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## LAND USE SUSTAINABILITY AND INTENSITY IN THE SHANGHAI COOPERATION ORGANIZATION: A COMPARATIVE ASSESSMENT

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**Annotatsiya.** Birinchi marta FAO va milliy statistik xizmatlarning yangilangan ma'lumotlari asosida SHHT yer balansidagi o'zgarishlarning tarkibiy tahlili o'tkazildi. Erlarning o'zgarishi vektori va agrar tabiatdan foydalanishning keskinlik darajasi bilan ajralib turadigan ishtirokchi mamlakatlarning to'rtta agroekologik klasterlarini ajratish asoslidir. ShHTning o'rtacha og'irlikdagi ko'rsatkichlari mintaqalararo chuqur qarama - qarshiliklarni yashirishi ko'rsatilgan-haddan tashqari yuqori shudgorlashdan tortib keng yaylovli erdan foydalanishgacha. Tadqiqot natijalaridan SHHT biznes kengashi va ishtirokchi mamlakatlarning ixtisoslashgan vazirliklari tomonidan oziq-ovqat xavfsizligi, "yashil" qishloq xo'jaligi va transchegaraviy suv-yer resurslarini boshqarish bo'yicha hamkorlik bo'yicha yo'l xaritalarini ishlab chiqishda foydalanish mumkin.

FAO va milliy statistika xizmatlarining yangilangan ma'lumotlari asosida birinchi marta SHHT yer balansidagi o'zgarishlarning tarkibiy tahlili o'tkazildi. Qog'oz ishtirokchi mamlakatlarning to'rtta agroekologik klasterlarini aniqlashni asoslaydi, ular erni o'zgartirish yo'nalishi va qishloq xo'jaligining ekologik bosimi darajasida farqlanadi. ShHTning o'rtacha og'irlikdagi ko'rsatkichlari mintaqalararo chuqur qarama-qarshiliklarni yashirayotgani, haydaladigan yerlarning o'ta yuqori darajasidan tortib, yaylovlardan keng foydalanishgacha. Tadqiqot natijalaridan SHHT ishbilarmonlar Kengashi va ishtirokchi mamlakatlarning tegishli vazirliklari oziq-ovqat xavfsizligi, yashil qishloq xo'jaligi, suv va yer resurslarini transchegaraviy boshqarish sohalarida hamkorlik uchun yo'l xaritalarini ishlab chiqishda foydalanishlari mumkin.

**Abstract.** Based on updated data from the FAO and national statistical services, for the first time, a structural analysis of changes in the SCO land balance was carried out. The paper justifies the identification of four agroecological clusters of participating countries, which differ in the direction of land change and the level of environmental pressure of agriculture. The SCO's average weight figures are obscuring interregional deep opposites, ranging from extreme levels of arable land to extensive use of grazing land. The results of the study can be used by the SCO Business Council and the relevant ministries of the participating countries to develop



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road maps for cooperation in the areas of food security, green agriculture, water and land resource cross-border management.

**Аннотация.** На основе обновленных данных ФАО и национальных статистических служб впервые был проведен структурный анализ изменений в земельном балансе стран ШОС. В статье обосновывается выделение четырех агроэкологических кластеров стран-участниц, которые различаются направлением изменения земель и уровнем нагрузки сельского хозяйства на окружающую среду. Средние показатели по весу стран ШОС скрывают глубокие межрегиональные противоречия, варьирующиеся от экстремальных уровней пахотных земель до экстенсивного использования пастбищ. Результаты исследования могут быть использованы Деловым советом ШОС и соответствующими министерствами стран-участниц для разработки дорожных карт сотрудничества в области продовольственной безопасности, экологически чистого сельского хозяйства, трансграничного управления водными и земельными ресурсами.

**Kalit soʻzlar:** er resurslari, barqaror erdan foydalanish, erdan foydalanish intensivligi, Shanxay hamkorlik tashkiloti (SHHT), qishloq xoʻjaligini rivojlantirish darajasi, oʻrmon qoplami, shudgorlangan er nisbati, ekin ekish intensivligi darajasi, mamlakat tipologiyasi, oziq-ovqat xavfsizligi, Klaster tahlili.

