

# Integrated management of water and land resources of the Kyrgyz Republic and characteristics of their use at the present stage

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**Abstract.** This article discusses topical issues of the current state of water and land resources of the republic and their integrated management. They are one of the main natural resources that ensure the sustainable development of agricultural production and environmental safety in general. At the same time, they have their own characteristics in organizing the rational use and protection of resources. The main feature is that land and water function as single interdependent means of production in the agricultural production process in the foothill and highland relief of Kyrgyzstan. In this regard, the considered issues require a more detailed study and a scientific approach. The country is in dire need of modernization of land and water management. It is necessary to change toward culture and philosophy of attitude to land, to strengthen local land management institutions, complete the formation of the land market, and to treat water resources with care and rationality.

## 1 Introduction

The territory of the Kyrgyz Republic is mountainous, located at an altitude of 400 to 7439 m above sea level and has sufficient water reserves. Numerous ridges, alternating with intermountain valleys and depressions, create an extraordinary dismemberment of the territory. This contributes to the natural and climatic conditions in mountain areas, creates specifics, and affects the peculiarities in the organization of the use of water and land resources [1].

The Kyrgyz Republic is located in the arid zone, which is a natural zone for which the average rainfall is 100-200 mm per year, and the sum of temperatures is more than + 100 °C. The arid zone is dominated by a sharply arid type of water regime of the soil. The probability of dry years is more than 30%, which indicates that agriculture is possible only with irrigation. As noted, the climatic features of the republic determine the development of

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mainly irrigated agriculture, which is the most productive in these conditions [1]. A distinctive feature of water and land resources is their use precisely in the conditions of irrigated agriculture. Irrigated agriculture is associated with water resources that largely determine its development. Irrigation water sources for irrigation of agricultural crops are rivers of the Aral Sea basin, i.e. the Syr Darya and Amu Darya river basins [2]. In addition, these are the basins of the drainless rivers Chu, Talas, Assy, and other smaller watercourses.

The regular irrigation of crops accounts for 8615 million m<sup>3</sup> and the watering of pastures for 1.0 million m<sup>3</sup> in agricultural production. As you can see, the main water-consuming industry is irrigated agriculture (over 90% of all water resources used by the republic).

Irrigation is the most effective means of intensifying agriculture [3]. As a result of irrigation, the hidden properties of the land as the main means of production in agriculture begin to be actively manifested [4-5].

Agriculture is one of the priorities of the national economy, but there is persistent land degradation and soil erosion due to unsustainable land use and a lack of public investment in the agricultural sector. In the republic, the degree of land degradation and limited water resources have reached a critical level and taking into account the consequences of climate change, they require fundamental decisions and changes.

The state should form mechanisms for consolidating the fragmented structure of landowners and maximizing added value to stimulate their most efficient and rational utilization.

## **2 Materials and methods**

The manuscript includes data from scientific, official sources (Normative legal documents) of Kyrgyzstan. It also uses statistical data from different sources of published and unpublished reports of last (i.e., before the initiative of private ownership of land, in 1999) and described the present dynamic of land and water resources in our study.

The tables show long-term official data, where they were taken from research institutes: Kyrgyzgiprozem, the Kyrgyz Research Institute of Irrigation, and others, as well as reports from the state institution "Cadastre" and the Department of Water Resources of the Kyrgyz Republic (Tables 1-5).

The research was carried out using the methods of statistical empirical analysis based on the use of economic-calculative and comparative legal approaches.

## **3 Results and discussion**

Water resources have a multi-purpose use. The total value of the average long-term flow of the rivers of the country is 45-47 billion m<sup>3</sup> of water. At the same time, the republic uses only about 20% of the flow. The rest of the runoff is used by neighboring states. Therefore, the rivers of the republic are mostly transboundary. On average, water from water bodies in the amount of 12,297 million m<sup>3</sup> is taken for economic needs in the republic. The total volume of withdrawn water is used in industry (162 million m<sup>3</sup>), in agriculture (11836 million m<sup>3</sup>), in housing and communal services (236 million m<sup>3</sup>), and in other industries (63 million m<sup>3</sup>).

The total area of irrigated agricultural land as of January 1, 2020, is 871.3 thousand hectares. Of these, the largest area falls on irrigated arable land, which occupies 795.0 thousand hectares.

