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SUSTAINABLE AGRICULTURE AND ENVIRONMENT: HOW THE MODERN POLICY IS PROMOTED IN AZERBAIJAN CONTEXT

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Abstract

Modernization of agriculture is announced as a strategic goal since 2015 in Azerbaijan with the aim of to replace import of important foods (wheat and increase the agriculture export. A trend in rapid population growth and increasing demand for food, changing environment evidently proofs to realize measures for sustainable, economically efficient and environmentally friendly agriculture sector. Current agriculture practices in the country are faced with the land fragmentation, poor irrigation systems, significant water losses, insufficient knowledge of farmers and other observed shortages in agriculture leading to reduction of the overall productivity of irrigated lands and worsening of their farming characteristics. Based on the quantitative analyses on the data the features of agriculture are investigated by assessment of the main influencing factors to sustainability of the current farming system. Examples from international experiences and region countries are reviewed to demonstrate similarity and dependence of the sustainability measures on the local conditions and agriculture practices. The result of this study proves that modern agriculture in the country is possible to be achieved through supporting the integrated and interlinked set of the measures, including consolidation of the small plots, construction of the new generation irrigation systems, strengthening and mobilization of the scientific and institutional capacities enabling realization of the new agricultural policy, education of the stakeholders with the advanced knowledge on the modern agriculture practices and its transfer to the farmers. The outcomes of this study provide well-grounded proposals in the preparation of action plans for the smooth implementation of the declared agricultural development strategies in the country and practical experience for other similar emerging market economies.

Key worlds: food demand, sustainability, farming practices, integrated measures, Azerbaijan

INTRODUCTION

Rapid development in Azerbaijan as a result of the oil boom in 2005-2015 has led to significant elimination of poverty in the country, growth of population revenues, in particular strengthening of social protection for totally one million refugees and internally displaced persons due to occupation of the mountain Karabakh and surrounded territories, as well as improvement of education and healthcare systems. To preserve the achieved welfare of population of the steep decline in oil prices on the world market, starting from late 2014 the government has announced acceleration of agriculture development as a major strategic policy. Targets are established to increase environmentally friendly agricultural production contributing to the country's export potential and achievement of high efficiency in agriculture with environmental protection of the land and water resources. Due to the fact that most of the sown areas locate in the arid areas where the groundwater is close to the soil surface, agriculture production in the country is based on irrigation combined with the drainage systems to regulate water-salt balance of the crop root zone. The changes that occurred in agriculture sector within the almost last two decades because of formation of the market economy and demand for ensuring food security and increase export potential of the country with the occurrence of the additional factors contributing strengthening of the environmental requirements make an urgent need to facilitate the implementation of set of the integrated actions and undertaking ecological measures, conceptual policy provisions for the upcoming years. The issue of the sustainability of agriculture is widely discussing in the international literatures with

peculiarities of the investigated country or region, however for the case of Azerbaijan these studies are not considers all complex changes occurred in both of the farming practices, institutional and legal framework of agriculture and usage of the resources under the small landholding. In this study the main peculiarities and observed challenges of the agriculture are investigated, as well as the comparative review on the understanding of the environmentally friendly agriculture concept with various experiences and dimensions from both of the developing and developed countries are made. The main finding of this study is to expand comprehensive acceptance of the complexity of the problems and understanding the necessity of the application of the integrated approach in elaborating solution measures for the above aims. As the proposed set of measures for Azerbaijan is elaborated based on the above principles and approaches, this study adds value to the international experience, especially for the emerging market economies.

MATERIALS AND METHODS

The study materials of this research have been obtained from own investigations, the published data of the relevant organizations and studies appeared in the recent scientific literature. As a basic methodology approach is accepted an understanding of the essence of the term of "sustainability in agriculture" in the scientific literature. Thus, sustainable farming is an activity oriented towards ensuring food security by preserving agro-ecosystem resources (Landeros-Sánchez, Mendoza-Hernández and Palma-López 2009). Agricultural sustainability is an important factor for the long term profitability of agricultural systems (Radulescu et all., 2011). Regarding to the water resources used in agriculture - sustainable water management in agriculture is understood as availability of water in required quantity and quality, at certain space and time, at affordable cost within acceptable environmental impact (Chartzoulakis and Bertaki, 2015). Although the basic elements that determine the sustainability of agriculture in most cases are identical, they are varying depending on the local conditions of the country or region under consideration. Consequently, these particular conditions predetermine the framework and range of the studies on the main influencing factors (European Union, 2012, Krall, 2015). Thus, sustainability of agriculture within this study is investigated by the quantitative assessment and data on the main influencing factors – population growth, demand for the main food, crop yield, irrigated area, water resources usage, trends in use of fertilizers, ecological and ameliorative condition of the soil, performance of irrigation and drainage systems, agriculture practices at farm level, peasant farms efficiency analyses. Farming efficiency is evaluated based on the collected data during 2012-2015 from 300 numbers of randomly selected peasant farms involved in intensive agriculture area, which included size of the farms, crop yields and income analyses. In terms of the comparison with the international experience, the policy measures undertaking or proposed to be realized in various regions are reviewed to bring practical evidences which address different efforts on the shifting from traditional agriculture to the environmentally and economically sound farming system through effective use of resources, preventing their further deterioration and quality, and meet the costs incurred for agriculture output. Similarly, a review of the recent policy measures undertaken by the Government of Azerbaijan (GOA) is considered. In order to ensure representativeness of the study, relevant data covering all irrigated area in the country, including publications of the state statistical agency, status technical reports of land reclamation service organizations, scientific studies carried out by different researchers are used, samples from the subject relevance international sources are analyzed. Data processing is executed by application of the Excel software. Finally, the outline of the measures for advanced farming is proposed for the smooth and efficient realization of the newly planned agricultural policy in the country. The study is methodically structured and set out in a logical sequential identification of the main features of the irrigated agriculture, resulted from the policy, have been implementing during the almost last two decades and changes occurring in the country, its influence to the farming structure and agriculture production, resource usage and their ecology. The understanding aims and actions for the concept of sustainable agriculture in different countries with the specific own conditions are discussed to emphasize main challenges and their relevance to the currently taken efforts in these countries. Based on the analyses made for both of the local and international conditions, and critical issues concerned throughout the study, the agenda with the integrated and interlinked set of measures and strategies for realization in Azerbaijan is defined. Therefore, in spite of the analyses and recommendations are made for the concrete country condition, the elaborated toolbox bears international significance and transfers practical recommendations for the similar regions and economies.