**Keywords:** land resources, sustainable land use, land use intensity, Shanghai Cooperation Organization (SCO), agricultural development rate, forest cover, plowed land ratio, cropping intensity ratio, country typology, food security, cluster analysis.

**Ключевые слова:** земельные ресурсы, устойчивое землепользование, интенсивность земледелия, Шанхайская организация сотрудничества (ШОС), сельскохозяйственная освоенность, лесистость, распаханность, коэффициент интенсивности возделывания, типология стран, продовольственная безопасность, кластерный анализ.

### INTRODUCTION

Amid escalating global climate change and increasing geopolitical turbulence, the sustainability of land resource use is transitioning from a purely environmental concern to a critical factor in ensuring food and national security. The land fund simultaneously serves as the spatial basis for economic activity, the primary means of production in agriculture, and a key component of biospheric carbon cycles. The Shanghai Cooperation Organization (SCO), which unites countries with a combined territory of approximately 35 million km<sup>2</sup> and a population exceeding 3 billion people, constitutes a unique testing ground for studying global and regional land-use trends.

The theoretical and methodological foundations for analyzing land-use sustainability were established in the seminal works of international scholars who have shaped the scientific discourse in agrarian economics, land management,





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geoecology, soil science, agrochemistry, and related disciplines [1, 2, 3]. In the international literature, considerable attention is devoted to the concept of Global Land Use Change [4]. In particular, issues of Land and Environmental Sustainability are actively investigated [5, 6, 7, 8]. The majority of existing studies, however, examine national land-use systems in isolation or within the confines of traditional micro-regions [9, 10, 11]. While the mainstream SCO research agenda has predominantly focused on political cooperation, energy security, or transport logistics, new scholarly contributions in the field of land management are beginning to emerge [12]. A relatively novel direction involves comprehensive studies that consider the SCO space as a unified object of land-use analysis [13]. The fundamental framework for assessing the intensity and sustainability of agricultural natural resource management is enshrined in the publications of the Food and Agriculture Organization (FAO) and various international research consortia [14].

Research concerning the SCO member states is being conducted by leading institutions, including the Xinjiang Institute of Ecology and Geography of the Chinese Academy of Sciences, the Indian Council of Agricultural Research (ICAR), the Kazakh Research Institute of Agricultural Economics and Rural Development, the Institute of Water Problems and Hydropower Engineering of Kyrgyzstan, the Institute of Geography of the Russian Academy of Sciences, the V.V. Dokuchaev Soil Science Institute, and other academic organizations and universities.

Nevertheless, a distinct deficit of comprehensive cross-national comparative studies specifically focused on the SCO region persists. This gap can be attributed both to the relative youth of the organization as an economic integration bloc and to the considerable challenges associated with the collection and harmonization of statistical data across the diverse member states.

The aim of this study is to provide a quantitative and qualitative assessment of the sustainability and intensity of land resource use within the SCO countries. This assessment is based on an analysis of structural changes in the land balance over the period 2010–2023 and a comparative evaluation of key indicators of anthropogenic pressure.

### MATERIALS AND METHODS

The empirical foundation of this study comprises official statistical data on the state and structure of land resources published by specialized agencies of the United Nations and national statistical services. Primary data on land area categories (total land area, forest land, agricultural land, cropland, permanent meadows and pastures, and other land) for the years 2010 and 2023 were aggregated from the FAOSTAT database of the Food and Agriculture Organization of the United Nations.

The object of the study is the aggregate land resource base of the ten SCO member states (within the boundaries as of early 2026). The temporal scope of the analysis spans the period from 2010 to 2023. This interval enables the identification



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of medium-term structural shifts in land-use patterns driven by both the implementation of national development programs and overarching global climatic and economic trends.

