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# Assessment of agricultural sustainability (Azerbaijan case)

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## Abstract

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The paper analyzed comparatively essence of agriculture sustainable issues, their economic, social and environment aspects, as well as some methods for measurement of the sustainability rate. The authors gave preference to the method that takes into account some current and target indicators. According to the methods there was carried out assessment of sustainability of the agriculture sector of Azerbaijan. The target indicators that were used for measurement have been taken from Strategic Road Map on agriculture of the Azerbaijan. Measurement of the sustainable rate of Azerbaijan agriculture sector confirms that economic and environment aspects of sustainability are weak. But the social aspect of the agriculture sustainability is in the medium level. Common level of agriculture sustainability of Azerbaijan is in the low. In the future increasing of the economic aspect of sustainability can decrease the environment aspect of sustainability. Low level of agriculture sustainability of Azerbaijan creates big welfare inequality between industry cities and agriculture regions.

*Keywords:* sustainable agriculture; target indicator; Strategic Road Map; economic aspect; social aspect; ecology aspect

## Introduction

Science and technology develop rapidly, but the importance of agriculture for human life and well-being does not decrease. Many raw materials, which are of vital importance for human beings and for economic development, are produced exclusively in the agricultural sector. Therefore, the development of the agricultural sector should be regulated so that both the present generation and the future generations can benefit from it. Unfortunately, the development of the agricultural sector for many reasons, including anthropogenic causes, is in danger. Climate change, increasing biodiversity loss, soil erosion and pollution, water pollution, increased production costs and other problems lead to weakening of agricultural sector and rural poverty. These problems highlighted the idea of "sustainable agriculture", which reflects sustainability in the development of agricultural sector that accompanied by sustainable growth, decreasing negative impacts on environment and increasing of the positive impacts on the social sphere. The expansion of environmental movements in most developed countries has drawn attention to the consideration of environmental requirements in the economic field, including the agricultural sector. This idea became more urgent after the 1987 report, known as the Brundtland Report. However, the concept of "sustainable agriculture", as well as the concept of "sustainable development", is also unambiguous, and in the scientific literature, including in the economic literature, there are different views on the meaning of these concepts.

Classification and generalization of approaches to the concept of "sustainable agriculture" in economic literature suggests that when so-called "sustainable agriculture" is mentioned, the agricultural sector is expected to be able 1) to meet the needs of people in food and clothing during long-term agricultural and livestock production; 2) to improve the environment; 3) to use non-renewable and agricultural resources effectively and to adapt the management system with biological cycles; 3) to ensure economic sustainability of activities in agricultural farms; 4) to develop quality of life of the people working in the agricultural sector and society as a whole continually. In general, the "sustainable agriculture" consists of more management procedures. These procedures should be based on the natural processes affecting the agricultural sector, and should ensure to minimize the environmental impacts and waste, to make agro system flexible, self-governed, to solve the problems related to sustainable development of the product considering the effective use of resources.

As we have noted, the concept of sustainability in the agricultural sector or the concept of "sustainable agriculture" is widely studied in economic literature, but it can be approached from different aspects. A comparative analysis of a large number of articles investigating this concept suggests that the main differences in approaches depend heavily on the subject matter of the research. When we say "sustainable agriculture" in our research, we will approach it from the aspect of social science and management.

Comparative analysis of research on agricultural sustainability or "sustainable agriculture" in economic literature suggests that three problems in the field of research are distinguished from one another: the first is the study of the problems of sustainable agricultural sector on the activity fields related to this sector. Secondly, it is the study of the agricultural problems from strategic point of view. Thirdly, the main targets are in the initial plan. In fact, these studies are complementary investigations, and studies with activity fields complement strategic studies, and latest ones complement studies with the main targets. Almost all researchers claim the main targets for sustainable agriculture are as: 1) economic; 2) social and 3) environmental targets. Environmental targets may include production or non-production environmental targets. As mentioned above, these targets can be different quantitatively for each country. But the development trend is that: 1) the volume of production in the agricultural sector is constantly increasing; 2) to increase social welfare of the population, reduce the poverty sustainably and eliminate it, reduce unemployment to the natural rate of unemployment, ensure high quality education in rural areas and provide access to health care; 3) to use natural resources efficiently, reduce waste from the agricultural production to the environment sustainably and reduce waste to the level where the environment can self-regulate, prevent pollution of water and land resources, and use these resources efficiently and so on.