Irrigation is the most effective means of agricultural intensification. As a result of irrigation, the hidden properties of land as the main means of production in agriculture begin to actively become evident.

At the present time, water taken for irrigation is used irrationally. Here there is a technical, economic, and organizational-territorial aspect of the problem. Thus, when transporting water through the main channels, 20% of the water intake from the head structure is lost, and 5% is due to other losses outside agricultural land use. The largest percentage (50%) is due to losses in domestic channels. These are transportation and operational losses.

Organizational and territorial problems of irrational use of land and water can be attributed to non-compliance with water-saving technologies during irrigation. Therefore, on irrigated lands with an area of about 1 million hectares, the used volume of water per hectare in the republic is 9670 m<sup>3</sup> while the average irrigation rate is 4860 m<sup>3</sup>.

The balanced use of water and land thus contributes to their rational use and protection. The main feature here is that in the process of agricultural production, land and water function as a single interdependent means of production. The main criterion for the efficiency of land and water use is the degree of interaction between land use and water use on agricultural lands [6-7].

The peculiarities of water and land use are as follows:

- a significant part of the republic's total area is agricultural land of 10460.2 thousand hectares or 52.3%, which indicates the agricultural reclamation of the territory;
- the use of water resources is aimed at meeting the needs of the population in drinking water and household needs. Most of it comes from agricultural irrigation and pasture watering;
  - among agricultural lands, the largest share is arable land 11.6% (1212.1 thousand ha) and pastures 86.1% (9005,8 thousand ha);
  - the most valuable arable land, which in the conditions of the republic is divided into two subspecies - irrigated and rich arable land;
  - -due to natural-climatic and geomorphological conditions, irrigated arable land is largely subject to soil-reclamation disorder;
  - natural pastures are owned by the State and are used under conditions of use for cattle breeding, taking into account the season of grazing [8-9].

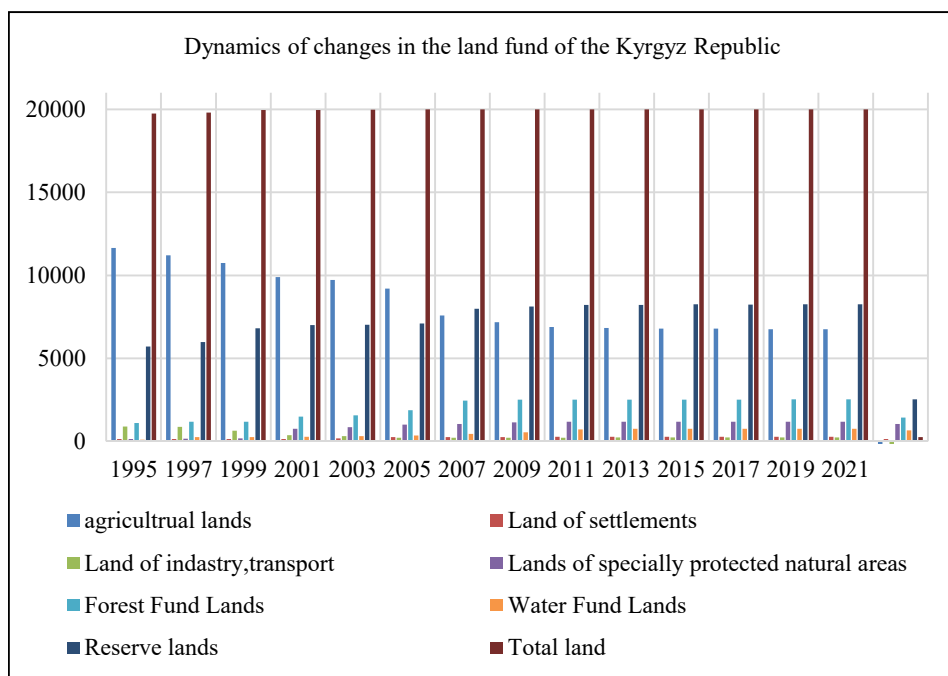
Within the state borders of the Kyrgyz Republic, there are 19995.1 thousand hectares, while 19994.9 thousand hectares are in use (table 1). This is a characteristic feature of the use of the land fund of the republic. Due to physical, geographical, and natural-climatic conditions, the republic has to use land in the territory of neighboring states. This is the so-called exorbitant (inordinate) land use. At the same time, other states use land plots on the territory of the Kyrgyz Republic. Such land use is provided by interstate government agreements [10-11].