To quantitatively assess the sustainability and intensity of land resource use, a suite of relative indicators was calculated based on unified formulas using absolute land area values: *Land Agricultural Development Rate (LADR)* — the share of agricultural land in the total land area of a country or region, expressed as a percentage; *Forest Cover (FC)* — the share of forest land in the total land area, expressed as a percentage; *Plowed Land Ratio (PLR)* — the share of cropland within the agricultural land area, expressed as a percentage; *Cropping Intensity Ratio (CIR)* — the ratio of the harvested area of agricultural crops to the physical area of arable land.

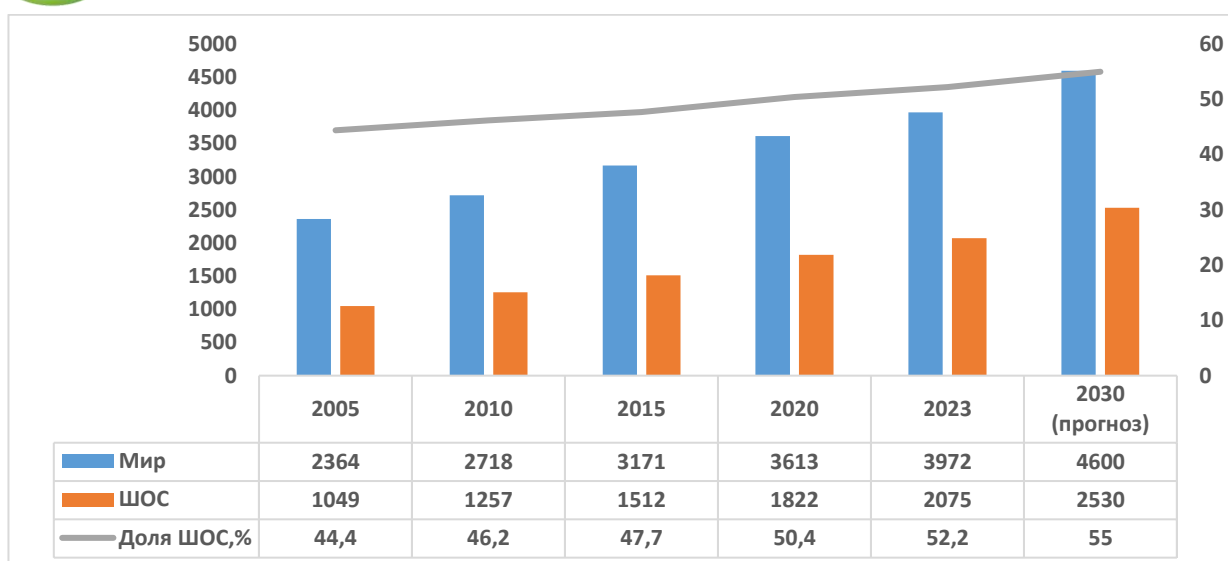
**Data Processing and Analytical Methods.** The processing and interpretation of quantitative data were conducted using the following methods: Comparative Geographical Analysis; Balance-Structural Method; Cluster Analysis (Agroecological Typology) - based on a matrix of normalized values for the four indicators (LADR, FC, PLR, CIR), the SCO countries were grouped into homogeneous clusters according to their land-use types. The delineation of clusters was performed using an expert-statistical method that incorporated threshold values of the indicators (e.g., critical plowed land ratio > 80%, low forest cover < 10%, high cropping intensity > 1.2). All statistical processing and calculations were performed using the MS Excel software package.

### RESULTS AND DISCUSSION

Agriculture (inclusive of forestry and fisheries) plays an exceptionally significant role in the economies of the SCO member states. The dynamics of the sector's value added (Figure 1) demonstrate that whereas the SCO's share of global agricultural value added stood at USD 1,049 million (in constant 2015 prices), or 44.4%, in 2005, it is projected by the author to reach approximately USD 2,530 million (or 55%) by 2030. Such a substantial increase is contingent upon the organization of sustainable and intensive land resource use as a fundamental economic factor.