RESULTS AND DISCUSSION

Current features of agriculture at national level:

As of the end of 2017, the population of Azerbaijan reached to 9,81 million inhabitants. This means 2,68 million increase compared with 1990 or an annual average growth of 92 thousand inhabitants (State Statistic Committee of Azerbaijan (SSCA), 2017a). As per the current situation, targets for the production of basic food to meet local demand have not been achieved yet. The indicators of the consumption of the main crop production for the last

years demonstrate that in spite of a reduction of the degree of dependence on the import, agriculture production in the country needs to be increased in the coming years relevant to the demand as seen from the Table 1 (SSCA, 2017b). A comparison with some CIS (Commonwealth of Independent States) countries shows that the amount of grain produced

Table 1. Dependence from import of basic crop products in Azerbaijan[1]

The name of crops	Year, %						
	2010	2011	2012	2013	2014	2015	2016
Cereals, including	43,5	35,2	35,7	36,1	39,4	35,5	36,5
Wheat	51,1	42,3	43,2	44,1	45,9	45,2	47,1
Barley	12,3	6,3	4,9	2,2	15,4	4,9	0,1
Maize	35,5	32,0	32,7	40,0	43,3	45,9	28,9
Legumes	34,9	29,6	28,9	24,2	24,0	30,7	31,7
Potato	6,9	8,3	7,8	7,7	15,7	14,8	18,1

[1] SSCA, 2017b. Food balances of Azerbaijan. Baku, Baku: Statistical publication: 70-76.

in Azerbaijan per capita during the period 2010-2016 has increased from 218 to 310 kg, but still stays lower than in most of these countries (Table 2) (SSCA, 2017c). Taking into account that rural population accounts for 47% of the total population, in terms of increasing the incomes of the rural population, the volume of production and processing of agricultural products is also important to be increased. The share of total agricultural products in the country's GDP is 5.6% (2016), dropping down from 16.1% in 2000, which demonstrates increase of the dependence of economy from the oil sector and declining of the non-oil sector (SSCA, 2017c).

Table 2. Production of cereals and dried pulses in some CIS countries, 2016 [2]

thousand tones							
Azerbaijan	Russia	Ukraine	Kazakhstan	Belarus	Moldova	Kyrgyzstan	Tajikistan
2 987	119 129	65952	20634	7461	2978	1861	1436
Per capita, kg							
310	812	1551`	1165	785	838	306	167

[2]SSCAR. (2017c). Agriculture of Azerbaijan. Baku: Statistical publication, 596-601. Own design

Reasons can be explained as follow: long time of the formation of market relations in the agricultural sector; loss of importance of large farms as a result of land reforms; distribution of agricultural lands among the rural families leading to their fragmentation; worsening of land use due to the increase of inter-farm road length and irrigation canal density beyond the standards; lack of new landholders capacity and skills in independent farming; and failure to fully comply with the requirements of the scientifically justified farming and other factors. Serious factor such as partly loosing of the traditional trade markets in the countries (Russia, Ukraine, Eastern and Central Europe members of former Council for Mutual Economic Assistance) due to similar processes had taken place during transformation to the market economy in these countries to which mostly agricultural production was exported from Azerbaijan in the period of planned economy, prior to 1990.

In early years after the gaining of independence in Azerbaijan (1991), considering financial restriction emanating from formation of the market economy, resulting from the institutional changes and adopted legislation was primarily arranged in "searching format" in terms of preventing the existing irrigation infrastructure from deterioration and maintaining it in the appropriate operational condition. This was due to the fact that, against the country's long period of centralized management, the experience in agriculture based on small landholding was not sufficient, as well as the new owners were not fully prepared to manage their own plots and infrastructure. However, targets to raise living standards of the population urgently require putting more efforts for reliable provision with food and weakening of the country's dependence on import. This task, in consideration of climatic and natural conditions, can be achieved by improvement of the farming system, precise regulation of salt-water balance of irrigated lands by improvement of existing irrigation and drainage infrastructure and their management.

How irrigated agriculture use the resources?: In the Azerbaijan Republic 4,77 mln. ha of land is suitable for agriculture, the area of the arable land under cultivation is totally 1,9 mln. ha and per capita area is 0,49 ha. Irrigated area covers about 1,431mln.

ha, including 163000 ha –under permanent crops (SSCA, 2017c).

After agrarian reforms the average size of land distributed for each rural family ranged from 1.5 to 5 hectares in different regions of the country. The farmers are free in using their land plot and choosing the cropping pattern. To encourage agriculture activity, the government pays the subsidy for fuel and motor oil - 50 AZN /ha (1 AZN = 0,588 USD as per 12.12.2018), additionally 40 AZN/ha for planting wheat and rice. The subsidy provided to the landholders to use fertilizers for farming covers 70% of its purchase price.

Under the market economy, landowners freely use their own lands, but in most cases they cannot apply crop rotation system because of the small size of the plot, surface irrigation at field level is complicated due to their location. Instability in crop sale prices limits to recover associated farming cost and to gain sustainable incomes. The individual farmers face difficulties in product realization. In the existing sown structure, the share of cereals and dried pulses is 60,1%, industrial crops 2,4%, potatoes, vegetables 10,5%, and fodder crops - 27% (Figure 1) (2017c).

Over the past 15 years, the total sowing area of cereals and leguminous (crops with the short length of vegetation period) increased from 648200 to 952100 ha. The increase in the sown area of fodder crops from 139000 to 428600 ha has compensated by reduction of cotton cultivated area to 18700 from 101200 ha (Figure 2). The main cause leading to changes in the structure of sown areas is farmer's preference to cultivate crops with less farming costs and gain relatively high income.