To achieve these and other common goals we mentioned, the "sustainable agriculture" requires some principles and strategies. For example: 1) flexible management; 2) cooperation; 3) adoption of an environmental strategy; 4) adoption of an economic strategy; 5) complex approach; 6) application of scientific and technical innovations; 7) application of subsidies. Such strategic steps include the implementation of activities in some areas. For example, 1) establishment of the agricultural food system; 2) management and solution of technological problems; 3) solution of social and environmental problems; 4) solving social and human capital issues; 5) formation of social, political and economic environment and so on.

The parallel presence of different views on the concept of sustainable development, as well as the concept of sustainable development in the agricultural sector, is also based on the differences in their measurement methods. Because if the level of development in a country differs from the other according to its sustainability, it means that it should be a certain dimension for "sustainability". The determinants of sustainable development dependent on different quantities in different countries and it should be able to demonstrate itself in the sustainability of development in these countries. They also refer to the level of sustainability in the agricultural sector.

If the sustainable agriculture differs from other levels of agricultural sector by its "sustainability", and if it has the dynamics of sustainability, it should be measurable. However, some authors, for example, David (1989), Webster (1999) believe that "sustainability" is a social structure and is merely operational. Since the sustainable agriculture is a dynamic process, there are authors who consider it impossible to measure it (Ikerd, 1993). However, some authors argue that although the agricultural sector is unable to measure accurately the extent to which it is sustainable, it may be possible to choose some of its parameters and to think about the direction in which these developments are going to change (Pretty, 1995). For example, if soil erosion happens, if annual productivity falls, if the living standards of the agricultural sector are decreasing, it means that development of the agricultural sector is not sustainable. Lynam & Herdt (1989) believe that volume and productivity of the product can be measured in terms of sustainability. Beus & Dunlop (1994) support the use of fertilizers in agricultural production to measure the degree of production and the variety of products. They consider the use of water and land resources important to measure the sustainability.

The question of measuring sustainable development in the agricultural sector requires the identification of the system

of indicators as it depends on the identification of all the elements and measuring each one individually. It's a complicated job, but it's possible to solve it. It should be borne in mind that measurement of sustainable development, including the sustainable development of agriculture, couldn't be considered exactly as it is impossible to take into account all the indicators it depends on. Because all aspects of the economic, social and environmental problems that characterize sustainable development are inaccessible, such measurements can only be taken in a certain approximation. It should be noted that methods used for the measurement of sustainable development are used in various estimates.

A system of indicators has been developed to measure the agricultural sector's sustainability in the PSR (Pressure-State-Response) model prepared by the Organization for Economic Co-operation and Development (*OECD)* (1991). This system of indicators also includes indicators prepared by the UN Commission on Sustainable Development. It should be noted that these indicators allowed agricultural sector to evaluate stability in the total level. The DSR (driving force-state-response), later developed by the OECD, provides new indicators and allows agricultural production organizations, for example, to evaluate the sustainability of farmers. State indicators that characterize the current situation evaluate the impacts of the agricultural sector on the environment, in particular, soil quality, water and air cleaning, biodiversity and landscape protection. Response indicators characterize activities aimed at changing the environment. The DSR Indicators System, developed by the OECD, includes 39 indicators, including the financial resources of farming, management of farming, fertilizer and pesticide use, land and water quality, biodiversity and landscape, access to information needed for farms, and other indicators. The system of OECD indicators is very extensive and even the majority of European countries cannot cover all of these indicators.

As mentioned above, the Indicators System suggested by OECD allows the agricultural sector to evaluate the sustainability at the aggregate level. However, in almost all countries, the agricultural sector consists of the most liberal and small-size farms. Therefore, both production and environmental impacts occur at the level of farming.

The agricultural sector's sustainability means the estimation in the farming level. Necessary steps to ensure sustainability are occurring in small farms. Continuously increasing production, social welfare of employees in farming, or environmental impacts in farming, ensures sustainability of the agricultural sector at the aggregate level. The farmers decide how to use the soil and new technology. That is why some researchers prefer the sustainability at farming level while speaking agricultural sector's sustainability. Sands & Podmore (2000) use the "Environmental Sustainability Index" (ESI) to evaluate the sustainability of the agricultural sector. This index is composed of 15 sub-indexes and covers the depth of the soil layer as well as groundwater. Gouda & Jayaramaiah (1998) used nine indicators in their research to evaluate the sustainability of rice production in India. Their index is diverse with economic, social and environmental aspects. This index covers the soil productivity, the level of water management, the use of fertilizers, the efficient use of production resources and other indicators.

