

Results and discussion

Economic Benefit and Strategic Collaboration – analyses results

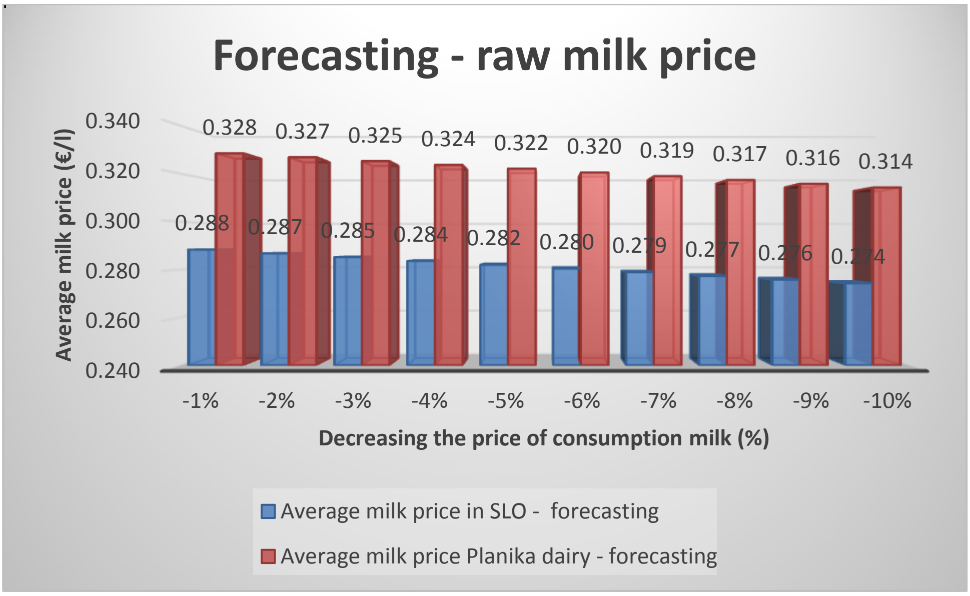
Econometric analyses results give clear directions of forecasting the prices of raw milk. The main independent variables in models were prices of consumption milk, which presents the most important dairy product on the market.

Results presented by Chart 1 show that the average milk price in Slovenia will decrease for -0.56 % if the price of consumption milk increases for 1 %. The average milk price in Planika dairy will decrease for -0.49 % if the price of consumption milk raises for 1 % (Prišenk, 2015). The results forecast the more "stable" milk price in Planika dairy compared to average milk price in Slovenia.

However, more important piece of information is the difference between the milk prices (Planika dairy vs. average milk price in SLO) which is 0.04 €.

If we suppose that the average milk productivity per cow is 8000 l/year, it means 320 € higher farmers` income per cow per year. Further, if the farmers` herd is 20 dairy cows it means 6400 € additional farm income per year. The high economic benefits belong to the farmers which are the members of Planika Value-based food chain.

Chart 1: ***Forecasting results of average milk prices in Slovenia and average milk prices in Planika dairy***



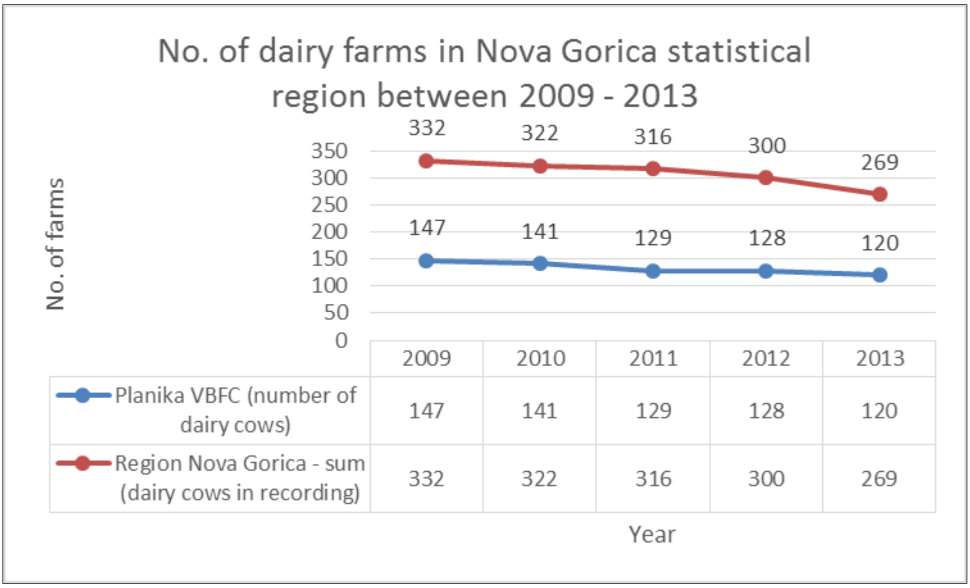
Farmers as strategic players – analyses results

There are approximately 120 to 140 farms producing the high-quality raw milk. The main and the only processor in the chain is Planika dairy. Farmers mainly come from the Slovenian mountain areas, especially from the western and north-western part of Slovenia. From the Chart 2 can be seen that more than 40% of all dairy farms in north-western part of Slovenia (statistical region of Agricultural and Forestry institute in Nova Gorica) are part of Planika VBFC in 5 years period (2009-2013). During this period the number of farms decreased, but on the other hand the percentage of farmers including in VBFC increased during the last two observed years (2012 and 2013). Moreover, in 2013 this percentage was the largest over the period under the scrutiny here (Table 1).

Table 1: ***Percentage of dairy farms included in Planika VBFC milk system collection***

year	%	decrease/increase
2009	44,28	-
2010	43,79	
2011	40,82	
2012	42,67	
2013	44,61	

Chart 2: ***Number of dairy cows herds in Nova Gorica statistical region compared to number of dairy cows herds in Planika VBFC between 2009 and 2013 (KIS 2010-2014)***

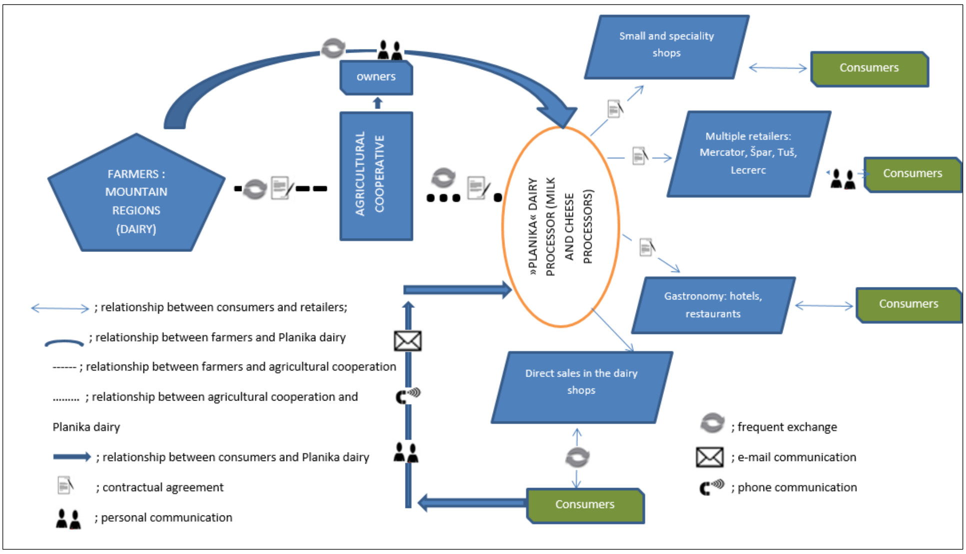


Open and ongoing communication with transparency component – analyses results

The milk is bought from the farmers directly by the Agricultural cooperative Tolmin and transported to Planika dairy. The direct network (communication) exists between producers and Agricultural cooperative, and between processor and Agricultural cooperative. There is a lack of direct communication and networking between the producers and processor. The main and most powerful actor in food chain is Planika dairy which maintains the processing and selling systems to this date. Planika diary enjoys the confidence among both producers and consumers. Agricultural Cooperative Tolmin coordinates transactions between farmers and the Planika dairy (processor). The dairy coordinate's transactions between itself (processor) and its selling points (retailers), and they have decision-making power about business movements in the chain and the main responsibility for the other actors in this value-based food chain. Planika buys the raw material from the farmers, and the negotiations about the purchase price of milk occur between Agricultural Cooperative Tolmin and the farmers.

The most frequent communication type is contractual agreement and email communication. These types (especially contracts) are the most trustful obligations between the actors. An analysis of interactions between the actors inside the value-based agro-food chain revealed well-developed communication about the quality of food and raw materials, using different modes of communication (i.e. phone calls, contractual agreements and email/personal communication). Actors intensively communicate with each other, especially with the actors before and after them in the chain, while a weakness was detected in communicating activities along the entire chain and, in particular, the communication between consumers and producers.

Picture 1: ***The networking analyses of Planika VBFC***



Conclusions

The main conclusions can be summarized as follows:

- The Planika agro-food chain has positive socio-economic effects on dairy farms from mountain regions.
- The Planika value-based agro-food chain's organisational structure represents a successful example of agro-food chain development processes, which is based on "healthy" relationships between the actors.
- A key actor (i.e. Planika dairy), according to our findings, is essential for an effective development process of value-based agro-food chains, as this actor manages and coordinates the obligations and responsibilities of other actors in the chain.
- The frequency and type of communication are crucial in building trust and sound relationships between the actors, consequently bringing about positive effects on further developmental processes in the chain.

One of the key approaches in any successful agro-food chain development process is a focus on developing valid relationships between actors inside the chain. If healthy relationships are damaged, the chains' competitiveness could be endangered. This issue has also been highlighted by the Slovene policy makers, who have proposed the institution of ombudsman shall be established in agro-food chains. The ombudsmen would mainly be responsible for implementing payment discipline and for respecting the payment deadlines. These two bottlenecks are namely seen as crucial problems alongside the Slovenian agro-food chains.

Acknowledgment

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EFFICIENCY IMPROVEMENT OF SOYBEAN PRODUCTION IN SERBIA

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Abstract

The non genetically modified (GM-free) soybean production in Serbia is growing steadily. The paper investigate differences in efficiency of soybean production among farms with objective to identify possibilities for further improvement. Examined sample of farms is located in Serbia-north region, that account for 96% of total soybean production in Serbia. Sample is structured from three group of farms: organic, conventional and conventional participating in extension program, classified by size. Data are gathered through questionnaire and interview during visit of farms in 2015 production year. To accomplish this, non-parametric models of Data Envelopment Analysis (DEA) was used to identify differences in efficiency of soybean production among farms. The results reveal importance of extension work in area of technology improvement in soybean production.

Key words*: soybean, efficiency, farms, DEA*

Introduction

The GM-free soybean production in Serbia increase stably in recent years. GM soybean production is forbidden by law. In last two decades harvested area is tripled reaching almost 200,000 hectares. Soya become third most important crop in Serbia after corn and wheat that are harvesting on 1 and 0.6 million hectares, respectively. There is several factors influencing farmers motivation to increase soybean area. Expecting crop profit is typically leading motive for farmer to include particular crop in production plan. Since cost of production are usually known before planting season, farmers profit expectations is based on its yield and price estimate. Soybean is less risky crop than corn (*Table 1*), since coefficient of variation is 19.5% comparing with 24.1%. On other side soybean have higher variability of yield than wheat 15.9% and sunflower 17%. In crop rotation Soybean and sunflower

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are competing oilseeds, although soybean was not first choice for farms in dry areas. In period from 2001 to 2015 soybean had slightly higher average yield than sunflower. Also, higher average prices and higher price stability of soybean, comparing with sunflower, in same period was additional factors for farmers to give more focus on soya production.

Table 1. ***Average yield of main crops in North - Serbia in t/ha***

Year	Corn	Wheat	Sunflower	Soybean
2001	5.6	4.1	2.0	2.4
2002	5.0	3.4	1.9	2.5
2003	3.4	2.3	1.8	1.7
2004	5.9	4.8	2.3	2.7
2005	7.8	4.4	1.8	2.8
2006	7.0	4.4	2.1	2.8
2007	4.8	4.3	1.9	2.1
2008	6.6	4.8	2.4	2.5
2009	7.1	4.4	2.4	2.4
2010	8.0	3.7	2.2	3.2
2011	7.1	4.8	2.6	2.7
2012	3.9	4.4	2.0	1.7
2013	6.8	4.8	2.8	2.4
2014	8.6	4.5	3.0	3.6
2015	5.8	4.8	2.7	2.5
Standard deviation	1.498	0.678	0.384	0.493
Average yield (t/ha)	6.2	4.3	2.3	2.5
Coefficient of variation	24.1%	15.9%	17.0%	19.5%

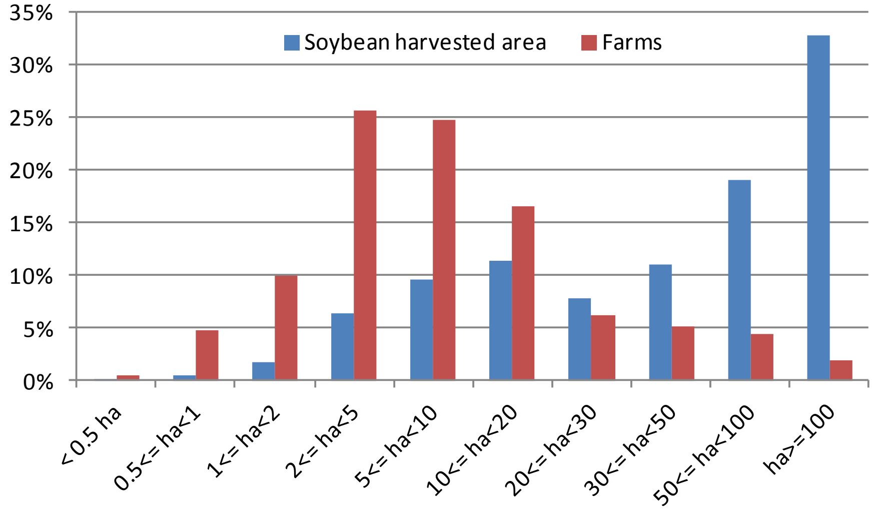
Source: *Statistical office of the Republic of Serbia*

Additional motivation for farmers to increase soybean production comes from lower fertiliser costs. Soybean symbiosis with bacteria able to fixate nitrogen from air reduce needs for nitrogen, and leave surplus for next crop. Good storage ability enables farmers prolonged time to sell soybean and gain higher prices than in harvesting season. Some farmers use soybean directly in livestock production, after heating treatment.

Climate changes in sense of higher amounts of precipitation bring opportunities for farmers to grow soybean in areas previously perceived as dry and unfavourable for soybean production. The highest yield recorded in 2014 year (*Table 1*) was result of above average rainfall. Surplus of precipitation enable to scarce farmers in dry region to achieve very high yield, while in favourable lowland region occasionally even damaged soybean production.

The main producers of soybean in Serbia are big and middle size farms in region Serbia-North (*Chart 1*). Big farms with 20 and more hectares of utilized agricultural area participate with 70.6% in total soybean harvested area. Middle size farms with 5 to 20 ha of utilized agricultural area participate with additional 20.8%. Small farms, although numerous, produce soybean on just 8.6% of total hectares under soybean.

Chart 1. ***Structure of soybean producers and harvested area by farm size classes in hectares in Serbia.***



Source: *Statistical office of the Republic of Serbia, Census of agriculture 2012.*

Danube soya project started in 2012 with objectives to: promote cultivation and processing of GM-free soya within the Danube region countries, and establish reliable supply and added value chains via member businesses, contributing to the independent European supply of protein. Serbia have been joined to project in 2014. One of project task was to research gross margins in GM-free soybean production among conventional and organic producers in Serbia during period 2014 to 2017. Goal was to identify efficiency differences between farms participating as a project partners and other soybean producing farms. Farms joined to project received additional knowledge during education process in classes, and practical knowledge on demo fields.

Literature review

The idea of defining the limits of efficiency was proposed by Farrell (1957), who described two types of economic efficiency: technical efficiency (TE) and allocative efficiency (AE) or price efficiency. Technical efficiency reflects the ability of firm to obtain maximal output from a given set of inputs, while allocative efficiency reflects the ability of a firm to use the inputs in optimal proportions. These two measures are then combined to provide a measure of total economic efficiency (Coelli J.T. et al., 2005).

Different methods have been used for calculating or evaluating the efficiency limits. One of them is data envelopment analysis (DEA). In their originating study, Charnes, Cooper and Rhodes (1978) described DEA as a 'mathematical programming model applied to observational data that provides a new way of obtaining empirical estimates of relations-such as production functions and/or efficient production possibility surfaces-that are cornerstones of modern economics'. DEA is a methodology directed to frontiers rather than central tendencies. Instead of trying to fit a regression plane through the centre of the data as in statistical regression, for example, one 'floats' a picewise linear surface to rest on top of observations. Because of this perspective, DEA proves particularly adept at uncovering relationships that remain hidden from other methodologies (Zhu and Cook, 2005).

Based on technology assumption, there are two basic type of DEA models: constant returns to scale (CRS) DEA model and variable returns to scale (VRS) DEA model. The CRS assumption is appropriate when all firms are operating at an optimal scale. However, imperfect competition, government regulations, constraints on finance, etc., may cause a firm to be not operating at optimal scale (Coelli, 2005). In that case, adjusting the CRS DEA model to account for variable returns to scale situations is suggested. Also, there are input-orientated DEA model and output-oriented DEA model. Input-oriented technical efficiency measures address the question: "By how much can input quantities be proportionally reduced without changing the output quantities produced?" while output-oriented technical efficiency measures trying to answer question: "By how much can output quantities be proportionally expanded without altering the input quantities used?" (Coelli, 2005).

DEA is widely applied in agriculture at macro and micro level. At macro level, efficiency of whole agricultural sector is analysed by various authors.

DEA as non-parametric method is practical to measure efficiency in multiple input and multiple output production units even in case when prices are not available. That is why in early beginning of application DEA method was frequently used in the public sector and non-profit decision management units (Psychoudakis, 1999).

Kočišova (2015) investigated efficiency using both the input and output-oriented models using the assumption of a variable return to scale in 27 agricultural sectors of the European Union (EU) countries during the period 2007–2011. The results showed that, in average, the agricultural sector in the EU performed efficiently, as evidenced by the relatively high values of the average input and output efficiency.

Bojanec and Latruffe (2008) analysed efficiency of Slovenian farms during the transition period from the previous socialist system to a market economy and adjustments to the European Union (EU) membership, by using DEA models with an output-orientation. The results showed that the average technical, scale, allocative and economic efficiencies for the whole FADN sample over the analysed period are relatively high (around or over 0.90), suggesting that, although the FADN sample contains very different farms, the latter have similar management practices, and are similarly able to make the best use of the existing technology.

Sharma et al. (1999) used DEA to measure technical, allocative and economic efficiency of swine producers in Hawaii. Their analysis of various firm-specific factors showed that farm size has a positive and significant effect on efficiency levels, suggesting that cost inefficiency can be reduced by exploiting economies of size.

Lansink et al. (2002) used DEA to analyse efficiency and productivity differences between conventional and organic livestock and crop farms in Finland. The efficiency and productivity estimates suggested that organic farms were more efficient relative to their own technology, but used significantly less productive technology than conventional farms.

Paudel et al. (2015) used DEA to compare technical efficiency of organic and conventional coffee farms in rural hill region of Nepal. Their results showed that mean technical efficiency scores were 0.89 and 0.83 for organic and conventional coffee farming, respectively.

Discussing usefulness of DEA for farm management purposes Psychoudakis (1999) conclude that only in case of adequately disaggregated inputs and outputs, results of DEA methodology is valuable for managers. Measuring relative productive efficiency by DEA is possible to identify source of inefficiency of farms and to provide improvement targets for inefficient farms.

Materials and methods

Data in the Danube Soybean project are collecting each year during farm visits using semi-structured questionnaire. During 2015 production year 34 soybean producing farms in Serbia-north region were visited and interviewed. Two production systems were analysed: organic and conventional. Organic production in Serbia is in developing phase and there was no possibilities to identify control group. In recent production systems two groups of farm were interviewed: first group of 10 farms that participate in Danube Soybean project as a partners supported by agricultural extension activities and second group of 13 farms with traditional approach in soybean production. Extension activities with farmers participating in the project ranged from technology to economy aspects of innovative soybean production. Farmers participating in project visited demo fields with improved technology in soybean production.

Quality of collected data were checked at several stages. During farm interview and in questionnaire, several cross checking questions were asked. After farm visits some data were discussed again with farmers by phone calls. Usually sources of misunderstanding were: different measurement units applied among farmers, language barriers, lack of understanding of semi structured questionnaire etc.

Comparison of organic and conventional farms brings some dilemmas, especially in case of comparison of farms from different regions or countries. In comprehensive analysis of various approaches of other researchers, Cisilino (2007) conclude that organic and conventional farming to be compared have to achieve the following requirements:

- similar environmental conditions (land fertility, climate, ...),
- same localization (Region),
- same endowment of productive factors,
- same business typology (farm type)

If organic farms represent sufficiently high number of all farms in region, the comparison procedure may become easier. Specific matching may not be needed anymore, as the organic farms can simple be compared to all conventional farms of similar farm type and same size in respective region (Offermann, 2005).

DEA is an analysis method to measure the relative efficiency of a homogeneous number of organizations that essentially perform the same tasks (Cooper, 2007). It involves the use of linear programming methods to construct an non-parametric piece-wise surface (or frontier) over data (Coelli, 2005). DEA is apply on set of pear organisations or entities called Decision making units (DMU) which convert multiple inputs to multiple outputs.

Consider n farms (j=1,...,n) as DMUs. Each DMU produces s outputs (r=1,...,s) from m inputs (i= 1,...,m). Suppose x_{ij} and y_{rj} are amount of *i*th input consumed and amount of *r*th output produced by *j*th farm, respectively. Let λ_j be a weight given to *j*th farm in the construction of best practice frontier. Let, s_i^-, and s_r^+ be input excesses and output shortfalls, respectively. Assume that the objective of each farm is to minimize its inputs, keeping the output level constant in the constant returns to scale (Charnes, 1978). Technical efficiency (TE) of target farm o (o=1,...,n) is then solution to the following linear programming (LP) problem.

$$Min\ \theta o - \varepsilon \left(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+ \right)$$

subject to:

$$\sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- = \theta_o x_{io},\ \ i = 1, \dots, m,$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} + s_r^+ = y_{ro},\ \ r = 1, \dots, s,$$

$$\theta_o, \lambda_j, s_i^-, s_r^+ \geq 0;\ \forall i\ and\ r;\ \varepsilon \geq 0,$$

where θ_o is a scalar value representing a proportion of current inputs that produce the chosen level of outputs.

For the DEA analysis LP problem had to be solved n times, one for each DMU. Each LP problem yields a set of solution values for θ, λ_j, s_i^-, and s_r^+. The optimal value of θ is minimum value over all possible values of θ that satisfy the set of constraints in the LP problem and is the efficiency score for target farm o. TE= θ, and if TE=1 while s^-, and s^+ are equal to zero, the target farm is technically efficient. Otherwise, if TE<1 target farm is technically inefficient.

Banker et. al (1984) developed DEA model that assumes variable returns to scale conditions. It enables decompositions of technical efficiency (TE) into pure technical efficiency (PTE) for management factors and scale efficiency (SE) for scale factors. Technical efficiency is product of pure technical efficiency and scale efficiency (Hung, 2012; Mousavi,2011). Scale efficiency is calculated as ratio SE=TE/PTE.

Each soybean producing farm is treated as decision making unit (DMU) and relative efficiency is measured for them. As the relevant inputs are chosen:

- variable cost in RSD per hectare,
- farm utilized land in hectares,
- value of farm mechanization in RSD per hectare,

- farmer education by level of diploma, and
- labour used in hours per hectare.

Variable cost include expenses for: seed, fertilisers, pesticides, fuel, irrigation, custom machinery services, seasonal labour, insurance and other variable costs (transport and storage). Farm utilised land represent farm size and include own and rented agricultural land.

Value of farm mechanization in RSD per hectare represents size of this fixed input. Farmer education level is quality dimension of farm manager. Coelli et al. (2005) propose use of quality dimensions of labour, as a key resource. Labour used in hours per hectare include paid seasonal labour and unpaid family labour.

From outputs as relevant was chosen gross margins. Gross margin is calculated as difference between revenue in soybean enterprise and all variable cost incurred in soybean production per hectare. In short run for farm manager gross margin is indicative as a profit potential indicator.

Since quantities are used on input side, except variable cost and value of mechanisation, and gross margin on output side, technical efficiency is estimated.

Table 2 presents descriptive statistics of data set for 11 organic and 23 conventional soybean producing farms. High standard deviation coefficients comparing with average values indicate of wide range used inputs. In organic soybean production farms vary from small with 4 hectares to big with 3,000 hectares.

Also, there is couple small farms with no mechanisation, middle size farms have mechanisation, but usually contract harvest with bigger farms, that have all production processes mechanised.

Soybean producing farms, both organic and conventional, are diverse in total farm land size, ranging from small to big farms. Also, in both groups, by one farm contract all operations with other farmers, while other farms have partial or complete mechanization in soybean production.

Cooper et al. (2001) propose that the number of DMU (farms) should be three times bigger than number of inputs and outputs used in DEA model. In this study number of farms is more than triple the number of inputs and outputs considered. That is developed DEA model hold good construct validity.

Table 2. ***Descriptive statistics of sample***

Organic soybean	Average	Min	Max	St. Dev.
Gross margin (RSD/ha)	102,463.7	33,920	142,758	37,287.3
Variable cost (RSD/ha)	61,739.7	37,906	108,338	24,494.1
Farm utilized land (ha)	518.1	4	3,000	1,007.4
Value of farm mechanization (RSD/ha)	170,403.0	0	1,082,400	307,870.5
Farmer education (1-no school to 5-Bechelor degree)	3.4	2	5	1.2
Labour (working hours/ha)	150.3	56	393	103.6
Conventional soybean				
Gross margin (RSD/ha)	57,772.9	20,184	101,940	22,582.3
Variable cost (RSD/ha)	61,226,0	41,843	101,618	16,300.8
Farm utilized land (ha)	69.7	3	488	99.3
Value of farm mechanization (RSD/ha)	96,212.1	0	203,525	55,756.3
Farmer education (1-no school to 5-Bechelor degree)	3.3	2	5	1.0
Labour (working hours/ha)	29.3	9	80	19.2

Table 3. ***Correlation coefficients among inputs and output***

	Variable cost	Farm utilized land	Value of farm mecha-nization	Farmer education	Labour	Gross margin
Organic soybean						
Variable cost	1.00					
Farm utilized land	0.18	1.00				
Value of farm mechanization	0.57	-0.21	1.00			
Farmer education	0.40	0.59	-0.20	1.00		
Labour	0.48	0.25	-0.32	0.41	1.00	
Gross margin	0.00	-0.37	-0.06	-0.18	0.04	1.00
Conventional soybean						
Variable cost	1.00					
Farm utilized land	-0.28	1.00				
Value of farm mechanization	-0.10	-0.26	1.00			
Farmer education	-0.41	0.49	-0.19	1.00		
Labour	0.25	0.01	0.37	-0.38	1.00	
Gross margin	-0.39	0.11	0.06	0.12	-0.15	1.00

The correlation analysis results are presented in *Table 3*. The application of DEA method presumes relation among inputs and outputs. The correlation coefficients between selected an output and five inputs are ranged from weak to strong. In most relations positive and negative correlation coefficients explain basic differences between organic and conventional production systems. For example, in organic soybean production farmers with higher education use more labour hours per hectare. Oppositely, on conventional soybean farms, more educated farmers relay more on chemical weed control, and tend to use less of labour.