During 1961 - 2014 the cereals yields increased from 7 to 23,44 c/ha and the cultivated area by two times in Azerbaijan. At the same period, in spite of observed decrease of the sown area in European Union (EU) countries by

10%, the yield of cereals increased up to 54,49 c/ha, which is two times more than in Azerbaijan. This can be explained by application of the intensive farming technologies (World Bank 2014; CSO [Central Statistical Office] 1967) (Table 3). The recent studies indicate high potential to increase the yields for some varieties of wheat in

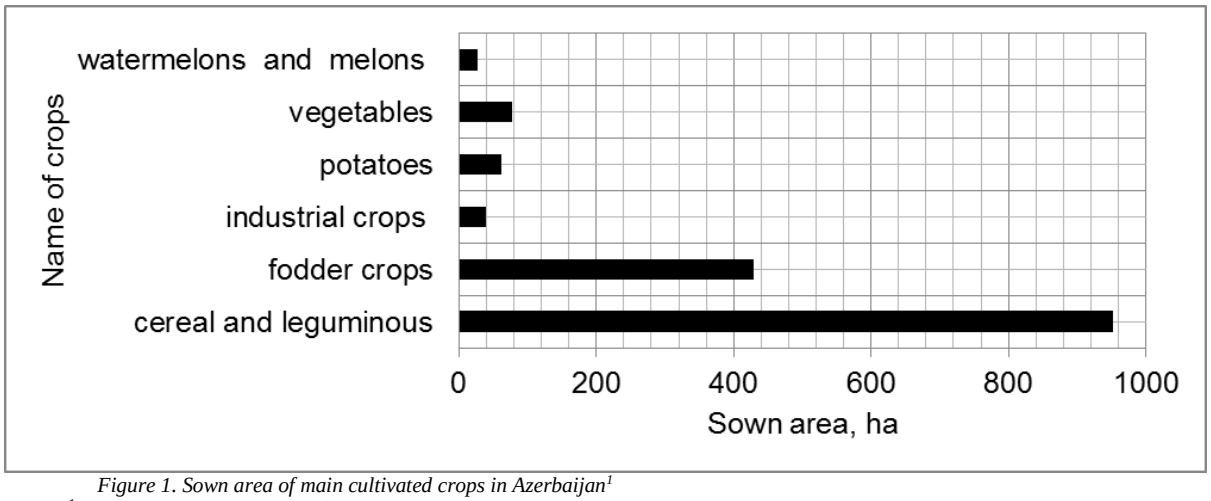

Figure 1. Sown area of main cultivated crops in Azerbaijan[1]

[1]*SSCA.(2017c). Agriculture of Azerbaijan. Baku: Statistical publication, 46-72. Own design*

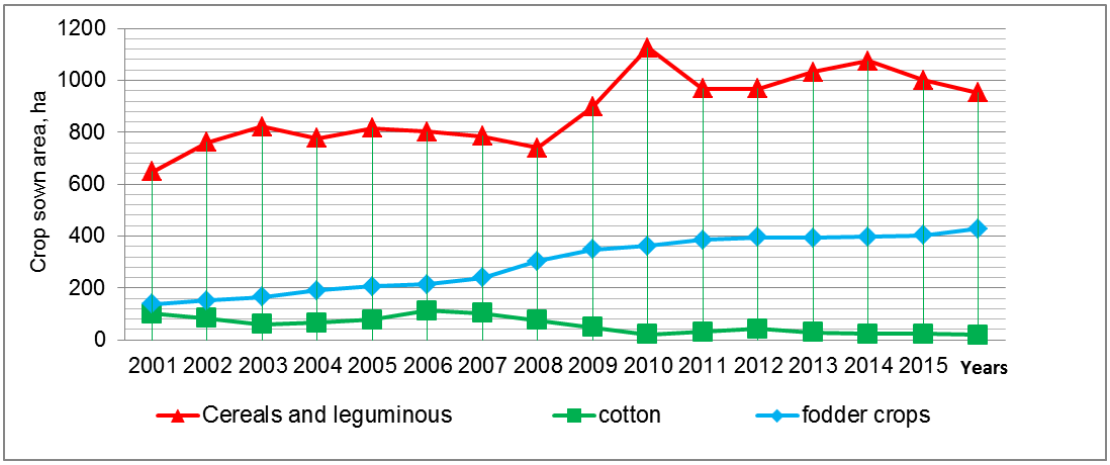

Figure 2. The change in the dynamics of sown areas of major crops2

[2]*SSCA (2017c). Own design.*

Azerbaijan (Akparov, 2008). During 2000-2016, the total import of mineral fertilizers has increased from 40,5 to 166,9 thousand tons (Figure 3). However, the real demand for all sown area in 2015 was estimated to be 948,9 thousand tons SSCA (2017c). Increase of the volume of fertilizers during 2000 -2015 for nitrogen was from 6,8 to 14,2 kg/ha, phosphate - from 0,1 to 2,2 kg/ha, and for potash from 0,7 to 1,6 kg/ha (FAO, 2015). During 2010-2015 application of mineral fertilizers to the sown area increased from 18 to 23 kg/ha, for cereals – from 20 to 21 kg/ha only. Totally during this time, the share of fertilized area, increased from 34% to 70% (SSCA, 2017c). In general, Azerbaijan belongs to the group of countries with low mineral fertilizer applications per hectare of arable land. This is one of the factors contributing to low level of plant productivity in the country (GoA, 2016).

During the period 2000-2016, despite the non-major change in the sown area, the volume of withdrawn water increased by 12,5%, increase in agricultural water usage as a whole by 66% (Table 4) (SSCA, 2017 d). The main problem is losses of water during transportation, distribution and on the fields due to the surface irrigation.

Table 3. Sown area and crop yields, and in different countries[3]

	Name of country/region	Sown area, ha		Yield, s/ha	
		1961	2014	1961	2014
1	Afghanistan	3313500	3344733	11,15	20,21
2	Albania	347764	143149	8,45	48,93
3	Azerbaijan	527,8	1 001,4	7,0	23,44
4	Belarus	2687000	2428132	8,2	37,21
5	Czech Republic	-	1412279	25,99	62,20
6	Iran	5063000	8689890	8,5	19,63
7	Latvia	972000	638900	24,5	34,86
8	Turkey	12865300	11553065	9,89	28,31
9	Ukraine	17 032000	14401200	19,9	44,01
10	European Union	64194718	58258568	19,78	54,49

[3] *World Bank. (2014). Cereal yield, land under cereals production. Retrieved from http://data.worldbank.org/indicator ; Central Statistical Office of the USSR [CSO].(1967). Страна Советов за 50 лет.Сборник статистических материалов) [Soviet country behind 50 years. Collection of statistical data], Moscow, Statistika: 131-137. Data retrieved from http://istmat.info/node/16602 Own design*