Since 1999, land reform has been carried out in the republic. At the beginning of its implementation, there were problems in the use of land and in the organization of land use that needed to be solved. Land reform caused the processes of land redistribution, reorganization, and rearrangement of agricultural land use, and differentiation of land use areas.

As a result of agrarian reform, significant changes have occurred in the use of the land fund by land category (Table 1).

**Table 1.** Republican Land Fund by land category [11].

Land fund categories	Years				Divergence +, -
	1995		2021		
	thous. ha	%	thous. ha	%	
Agricultural lands	11647,1	59,0	6752,8	33,4	- 4894,3
Land of settlements	137,4	0,7	278,3	1,4	+ 140,9
Lands of industry, transport, communications, defense, and other purposes	888,8	4,5	231,9	1,2	- 656,9
Lands of specially protected natural areas	145,1	0,7	1187,5	5,9	+ 1042,4
Forest Fund Lands	1107,1	5,6	2529,9	12,7	+ 1422,8
Water Fund Lands	93,7	0,5	767,3	3,8	+ 668,6
Reserve lands	5721,0	29,0	8247,3	41,3	+ 2526,3
Total land	19740,2	100	19994,9	100	-



**Fig. 1.** Dynamics of changes in the land fund of the Kyrgyz Republic (1995-2021 years) [12]

Note: Report data (Form 22 and Form 22a) are taken from the design institute Kyrgyzgiprozem from 1995 to 2021). The state (national) report on the state and use of the land fund of the Kyrgyz Republic as of January 1 in the form of text and graphic materials is submitted every year to the Government of the Kyrgyz Republic for approval. Article 106 of the Land Code of the Kyrgyz Republic states: The state (national) report (Form 22 and form 22a (availability of irrigated land)) is compiled annually and includes information on the quantitative and qualitative state of the land, their assessment in the whole country

and in the context of administrative-territorial formations, their distribution by categories, types of property and other information.

In particular:

- a reduced area of agricultural land by 4894.3 thousand hectares by transferring to other categories of land, in particular to settlements and reserve lands;
- the land area of settlements has increased significantly. To solve housing problems, land with an area of 140.9 hectares was provided;
- forest lands increased by 1422.8 thousand hectares due to forests that were previously in the long-term use of agricultural enterprises;
- increased the land area of the reserve by 2526.3 thousand hectares by including the area of natural pastures under state ownership.

Changes in the composition of land categories [11-13] have occurred as a result of ongoing land management actions to implement the Laws of the Kyrgyz Republic, Decrees of the President of the Kyrgyz Republic, and Decrees of the Government of the Kyrgyz Republic on the implementation of land reform.

When implementing regulatory legal documents, land management actions were carried out to maintain an inventory and classification of all land lands, work on the reorganization of collective farms and state farms and the formation of new economic entities of a market type, an inventory of the lands of settlements with the definition of their external borders and other land management measures [12-13].

For the territorial quantitative and qualitative characterization of land, a unified classification of land in the Kyrgyz Republic has been introduced. The land is recorded according to its actual condition and use.

Table 2 shows the distribution of agricultural land in the Land und of the republic.

**Table 2.** Distribution of agricultural land [11].

Across the republic	Total area in thousand , ha	Including agricultural land					Total agricultural land
		arable land	perennial plantings	fallow	hayfields	pastures	
Total	19994,9	1212,1	37,7	34,8	169,9	9005,8	10460,2
Including arable land	1024,7	795,0	37,1	1,7	8,7	28,7	871,3

Irrigated arable land is the most valuable and intensive type of land. Thus, the estimated productive capacity of one hectare of irrigated arable land, expressed in the cost of gross crop production, exceeds the productive capacity of one hectare of rain-fed arable land by 2.5-3 times. Although irrigated land is more capital-intensive and requires significant expenditures compared to rain-fed land.

Irrigated arable land is located in the lowland part of valleys and depressions and is a large compact massif. They differ among themselves in hypsometric, hydrothermal, and soil conditions. At the same time, they have common features, since they are characterized by a desert or dry-steppe climate regime, which entails a lack of humidification.

Irrigated land is land that is suitable for agricultural use and irrigation, where there is a permanent or temporary irrigation network connected to the source of irrigation and whose water resources provide irrigation of agricultural crops in a timely manner and according to established standards [14].