Results

Computer program DEAP version 2.1. developed by Coelly (1996) were used to analyse relative efficiency in sample of soybean producing farms in Serbia in 2015. Input - oriented multi stage model with variable return to scale was chosen for analysis. The results of CRS and VRS DEA models presents TE and PTE respectively. Scale efficiency is the ratio of TE and PTE. If ratio is equal to 1 than farm is scale efficient, otherwise results lower than 1 indicate scale inefficiency.

The results of DEA models are presented in *Table 4*. The average efficiency for whole sample of 34 farms was 0.63, and only 8 farms achieved technical efficiency score of 1. Besides technically efficient farms, additionally 10 more farms had pure technical efficiency indicating its disadvantageous conditions with size of business i.e. low scale efficiency. The technical efficiency varied from 0.131 to 1 with standard deviation of 0.281 which is highest among other two efficiencies. Wide variation of technical efficiencies between farms indicating wide range of various production techniques applied (organic and conventional). Also, wide range of TE among farms can be result of differences in management quality regarding time and quality of operations in soybean production.

Table 4. ***Average efficiency of 34 soybean producing farms***

	Average	**SD**	**Min**	**Max**
Technical efficiency	0.630	0.281	0.131	1
Pure technical efficiency	0.880	0.167	0.419	1
Scale efficiency	0.704	0.254	0.237	1

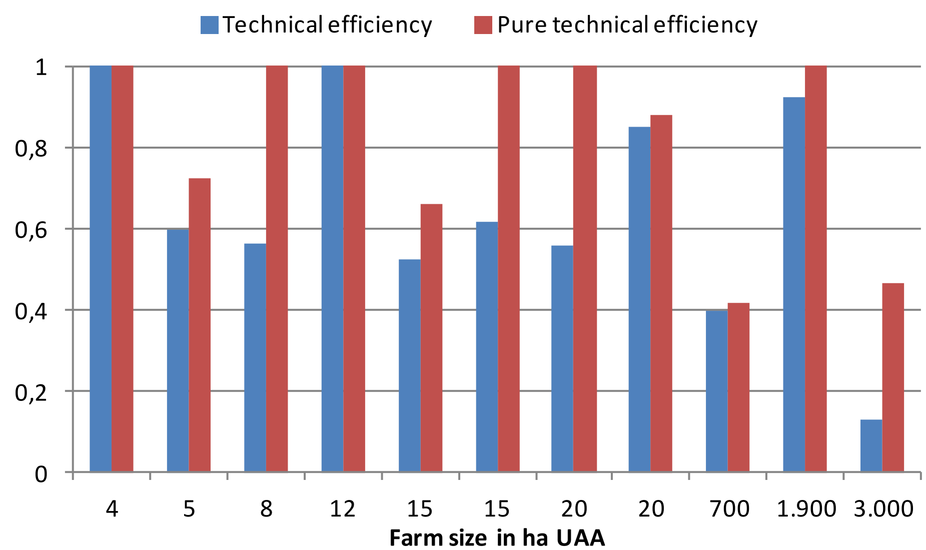
The average efficiency by subgroups is presented in *Table 5*. Organic farms scored average technical efficiency 0.652, lower than conventional farms 0.769, but higher than conventional-control farms 0.505. It proves positive results of extension work with farmers in both organic and conventional soybean production systems. All three analysed groups of farms have higher pure technical efficiency than scale efficiency. Especially low scale efficiency have farms in conventional-control group, which is main source of its lower technical efficiency. Similar scores in pure technical efficiency between farm groups indicate similar level of applied technology in soybean production.

Table 5. *Average efficiency of soybean producing farms by production system.*

	Number of farms	**Technical efficiency**	**Pure technical efficiency**	**Scale efficiency**
Organic	11	0.652	0.832	0.771
Conventional	10	0.769	0.942	0.802
Conventional-control	13	0.505	0.873	0.571

Increasing return to scale (IRS) dominate in sample, since TE/PTE < 1. It implies that soybean producing farms are technically inefficient because of scale inefficiency, rather than from pure technological inefficiency. Inefficient farms could increase efficiency by increasing arable land area and improving management skills.

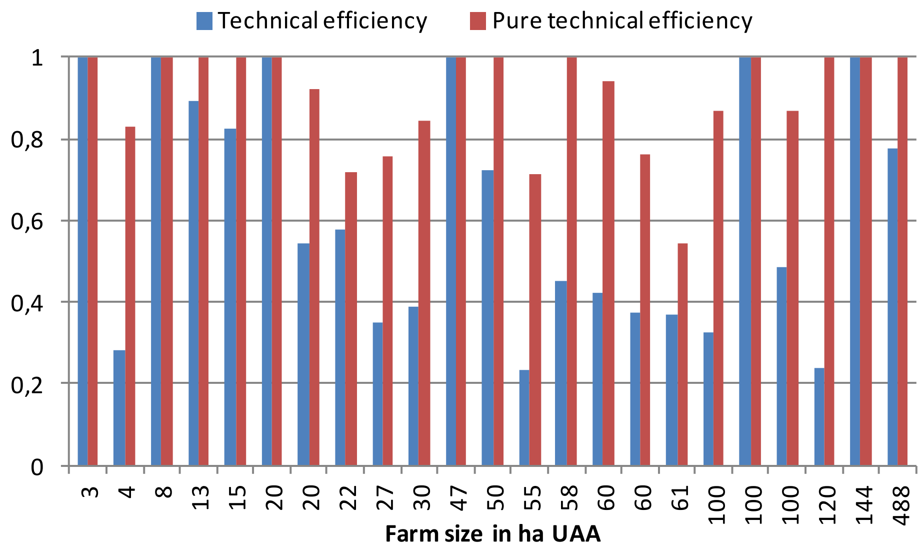
Chart 2. *Efficiency score distribution of organic soybean producers by farm size in ha UAA*



Efficiency score distribution presented in *Chart 2*, revealed that, from analysed 11 organic farms, 6 of them had PTE score of 1, while only 2 farms scored TE with value 1. Efficient farms exist in all range of farm size, measured in utilized agricultural area (UAA). Reason why 4 farms didn't score higher TE lies in disadvantageous lower scale of size. Rest of 5 organic farms scored TE and PTE coefficients lower than 1, indicating mainly problem with management of production factors.

Two big organic soybean farm with 700 and 3,000 ha scored significantly lower TE and PTE in group. It raises question about specific management needed for organic production in big production systems. Weed control is one of most labour consuming activities in organic soybean production. Lost control over weeds significantly reduce soybean yield. Obviously low technical efficiency here coming from low PTE, which mean low management level.

Chart 3. *Efficiency score distribution of conventional soybean producers by farm size in ha UAA*



The results of efficiency scores for conventional soybean farms are presented in Chart 3. From 23 farms, 12 have PTE score of 1, while half of them have TE score of 1. Efficient farms exist in all groups of farm size. Farms with PTE scored with lower coefficient than 1, in most cases have bigger problem with low scale of business size, than with low PTE.

Conclusions

Production of soybean in Serbia is growing as result of increasing harvested area and yield. The biggest producers of soybean in Serbia are big and middle size farms, accounting 70.6% and 20.8% of total harvested area respectively. There is several drivers that motivate farmers to increase soybean production. First is, the stable profitability potential. It comes from more stable yield comparing with corn and higher average yield and better price stability comparing with sunflower. Second, lower fertiliser cost and cost savings for later crop. Additionally, good storage ability enables to farmers to sell soybean in longer period. Climate changes enables soybean production in areas previously treated as dry and unfavourable for soybean production. This study examines technical efficiency of 34 soybean producing farms with two producing systems: organic and conventional in 2015 production year. DEA input - oriented multi stage model with variable return to scale was applied to measure relative efficiency scores. The results revealed that both group of farms participating in project, organic and conventional soybean producers score higher average level of technical efficiency than control group of conventional soybean producers. It proves that extension work with farmers had positive influence on its TE. Also, technically efficient farms exist in all farm size classes, implying that management is key resource for farm efficiency. Beside 23.5% of technically efficient farms 29.4% of farms reached PTE score 1. Rest of 47.1% farms in sample were inefficient. Inefficiency comes mainly from scale inefficiency. Inefficient farmers could increase technical efficiency of their soybean production by increasing arable land area and area planted with soybean, or decreasing level of used inputs, as well as improving management skills. This research had some limitations. Farms participating in the Danube soya project consist a bias in sense of its outputs. Usually leading farmers take participation in such projects. As a leaders those farms much faster acquire new knowledge and technology progress, than other average farms and as result gain higher yields. To alleviate this bias, in selection of farms for subsample of conventional-control group advantage was given to farmers leading in their communities. Absence of prices for some inputs prevents analysis of economic efficiency. It could be topic for next research, as well as technological change measurement, for what necessary preconditions is to provide continuity with data collecting in next few years.

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MODELS OF SUCCESSFUL FAMILY BUSINESS ON FARMS BASED ON THE PRODUCTION OF MILK AND TRADITIONAL DAIRY PRODUCTS

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Abstract

Using the experience of more developed countries in terms of a successful family business on registered farms and own experience through the creation of a large number of projects for facilities in the household and sole trade businesses (STB) for milk processing and production of various dairy products in Serbia, this paper presents models of successful family business in medium and small farms. It concerns the registered farms (RF) dealing with bigger or lesser production of milk (cow, goat or sheep), where there are basic predisposition for a narrow specialization in milk processing, primarily in the production of indigenous, but also other dairy products, where with the small investments a serial production and good quality of products can be provided. Past experiences show that due to the non-inclusion of science and practice in such projects, small producers are generally left to cope with production alone, and are in the hands of dairy plants and milk prices that they designate. It is not unusual that in the period when dairies have a surplus of dairy milk, they cancel the purchase of milk starting from the small producers, and especially then farmers find themselves in trouble if they do not have possibilities for their own processing.

The paper presents technical and technological solutions for improvement of the quality of those producers who sell their products on the market, because they make up for a large percentage of the total producers. With the joining of Serbia to the EU, conditions of production of food of animal origin on the RF will change in regards to the conditions in which it was previously possible to

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produce these products. These conditions will be similar to what we see today in many RF in Croatia, Slovenia, Austria, Italy or France. In order to help our producers, it is important to develop projects and create technical and technological conditions and provide funds for needed equipment for the manufacture of products, as it was done in the project of the Provincial Secretariat for Agriculture, Forestry and Water Management of AP Vojvodina 2013-2016. With this project, adaptation of premises and purchase of necessary equipment in 32 RF was co-financed, in order to align with EU standards in the field of production and processing of milk. This is an example of project that improves the quality of milk, increases livestock, employment of household members engaged in livestock production, expands the range with new products, product branding and raising standard of living in the countryside.

Key words*: family businesses, farms, milk production, traditional dairy products*

Introduction

In addition to residents who leave the individual households and villages and move into the cities, part of the population and the labor force is employed in non-agricultural sectors, but remains living in the household. With the first type of abandoning agriculture elderly households arise, but also with other means of leaving farming households remain without agricultural labor force and from the point of view of agriculture as an activity, these households are elderly. The rapid economic development during the 50s and 60s of the last century, allowed the mass departure of young people from individual farms (Marković, 1963). The volume of leaving individual farms was higher than the population growth rate quotas. Most of the young people who left the village and individual farms engaged in non-agrarian activities and various social services. So a mass exodus from agriculture caused a reduction in the agricultural population.

The existence of a large number of elderly households points to the further movement of the rural population. Assuming that the birth rate is decreasing, the total population of the agricultural population will be increasingly smaller. Population growth rate of the agricultural population in relation to the non-agricultural population will be increasingly smaller, due to the increasing number of population (elderly households) in agriculture which will not reproduce. (Marković, 1963).

The Republic of Serbia began to deal with the negative consequences of the spill-over of the global crisis on the domestic financial and economic or business life in the second half of 2008. These processes affected also agriculture, which still represents a very important branch of the Serbian economy, given the resources at its disposal. The rural population is still retaining a large percentage of the total population of 42.94% (Food and Agriculture Organization, 2014), provided that the rural landscape is still characterized by extremely unfavorable age, professional and educational structure of the population, as well as undeveloped municipal, economic and socio-cultural infrastructure in rural areas. Given the availability of significant natural and human resources, as well as to the level of production and processing, agricultural production is one of the most important economic activities in Serbia. Supporting this fact is the data on the participation of agricultural production in the implementation of Gross Domestic Product (GDP) of Serbia in the period from 2002 to 2013. year, which ranged from 15.5% to an estimated 11.8% in 2013. (Madžar, 2014).

With regards to the planning entrance of Serbia to the EU, farmers are mostly concerned about their future in an open market, especially in terms of where our country is dominated by fragmented, uncompetitive and elderly households with high production costs. Such characteristics of agriculture affect increased caution and fear of the consequences of joining the European Union (Franić et al., 2009). Today, the size of the estate in developed countries is increasing, and the number of farms is decreasing, which is the essence of the process of concentration and centralization (Pejanović and Tica, 2005). The prerequisite for defining and implementing the strategy of integrated and sustainable development is a holistic approach to planning research and development of rural communities as a specific socio-spatial entities.

In addition to the activities of farmers itself, it is important that households get the support of political leaders, in the form of stimulating economic and agricultural policies, developed institutional capacities of the state, and developed physical, market, financial and scientific infrastructure in the country (Paraušić and Cvijanović).

The future development of the agricultural sector in Serbia should be directed towards modernizing and changing the production structure towards market orientation and improvement of overall efficiency. The systematic and structural reform of the agricultural sector in Serbia started after 2000. It is necessary to continue reforming the field of agriculture in Serbia, in order to ensure further development of the area. The harmonization of Serbia's agricultural policy and the Common Agricultural Policy (CAP) of the European Union provides a series of benefits for the agricultural sector (Stanković, 2012).

Material and methods

Criteria for the selection of holdings

Households that have been involved in the projects have had to meet the following requirements: to be engaged in keeping cows or goats and/or sheep and goats, and to have their own production of conventional milk and/or that are under conversion to organic milk production and/or have organic milk production; to have stalls with good farming conditions, mechanical milking and milk cooling devices; to have their own land and leased land and to produce food for the animals; to have facilities that can adapt into the space for dairy in household or object in the final stages of construction for a dairy, or to put into operation a dairy; that based on their own previous investment (in reconstruction and equipment) and planned new investments (3.250.000,00 RSD) can close the circle of processing and also in terms of space and/or equipment, and that they can get approval of operation from veterinary inspection (where necessary), under conditions of maintaining control and HACCP system which provide healthy and safe production; have a market for their products and that they can reach the price of milk up to two to two and a half times higher when compared to selling off the milk to other dairies based on the current own processing and production of finished products, to increase in this way the profitability of its milk production; that some of their own products: rolled cheese, white cheese, kaymak, paprika in sour cream, cheese with various additions and smoked cheese etc. will be able to be produced under the label "Best of Vojvodina", or "Organic", or as the original product of Vojvodina with "Protected Geographical Origin"; that the processing creates the conditions for greater employment of household members and to ensure employment of new workforce and improve the standard of people in the countryside; to increase the employement of agriculture engineers and technologists and improve product quality and expand the range; that agricultural holdings over time can grow into "Association of Small Cheese Producers" and organize the festival of cheeses from Vojvodina (which would be held every year), where the visitors could taste controlled cheeses from different producers from Vojvodina, and also other indigenous products of Vojvodina, which would had a promotional cause, significant in terms of marketing and sales.

Analysis of existing conditions

Analysis was performed in milk and milk products originating from farms, and on the basis of these results necessary suggestions were made. Proposal of measures that the chosen experimental farms need to implement to bring an improvement of production were made.

Proposal of measures includes measures in the production technology, product control, activities for the protection of geographical indications (where there are conditions).

- Analysis of raw milk in accordance with legal regulations
- The technological quality of milk in terms of eligibility for certain products that are made or will be made on the farm
- Record existing technology and providing guidance for high quality and good product yield
- Construction engineering regarding the adaptation of the dairies, equipment selection and arrangement of rooms and equipment
- After the adaptation of the dairies and installing the equipment, the practical manufacture of products and provision of the necessary technological instructions
- Providing work procedures regarding the washing and cleaning
- Creating a flowchart of production and the determination of the CCP (Critical Control Points)
- Writing producer specifications and declarations
- Determination of the shelf life of the product

Analysis of milk, dairy products and animal feed

Analysis of milk and dairy product were done in the Dairy laboratory on the Faculty of Agriculture in Novi Sad, using standard methods, for fat, protein, dry matter and acidity. Owners of farms have provided data on race, average milk yield, system of feeding, contents of the meal and its daily amount. Chemical analysis of feed differed with respect to whether the feed was concentrated or not, or which are important indicators from the point of ruminant nutrition. For these reasons, the forages were evaluated for: moisture content, dry matter, protein, fat, crude fiber and neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL). Concentrated nutrients are tested for moisture content, dry matter, protein, fat, cellulose, ash, macronutrients (calcium and phosphorus), but because of the great importance in animal nutrition analysis of mycotoxins (aflatoxin and deoxynivalenol) was performed.

Results and discussion

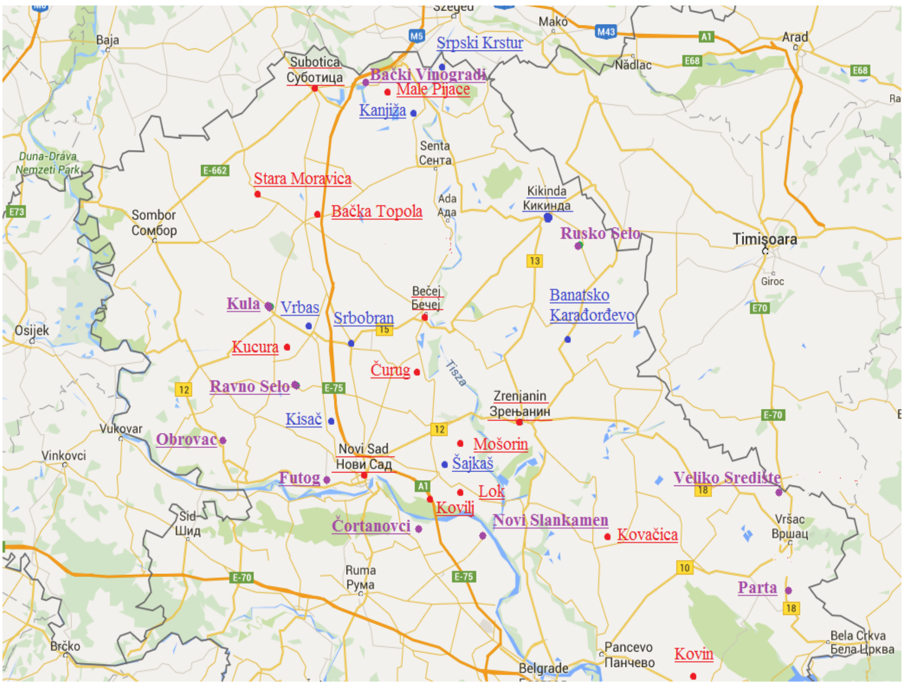
On the basis of selection (*Figure 1.*) and the monitoring of registered farms from AP Vojvodina, who wish to engage in the processing of cow, goat and sheep milk and production of cheese and other dairy products and to meet the criteria for obtaining the sign "Best from Vojvodina" and/or the "Organic"sertificate and/or signs of origin and /or geographical protection of products, conceptual projects were made.

Table 1. ***Location/municipality of participants in projects of improvement of production and the introduction of EU standards***

No.	First year	Second year	Third year
1.	Čortanovci, Inđija	Kikinda, Kikinda	Mošorin, Titel
2.	Novi Slankamen, Inđija	Banatsko Karađorđevo, Žitište	Čurug, Žabalj
3.	Parta, Vršac	Šajkaš, Titel	Lok, Titel
4.	Obrovac, Bačka Palanka	Kanjiža, Kanjiža	Subotica, Subotica
5.	Ravno Selo, Vrbas	Vrbas, Vrbas	Mošorin, Titel
6.	Rusko Selo, Kikinda	Kisač, Novi Sad	Kovilj, Novi Sad
7.	Veliko Središte, Vršac	Srpski Krstur, Novi Kneževac	Zrenjanin, Zrenjanin
8.	Kula, Kula	Srbobran, Srbobran	Stara Moravica, Bačka Topola
9.	Futog, Novi Sad		Male Pijace, Kanjiža
10.	Bački Vinogradi, Subotica		Kovačica, Kovačica
11.			Kucura, Vrbas
12.			Bečej, Bečej
13.			Kovin, Kovin
14.			Novi Sad, Novi Sad

Source: *Author archives*

Figure 1. ***Map of Vojvodina with marked locations of selected participants in projects***



Source: *Google Maps*

Suggestions to the breeders

During the project, farm animal production was analyzed and some suggestions are given to breeders of goats, cows, and sheeps. Unlike other ruminants, goats are much more "gourmet" animals, because during the day, in relation to their body weight, they may eat more food than sheep and cattle. The goat eats a meal that is 6.5 to 11% of its body weight, while in sheep and cattle that is 2.5 to 3% of their body weight. High milk producing breeds of goats can eat up to 2.5 times more food relative to body weight than it is the case with the dairy cow herd.

Feed for goats must have such nutritional properties, which will allow the maximum activity of microorganism (Krajinović, 2006). The substances necessary for the normal operation of microorganisms are easily soluble carbohydrates (sugars, starch), easily soluble proteins, soluble minerals. For normal digestion significant is also the physical structure of nutrients.

Figure 2. ***Goat stall***

Source: *Author archives*

The main problem for most households is the fact that the animals are not separated according to product groups, and they are given the amount of food that is needed to animals with the highest production. For these reasons economical consumption of food is not present. Nutrients are mostly purchased spontaneously, and the diet is not in accordance with nutrients during lactation, but is made with the available nutrients in that moment (storage for several months of feeding are not made), which results in a lower milk yield per animal. Premix as one of the most important segments of the concentrate is not intended for lactating goats, the most commonly used premix in goat's nutrition is that for lactating cows. For all these deficiencies in production technology, each individual case was analyzed, and the breeders were presented with solutions how to overcome the existing problems.

In order to ensure a quality environment, which would ensure high productivity and good health of goats, the facilities to accommodate goats need to provide the following microclimate conditions:

The optimum temperature for goats is 10-15 ºC, with humidity up to 85%.

- Goats tolerate temperatures down to 0 ºC, while temperatures below the freezing point and major daily fluctuations of temperature must be avoided as much as possible, as each major oscillation in temperature affects production.
- In facilities for accommodation of lactating goats, the temperature should not fall below 6 ºC, nor be higher than 27 ºC.
- The optimum air temperature in facilities for young kids is 12 ºC to 18 ºC, while the temperature below 5 ºC can seriously affect the health and vitality of the kids.
- Optimal humidity in buildings for dairy goats is 65-70%.
- Optimum air velocity is 0.2 to 0.4 m/s and should not be allowed to exceed 0.5 m/s.
- The maximum level of carbon dioxide were 0.035%, 0.003% carbon monoxide and hydrogen sulfide 0.002%.
- For lactating goats in the summer, it is necessary to provide approximately 120 m^3 of fresh air per hour per head, while in the winter is 4 times less, about 30 m^3.
- Facilities need to be sufficiently illuminated, and to take advantage of day lighting, window area should be 1:20 in relation to the floor area of the building. Electric lighting should be provided with lighting 60 lux/m^2 floor area.

In most of the observed farms environment was not a problem limiting production which indicates that manufacturers are familiar with this issue.

For all the shortcomings in the production technology each individual case was analyzed, and breeders presents how to overcome the problems that they have.

Based on a monitoring of farms in 2015 when the number of somatic cells in stall milk exceeds million, it is necessary in addition to the identification of cows with an increased number of somatic cells also to identify the fourth of udder with impaired secretion, after which the cause of an increase in the number of somatic cells must be determined. Measures are to be taken, including control of milking hygiene and housing of animals.

Figure 3. ***Cow stall***

Source: *Author archives*

If bacteriological analysis of milk samples can isolate pathogen microflora, it is necessary to make the antibiotic treatment of cows and start the treatment depending on bacteriological findings - pathogens.

Therapy should be performed in lactating (for certain causes), or in dry period (in cases where there is only an increase in number of somatic cells) and under strict control of veterinary professionals.

On cattle farms where the number of somatic cells were increased in more than 30% of cows, these measures should be necessary to start immediately, with the use of California mastitis test every month.

The objective of monitoring of cows is to determine the health status in order to obtain the proper hygienic and safe milk for public consumption. The said monitoring was aimed at determining the health status of each herd to start with the program of preserving the health status of tested cows.

When it comes to the population of goats, somatic cells should be monitored in early lactation to control their health status as confirmed by the experience that the number of somatic cells in early lactation in stall milk did not exceed 300.000, but during lactation somatic cell count rises and at the end of lactation increases up to a million.

What is characteristic for stall milk cows in terms of somatic cells can not be applied in goats and sheeps in lactation due to differences in the number of somatic cells during lactation which are much shorter and seasonal.

Figure 4. ***Sheep kept in open stall***

Source: *Author archives*

Mycotoxicological examination

In samples of concentrated part of the meal a mycotoxicological analysis is done. In the selection of mycotoxins to be analyzed, above all was their importance for human and animal health, but also their occurence during the period of monitoring.

In this regard, feed was tested for total aflatoxin, due to their transfer into milk, and deoxynivalenol (DON), because of their high representation in samples of corn from the harvest of 2014. The results mycotoxicological analysis in the second year of project cycle are shown in *Table 2*.

Table 2. ***Example of results of mycotoxicological analysis of concentrated meals (2015.)***

Household location	Type of sample	Aflatoxins (mg/kg)	DON (mg/kg)
Šajkaš	Concentrate	< 0,005	0,882
Kikinda	Concentrate	< 0,005	1,064
Vrbas	Concentrate	< 0,005	0,684
Banatsko Karađorđevo	Concentrate	< 0,005	2,041
Srpski Krstur	Concentrate	< 0,005	0,449
Kisač	Concentrate	< 0,005	1,271
Kanjiža	Concentrate	< 0,005	0,948
Srbobran	Concentrate	< 0,005	1,234

Source: *Faculty of Agriculture Novi Sad, Department of Animal Science*

From the results it can be concluded that there was no risk of exposure of animals to aflatoxin, because in all samples tested, the level of aflatoxin was below the levels that can be determined.

When it comes to DON, although its presence in samples is very high (100%), the content of this mycotoxin was well below the maximum permitted level laid down by Serbian regulations, and relevant regulations of the European Union.

Analysis of dairy products

A variety of dairy products from households were analysed. They showed high variability of physical-chemical properties, but also high quality as well as sensory characteristics. Lack of standardisation among the products of the same type can be observed.

Figure 5. ***A variety of cheese types from examined households***

Source: *Author archives*

Technological processes of production of dairy products were carefully monitored, and changes in the important steps were done.

Market of dairy products

Farmers markets as market institutions are still very significant in providing consumers with cheese. The following types of cheese are the most represented: white cheese in slices, cottage cheese, and small quantities of other cheese types. Selling cheese at farmers markets is done in the traditional way, directly - without intermediaries and at a lower prices than the prices of cheese in retail stores.

Lower selling prices and a substantial portion of the acquired habits of consumers to consume these types of cheeses have an impact on the demand for cheese in the markets. It can be seen that sales of cheese in markets are an important part of the overall sale of cheeses of producers involved in the project.

A part of cheese is sold through conventional ads. Modern possibilities for selling final products – through Internet, are not common, and it is a feature more employed in the highly developed countries of the world.

Development of projects

Developing the projects, technical and technological solutions to improve the production and processing of milk and dairy products were given.

