Indicators for Managing the Efficiency of Water Consumption in Agriculture in The Regions of Uzbekistan

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Abstract. **The purpose of this study is to build and test on the open data of official statistics a system of mathematical models of the socio-economic efficiency of water consumption in agriculture in the regions of Uzbekistan and to develop on this basis indicators of water consumption management, taking into account regional characteristics.**

***Keywords*:** Management, socio-economic efficiency of water consumption, agriculture, water management.

1. INTRODUCTION

The Concept for the Development of the Water Resources of the Republic of Uzbekistan for 2020-2030 [1] defines among the priority areas “further expansion of the scale of the use of water-saving irrigation technologies and increasing the efficiency of water use, further development of the system of state support and incentives for agricultural producers who have introduced water-saving methods and technologies”. [1]

Ensuring the "full, timely and high-quality implementation of the Concept" requires the solution of methodological and information-algorithmic issues of continuous monitoring of the achievement of established target indicators, including those reflecting the implementation of "the existing huge potential to improve the efficiency of water supply to farmers, as well as increase the efficiency and productivity of water use this water at the level of agricultural holdings”[1].

To assess the relevance of developing methods for quantitative research of the efficiency of water consumption in agriculture in Uzbekistan, taking into account the factors of its regional differentiation, scientific and practical works in this subject area were analyzed.

2. LITERATURE REVIEW

The task of developing and analyzing indicators of water consumption in agriculture, systemically related to the corresponding indicators of water consumption in other sectors and sectors of the economy, Kundius Vladislav Vladimirovich [4], Zharnitskaya N. [5], Abdullaev I. [6], Gober P., [8], Danilov- Danilyan V.I., [10], as well as indicators of socio-economic efficiency, was set at the 24th session of the FAO “Water Resources Management for Agriculture and Food security” (Rome, 29.09 – 03.10.2014), where it was noted: “Agriculture, whose needs in total water consumption are estimated at 70%, is increasingly claiming its own share of water resources for food production and ensuring food security. At the same time, the rationality of water use for agricultural purposes is under increasing scrutiny.” [2]

The presented review of literature sources, on the one hand, demonstrates the insufficient representation in them of an important area of quantitative research that requires development both in methodological and informational terms. Namely: the formation on the basis of open data sources of tools for modeling and analyzing the "response" of macroeconomic indicators at the level of the country and regions to changes in the volume of water consumption in agriculture.[7]

This direction is very relevant for the Republic of Uzbekistan and the regions in connection with the above Concept for the Development of the Water Resources of the Republic of Uzbekistan for 2020-2030, the task of constantly monitoring the achievement of the main target indicators for improving the efficiency of the use of water resources.

On the other hand, the presented review of the works makes it possible to take into account their individual aspects in the formation of the purpose and objectives of this study.

3. PURPOSE AND OBJECTIVES OF THE STUDY

To achieve the goal of the study, the following **tasks were solved:**

1) Creation of an information array based on official statistics of Uzbekistan, including spatial and dynamic characteristics of water consumption, as well as indicators of economic growth of the economy as a whole and agricultural production.
2) Performing statistical cluster analysis in order to identify homogeneous groups of regions of the Republic of Uzbekistan in terms of water consumption and economic growth in the economy and the agricultural sector.
3) Carrying out a quantitative "causal" analysis in order to identify and assess the direction of the relationship between indicators of the dynamics of water consumption in agriculture and indicators of economic growth, assess the specifics of these relationships for individual regions and regional clusters.
4) performance management indicators water consumption. taking into account regional features of the "response" of the economic system to the use of water in agricultural production.

4. ANALYSIS OF RESULTS

In accordance with the Law of the Republic of Uzbekistan "On official statistics" (2021), state statistical bodies must " provide statistical data to public authorities and administrations"; at the same time, they carry out "integration with information systems of state and economic administration bodies, as well as local executive authorities in order to conduct statistical observations, generate and analyze official statistical data" [11].

The presented indicators make it possible to form a hypothetical directed graph of information links (Fig. 1), which includes direct (solid arrows) and indirect (dashed arrows) mutual influence of indicators characterizing water consumption in the economy as a whole and agriculture and the corresponding indicators of economic growth. The objectives of this study included a statistical assessment of the directions and strength of the connection of the graph elements based on the generated data array for the regions of Uzbekistan, as well as an assessment of the response of the economic growth of the regions due to the growth of agricultural production (, due to changes in the volume of water consumption in $\Delta_{\mathbf{1}\,(t)}$)agriculture ($\Delta_{\mathbf{2}\,(t)}$)**.** [9]

The presented graph also indicates the two-way orientation of the cause-and-effect relationships of the indicators under consideration (this is reflected in the figure with the help of two-way arrows). With this in mind, the problem of estimating the priority direction of the causal relationship between the indicators under consideration was solved to include them in the model, the resulting values of which are the response indicators (and) of $\Delta_{\mathbf{1}\,(t)}$economic $\Delta_{\mathbf{1}\,(t)}$**growth** and the growth of agricultural production to the dynamics of water consumption in agriculture (in Fig. 1 indicated by unidirectional arrows).

