

**NEW CONCEPTS IN THE TECHNOLOGICAL DEVELOPMENT OF AGRICULTURE**

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**Abstract**

Agriculture in the Republic of Macedonia is in a constant development crisis, based on structural agri-policy origin. Agricultural holdings occur in several structures, such as: very small individual holdings (farms) that use about 80% of the agricultural land; agricultural companies; and several cooperatives that use about 20% of the best quality agricultural land in the country. The industrial labor organization in the some of the agricultural corporations: disrupts the natural cycle of the plant and animal production, increases the input, decreases the production capacity of the land and creates environmental issues. The phases that include reproduction and milk production, as phases of the farming process, are especially expensive and require individual treatment of animals. The trend of development of village structure which can encompass the principles of agricultural production is negative. The small land property structure, which is worsening each year, cause de-professionalization, especially in the hilly and mountain regions. Therefore, strategy for technological development in agriculture is proposed in this paper. The strategy is expected to contribute in the development and strengthening of agriculture in the villages in accordance to the west European examples based on cooperative investment and ownership.

**Keywords:** agricultural corporations, environment, production potential, production phases, R. Macedonia, structure, technological development.

**Introduction**

In the last decades of the 20th century and the first decades of the 21st century there has been an extraordinary development of biotechnology and agricultural technologies, particularly in the western industrial countries. It seems there is no end to the biological and technical innovations, as basis of the technological revolutions of the such scale. The development of new scientific disciplines is promising opportunity for further rationalization and increase of agricultural production. The development strategies of these countries led by the hyper production in the future, will likely be directed towards a rational limitation of agricultural production, improving product quality and quality of life, as well as the long-term preservation of natural resources, especially the fertility of agricultural land, genetic resources and solving environmental problems. Despite this, the Republic of Macedonia did not solve the problem of sufficient food production. The agriculture was in deep development crisis with social and environmental problems. In some mountainous areas the abandoning of farming is so emphasized to endanger the population and economic vitality of the regions, so the revitalization is questionable. This crisis is not a consequence of underdeveloped biotechnical sciences, or lack of technological knowledge, as in Macedonia has enough educated professional personnel and agricultural research institutions with good results in the last twenty years. It is a structural crisis in the development, which is of a systematic nature. Biotechnical sciences cannot solve the most vital problems of the agricultural crisis in Macedonia. Their successful work can only facilitate the exit from the crisis. The most vital problems of technological development of agriculture are of agricultural policy origin, and in the same time they are dependent on the modernization of the entire society.

#### **Material and methods**

The methodology included linear method, comparative analysis, method of indices, induction and deduction, as well as the method of analysis and synthesis. As a material for the preparation of this paper we used various literature, archival and statistical sources. Secondary sources are the main source of data used for the description and analysis of this paper. Secondary sources are widely used in the social sciences, especially with regard to economic sciences. In the case of economic, and especially macroeconomic aspects and data, the secondary ones are usually the only available data. At the same time, such data provide an opportunity to analyze time series and the possibility of comparative analysis, as is the case with this paper.