The main technological projects consist of the project goals, the general characteristics of the object, the list of legislation, conditions for the construction and renovation of the facility, plan production program and product range, quality standards of raw materials and finished products, defining the technological processes of the production process of finished products, the specification of technological equipment, capacity and energy balance, the description of the laboratories and the necessary accessories, material balances for projected production, norms of consumption of raw materials, packaging and energy characteristics and water balances, environment protection and safety at work. Enclosed is a graphic documentation consisting of the situation, layout, equipment layout, and technological production schemes.

On the basis of finished projects, the renovation of buildings is carried out, in some places also building, the purchase of equipment, installation and training for the production of dairy products, on places where the necessary conditions are established.

Figure 6. ***Project for improvement of quality of milk and dairy product production on the experimental farms***

Source: *Author archives*

Educations of participants

In addition to visiting the manufacturers during the work in their farms and dairies and providing useful suggestions on the spot, training were held at the Faculty of Agriculture in Novi Sad for the producers of this project, where they participated in the lectures on the production of milk and cheese as well as other dairy products, educated how to ensure the safety and nutritional value of the product, and further lectures on breeding of animals, ruminant nutrition, as well as marketing and marketing of dairy products.

Figure 7. ***Education of participants in the projects***

Source: *Author archives*

Conclusion

The projects that were implemented in AP Vojvodina using logistics of Faculty of Agriculture in Novi Sad, with the financial support of the Provincial Secretariat for Agriculture, Water and Forestry has managed to achieve the original intent of improving the quality of milk, increase livestock, employment of household members engaged in livestock production, expansion of assortment with new products, product branding and raising standard of living in the countryside.

Using analyzes of existing condition, analysis of animal feed, animal health, raw milk and dairy products, the achievement of improvements in production in selected experimental farms was done, and making the technology projects and providing the logistical support for the introduction of standards in the domestic dairies and registered dairies enabled the production of milk and dairy products on family farms.

Bearing in mind the practical archieved results, these type of projects for improvement of production will continue in the future, in order to ensure better market competitiveness of small producers, and greater employment of young people in the countryside.

Acknowledgement

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ECONOMIC JUSTIFICATION OF APPLE STORAGE

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Abstract

Competitiveness in the global market involves quantitative and qualitative security to offer. In order to ensure continuous supply of market with high-quality fruit during the year, it is necessary to store freshly harvested fruits. The basic method for successful storage of fresh fruit is cooling. Cold storage facilities provide optimum conditions for preserving the quality of the fruit until the moment of their launch on the market. In addition to preserving the quality of fruit in cold storage facilities, disposal of investments provides the opportunity to achieve higher selling prices. Apple, as one of the most important fruit species on the Serbian market is characterized by strong seasonal character of offer. This practically means that most producers sell apples during harvest season, when supply is greatest, and thus accept the price established by the market, which is usually very low in this period. Investing in the construction of cold storage would allow the postponement of the sale, which would give producers the opportunity to sell their products at a time when the offer is less, but demand is higher. By postponing sales, and with effective storage in cold storage facilities, producers are able to sell their products at a time when the offer is lower and demand is higher. On this way is achieved much better financial result.

Key words: *market, cold storages, sales price, apple*

Introduction

Because of its climate and geography, Serbia has great potential for the apple production, as one of the most important fruit crops in the world. However, immediately after harvest, there are losses, which in the developed countries amount from 5 to 25%, and in the developing countries the percentage of loss is ranging from 25 to 50% (*Gladon, 2006*).

In order to prevent these losses, first it must be understood that the fruit continues to live after harvest. Specifically, this means that the fruits continue

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to grow, breathe, lose moisture, continues to be sensitive to physiological changes, and are also susceptible to all kinds of damages and diseases (*Kader*, *2002*). The most effective solution to reduce these losses is certainly the storage of fruit immediately after harvest.

In addition to reducing the losses that occur after harvesting, the objective of storage is to equalize fluctuations in market supply, and then to ensure regular and continuous supply of raw materials for the processing industry, as well as striking a balance between supply and demand, resulting in a stabilization of market prices (*Alexander Corinne and Kenkel*, *2012*).

In this paper, the economic feasibility of apple storage was analyzed on concrete example, while at the same time, the amount of total investment in building a cold storage with ULO (Ultra Low Oxygen) technology, used for the purposes of storing, was determined.

Calculations by Kalanović Bulatović et al. (2009) were used in determining the value of the investment. The desired economic effects are realized by delaying the sale, or achieving higher purchase prices, which would therefore mean higher profit (*Kokot and Marković*, *2015*).

Storages (in this case cold storages) built its economy on the difference between the real growth of the sale price of certain agricultural products and the costs of their storage and shrinkage (*Novković et al*, *2006*).

Based on the analysis of these parameters in the ten-year period (2006-2015), the main objective of the research is to determine the economic effects of storage, with attention dedicated to defining the optimal period for the sales of apples.

Materials and methods

The database of the Statistical Office of Republic of Serbia (for the period from 2006 to 2015) as well as data from the company "Atos Fructum", from Mala Remeta, Irig municipality, which owns ULO cold storage with capacity of 3,200 t, in which harvested apples are stored, were used for the realization of the set goal of research.

Different methods of scientific knowledge and research, such as analogies, methods of induction and deduction, and methods of analysis and synthesis are used in this paper. Different technical literature was used to create and design the theoretical part of the work.

The advantages of apple storage

Market demands for the apple production are high and only high-quality and healthy fruits are possible to sell. Good quality implies healthy fruits or the fruits with no damage caused by diseases and pests (*Inđić et al, 2011*).

Apples after harvest remain physiologically active. Breathing, as the primary metabolism, may limit the useful life of apple, negatively affect the quality, and cause a change of nutrients during storage. Given that apple has a high water content, over 85% (*Šoškić, 2011*), improper storage can lead to weight loss due to evaporation. Fruits during ripening after harvest produce ethylene, which can accelerate the aging of fruits and weaken the antiviral and antimicrobial capabilities. All of that result in a decline of the quality, nutritional value and safety of fruits after harvest (*Li and Li, 2008*).

Low humidity leads to intense transpiration causing large losses of mass, and the fruits shrivel and lose their freshness. Lower temperatures reduce the respiration of fruits, biochemical processes in fruits are slowing down, while the growth of microorganisms also slows down and stops. On the other hand, a low content of O_2 and high CO_2 leads to the prevention of fruit ripening by inhibition of respiration (*Simeunović Brankica, 2014*). For these reasons, it is necessary to store apple in cold storages soon after harvest that will enable an environment with low temperature and high humidity or with low O_2 and high CO_2.

In order to prolong the shelf life of apple, while preserving the quality of the fruits, in recent times, in addition to storage at low temperatures, ULO technology is also applied, which means that it reduces the presence of oxygen. The most important advantages of storing apples in ULO cold storages are (*Kalanović-Bulatović Branka et al, 2009*):

1. Kalo with the ULO cold storage is < 1%,
2. Skin color and the kernel of the fruit remains unchanged during the storage period,
3. Freshness is kept,
4. Quality remains unchanged,
5. Fruit retention period is considerably longer within ULO cold storage than that of ordinary cold storage.

The need for apple storage comes from need for delay of sale, with the main objective to achieve better economic effects, respectively higher profit. In this case, storage is particularly important, given that apple is an agricultural product that is seasonal and arrives once a year and is the subject of trade throughout the year (*Novković and Mutavdžić Beba, 2009*).

Basic characteristics of ULO cold storage

In addition to high standards in production, the intention of "Atos Fructum" was the construction of modern cold storage as part of the orchard, with which will be provided access to the most advanced apple storage (*Figure 1*). Built cold storage has a capacity of 3,200 t, with ULO technology which represents the latest achievement in the field of long-term storage of fresh fruits. ULO regime in chambers gives the possibility that the entire yield of apple can be stored and offered to the market at any time of the year, whereby the production properties of apple are fully preserved without any chemical intervention. This form of storage is applied in developed European countries (Germany, Denmark, France, Italy, the Netherlands, etc.) for storing up to 70% of the total quantity of fruits, and in the US for 50% volume (*www.atos-fructum.com*).

Technological parameters maintained by ULO installed equipment, vary both by individual varieties of apples, as well as for individual countries in the world because of the variety of climate zones and external weather conditions.

Established integrated system ensures that from the time when apple is picked to the time it enters into a controlled atmosphere of ULO cold storage, it passes a maximum of 60 minutes.

Figure 1. ***The exterior of ULO cold storage***

Source: *Atos Fructum LLC*

The basic working principle of ULO cold storage comes down to control of the temperature, humidity, oxygen and carbon dioxide. ULO regime is characterized with oxygen level of 0.9 to 2.2%, with the level of carbon dioxide from 1.5-2%, and high relative humidity, usually from 90 to 95% (*Weber et al, 2011*). In such storage conditions, all biological processes in the fruits are slowing, and fruits like apple can be kept through the whole year, without a significant impact on the quality. When storing apple in conventional cold storages, the losses ranging from 7 to 10% are occurring, while in storing apple in ULO cold storages, losses are not exceeding 1% (*Marković et al, 2011*).

ULO cold storage consists of manipulative and operational part. The manipulative part are offices, rooms used for storing apples in crates, sorter etc. Operative part of cold storage consists of hallway and ULO chambers which are laterally arranged in relation to the hallway. Analyzed cold storage consists of 17 chambers whose capacities ranges from 88 to 236 t. The interior of the cold storage is shown in *Figure 2*.

Figure 2. ***The interior of the ULO cold storage***

Source: *Atos Fructum LLC*

Investment in the construction of ULO cold storage

For the functioning of ULO cold storage is necessary to build the access and internal roads, main and supporting facilities, transport and communication infrastructure, a system for wastewater and storm waters, and ensure the smooth supply of water and electricity.

The total investment in the construction of ULO cold storage consists of the cost of purchasing the land, carried out ground works, the building costs of cold storage and the equipment value built in the facility (*Bulatović Kalanović Branka i sar, 2009).*

Based on *Table 1*, it can be concluded that the total value of the investment in the construction of ULO cold storage amounts to 213,460,680 RSD, or € 1,778,839.

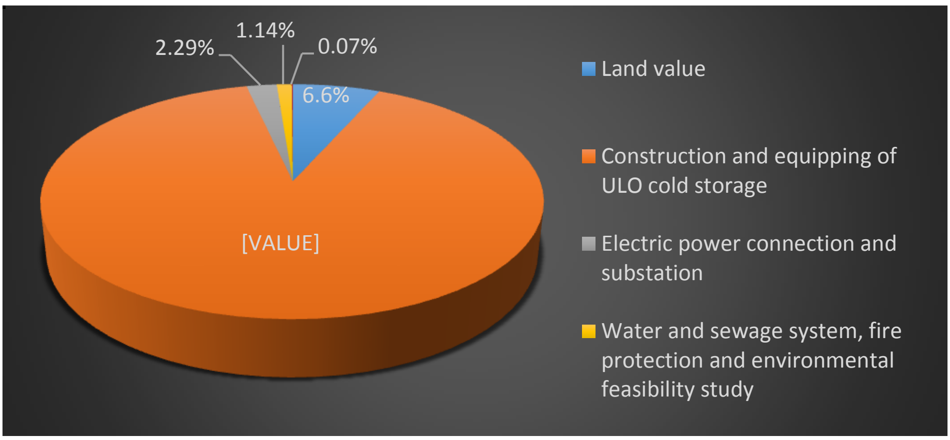
Table 1. ***The cost of construction of ULO cold storage capacity of 3,200 t***

Serial no.	Elements	Amount	
		RSD	€[3]
I	Land value	14,147,160	117,893
II	Construction and equipping of ULO cold storage	192,051,000	1,600,425
III	Electric power connection and substation	4,683,840	39,032
IV	Water and sewage system, fire protection and environmental feasibility study	2,425,800	20,215
V	Video surveillance	152,880	1,274
Total		**213,460,680**	**1,778,839**

Source: *Authors' estimate based on Bulatović Kalanović Branka et al, 2009; Atos Fructum LLC*

In the structure of total investment, a dominant share has costs of building and equipping, with the participation of more than 89%. In second place is the value of the purchased land, while all other costs have significantly lower participation, which can be seen on the *diagram 1*.

Diagram 1. The structure of the construction costs of ULO cold storage



Source: *Authors*

[3] 1€=120RSD

The costs of the structural part include the cost of all work on the preparation of the land and the cost of works on the construction of the facility. Preparation of project documentation precedes over the commencement of works.

Preparation of the land involves removing the surface layer of humus, filling the buffer layer of sand and gravel, building a foundation, construction of concrete floor, as well as the construction of access roads. After completion of ground works, installation works and equipping the facility follow. Review of the total expenditures of construction is given in *Table 2*.

Table 2. ***The costs of preparing the land and costs of construction works***

Serial no.	Elements	Amount	
		RSD	**€**
I	Preparation of project documentation	768,000	6,400
II	Ground works	29,162,160	243,018
III	Installation works	8,986,320	74,886
IV	Commissioning and proving of cooling parameters	972,000	8,100
Total		**39,888,480**	**332,405**

Source: *Authors' estimate based on Bulatović Kalanović Branka et al, 2009; Atos Fructum LLC*

The equipment value that is built into the cold storage includes the value of the steel structure, thermal insulation, the costs of introducing electrical and lighting, cooling and ULO equipment as well as spare parts (*Tab. 3*).

Table 3. ***The value of installed equipment***

Serial no.	Elements	Amount	
		RSD	**€**
I	Steel construction	32,066,280	267,219
II	Thermal isolation	46,274,640	385,622
III	Cooling equipment	45,449,880	378,749
IV	ULO equipment	25,058,040	208,817
V	Electrical installation	1,002,360	8,353
VI	Installation of lighting	1,458,000	12,150
VII	Spare parts	853,200	7,110
Total		**152,162,400**	**1,268,020**

Source: *Authors' estimate based on Bulatović Kalanović Branka et al, 2009; Atos Fructum LLC*

On this occasion the value of additional equipment such as boxing pallets, technological equipment for sorting, packaging technology equipment and means of internal transport (forklifts) were not taken into account (*Tab. 4*).

These costs can be significantly reduced if for example for a start a particular piece of equipment is leased or the used equipment is purchased.

Table 4. ***Other technological equipment***

Serial no.	Equipment name	Amount (RSD)	Amount (€)
I	Technological equipment for sorting	57,600,000	480,000
II	Packaging technology equipment	11,520,000	96,000
III	Means of internal transport	11,520,000	96,000
IV	Boxing pallets	174,600,000	1,455,000
Total		255,240,000	2,127,000

Source: *www.tehnologijahrane.com*

The costs of apple storage

Operating costs of analyzed cold storage can be divided into fixed and variable costs. The variable costs include the cost of electricity, while other costs have the character of fixed or mostly fixed.

Cold storage is commonly in use since September, when the harvest starts, until May, where operating costs incurred regardless of the percentage of cold storage used capacity.

Table 5 shows the amounts of all the elements involved in the structure of total operating costs of ULO cold storage per annum. As can be seen in the structure of total costs, the amortization costs dominate.

This is due to large investments in the construction of the cold storage (*Kart and Demircan, 2015*). Amortization is calculated on the value of the building structure and ULO equipment.

Table 5. ***Operating costs of ULO cold storage***

Elements	Annual amount		%
	RSD	**€[4]**	
Electricity costs	3,719,520	31,000	17
Salary and salary compensation costs	1,789,200	14,910	8
- Salary costs (net)	1,296,000	10,800	5.7
- Tax and contribution costs	493,200	4,110	2.3
Amortization costs	15,840,000	132,000	70
Maintenance costs	360,000	3,000	1.6
Provisions costs	200,000	1,670	1
Intangible costs - tax costs	528,000	4,400	2.4
- Property tax - land	48,000	400	0.3
- Property tax – ULO cold storage	480,000	4,000	21
Total	**22,436,720**	**186,980**	**100**

Source: *Atos Fructum LLC*

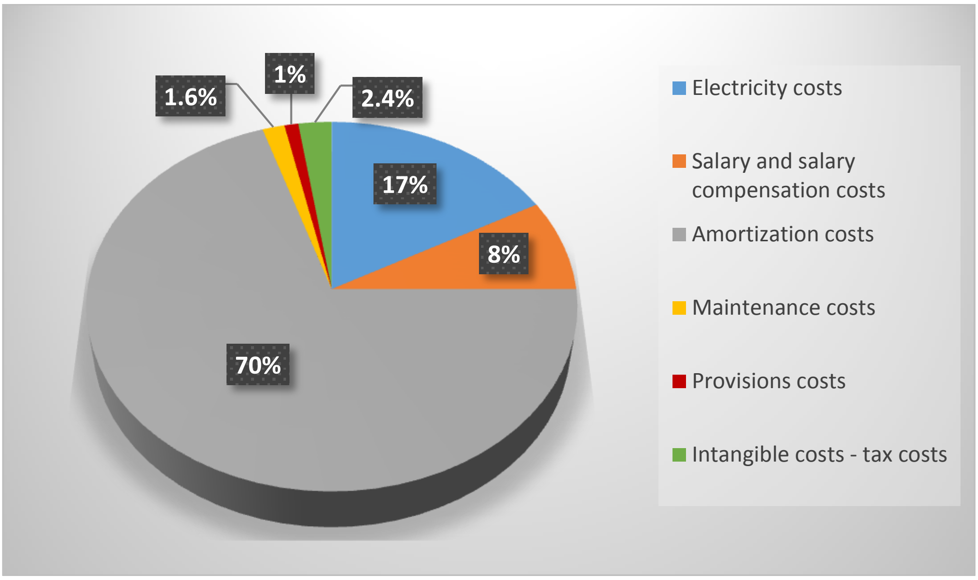
On the second priority are the costs of electricity. The maximum power consumption was recorded in the period from September to April of next year, when the realization of stored apple is usually done. The costs of electricity generate also in the months when the cold storage is not in use, but in this period they are twice lower.

Maintenance costs include the costs of regular servicing of equipment, while the provision costs include the costs of elimination of possible breakdowns and replacement parts. These costs occur only once, and their share in structure of total costs is not significant.

For jobs in the cold storage, three full-time employees are hired. Temporary labor force is engaged only during the screening apple before the sale, however, these costs do not affect the operating costs of cold storage, considering that this operation is performed regardless of whether the apple is stored after harvest or not. Structure of labor costs for analyzed ULO cold storage is shown in the *diagram 2*

[4] 1€ = 120 RSD

Diagram 2. ***Structure of labor costs for ULO cold storage***



Source: *Authors*

Economic effects of storing apple

Based on the analysis of monthly trends of purchase prices of apple, in the period from 2006 to 2015, significant seasonal fluctuations were established.

As stated above, the purpose of storage of agricultural products is to delay selling until the moment when the purchase price is most preferable. Sales delaying (storage) economy is based on the difference between the growth of purchase price of agricultural products and the costs of their storing.

In order to estimate the economic effects of apple storage, it is necessary to analyze trends of average monthly purchase prices in the last ten years (*Tab. 6*). This analysis should show is it more profitable for farmers to sell apple immediately after harvest, or to postpone the sale and wait for higher purchase prices.

Also, the analysis should demonstrate in what months the purchase prices of apple were the highest, respectively in what period the highest incomes from storing were realized.

Table 6. ***Average purchase price of apple for consumption per months in the 2006-2015 (RSD/kg***

Month \ Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
I	-	26.07	31.39	41.30	30.34	46.61	45.88	57.11	40.75	58.95
II	-	27.32	34.88	35.02	38.78	56.17	42.42	58.91	37.41	50.84
III	-	25.55	31.52	32.63	31.50	57.63	44.84	56.12	38.34	56.40
IV	-	27.49	38.33	36.33	33.78	55.43	43.51	43.91	34.13	**67.61**
V	-	37.28	36.38	36.63	23.45	**60.58**	46.13	55.61	**41.77**	63.84
VI	-	30.44	20.57	**49.61**	35.93	52.08	**64.21**	**61.37**	41.47	58.45
VII	-	**47.44**	**57.20**	35.39	**62.13**	54.06	57.36	48.48	30.68	53.39
VIII	-	36.63	37.16	29.93	34.23	43.09	58.22	36.18	33.92	37.08
IX	20,67	29.97	30.35	27.15	35.21	32.60	50.84	38.42	40.64	33.71
X	21,22	29.52	26.10	26.08	36.45	34.30	51.02	30.88	36.91	-
XI[5]	22,60	34.00	34.56	23.72	39.37	40.14	51.66	32.29	42.22	-
XII	24,76	29.91	35.62	25.73	33.70	46.06	51.16	32.77	45.15	-
Max purchase price over year	-	47.44	57.20	49.61	62.13	60.58	64.21	61.37	41.77	67.61
Price at the time of harvest	-	20.67	29.97	30.35	27.15	35.21	32.60	50.84	38.42	40.64
Difference	-	26.77	27.23	19.26	**34.98**	25.37	31.61	10.53	3.35	26.97

Source: *Statistical Office of Republic of Serbia and authors' estimate*

Based on *Table 6* it can be concluded that storing was economically justifiable in all the years of the analyzed period. The highest income from storage was recorded in production year 2009, when it was achieved the highest positive difference between the month when the harvest was made and the month with the highest purchase price. This means that it was possible to make a profit of 34.98 RSD/kg, if the sale of stored apple was executed in July 2010. The lowest earnings of apple storage were realized in production year 2013, when the maximum positive price differential compared to the moment of harvest, was only 3.35 RSD per kilogram, in May next year.

The analysis of monthly purchase prices of apple, in the past ten years, led to the conclusion that the farmers, who have opted for storage, while selling the apple can achieve on average for 22.90 RSD/kg higher price

[5] Harvest and apple storage are done in September.

than those they would get if they did not go for storage. Also, it is obvious that the highest income of apple storage is achieved in the period from VIII to XI month of storage, i.e. in the period from April to July.

Table 7. ***Economic effects of storage (RSD/year)***

Elements of calculation	Unit measure	Amount
- Average apple price increase throughout the year	RSD/kg	22.90
- Cold storage capacity	kg	3,200,000
A. Total revenue	RSD	73,280,000
- Fixed costs	RSD	18,717,200
- Variable costs	RSD	3,719,520
B. Total expenditure	RSD	22,436,720
FINANCIAL RESULT (A-B)	**RSD**	**50,843,280**
FINANCIAL RESULT (A-B)	**€**	**423.694**

Source: *Authors' estimate*

As it can be seen from table 7, the average annual income of apple storage amounts to 73,280,000 RSD. When operating costs of cold storage are deducted from that amount, it can be concluded that the apple storage can achieve an average annual profit of 50,8 million RSD, or around € 423,7 thousand. It also means that producers can make a profit of 15.89 dinars for each kilogram of stored apples.

Conclusion

Storage of apples reduces the losses incurred after harvest, allows the preservation of quality, while on the other side provides a better economic result, which is based on sales delay and achieving a higher purchase prices.

ULO cold storages are characterized by extremely low levels of oxygen and carbon dioxide, as well as with high relative humidity. In such circumstances, all biological processes in stored apple significantly slow down, and apple can be stored in cold storage throughout the year. Also, greatly important advantage of ULO cold storage is a very low percentage of losses that do not exceed 1%.

Analysis of movements in the monthly purchase prices, in the last ten years shows that the apple storage was economically justified in all years of the analyzed period, whereby there is a noticeable tendency of significant increase of purchase prices in the period after harvest.

Annual earnings from storage amounts to average of 22.90 RSD per kilogram, while storage costs at a level of 7.01 dinars per kilogram, which ensures that analyzed cold storage realizes pure annual profit of 50,8 million RSD. Total investment in the construction of analyzed ULO cold storage is 213,460,680 dinars, or the € 1,778,839.

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SESSION THREE

Technology Transfer and Impact on Agricultural and Rural Development

TECHNOLOGY TRANSFER IN CONTRIBUTION TO REGIONAL DEVELOPMENT THROGH AQUACULTURE PRODUCTION

Alexander Itskovich[1], Maksim Ovchinnikov[2], Elena Patrina[3]

Abstract

World aquaculture is one of the fastest growing industries for the production of food of animal origin. Currently, many countries are engaged in fishing are considering the fishery as a component of the strategic importance of providing food security, and promoting social and economic development of certain regions. Nowadays, Russia is among the ten largest producers of fish products, ranking 7-8 places among the countries of the world in terms of yield, which is about 4 million tons. Global fish production has grown steadily over the last five decades, the supply of fish intended for human consumption, grew by an average of 3.2% per year, outpacing the global average annual population growth of 1.6%. In 2015, the fishing industry has continued its development, demonstrating an increase in output, demand, trade volumes and prices.

Aquaculture in the world are often run on by small and family businesses that had to be developed in the federal and regional programs of small and medium agribusiness development programs of agriculture and its sub-sectors. In most countries the development of aquaculture policy is based not only on the principle of stimulating the industry by including a preferential lending, funding research, providing farms for planting, free allocation to companies ponds to grow fish and other aquatic biological resources, but also by developing the innovation through mechanism of technology transfer.

Key words: *fisheries, governance of fisheries, regulation of fishing activities, technology transfer in aquaculture.*

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Introduction

At the moment in Russia (RF-Russian Federation) the fish production is much smaller than in Soviet times. Comparing to the record of 1990 yr. the catch of fish and aquatic biological resources was reduced from 7.8 million tons to 3.3 million tons in 2003 yr., or almost two times less. For Russia, which coast is washed by 15 seas, 3 oceans and on whose territory flows of 2.5 million rivers, this was not the best result. Russia has the largest fund of inland waters. So, The Fisheries Fund internal freshwater of Russia includes 22.5 million ha of lakes, 4.3 million ha of reservoirs, 0.96 million ha of agricultural multi-purpose reservoirs, 142.9 thousands ha of ponds and 523 thousands km of rivers.

Herewith the basis of the industry is oceanic fisheries, whose share in total Russian catch about 94 %; the share of inland waters has nearly 6 %. Obviously, such a situation required the active intervention of the state to move to a different economic model, ensuring a stable and efficient development of the industry in the medium and long terms. The fishery of Russia still focuses on growth of production of aquatic biological resources mainly in the areas of marine fisheries. Russian specificity is the presence of large stocks of aquatic resources. However, their more complete development is more effective than investing in aquaculture, which is contrary to world trends.

Fisheries are interconnected production and economic complex with a developed diversified and multi-sector cooperation. Despite the recognition of its leading role in shaping the food balance of the country, since the beginning of the agrarian reform (1991 yr.) the catch of aquatic resources in the Russian Federation decreased from 7.88 million tons in 1990 yr. to 3.3 million tons in 2003 yr. The decrease resulted in a reduction of catches total output of fish products, both food and non-food - from 4.6 million tons in 1991 yr. to 3.1 million tons in 2003 yr., i.e. almost 33 %. The most reduced production of this period is a canned fish - from 1.98 to 0.57 billion standard cans or 4 times. The production of non-food products amounted to only 16 % in 2003 yr. from the 1991 yr. level, including the issue of fish flour - 13.4 %. The basis of the industry mostly included ocean fisheries, the share of which in the period of 1990-2003 yrs. in total Russian catch was about 94 %, 6 % had a share of inland waters.

Obviously, such a situation required the active intervention of the state to switch to a different economic model, ensuring a stable and effective development of the industry in the medium and long terms.

In these circumstances, it is necessary to formulate the main strategic directions of development of fisheries in Russia and output of the industry from the crisis. The legal basis for this work is the Concept of Fisheries of the Russian Federation for the period until 2020 yrs., approved 02.09.2003 yr. by Governmental decree. This paper analyzed the state of the country's fisheries and identified the following main problems hindering its development efficiency:

- Lack of an integrated approach to governance of fisheries development in the Russian Federation;
- Lack of adequate legal and regulatory framework;
- increase the scale of illegal fishing of aqua- and marine biological resources and the illegal export of fish products abroad;
- A sharp decline in stocks of aquatic biological resources;
- increased competition in global fisheries;
- A significant discrepancy stocks of certain types of aquatic biological and logical resources capacity of the fishing fleet;
- A high level of physical deterioration and progressive obsolescence of fixed assets of Fisheries;
- Structural imbalances and the crisis in the fisheries sector, its disintegration;
- Raw material orientation of exports of fish products;
- Poor development of financial and credit relations, the lack of a developed market of fishery products and efficient market infrastructure.