While economic literature offers a variety of indicators regarding the sustainability of the agricultural sector, it is also possible to divide these indicators into three groups based on economic, social and environmental considerations. The main indicators that are used as economic indicators in these studies are: 1) average production volume; 2) total costs for production; 3) off-farm income; 4) farm income; 5) degree of economic efficiency; 6) profitability rate; 7) level of wages paid to farmers; 8) employment opportunities; 9) availability of markets for agricultural products; 10) entrepreneurial level of land; 11) land use management and other indicators.

Among the indicators used as social indicators in research are the following: 1) level of education of household members in rural areas; 2) housing conditions of households; 3) level of studies in agricultural sphere; 4) health status of household members; 5) improving the decision-making process; 6) improving the quality of life in rural areas; 7) work and living conditions; 8) social capital; 9) social equality and so on. As environmental indicators in research related to sustainability issues on agricultural sector: 1) improving of water resource management; 2) volume of use of the pesticides; 3) volume of use of organic fertilizers; 4) volume of use of green fertilizers; 5) physical expenditure on production and their efficient use; 6) physical productivity; 7) variety of plant-growing; 8) use of alternative plant-growing; 9) use of rotation in agriculture; 10) direction of changes in climatic conditions; 11) use of chemical fertilizers; 12) erosion control; 13) use of energy; 14) pesticide use management and other indicators are widely used.

While the indicators proposed for measuring stability in the agricultural sector can be measured individually, the reliability of the integral indicator generates certain questions. This problem was studied widely by Norman et al. (1997). Thus, because of the interconnection between the environmental, economic and social indicators that are essential for sustainability, development of any can be observed by the weakening of the other. On the other hand, taking into account the intensive work of farming, additional time to monitor the indicators required for sustainability becomes a serious problem. Therefore, most farmers are unable to make a decision to improve the outcomes on all three indicators.

One of the most important problems in measuring the sustainability of the agricultural sector is the inability of successful implementation of most indicators of sustainability in all countries. Researches carried out by Rasul & Thapa (2003) show that the indicator applied successfully in one country may not be beneficial to another country. Studies conducted by Dumanski & Pieri (1996) show that most of the sustainability depends on the nature of the agricultural sector and socio-economic situation in the country. On the other hand, when it comes to the agricultural sector's sustainability, the level of sustainability should be taken into consideration. In the economic literature, the specific level of farming or cattle-breeding, farmers' level, community level, country level and international level are distinguished (Norman et al., 1997). At each of these levels, sustainability can depend heavily on decisions made at subsequent levels. For example, farmers' sustainability is largely dependent on decisions taken at community level or across the country on economic, social and environmental issues. Decisions on change of environmental requirements at the country level should be made by all economic entities throughout the country, including farm households.

Along with the effects among levels, the impacts of all three components of the agricultural sector's sustainability – environmental, social and economic components should also be taken into account. Particularly, the two components – the possible contradictions between environmental and economic, or environmental and social components – have developed in different ways in developing and developing countries. For example, a farmer who wants to gain economic benefits in developed countries is not forced to engage in activities that can lead to new environmental problems. Because subsidies directed by the state in the agricultural sector prevent farmers from such an activity. In most developing countries, economic or social benefits bring environmental sustainability to a second level. By examining these problems widely, the World Bank concludes that the solution of environmental problems is impossible without solving the problem of poverty (World Bank, 1992).

Zhen & Routray (2003) offer one of the suggested systems of indicators for measuring sustainability in the agricultural sector. The indicators proposed by them are also distinguished in three sub-groups, i.e. economic, social and environment. First of them includes productivity, income of households from farm, profit-expense ratio in the production and grain production for per capita food. Social indicator includes food self-sufficiency, equal distribution of income and food, availability of resources and services, awareness of farmers regarding the maintenance of resources. Environment indicator includes some sub indicators as the amount of pesticides used in a single area planted, the amount of irrigation water used in a single area planted, quantity of nutrients in the soil, the depth of ground water, quality of ground water for irrigation, effectiveness of water use, nitrate composition of plant-growing and groundwater.