#### **Results and discussion**

The basic principle of effectiveness of natural bio-systems is the principle of minimum entropy that is: more life with less use of energy and matter. It is generally determined at both the individual level and ecological systems. At the level of individuals, that basic biological law means minimal loss or maximum use of energy and matter to the effective functioning of biological functions. The minimum entropy in a healthy balanced ecosystem means minimal loss of energy and matter from the system in the process of natural circulation, recycling. Moreover, the living conditions in a healthy ecosystem are stable and improving. The farming (farm household) is artificially biotic system. The human is maintaining it for the production of food and industrial raw materials. His/hers goal is with less inputs to produce the maximum benefit while also maintains and increases its production potential. Efficiency and rationality of that artificial biosystem is only possible with maximum respect of the fundamental law, the law of entropy. This means practicing the maximum possible recycling, while taking from the system only the things for which it is maintained i.e. the agricultural products. Such definition of farm household may serve as a template for agriculture, unlike industrial type of agricultural production, which normally interrupts the circulation of matter in the system, increase input, reduces the production potential of the land and creates environmental problems. The most important subsystems in agriculture are crop production and the production of fodder plants on one hand, and livestock on the other. In developed European countries, the share of livestock is more than two thirds of the total value of agricultural production. About 85% of plant production is used as animal feed. The animals utilize only 10-20% of the total matter of the feed, 10-20% nitrogen (N), about 20% phosphorus (P), 2-5% potassium (K) and 5-15% calcium (Ca). The rest of these inorganic materials, which are the most important food for plants, some microelements and 20 to 40% organic matter, are in the manure and urine. Following the principle of recycling, this whole matter should be returned to agricultural land, or to upgrade with fertilizer and other sources of organic matter to maintain the level of humus and microbial activities of the land. Because of the low concentration of feed ingredients and large mass, the transport manure that is greater than 1 km has questionable economic viability, while the transport of more than 3 km is quite unjustified (Leskoshek, 2016). This is why the large fattening farms for pigs and cattle release the manure into watercourses, which is environmentally unacceptable. There is no cheap technological solution to that problem and is not very likely to have in the future. Nutrients are lost, which should be complemented with a huge amounts of artificial fertilizers per ha of agricultural land. On the other hand, the mass of feed, especially the bulk feed for ruminants is even greater and requires adequate transportation costs from the soil to large industrial livestock facilities. We are talking about 50 more tons of mass per ha in the production of silage or about 15 more tons per head of cattle per year. Because of limited energy resources, expensive vehicles and rise in living labor, the cost of transport in the future will grow, not shrink. First of all, because of those limitations, as a rational size of livestock facilities in Germany the following limits are recommended (Becker, 2015). Optimization within those borders have not achieved yet by any country, although some are closer to it (the Netherlands). It should be mentioned that these are the sizes facilities that can be run by a family with modern techniques. They are not industrial facilities with industrial organization of labor.

Table 1. Optimal size of livestock farm in Germany

Farm type	Size (number of animals)	
	Lower limit	Upper limit
Broilers	25.000	50.000
Hans	10.000	30.000
Pigs total	600	1.000
Fattening pigs	400	1.000
Breeding sows	75	100

Source: Seuster, H.: *Ökonomik der Bauernbetriebe in der B. R. D. unter besonderer Berücksichtigung der Investitionsfinanzierung*. 2016.