The main areas of implementation of the Concept have been recognized after-following activities:

- Improving water management of biological resources;
- Regulation of fishing activities and creation of conditions for the supply of fish products to the Russian Federation;
- Organization and development of coastal fisheries, aqua- and mariculture;
- Creation of conditions for the work of the Russian fishing fleet in the exclusive economic zones of foreign countries, in areas where international conventions on fisheries and in the open ocean;
- Improving the system of protection of water biological resources and their conservation;
- Improvement of industrial research and whole system of education.

Unlike the Russia world aquaculture is one of the fastest growing industries for the production of food of animal origin of last 20 yrs. According to the

FAO projections, by 2023 yr. the volume of world fish production will reach 186 million tons, which is 15 % higher than the volume of production in 2015 yr. It is expected that aquaculture will provide the entire fish production growth: the proportion of farm fish in total production will reach 49 % by 2023 yr. In this case, the amount of fish consumption by households at share of aquaculture products will increase from 50 % in 2015 yr. to 55 % in 2023 yr. Global fish consumption per capita in 2015 yr. increased and FAO estimates reached 19.6 kg, which is 2 % more than in 2013 yr. Per capita consumption of fish in the world population has increased from 9.9 kg in average in the 1960s to about 19.6 kg in 2015 yr.

Technology transfer in context of regional development

According to the FAO, by the end of 2015 yr. the world produced about 166.5 million tons of fish, which is 2.3 % more than in 2013 yr. Of those caught 93.7 million tons and 72.8 million tons of cultivated fish. The share of aquaculture in world fish production is growing from year to year: it amounted to 39.8 % in 2011 yr., reached about 45 % in 2015 yr.

Table 1. Dynamics of production of world fisheries production, mln. tons

Type of production	**1999/2001 yrs.**	**2010 yr.**	**2016 yr.**
Products of fishing	93,8	101,1	108,0
Aquaculture production	35,6	57,8	68,8
Total production	129,4	159,9	176,8
including food products	98,6	116,2	130,3
non-food products	30,8	42,7	46,5

Source: the Food and Agriculture Organization of the United Nations, the FAO

According to forecasts, in 2023 yr. the world fish consumption should reach 20.9 kg per capita. World prices of fish and seafood slightly decreased in 2014 yr. against the backdrop of record results in 2013 yr. due to faster growth in production in comparison with the growth of consumption. The average price of fish in nominal terms in 2014 yr. is estimated at 2792 US dollars per ton, and according to the forecast of the FAO, by 2023 yr. will reach 3368 US dollars per ton.

Nowadays the source of increasingly production of fish products is aquaculture. If in 1980 yr. the share of aquaculture accounted for 9 % of fish consumed in the world, there are currently more than 40 %. But according to the Federal Agency for Fishery, Russia produces about 0.2 % of world aquaculture production.

Aquaculture of the Russian Federation develops on the territorial principle. Aquaculture development in the Russian Federation is carried out in four areas: pasture, pond, industrial, recreational. The waters of the Russian Federation inhabited by 295 species of freshwater fish. The most important species are common carp (Cyprinus carpio), silver carp (Hypophthalmichthys molitrix), bighead carp (Hypophthalmichthys nobilis), grass carp (Ctenopharyngodon idellus), trout and sturgeon.

Taking into account the total area of water resources belonging to fisheries, as well as Russia's population, it can be argued that for every inhabitant of the country accounts for 0.19 hectares of water areas suitable for aquaculture development.

Aquaculture in the world are often run on by small and family businesses that had to be developed in the federal and regional programs of small and medium agribusiness development programs of agriculture and its sub-sectors. A clear evidence of the absence of such work can be seen in experience of the Volgograd region. According to the Russian Federal Agency for Fisheries the Volgograd region there is among the top ten producers of fish products in the country. Last year the region produced more than 2240 tons of products.

However, the regional program to support the fishing and processing industries will be launch in the area only in 2016 yr. The program provides a fifty percent compensation for costs of fish farms for the purchase of feed and processing equipment, as well as part of the cost of electricity used in the process of growing fish. It is planned to subsidize the producers of fishery products interest rates on short-term and long-term bank loans. However, given the substantial budget cuts in 2015 yr., we should not expect significant support from budgetary sources of the program that is likely to determine its "failure".

Among the urgent problems - the organization of technology transfer in aquaculture. Technology Transfer is the delivery of scientific and technical expertise to increase production. The absence of this mechanism is the threat of a plan to increase production volumes of aquaculture production and development of the regions with the potential for aquaculture. Of particular importance of Technologies in transfer there are such characteristics as operating conditions, safety and environmental friendliness, competitive advantages and results of comparative testing and engineering services for the implementation and operation, ability to adapt to specific customer requirements. Thus, the union of two concepts such as new technologies and Technology transfer will determine the success of Regional development with aquaculture potential.

The basic form of technology transfer is external transfer, i.e. the process of technology diffusion, which involves independent developers and users of technology. It is necessary to find effective tools and modes to accelerate innovations through technology transfer. Among the reasons for the low level of domestic commercialization of innovations are the following problems:

- The low level of innovative activity of the real sector of the economy (about 10 %), contributed to the low demand for new technologies and the ability to use them in business;
- Imperfect legislation in the field of protection of intellectual property rights;
- Carrying out research without taking into account market demand;
- Unavailability of innovation for the market due to lack of study of their economic component (no formalized business plan, market research, evaluation of the implementation risks, etc.);
- Underdevelopment and lack of innovation infrastructure organizations engaged in supporting the commercialization of innovations.

One of these tools, the effectiveness of which is confirmed by international practice, is the centres of technology transfer and commercialization (the CTT). Their main function is to promote the implementation of innovative projects developed on the basis of intellectual property with a view to their commercial use. Thus, CTT acts as an activator of the innovation process in the area. The main results of CTT operation expressed indirectly, and are to increase the tax revenue of innovative companies to the federal, regional and local budgets. In this way, CTT contribute to the socio-economic development of the territory in which they operate.

Analysis of CTT shows that the purpose of their creation is dependent on the composition of the founders and usually is as follows:

- The economic development of the territory;
- To promote the development of technological business cooperation between enterprises and research organizations;
- Assist in attracting investments for implementation of innovative projects;
- The commercialization of the results of research and development;
- Transfer of innovation in industry and market;
- Integration of science, education, manufacturing, government and consumers.

Non-commercial transfer technologies and materials most commonly used in the field of the fundamental nature of scientific research. It usually accompanied by small costs and can be maintained both on the state line, and on the basis of contacts between firms, and personal contacts.

Table 2. ***Elements of non-profit technology transfer for agrarian regional development***

Name	**Elements**
Object	Scientific and technical and educational literature, manuals, reviews, standards, patent descriptions, license, brochures and catalogues, etc.
Form	Scientific and technical publications, holding of exhibitions, fairs, symposiums, exchange of delegations and meetings of scientists and engineers, outsider experts, education undergraduate and graduate students. The activities of international organizations on cooperation in science and technology, and others.

Source: processed by Authors.

Transfer of technology in non-commercial forms implies that it is a specific product, so for the purpose of development of agrarian regions it is advisable to use the tool of CTT with matching set:

- the economic development of the territory;
- the development of technological business cooperation between enterprises and research organizations;

In most countries with developed aquaculture policy is based on the principle of stimulating the development of industry and government support, including through concessional lending, funding research, providing farms for planting, free allocation to companies ponds for growing fish and other aquatic biological resources. However, an economic mechanism to stimulate the development of the fishing industry and its individual branches is currently the least developed.

Significant for the representatives of innovation infrastructure in regional development are the following types of support from the regional authorities: a joint public-private financing; subsidies to cover part of the costs; assist in the mobilization of extra budgetary funds; grants for payment of interest on loans; tax benefits, for example, exemption from the property tax and land tax; the state order by the regional authorities; preferential insurance contribution rate.

The main institution implementing the technology transfer in the acceleration of regional development may be the technology transfer centres at universities. To accelerate the development of the Volgograd region of river fish farming can be a Transfer Centre (Centres of technology transfer-CTT) at the Agrarian University.

The main directions of TTC at the Agrarian University are as follows:

- Ordering, assessment and protection of existing intellectual property at the university;
- Active promotion of information on the developments of the intellectual property having commercial potential;
- Provision of information, financial, marketing and other advice to developers and potential buyers of intellectual property for the removal of obstacles in the commercialization of technologies;
- The involvement of orders for the study of the commercial sector, both of Russian and foreign non-budgetary funds;
- Development of business partnership with Russian and foreign companies involved in work and academic institutions.

An important feature of CTT should be considered as the ability to implement a number of important functions for small agro business and high school:

- Identification, collection and evaluation of the commercial potential of the results of the research activities of the university;
- Patent examination, development and protection of intellectual property of the university;
- Examination of the scientific and technical level of development;
- Adjusting the transfer of objects and supporting documentation to the readiness for commercialization;
- Implementation of marketing activities in respect of intellectual property, scientific and technical production of university;
- The financial assessment of projects, the development of the financial conditions for the agreements on the commercialization and further support;
- Training, counselling and dissemination of information in the field of commercialization and protection of intellectual property of University;
- Cooperation with governmental and non-governmental organizations, funding research;
- The development of business partnerships and negotiating on behalf of the University.

The efficiency of this structure, especially in the first phase will depend on the interaction with the management and staff of the university. The required level of authority in the university CTT management system should be as follows:

- Participation of the head of TTC in decisions on future research directions and feasibility of further expenditures on research already financed;
- Access to CTT workers all relevant information on the theme of this university research;
- Management of university patent policy;
- Management of the distribution of incomes received as a result of the transfer of technologies.

The effectiveness of CTT should be determined by results, which achieved in accordance with the prepared business plans for technology transfer. Nevertheless, there are several of key performance criteria CTT such as the amount of attracted funding in research and the number of new companies created based on technology of university.

Conclusive consideration

Aquaculture in the world are often run on by small and family businesses that had to be developed in the federal and regional programs of small and medium agribusiness development programs of agriculture and its sub-sectors.

The regional programs to support the fishing and processing industries launched in some Russian regions only in 2016 yr. The programs provide a fifty percent compensation for costs of fish farms for the purchase of feed and processing equipment, as well as part of the cost of electricity used in the process of growing fish. It is planned to subsidize the producers of fishery products interest rates on short-term and long-term bank loans.

The most effective instrument of technology transfer is a Centre of technology transfer (CTT). Main function of this institution is to promote the implementation of innovative projects developed on the basis of intellectual property with a view to their commercial use. Thus, CTT acts as an activator of the innovation process in the area. The main results of CTT operation expressed indirectly, and are to increase the tax revenue of innovative companies to the federal, regional and local budgets. In this way, CTT contribute to the socio-economic development of the territory in which they operate.

So significant for innovation infrastructure in regional development are the following types of support from the regional authorities: a joint public-private financing; subsidies to cover part of the costs; assist in the mobilization of extra budgetary funds; grants for payment of interest on loans; tax benefits, for instance, exemption from the property tax and land tax; the state order by the regional authorities; preferential insurance contribution rate.

The effectiveness of CTT should be determined by results, which achieved in accordance with the aims of regional development through technology transfers.

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STATE AND CONDIDTION FOR IMPLEMENTING ICT IN RURAL TOURISM IN THE REPUBLIC OF SERBIA[1]

Predrag Vuković, Vesna Popović, Slavica Arsić[2]

Abstract

Information and communication technology (ICT) has been rapidly developing since seventies of twenty century. ICT development has affected to all spheres of society. ICT can help industries to be more competitive on the market. Advantages of business that can be realized by using IT influenced that its application has been made in all sectors of the economy. Implementation of ICT in some countries has shown that ICT can play a key role in business (for example, Small Business and Entrepreneurship), as well as the impact on the development of certain regions (rural or urban), or on development of local economies, etc.

Advantages that can bring implementation of ICT also recognized in tourism business. Implementation of ICT is nowadays especially present in so-called "mass forms of tourism". Application of computer reservation systems (CRS) and global distribution systems (GDS) completely changes the role that intermediaries (travel agencies/tour operators) have until recently. On the other hand, the application of ICT in rural tourism has been late. This has resulted in the backwardness of rural tourism development for other forms of tourism. This is a global problem.

A characteristic of rural tourism is the physical distance between the rural tourism supply and demand which is located in the urban city centers. A role of tourism intermediaries is to make their connection. The application of ICT has significantly contributed to improvement of intermediaries business. In order to made rural tourism supply available for urban tourist demand, one of the important conditions is to educate local rural population for use IT in rural tourism business. This requires special training programs. This comes

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from the fact that progress in the development of ICT has enabled a wide range of tools and services with which improved business in tourism.

Rural tourism in Serbia has been developing since the seventies of the twentieth century. The period in which rural tourism recorded the stagnation of development and later lag, was in the nineties and reason is „well-known events“ that were characteristic of the entire area of former Yugoslavia. After 2000 begins new accelerated development of rural tourism. A special expansion has been recorded since 2006, when the Ministry of Agriculture, Forestry and Water Management of the Republic of Serbia allocated around 92 million dinars to develop rural tourism. Today, almost all regions in Serbia have a greater or lesser level of development rural tourism. What appears as a problem in tourist business is just a lack of application ICT. This is characteristic of the organization and management of rural tourism at all levels from local, regional to the national. Also, the use of the Internet in the tourism business is not satisfactory.

As one of the tasks which stands in front of Serbia is development of network economy, which would be based on the adopted Strategy for the Development of the Information Society till the 2020. Expectations are that the implementation of ICT should contribute to develop rural tourism, and increasing the income of the local population, also it would enable farms as small business entities to remain competitive in the tourism market which is precisely one of the characteristics increased competition. The aim of paper work is based on the analysis of the current situation in the sector of rural tourism in Serbia and point out the importance that can bring implementation of ICT in rural tourism business. Article indicates the necessary steps which would promote business of rural tourism in the micro level (small family farms) and macro level (operations at the level of rural tourist destinations – villages, local rural areas, region or country as a total destination system).

Keywords: *rural tourism, destination, business, Internet, databases.*

Introduction

ICT is one of the future's basic technology fields pressing their fingers to the first quarter of the 21st Century.[3] Therefore, countries must use IT in every sector of the economy to win the competition.[4]

[3] Akca, H., Sayli, M. and Esengun, K., (2007): „*Challenge of Rural People to Reduce Digital Divide in the Globalized World: Theory and Practice*“, Government Information Quarterly 24 (2007), pp. 404-413. Hollifield, C. A. Donnermeyer, J. F. (2003): „*Creating Demand: Influencing Information Technology Diffusion in Rural Communities*“, Government Information Quarterly 20 (2003) pp. 135-150, etc.

So far, in the literature there is no general consensus about fact what are the critical success factors of application IT. According to research conducted at the Technical University of Eindhoven (*Netherlands*), critical success factors are discussed from the technical and organizational point of view. On the technical side, the focus is on the information system, whereas the organizational part, emphasis on organizational culture, structure and business processes. Within these divisions continue to vary factors affecting the long-term goals (strategic) and the factors that influence the short-term operational objectives (tactical).[5]

The practice in some countries has shown that the impact of IT on specific categories of business (eg, small business and entrepreneurship), then the impact on the development of certain regions (for example, rural or urban), and impact on local economies is vital.[6]

Enright and *Newton* (2005)[7] stated that "a destination is competitive if it can attract and satisfy potential tourists, and this competitiveness is determined by both tourism specific factors and a much wider range of factors that influence the tourism service providers." The number of tourism destinations worldwide is constantly growing. As destinations strive for bigger market shares, there is great competition on the international tourism market. Competitiveness is increasingly being seen as a critical influence on the performance of tourism destinations in competitive world markets.

One of the area which aim is to make closer rural tourism supply with urban demand (to make their connection), is via ICT. Those destinations which present their promotional activities to a wider range of consumers/tourists will be in a better position, or better words is that destination will be in a position to achieve higher incomes and therefore would be more competitive. Hence, the interest in tourist destinations should be directed towards the development of ICT.

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[4] Gul, A., Mutulu, S. and Bal, T. (2004): „*Informatics in Food Industry in Cukuruva Region Turkey*", Information Technology Journal, 3 (2), pp. 133-138.

[5] Stankić, R. (2014): "*Key Success Factors for Implementation of Business Information System*", pp.18-25. Proceeding No. 8. University in East Sarajevo, The Faculty of Economic, Brčko, November 2014. Web site: http://www.efbrcko.ba/doc/Zbornik_Radova/13.01.2015.%20Zbornik_2014_EF_Brcko__web_izdanje.pdf#page=24

[6] Premkumar, G. and Roberts, M, (1999): "*Adoption of New Information Technologies in Rural Small Businesses*", p. 467. The International Journal of Management Science, 27 (1999) pp.467-484.

[7] Enright, M. J. and Newton, J., (2005): „*Determinants of tourism destination competitiveness in Asia Pacific: Comprehensiveness and universality*", p. 340, Journal of Travel Research 43 (May): 339–350.

Popović, V, Milijić. S. and Vuković, P. (2012)[8] defined principles of tourist development: economic sustainability; social and cultural appropriateness; environmental acceptability; encouraging the tourism destination development in order to create competitive tourism products, as well as institutional and functional organization of tourism area offer; development of all-year round tourism offer; creating conditions for integrating the tourism with complementary sectors of economy and society – through partnership between the public, private and non-governmental sectors (eg. ICT networking of stakeholders etc.); strengthening the cross-border cooperation in tourism and complementary activities; harmonizing the tourism development regulations with European standards; and ensuring public participation in conceiving and implementing sustainable tourism spatial development.

Characteristic of rural tourism in the Republic of Serbia

The modern trends in the tourism market move further from the concept of mass tourism offered by vacations in destinations located on the seashore and/or mountain ski resorts. There is a strive towards activating all segments of tourist demand in order to achieve the best results in tourism development. In this way the countries, i.e. destinations that do not possess the resource base for developing the so-called "mass tourism" or besides that, seek their chance on the tourism market by offering alternative tourism products, such as thermal baths, spa and welness tourism[9] and various form of sustainable tourism based on interaction between the multifunctional agriculture and regional natural and cultural values[10], especially in high nature value (HNV) farmland areas[11].

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[8] Popović, V., Miljić. S. and Vuković, P. (2012): „*Sustainable tourism development in the Carpatian Region in Serbia*", p. 45. SPATIUM International Reviw, No. 28/ 2012, pp. 45-52.

[9] Vuković, P., Čavlin, G. & Čavlin, M., (2015): „*Complementarity in Development of Rural Tourism with the Development of Thermal Baths, Spa and Welness Tourism*", p. 260, journal: *Ekonomika poljoprivrede/Economics of Agriculture*, pp. 259-270. No.1(1-284), 2015 Belgrade.

[10] Popović, V. and Živanović, M. J. (2012): "*Wine Tourism and sustainable rural development in the Danube basin area in Serbia*", p.1566. Thematic proceedings: *Sustainable agriculture and rural development in terms of the Republic of Serbia Strategic Goals Realization within the Danube region - Preservation of Rural Values,* the Institute of Agricultural Economics, Belgrade, pp. 1565-1584,

[11] Popović, V., Vasiljević, Z., Bekić, B. (2012): "*HNV farming in the area of the Radan mountain and the role of agri-environment payments*", p. 69. Thematic proceedings: „*Rural areas and development",* Vol. 9. European Rural Development Network, Institute of Agriculture and Food Economics – NRI, Poland, Institute of Agricultural Economics Belgrade, pp. 67-88,

Accepting attitudes of phase development of rural tourism with the appropriate characteristics presented by *Zodorov, A. V.,* (2009)[12], it can be concluded that the Republic of Serbia, as well as most other countries, rural tourism developed on the same way with the same characteristics; even accurately it can be determine duration of development phases.

The first phase, *independent establishing.* Rural tourism in Serbia has begun to develop since the seventies of the twentieth century. Villages who have been "pioneers" of development were: Sirogojno, Seča Reka and Devići. The leading tourist agency "*Yugotours*" and "*Putnik*" involved in the affairs of bringing foreign tourists to rural areas soon after began. Thus, according to the data from Tourist Organization of Serbia from 1992, in the municipality of Knić were about 35 000 foreign guests from 21 countries. The largest number of tourists was recorded from Great Britain, Germany, Russia and Italy.[13]

Municipalities of successfully developing rural tourism by the year 2000 were Brus, Valjevo, Gornji Milanovac, Ivanjica, Knić, Kosjerić, Kraljevo, Lučani, Mionica, Požega, Prijepolje, Rača Kragujevačka, Dimitrovgrad, Užice, Čajetina, Čačak and Šabac. Indicators of rural tourism development in Serbia between 1990 and 2000 were presented in *Table 1*.

Table 1. ***Indicators of rural tourism development in Serbia****

Year	**1990**	**2000**
Number of villages	50	41
Number of farms	800	170
Number of beds	3 000	800

* Tourist organization of Serbia, data
Source: *Milojević, Lj., (2004): „Rural Tourism in Serbia", p.30, UNWTO: „Rural Tourism in Europe: Experiences, Development and Perspectives", pp. 27 -31, Proceeding from Seminars, Belgrade (Serbia and Montenegro, 24-25 June 2002), Kielce (Poland, 06-07 June 2003), Yaremcha (Ukraine, 25-26 Sept. 2003) published by UNWTO 2004.*

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[12] Zdorov, A. B., (2009): „*Comprehensive Development of Tourism in the Countryside*", Studies on Russian Economic Development, 2009, Vol. 20, No. 4, pp. 453–455.

[13] Todorivić, M. and Bjelac, Ž, (2009): „*Rural tourism in Serbia as a Concept of Development in Undeveloped Regions*", p.455, journal: Acta Geographica Slovenica, 49-2. (2009), pp.453-473; Milojević, Lj., (2004): „*The Social and Cultural Aspects of Rural Tourism*", p. 117, UN WTO: „*Rural Tourism in Europe: Experiences, Development and Perspectives*", pp.115-121, Proceeding from Seminars, Belgrade (Serbia and Montenegro, 24-25 June2002), Kielce (Poland, 06-07 June 2003), Yaremcha (Ukraine, 25-26 Sept. 2003) published by UNWTO; Štetić, S. and Todorović, M. (2009): „*Rural tourism*", University of Belgrade, the Faculty of Geography, p. 65.

The reasons for the appearance of negative trends in development of rural tourism in the observed decade should be seen primarily through deep political, social and economic crisis which was reflected on all segments of society and therefore the on tourism.

The strengths in development of rural tourism which characterized that decade were: good preservation of natural resources and their large number, rich cultural and historical heritage, large number and diversification of rural settlements, the wealth of local traditions, Traditional hospitality, and diversification of the tourist product. Same characteristics also are present nowadays.

Weaknesses included: inadequate rural infrastructure, "archaic" tourist product, underdeveloped information system, unsatisfactory level of quality accommodation and other services, lack of educational programs (training) farmers to provide adequate quality of service, lack of experience, lack of motivation, underdeveloped awareness in rural areas of economic and other benefits of the development of rural tourism.

The second phase, *dedicated development* began in 2006. Ministry of Agriculture, Forestry and Water Management of the Republic of Serbia has been allocated in total amount 91,580,215 dinars for rural tourism development and diversification of economic activities in the countryside in the period since 2006 to 2008. In 2008, there were 173 beneficiaries of these funds (141 registered agricultural producers, 23 associations of citizens, 7 legal persons and 2 cooperatives)[14].

The largest amount of assets distributed in the region of Western Serbia and Vojvodina, while through the districts most assets were distributed in Zlatibor district, and at least in the North Bačka district. Analysis of the types of investment indicates that 91% of allocated funds directed to the restoration of traditional rural households (renovation, extension and renovation of facilities, equipment, etc.), while 9% allocated to promotional and educational activities.

Until the year 2011, there were no reliable indicators of rural tourism development in Serbia. That is when *The Master Plan of Sustainable Development of Rural Tourism* (2011) was made, which presented the results

[14] "*Analysis of the Budgetary Support to the Development of Rural Tourism in Serbia and Diversification of Economic Activities in the Countryside*" (2009), the Ministry of Agriculture, Forestry and Water Management of the Republic of Serbia, RD Sector, p. 2.

that 106 local tourist organizations made in cooperation.[15] According to this source, rural tourism encompassed 2.7 million overnight stays, which is the sum of individual overnight stays in rural tourism (145,354)[16] and the number of common tourist overnight stays usable for rural tourism (2,556,128)[17]. Rural tourism provides more than 32,000 beds (registered and unregistered), where more than 10,000 beds are in the countryside. The total number of beds is estimated to bring more than 5 billion RSD annually in income and 5 bn. RSD in direct income to the tourism sector. The income of 10 bn. RSD does not include visitors who stay for a night or stay with their friends or family (although they also spend money on tourism and other services during their stay) and it does not include the indirect contribution to the local economy in the sense of income and employment. The income of 10 bn. RSD is 16% of direct GDP from travel and tourism, as calculated by the *World Council for Travel and Tourism in Serbia* for the year 2010, which is 64.2 bn. RSD[18]. Based on this, we can conclude that rural tourism today has an up-going trend in development. It can be concluded that after the year 2008 until 2016 (after approval financial resources) development of rural tourism is nowadays present almost in all regions of the Republic of Serbia.

Information and comunication technology (ICT) in rural tourism

It is found that a whole system of information technologies (SIT) is being adopted by *all segments* of the travel industry. The SIT, however, will not attack the human content of tourism. Rather, it will affect the core information-intensive areas of management, organization, product blending and packaging, marketing, distribution, and industry linkages. Factors likely to affect the diffusion of the SIT in tourism are identified. Implications of technology adoption for future organization, management, and distribution of tourism services are drawn out.[19]

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[15] Vuković, P., Čavlin, G. and Čavlin, M., (2015): „*Complementarity in development of rural tourism with the development of thermal baths, spa and welness tourism*“, p. 261, journal: *Ekonomika poljoprivrede/Economics of Agriculture*, pp..259-270., No.1(1-284), 2015 Belgrade

[16] This data comes from the municipalities and LTOs. As pointed out in this document, "*no central institution is in charge of gathering this data, except the Council of each municipality or the LTO*", p.15.

[17] The Master Plan states: "*The Common Tourist Overnight Stays Usable for Rural Tourism*" means accommodation in rural areas that can be used by tourists who visit the rural areas, but cannot be called "*rural households*".

[18] Ibid, p. 74-75.

[19] Poon, A., (1988): „*Tourism and Information Technologies*“, Annals of Tourism Research, Vol. 15, pp. 531-549.

Travel agents utilize computerized reservation systems (CRS) to obtain information and make bookings. Hotels use the technologies to integrate their front office, back office, and food and beverage departments. Airlines use technologies for almost every aspect of their operations, from schedule generation to flight planning and analysis. [20]

Allen, J. C, at al. (1993)[21] points out that the new ICTs made that the distance between tourist destinations and visitors are irrelevant for the normal course of business nowadays. Small rural enterprises can due to ICT equally participate in competition on tourism market with the "urban enterprises" and in that sense can exercise a certain kind of competitive advantage.

On the other hand, the lack of ICT can lead to a reduction in demand for holidays in rural destination, reduction in economic activity, and therefore may adversely affect the development of rural areas, that could lead to a reduction in future investments.[22] ICT opens up new markets that previously were not available to rural tourist destinations and provides a numerous of advantages in business[23] and provides such a large number of advantages in business.