In terms of measuring the sustainability of the agricultural sector, the system of indicators proposed in the economic literature can be divided into two groups, both theoretical and practical. Indicator systems prepared theoretically are reflected in the studies by Barbier (1987), Lynam & Herdt (1989), Tisdell (1996), Simon (1989), Brklacich et al. (2000), Senanayake (1991) Stock et al. (1994), Smith and McDonald (1998) and others researchers.

Barbier (1987), in his research, considers the agricultural sector's sustainability as a particular feature of economic sustainability, and emphasizes genetic diversity, biological productivity, income equality, social justice and decision-making as crucial indicators of sustainability. According to the results, the productivity and income equality in the agricultural system is an essential condition for sustainability.

In the studies conducted by Lynam & Herdt (1989), the agricultural sector's sustainability is regarded as a criterion for research in the agricultural sector. By examining the difficulties and consequences of applying the sustainability criterion to international research, researchers have suggested the following five key steps for sustainability: 1) recognizing the need for agricultural sustainability issues; 2) identification of a method and indicator system suitable for measuring sustainability; 3) measurement of empirical sustainability in the farming and livestock sector; 4) identify external influences that affect the sustainability of these systems; 5) preparation of a method for measuring such external influences.

Tisdell (1996) claims that if the idea of sustainability does not generate economic benefits, it does not have any meaning. Therefore, it offers parallel use of another indicator. This indicator means to redivide the difference of the volume of production with expenditures by the volume of expenditures. It is important that this value is greater than zero, but at least equal to zero. Such a demand for sustainability depends on its economic aspect, as we have mentioned above.

Analysing comparatively the studies dedicated to the agricultural sector's sustainability problem, Simon (1989) concludes that sustainability is a central concept that combines human activities with a physical environment and broad political economy.

Brklacich et al. (1991), in their researches, suggest the calculation of six indicators for the sustainability of the food production system. From an economic point of view, this system of indicators includes a continuous increase in the production. Particular attention is paid to access to food,

security and equity, as indicators of social justice. Environmental protection indicators include restrictions on the land plots allocated for agricultural production and the maximum number of people provided with the food by the sector. The composite index offered by Senanayake (1991) allows the calculation of environmental sustainability, which is an important factor for agricultural sector's sustainability.

The system of indicators that have been practically prepared and applied has been found by the UN Food and Agriculture Organization's Working Group (FAO) (2000), in the studies of Sands & Podmore (2000), Tellarini & Caporali (2000), Morse et al. (2001). As mentioned above, the system of indicators is diverse and during the research, a system of indicators that is appropriate for the region should be selected from such diversity.

Taking into account the diversity of indicators for the agricultural sector's sustainability measurement, we will use the OECD methodology in our research (2001). In this methodology, the agricultural sector's sustainability is studied in three aspects – economic, social and environmental aspects.

## Methods

We will use a system of generalized indicators in our research by taking into account the diversity of the indicator system for measuring the sustainability of the agricultural sector. In the methodology we apply, it will be necessary to apply target indicators for all three aspects of the agricultural sector's sustainability, namely, the economic, social and ecological aspects. This is because the current state of sustainable agriculture should be compared with the target indicators. "Target indicators" will provide the best possible outcome, depending on the country's climatic conditions and the current level of scientific technical development. It is notable that target indicators may vary from country to country. For any aspect, for example, threshold indicators for the environmental aspect are related to the country-specific norms, the diversity of total threshold indicators will also be inevitable for the integral indicator of sustainability. We accept the target indicators as threshold indicators in the "Strategic Roadmap on production and processing of agricultural products in the Republic of Azerbaijan" (2016) approved by the Decree of the President of the Republic of Azerbaijan dated December 6, 2016 to determine target indicators during calculations. It should be noted that quantitative assessment of the country's agricultural sector's sustainability would also change as the target indicators change for the medium and long term.