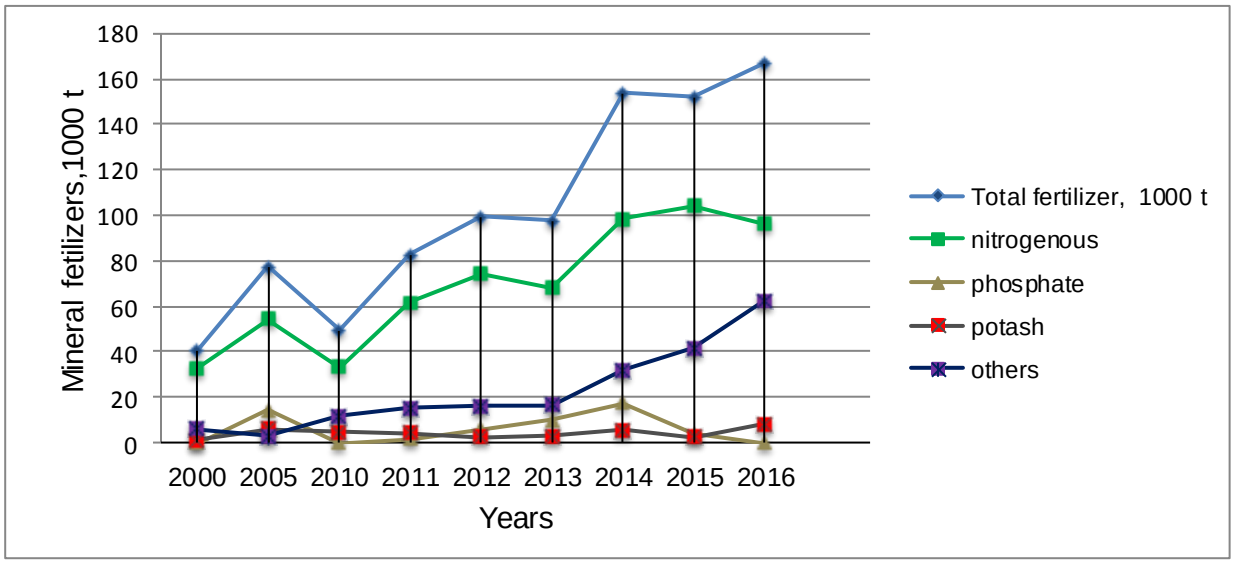

Figure 3. Trends in import of mineral fertilizers by kinds, in physical weight3

3*SSCA (2017c). Import of mineral fertilizers by kinds, in physical weight. Own design.*

Are irrigation facilities responsive to the requirements?: Irrigation and drainage facilities in Azerbaijan were mainly constructed during the Soviet Union period (1920-1990), associated with the rapid expansion of new areas and their integration into agricultural use, but the systems were not technically and technologically advanced. In the course of the 1990s land reforms, the operation of on-farm systems was poorly organized due to the limited institutional capacities and financial resources. The process of transfer of the on-farm systems management to the Water User Unions (WUU) has been initiated. Currently, at the regional level, the operation and maintenance of the irrigation and land reclamation systems are provided by the public subordinated local organizations. The uninterrupted maintenance and operation of the systems during the year are secured mainly by state funds. The negative impact on the irrigation systems after collapsing the planned economy can be summarized as follow: 1) the cultivation of crops is executed in small individual private plots (during the land reforms previously existed big size fields divided and distributed between the individual landowners); the sowing structure over the last 20 years has undergone profound changes and every year have been chaotically arranging relevant to the plans of the farmers; 2) dividing big size fields into small plots has led increasing of the farm roads'

Table 4. Indicators of water usage in Azerbaijan, 10^6 m^3 [4]

Years	2000	2003	2006	2009	2012	2015	2016
Water taken from the sources	11110	10772	12360	11425	12484	12285	12504
Water consumption	6588	7370	8865	7639	8249	8567	8824
including :							
Irrigation /agriculture	3819	4579	5817	5587	5772	6057	6342
household-drinking purposes	449	512	523	384	279	323	308
Losses during transportation	3053	3402	3495	3786	4236	3718	3680

[4] *SSCA, 2017d. Environment in Azerbaijan. Main indicators characterizing protection of water resources and their rational use. Page 73.*

length (averagely by two times), but still existing old on-farm irrigation systems have not yet been completely adapted to the new land use structure, leading to difficulties in water delivery to the individual plots ; 3) the still existing outdated irrigation networks which has not yet rehabilitated are not able to function properly and delivery of water to the individual plots in accordance within required engineering norms; 4) operation of the rehabilitated on-farm irrigation systems and on-farm water distribution is executed by the WUUs, but their technical and financial capacity and experience have not yet enough for normal maintenance and operation of the systems, in some cases leading to deterioration of the previously rehabilitated structures and reducing the operational indicators of the overall systems (Rzayev 2017a).

In operation of earthen drainage systems, key difficulties are in the timely cleaning of slopes, bottoms from weeds and rehabilitation of deformed sections. Due to the imperfectness of water conveyance facilities and the untimely leveling works in the fields causes water losses and their percolation into the drainage and collector networks. Such losses increase loading of the drainage systems operated by the pumping stations and that is why more need for the electricity, thus raising their operational costs. During the last 15 years losses in the conveyance of irrigation water has increased by 15%. According to the Lowe Mugan Ameliorativ System Administration data in the collectors serving to the south-east part of the Kura- Araz lowland the salinity of the drainage water during 2005-2015 has declined averagely from 10,5 to 5,1 g/l and discharge to the Caspian Sea increased by 12%. This proves that this decline is due to an increase in the loss of fresh water from canals and their discharge into the drainage network (Rzayev,2017 b).

Ecological condition of the irrigated lands shows that currently 700159 ha of lands are exposed to salinization and solonetzicity in the country. The area with average and high salinity amounts to 152012 ha, solonetzic soils - 22141 ha. Areas most exposed to salinization are Mugan - Salyan and Shirvan zones. Solonetzic soils prevail in Mil-Karabakh zone (Table 5). The areas exposed to salinization and solonetzicity covers 49% of total irrigated lands. Initial estimations suggested land reclamation works by capital leaching in 345595 hectares, restoration of irrigation systems serving 248570 hectares and collector – drainage network covering 93048 hectares of land (Hydrogeology Ameliorative Services Administration (HASO, 2015). In irrigated areas conducted agro-production grouping assessment of the main soil types by their bonitet scale variation (soil evaluation) recommends to improve soil fertility and agro-reclamation works and implement other measures to raise their productivity (Table 6) (Mammadov, 2015).