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**Fig. 1. Value added of agriculture, forestry and fishing (USD million, 2015 prices)\***

*\*Source: Compiled by the author based on FAOSTAT data*

We now turn to a quantitative analysis. Changes in the extent and structure of land resources within the SCO countries and globally are presented in Table 1. First and foremost, we note the increase in the SCO's share of global forest area to 28.34% (+1.15 percentage points). This indicates that the economic growth of the member states over the past decade has been coupled with an expansion, rather than a depletion, of ecological capital. In discussions concerning the relationship between GDP growth and environmental degradation in developing economies, this observation may serve as an important counterargument. It should be emphasized that three SCO countries—Russia, China, and India—account for over 90% of this increase. This finding correlates with FAO data on large-scale state afforestation programs (e.g., China's "Green Wall" program, the Russian Federation's National Project "Ecology," and various environmental initiatives in Uzbekistan).

Agricultural land and cropland dynamics determine the direction and outcomes of the ongoing transformation of farming models. A key contradiction observed here is the reduction in the SCO's total agricultural land area (-10.6 Mha), concurrent with a decline in the share of cropland within the SCO's land structure (from 14.8% to 14.7%) and a decrease in the SCO's proportion of global cropland (from 33.96% to 32.53%). We posit that in this context, it is essential to consider intensification as an alternative to extensification. The reduction of 5.4 Mha of cropland within the SCO has not precipitated a food crisis in the region. It can be concluded that the SCO is completing the phase of "virgin land expansion" and entering a phase of "land bank optimization."



Table 1

**Structure of Land Resources in the SCO Countries and the World\***

	Shanghai Cooperation Organization - SCO (10 countries)				World			
	2010		2023		2010		2023	
	Mha	%	Mha	%	Mha	%	Mha	%
Total land area	3484.4	100.0	3480.9	100.0	12982.5	100.0	12993.5	100.0
Forest land	1116.7	32.0	1146.2	32.9	4106.3	31.6	4043.9	31.1
Agricultural land	1271.2	36.5	1260.6	36.2	4793.8	36.9	4800.9	37.0
Cropland	516.6	14.8	511.2	14.7	1521.0	11.7	1571.4	12.1
Permanent meadows and pastures	754.6	21.7	749.4	21.5	3272.8	25.2	3229.5	24.9
Other land	1096.5	31.5	1074.1	30.9	4082.4	31.4	4148.7	31.9

\*Source: Compiled by the author based on FAOSTAT data

Within the SCO, a reduction in the area of permanent meadows and pastures is observed (-5.2 Mha), which aligns with the global trend (-43.3 Mha). This may be attributable to the degradation of arid zones in Central Asia (notably Kazakhstan and Uzbekistan) and the conversion of a portion of forage lands into fallow.

The "Other land" category can be regarded as an indicator of economic recultivation activity. The uniqueness of the SCO data lies in the observed contraction of this land category by 22.4 Mha (from 1,096.5 to 1,074.1 Mha), contrasting sharply with a global increase of 66.3 Mha. These findings can be interpreted as follows: in global practice, the "Other land" category often expands due to urbanization and agricultural land abandonment. Conversely, the SCO member states exhibit a negative trend for this balance sheet item. This likely signifies the reclamation of unused lands into economic turnover (either through afforestation or agricultural use) and a relative deceleration of desertification rates compared to global averages (facilitated, for instance, by China's climate mitigation projects in the Gobi Desert). Consequently, the land balance of the SCO is trending towards greater equilibrium, marked by a reduction in the proportion of unproductive lands.

An analysis of the land balance allows for the reconstruction of land redistribution flows within the SCO for the period 2010–2023. The total decrease in non-forest categories amounts to approximately 33 Mha, comprising reductions in cropland (-5.4 Mha), meadows and pastures (-5.2 Mha), and other land (-22.4 Mha). In contrast, forest land registered a net gain (+29.5 Mha). The residual balance difference of approximately 3.5 Mha can be attributed to adjustments in the total



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land area due to the refinement of water body and coastline boundaries, as well as statistical discrepancies. The primary land-use trajectory for the SCO is, therefore, agroforestry amelioration, facilitating the withdrawal of lands from low-productivity agricultural rotation and the "other" category for transfer to the forest fund.