Different methods can be used to determine the extent of sustainability compared to the target indicators in the agricultural sector. Each of these methods involves the use of different indicators. Our approach to the nature and estimation of the agricultural sector is more appropriate for the approach of Parkhomenko & Shukina (2014), and we will use the methodology they developed during quantitative assessments. This method involves the implementation of operation consisting of four stages. In the first stage, "target indicators" are defined on all three aspects of sustainability. In the second stage, a system of indicators for these aspects is defined. The greater the number of such indicators, the more objective results can be achieved. At the third stage, the length of vectors corresponding to the actual indicators ($f_{ij}$) and target indicators ($t_{ij}$) are calculated on each aspect. We can show the length of these vectors as,

$$|\bar{S}_j| = \sqrt{\sum_i^n f_{ij}^2} \text{ və } |\bar{\lambda}_j| = \sqrt{\sum_i^n t_{ij}^2} \quad (1)$$

Here, $j$ – ranging from 1 to 3, expressing the economic, social and environmental aspects of agricultural sustainability. The other index, $i$ – varies by specifying the subindicators of each aspect. In our study, the economic aspect varies from $i$ – from 1 to 12, the social aspect from 1 to 15, environmental aspect from 1 to 6.

According to the methodology applied, the next step is to find the scalar product of these vectors. In this case,

$$(\bar{S}_j, \bar{\lambda}_j) = \sum_i^n (f_{ij} * t_{ij}) \quad (2)$$

The ratio of the scalar product to the length of these vectors

$$\cos \varphi_j = \frac{(\bar{S}_j * \bar{\lambda}_j)}{|\bar{S}_j| * |\bar{\lambda}_j|} \quad (3)$$

At the next stage as a generalized indicator of sustainability is accepted:

$$\sigma_j = \frac{|\bar{S}_j|}{|\bar{\lambda}_j|} * \cos \varphi_j \quad (4)$$

Here $\sigma_j$ – is the sustainability indicator according $j^{\text{-th}}$ aspect. Taking into account all three aspects of the agricultural sector's sustainability, we can accept for a complex sustainability:

$$AS = \sum_1^3 \sigma_j * a_j \quad (5)$$

Here $a_j$ – sustainability is the weight of $j^{\text{-th}}$ aspect to the general sustainability. You can use the hierarchy analysis method to determine this weight. In the initial approximation, we will accept the same weight (1/3) for all three aspects. So, we can simplify the (5) identity as

$$AS = \frac{1}{3} \sum_1^3 \sigma_j \quad (6)$$

In our research, we will differentiate between four groups as in the studies conducted by Parkhomenko & Shukina (2014) the agricultural sustainability, depending in AS value, 1) low (if AS ≤ 0.5); 2) medium (if 0.5 ≤ AS ≤ 0.75); 3) high (if 0.75≤ AS ≤ 1.0); 4) fully sustainable (if AS ≥ 1.0).

## Results

In order to determine the "target indicator" for the economic aspect of the sustainable agricultural sector, we will consider mainly the outcome of the aggregate activity of all economic entities, including farming households, collective farming working in agricultural sector. It includes financial resources of farming households, including the value added in the agricultural sector, labour productivity in plant growing and livestock, the total volume of crops in various industries, and so on. We will only use 12 of those indicators. However, there is a need to increase the number of indicators several times to make the calculations more accurate. For example, it would be better to include the activity of the farming households, especially the variety of planting crops, the size of the sown areas, the variety of plant species falling into one farm in the calculations. However, we could not include these figures in calculations because it was difficult to determine the "target indicator" in relation to these indicators. On the other hand, we use the results of some countries, including Turkey and average results all over the world according to some indicators, for example, the productivity of cereals and legumes, cotton, tobacco, potatoes, tea leaves, as well as milking per cow for one year to determine "target indicators". Since the agricultural sector's sustainability depends on time, we rely on the comparison of actual results for 2017 with "target indicators".

Thus, the comparison of actual and "target indicators" on economic indicators of sustainability of agricultural sector in Azerbaijan in 2017 suggests that the actual results for these indicators are much lower than the "target indicators". Even the actual productivity of potatoes is 30% less than the average indicator all over the world. The productivity of tea