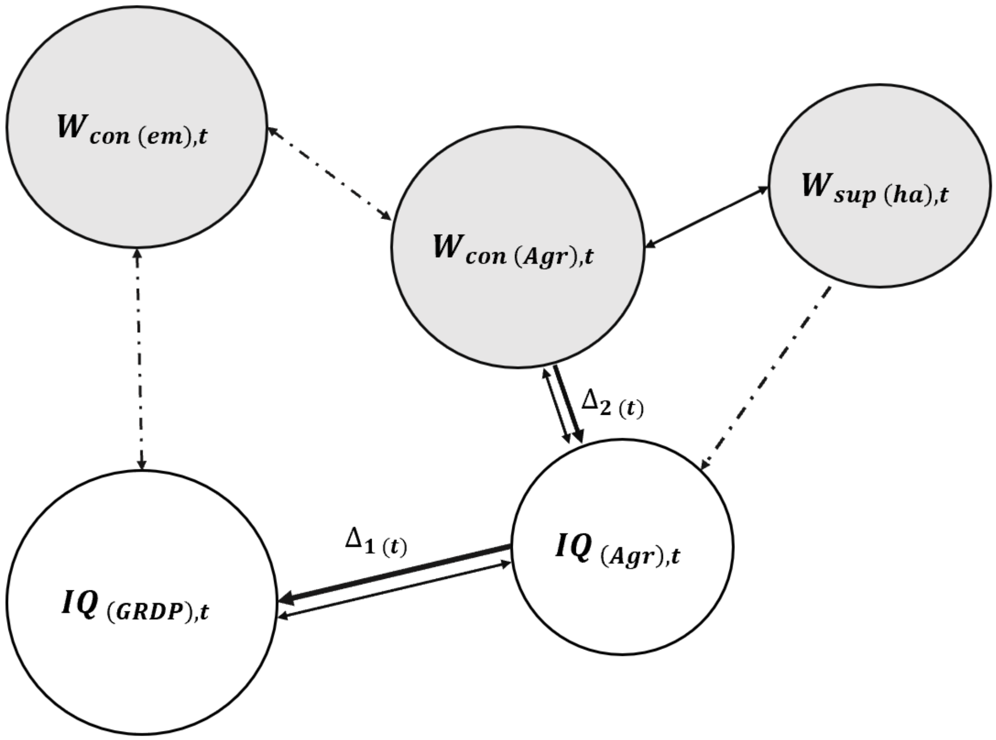

Fig.1. Graph of links (hypothetical) of indicators of official statistics characterizing the efficiency of water consumption in agriculture of the regions of the Republic of Uzbekistan.

The formed information base of the study made it possible to perform a cluster analysis by years delimiting the study period (2015 and 2022), as well as by years of the " post-COVID " period (2020 and 2021). Hierarchical cluster analysis was performed by Ward's method (Ward 's method) using the "Euclidean" distance estimation metric (Euclidian distance) between population units.

As follows from the data in Table 1, there has been a change in the cluster composition over the years under consideration. To study the depth of time lags taken into account when analyzing the direction and strength of causal relationships between indicators, it is necessary to assess how significant the divergence of the cluster composition of regions is in certain intervals, and then take the lag for estimating the relationships of indicators over the time interval with the largest change in the cluster composition.

Table 1 presents two-input contingency tables containing the results of the distribution of regions in two clusters in the compared years (2023 and 2015 and 2022 and 2021).

Table 1. Assessing the contingency of the results of clustering the regions of the Republic of Uzbekistan in terms of the efficiency of water consumption in agriculture

(a) 2015 – 2023

2015 / 2022	Cluster 1	Cluster 2	Total
Cluster 1	6	1	7
Cluster 2	3	3	6
Total	9	4	13

(b) 2021 – 2023

2021 / 2022	Cluster 1	Cluster 2	Total

Cluster 1	5	2	7
Cluster 2	4	2	6
Total	9	4	13

evaluate the similarity between two cluster partitions, the Fowlkes - Mallows index can be used . index). [12]

The assessment of this index (FM) was carried out according to the method described in the Internet resource "Quality Assessment in the Clustering Problem" [13]. The following values were used:

TP is the number of elements belonging to the same cluster in both years (in the first case: 2015 and 2022);

FP is the number of elements belonging to the same cluster in the base year (2015) but to different clusters in the compared year (2022);

FN is the number of elements belonging to the same cluster in the compared year (2022) but to different clusters in the base year (2015).

FM index is calculated using the formula:

$$FM = \sqrt{\frac{TP}{TP+FP} * \frac{TP}{TP+FN}}.$$

According to Table 2 (a), the value of the FM index was 0.43, and according to the data of the same table, but point (b), it was 0.35.

A higher index value means greater similarity between the clustering of regions in the indicated years.

It can be concluded that in the last years of the " post-COVID " period, an increase in "territorial stratification", i.e. in this study, the differentiation of regions in terms of the efficiency of water consumption in agriculture was significantly more intense than in the previous eight-year period.

5.Conclusions

Taking into account this conclusion, for the purposes of analyzing the directions of causal relationships of the indicators under consideration and including the effect of "lagging influence" in econometric models, indicators with "current" values and values with lags of 1-2 years were used.

1) Implementation of a water pricing system: A pricing system that charges users based on the amount of water consumed can encourage efficient use of water resources. This can be done by introducing a tiered pricing system where users pay more for higher levels of water consumption.
2) Promotion of water-saving technologies: By encouraging the use of water-saving technologies such as drip irrigation and water-saving devices, water consumption can be significantly reduced.
3) Encourage water conservation practices: Water conservation practices such as rainwater harvesting and greywater recycling can help reduce water consumption.
4) Investing in water infrastructure: Investing in water infrastructure, such as water treatment plants and distribution systems, can help reduce water loss due to leakage and improve overall water use efficiency.
5) Educating the population: explaining to the population the importance of water conservation and the need for efficient use of water will greatly help in reducing water consumption and improving water resources management.

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