Are peasant farms enough organized to be more efficient?: The peasant farms land sizes used under the intensive agriculture range averagely from 1.5 to 5 ha depending on the family composition and distributed lands of the former collective farms. The result of the interview among totally 300 number of the farmers showed that during 2012-2016, the cost of crop growing for cotton increased by 16% , winter wheat- 13%, alfalfa (1-st year and old) – 11- 12.5 %. The yield of cotton increased by 2.7%, in winter

wheat – 11%, and alfalfa – 5.5% (Table 7). The average net income for per hectare is varying from 258 to 308 AZN depending on the farm sizes (Table 8). The differences in the costs and incomes is due to the fact that in relatively large size farms the crop growing is organized in a more optimal way by the preservation of a stable labor force and possibility to use more intensive farming techniques. The income of farmers and access to the financial sources is limited to apply all necessary farming techniques for land improvements, other reclamation works, land leveling, cleaning up the field drains and earth irrigation canals and apply advanced irrigation technologies (Rzayev, 2017). The WUUs applied water tariffs which ranged 1.4. AZN for 1000 m^3 is not enough for proper on-farm system operation. Their institutional capacity can be evaluated as a weak due to the limited finances, insufficient knowledge of the staff on irrigation water management at farm level, weak on-farm irrigation infrastructure and WUUs members insufficient enthusiasm, therefore they have not yet turned into the strong organization capable for proper maintenance and operation of the on- farm infrastructure and still heavily depend on the public support.

The necessary basic knowledge of farmers also is not sufficient. According to our discussion with the farmers, there is not organized regular trainings for WUUs members on improvement of the farming practices and agricultural land management issues. The connection between the public scientific institutions and farmers is still weak to conduct regular discussions, trainings and exchange of experience between the farmers. Only 20% of farmers clearly understand the direct linkage between farming practices and ecological impacts to the resource use in agriculture. The qualified advisory services have not been sufficiently developed in the regions and there is lack of the experienced experts' teams capable to support farmers continuously especially during the crop growing period. The farmers have limited access to the soft public loans. Loans on commercial terms they cannot afford due to high interest rates. Generally in the end of 2016 the allocated loans for agriculture and processing industry were 441.3 mln. manats. Thus, along with the soil and climatic conditions peculiar to the arid zones, small landholding has institutional and financial problems such as the farmers' low levels of knowledge and restrictions on access to the credit, as well as poor infrastructure and the introduction of new technologies and advanced management tools in the farms (Berkum, 2017).

Principles of the sustainable agriculture and environment: what do current studies say?: While analyzing sustainability of irrigated agriculture San Joaquin Valley, California (Schoups et al., 2005) noted that sustainability in most arid zones is vulnerable because of the limited fresh water resources, insufficiency of drainage system, high groundwater table and the soil and groundwater salinization. In the countries where irrigated agriculture plays the key role in the economy, the main issues are to achieve efficient agriculture by protection of soil fertility, water resources and plant productivity (FAO, 2012a; Assouline et al., 2015). Sustainable agriculture should be able to satisfy for food and comply with the strict environmental requirements, using of resources efficiently and economically justified (FAO, 2014a). The concept of sustainable intensification in agriculture specifically for the EU is proposed considering the following conditions: food demand will be arisen outside; agriculture is already intensive; agricultural land in the last fifty years has tendency of reduction; failing of defined environmental standards; existence of the large environmental footprint through agricultural imports to EU. It includes set of indicators for land quality, nutrient management, biodiversity and landscape conservation with the at least the same agricultural outputs. In Europe 41 percent of land is evaluated subject to ecological pressure (Buckwell1 et al., 2014). The general agrarian policy is directed to save irrigation water, support farmers in an improvement of irrigation infrastructure, irrigation methods and protection of the water quality and soil health. Agri-environmental measures are considered as a key policy instrument to encourage farmers to protect and improve landscape elements in their own lands. This provides farmers payments instead of their services to reduce ecological risks in connection with modern farming and preserve natural resources, soil and cultivated landscapes, covering currently nearly 38.5 million ha and represented 20,9% of the total agriculture area of EU (Lefebvre, Espinosa and Gomez y Paloma, 2012).

In the USA starting from the middle of the 1970s, in spite of the rapid increase in population size and economic development, water usage is significantly optimized. In California during 1989-2009 the yields of field and seed crops increased from 1,6 to 2,5 tones without any rising of water withdrawn. However, there is still additional potential available for more increase in the crop yields, as the recent investigations show that only 39% of farms are using scientific irrigation scheduling. Nearly 60% of crops are still grown with flood irrigation (Gleick et al., 2011). Forecasted climate change in Sauss area in Morocco will decrease productivity of the corn and other crops, negatively affecting food security in the region. Therefore, an effective adaptation requires development and implementation of mitigation measures for strengthening stakeholder's actions to such major changes (Hirich et al, 2016). Intensification of agricultural production itself cannot create environmental degradation. Damaged factors originated from overgrazing, inefficient water use, excessive and untimely application of fertilizers and pesticides and others. Countries with relatively low levels of farming intensity need to develop their control

and monitoring system in parallel with the intensification of agricultural production. Otherwise, even in case of the poor intensity agriculture production there is a certain risk of large-scale environmental damage. In EU area the issue of environmental sustainability is given serious attention. Therefore, prediction of an increase in the use of fertilizers by 20 % for crop production by 2050 requires keeping this concern at the center of attention. The usage of fertilizer and chemicals in other regions of Europe and Central Asia is less than EU; however, in Turkey and Eastern Europe, negative environmental impacts should also be taken as an issue to be properly controlled. In the Caucasus and Central Asian countries (including Azerbaijan) farmers do not use many fertilizers and other chemicals in comparison with developed countries, but currently, have big pressure on water resources because of increasing irrigation water consumption. Water stress will continue for the Caucasus and Central Asian region through 2050. The risk of environmental externalities can be softened by the adoption of practices to partly replace chemicals with agronomic knowledge inputs and other measures. Reduction of fertilizer usage can be achieved by application of precision agriculture. The principle consists of a farm management in which inputs for the concrete field, including seeds, fertilizer, pesticides, water, variety selection, planting, tillage and harvesting are varied depending on soil and crop conditions across a field. This practice makes possible for farmers to regulate the rate of fertilizer application across the field, according to the need as identified by Global Positioning System (GPS) guided grid or zone sampling. Application of the technologies for the variable rate of fertilizer across agricultural fields based on the actual demand is practiced in the United Kingdom, France, USA, Canada and Australia (FAO, 2012a). In recent years recommended Agro-Ecological Zones (AEZ) methodology makes possible to generate large databases on the availability of natural resources in agriculture, land assessment in terms of their qualities, achievable crop yields and estimated yields of key crops in irrigated lands (Fischer et al., 2008). On the basis of this methodology land evaluation is performed at four technologies and management levels in accordance with the soil, relief and climatic features. The SAFA (Sustainability Assessment of Food and Agriculture systems) guidelines elaborated by FAO covers all dimensions of sustainability, including such elements of proper management, ecological balance, economic growth and improvement of the life quality (FAO, 2014b). The harmonized application of the EU Water Framework Directive and EU Common Agriculture Policy reforms are considered as key instruments to be developed forward by strengthening the relationship between agriculture, natural resources and social policy tasks (Bartolini et al., 2010; Iglesias a Ana, Garroteb L 2015). Investigations on the current agriculture practices in Italy concluded that institutional coordination represents strategic importance in irrigation systems to turn from heavy subsidized output-oriented agriculture into an environmentally safe and cost recovery sector. For olive farmers who do not voluntarily reduce agrochemicals is proposed to apply varioures tools such as encouragement by showcasing farmers who did reduce their agrochemical use, pressure from consumers, rules of the agri-environmental legislation (Giomi, Runhaar P. and Runhaar H. 2018) .