The second type that can be taken in consideration for the rational organization of livestock production is assessing the nature of biological innovations. The most important biological innovations in animal husbandry are the results of modern genetic selections. The development of population genetics, the theory of selection and electronic data processing, enable extraordinary genetic changes in the population of livestock. In the near future, the new genetic reproduction techniques will provide even better results. The results are highly developed living beings with outstanding manufacturing skills: dairy cows with 10 and more tons of milk per lactation, sows with 30 piglets per year, sheep with more than 5 lambs a year etc. They are not industrial machines for factories. They require optimal microenvironment conditions as well as optimal social environment including the breeder. It is a real relationship of symbiosis between the farmer and his animals. The quality of breeding and care of the livestock in developed countries is more and more ethical and moral problem, in addition to the production problem. Increasing labor productivity, i.e. increasing the number of livestock per worker is a result of technical innovation. The technique reduces the scope of routine, physical work, and increases the value of knowledge and professional awareness of farmers. The actual production depends mostly on quality of labor, but also on genetic characteristics of highly productive animals. Farmers with the same educational background can achieve 5,200 liters to 6,500 liters per milking cow, which means that in equal conditions of work one produces 5,200 liters, and another 6,500 liters of milk per cow (Sambraus, 2016). The difference in their labor is in their different attitude with animals. In this sense the interest of farmers for their profession is more than just earning interest. Just for earning, one can choose countless other professions. From partial aspect, efficiency of the organization of work within the livestock operation is possible via the Industrial Labor Organization, but only in relatively simple stages of reproduction, such as fattening, egg production and reproduction in poultry. More complex stages of production, such as mammalian reproduction and milking, require individual (personal) treatment, and no mechanical relationship with livestock. Therefore, these stages are most problematic in the large livestock production. Surely there are complex reasons for not executing capitalist concentration of capital and land in primary agriculture in capitalist countries. The exception is some crop production, mostly in the former colonial countries. Besides the already determined importance of the quality of labor, especially in modern animal husbandry, and the extraordinary progress in technology, which allows an increase in family businesses to the borders of rational transport opportunities, reasons may be even the following: expensive labor in industrialized countries; seasonal uneven distribution of working hours; 7-day workweek in livestock production; divided daily working hours; dependent on climatic conditions and the need for quick decisions, etc. These are sacrifices that can be taken primarily by family farms, which will choose the agricultural profession. This is also done because of other advantages, such as: relative autonomy and security work at home, diversity, work in nature, etc. The labor productivity in developed countries, primary in agriculture, grew that far, so one worker farmer produces food for 70 or more people, and agriculture employs even less than 4% of the workforce (UK, USA, Netherlands). In such conditions, where the increase of productivity in agriculture is 100%, the reduction of the workforce by 4 to 2% in terms of social productivity of labor is insignificant. In modern societies of cyber era more important than maximum productivity will be: production quality, aesthetics of the cultural environment, the ethics of livestock production,

environmental aspects, sustainable conservation of natural resources, quality of life in the countryside, minimum use of chemicals, energy, etc. However, this type of agriculture is still not a better solution than optimal rural agrarian structure with vital economic agrarian regions, developed social and physical infrastructure which provides quality of life, development of tourism, recreation of urban people, etc.

*Agrarian structure in developed Western countries*

There is no single country in the world that has optimal agrarian structure. The western industrialized countries experience very rapid changes, especially in the last three decades (Peters, 2015). These changes are the result of adaptation to technological development. More or less controlled, guided by agricultural policy and implemented without significant social problems. There are failures and criticism. The most significant criticisms are for the agricultural overproduction as a result of these changes and partial deviation from the principles of agriculture with all the shortcomings, mainly environmental (Priebe, 2015). They introduce more government regulation to reduce overproduction and environmental problems. Consideration of this development for us is interesting because that is the most efficient farming in similar natural conditions.

*Agricultural structure in the USA*

The US is the most liberal capitalist country, that according to the political-economic theory of XIX century should have completed the capitalist concentration in primary agriculture. By 2000 it had happened. Out of 1.2 million commercial farms in the United States 45 270 are owned by corporations. They own 12% of agricultural land, and sell on the market more than 24% of the total market production. They are limited to extensive cattle fattening farms (33%) and other plantation agriculture (37% fruit, vegetable 66%). The grain production is insignificant (8.2%), and virtually they have no other activities of primary production. The cause of a corporative approach is to increase efficiency in comparison with individual holdings of medium size, but primarily in tax policy. According to G.L. Cramer and C.W. Jensen (2015) significant growth of the corporations can not be expected, primarily because alternative opportunities for investment capital are more secure.

Table 2. Number, size and workforce on the farms in USA

Year	Number of farms 000	Average size in ha	Average workforce in 000	Part time/seasonal work force in 000
1920	6.518	59,7		
1940	6.350	67,8		
1960	5.648	86,5	7.252	2.090
1970	3.962	120,6	5.172	1.885
1980	2.924	155,5	3.348	1.175
1990	2.491	173,4	2.500	1.273
2000	2.322	182,7	2.402	1.273
2010	2.309	183,9	2.402	1.303
2015	2.434	173,8	2.236	1.094

Source: Carner & Jensen, 2015

Therefore, the family agrarian structure is prevailing, which otherwise is much divided, and employs a significant proportion of the employed labor force, mainly for seasonal work. A significant part of the employed labor force is of foreign origin, mostly from Mexico. Until 1960, the farm is considered a holding with more than 4 hectares, or it sells products worth at least \$ 250per year. Right after that year, a farm represented a holding whose annual production could be at least \$ 1,000. The rapid decrease in the number of farms started after 1960. In the recent years, the number of farms is constant, but stratification continues, as seen from Table 3.