Based on this definition, depending on the presence of irrigation water in a particular year, irrigated arable land is divided into regularly irrigated and conditionally irrigated. Regularly

irrigated arable land is the arable land for which, with the adopted composition of crops, water is supplied in the necessary quantities (according to established standards) and within the established time frame.

Conditionally irrigated arable land is considered to be the one where crops are not provided with irrigation water in sufficient quantity according to the established standards throughout the growing season.

All technical crops, melon vegetables, potatoes, more than 60% of cereals, and about 50% of fodder crops are cultivated on irrigated arable land.

Rainfed arable land is land plots whose productive capacity depends on the amount of precipitation. It occupies separate parts of foothills and low mountains, slopes, saddles, peaks, hills, inter-valley hollows, and river hilly terraces, and forms a certain high-altitude zone. Rainfed arable land is characterized by a divided terrain with significant slopes and they differ in size and configuration.

The high-altitude location determines the different classifications of rainfed lands. There is an unsecured bogara when the amount of precipitation per year is 110-280 mm. This indicator is 280 – 350 mm for a semi-secure bogara, and 350 - 400 mm per year for a well-off bogara.

Only drought-resistant grain crops and annual grasses are cultivated on rain-fed arable land. It should be noted that agricultural land, especially irrigated land, is subject to overexploitation and anthropogenic impact, which affects the development of degradation processes and reduces their biological and economic productivity.

On the other hand, the presence of large ridges, intermountain depressions, sharp continental, and dry climates, various humidification by atmospheric sediments, the activity of denudation processes, the variety of soil-forming rocks, the wide distribution of both surface and underground waters, the nature of their movement and accumulation depending on geomorphological and hydrogeological conditions determine the soil land reclamation state [15].

Among the irrigated areas of the republic, there are land plots of saline and saltwater lands. Moreover, saline lands are often found in the form of complexes. Many areas of irrigated land in the foothill zone are replaced.

Table 3 shows the general characteristics of the distribution of land subject to soil reclamation in the context of the administrative-territorial formations of the republic. The characteristics are based on irrigated agricultural land of agricultural land use.

**Table 3.** Characteristics of soil reclamation state of irrigated land, thousand hectares [11].

Regions	The total area of irrigated agricultural land	Land reclamation				
		salinization	alkalinity	stoniness	wind erosion	water erosion
Jalal-Abad	94,7	3,3	0,2	26,2	92,0	134,9
Issyk-Kul	139,1	16,0	0,6	23,4	130,9	92,3
Naryn	111,1	16,1	11,5	44,7	76,0	217,7
Osh, Batken	136,6	19,0	3,0	49,6	119,5	111,9
Talas	91,0	5,6	6,5	13,6	94,2	73,9
Chuy	275,2	160,0	60,0	38,6	138,5	134,9
<b>Total across republic</b>	849,1	220,0	81,8	196,1	651,1	765,6

A cadastre of land reclamation status as of 1 November of the relevant year is maintained annually in the Kyrgyz Republic.

The cadastre is maintained by structural divisions of the Reclamation hydro-melioration expedition.

The characteristics of the main indicators for the area are taken from maps of groundwater level (GWL), mineralization of groundwater, soil salinization, reclamation status, and reclamation measures aimed at improving them, which are updated annually in the middle of the growing season. The cadastre consists of two main blocks: the state of the land and measures to improve it.

The state statistical form 22A “Report on the availability of irrigated land in the Kyrgyz Republic and its distribution by categories, owners, land users and land plots” is the basis of the cadastre of the reclamation state of irrigated land.

According to the cadastre of the reclamation state of irrigated lands, out of the total area of the republic's irrigated lands, 872337 ha are in good condition, 61983 ha are in satisfactory condition, and 89688 ha are in unsatisfactory condition. Including: due to the close occurrence of the groundwater level (GWL) – 30820 ha; due to soil salinization-50624 ha; in combination with unacceptable GWL and soil salinization – 8244 ha (Table 4).