ICT to rural residents give possibilities:[24]

- to promote rural tourist products,
- to use benefits of e-trade,
- to make transfer knowledge from urban to rural areas and vice-versa,
- to apply in official state procedures - for example, applications for funds from various state funds, such as funds intended to stimulate the development of rural tourism, etc.,
- to use geographical information system (GIS) for management of natural resources, etc.,

Hollifield, C. A. and *Donnermey, J. F.,* (2003)[25] point out that IT allows overcoming physical barriers and help to restructuring rural economy and

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[20] Ibid, pp. 531-549.

[21] Allen J. C., Johnson B. B, Leistritz, L. F. (1993): „*Rural Economic Development Using Information Technology: Some Directions for Practitioners*", Economic Development Review 1993; 11 (4), pp. 30-33.

[22] Premkumar, G. and Roberts, M. (1999): "*Adoption of New Information Technologies in Rural Small Businesses*", p. 467, The International Journal of Management Science, 27(1999) p.467-484.

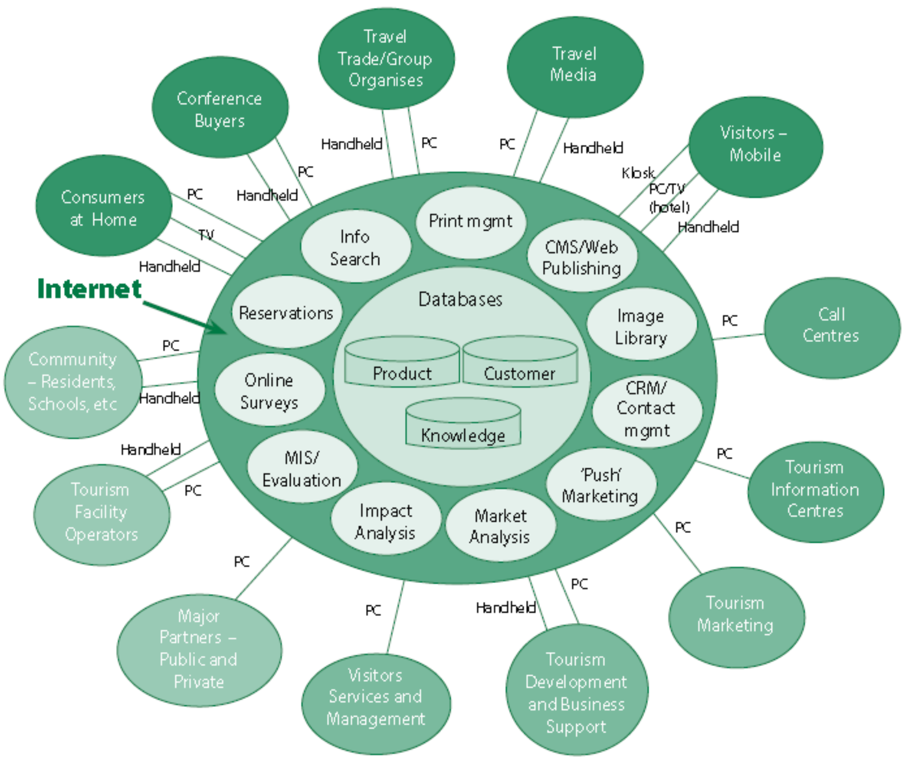
[23] Hollifield, C. A. and Donnermeyer, J. F., (2003): „*Creating demand: influencing information technology diffusion in rural communities*", op. cit., p. 136. Premkumar, G. & Roberts, M. (1999): "*Adoption of New Information Technologies in Rural Small Businesses*" op. cit., p. 468.

[24] Akca, H., Sayli, M. and Esengun, *K.* (2007), op. cit. pp. 406-407.

[25] Hollifield, C. A., & Donnermeyer, J. F. (2003), op.cit, pp.135−150.

set long-term sustainable development. They find for people for whom there is good communication connections there exsist biger interest to adopt new innovation and technology. Low population density of rural areas make obstacles for application of highly advanced ICT. The authors point to existence of a time "gap" that occurs when adopting way how to use ICT by local stakeholders and possibilities for practical application in rural business and the continuous progress that is immanent for ICT. *World Tourist Organization – UN WTO* (2007)[26] argue that ICT and e-business enable destination organizations to develop and implement a wide range of e-business relationships with consumers, product suppliers and market intermediaries. *Figure 2* provides a diagrammatic representation of a destination e-business system. It shows (reading from the outer ring towards the centre) different categories of users, accessing the system through one or more channels (PC, handheld device, interactive TV, kiosks, in-car systems, etc). Having accessed the system, the users may select from a wide variety of services (or applications) that will draw, in turn, on the appropriate database(s).

Figure 1. *Tourist destination e-business system*



Source: UNWTO (2007): "Practical Gide to Tourist Destination Management", Madrid, p.129

[26] UNWTO (2007):"A Practical Guide to Tourist Destination Management", Madrid, p.128.

IT literacy and education programmes

Using the Internet in the tourism business in Serbia is in initial phase. Businesses late in the development of ICT for developed countries of Western Europe and North America. This kind of trading is a new and represent great challenge, but also and a threat. Reason because it inevitably leads to the disappearance of the classic tourist intermediary. In the future, it can be expected expansion of new electronic tourist intermediaries.

Intermediaries in the tourism business in Serbia use applications of GDS and it must be notice that system "*Amadeus*" has the largest market share.[27]

The limiting factor in the application of IT in rural tourism in Serbia is level of computer literacy of local stakeholders. According to the data "ECDL" (*European Computer Driving Licence*) from 2012, Serbia is on the field of computer literacy six times behind for Slovenia, and more than thirty times behind for some EU countries.[28]

Data presented by the Republic Statistical Office (RSO) on the basis of research conducted and published in September 2013, whose results were published by the Ministry of Foreign and Internal Trade and Telecommunications, says that in the meantime Serbia made progress in process developing IT literacy: [29]

- More than 2.4 million citizens of Serbia use the Internet every day or almost every day, which is more than 300 000 in 2012.
- Computer owns 59.9% of households, and the Internet connection has 55.8%. Number of households that have a computer is 4.7 percentage points higher than in 2012, while the number of Internet connections increased by 8.3 percentage points.
- Internet connection owns households with a income for more than 600 euros monthly (of such households in that category was 89.8%), while among households with an income of 300 euros it is only 39.5%.
- In the cities, computers has 66.3% of households, while in villages 50.9% of households. It was noted that the difference is process of decreased, if it compared with data from 2012.

[27] Pavlović, D. and Spasić, V., (2008): „*The Effects of the Application of Modern Information Technology in the Operations of Small Travel Agencies*", p.155, journal: Turizam i hotelijerstvo, Vol. 5/No.1, pp. 148-156.
[28]Web site: http://www.ecdl.rs/arhiva/index.htm (accessed: 25. 06. 2016.).
[29] The Ministry of Foreign and Internal Trade and Telecommunications of the Republic of Serbia, http://mtt.gov.rs/slider/raste-broj-korisnika-interneta-u-srbiji/ (accessed: 23. 04. 2014).

OECD (1994)[30] highlight that education and training represent one of the most important factors in development of RT. Training for rural tourism professionals, planners and administrators is less well developed. Also, the use of the *Internet* in the rural tourism business is not satisfactory. One of the main obstacles to the computer implementation in RT business is non-education of the local rural population (farmers).

Baum, T, at al. (2001)[31] made distinguish between formal and informal education system. These are the concepts that are complementary, and there should not be divided, because their combination leads to better effect in the development of tourism. Education of farmers will enable higher quality services. The quality of services has in recent years become a major factor in choosing a tourist destination.[32]

Training and education are essential in the development of rural tourism, especially in the initial phase of development. Training and education are taking place at several management levels:[33]

1) *Training for officials in the administration*. Education and training programs are essential for this important group, because many officials who work in Government or municipalities are aware of the benefits of the development of rural tourism.
2) *Education of trainers.* Trainings are necessary for individuals involved in appropriate positions at the local level. With the appropriate knowledge and skills, these individuals who are well positioned, have the opportunity to train other individuals at the operational level.
3) *Training for direct service providers*. Providers of rural tourism product and operators require education and training in the following range of topics: care for consumers; knowledge of languages; standardization of tourism products; understanding the needs of the partners; knowledge about tourist product; basics knowledge regarding marketing; work on computer and Internet.

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[30] OECD (1994): "*Tourism Strategies and Rural Development*", Paris 1994, OCDE/GD (94)49, p.44.

[31] Baum, T., Wahab, S. and Cooper, C. (2001): "*Education for Tourism in a Gloobal Economy*", pp. 198-212, in "*Tourism in the Age of Globalisation*", edited by Wahab. S. and Cooper, C. published by Rotheldge, Taylor & Francis Groop, London and New York.

[32] Vuković, P., Arsić, S. and Cvijanović, D., (2010): „*Competitiveness of Rural Tourist Destinations*", p. 58, journal: Ekonomika poljoprivrede/Economic of Agriculture 57, januar-mart, Beograd, God./Vol. LVII, N0 1(1-153), 2010, pp. 47-60.

[33] "*7. Training and Education*", p. 9, WTO seminar, "*Rural Tourism in Europe: Experiences and perspectives*", Belgrade, Yugoslavia, 24-25 June 2002, Conclusions, web. link: http://dtxtq4w60xqpw.cloudfront.net/sites/all/files/docpdf/ruralt-sem-2002-concl.pdf (accessed: 05.07.2016)

It is necessary that residents get acquainted with all the possibilities that can be offered by development of rural tourism: 1) create additional incomes for farmers; 2) strengthening agriculture through the sale of agricultural products to tourists; 3) strengthening the entire infrastructure in rural areas; 4) preventing the process of depopulation; 5) development of trade; 6) development of traffic; development of the service sector; etc.

Need for development database of rural tourism products and it connection to GDS

Haines, P, (1994)[34] considers that DIS gives opportunity for small holders of tourist supply that they should stay in competitive struggle with large tourism companies that have complete access to sophisticate IT. ICT should consist of:

- *Product Database*. Containing accommodation, transportation, attractions and public facilities.
- *Client data base*. Containing profile detail (client history, contact information) of actual and potential travelers.
- *Marketing assets.* Comprehensive selection criteria and the possibility of collecting addresses, the possibilities of relational databases, summary information for marketing planning.
- *Finding information*. The mechanism that allows easy retrieval of information relevant to users.
- *Booking*. The ability to profile information stored for potential client and to reserve the whole "range" of various tourist services.
- *Distribution*. The ability to offer all previously via communication technologies.

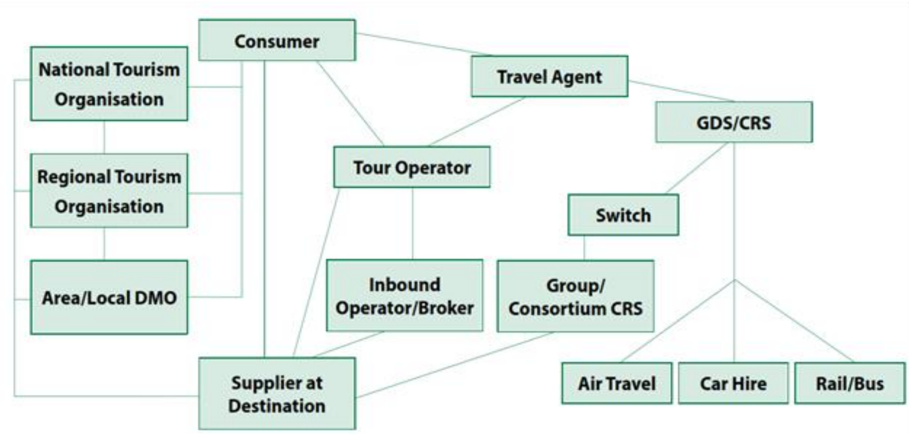
UNWTO (2007) make difference between traditional and emerging distributive net. Traditional systems consist of:

- Direct consumer to supplier channel;
- The DMO playing a facilitating channel role through carrying product information in brochures, information offices, webpages, etc.;
- Intermediaries including travel agents, wholesale tour operators and inbound tour brokers;

[34] Haines, P. (1994): „*Destination Marketing System*“, pp.50-63. in Schertler, W., Schmid, B., Tjoa, A. M, and Werthner, H., (eds.): „*Information and Communications Technologies in Tourism*“, Proceedings of the International Conference in Innsbruck, Austria, 1994 , Springer-Verlag, Wien.

- Dedicated technology distribution systems such as Global Distribution Systems (Amadeus, Galileo, Sabre, etc.) and Central Reservation Systems (*Figure 2*).

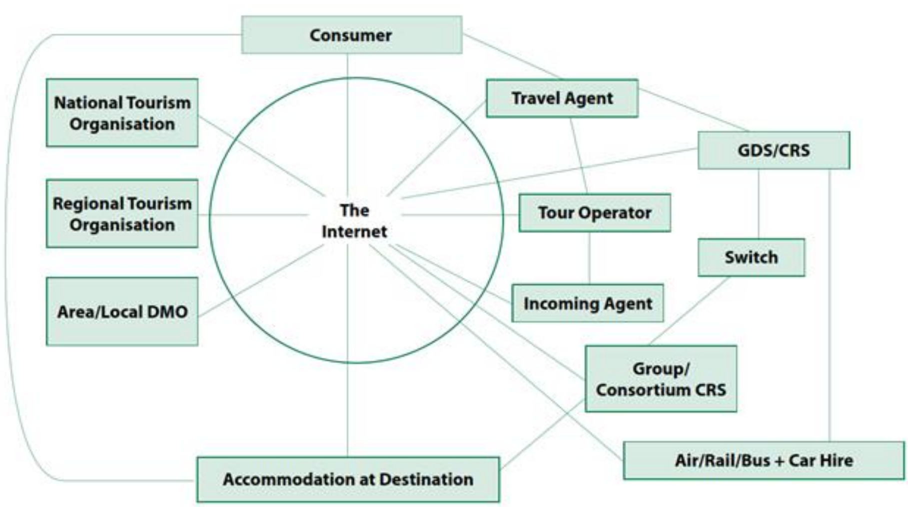
Figure 2. ***Traditional travel distribution systems***



Source: UNWTO (2007): "Practical Gide to Tourist Destination Management", Madrid, p.73.

UNWTO argue that under the emerging distribution systems includes all systems that use *Internet technology* with which the improved business because of the opportunity to consumers via the *Internet* have access to a wide range of information about various tourist destinations and tourist products, and based on available information, as well as appropriate " tools "offered by modern ICT create your trip and stay in the area in a way that suits them (*Figure 3*).

Figure 3. ***The emerging distribution systems***



Source: UNWTO (2007): "Practical Gide to Tourist Destination Management", Madrid, p.73.

For the time being for the needs of rural tourism there is no central server at the global level, with databases that combine data collected from all servers, or there is no information that in near future can expect the existence of a global database that will be able to collect, integrate, process and offer good organized information in the field of rural tourism. Since 2006, the company „*Pegasus Solutions Inc.* “[35] which is a global leader in advanced technologies and services to hotels and travel distributors and is the world's largest hotel representation service, with the largest:

- Central reservation system (CRS),
- System of processing electronic bookings via the *Internet* and global distribution system (*Amadeus, Galileo, Worldspan, Sabre*)
- System for processing agency fees in the world, operates in Serbia through company "*Congrexpo* doo”.[36]

The mission of this company is to maximize the revenue and profitability of hotels and intermediaries in tourism around the world, ensuring the use of the most advanced and most innovative technology in the tourist industry.[37] The aim of this association is a global sales service as well as marketing of accommodation facilities. Including accommodation facilities in the "Pegasus" system "*Utell*" or "*Unirez*" enables access to the Global tourist market. In this way the accommodation facilities becomes available for more than 650 000 travel agencies worldwide and is available for booking in any part of the world. This system is connected to a number of hotels in Serbia such as "*Serbia*", "*Union*", "*Alexander Place*", "*N*", "*Gymnass*" etc. This enables that the accommodations are available to tourists and travel agencies from all over the world. In Central Serbia reservation system includes the "on-line" system "*Booking Serbia*"[38] through which it is provided possibility for booking units of rural tourism (rural households, farms, villas, pensions, etc.). On this way it is possible that small units are connected to a global distribution system.

However, what appears as a problem is the fact that the system does not include all the accommodations units of rural tourism in Serbia, and that list is not updated continuously. Between the offers, which is located on the "*on-line*" system "*Booking Serbia*" and database which in this moment has the largest accommodation supply of rural tourism in the Republic of Serbia which is presented on the website of "The *Rural Tourism of Serbia*" (www.selo.rs and www.selo.co.rs), currently there is no connection. Expectations are that in

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[35] Web site: http://www.pegs.com/ (accessed: 28.04.2016).
[36] Web site: http://www.congrexpo.co.rs/?p=about_us (accessed: 28.04.2016).
[37] Web site: http://www.ekapija.com/website/sr/page/65799 (accessed: 28.04.2016).
[38] Web site: http://www.bookingserbia.com/ (accessed: 28.04.2016).

the foreseeable future these connections ("link") could be established and potential tourists, travel agencies would be in position to offer a complete accommodation offer of rural tourist destinations to costumers/tourist.

National Association "*The Rural Tourism of Serbia*" established nine associations in 2002. Today association is counting more than 500 members. In 2004, the association has set up a presentation www.selo.co.yu which is designed as a database of the total rural tourist accommodation deals. In 2005, it realized project "Promotion of rural tourism in Serbia," which includes all municipalities and tourism organizations of municipalities and cities that have a rural tourist offer. During the years, the Internet site has recorded continuous rise in the number of visitors, and in 2006 over 200 rural households that are located in the database of the site received 90% of the guests particularly through the website. Thanks to the results of the Internet website, the National Association "*Rural tourism of Serbia*" is an active member and representative of Serbia in the "*European Federation of Rural Tourism*" (*EUROGITES*).

Conclusion

Rural tourism in Serbia has been developing the last forty years. The rapid development started 2006, when the Ministry of Agriculture, Forestry and Water Management gave assets for diversification of economic activities in the countryside and rural tourism development. As a result of this fact, rural tourism nowadays is present in almost all regions of Serbia.

In order to accelerate development, it is necessary to make appropriate management and marketing activities, as well as the modernization of the facilities and tools from which would improve the quality of tourism services. Expectations are that on this way the rural tourist product will be more competitive on the tourism market.

One of the activities which would certainly contribute to development of rural tourism is implementation of ITC in tourism business. In order to achieve this it is essential that all stakeholders (at all levels from top to operating) pass the appropriate educational programs. This requires good organization of courses and training. In such programs should be included Ministry of Trade, Tourism and Services, Ministry Agriculture, Forestry and Water Management, the Tourist Organization of Serbia, as well as local administrations. Also, it is necessary that the existing advisory services are able to present for local farmer’s benefit which bring rural tourism business, as well as the advantages of using ICT.

Nowadays tourism business trend is to do business via Internet and GDS also replaces the role of tourism intermediaries. This is particularly evident in the so-called "forms of mass tourism." In Serbia, for many years operating system "Amadeus" with good results and in recent years operate system "Galileo".

In the world there is no unique database of rural tourist products (rural tourist accommodations) currently. Organizations that deal with rural tourism at the international and regional level (for example, EUROGITES etc.) on websites usually forward visitors to the national organizations and associations of rural tourism.

Unique database of rural tourism supply does not exist in the Republic of Serbia. Existing lists of accommodation facilities are not complete and do not update regularly. If one of these databases would be connecting to one of the GDS, the supply of rural tourism products would be made available not only domestic but also foreign market. The results would be: increase of tourist trade, higher revenues from tourism, and the higher number of tourist overnight stays etc. This would make positive effects on development of rural tourism, which supposed to represent one of the mechanisms on which it could stop the negative trends that nowadays burden life of local population rural areas (depopulation, migration of local population to urban city centers, reducing macro-economic indicators, etc.). On this way development of IT could contribute to rural development.

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THE AGRICULTURAL KNOWLEDGE AND INNOVATION SYSTEM: RESEARCH AND TECHNOLOGY ADOPTION IN SERBIAN AGRICULTURAL SECTOR

Biserka Komnenić[1], *Danilo Tomić*[2]

Abstract

Purpose *– The purpose of this paper is to empirically investigate efficiency of implementation of Agricultural Knowledge and Information System in Agricultural Sector of Serbia (AKIS). The study sought evidence from main Serbian AKIS institutions: The Serbia public agricultural research and educational institutions and extension services.* ***Design/methodology/approach*** *– Empirical analysis is conducted through questioner designed in accordance with the purpose of research, which is distributed to public agricultural research and educational institutions: research institutes, laboratories, and agricultural faculty's agricultural stations and advisory service institutions.* ***Structure of paper:*** *In introduction we explain the contemporary paradigm of Knowledge Economy and its influence on new approach to knowledge and innovation approach. In first part of the paper importance of AKIS, his theoretical and political background, especially in relation to EU agricultural policy and goals determined by the European Union's Standing Committee on Agricultural Research (SCAR) is explained and definitions of AKIS and its key subcomponents were given. Second part explains the new changing pattern of innovation and gives innovation classification frame which is further used in empirical research. In third part of the paper empirical research is presented and analysed and at the end of the paper one overall conclusion is given.*

Key words*: Agriculture, Knowledge, Innovation, Research, Transfer, Serbia*

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Introduction

The contemporary socio-economic context is articulated in the new paradigm of Society and Economy Based on Knowledge, which has a decisive influence on the present understanding of the socio-economic importance of the agricultural research and practice, and their current and future challenges and trends. In order to understand the challenges of the 21 century which the agricultural sector is facing, there is necessity for understanding basic determinants of this new socio / economic paradigm. The concept of Society and Economy Based on Knowledge presents a framework term designed to define the changes that are the result of development and progress of industrial society in the late twentieth and early twenty-first century. Modern society can be described as a society based on a deep and broad penetration of scientific and technological knowledge in all spheres of social life and its institutions. From the late 1980s to the middle 1990s, as the most popular alternative to the widely accepted concept of Post-Industrial Economy and Society, the concept of Knowledge Economy was adopted by the scientific community and political milieu, as an analytical framework that in most effective way articulates the essential characteristics of the new technologies and other forces which had the potential to change the trend of economic stagnation into economic growth and development.[3]

The so called *new theories of growth*, articulated by Romer (1990) and others (Lucas 1988; Grossman and Helpman (1991); Dosi and Nelson (1994) perceive knowledge (precisely existing stock of knowledge in the form of technological knowledge and know-how) as a factor of production and argue that since use of knowledge does not lead to its decrease but instead to its growth, knowledge represents a resource which does not fall under the law of diminishing returns but to the law of increasing returns. Also innovation and creativity, especially technological, becomes an integral part of economic activity and a potential source of added value and it is seen as an evolutionary matrix of economic growth.[4]

Observing the growing importance of knowledge based resources, the economic science developed innovation theories and articulated terms

[3] The concept of the knowledge economy so far was defined in many ways, but in the simplest terms it means that economic wealth is generated through the creation, production, distribution and consumption of knowledge and products intensively based on knowledge.

[4] Contrary to the neoclassical theories of growth, for the new theories of growth, technical progress is not seen as exogenous but endogenous element of the economic growth process. The focus of the new growth theories is on the analysis of the impact of knowledge on economic growth, its implementation and diffusion in the economy.

such as non-material assets, intangible resources, and intellectual capital. Since innovations are created by intangible resources those resources have some characteristics that differ substantially from physical resources. These differences implicate different economic principles and the matrix of value creation from those that are characteristic of physical resources. For example, the use of intangible resources does not lead to their decrease but on the contrary, to their enlargement, because using knowledge leads to its growth and spreading, which is why it is associated with the law of increasing returns and continuous growth opportunities. Because of its nature, the economic growth based on innovative knowledge is possible to restrict only artificially, because knowledge is not familiar with any kind of physical limitations. This is contrary to the law of diminishing returns, which is characteristic of the physical resources because their amount is limited by their physical nature.

Agricultural knowledge and innovation system - AKIS

Since Lisbon agenda according to which till the end of 2020 EU should become one of the strongest knowledge economies in the world, EU is designing and implementing policies to promote innovation as a method to improve labour productivity and the competitive position in the agricultural sector and food production. In 1974 Standing Committee on Agricultural Research (SCAR) was established by a Regulation of the Council of the EU. It was formed by representatives of member states, and has been given the mandate to advise the European Commission and the member states on the coordination of agricultural research in Europe. In 2006, the Ministers recommended "that, in accordance to Lisbon agenda SCAR should focus on promoting questions of the improvement of the links and cooperation between the advisory services, education, training and innovation. In 2008, conclusion from the one of the SCAR workshops was that European farming and agro-industry need knowledge from many different sources to compete with quality products in a globalised world. It was concluded that contemporary farming is much more diverse than in the past and is often combined with other activities. New knowledge is generated by farmers, researchers (basic and applied) and private companies. Therefore, the old linear model of technology transfer (from scientists to the users) is out dated and should be replaced by an interactive model of networking systems, which integrate knowledge production, adaptation, advice and education. In 2009 the conference on "The Knowledge Triangle: Shaping the Future of Europe", organised by the Swedish Presidency of the EU in Gothenburg highlighted the importance of a well-functioning knowledge triangle:

education-research-innovation. Today, EU policy encourage universities to develop their diverse missions and new operative models, where innovation and entrepreneurship must be integrated while maintaining education and research as core activities. Also since contemporary agriculture is facing complex challenges EU policy recommend adoption of inter-disciplinary and even trans-disciplinary approaches for problem solving.[5]

The AKIS concept generated from AKS (Agricultural Knowledge Systems) concept, which originated in 1960s in scholarly work on agricultural advice and extension. That system was driven by an interventionist agricultural policy that sought to coordinate knowledge and innovation transfer in order to accelerate agricultural modernization. In many countries this was reflected in a strong integration of public research, education and extension bodies, often under the control of the Ministry of Agriculture. In the 1970s AKS has been transformed to AKIS. First the meaning of AKIS was Agricultural Knowledge and Information Systems, but later it becomes Agricultural Knowledge and Innovation Systems. Among the other important drivers which influenced transformation of the AKS to the AKIS was the deep on-going restructuring of the research, extension and education systems under the influence of the liberalization discourse (privatization of service delivery, the multiplication of extension organizations, farmers contributing towards the cost of these services, competitive bidding for research and extension contracts and tighter evaluation procedures); Also there was increasing concern over the environmental impact of industrial agriculture, the quality of life of rural populations, rural employment and the need to support the positive externalities linked to agricultural production. Furthermore, the linear model of innovation has become outdated and been replaced by network approach, in which innovation is seen as a result of the interactions between all stakeholders in the food chain. Moreover, the growing disconnection between farmers' knowledge and research and extension systems was observed. In almost all countries the Agricultural knowledge and innovation system is composed of research, extension and educational organizations, structured and governed by the government through a sectorial agricultural policy. In all cases the historical goal was to increase the productivity of the

[5] All information used in the paper about AKIS are generated from the *Agricultural knowledge and innovation systems in transition – a reflection paper,* Standing Committee on Agricultural Research (SCAR) and Collaborative Working Group AKIS, Brussels, March 2012.

agricultural sector, by making farmers more professional. In 2011, European Commission published proposal for the Common Agricultural Policy after 2013 which underlines the importance of research, knowledge transfer and innovation in addressing the challenges faced by European farmers and the central role of Agricultural Knowledge and Innovation Systems in this context. Among other important measures, reinforcement of the role of the Farm Advisory Service (FAS) and creation of the 'European Innovation Partnership (EIP) for agricultural productivity and sustainability' was proposed. EIP was created with the purpose to 'facilitate the information flow between research and practice', concretely to promote a faster and wider transposition of innovative solutions into practice. The result of the impact assessment carried out by the European Commission on its proposal is the opinion that currently new approaches take too long to reach the ground and the practical needs on the ground are not sufficiently communicated to the scientific community. According to the EC analysis, a major weakness is the insufficient information flow and missing links between different actors of the AKIS (farmers, advisers, enterprises, researchers etc.). Other challenges faced by the AKIS are:

- To support pluralistic scientific approaches to meet the numerous challenges faced by the agricultural sector. Also, the required innovation cannot only be technological. Social and organisational innovations are also needed.
- To boost advisory services and other stakeholders that act as an interface between research providers and users in order to counterbalance the low level of attention to these actors in recent decades and the current trend for fragmentation of the organisations of extension.
- To facilitate the inclusion of small farms in the AKIS as they are not sufficiently involved in the current research and innovation systems.
- To stimulate collaborative and learning networks that are recognised as effectively contributing to in-novation as platforms for exchanging information and for learning processes.