In developing countries agricultural intensification can create high risks of land degradation, this may occur especially in the case of insufficiency of soil protection measures, including in case of improper and imbalanced use of the fertilizers for compensation of nutrients used by the crops during the growing period. In most cases this risk is expected to be continued in some countries due to impossibility to realize necessary technological changes to ensure continuous intensification of land usage (Alexandratos and Bruinsma, 2012).

Based on the past experience (Schultz and De Wrachien 2002) concluded that in irrigated agriculture the observed deficiencies are connected with the poor design and management of the irrigation systems as well as due to the insufficiency of engineers and managers understanding influence of irrigation and drainage systems to water resources use. In arid regions under deficit water conditions, the use of alternative opportunities and water sources become necessary. This is especially typical for the countries with limited water and land resources (Kislev, 2011). In evaluating suitability for agricultural intensification in southern Tanzania a spatially multi-criteria evaluation is applied to introduce a framework for considering socioeconomic and environmental factors (Nijbroek and Andelman 2016). In general, different methods of measurements and parameters on agricultural sustainability have been developed and there are many methods of research on this topic (Hayati, Ranjbar and E.Karami 2010; Peano, Migliorini and Sottile 2014). The main indicators of sustainability are different at the levels of agriculture plot, farm, area, national and regional scale. Therefore, changes in maintaining of farming activity, including environment, economy and climate changes defines key directions of the responsibilities at various levels on adapting of system performance to these changes and improvement of their operation. Studies conducted on the multidimensional aspects of agricultural sustainability in the other region countries confirm similarity of the trends and its environmental consequences. In Iran during the last 50 years is observed the population growth, decline of agriculture share of GDP, increase of usage of fertilizers, irrigated areas, soil salinization and desertification, water deficit. Improved water use efficiency in irrigation by crop pattern change, soil erosion and salinity control, more investments into the agricultural sector, enlargement of drought-resistant plant growing is necessary to achieve sustainability goals (Emadodin , Narita, Rudolf 2012; Ahmadaali et al., 2018). Farmer's personal attitude forward to farming system improvements is also considered as an important tool (Joneydi, 2012; Vaninee et al., 2016). While conducting ecological footprint analysis (Naderi et al., 2018) concluded that in most farms water, land and energy resources management must become a preferred concept with the comprehensive plans of environmentally advantage farming technologies.

Table 5. Main characteristic indicators of ecological –ameliorative condition of the irrigated lands in different zones of Azerbaijan

	The name of zones	Irrigated area, ha	Drained areas, ha	Saline soils, ha	Solonetzicity soils, ha	By ground water depth, ha						By mineralization of degree of ground water, q/l ha			
						< 1m	1-1,5m	1,5-2m	2-3m	3-5m	> 5m	< 1,0	1.0-3.0	3,0-5,0	> 5,0
1	Mugan-Salyan	196313	196313	86931	77779	1228	13469	71771	96696	13149	-	25219	120700	33396	16998
2	Shirvan regional	230139	153280	127313	98455	4981	24108	66053	87238	43741	4018	33941	101855	48942	45401
3	Mil-Karabakh	415218	184864	73358	115229	4358	10836	104586	139669	75206	80563	186010	169422	48806	10980
4	Nakhchivan area	57645	15100	7422	-	1293	2305	9486	18525	16366	9670	51535	5905	205	-
5	West regional	179957	940	16559	6656	-	-	1483	22291	127385	28798	130091	41147	5754	2965
6	Ganikh-Ayrichay	116256	5310	377	23137	-	2788	8394	20557	65137	19380	115508	748	-	-
7	South	71445	29770	21844	11844	118	3046	5605	34600	20597	7479	30287	21415	14241	5502
8	North	145860	23889	15100	14589	860	2847	6713	36879	98028	533	106533	15298	21966	2063
9	Mountain regions	5243	-	-	1083	-	-	-	-	-	5243	5243	-	-	-
10	In city areas	9660	-	2483	-	-	-	1858	2291	5511	2700	5332	1628	-	-
	Total	1427736	609466	351387	348772	12838	59399	275949	458746	465120	155684	687067	481822	174938	83909

Table 6. Average bonitet scale variation (land evaluation) of the main irrigated soil types in Azerbaijan

Name of the zones	Name of the main soil types	Average bonitet scales*	Agro-production grouping and soil quality by their bonitet scales
Mugan-Salyan	gray	73	*I group* – 100-81 –high quality soils, with the thick humus layer, favorable granulometric content, is characterized by ability to give higher yields. *II group* – 80-61 – good quality soil with the possibility to bring to the 1-st quality by taking additional measures to reduce the constraining factors limiting soil fertility; *III group* 60-41 – average quality agricultural land and possible to gain high yields by elimination of unfavorable characteristics through agro-technical and land reclamation measures; *IV group* - 40-21 – low quality gray-brown, soils exposed to different degrees of salinity, solonetzicity and erosion. Complex and very costly land reclamation with agro-technical measures are required to make them possible to use for cultivating different agricultural crops. *V group* - 20-1 this soils are considered conditionally unusable for agriculture. But they can be restored for agriculture usage by erosion control, forest- land treatment, drying and other reclamation measures.
	meadow - gray	70	
	floodplain- meadow	68	
	boggy- meadow	62	
Aran- Shirvan	dark gray-brown	78	
	light gray- brown	45	
	meadow gray	70	
	light- gray	62	
	elementary - gray	40	
	floodplain meadow	63	
	meadow-boggy	71	
Mil-Karabakh	dark gray-brown	78	
	light gray- brown	45	
	meadow gray	70	
	light- gray	65	
	floodplain meadow-forest	75	
	floodplain meadow	68	
	meadow-boggy	62	