**Table 1. Actual (2017) and target indicators for the economic aspect of sustainability of agricultural sector**

| | Economic aspects | $f_{1i}$ | $t_{1i}$ | Source of target indicators |
|---|---|---|---|---|
| 1 | The volume of GDP in the Agricultural Sector (mln.AZN) | 3949.3 | 5184.3 | Strategic Roadmap |
| 2 | The productivity of cereals and legumes (t/ha) | 2.98 | 10 | New Zealand |
| 3 | The productivity of cotton(t/ha) | 1.53 | 1.887 | Australia |
| 4 | The productivity of tobacco (t/ha) | 1.66 | 1.922 | Argentina |
| 5 | The productivity of potato (t/ha) | 15 | 20 | Average over the world |
| 6 | The productivity of tea leaves (t/ha) | 1.11 | 2.987 | Turkey |
| 7 | Milking per cow and buffalo (one year kg) | 1528 | 2200 | Average over the world |
| 8 | Meat production (1000 t) | 316.8 | 380.16 (+20%) | Strategic Roadmap |
| 9 | Milk production (1000 t) | 2024.1 | 2631.33 (+30%) | Strategic Roadmap |
| 10 | Cotton production(1000 t) | 207.5 | 830 (x 4) | Strategic Roadmap |
| 11 | Cocoon production (ton) | 245.2 | 245200 (x1000) | Strategic Roadmap |
| 12 | Size of sown area (thousand ha) | 1665.71 | 1749 (+5%) | Strategic Roadmap |
| | $\lvert\bar{S}_1\rvert = \sqrt{\sum_i^n f_{1i}^2}$ | 5000.711 | | |
| | $\lvert\bar{\lambda}_1\rvert = \sqrt{\sum_i^n t_{1i}^2}$ | | 245286.72 | |
| | $(\bar{S}_1, \bar{\lambda}_1) = \sum_i^n (f_{1i} * t_{1i})$ | | | 92491396.7 |
| | $\cos\varphi_1 = \frac{(\bar{S}_1 * \bar{\lambda}_1)}{\lvert\bar{S}_1\rvert * \lvert\bar{\lambda}_1\rvert}$ | | | 0.0754 |
| | $\sigma_1 = \frac{\lvert\bar{S}_1\rvert}{\lvert\bar{\lambda}_1\rvert} * \cos\varphi_1$ | | | **0.00154** |

*Note:* calculated by the authors

leaves is 2.5 times less than actual figures in Turkey. Azerbaijan is behind the average in the world on the indicator of "milking per cow and buffalo". The Strategic Roadmap sets the target for speeding up production of meat, milk, cotton, cocoon production for a near term. At present, the volume of production in the country is far behind from these levels. For example, cotton production is expected to increase fourfold in the near term and reach 830,000 tons.

We can get the results in Table 1 for the economical aspect of the sustainable agricultural sector, taking into account the factual figures of these indicators for 2017 and the "target indicators" for the near term.

As can be seen from Table 1, sustainability of the agricultural sector on the economic aspect in Azerbaijan is currently very low ($\sigma_1 = 0.00154$). Though we increase the number of indicators used in such calculations, there is a doubt that the results will change dramatically. Because, Azerbaijan's indicators on plant and livestock products included in the table are higher than the production of other commodities. Perhaps the inclusion of indicators on horticulture and vegetable production has led to a slight increase of $\sigma_1$. But such growth will not be sharp.

The second important aspect of the agricultural sector's sustainability is that the logic for the quantitative measurement of the *social aspect* is that people with a sustainable agricultural sector tend to live, work and build. They have no interest in moving to other areas. In other words, the social aspect of the agricultural sector is characterized by the