These proposals reflect the systemic approach to innovation: the systems of innovation thinking in which the concept of Agricultural Knowledge and Innovation Systems is grounded.

The changing pattern of innovation

The modern innovation theory sees knowledge creation in a much more diffuse way. Firstly, innovation rests no more only on discovery but also on learning. Learning does not need to necessarily imply discovery of new technical or scientific principles, and can equally be based on activities which recombine or adapt existing forms of knowledge; this in turn implies that activities such as innovative application of exiting knowledge can be considered as knowledge-generating activities.[6] The second key emphasis in modern innovation analysis is on the external environment of the organizations (Lundvall, B.A., S. Borras. 1997). Understanding of the contemporary innovation process is inseparable from the growing awareness that the development of technology and innovations points to the coexistence of social and technical processes and that innovation is the result of cooperation involving a large number of both internal and external participants. This has led to greater attention to the ties and social relations between participants in the innovation process and the process of organizational learning. The interaction between the various participants and systems that influence or participate in the innovation process becomes the most important prerequisite for innovation. The basic idea behind the interactive mode of innovation is to connect different types of knowledge.[7] Another important feature of this model of innovation is its emphasis on cooperation, not on a competitive contest.[8]

In this paradigm change grouping of economic sectors in those intensively based on high-tech and knowledge becomes less and less meaningful, because now the so-called traditional economic sectors (manufacturing, textile, food, etc.), are as based on knowledge and the outputs of tangible and intangible technological knowledge as so called high technology sectors. Relevant knowledge base for many industries is not internal to the industry, but is distributed across a range of technologies, actors and industries.[9] The receiving industry must of course develop the knowledge, skills and competences to use these advanced knowledge-based technologies. Competitiveness within 'receiving' industries depends heavily on the ability to access and use such technologies.

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[6] The latest versions of the Frascati and Oslo Manuals are no longer exclusive of science and technology. The concept of 'research' is now open to include any creative work. Experimental development is open to the use of any stock of knowledge to devise any new application. Innovation is open to any implementation.

[7] Lundvall, B.A., Johnson, B.(1994), „The learning economy", *Journal of Industry Studies,* Vol. 1. No2, pp. 23-42.

[8] Teece, D. J. (1989), „Inter-organizational requirements of the innovative process", *Managerial and Decision Economics,* (Special issue), pp. 35-42.

[9] A distributed knowledge base is a systemically coherent set of knowledge, maintained across an economically or socially integrated set of agents and institutions.

Agricultural sector is one of the largest and most multidisciplinary sectors in all OECD Economies. Clearly many different kinds of skills, scientific disciplines and knowledge areas are involved in the functions and activities in this sector. It might well be claimed that agriculture sector is one of the most knowledge-intensive sectors of the entire economy. Actors in agricultural innovation systems are very diverse: policy makers, administrative bodies, universities and research institutes, innovation agencies, private firms with their own R&D divisions, industrial research centres. They are financed from public or from private funds, and some of them combine financing from both types of funds. There is the trend of increasing of the public-private partnerships and the tendency for research or innovation agendas to not only be defined by the government and universities but increasingly also by private and public stakeholders. At the same time, government, universities and research institutes maintain a strong influence over AKIS, including its innovation systems, although the degree to which they do so differs between countries. Over the years, the role of research labs in producing new innovations has drastically increased. The heterogeneity of agriculture and its vulnerability to random events such as changes in weather and pest infestation led to the development of a network of research stations which address the spatial variability of agricultural production. A large body of agricultural research has been aimed at adaptive innovations developing practices and varieties that are appropriate for specific environmental and climatic conditions. Random emergence of new diseases and pests led to the establishment of research capacity for productivity maintenance, which aimed to generate new innovations in response to adverse outcomes whenever they occurred.

In order to provide insight into the types of innovation characteristic for agricultural sector and their impact on the improvements in this sector among the many high-quality works on this subject, Sunding and Zilberman (1999) paper: *The Agricultural Innovation Process: Research and Technology Adoption in a Changing Agricultural Sector*, which embodies all essential elements necessary for a concise explanation of these topics is chosen.[10] According to Sunding and Zilberman (1999) innovations can be categorized according to their tangible or intangible nature, their impact on markets and market forces, and their form.

[10] Sunding D., Zilberman D. (1999) The Agricultural Innovation Process: Research and Technology Adoption in a Changing Agricultural Sector, (For the *Handbook of Agricultural Economics)*, Department of Agricultural and Resource Economics, UC Berkeley.

Embodied vs. Disembodied Innovations are ones which are embodied in capital goods or products and ones that are not embodied in any physical item. (Tractor vs. new formula for improving irrigation scheduling).

Categorizing Innovations According to Their Impact

The economic modelling of an innovation depends significantly on the way it affects markets and agents in the economy. Sunding and Zilberman (1999), classified several types of innovation in accordance to their impact on markets and market forces. First type of innovations is related to the New Products. Other type of innovations is related to process innovations which improve the performance of existing products. Innovations that improve existing products can be classified in the following categories:

- *Yield-Increasing Innovations* - those innovations improve performance of existing products or livestock system through their impact on output per unit. One of the examples for this kind of innovations is new irrigation technologies which yield-increasing effect has been a crucial element that led to their adoption.
- *Cost-Reducing Innovations* - impact of innovations can be distinguished according to their influence on fixed and variable cost. For example, new and improved type of harvesting equipment decrease labour costs and new irrigation technology may reduce water costs.
- *Innovations that Enhance Product Quality* - this type of innovations creates value added in agriculture products. For example, new genetic engineering varieties can improve the nutrient content, and appearance of agricultural products.
- *Innovations that Protect Health and the Environment* - the development of technologies that improve environmental quality or at least reduce damages relative to existing technologies is becoming a major research and policy priority.

Classification of Innovations According to Form

This category of innovations is consisted from mechanical innovations (improvement in tractors and combines), biological innovations (new seed varieties), chemical innovations (new fertilizers and pesticides), agronomic innovations (new farm management practices), biotechnological innovations, and informational innovations that mainly rely on computer technologies.

Empirical research

Purpose and Methodology of Research

The main purpose and objectives of research

The main purpose of this research is to empirically investigate the prevailing matric and level of the efficiency of the implementation of Agricultural Knowledge and Innovation System (AKIS) in Serbia and to identify most common type of innovations created in agricultural sector. The study sought evidence from the institutions which constitute Serbian Agricultural Knowledge and Innovation System (AKIS).

Method and Sampling

For the purpose of data collection, and data analysis, a descriptive research approach, with cross sectional online survey was used. When the problem is specific, respondents which could give answers about that problem are also defined by specific criteria. Therefore, since the subject of this research is specific, judgment/nonprobability sampling based on researchers' knowledge and professional judgment was used as a sampling technique. The data base of the Institute of Agricultural Economics – Belgrade was used as a sample frame. Data base consisted of total 84 public institutions: Reserch institutes, Agricultural faculties, Advisory services, Agricultural stations and Laboratories.

Questionnaire Instrument Development

In an attempt to address the content validity of the survey instrument, there were 3 stages of development and revision of the questionnaires used in this research: 1) Generating the preliminary list of questions from literature reviews and researchers' experience, 2) Developing the pilot Questionnaire which was administered to Focus groups, (3) Constructing the Final Questionnaire which was administered in the Survey based on the data collected through the Pilot Questionnaire. In designing the questions, a combination of structured questions was used. Also, Dichotomous questions, Multiple-choice questions, and filter or contingency question were used. The questionnaire for this survey was created for professionals who work in public agricultural research and service institutions: Scientific institutes, faculties, laboratories, advisory services, agricultural stations. Those institutions represent the Serbian Agricultural Knowledge and Innovation System: research, education, extension, and support institutions. There were respectively 18 questions. The questionnaire contained two groups of questions. The purpose of the first group of questions was to acquire opinion from professionals who work within the Serbian Agricultural Knowledge and Innovation System about efficiency and best way of transferring knowledge and innovations to the end users (agricultural enterprises and individual farmers) and the prevailing matrices of this transfer. The purpose of the second group of questions was to acquire information about most common type of research and innovations created by Serbian research institutions in accordance to Sunding and Zilberman (1999), classification of the innovations. Also the purpose of second group of questions was to obtain information's about the prevailing source of financing research and innovation activities, the level of cooperation with other stakeholders during the process of development and dissemination of the innovation, and the level of the commercialization of the innovations. A total of 47 questionnaires were collected, with the response rate of 55%.

Results

For the first group of questions related to the efficiency of the transferring knowledge and innovations to the end users and the prevailing matrices of this transfer, results of survey showed that 81% of the respondents believe that direct contact with end users is the most efficient way of transferring knowledge. Also, 13% of them think that educational seminars are the most efficient mechanism for knowledge transfer and rest of them thought that most efficient mechanism for knowledge transfer is internet or other media. On the question: What is the impact of feedback information's from farmers to advisors and from the advisors to the scientific - research institutions? largest percentage of the respondents (40.4%) believes that this impact is moderate, 38.3% of them answered that it is small and 21.3% of them that it is large. Besides, results of survey show that 81.5% of the respondents think that end users don't have sufficient knowledge about benefits of the application of new technologies (IT and Bio Technology) and their impact on the prices and performance of agricultural products and production. Majority of the respondents believe that in order to improve the efficiency and effectiveness of the transfer of scientific and technological knowledge to direct users, the most important thing is to improve the efficiency of networking with end-users (63.8%). Furthermore, considering same question, 48.9% of the respondents consider promoting of continuing education of advisory services as an important mechanism for the enhancement of the successfulness of knowledge transfer to the end users, while 29.8% stated that cooperation with scientific institutions should be improved. Result of survey also showed that majority of the respondents (63.8%) believe that their institution fits in the Triple Helix model of innovation system, which includes mutual cooperation of three independent institutional structures: the state, agricultural business and agricultural science and education institutions.

Results of survey for second group of questions related to the matters relevant for the innovation activities showed that with regard to the two offered types of the motivation for research: Science driven research (emerging science that can contribute to solving a societal issue, or a scientific question) and Innovation driven research (an issue/problem in society that can be solved by new research, or a new idea to solve an existing issue) majority of respondents stated both options as their motives (63.8%), while 29.8% of them stated that their research is fitting in the type of Innovation driven research and 6.4% in the Science driven research. With regard to quality criteria which respondent apply to the assessment of their research work majority of the respondents (58.7%) stated that they apply both offered criteria: scientific criteria and relevancy of their research for the application in the practice, while 30.4% of the respondents stated that their main criteria is relevance of their work for the practice and 10.9% of the respondents stated that their main criteria is scientific criteria. With regard to the model of the dissemination of the innovations, large majority of the respondents (77.3%) chose systemic network approach as their main model, while rest of them (22.7%) stated that they have linear approach, or in other words they disseminate their results through scientific channels. In order to obtain information about the types of research developed within respondent’s institutions respondent were given four options with the possibility to choose several of them. Results showed that applied research is the most common type of research carried in Serbian agricultural scientific institutions (68.9%). Second is the multidisciplinary type of research (55.6%), on the third place is fundamental research (15.6%), while 8.9% of the respondent chose interdisciplinary research. Furthermore, 88.5% of the respondents who work on faculties stated that entrepreneurial initiative and innovation spirit are not integral part of the faculty educational and scientific activities. On the question do their system of innovation development considers cooperation with all relevant subjects in agricultural food supply chain (individual farmers, agricultural firms, advisory services, end customers, civil sector, and public policy makers) 56.8% of the respondents answered positively and 43.2% of them negatively. With regard to the main characteristic of the respondents model of innovations results showed that the most common characteristic is orientation towards concrete implementation in practice (70.7%), while characteristics such as transdisciplinarity, quality management based on broader spectre of criteria, and commitment to social responsibility share same percentage of responses (22%). Also the results of survey showed that largest percentage of institutions (44.2%) are engaged in development of embodied and disembodied types of innovations, while 32.6% develop just disembodied type of innovations and 23.3% develop only embodied type of innovations. Furthermore, 71.4% of the respondents stated that their institutions develop innovations both categories of innovations ones which are resulting in new products and ones which improve the performance of existing products (process innovations). 28.6% of the respondents stated that their institutions develop only process innovations. With the regard to the type of innovations that improve existing products classified in the following categories: Yield-increasing innovations, Cost-reducing innovations, Innovations that enhance product quality, and Innovations that protect health and the environment, results show that the most prevalent type of innovations on which respondents were engaged are ones which enhance product quality (65.9%). On the second place are innovations that protect health and the environment (59.1%). On the third place are yield-increasing innovations (56,8%) and on the fourth place are cost reducing innovations (52.3%). With regard to the classification of innovations according to their form (mechanical innovations, biological innovations, chemical innovations, agronomic innovations, biotechnological innovations, informational innovations), results of survey showed that the most prevalent type of innovations on which respondents were engaged are agronomic innovations (59.1%), and biotechnological innovations (47.7%). In third place in representation are biological innovations (36.4%), in fourth place are informational innovations (20.5%), while the last place in representation share mechanical and chemical innovations (18.2%). The results of survey also show that the most prevailing source of financing research and innovation activities is state funding (84.4%). Second most prevailing source of funding is through international projects (24.4%). State-private and only private sources of funding are on the third (17.8%) and fourth (15.6%) place respectively. Finally, the results of survey show that the most common percentage of commercialized innovations in comparison with the total number of innovations developed in one institution is one between 10%-20% (48.7% of the respondents chose this percentage option). Also, almost a third of the respondents stated that their institutions commercialized somewhere between 40%-60% of their total innovation portfolio. Only 7.7% stated that their institutions succeeded to commercialize 80% - 100% of their innovation portfolio.

Conclusion

Survey findings suggest several conclusions. First set of conclusions is related to the efficiency and effectiveness of Serbian Agricultural Knowledge and Innovation system. According to the results of survey there is a lot of space for improvement of the efficiency of knowledge and innovations transfer to the end users in agricultural sector, since 81% of the respondents stated that impact of feedback information's from farmers to advisors and from the advisors to the scientific - research institutions is moderate or small. Also, results indicate that direct users of agricultural knowledge and innovation system don't have sufficient knowledge about benefits of the application of new technologies (IT and Bio Technology) and their impact on the prices and performance of agricultural products and production. Furthermore, opinion from professional's who work in Serbian AKIS institutions indicate that improving efficiency of networking between main actors of Serbian AKIS and direct users of knowledge and innovations in agricultural sector is priority for more successful knowledge transfer. Moreover, results point out on the necessity for promotion of continuing education of advisory services in order to serve their users more successfully which is also in line with EU intention to boost advisory services and other stakeholders that act as an interface between research providers and users in order to counterbalance the low level of attention to these actors in recent decades. On the other side results showed that in Serbian agricultural faculties' entrepreneurial initiative and innovation spirit is not the integral part of educational and scientific activities.

Second set of conclusions is related to the matters relevant for the innovation activities. According to the results of survey largest percentage of Serbian AKIS institutions are engaged in science driven and innovation driven research which indicates the existence of a fine balance between these two research motives. Also, the main model through which Serbian AKIS institutions disseminate their innovations is systemic network approach which shows that Serbian knowledge institutions are aware of the importance of intense and broad communication with all relevant stakeholders which is correspondingly the one of the key conclusions in EU AKIS agenda. Furthermore, results showed that applied research and multidisciplinary type of research is the most common type of research carried in Serbian agricultural scientific institutions which is also in line with the latest SCAR and EU AKIS agenda which promote application driven research and trans-disciplinary approaches for problem solving. Also results showed that majority of institutions develop both categories of innovations, ones which are resulting in new products and ones which improve the performance of existing products (process innovations). With regard to the type of innovations that improve existing products the most prevalent type of innovations is one which enhances product quality (65.9%). However, results show that other groups of this type of innovations are also largely represented.

In regard to the level of commercialization of projects, results of survey showed that in Serbian public research institutions the level of commercialization of research and innovation outputs is moderate since most common percentage of commercialized innovations in comparison with the total number of innovations developed in one institution is between 10%-20%. The increase of commercialization can be achieved through partnerships with the private sector therefore increasing private sector investment in Research and innovation activities as well as creating revenue directly from research outputs.

Appendix

QUESTIONNAIRE

What is the most efficient way of transferring knowledge to the farmers (Please circle one of the offered answers)

- Direct contact with producers
- Educational seminars
- Communication through internet
- Through media

What is the impact of feedback information's from farmers to advisors and from advisory to the scientific - research institution? (Please circle one of the offered answers).

- Small
- Medium
- Large

From yours opinion to which extent the farmers are familiar with the benefits of development and application of new technologies (IT and Bio Technology) and their impact on product prices and the improvement of agricultural production? (Please circle one of the offered answers).

- Large
- Medium
- Small

From your opinion which options listed below should be improved in order to increase efficiency and effectiveness of the transfer of

scientific and technological knowledge to direct user? (You may circle one or more answers).

- Cooperation with scientific and educational institutions
- Laboratory equipment
- Permanent education of advisory services
- The efficiency of networking with the end users of knowledge and innovation (individual Farmers, agricultural companies, cooperatives)

Does your institution fits in Triple Helix model of innovation system, which includes mutual cooperation of three independent institutional structures: the state, agro-industry and education sector?

- Yes
- No

What is your main motive for conducting research or development of innovation? (Please circle one of the offered answers).

- Science driven research (emerging science that can contribute to solving a societal issue or a scientific question)
- Innovation driven research (starting from the already existing issue/problem in society that can be solved by new research, or a new idea to solve an existing issue
- Both of them

What quality criteria you apply to the assessment of your work on research? (You can choose one or multiple answers).

- Scientific quality
- Relevancy of the work for application in practice

What is your model of diffusion of innovation? (Circle one of the answers).

- Linear approach (dissemination through scientific channels)
- Systematic network approach (dissemination on more levels and to more users)

What kind of research you conduct? (You can choose one or multiple answers).

- Fundamental
- Applied
- Multidisciplinary

- Interdisciplinary

If you work in faculty, do you think that entrepreneurial initiative and innovation are integrated in educational and scientific activities? (Circle one of the answers)

- Yes
- No

Does your system of developing innovation involves cooperation with all relevant stakeholders in the agro-food value chain such as farmers, advisory services, consumers, agroindustry, civil society and policy makers? (Circle one of the answers).

- Yes
- No

Which of the following characteristics of innovation process falls into your model of innovation? (You can encircle one or more offered answers).

- Trans disciplinary
- Heterogeneous
- Non-linear and volatile
- Quality management on a broader set of criteria
- Accountable to society
- Oriented toward application

Which of the below offered two types of innovation are the most represented in your work and work of your institution? (Circle one of the answers).

- Embodied (one materialized in physical form or products such as tractors, seeds, pesticides or fertilizers)
- Disembodied (one which don't have material form, for example new formula to improve irrigation scheduling)

On what kind of innovations your institutions have main focus? (Circle one of the answers).

- Innovation which final result is new product
- Innovation which final result is improvement of existing product
- Both of them

The economic modelling of an innovation depends significantly on the way it affects markets and agents in the economy. The following categories are listed according to their impact on markets and market forces. Please circle categories of innovations in which development you or your institution have been participated.

- Yield-Increasing Innovations
- Cost-Reducing Innovations
- Innovations that Enhance Product Quality
- Innovations that Protect Health and the Environment

The following classification of innovation is according to their form. Please circle ones in which development you or your institution have been participated.

- Mechanical innovations (improvement in tractors and combines),
- Biological innovations (new seed varieties),
- Chemical innovations (new fertilizers and pesticides),
- Agronomic innovations (new farm management practices),
- Biotechnological innovations,
- Informational innovations that mainly rely on computer technologies.

On what sources of financing you mostly relay during the development of innovation? (You can choose one or multiple answers).

- State
- Private
- Public-private
- International projects financing

Which per cent from the total sum of produced innovations your institution has placed on the market? (Circle on of the offered answers)

- 10% do 20%
- 20% do 40%,
- 40% do 60%,
- 60% do 80%,
- 80% do 100%.

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EXPORT PERFORMANCES OF AGRICULTURAL SECTOR OF THE WESTERN BALKAN COUNTRIES

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Abstract

Within the process of accession to the European Union, the agricultural sector of the Western Balkan countries is one of the most important chapters in process of negotiations, both because of its importance in overall economy and its low competitiveness. The transformation of the Western Balkan countries' agricultural sector created the gap in agricultural development performances between these countries and the European Union countries. The analysis of export performances of agriculture includes dynamics of agricultural production growth, level and structure of export, as well as the value of export in relation to engaged labour and agricultural land. In order to find the level of comparative advantages of agro-food products at the international market, an index of revealed comparative advantages is dynamically analyzed. All indicators are calculated separately for each country and comparison with the countries of the European Union has been made. In relation to the main objective of this article, which was to identify the development of exporting performances of agricultural sector in the Western Balkan countries within the process of integration to the European Union, it may be stated that despite the good comparative advantages of agricultural sector which these countries have, performances in the Western Balkan counties are noticeably worse than in the European Union countries, so good pre-accession policy, as well as market adjustment, are crucial tasks for the Western Balkan countries during the accession process.

Key words: *Agriculture, Comparative advantage, Western Balkan.*

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Introduction

After World War II all Western Balkan countries (Albania, Bosnia and Herzegovina, Croatia, Macedonia, Montenegro and Serbia) were centrally-planned socialist economies. The political and economic changes that have occurred in these countries in the late 20th century, such as transformation from the centrally-planned to market economy and disintegration of SFR Yugoslavia, had huge effect on whole region. After this turbulent period, all countries have entered into the process of accession to the European Union (EU). This is a long and complex political and economic process, where different stages – from signing of the Stabilization and Association Agreement to the enforcement of the Accession Treaty – are formally determined. According to the experience from previous enlargements, the duration of accession process is estimated at on average 8 years and could be in the case of the Western Balkans even longer (Erjavec, 2008). In 2013, Croatia has become a full member, while Albania, Bosnia and Herzegovina, Montenegro, Serbia and FYR Macedonia are in different stages in accession process *(Table 1).*

Table 1. ***Western Balkan countries in accession process to EU***

Country	Membership status	Last activity
Albania	Candidate	In June 2014, Albania was awarded candidate status by the EU
B&H	Potential candidate	The Stabilization and Association Agreement (SAA) has been ratified and entered into force on 1 June 2015.
Croatia	Member	Croatia became a member of EU in 2013.
Montenegro	Candidate	The accession negotiations with Montenegro started on 29 June 2012.
Serbia	Candidate	On 21 January 2014, the 1st Intergovernmental Conference took place, signalling the formal start of Serbia's accession negotiations.
FYR Macedonia	Candidate	In October 2009, the Commission recommended that accession negotiations be opened.

Source: *European Commission, 2016*

The transformation of the Western Balkan countries' agricultural sector created the gap not only in agricultural development performances between these countries and the European Union countries but also in export performances. Although agriculture's share in the economy has decreased since 2000, it is still relatively more important in the Western Balkans than in the EU, both in terms of value added and employment (Volk, 2010). For export performances of agricultural sector of Western Balkan countries is very important that all countries, except Croatia (Croatia left CEFTA after accession to EU), are members of CEFTA which means that free trade between countries exists. Except for Serbia, all other Western Balkans countries are net importers of agricultural products and their trade deficit has been increasing constantly (Volk, 2010). This indicates that there is a potential for improvement of their export performances.

Material and methods

In this paper, the analysis of production and export performances of agricultural products of the Western Balkan countries in process of EU integrations in period from 2006 to 2013 is realized, primarily based on development characteristics. The research was based on the data of the Food and Agricultural Organization (FAOstat), especially the data related to production, resources and foreign trade of agricultural products. Standard mathematical and statistical methods were used for the analysis of the main trends and characteristics of the production and export performances of agricultural products of the Western Balkan countries. The term agricultural products include following sections, which are classified according to the Standard International Trade Classification (SITC) – Revision 4: 0 - Food and live animals, 1 - Beverages and tobacco, 2 - Crude materials, inedible, except fuels. 4 - Animal and vegetable oils, fats and waxes.

For the analysis of main trends and characteristics of export performances, there were analyzed level and structure of export, as well as the value of export in relation to engaged labour and agricultural land. Also, tendencies of agricultural production are showed for observed period. In the aim of consideration of the effects of EU integration on export performances, an index of Revealed Comparative Advantages (RCA) is dynamically analyzed. Index of RCA is used in basic form (Balassa, 1965; Stojanović, Dragutinović-Mitrović, Popović-Petrović 2013; Ignjatijević, Matijašević, Milojević, 2014):

$$RCA_{ij} = \frac{\frac{X_{ij}}{X_{it}}}{\frac{X_{nj}}{X_{nt}}}$$

where is: X – export, i – country; j – section; t – total export; n – exporting country (group of countries).

When RCA index is larger than 1, the comparative advantages are revealed. Within the increase of the value of RCA index, comparative advantages of that section also increase. The section whose RCA index is larger than 3 have strong comparative advantages, the value of RCA index between 2 and 3 indicates significant comparative advantages, and value of RCA index which is between 1 and 2 indicates the satisfactory comparative advantages.

In Western Balkan countries there are few researches related to the analysis of production and foreign trade performances. Erjavec et al. (2014) in their research concluded that total agricultural production and individual production activity is unsatisfactory. The main reasons for this weak performance according to these authors are varied and not easy to deal with in the short term and without substantial changes in the focus of national strategies and policy measures. A low level of knowledge of farmers, poor extension services, as well as old production methods and technology are the main challenges.

In their research Zekić, Lovre and Gajić (2010) analyzed production performances of agriculture in Western Balkan countries in the transition process and results show poor performances of agricultural production of Western Balkan countries to the EU. According to these authors, a low level of productivity, especially labour productivity is, of course in addition with other factors, one of the main factors of lower levels of agricultural competitiveness in the Western Balkan countries in comparison to the EU.

On the other hand, according to Tomić and Njegovan (2013) the achieved competitiveness is relatively low in Western Balkan countries due to a high share of products with a low value added level, an inadequate quality, an insufficient quantity of agricultural products and their high fluctuations year in year out, as well as a low price competitiveness, etc.

Authors Birovljev, Matkovski and Ćetković (2015) analyzed comparative advantages of Serbian agro-food export in Western Balkan countries, and the results of their research showed that Serbia, although having the similar trade structure as the regional countries, owns comparative advantages in all Western Balkan countries. In research Ignjatijević, Matijašević and Milojević (2014) who analyzed the level of international competitiveness of the processed food sector for countries of the Danube region concluded that there is no doubt that in future, the EU expansion process will have important implications for the level of competitiveness of the food sector of the countries analyzed.

In Bojnec and Ferto (2009) research, an agro-food competitiveness of Central European and Balkan countries is analyzed and results show that the EU enlargement has a negative impact on agro-food relative trade advantages as a result of increased competitive advantages. Because of that, according to Zekić and Matkovski (2015), an improvement of export performances, through the increase in competitiveness of the agro-food sector in the international market, represents an imperative due to the current international economic integrations.