Table 7. Average yields and cost of farming for per hectare in investigated peasant farms

crops	2012		2013		2014		2015	
	cost of farming, AZN	yield, t/ha	cost of farming, AZN	yields, t/ha	cost of farming, AZN	yields, t/ha	cost of farming, AZN	yields, t/ha
cotton	568	2.23	591	2.20	632	2.25	660	2.29
winter wheat	327	2.08	340	2.19	349	2.23	370	2.31
alfalfa(1-st year)	407	10.8	415	10.3	429	10.6	452	11.4
alfalfa (old)	248		256		266		279	

Table 8. The average farm net income per hectare, AZN

farm size, ha	1-2	2.1-3	3.1- 4	> 4
1-2	258	265	307	308

The strategic plan and results of the researches for the modern agriculture to prevent the soil degradation, soil salinity, excessive water usage in Turkey includes high competitiveness in agriculture sector, protection of the biological diversity, water, land, forests, modern irrigation technologies and more effective social benefits (MoD 2012; Acar et al., 2014; Dogan 2016; Okur et al., 2016). The farmer's active participation to eliminate misusage of the resources through their education and training is considered one of the important tool as well (Aydogdu and Yenigun, 2016; Arisoy and Ataseven, 2017). In Pakistan due to the unsustainable farming practices in the rainfed agriculture is proposed improvement measures such as application of the modern irrigation methods for more water use efficiency, changing in sowing structure by application of the drought resistant crops, reasonable fertilizers management techniques to restore soil productivity for sustainable high crop yields (Baig et al, 2013). The country vision 2025 for sustainable agriculture and environment has defined key direction and policies and institutional reforms to overcome the experienced problems arisen from the inefficient use water and lands in agriculture due to the poor irrigation and drainage systems, old farming techniques, risky application of the fertilizers for the health and environment, lack in the governance at all level of agriculture management (Hassan et all., 2016). The investigations for the environmental, economic and social dimensions such as crop diversification, soil salinity, application of the fertilizers and pesticides, crop production, employment in the rural places and food security in various provinces

confirmed regional differences in agricultural sustainability in Pakistan, for this reason based on the all aspects of the local farming, elaboration of the effective policy measures for each region is recommended (Zulfiqar and Thapa, 2017).

As we can see from the examples above, the content of the study and proposed measures gor agriculture improvements and its impact to the ecology and natural resources depends on the area of investigations, character of the farming, availability of the resources and applied farming technologies.

What is the current agenda for sustainability?: Azerbaijan has gathered long experience in the development of irrigation and drainage systems and its scientific support, especially during the last century due to the rapid development of agricultural lands (Ahmedzade, Hashimov and Verdiyev, 2014). Current sustainability measures of the irrigated agriculture in Azerbaijan cover the following dimensions:

Improvement of agriculture land use: These measures include establishment of WUUs, realization of the regional programs on the rehabilitation of on-farm irrigation systems under the various natural - economic conditions, improvement of their operation, training of farmers on new knowledge of modern farming practices, introduction of measures on increasing of soil fertility and more productive crop varieties;

Monitoring of the irrigated lands and improvement measures: The main activities in this area are the control in changing of groundwater regimes and their mineralization, monitoring of condition of the lands, regulation of ground water through improvement of operation and rehabilitation of existing drainage network, soil leaching and complex reclamation measures;

Improvement of soil productivity and fertility indicators: They cover evaluation of irrigated lands in terms of soil quality, analysis on changes in mechanical, physical, chemical composition and forecasting, study on nutrients content, and scientifically justified measures for its improvement according to specific plant requirements;

Irrigation water quality monitoring: This includes studies on water quality changes supplied from sources to irrigated areas by anthropogenic and other impacts, complex measures on protection of irrigation water from pollution and improvement of water quality;

Protection of irrigated areas to prevent consequences of global climate change in recent years: They include various hydraulic engineering measures for protection of irrigated lands and nearby rural areas from river floods, especially during early phase of vegetation period, protective forestation against risks such as landslides and erosion, reduction of water losses during water conveyance through restoration of irrigation canals, accurate regulation and improvement of their operation.

Activities related to the above-mentioned directions across the country are provided by the relevant government agencies, scientific-research institutions, targeted projects implemented in the regions, especially designed government regional programs. In the process of the formation of the market economy, the number of investment projects to improve on-farm systems has been carried out. Legal framework regulating land and water relations was established and developed with the consideration of the international experience. Finally, the improvement measures are validated, however, they are not enough sufficient (Rzayev, 2015). The increase in population and the demand for more food in the country required new views on the agricultural policy and its further intensification. Necessary conditions are the increasing of the cultivation of environmentally friendly agriculture production serving to the strengthening of the human health, protect the environment and efficient use of the resources. In order for addressing the challenges, *the GOA has adopted the country's strategic road map* for the national economy and has identified the main directions of environmental sustainability (GoA 2016). In general, according to this document the following areas are planned to be covered:

-Elaboration of evaluation system to assess the effects of climate change on agriculture and the development of adaptation measures; improvement of agrometeorological database; the further strengthening of coordination among the relevant bodies;

-Determination of the limits of the environmental regulations indicators in agricultural production, field protective forest planting, application of economic approach in environmental protection through expansion of green landscape territories, agro-biodiversity conservation, assessment of the potential for transition to "green economy" and use of alternative energy sources;

-Measures on improvement of mechanisms for efficient use of agricultural lands and water resources; elaboration of tools for assessment of environmental effects of the process of changing of the land designation; implementation of measures for land reclamation and re-cultivation; updating of soil maps, improvement of pasture management; reduction of water losses through repair of irrigation canals; improvement of functioning and reconstruction of collector - drainage networks to raise efficiency of land reclamation; water resources assessment and data provision, assessment and use of waste water; measures to improve water use in dry territories, construction of new irrigation canals and reservoirs, rain water collection and usage; improvement of management of mountain rivers, protective measures for surrounding settlements and sown areas;

-Development of legal base for enlargement of ecologically friendly agriculture production; implementation of pilot projects on organic farming, increase farmers' knowledge in this area and measures to support the establishment of farms; measures for the development of environmentally-friendly agricultural products market.