**Table 2. Actual (2017) and target indicators for the social aspect of agricultural sector sustainability**

| | Social indicators | $f_{2i}$ | $t_{2i}$ |
|---|---|---|---|
| 1 | Overall fertility indices for rural areas | 2 | 1.7 |
| 2 | Share of the men with higher education in rural areas in the total number of the male population of the country | 6.2 | 12.3 |
| 3 | Share of the men with secondary, college and secondary general education in rural areas in the total number of male population of the country | 42.4 | 34.8 |
| 4 | Share of the women with higher education in rural areas in the total number of the female population of the country | 3.9 | 10.6 |
| 5 | Share of the women with secondary, college and secondary general education in rural areas in the total number of female population of the country | 45.9 | 41.3 |
| 6 | Average per capita income in rural areas (manat) | 256.75 | 278.65 |
| 7 | Central heating system (%) | 6.8 | 34.4 |
| 8 | Joining to the phone (%) | 60.9 | 91.1 |
| 9 | Availability of a sewage system (%) | 96.2 | 99.9 |
| 10 | Availability of bathroom, shower, bath (%) | 81.5 | 96.0 |
| 11 | Network gas connection (%) | 84.0 | 97.4 |
| 12 | Availability of hot water supply (%) | 47.0 | 80.6 |
| 13 | Connecting to a water pipe (%) | 75.8 | 98.9 |
| 14 | Number of employers in the agricultural sector (%) | 1752.9 | 1772.9 |
| 15 | Number of people with all agricultural specialties (person) in the higher education institutions | 2884 | 3460.8 (+20%) |
| $\lvert\bar{S}_2\rvert = \sqrt{\sum_i^n f_{2i}^2}$ | | 3390.377 | |
| $\lvert\bar{\lambda}_2\rvert = \sqrt{\sum_i^n t_{2i}^2}$ | | | 3905.840 |
| $(\bar{S}_2, \bar{\lambda}_2) = \sum_i (f_{2i} * t_{2i})$ | | | 13206382 |
| $\cos\varphi_2 = \frac{(\bar{S}_2 * \bar{\lambda}_2)}{\lvert\bar{S}_2\rvert * \lvert\bar{\lambda}_2\rvert}$ | | | 0.9973 |
| $\sigma_2 = \frac{\lvert\bar{S}_2\rvert}{\lvert\bar{\lambda}_2\rvert} * \cos\varphi_2$ | | | **0.86568** |

*Note:* calculated by the authors

self-confidence of employees in this sector. Different indicators can also be used for the social aspect of sustainability. We will use fifteen indicators that are more relevant to the social situation of the population. But it is also possible to increase their number significantly. Among these indicators are the indicators that are essential for the minimum welfare of households. For example, the availability of heating systems, access to gas, electricity, connecting to water junctions, telephone use, number of the people with higher education in rural areas and so on.

In order to define "target indicators" on the *social aspect* of sustainable agricultural sector for Azerbaijan, we will take the targets set for the nearest period on the Strategic Road Map. As the fertility indicator in urban areas, an indicator – the "target indicators" for "overall fertility indices for rural areas" was taken (Table 2). And according to this indicator, the indicator of the rural areas exceeds the "target indicator".

Other indicators need to be considered in assessing the social aspect of agricultural sustainability. For example, the age group of workers in the agricultural sector, the size of the families, pluractivity in farming households and so on. Usually, the age group shows the level of education, management skills, and experience in agrarian work, and so on. And in the future, the extent to which the knowledge and skills in the agricultural sector transmitted to the new generation depends largely on the age group. The first two of these indicators are reflected in the indicator "overall fertility indices for rural areas". Obtaining statistical information on the third indicator is difficult little. However, the inclusion of this indicator into calculations is of great importance. So, some of the rural population works in the agricultural sector as well as engaged in other activities. For example, rural teachers, health workers, civil, municipal servants, and employees in the service sector are also engaged in agricultural activities after their working hours. Such pluractivity creates the opportunity for including of additional income to their family budget.

The social aspects of sustainability of agricultural sector (Table 2) show that Azerbaijan has a high consistency on this aspect ($\sigma_2 = 0.86568$). As a result of state programs on the socio-economic development of the regions over the past decades, the improvement of power supply, gas and water supply in rural areas has been reflected in the social aspect of sustainability.

Establishment of major industrial facilities in Baku and surrounding regions, Sumgayit, Ganja, Mingachevir and Dashkesan cities, as well as the fact that the agrarian processing enterprises do not operate extensively shows that the third-environmental aspect of the agricultural sector's sustainability does not have a serious negative impact on the environment in the country. The low volume of production in comparison with 1990 has reduced the use of fertilizers and chemicals. The increase in the use of pesticides, which has adverse effects on land, water basins, and all living things, including human health, is inextricably linked with the level of sustainability. Pesticides should be used as little as pos-