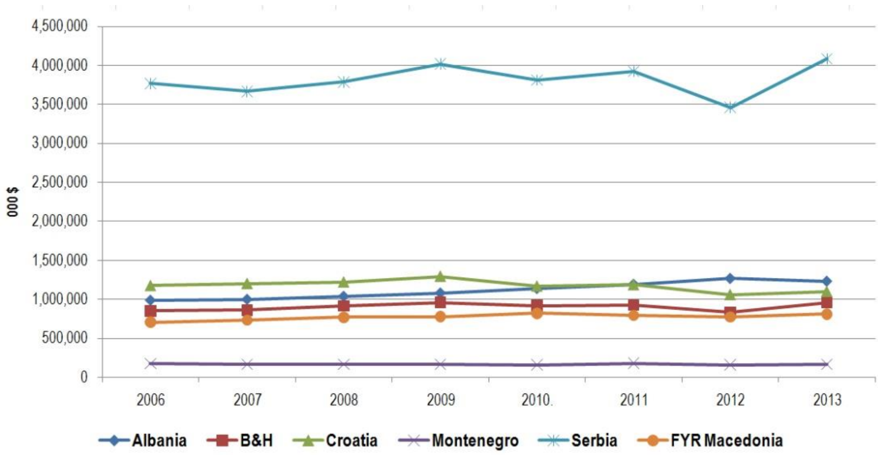
Also, it is necessary to follow the rules of technological adaptation, and of a higher level of efficiency in production. Also, authors Mizik and Meyers (2013) analyzed the possible effects of the EU accession on the Western Balkans´ agricultural trade and concluded that experience of other new member states from Central and Eastern Europe shows that price, production and trade can change significantly after accession as well as during the pre-accession period. The level of this adjustment occurs before or after accession, depending on the pre-accession policy and market adjustments.

Results and discussion

Agricultural production and foreign trade

According to the economic theory, there is a tight correlation between the level of agricultural and economic development. The higher the level of economic development is, the higher is level of agricultural development as well, and vice versa. For all Western Balkan countries agriculture is of great strategic importance. In last decade, the dynamics of agricultural production in these countries shows different trends, (*Chart 1*). Serbia has achieved the highest level of agricultural production in the whole period, followed by Albania and Croatia. Due to Albanian annual growth rate of agricultural production of 3.9% and Croatian negative growth rate of -1.5%, Albania has become the second country in region by value of agricultural production. Because of lack of agricultural resources, Montenegro has the lowest value of agricultural production.

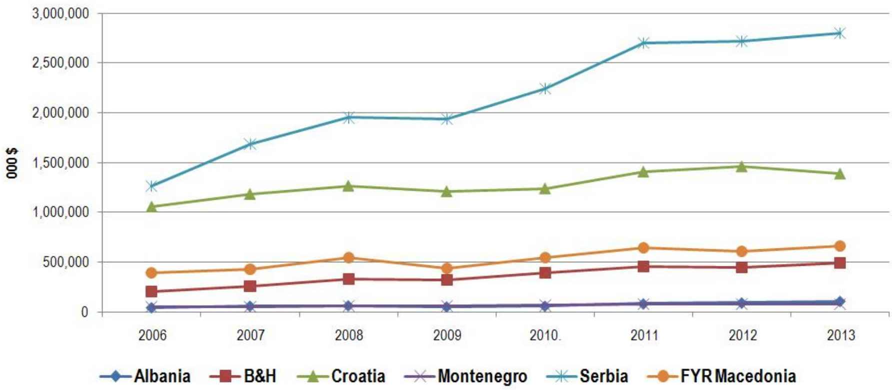
Chart 1. ***Tendencies of agricultural production***



Source: *FAOstat, 2016*

From standpoint of export of agricultural products, Serbia was a leading country in region *(Chart 2)*. In observed period, Serbia achieved annual growth rate of agricultural export of 9.19%. According to Zekić and Gajić (2013), the bilateral agreements within CEFTA, trade liberalization with the EU, as well as the privileged position in the Russian market, have significantly contributed to continual Serbian increasing foreign trade surplus of these products.

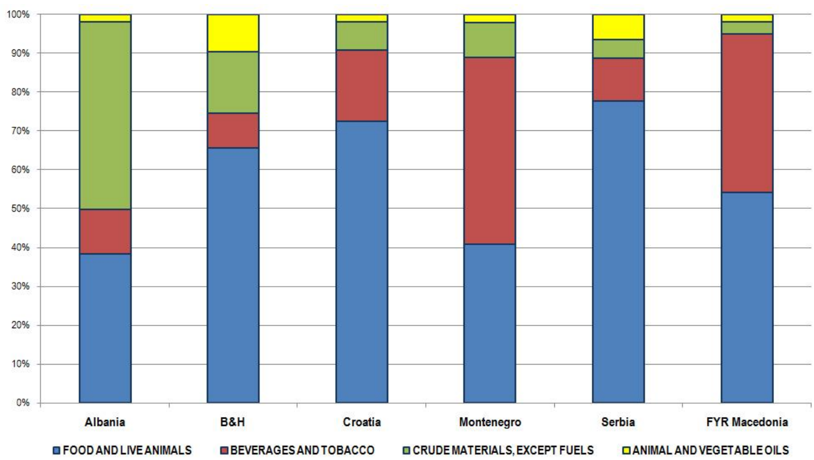
Chart 2. ***Tendencies of agricultural export***



Source: *FAOstat, 2016*

All Western Balkan countries have similar structure of agricultural export *(Chart 3).* Food and live animals have the largest share in export in all countries, except Montenegro. According to Zekić and Gajić (2013), production structure dictates the structure of agricultural exports of Serbia, which is dominated by plant products of lower level of processing, or products with the low added value. In this context, the small share of products of animal origin and final products is quite alarming.

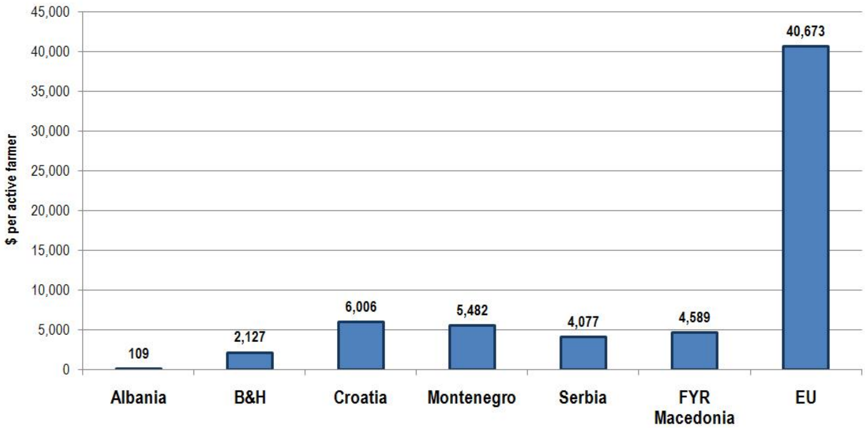
Chart 3. ***Structure of agricultural export in period 2006-2013***



Source: *FAOstat, 2016*

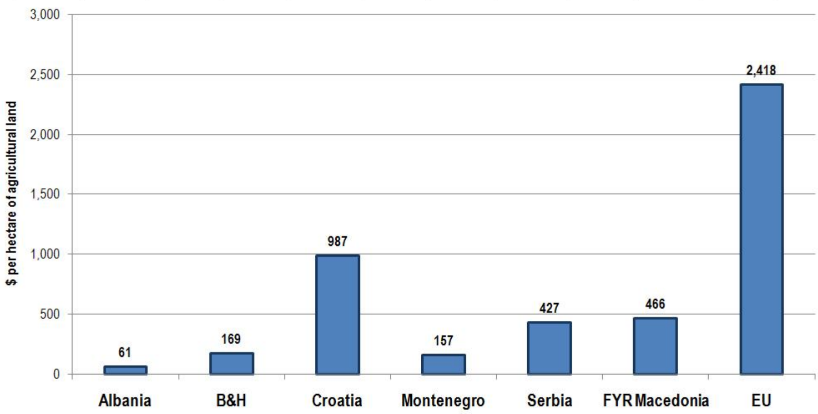
In relation to the primary resources - labour and land, the agricultural export performances of the Western Balkan countries show that all countries lag behind the EU. The export per active farmer shows the best performances in Croatia and Montenegro *(Chart 4 and Chart 5).* Also, Croatia led in region when the export value of agricultural products per hectare of agricultural land is considered. Although the positive foreign trade balance in the agricultural sector has been continuously realized in Serbia, if the agricultural export is considered in relation to the engaged labour and land, a rather modest performance is achieved. That is another indicator of the extensiveness of Serbian agriculture, i.e. the underutilization of its production potential (Gajić et al, 2015).

Chart 4. ***Export of agricultural products per active farmer in period 2006-2013***



Source: *FAOstat, 2016*

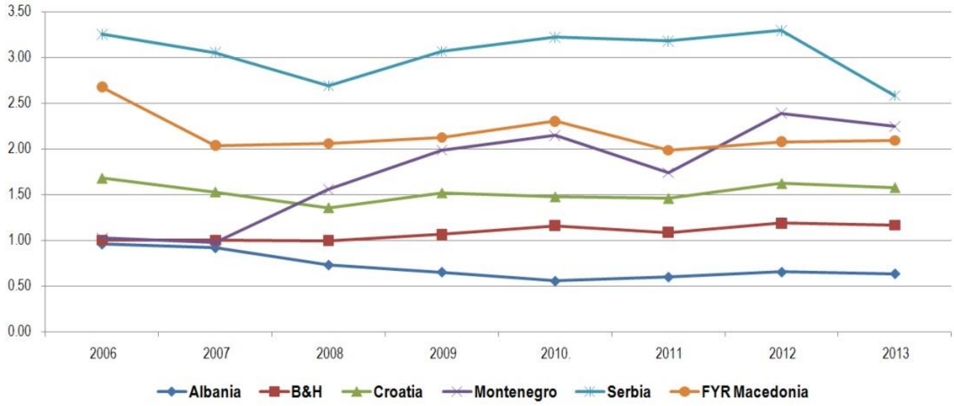
Chart 5. ***Export of agricultural products per hectare of agricultural land in period 2006-2013***



Source: *FAOstat, 2016*

The index of revealed comparative advantages of agricultural sector of the Western Balkan countries was analyzed for the global market *(Chart 6)*. Analyzing the RCA of the Western Balkan countries in period 2006-2013, it can be concluded that all countries of the Western Balkan, except Albania, had comparative advantages in the export of agricultural products.

Chart 6. ***Index of comparative advantages (RCA) of agricultural products***



Source: *FAOstat, 2016*

Analyzing the differences in comparative advantages by countries of the Western Balkan, it is obvious that Serbia had the strongest level of comparative advantages of agricultural products, while Macedonia has significant comparative advantages of this sector on global market. Comparative advantages of agricultural sector on global market of Bosnia and Herzegovina, Croatia and Montenegro in analyzed period were on satisfactory level, and the largest increase in RCA was in Montenegro (RCA had increased 13% annually). The worst situation is in Albania, where RCA index was bellow 1, with falling rate of 6% annually in analyzed period, primary because of the low level of export of agricultural products, but also because of the low export performances per active farmer and agricultural land. Although, in all countries of the Western Balkan export has grown, situation with comparative advantages is not same. In some countries RCA index had negative tendencies in analyzed period and one of the reasons are inadequate responds for increased competitiveness imposed by the global market in process of global integrations.

Conclusion

In last period, countries of the Western Balkan had transformed economy from the centrally-planned to the market economy, and the consequences of this transition process are lower production and export performances of agricultural sector than in the EU. Analysis done in this paper also confirms such production and export tendencies. Despite poor export performances per active farmer and agricultural land in countries of the Western Balkan, value of export had grown in analyzed period, and comparative advantages of this sector in majority of these countries were on satisfactory level. Serbia has the strongest comparative advantages among the Western Balkan countries; all other countries have satisfactory level of comparative advantages, except Albania, which has not comparative advantages of this sector on global market. Despite good indices of comparative advantages, in next period reaching EU standards and requirements concerning product quality will be the large problem for the Western Balkan countries. The main problems of export of agricultural products of the Western Balkan countries are domination of products with a low added value in agricultural export, a low quality, quantity and fluctuations, as well as low price competitiveness. Since accession to the EU is the important goal to all countries of the Western Balkan, adopting national agricultural policies is an imperative. Because of that, the countries of the Western Balkan have to adapt agriculture in order to increase agricultural productivity and competitiveness.

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WELFARE IMPACT OF RURAL INFRASTRUCTURE IN NIGERIA

Olagunju Oluseyi Kehinde[1], *Nikola Trendov*[2]

Abstract

This study examined the impact of infrastructure development on poverty status among rural households in Oyo State, Nigeria. Data collected from a random sample of 263 households were subjected to descriptive statistics and inferential statistics such as Foster, Greer and Thorbecke (FGT) poverty measure and probit regression model. Findings revealed that majority (77%) of the households were categorized as poor. The likelihood of rural households being poor was influenced by years of experience, livelihood diversity, access to good road, access to educational facilities, access to agro-processing facilities, access to health care facilities and access to electricity. The poor state of infrastructure and services calls for major investments across all categories which was found to have contributed to negatively to improved welfare of households in the study area. Rural poverty reduction polices should be designed to provide incentives and attract private sector investments towards infrastructure development in rural areas at affordable cost.

Key words: *Infrastructure, Poverty, Impact, Probit regression, Nigeria.*

Introduction

Recently, the issue of poverty reduction has been a global concern in policy making leaving the World Bank to set a target to eradicate poverty as the first target in the Millennium Development Goals (MDGs). The drive to eradicate extreme poverty in developing countries has become more urgent, given the need to attain the United Nations Millennium Development Goals by 2015. Poverty eradication, being the first of the eight goals, becomes crucial, since more than one billion people live on less than US$1 per day (Yusuf and Ukoje, 2011). A substantial proportion of world poor are located in the rural areas.

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Without iota of doubt, sustainable rural development in terms of livelihood security, reduced poverty and improved welfare is hinged on the provision of adequate infrastructure (Adeoye et al, 2011). Imperatively, effective infrastructure has been described as a key foundation for strong economic growth (ILO, 2011) that plays a critical and essential role in ensuring efficient poverty eradication (Ondiege et al, 2011). Thus, rural infrastructural facilities are basic services without which the needed environment as well as primary, secondary and tertiary productive activities will not be able to function (Obayelu et al, 2014).

Unfortunately, rural infrastructural development in Nigeria has long been neglected. Little or no investments in health, education and water supply have largely been focused on the cities. Consequently, the rural population has limited access to services such as schools and health centers, and about half of the population lacks access to safe drinking water. Limited education opportunities and poor health perpetuate their poverty cycle. Limited access to good roads has limited the access to market by rural dwellers. The neglect of rural infrastructure has also reduced the profitability of producing for the markets (Egbetokun, 2009; Calderon, 2008; Ndulu, 2006). The challenges of rural communities in Nigeria include lack of basic infrastructures, therefore, making them socially discriminated against and have no channels through which to voice their concerns.

There cannot be genuine national development in Nigeria if the vast rural areas of the country remain largely under-developed with poor access roads, poor health facilities, high unemployment and inadequacy of other social amenities. To deal with these numerous problems facing our rural communities, government at various levels have instituted a lot of programmes and projects aimed at transforming them into the mainstream of national development. Some of these programmes include: Operation Feed the Nation (OFN) 1976, the Green Revolution (GR) 1985, the Directorate of Food, Roads and Rural Infrastructure (DFRRI) 1985, Better Life Programme (BLP) 1986, Family Support Programme (FSP) 1987, the Family Economic Advancement Programme (FEAP) 1988 and the National Poverty Eradication Programme (NAPEP) 1999, to mention but a few. In spite of the above mentioned programmes and projects, our rural communities remain underdeveloped, lack basic amenities such as good roads, power supply, health care facilities and at the same time rural poverty persists.

Research outputs on the impact of infrastructural facilities on welfare and food security remains ambiguous, partially because it is hard to disentangle cause and effect. There is even less evidence on where investments might be the most transformative in creating new opportunities to link producers to markets. Also, given limited resources, there is a need for selectivity in deciding what investments should occur and where these should be located. This paper aims at tackling these issues by drawing on, and improving upon, the best data available, and by using a somewhat novel approach to overcome some of the technical challenges. This paper will use different econometric models to extent to which various infrastructures can improve livelihood of rural households. This will provide policy makers with policy direction in term of prioritization of important infrastructural facility(ies) that is or are key to welfare improvement. The approach that will be used in this paper will provide a more complete picture of the extent to which household welfare and food security are expected to improve with a given access to infrastructural facilities in the study area.

Materials and methods

Data collection and sampling techniques

The study was carried out in Akinyele Local Government area of Oyo state, Nigeria. Akinyele local government area occupies a land area of 464,892 square kilometers with a population density of 516 inhabitants per square kilometer. The Local Government Area has her large proportion constituted of the rural areas.

A multi-stage sampling method was used in sampling the respondents. The first stage involved the purposive selection of communities that are predominantly classified as rural in the local government area based on World Bank definition of rural (World Bank, 2007). These communities include Ikereku, Olanla, Idi-Iroko, Alabata and Olorisa-Oko. In the second stage, households were randomly selected and interviewed. Data on socioeconomic characteristics and infrastructural facilities available were collected using structured questionnaires which were distributed based on sizes proportionate to the number of inhabitants in the different communities. The distribution will be as follows: Ikereku (72), Olanla (57), Idi-Oro (49), Alabata (44) and Olorisa-Oko (41). About 263 rural household heads were sampled in total.

Empirical model specification

Poverty analysis was used to classify the households according to their poverty status using the food security. The analysis of poverty was based on P-alpha (α) measure proposed by Foster, Greer and Thorbecke in 1984. The use of FGT class of measure requires the definition of poverty line, which was calculated on the basis of disaggregated data on per capita monthly

consumption expenditure on both food and non-food items following (Amoo and Adeyemi, 2008).
The FGT measure was based on a single mathematical formulation as follows:

$$P_\alpha = \frac{1}{N}\sum_{i=1}^{q}\frac{(Z-Y_i)^\alpha}{(Z)} \quad (1)$$

Where:
z= the poverty line obtained as 2/3 mean per capita monthly total expenditure;
q = the number of individuals below poverty line;
N = the total number of individual in reference population;
Yi = the monthly per capita expenditure of household; and
α = the degree of poverty aversion; (α =0 measures the incidence of poverty. α =1 measures the depth of poverty. α =2 measure the severity of poverty).

In this study we only look at the poverty incidence among the rural households in the study area (that is when α = 0).

The poverty line is a predetermined and well-defined standard of annual income or value of consumption. In this study, the poverty line was based on the monthly expenditure of the households. Two third of the mean per capita annual expenditure (2/3 of MPCHE) was used as the moderate poverty line. Respondents above this value are classified as non-poor (those spending greater than 2/3 of MPCHE) and those below it as poor.

Probit Regression model was used to analyse impact of access to infrastructures on the poverty status of the rural households in the study area. The probit model which is based on the cumulative probability function was adopted because of its ability to deal with a dichotomous dependent variable and a well-established theoretical background. Probit regression is a uni/multivariate technique which allows for estimating the probability that an event will occur or not through prediction of a binary dependent outcome from a set of independent variables (Sala - i – Martin, Xavier and Maxim, 2010). The model is specified following the welfare impact of adoption of agricultural technology on poverty reduction (Awotide et al, 2012).

A household - level regression model is estimated thus:

$$Prob(Yi=1)=f(bkXk+biXi+ui) \quad (2)$$

Where *Yi* is the dummy variable for house hold poverty status (1= poor; 0=Non-poor). *Xk* and *Xi* are vectors of exogenous variables affecting households' poverty status. Also, *bk* and *bi* are vectors of parameters to be estimated, *ui* is a zero-mean error term, and *f*(.) is a probit or logit function. The model estimates are in 0-1 range and these probabilities are non-linearly related to the explanatory variables. In this paper, the probit model is employed to estimate the parameters of the model. Variables included in the model are presented as follows:

Y = Poverty status of the i^{th} household (1 = poor, 0 if otherwise)

Explanatory Variable;

X_i- Socioeconomic Variables

X_1= Age in Years
X_2= Household size (in numbers)
X_3= Primary occupation (1, farming, 0, if otherwise)
X_4= Year of working experience (in years)
X_5= Livelihood diversified (1, If diversified, 0, If otherwise)

X_{ii} – Access to Infrastructure Variables

X_6 = Access to road networks (1 if yes, 0,if no);
X_7 = Access to potable water (1 if yes, 0 if no);
X_8 = Access to schools (1,if yes,0,if no);
X_9 = Access to health care facilities (1, if yes,0, if no);
X_{10}= Access to public markets (1, if yes, 0, if no);
X_{11}= Access to agro-processing center (1 if yes, 0, if no); and
X_{12}= Access to electricity (1 if yes, 0 if no).

Results and Discussion

Socioeconomic Characteristics of Respondents

As shown in *Table 1*, majority of the households (67.3 %) were males and 32.7 % were females. Male respondents are dominants among the respondents could be the result of males having greater access to farm land than females. This implies that the main occupation, farming, in the study area is mostly done by male farmers who have and could have access to land resource. The age distribution of the respondents revealed that 8.8 % were aged between 21–30 years while 66.2 % were aged between 31-50 years, while 10.6 % of the respondents were above 60 years. This implies that majority of the households heads are in their economic active years. The household size was relatively high; with 75 % of the farmers having household size that ranged between 1–5 members and 5–6 members (23%) while 2 % had household members that are above 11. The educational background of the respondents revealed that 15.6 % had never been to school, 41.6 % had at least primary education, and 38.0% attempted secondary school education while only 4.6% had primary education. Majority of the respondents (69.6 %) have farming as their primary occupation.

Table 1. Socioeconomic characteristics of households

Variable	Frequency (n=263)	Percent age (%)	Minimum	Maximum	Mean
Gender					
Male Female	177 86	67.3 32.7			
Age					
21- 30 31- 40 41-50 51-60 > **60**	23 97 77 38 28	8.8 36.9 29.3 14.4 10.6	23	73	43
Household size					
1-5 6-10 >11		75.0 23.0 2.0	1	12	4
Education (years)					
No formal Primary Secondary Tertiary	41 110 100 12	15.6 41.8 38.0 4.6			
Main occupation					
Agricultural Non- agricultural	183 80	69.6 30.4			

Source: *Field survey, 2016.*

Expenditure profile and poverty status of respondents

Table 2 showed that the estimated monthly household expenditure on food consumed and non-food items were ₦3626.00 and ₦5234.00 respectively summing up to the total monthly household expenditure of ₦8860.00 while the mean per capita household food expenditure (MPCHHE) was ₦1772.00. The poverty line was computed for respondents using the two-thirds MPCHHE, the poverty line was calculated as ₦1187.20 per month based on the 2008 World Bank revised purchasing power parity (PPP) figure of $1.25 (World Bank, 2006; World Bank 2007).

Table 2. Monthly household food and non-food expenditure pattern

Variable Item	Average Monthly Expenditure (Naira)
Food expenditure	3626.00 (25$)
Non-food expenditure	5234.00 (35$)
Total monthly expenditure per head	8860.00 (60$)
Mean per capita household expenditure (MPCHE)	1772.00 (9$)
Poverty line (2/3rd of MPCHHE)	1187.20 (7.8$)

Source: Field survey, 2016.

Table 3. profiled the rural households into poor and non-poor groups based on their per capita expenditure. The food insecurity line for the study is calculated as N 1187.20 per month. Household whose per capita expenditure falls below N 1187.20 are categorized as being poor while households whose mean per capita food expenditure equals or greater than the poverty line (N1187.20) are non-poor. Majority of sampled households 77.19% of are poor.

Table 3. ***Households' poverty status of the rural households in the study area***

Households Poverty status	Frequency	Percentage (%)
Poor	203	77.19
Non-poor	60	22.81

Source: Field survey, 2016.

Households access to physical and social infrastructure and poverty status

A comparison of access to infrastructure was made between poor and non-poor rural households. This was done with a view to examine if access to infrastructure has any effect on households' poverty status. In the pooled sample, more than half of the sampled households of the respondents have access to potable water, good roads and schools while less than 40% of the households have access to agro-service centers, health care center, public market and electricity. This suggests that access to potable water, roads and schools are not constraints in the study area.

Infrastructures considered in this study are both the physical and social infrastructure which has a latent potential of influencing the welfare of rural dwellers. Among the infrastructures considered is potable water access point which is health and productivity of inhabitants of the study area (Olagunju et al, 2015). The results showed that 74.9% of households that are living below the poverty line do not have access to and or could not afford potable water. This signifies that these household depend on water source that are not hygienically reliable. As shown in the Table 2, about 36.5% of the categories of households that are poor have access to public market compared with non-poor category with about 75% having access to public markets.

All indications from the results presented in table 4 shows that majority of households that fell in poor category do have access to infrastructural facilities in the case of potable water, good roads, agro service centers, health care center, public market and electricity. Infrastructural facilities such as good roads, agro service centers, public market and schools are vital in linking rural dwellers who are farmers to the potential final consumers of their products who will not buy their products at farm gate price but at a reasonable amount that will be profitable for the farmers.

Among the poor households, only 30.0%, 27.1%, 46.1%, 36.5%, 34.0% while among the non-poor households, only 76.7%, 85.0%, 76.6%, 75%, 75.0%, 78% have access to good roads, agro-service center, health care center, and electricity respectively. However, taken average of the percentages of the two categories it was found that only 40% of the poor households have access to both social and physical and social infrastructures leaving the remaining 60% dearth of infrastructural facilities.

Table 4. ***Distribution of access to rural infrastructural facilities by poor and non-poor households***

Access to Rural Infrastructural Endowment	Pooled (n=263)	Poor households (n= 203)	Non-poor households (n=60)
Have access to potable water	197(74.9)	59(29.1)	31(51.7)
Have access to good roads	194(73.8)	61(30.0)	46(76.7)
Have access to Agro-service center	64(24.3)	55(27.1)	51(85.0)
Have access to schools	202(76.8)	156(76.9)	46(76.6)
Have access to health care center	109(41.4)	94(46.1)	45(75.0)
Have access to public market	89(33.8)	74(36.5)	45(75.0)
Have access to electricity	82(31.8)	69(34.0)	47(78.0)

**Legend: Values in parentheses are percentage of the total observations*

Source: Authors' editing, 2016.

Impact of access to infrastructural facilities and socioeconomic factors on poverty status among rural households

Table 5 presents the estimated coefficients of the explanatory variables (socioeconomic factors and infrastructures) and their marginal effects of a unit change in these variables on the probability of households' poverty condition. The diagnostic statistics reveals that the chi square value for the model is significant at the 1% level which means that the explanatory variables jointly influence households' poverty condition. The signs show the direction of change in the probability of the households being poor given the change in the explanatory variables. A positive sign shows increase in the probability of being poor while a negative explains the converse.

Age, household size, primary occupation, access to potable water and access to schools do not significantly influence the probability of household's being poor. However, years of work experience, livelihood diversified, access to road, access to health facilities, access to public market, access to agro-processing center and access to electricity significantly influence the probability of household's being poor.

Years of work experience: It was found to significantly influence the poverty status of rural households at 5% level of significance. It has a marginal effect of 0.118 meaning that a unit increase in years of work experience will reduce the probability of household being poor or living below the poverty line by 11.8%. This could be due to the mastery of the households’ livelihood activities, there, resulting, in improved productivity implying improved welfare in the study area.

Livelihood diversified: A unit increase in the rate of diversification by rural households in the study area will increase the likelihood of households being poor by 4.9% at 10% level of significance. The emergence of this occurrence can be reason out due to the fact that as livelihood is been diversified, resources are also diversified alongside. Thus, there is low concentration on major livelihood source and result in the likelihood of being poor.