Type of farm	Year	No. of farms	% of farms	Value of production (%)	Value of production by farm (\$)	Net income by farm in (\$)	Nonfarm activities income
A	1980	973.000	8,6	51,6	51.340	11.743	1.844
	2000	350.000	39,9	93,5	141.726	21.785	10.610
	2015	309.000	30,2	85,0	166.800	25.400	12.800
B	1980	1.774.000	44,8	42,7	8.397	3.409	1.580
	2000	953.000	39,1	6,0	9.300	4.500	18.423
	2015	845.000	30,2	7,8	10.900	4.900	20.542
C	1980	1.849.000	46,4	5,8	1.104	806	2.732
	2000	511.000	21,0	0,5	1.411	1.100	22.425
	2015	485.000	18,9	2,2	1.990	1.320	24.120

Source: Carner и Jensen, 2015. (A - farms with more than \$ 20,000 in annual, sales, B - farms between 2,500 and 19,999 dollars in annual sales, C - farms with less than \$ 2,500 in annual sales)

Farms of type C, are considered as hobby farms. The stratification is largest in farms of type B, which normally are mixed economies. About 94% of market production is concentrated on less than one million farms, where the most of the employed labor force is located. The average size of farms type A is approximately 400 hectares and is variable. The value of production per ha per year on average is about \$ 350. The US Agriculture has a very large capacity in terms of agricultural land (1.8 ha per capita) and equipment, but the intensity of production per ha is behind agriculture in developed Western countries. Lesser intensity per ha conditions the size of commercial farms, which is far above Europe.

#### *Agricultural structure in Western Europe*

The Western Europe has a small capacity of agricultural land per capita. In the European Union area of arable land per capita averaged 0.48 ha and the total agricultural land only 0.77 ha. Very limited areas of agricultural land are the reason for very intensive use of land. Therefore the structure of the agriculture as a whole, differs greatly from US agriculture. The data in Table 4, show very variable average size of agricultural economy in the European countries, which is partly due to historical reasons, the general productivity of labor and the type of economy that depend on terrain, climate, etc. Noticeable is the dependence of labor productivity, measured by the area of agricultural land per worker and the size of the economy.

Table 4. Size of farms and labor productivity in some European countries (data from 2000 and 2015)

Country	Size of farms in ha	Full work force on 100 ha	ha/ Full work force	Employment in agriculture %
Great Britain	69,4	3,2	31,25	2,7
France	27,1	5,6	17,86	8,7
Luxemburg	29,9	7,0	14,29	5,7
Denmark	26,3	4,9	20,41	8,1
Ireland	22,5	3,6	27,08	10,2
Holland	16,1	10,0	10,0	4,1
Germany	15,8	6,6	15,5	6,0
Belgium	16,0	7,0	14,29	3,0
Italy	7,4	11,5	8,7	14,2
Austria	10,2	10,1	9,90	12,5
Check Republic	21,3	12,7	7,87	9,5
Poland	47,5	11,1	9,01	12,8

Source: Brun, A. Land ownership and farm unit, European review of agricultural economics, br. 3-4/2016.