**Table 3. Actual (2017) and target indicators for *environmental aspect* of sustainability in the agricultural sector**

| | Environmental aspects | $f_{2i}$ | $t_{2i}$ |
|---|---|---|---|
| 1 | Specific weight of the fertilized area in the total planting area, % | 72 | 100 |
| 2 | Use of mineral fertilizers (1000 tons) | 118.7 | 148.375(+25%) |
| 3 | Provision of agricultural products manufacturers with techniques, machinery and equipments, as well as small-size technique, machinery and equipment (1000 hectare sown area) | 13.1 | 15.72 (+20%) |
| 4 | The rate of utilization and disposal of waste generated in the agricultural sector (%) | 0.32 | 100 |
| $\lvert\bar{S}_3\rvert = \sqrt{\sum_i^n f_{3i}^2}$ | | 139.480 | |
| $\lvert\bar{\lambda}_3\rvert = \sqrt{\sum_i^n t_{3i}^2}$ | | | 205.578 |
| $(\bar{S}_3, \bar{\lambda}_3) = \sum (f_{2i} * t_{2i})$ | | | 25050.04 |
| $\cos \varphi_3 = \frac{(\bar{S}_3 * \bar{\lambda}_3)}{\lvert\bar{S}_3\rvert * \lvert\bar{\lambda}_3\rvert}$ | | | 0.8736 |
| $\sigma_3 = \frac{\lvert\bar{S}_3\rvert}{\lvert\bar{\lambda}_3\rvert} * \cos \varphi_3$ | | | 0.59272 |

*Note:* calculated by the authors

**Table 4. The level of sustainability of the agricultural sector of Azerbaijan (2017)**

| | $\lvert\bar{S}_j\rvert$ | $\lvert\bar{\lambda}_j\rvert$ | $(\bar{S}_j, \bar{\lambda}_j)$ | $\cos \varphi_j$ | $\sigma_j$ |
|---|---|---|---|---|---|
| Economic | 5000.711 | 245286.72 | 92491396.7 | 0.0754 | 0.00154 |
| Social | 3390.377 | 3905.840 | 13206382 | 0.9973 | 0.86568 |
| Environmental | 139.480 | 205.578 | 25050.04 | 0.8736 | 0.59272 |
| AS (2017) | | | | | 0.48665 |

sible to ensure environmental sustainability. Unfortunately, it is not possible to provide the development of agricultural sector without pesticides yet. The country's irrigation system is not at a high level. However, expansion of production will also make it necessary to expand the irrigation system. The use of irrigation water or the use of less water-intensely cultivated crops is crucial for the sustainability of the agricultural sector. However, in the Strategic Road Map it is expected that the development of cotton-growing at least four times in the near term will increase demand for water.

Setting agrarian production as a strategic target will *increase the use of agricultural machinery*. The use of heavy techniques can seriously damage the environment from the use of machinery and mechanisms when evaluating the economic aspects of sustainability in the agricultural sector. Because of the excessive soil consolidation in the areas where the technique operates, more productivity and utility for agriculture are eliminated.

We will use four indicators to assess the environmental aspect of the agricultural sector's sustainability. Indicators such as "The volume of use of plant protection products by the agricultural producers", "The level of use of certified seeds, saplings by the agricultural producers" and "The amount of gases generating heating effect with $1 added value in the agricultural field" is of great importance to assess the environmental aspect of agricultural sector sustainability. However, these indicators are difficult to access and are not included in the calculations.

Thus, taking into consideration on the estimates based on actual and "target indicators" for four indicators for 2017, it can be shown that the level of sustainability in the agricultural sector can be considered as average in Azerbaijan ($\sigma_3 = 0.59272$) (Table 3).

The main reason for the high level of sustainability of the agricultural sector on the environmental aspect is the high cost of "target indicators" on two indicators. Thus, a maximum of 100% for the "specific weight of the fertilized area in the total planting area" and "rate of utilization and disposal of waste generated in the agricultural sector" indicators was achieved. Of course, it is possible to achieve it in the first indicator in reality. It is possible to give the necessary amount of fertilizers to all sowing areas. The second indicator – it is difficult to achieve a 100% result on the indicator of "the rate of utilization and disposal of waste generated in the agricultural sector". However, given the extent to which waste is generated in the agricultural sector in Azerbaijan, it is possible to completely neutralize the non-usable part thereof.

So, using the equations (1) – (6), we can get AS = 0.48665 for all three aspects of the agricultural sector's sustainability and total level of sustainability of agricultural sector in general. Comparative description of all three aspects of sustainability (Table 4) suggests that the most sustainable one of these aspects is the social aspect.

## Conclusions

In Azerbaijan, the agricultural sector's sustainability on the economic and environmental aspect is weak. Only the social aspect can be regarded as moderate. The overall agricultural sector's sustainability is also below average. Increasing the sustainability of the economic aspect can have a significant impact weakening of the environmental aspect in the future. However, the weakness of the sustainability of agricultural sector in general creates certain inequalities between the rural regions and urban regions, especially in Baku.

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