Access to good roads: was found to be significant and negatively signed. This explains that access to good roads could reduce the probability of households being poor. Good transportation facilities and network is key to improving market linkages and also enhancing improvement of private investments in the local community therefore, improving the livelihood of the rural poor.

Access to health facilities: was found to be significant, negatively signed and has a marginal effect of -0.229 implying that access to health facilities reduced the probability of rural households falling below the poverty line (being poor) by 22.9%. The lack of direct access to primary health facilities subject rural dwellers to both direct cost and indirect cost as a result of health risk and transaction cost to receive health care service, therefore, causing a leakage to economic prosperity of the local community (Ogunnyi et al, 2015).

Access to public market: was found to be significant, negatively signed has a marginal effect of -0.002 implying that access to public market reduced the probability of rural households falling below the poverty line (being poor) by 0.2%. Access to public market is pertinent to providing a platform for getting reasonable prices for products, therefore accruing increased revenue stream and helping rural dwellers scale the poverty line.

Access to agro-processing center and access to electricity: were found to be significantly influence the poverty status of rural households. They are negatively signed and have marginal effects of -0.117 and -0.060 respectively.

Table 5. ***Probit regression output of the impact of access to infrastructural facilities and socioeconomic factors on poverty status***

Variable	Coefficient	P (Z/Z)	Marginal effect
Socioeconomic factors Age	0.017	0.276	-0.006
Household size	-0.534	0.719	0.099
Primary occupation	0.399	0.365	0.457
Years of work experience	-0.060**	0.004	0.118
Livelihood diversified	1.138*	0.083	0.049
Infrastructures variables Access to road	-0.531***	0.001	0.068
Access to potable water	-0.359	0.211	-0.047
Access to schools	-0.574	0.141	-0.506
Access to health facilities	-0.575**	0.013	-0.229
Access to public market	-0.003**	0.022	-0.002
Access to agro-processing center	-0.534***	0.002	-0.117
Access to electricity	-0.306*	0.063	-0.060
Number of observations =263 *Pseudo R^{2-}= 0.416* *LR chi square(13) = 117.5* *Prob > chi2 = 0.000* *Log likelihood = -82.46* ****Significant at 1% level, ** Significant at 5%l evel, *Significant at 10% level*			

Source: Authors' editing, 2016.

This explains that access to agro-processing center and access to electricity reduced the likelihood of rural households falling below the poverty line (being poor) by 11.7% and 6% respectively. Processing creates value addition to primary products, reduces post-harvest loss and also creates more opportunities for rural economy therefore increasing the family income streams.

Conclusion and recommendation

The provision of rural infrastructures is basic to rural economic development which encompasses improving the welfare and well-being of rural households. The development of rural infrastructure for poverty reduction in the past or presently is major emphasis of the rural development programmes in Nigeria. Regrettably, little less than nothing has been achieved due to faulty implementation () thereby making rural areas subject to poverty and other economic crisis. This study assessed the impact of rural infrastructure on poverty reduction among rural households.

For poverty to be reduced to its minimum through facility provision in the rural areas of Nigeria, a number of policy related issues have been raised by this research. The government has to put in place a number of policies in order to improve the rural infrastructures to promote rural households welfare in Nigeria.

Further to this, the following recommendations were suggested:

- There should a balance in the pattern of infrastructural development. Attention should be given to this by adopting a discriminate investment in infrastructural facilities in favour of under-privileged areas;
- The existing facilities can be expanded to accommodate the increasing demand for services. More road network should be built, the primary health care centers can have annexes in some of the localities while more public markets and many more in the study area. By these, facility services will not only be functioning, the impacts of infrastructure location will be accelerated;
- Rural development plans and come out with a more viable and formidable programme which entertains the entire needs of the rural people. This programme should be genuinely set and governments at the various levels should be involved in the operationalization and implementation for improved standard of living of the rural people.

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SUPPORT OF USE OF RENEWABLE ENERGY SOURCES AS WELL AS AN INSTRUMENT OF RURAL DEVELOPMENT

Goran Vasić[1]

Abstract

Mankind is faced with many challenges caused by increasing human population. Despite the problems, such as the supply of food and drinking water, organization of health care, one of the most urgent problems is the supply of energy. Republic of Serbia has made a commitment to follow the energy policy of the European Union, and to reach the target of 27% share of renewable energy sources (RES) in the energy mix, by the year 2020. Biomass, which is predominantly located in rural areas makes about 60% of registered potential that can be exploited to meet this goal. Despite of significant contribution to environmental protection, accelerated implementation of the RES can be a very effective instrument for rural development. Guarantee Fund of AP Vojvodina has developed a special-purpose credit line thanks to which existence they first realized projects and gained initial experience in implementing this important policy.

***Key words**: Renewable energy sources, rural development, biomass, Guarantee Fund of AP Vojvodina*

Introduction

The European Union (EU) observed as a whole is the second global economy and participates in the fifth of the world s energy consumption. (European Commission, 2012). Energy sector has a strategic importance in providing lifestyle and level of standards. Fortunately the high dependence on imports is compensated by diversified energy mix at the disposal of Member States from hydropower plants in Austria, the coal mines in Poland, the powerful potential of nuclear energy in France, significant oil and gas deposits in the northern coastal region of the Atlantic Ocean, etc. Oil for the needs of EU is imported mainly from OPEC[2] states and Russia, while gas is purchased from Russia, Norway and Algeria. About 350 billion € (European Commission, 2012) must be set aside, for this purpose every year. EU member states are aware that their

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[2] OPEC – Organization of Arab Petroleum Exporting Countries – with headquarters in Vienna since 1965 founders are Algeria, Angola, Ecuador Iraq, Iran, Kuwait, Libya Nigeria, Qatar, Saudi Arabia, United Arab Emirates and Venezuela

advantage is in coordinated action on such a significant strategic field. Therefore they have decided to form a joint policy through the integrated efforts to ensure a secure supply of energy at affordable prices. EU member states are free to develop the energy resources of their choice and are only obliged to take care of common objectives relating to RES.

The importance of RES in the Republic of Serbia

At the meeting of the Ministerial Council of the Energy Community, which was held 18 October 2012 in Budva, Montenegro made the important decision for RES in the Republic of Serbia (RS). Participation in binding of RES goals in the energy mix of nine contracting parties was estimated on the basis of EU methodology.

Table 1. ***National overall targets for the participation of RES in gross final energy consumption in 2020***

Country	Target in 2009	Target in 2020
Albania	31.2%	38%
Bosnia and Herzegovina	34.0%	40%
Croatia	12.6%	20%
BJR Macedonia	21.9%	28%
Moldova	11.9%	17%
Montenegro	26.3%	33%
Serbia	21.2%	27%
Ukraine	5.5%	11%
UNMIK – Kosovo	18.9%	25%

Source: *(Ministerial Council of the Energy Community, 2012)*

Preparatory work for adoption of this decision showed that the region of South Eastern Europe has great potential for the use of RES. By making such a decision Member States have decided to establish binding targets to increase the participation of RES in their energy mixes, but this also has resulted in the bringing of new business opportunities, attracting investors and helping the region to diversify its energy mix and reduce dependence on foreign suppliers.

Energy resources of the Republic of Serbia and RES

Dominant position and the key support when it comes to energy resources of the RS continue to make beds of coal - lignite. Geological lignite reserves comparing to the geological reserves of all types of coal in the RS consist of 93%. On the basis of data from the Energy Balance of the RS in 2013 (Official Gazette No. 122/12) energy import dependence in the RS in 2011 amounted to 30.28%. For the future of the RS, the most important thing will be to provide safe, high-quality and reliable supply of energy and reduce energy dependence on state.

It is estimated that the technically exploitable potential of RES is 5.6 Mtoe per year and that its use can significantly reduce the use of fossil fuels and contribute to achieving the proclaimed goals. Biomass potential is about 3.4 Mtoe per year (2.3 Mtoe is unused and 1.1 Mtoe already in use). Except biomass emphasis is made to the importance of the hydropower potential estimated at 1.7 Mtoe per year (unused portion of the hydro potential is at the level of 0.8 Mtoe, while in the previous period used part is at 0.9 Mtoe). Other RES that are of importance have a share of less than 10%.

National action plan of the Republic of Serbia for RES by 2020

For the preparation of a National Action Plan for RES two scenarios have been developed for the definition of gross final energy consumption by 2020 as well as by sector (sector of electricity, heating and cooling sector and the transport sector). Reference scenario does not take into account energy saving measures, but is based on an increase in final energy consumption in line with the forecasted economic growth in the observed period. Scenario with the implementation of energy efficiency measures takes into account the saving of final energy consumption in the household sector, both public and commercial activities, industry and transport sector, which are defined in the National action plan for energy efficiency from 2010.

Table 2. ***Production of electricity from RES of new plants in 2020***

RES	MW	The anticipated number of working hours	GWh	Ktoe	Partici-pation %
HE (> 10 MW)	250	4,430	1,108	95	30.3
MHE (< 10 MW)	188	3,150	592	51	16.2
Wind energy	500	2,000	1,000	86	27.4
Solar energy	10	1,300	13	1	0.4
Biomass CHP	100	6,400	640	55	17.5
Biogas CHP	30	7,500	225	19	6.2
Geothermal	1	7,000	7	1	0.2
Waste	3	6,000	18	2	0.5
Landfill gas	10	5,000	50	4	1.4
Total planned capacity	1,092		3,653	314	100.0

Source: (Ministry of Energy, Development and Environmental Protection, 2013)

Table 3. ***Production of energy in the heating and cooling of new capacity using RES by 2020***

RES	Ktoe	Participation in further planned production of thermal energy by 2020 compared to the base 2009 %
Biomass – CHP	49	33
Biomass (SDG)	25	16
Biogas – CHP	10	7
Geothermal	10	7
Solar energy	5	3
Biomass in individual households	50	34

Source**:** *(Ministry of Energy, Development and Environmental Protection, 2013)*

In the transport sector in 2009 RES (i.e. biofuels) have been represented on the market with only 0.21 ktoe (this amount is not recorded in national statistic). That quantity of biodiesel is sold under the label B100 and used in agriculture. Biofuels are not there on the market in mixtures with petroleum-derived fuels for motor vehicles, in accordance with allowed amounts to appropriate standards for gasoline and diesel fuel. In accordance with Directive 2009/28 EC for mandatory RES target for participation of RES in the transport sector is 10% in 2020. According to a specified target and proposed scenario, the amount of RES in transport sector will amount to 264 ktoe in 2020 which represents 2.6% of RES.

Agriculture and residential sector are significant consumers of energy

On the basis of data from the Energy Balance, which is drawn up in accordance Eurostat methodology (Eurostat statistical books, 2014) final energy available for consumption for energy purposes in the Republic of Serbia in the reference year was 8,488 ktoe. A detailed review of the sector can be seen in *Table 4*.

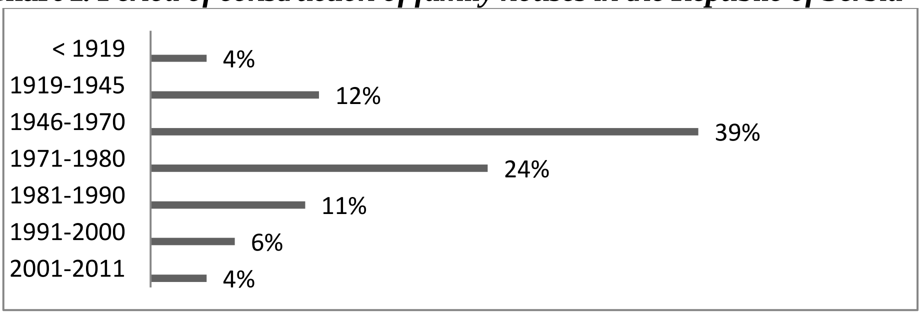
Table 4. ***Final energy consumption in the Republic of Serbia in 2012***

Sector	Final consumption Ktoe	Final consumption %
Industry	2,487	29.30
Transport	1,840	21.67
Other sectors	4,161	49.02
+ commercial and public services	842	9.91
+ residential	3,135	36.93
+ agriculture and forestry	184	2.16
TOTAL	8,488	100.00

Source: *(Eurostat statistical books, 2014)*

A group of authors from the Faculty of Architecture in Belgrade has analyzed the characteristics of family homes in six regions in the RS and defined their core typology. This publication is based on statistical data, data collected by field research, as well as the accumulated knowledge gained prior to professional and scientific experience and with the help of GIZ[3]. Atlas of family houses in the RS (Jovanović Popovic & others, 2011) included the systematization and formed a typology of family housing and represent a good basis for various analyzes and recommendations, including the assessment of the situation and possibility of improving energy efficiency. The most intensive time of construction was after the Second World War 1946-1970, from which originates almost 40% of total fund. Detailed overview can be seen in *Chart 1*.

Chart 1. ***Period of construction of family houses in the Republic of Serbia***



Source: *(Jovanović Popović & others, 2011)*

There is an increasing use of thermal insulation in the houses which is consistent with the trend of increasing energy prices on the world oil crisis period, raising the level of knowledge and awareness of the problems associated with thermal performances as well as the availability of insulation materials on the market. On the other hand the authors point to the fact that the average thickness of insulation is only 5 cm, which is not enough under the conditions defined in the Regulations on energy efficiency in buildings (Regulations on energy efficiency in buildings, 2011). This research has shown that there are a very large number of unfinished buildings, constructed without a facade in which people live for more than 30 years, and that 51% of the windows are older than 30 years or have inadequate thermal characteristics. It is not necessary to prove the existence of high thermal losses in these facilities. Among other things, this study showed that 87.35% of all dwellings in the RS consists of objects of family housing. This information was confirmed in a slightly altered percentage in the National report on social

[3] Deutsche Gesellschaft fur Internationale Zusammenarabeit - the German Federal Enterprise for International Cooperation

inclusion and poverty reduction in the RS (Government of the Republic of Serbia, 2011). The authors of this publication may refer to data from Survey on income and living conditions in the RS from 2013, which confirmed that 78.1% of the population lived in family house.

EU member experience and knowledge transfer

Most EU countries have developed specific instruments of support for the development of RES and at the same time harmonized measures to increase energy efficiency. German Baden-Wurttemberg region excels in the implementation of energy efficient technologies that are pushing the use of RES. Regional authorities have valuable decades of experience in designing energy policies, well matched with the national level of decision making, which together create a stimulating environment that encourages investors to behave in line with targets. The foregoing reasons influenced the decision to the 9th and 10th September 2014 the initial conference dedicated to partnership Baden-Württemberg and RS in the field of bioenergy. On this occasion they organized visit to the Vutermasholderbah, village of bioenergy representing a successful example of application of the concept that significantly changed lifestyle and economy in this extremely rural settlement. Central place in this case makes biogas plant which can be seen in *Picture 1*. Biogas plants were determined by the type of substrate used for the production of biogas. If the substrate is from agriculture (manure and/or energy crops) biogas plants are classified as agricultural. Similarly, if the substrate represents the benefits of organic waste from the food industry, they are classified as industrial. Plants using waste, as a substrate for biogas production, using waste from slaughterhouses, municipal solid organic waste and sludge produced by scrubbing the industrial and municipal wastewater and are classified as biogas plants for disposal of organic waste.

Picture 1. ***Biogas plant and solar panels - Vutermasholderbah***

Illustrated plant is obviously the agricultural type and is located near the cow farms and pig's farms. At the majority of biogas plants in countries with favorable feed-in tariffs, the share of biogas produced from silage ranges from 30 to 100%. Differently from the manure silage has a price, which significantly affects the economic indicators. Silage price depends on the price of agricultural products, for example, maize grain. In this case, the gas from biogas plants is used to run the gas engine which will have power 350 kWe and will delivers "green" electricity directly into the national electrical grid. In this process 250 kWt heat is released and is used in winter for heating residential and public buildings in the village. All residential buildings, family houses and buildings of public importance such as school, nursery, infirmary, local government facilities etc. are supplied with thermal energy from village district heating system. During the summer heat is used for drying wood chip. In the surroundings there are significant area of forest and local companies are engaged in rough wood processing. Waste wood from sawmills and wood obtained by maintenance of fire-protecting roads and the maintenance of forest is chopped and so obtained wood chips are dried. Part of the wood chips are used as fuel for standby mode, which is activated in the event of failure or downtime on the primary biogas plants, and the remaining amount is placed on the market.

Houses, barns and storage facilities that are conveniently oriented on their roofs are installed with photovoltaic panels, which can be seen in the picture 1. Surplus energy obtained in this way is delivered directly to the network, or the relevant distributor of electricity. Village annually depending on weather, quantity of solar energy and the number of cold days in winter produces 10 to 12 times more electricity than it consumes. This project is implemented with the financial assistance of European, national and regional funds and "soft" loans. Proceeds from the supplied "green" electricity are directed to servicing credit obligations while thermal energy is the "extra profit". Project, in addition to its outstanding environmental dimensions enabled engagement of local resources and creating additional jobs.

Necessary conditions for the implementation of the concept of bioenergy villages and barriers observed in the Republic of Serbia

It is clear that RS has all the natural, climatic and geographical conditions for the implementation of the project of bioenergy village. In the process of harmonization of legislation, which regulates the energy sector whole set of laws and bylaws were adopted, and thus created the necessary framework for the establishment of incentives in the form of feed-in tariffs. It can be concluded that the RS owns operating mechanism that privileged producers of electricity to purchase at guaranteed prices in line with the feed-in tariff over a period of 12 years, which is sufficient for investments of this nature which can be classified into cost-effective and economically justified.

Opposite of the aforesaid, heat generation from RES is under jurisdiction of local governments. Biomass as the most abundant potential for renewable energy production is geographically distributed mostly in poor and underdeveloped municipalities. Local self-government in these municipalities usually have a problem with a lack of quality and trained staff who would successfully be able to support projects of this type. Complicated legal procedures, a large number of required licenses, significantly discourage investors. Low on Public Procurement with its rigid approach that prevents the signing of multi-year contracts for the supply of thermal energy for schools, hospitals, kindergartens and other facilities that are within the competence of local authorities represents the biggest obstacle.

On several occasions the authorities at the national level are announcing the formation of specialized center that would serve investors and monitor projects in one place, from the initial idea to realization, according to the principle "one stop shop". The formation of Conference/Steering Committee was announced and there the representatives of producers and importers of equipment, representatives of the academic community, interested investors and bankers, would meet and they should together with the representatives of competent ministers, deal with by proposing simplification of legislative procedures and the development of inceptives mechanisms. Unfortunately both of this initiative has remained in form of proposal. Repeatedly it was pointed out that one of the systemic barriers to more intensive penetration of RES is low price of electricity in RS compared to EU member states. Confirmation of this attitude can be seen in table 5, which shows the price of electricity and natural gas supplied to households in selected EU member states.

Table 5. ***Comparative overview of the price[4] of electricity and natural gas***

Country	**Electricity** ***€cent/kWh***	**Natural gas** ***€cent/kWh***
Serbia	5.17	3.20
Croatia	10.60	3.09
Slovenia	11.76	6.20
Austria	13.61	5.62
German	14.89	4.76
Hungary	10.19	4.40

Source: *EUROSTAT and Energy Agency RS*

[4] Prices for electricity relating to the second semester of 2013, while for natural gas in the first semester 2012. The prices are without VAT and associated taxes.

This complements a series of obstacles and lack of special purpose credit lines with aligned interest rates and longer repayment time appropriate to the nature of these projects and the cash flows that they could generate.

Role of the Guarantee Fund of AP Vojvodina

Guarantee Fund of the Autonomous Province of Vojvodina was founded on 18 December 2003. Mission of the Fund is to provide easier access to financial markets and favorable credit conditions (lower interest rates, longer loan repayment periods, long grace periods). Guarantee Fund is a member of AECM – European Association of Mutual Guarantee Societies which has 42 members.

Table 6. ***Value of portfolio***

	2011	2012	2013	2014	2015
Outstanding guarantees (€)	8,608,480	7,495,026	9,296,665	10,836,423	10,049,348

Due to the great potential and the amount of biomass produced in Vojvodina, part of RS having the greatest number of farmers Guarantee Fund in cooperation with the foundation Heinrich Boll Stiftung implemented the project "Your biomass your energy" which is aimed to help farmers in an effort to make use of biomass as an energy source for plants, farms and companies. Steps in the project are meant to develop a model of use of energy from biomass obtained in agricultural production, and to develop information brochures "Your biomass your energy", and organize info-sessions where farmers would be firsthand informed about the project. An open competition for the purchase of equipment and isolation facilities, was prepared in cooperation with commercial banks (AIK Bank, Banca Intesa, Credit Agricole, Hypo Alpe Adria, Komercijalna Bank, ProCredit Bank). The International Conference "Promotion RES: biomass in agriculture", 12th May 2015 at the Novi Sad Fair as a final project.

During the implementation of this project and contracting special-purpose credit lines, another obstacle was observed in penetration RES in the energy market. It is a silent obstruction and resistance in banking circles. Even before the beginning of the project most of banks had available a favorable international financial resources for these purposes. There is a certain willingness and intention to managerial teams to prepare banking products of this profile. However, this new topic, full of unfamiliar technical terms, less-known to banking officials is full of hidden risks, and caused a great aversion during the implementation. The emergence of informational brochures contributed to the "start-ice" and creating a better atmosphere, but the general impression is that in the future, special attention must be paid to work with bank officials having lower positions that are in direct contact with clients.

First experiences and examples of good practice

In accordance with the expectation the first applications for special purpose loans related to the projects that are technically simpler that requires less work on collecting permits and supporting documentation and require less investment amounts.

A good example is a company from Zrenjanin "Eurobriket doo". They launched production of briquettes, which are used as raw material residues from agricultural production, i.e. straw. Applied technology is simple and involves the formation of briquettes by pressing crushed particles of material without bonding agent under certain conditions: high pressure, elevated temperature and optimal moisture in the material. In the pressing of biological material volume decreases about 10 times, thereby providing a density of the briquette 800-1,200 kg/m^3. Optimum moisture content is about 15%. Calorific value of briquettes is approximately the same as the domestic coal (15 do 17 MJ/kg) (Brkić, 2007).

In 2015, 350 tons of raw materials were processed at the facility. Successful business in the first year of production has contributed to the establishment of a well-designed business policy. Favorable location of the plant allows the supply with row material from the fields that are within the radius of 20 km.

Picture 2. ***Production line for briquettes – "Eurobriket"- Zrenjanin***

Costs of collection and transport of row materials are extremely critical for successful operations. Threshold of profitability is within the radius of 50 km. The owner contracted the supply of raw materials based on the principle of compensation of straw-briquettes. This way he avoided the impact of fluctuations of raw material price. Finished product – briquettes are mostly marketed to households with an older population – pensioners who use it as a substitute for firewood and coal. Delivery is well organized to every household with transport to the space in the family house, which is designed for warehouse. Cost-effectiveness threshold range from end-user manufacturing plant is identical to the raw material and it is 50 km, at this level of production. In addition to the financial aspect, end users highly appreciated provided transport and unloading directly close to the boiler, as and additional value of this products, which relieves them of hard work and physical manipulation that is common with traditional fuels.

Second example relates to the use of RES in the process of tobacco drying. In this production an energy source that is used in dryers in picture 3 is usually natural gas and participates in the costs of production with 40%. Company "Terming" from Kula has managed to produce heat generator that can be used for drying tobacco with capacity 80-150 kW. Fuel that is used in the generator heat is agropelet, which allows automatic mode of operation and good control of desired temperature. One of the great challenges faced by designers of such plants is lower melting point of ash generated by burning straw (Martinov, Program for evaluation of economic indicators for the application of biomass energy, 2011).

Picture 3. ***Heat generator and drier for tobacco***

This phenomenon, if not properly controlled can lead to adhesion of melted ash on heating surface. The formation of silicate materials in the boiler rooms in addition to difficulties in cleaning, may even lead to serious damage. After a full season the exploitation during 2015, on joint meeting of farmers, equipment manufactures and representatives Japan Tobacco who purchase dried tobacco, it was found that they were very satisfied with the quality of applied technology, savings in applied energy source, and preserved the quality of dried tobacco. The saving energy in the applied energy source are in a relation 1:4 which is very important if we take into account the fact that the source of energy makes up 40% of the cost of production from planting to plant dried tobacco. At this meeting it was pointed out that despite the use of this type of heat generator for drying tobacco in neighboring Croatia, there are several applications for drying herbs and medicinal plants. It is expected that this trend expand to the territory of AP Vojvodina and RS.

Ten-year experience of the Guarantee Fund of AP Vojvodina shows that in the initial stage of development of line of credit farmers have a cautious approach and decide first for investments with smaller financial amounts. The expression of interest at the level of collecting data and compiling the first calculations was shown in the case of investment in biogas plants, which often amount to several million € . Each plant represents a small, specialized factory, which requires considerable logistics, equipment and supporting knowledge management process. The lack of use of manure as a substrate is due to its low energy potential due to the high content of water. Compared to corn silage, manure can have ten times smaller biogas yield per unit of weight, which means that for the same size biogas plant need ten times the amount of manure. One conditional head of cattle, weighing 500 kg, provides from 0.11 to 0.15 kWe of installed capacity. Thus for the plant with nominal electric power of 150 kW, it would take at least 1.000 livestock units (Martinov & Đatkov, Biogas plant - instruction for elaboration of feasibility studies with the example of biogas plant, 2012). Data obtained from the Ministry of Agriculture of RS relating to the territory of AP Vojvodina indicate that the structure of farms with livestock is dominated by small farms.

Table 7. ***Size of farms with livestock in AP Vojvodina***

Number of livestock	>50	>300	>1,000
Number of farms	806	47	7

RS has the possibility to use the funds from IPARD[5] in the period from 2014 to 2020. In this program are planned funding for the construction of biogas plants. In the rules for the use of funds, it was specified that they are only available to farms that have more than 300 head of cattle. Currently in the territory of AP Vojvodina in operational work, there are only two plants of Mirotin Energo, Vrbas of installed capacity of 1.5 MW and Global Seed, Čurug of installed capacity 600 kW.

[5] IPARD – Instruments for Pre-accession Rural Development

It is obvious that the livestock on the observed territory is in constant crisis and in spite of small number of cattle in comparison with the projected agrarian policy, is characterized by a low concentration, which is one of the obstacles to the emergence of a larger number of investments.

Conclusion

The greatest challenge that humanity faces today is rapid human population growth. At the same time it is the starting point of the analysis conducted by Jeffrey Sachs (Sachs, 2014.) pointing out that on our planet today live about 7 billion and 200 million people, which is nine times more than in 1750, which is taken as the initial years of the industrial revolution. This fact induces many challenges such as food supply, drinking water, energy, accommodation, organization of health care and education, etc. None is more urgent of all of the previously mentioned problems, which are directly related to the growth of harmonization with planetary limits, but at the same time none is more complex than the challenges that we are facing the world's energy system.

It has been shown on examples of good practice from EU member states, that the use of incentives for RES in rural areas and on farms can be a very successful mechanism for rural development. Production of biofuels has been shown to be a positive step achieved in rural development, better utilization of human and material resources (employment), reducing of dependence on imports (current account deficit) and other socio-economic indicators which are essential for the observed area.

With view to the effective and efficient use of RES in rural areas, there are numerous obstacles. It is important to identify them and then develop an action plan for their removal or reducing. This requires the cooperation of farmers, equipment manufacturers, the academic community and state representatives at local, regional and national level.

Experience that EU countries have in this field and the fact that have already passed great part of this road by developing their own programs for application of RES and implementation of energy efficiency measures is important for RS. Additional importance for the development of RES is in existence of EU funds which are available to RS.

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