An analysis of SCO countries by land-use typology enabled the delineation of four distinct agroecological clusters.

**Cluster 1. Forest-Industrial with Extensive Agriculture (Russia, Belarus).** This cluster is characterized by a low Land Agricultural Development Rate (LADR) (13–40%), high Forest Cover (FC) (>43%), a moderate Plowed Land Ratio (PLR), and a low Cropping Intensity Ratio (CIR) (<0.55). Russia represents a unique case within the SCO. While possessing the lowest agricultural development rate (13.2%), the country concentrates half of its land fund under forest cover (49.8%). A cropping intensity ratio of 0.53 indicates the prevalence of bare fallow and monoculture practices in zones of risky farming (characterized by a single harvest every two years on certain plots or the dominance of fallow land). Belarus exhibits a higher development rate (39.6%) and a very high plowed land ratio (70.4% of agricultural land) alongside substantial forest cover. This represents an example of a balanced model featuring advanced farming culture and the preservation of an ecological framework.

**Cluster 2. Agrarian-Intensive (China, India, Pakistan).** This cluster is defined by high LADR (>46%), an exceptionally high PLR (>86% in India and Pakistan), and a CIR exceeding 1.29 in two of the three countries. India and Pakistan demonstrate critical levels of agricultural land plowing (94.3% and 86.1%, respectively). This implies a near-total absence of natural forage lands (pastures). Livestock husbandry in these contexts is sustained either through stall-feeding reliant on imported fodder or through grazing on degraded "other lands." The cropping intensity ratios (1.29 and 0.74) indicate a high anthropogenic load on the soil cover. China presents a more balanced structure (PLR = 24.6%), reflecting significant pasture areas in Inner Mongolia and Tibet. A key indicator is its CIR of 1.43—the maximum recorded within the SCO—attributable to the widespread deployment of irrigation and multi-cropping technologies in the southern provinces.



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Table 2

**Indicators Characterizing the Sustainability of Land Resource Use in the SCO Countries and the World\***

	Land agricultural development rate (LADR), %	Forest cover (FC), %	Plowed land ratio (PLR), %	Cropping intensity ratio (CIR)
Belarus	39.6	43.4	70.4	0.54
China	55.3	23.9	24.6	1.43
India	60.1	24.5	94.3	1.29
Iran (Islamic Republic of)	29.0	6.7	37.4	0.67
Kazakhstan	79.4	1.3	13.9	0.68
Kyrgyzstan	54.0	7.1	13.2	0.69
Pakistan	46.7	4.7	86.1	0.74
Russian Federation	13.2	49.8	57.3	0.53
Tajikistan	28.0	3.1	27.0	0.82
Uzbekistan	58.1	8.6	17.5	0.75
<b>SCO</b>	36.2	32.9	40.6	1.04
<b>World</b>	36.9	31.1	32.7	0.95

\*Source: Compiled by the author based on FAOSTAT data.

Cluster 3. Arid-Pastoral (Kazakhstan, Kyrgyzstan, Uzbekistan, Tajikistan). This cluster is characterized by low or moderate FC (<10%), low PLR (<20%, with the exception of Tajikistan), and a CIR < 1.0. Kazakhstan records the maximum LADR in the SCO (79.4%) alongside minimal forest cover (1.3%) and an extremely low plowed land ratio (13.9%). This represents a classic region of extensive transhumant pastoralism. Vast expanses of land are classified as agricultural but are utilized as seasonal pastures with low productivity. The Central Asian states (Kyrgyzstan, Tajikistan, Uzbekistan) exhibit low plowed land ratios (13–27%), with the exception of irrigated oases. Their cropping intensity ratios (0.67–0.82) underscore a dependence on irrigation and, frequently, the incomplete utilization of arable land due to water scarcity or soil degradation.

Cluster 4. Arid-Mixed (Iran). This cluster is represented solely by Iran, which occupies an intermediate position. The country exhibits a Land Agricultural Development Rate (LADR) of 29% (reflecting extensive desert and mountainous terrain) and low Forest Cover (FC) of 6.7%. Its Plowed Land Ratio (PLR) of 37.4% exceeds that of the Central Asian states, a characteristic attributable to the well-developed horticulture and nut cultivation sectors reliant on irrigation.