Based on the discussion above, considering worldwide and regional experience as well as current government efforts, the following set of the integrated and interlinked measures is proposed within current study:

Increasing the efficiency of land resources use: they include evaluation of soil fertility by advanced methods,

identification of trends of changes and evaluation of lands, cultivated under various crops; development of the legal framework acceleration of the consolidation of the small plots and establishment of the voluntary cooperative associations, development of system of incentives for this aim; introduction of piped irrigation and drainage systems to raise efficiency of land use and reduction of on- farm roads and canal systems density; crop rotation system to protect and enhance soil fertility; preference in application of the productive local seeds for high agriculture yields; soil protection against erosion and various natural phenomena can be provided by improvement of irrigation techniques and protective green zones; maintaining groundwater table below critical level through the construction of piped drainage system in areas with land salinization problem where proper regulation of groundwater regime is necessary;

Improving the efficiency of irrigation water use: Gradual improvement of entire water control and management system starting from water intake, conveyance, distribution and usage in the fields. To support this measure design and construction of the new generation irrigation systems, including introduction of lined canal systems, piped networks, application of automatic system for conveyance and distribution of irrigation water, especially mandatory installation of individual meters for water users (cooperatives) allowing for precise water consumption records; leveling of fields and other measures to encourage the development of advanced irrigation technologies; supply of sprinkling, drip irrigation equipment and improved surface technical facilities to cooperatives (landowners) on preferential terms; improvement of information-advisory systems for providing farmers regular information on accurate data on dynamics of moisture in the fields for the purpose of precise irrigation; usage of drainage water in irrigation of certain crops cultivated in less risky territories. These measures can make a significant contribution to save fresh water resources and protect them from pollution in the areas under the intensive farming.

Scientific support for the realization of the new agricultural policy in absolute term require branch experts to increase their scientific and practical knowledge and actively be involved in this process relevant to this declared policy. To this end, it is necessary to determine needs for raising the level of scientific-technical potential and logistical base, training of personnel and carry out financing on the basis of identified needs. And also, research and development programs should be focused on comprehensive solutions to address the existing problems in the particular area and must be provided up to the level of their practical implementation and use of their results. Consequently, the scientific research programs should be conducted jointly on the integrated basis by relevant scientific research institutions aiming to increase the efficiency of agriculture in certain areas. The programs of scientific research works should be discussed with both scientific institutions, and among all stakeholders (landowners, local environmental monitoring organizations, agriculture, irrigation and drainage service agencies and other relevant organizations) and to be agreed on the research questions and expected outputs. Coordinated and joint actions of the existing scientific potential can improve both quality of scientific research and the practical application of their findings and recommendations.

Due to the application of the modern technologies in design, construction, and operation of the environmentally and economically sound irrigation schemes, the strengthening of the universities with agriculture, irrigation, and water resource engineering facilities is necessary. This will ensure education and preparation of engineers, environment management specialist and planners with the advanced knowledge on the modern technologies applied in agriculture practices with consideration all currently existing constraints and challenges. To develop targeted exchange student programs with the advanced universities from developed and region countries deeply involved in investigations in the fields of irrigation, drainage technologies, irrigation water management, land development, environmentally responsive farming systems is advisable as one of the supportive measure for rapid success in the training of future specialists.

The above measures will be realized by preparing, discussing and adoption of the detailed implementation program with the indication of the amount of the required financing resources allocated by years, time deadlines and predefined indicative targeted results. This implementation plan should include the source of financing, participants and executers from both of the public and private sectors, structure of the targeted groups as well as direct beneficiaries. Especially institutional development for better governance at farm level (individual farmer- WUUs) up to the main irrigation systems (irrigation administrations) is essential to be considered in this plan in parallel to the physical rehabilitation works and new construction of the irrigation and drainage facilities, improvement of the land use structure, land consolidation, application of the modern farming practices and water resources management in irrigation, new irrigation technologies.

In addition to the expected positive environmental impacts, the indicative outcomes of the realized measures should also demonstrate improvements in farming system and rising of the economic indicators in the rural areas.

CONCLUSIONS

The rapid development of agricultural science and technology in the twenty-first century along with the population growth and the increasing demand for food creates broad possibilities for management of agricultural production while adhering to high environmental requirements, including in Azerbaijan Republic. The problems of agriculture in Azerbaijan originate from long time period of formation of the market relations in agriculture sector after abundant of planned economy, low productivity of agriculture due to deep fragmentation of the farmlands, out of date irrigation facilities,

insufficient application of the advanced technologies in irrigation management leading to increase of water losses and soil salinity, as well as due to the weak institutional and financial capacities of the peasant farms. Our review shows that new stricter environmental regulations in the use of land and water resources under intensification of agriculture in the EU and other countries with developed agriculture aimed of balancing environmental protection and the development of appropriate food systems has been already yielding the targeted positive results, although still requires incessant integrated actions for maximum benefits for the human habitat. But in some other regions, especially in developing countries these aims are still restricted due to insufficiency of financial and institutional capacities.

The discussion along the study proofs that the goals for the sustainable agriculture depends on the local conditions and capacities, for this reason the dimensions and targeted level of indicators are differ and inherent for each country. The main influencing factors on agriculture sustainability for this study have been identified on the basis of the above methodological principle. Based on the new agricultural policy, the government has lately adopted strategic road map for agriculture development and intensification in the country.

Our study proves that due to the insufficiency of the institutional, engineering and financial capacities, the process of the establishing environmentally-friendly farming systems in the country is recommended to be realized in stages. For this aim the content of the interlinked, mutually supportive integrated activities to comply with the economic, institutional and environmental requirements for agriculture development is proposed.

Thus, in the near period realization of environmentally-friendly, economically viable, health protective methods and practices in agriculture is the new targeted policy in Azerbaijan. Successful realization of this integrated task will create strong basis for maintain ecological balance in the use of resources for better future and provide more healthy environment and economic life in the areas under the intensive agriculture.

This case study brings experience for one country also considers comparative analyses on the efforts for the successful balancing of the agriculture development and environmental safety in other regions with different economic background, therefore provides with the practical example for the other emerging economies as well.

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