The data in the table results in the calculated equation:

$$y = 4,92 + 0,53x - 0,0022x^2 \text{ (} r^2 = 0,86 \text{),}$$

where “y” is the number of hectares per worker, and “x” is average size of the farm. The increase in labor productivity is not growing quite linearly with the size of the economies, however with the rising of holding for 1 ha, the labor productivity increases by around 0.5 ha per worker. This fact can be interpreted like this: farms in Europe are growing in size to be able to fully employ the family labor. In the case of average conditions, the Western Europe has reached full employment of two workers on family farms, when the average size of farm is 55 ha. In that case ha productivity per worker is 27.5 ha. This claim applies to conditions of agriculture in Western countries, while accepting all variability from small horticultural farms to large agricultural holdings, terrain and climatic conditions of the Mediterranean, alpine and temperate climate of Europe (Zagozhen 2016). In this context, in comparison with other EU countries, the Czech Republic has the lowest labor productivity in agriculture, although it has a prevailing agricultural-livestock type of farming in very high concentration of land. The difference in labor productivity would be even greater if measured in the value of output per worker. In this context it is important to add this conclusion: Dutch agriculture can compete with US agriculture in labor productivity, measured in value of output per worker, although the Dutch farmer has 10 times smaller area than American farmer. The rapid stratification of rural agricultural economies of Western Europe began in the sixties of the 20th century and not completed. The annual rate of change in the number of farms in Western Europe in the years 2000 and 2015 was: Germany - 3.5%; France - 2.9%; Netherlands – 2.6%; - Belgium - 4.1%; - Great Britain - 2.6%; - Denmark - 2.2 % (Brun, 2016). The number of wage labor has even quicker changes. For example, in the Austrian Styria, the number of wage-labor from 2000 to 2015 is decreasing at an annual rate of 5.5%. The farms smaller than 200 ha total land, usually do not employ wage labor. In Western Europe, especially in the mainland, the employed labor force is very limited with some minor exceptions (Schulz-Borck, 2015). The stratification of peasants and abandonment of agriculture by peasants and engaging in other activities is gradually. A change in the type of agricultural holdings and abandonment of agriculture, as a rule, occurs with a shift of generations of agricultural holdings. Table 5 shows the process in Germany.

Table 5. Changes in the structure of agricultural Germany

Type of holding	Total number in 000		Average size in ha in 2000	Average size in ha in 2015
	2000	2015		
Agricultural holdings	466	399	25	77
Mixed holdings type 1	233	93	15	10
Mixed holdings type 2	380	316	6	13

Source: Part – time farmers, Ljubljana 2016

The mixed holdings of earn income more than 50% from non-agricultural activities, and mixed farms type 1 less than 50%. The conclusion is that farms that are not capable of its expanded reproduction, are moving into mixed farms type 1, and then rapidly into mixed farms type 2, until they cease to exist as farms and move into non-agricultural households. Agricultural land is concentrated in a reduced number of farms, which operate in a very high professional level. What does the professionalization of agriculture in Germany means, Seuster (2016), is demonstrated by the figures in Table 2. The development in Western Europe has these features: the number of farms is rapidly shrinking, agricultural land is concentrated in professional farms with a size of 20 to 60 ha, and mixed holdings are in relatively low variable rate, as a transitional group or hobby farms.

There are several structures In the Republic of Macedonia. There is a public and private land, private enterprises and agricultural cooperatives on the one hand, and individual farms or households on the other. The major private agricultural companies use about 20% of the best agricultural land, and the remaining land of about 80% belongs to very small rural farm holdings. The productivity of private agricultural companies and agricultural cooperatives, measured in hectares per worker, is somewhat better than in the Czech Republic, reaching 9.90 ha. That is equal to productivity in

Austria, where the average size of farms is 10.2 ha and is less than other countries in Western Europe (up 31.25 ha per worker in the UK). The production in private farms is relatively very expensive, especially in livestock, shown in table 7.