**Table 4.** Reclamation state of irrigated lands of the republic, thousand hectares [11].

Regions of the republic	Total area of irrigated land		Reclamation status of irrigated land					
			good		satisfactory		unsatisfactory	
	1996	2020	1996	2020	1996	2020	1996	2020
Jalal-Abad	131,0	125,0	128,7	119,7	0,3	2,5	2,0	2,8
Issyk-Kul	169,3	156,6	158,1	139,3	6,2	6,2	5,0	11,1
Naryn	129,3	120,5	107,8	98,4	12,0	12,0	9,5	10,0
Osh, Batken	198,6	187,5	186,9	176,3	3,7	4,3	8,0	6,7
Talas	115,1	112,8	100,0	98,5	5,1	8,1	10,0	6,2
Chuy	330,5	321,6	237,0	239,0	36,7	28,8	56,8	52,8
<b>Total across the republic</b>	1073,9	1024,0	918,5	872,3	64,0	62,0	91,3	89,7

Table 4 shows that during the period of 1996-2020 the area of irrigated land in the republic decreased by 49.9 thousand hectares, including 46, 2 thousand hectares in good land reclamation condition. The availability of land with unsatisfactory land reclamation status is associated with an increase in groundwater levels in irrigated areas of agricultural land. The level of groundwater increases primarily due to the unsatisfactory technical condition of the reservoir drainage and irrigation network, and non-compliance with the irrigation regime of crops.

It should be emphasized that today's satellite systems and technologies for data collection, processing, and dissemination provide the low-cost solutions needed to ensure the payback of remote crop monitoring systems [16-17-18-19].

Due to reduced investment and lack of repair of irrigation and drainage systems, the area of reclamation and poor land is increasing. The creation of a common monitoring system for irrigated areas is necessary to solve environmental, economic, and social problems in the country. This requires, first of all, the development of methodological issues and the solution of technological problems. This work should be based on modern scientific and technical achievements, including the materials of modern surveys and new technologies for working with them. Currently, the monitoring system is being created in Kyrgyzstan with the support and funding of the state and international communities.

One of the main types of economic activity in the republic is animal husbandry, with the use of cheap pasture feed, which makes up 90% of the animals' diet. Grazing land in the Land fund of the republic covers 9.1 million hectares or 84% of the agricultural land, or

45% of the territory of the republic. The area of pastures is seven times the area of arable land. This is due to the highly divided terrain and height above sea level, which limits the plowing of the territory and the set of cultivated crops.

Pastures are located in various natural and climatic zones, in tracts, often isolated and separated from each other. The determining factors here are the terrain, elevation above sea level, and climate. The mountain topography and the associated differences in climatic conditions at different altitudes determined the distribution of pastures by altitude and vegetation type, which is subject to the laws of high-altitude zoning.

Therefore, pastures here are classified as high-altitude (2600-4000 m above sea level), medium-altitude (1700-2600 m), and foothill (600-1700 m). Since different types of plants adapt to the prevailing natural conditions, this circumstance makes it necessary to classify pastures by vegetation types (cereals, legumes, sedge), and by the nature of vegetation – desert, semi-desert, steppe, meadow-steppe, and meadow pastures.

For the organization of rational use and protection of natural pastures, there is a classification by season of use.

Summer pastures are located at an altitude of more than 2500 m above sea level. They cover 5.1 million hectares or more than half of the total area of natural pastures. These pastures are predominant both in the area and in feed reserves. The yield of these pastures in dry food mass is 5.5 C/ha on average and this is the main reserve for livestock production, mainly sheep.

Pasture lands are located at altitudes from 600 to 4000 m above sea level. Almost a third of the area (2.5 million ha) is covered by spring and autumn pastures. They are mainly concentrated in the agricultural zone and are located along the plumes of mountains and foothills at an altitude of 500-2000 m above sea level. The average yield of these pastures is 3.9 c/ha in dry food mass. The greatest load on these pastures falls on the spring period before the cattle are driven to the summer pastures. Winter pastures cover 1.4 million ha or 16% of the total pasture area. On these pastures, not only the area is not large, but also their yield, which is 1.7 c/ha in the dry mass eaten. The main conditions for winter grazing are little or no snow cover (Table 5).

The seasonality of pasture use was determined by the distant pasture of animal husbandry. This system is typical for mountainous areas. Here the animals spend most of the year on pastures and are driven from one seasonal pasture to another.

In Soviet times, natural pastures were transferred for long-term use to collective and state farms, and a scheme for using pastures was formed. This was a well-balanced scheme for the seasonal use of pasture land. The developed management system regulated the movement of more than 9 million sheep and goats between spring and autumn, and summer and winter pastures.