A comparison between the Shanghai Cooperation Organization (SCO) aggregate and global averages reveals several critical structural features:

Land Agricultural Development Rate (LADR). The LADR values for the SCO (36.2%) and the world (36.9%) are practically identical. Consequently, the SCO can



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be considered a representative model of global land-use patterns with respect to this specific parameter.

**Forest Cover (FC).** Global forest cover stands at 31.1%, whereas the SCO average is 32.9%, representing a margin of +1.8 percentage points. This advantage is achieved exclusively due to the substantial "green weight" contributed by the Russian Federation (49.8%) and Belarus (43.4%). Excluding these two nations, the forest cover of the remaining SCO member states would be significantly lower than the global average.

**Plowed Land Ratio (PLR).** The global PLR is 32.7%, while the SCO average reaches 40.6% — a critical excess of 7.9 percentage points. This constitutes a key risk factor for the organization. The high proportion of cropland within the agricultural land structure (driven predominantly by India and Pakistan) renders the SCO's food security highly vulnerable to soil erosion and the impacts of climate change.

**Cropping Intensity Ratio (CIR).** The global CIR is 0.95, compared to 1.04 for the SCO (+0.09). This excess indicates that the agricultural sector of the SCO operates under a regime of higher soil resource exploitation than the planetary average.

### CONCLUSIONS AND RECOMMENDATIONS

The analysis conducted demonstrates the emergence of the Shanghai Cooperation Organization (SCO) as a global ecological donor to the carbon balance. While the world at large is experiencing a net loss of forest cover, the SCO is expanding its forest area at rates comparable to those observed in developed nations, albeit on a considerably larger absolute scale. The SCO's share of global forest resources increased from 27.2% to 28.3% over the study period.

A distinct trend toward the transformation of agricultural specialization has been identified. The decline in the SCO's share of global cropland (-1.43 percentage points) does not signify a downturn in the agricultural sector. Rather, it reflects a systemic transition from extensive farming practices (expansion of plowed area) toward intensive methods (enhanced crop yields) and ecologically oriented land management (reversion of low-productivity arable land to forest cover).

In assessing land-use efficiency, it is noteworthy that the reduction in the "other land" category within the SCO, juxtaposed against its global expansion, constitutes a unique statistical phenomenon. This trend attests to the comparatively higher efficiency of cadastral registration and the reclamation of lands into productive economic turnover within the transitioning economies of Asia.

This study provides a typology of land-use patterns within the SCO. Based on the calculated indicators, the existence of four distinct and stable agro-landscape clusters has been substantiated. Economic and environmental policies implemented under the auspices of the SCO Food Security Program should be differentiated accordingly: for Cluster 1, the emphasis should be placed on forest conservation and organic farming; for Cluster 2, the priority is combating soil exhaustion; and for Cluster 3, the focus should be directed toward combating pastureland desertification.



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A paradox of land-use sustainability within the SCO has been observed. Despite the relatively high aggregate forest cover (32.9%), the internal structure of agricultural land use in the SCO is subject to greater stress than the global average. The proportion of cropland within agricultural land (40.6%) ranks among the highest of any major macro-region. This circumstance creates substantial potential for transboundary cooperation: member states endowed with surplus pasture and forest resources (namely Russia and Kazakhstan) may serve as ecological donors to countries characterized by excessive plowing (India and Pakistan) through the supply of livestock products and participation in carbon credit mechanisms.

The Cropping Intensity Ratio (CIR) serves as a quantitative marker of water stress. The elevated CIR values observed in China (1.43) and India (1.29) are achieved primarily through extensive irrigation. Given that the principal river basins within the SCO sphere (the Indus, Ganges, Brahmaputra, and Irtysh) are transboundary in nature, this indicator provides compelling quantitative justification for the imperative of joint management of water and land resources to avert an impending soil fertility crisis.

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