Table 6. University degree holders and net income of the family calculated by Full Force – FS

Professional education of the owner of the farm	Net income of the family calculated at one unit of average workforce
Low	100
Assistant	130
Master	171

Table 7. Cost of production of cow's milk of selected farms in the Republic of Macedonia in 2015

Group of holding	Number of holdings	Average number of cows	Price MKD/lit
Group (Farmers with more than 20 cows)	10	26.7	14.83
Group (Farmers with 15 to 20 cows)	10	17.7	22.97
Group (Farmers with 10-15 cows)	10	13,1	24.50
Group (Farmers with 5-10 cows)	10	7.9	25.59

Source: Hadzievski, 2016

The first group size is approaching the Western European average and has cheapest production. Medium-sized farms are more expensive by 50% and the smallest farms are more expensive even by 72%. The price of raw milk at the time was 18.91 MKD/litre. Model calculations show that in the present economic conditions the viability of agricultural production begins on farms larger than 10 ha, if it comes to cows or larger than 20 hectares, if it comes to other combinations of crops and livestock production (Hadzievski, 2016). In conditions of increased competition (the case of overproduction), the threshold of profitability of the economy would be greater. The rural structure (size of holdings) in the country is very small. It is smaller than before the independence in 1991, and still going. It is significant that the number of farms with more than 8 ha is rapidly decreasing, especially in economically developed areas. Mixed farms normally shrink. The expected trend of development can be seen from the social structure of agricultural holdings in the following table. Due to this trend the country loses annually about 1% of agricultural land. The average size of agricultural holdings (all agricultural areas) decreased from 3.5 ha in 1981 to 2.0 ha in 2016. Since 1960, the number of farms with over 10 hectares total land is decreasing at a rate of 1.5% per year.

Table 8. Source of income for farms in the country (population census 2002)

Source of income	Number of holdings	%
a) exclusively from agriculture	52.601	27,3
b) exclusively from non-agricultural activities	21.772	11,3
c) exclusively from its own income (pensioners)	29.864	15,5
d) from agricultural and non-agricultural activities	32.562	16,9
e) agriculture, non-agriculture, own income	10.982	5,7
f) agriculture and own income (pensioners)	8.670	4,5
g) non-agriculture and own income (pensioners)	34.296	17,8
h) no income	1.928	1,0
Total farms	192.675	100%

Source: Census of agricultural holdings in the Republic Macedonia in 2007

Without structural changes the agriculture in the country cannot be intensified and professionalized, but certainly the trend of development will be reversed, which means the agriculture will regress. The conditions for transformation in a positive sense depend entirely from agricultural policy nature, for which we need ideological unblocking. In this context, the program for subsidizing agriculture

promises significant milestone. In long term, it can even be dangerous because the primary agricultural production experienced a setback in physical volume and quality, and the country has seen a negative foreign trade balance.

#### Conclusions

The Republic of Macedonia should implement a patient discussion seeking answers in the direction of gradual restructuring of agriculture in the modern, professional farming from Western type in conditions of transitional society that aims to modern capitalist system. According to the climate, terrain and areas of agricultural land per capita, The Republic of Macedonia has some slight resemblance to the production potential of some Western European countries such as: Denmark, Netherlands, Belgium, Luxembourg; but does not uses them optimally. The strategy for economic and technological development of agro-industry is not optimal, and in the mountainous regions is not even possible.

The following issues are a matter of debate and discussion:

- Development of modern co-operative movement based cooperative ownership, with operating features;
- Possibilities for gradual implementation of agrarian reform in favor of rural (village) agriculture;
- Regional development of agricultural activities in the non-agricultural, especially in the mountainous regions, including the development of social and physical infrastructure;
- Execution of the redistribution of fields and land consolidation of agricultural land in the country;
- Development of agricultural vocational education of farmers and villagers who plan to deal with primary agricultural production;
- Development of technical infrastructure for faster transfer of technology and biological innovation in agriculture;
- all other socio-economic measures that can speed up the process of restructuring.

The development of agriculture in the proposed direction will trigger enormous human development forces and solve some problems with smaller investments in social capital than in the development of agro-industry. The Republic of Macedonia has no short-term economic strength and hardly acceptable long-term investments in agro-industry without securing a strong primary agricultural production.

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