**Table 5.** Characteristics of pasture area and productivity [11].

Season of use	Area, thousand ha	%	Feedstock, thousand centners		Environmentally sound livestock, thousand heads
			Dry weight	Feed units	
Total pastures	9184,1	100	3975	21678	6022
Spring-autumn	2494,8	27	12121	6786	1885
Summer	5138,6	57	23175	12364	3435
Winter	1438,3	16	4458	2528	702

During the land reform process, natural pastures remained in state ownership. In the first stages of the reform, it was supposed to transfer pasture plots for use by individuals and legal entities on lease terms. A "Regulation on the procedure for leasing and using pastures" was developed.



The unsatisfactory economic condition of pastures began to affect them. They have been subjected to various types of degradation, which leads to the destruction of the grass stand and to the loss of natural and economic significance. The results of monitoring rangeland resources conducted by the project Institute “Kyrgyzgiprozem” was established: 1661 hectares are affected by degradation to a great extent; 416 thousand hectares affected by the erosion of different degrees; 397 thousand hectares are located on steep slopes (40 degrees or more); 1554 hectares bushed; 1154 hectares clogged necrovile herbs; 1500 thousand hectares rocky; 1458 thousand ha are considered to be relatively clean.

With proper management of pastures, taking into account regulated grazing and applying calculations of optimal loads, the existing livestock can be grazed without compromising the environment. To solve this problem, the Law of the Kyrgyz Republic “On pastures” was adopted in 2009 [7].

According to this law, responsibility and control over pasture management, in addition to the right of disposal, is transferred to local self-government bodies. A local government body has the right to delegate its powers to Pasture Users’ Associations. The Executive body of the Association is the Pasture Committee. Its powers include functions defined by land legislation. In particular, from the point of view of land management actions, it is possible to draw up a map of a pasture plot, which indicates the external and internal borders of pastures, their areas, protected areas, cattle run, watering areas, and other items of pasture infrastructure.

There is a fee paid for the use of pastures. It is set annually for each pasture system and for each type of pasture use. The establishment of pasture fees and collection of fees for use of pastures is vested in the Pasture Committee. The funds from the payment are allocated for the improvement of pastures and other expenses determined by the Pasture Committee.

## **4 Conclusions**

It is necessary to conduct an inventory of the land fund of the republic and draw up an updated land cadastre, audit the entire land fund owned by the state, and form new mechanisms for providing land for temporary use with the involvement of strategic investors;

During the years of independence, the country has experienced a number of political upheavals, which are the result of a number of unresolved deep social crises, injustice in the distribution of land resources;

Stimulation and state support for the introduction of new lands into agricultural production by developing unproductive lands, foothill, and sloping lands, improving the reclamation state of agricultural lands;

The concern is caused by the level of degradation of pasture lands, excessive and unregulated grazing and deforestation in the context of global climate change, extensive agricultural production;

The poor current state of the irrigation infrastructure requires attention and speedy rehabilitation and further development. The main problems are the lack of effective management of water resources in market conditions, the poor technical condition of the irrigation infrastructure due to deterioration of facilities, lack of funds for repairs and maintenance, as well as the construction of new facilities;

As part of the renewal of the Land Code of the Kyrgyz Republic, it is necessary to revise and lay down the norms that contribute to the liberalization of the land market, as well as the rational use of agricultural land (withdrawal, alienation, acquisition, pledge, appraisal) [20];

The state should form mechanisms for consolidating the fragmented structure of land owners and maximizing added value to stimulate their most efficient and rational exploitation and eliminate land degradation;

Lack of highly qualified personnel due to low wages in the state structures of the country's land and water management and high migration;

Development and improvement of the legal framework for the water sector;

Strengthening the legal framework and mechanisms to promote sustainable land and water management.

With the support of international organizations, sectoral programs and projects are being implemented in the Republic aimed at restoring the productivity of degraded lands, and preserving the value and economic efficiency of the use of agricultural land and water resources.

Integrated management of water and land resources can be defined as a management system based on taking into account all possible sources of water and land, linking intersectoral interests and all levels of the hierarchy of water use, the hydrographic method, the broad involvement of all water users and the rational use of water and land resources, ensuring environmental safety and conservation of ecosystems in general [21].

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