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ECONOMIC ASSESSMENT AND OPTIMIZATION OF REGIONAL SPECIALIZATION UNDER CONDITIONS OF LIMITED WATER RESOURCES

Sodiqova Nigora Turayevna
Lecturer at the Department of Economics
Asia International University, Bukhara

Abstract: Water scarcity is becoming a decisive factor in regional economic development and in the territorial organization of production. Traditional approaches to regional specialization mainly consider land, labor, production costs, market demand, and historical production patterns, but they often underestimate the economic value of water and the long-term environmental effects of excessive water use. This article examines the economic assessment and optimization of regional specialization under conditions of limited water resources. It argues that specialization should be evaluated not only by output or land productivity, but also by value added, employment, and export revenue generated per unit of water used. The proposed approach supports the identification of sectors that should be expanded, technologically modernized, gradually reduced, or replaced. It is especially relevant for arid and semi-arid regions where irrigation-dependent agriculture remains central to regional income and employment.

Keywords: water scarcity, regional specialization, water productivity, resource allocation, regional development, agricultural diversification.

Introduction: Water resources are among the most important determinants of sustainable regional development. Population growth, climate change, urbanization, industrialization, and increasing agricultural demand intensify competition for freshwater. In dry regions, water availability directly affects agricultural production, food security, employment, industrial location, household income, and environmental stability.

Regional specialization refers to the concentration of production in sectors in which a territory has natural, economic, technological, or institutional advantages. Traditionally, specialization has been assessed through production volume, labor productivity, cultivated area, employment, exports, and market share. These indicators remain important, but they are insufficient when water becomes a scarce strategic resource. A region may produce high output per hectare while obtaining a low economic return from the water consumed. Therefore, specialization under water scarcity should be based on the economic and social efficiency of water use rather than on physical production alone.

The purpose of this study is to develop a concise framework for assessing and optimizing regional specialization under limited water resources. The analysis focuses on the relationship between water scarcity, regional competitiveness, sectoral efficiency, environmental sustainability, and structural transformation.

Theoretical Background: The concept of regional specialization is closely connected with comparative advantage. Regions benefit when they concentrate resources in activities where relative economic costs are lower and local conditions are more favorable. However, comparative advantage is not permanent. It changes under the influence of technology, infrastructure, markets, environmental conditions, and resource scarcity.

A high concentration of a particular activity does not always represent efficient or sustainable specialization. Production structures may reflect historical planning, subsidies, administrative decisions, or the underpricing of natural resources. When water is allocated without considering

scarcity, water-intensive production may appear profitable even though its broader economic and environmental costs are high.

Water scarcity has both physical and economic dimensions. Physical scarcity arises when demand approaches or exceeds available supply. Economic scarcity occurs when water cannot be efficiently delivered or managed because of outdated infrastructure, weak institutions, insufficient investment, and poor monitoring. In both cases, allocation involves an opportunity cost because water used in one sector cannot simultaneously be used elsewhere. Regional policy should therefore identify those activities that create the greatest economic and social benefit from limited water resources.

Methodological Approach: The assessment of regional specialization under water scarcity should begin with the current sectoral structure. It is necessary to identify dominant sectors, major agricultural products, employment patterns, exports, and the contribution of each sector to regional value added. This information should then be compared with water consumption, irrigation requirements, production costs, market demand, and environmental risks.

The first analytical task is to determine whether existing specialization reflects a genuine economic advantage or merely historical concentration. The second task is to compare activities according to the value added and employment created per unit of water. The third task is to assess ecological consequences such as soil salinity, groundwater depletion, land degradation, and ecosystem pressure. The final task is to design a more balanced regional structure by reallocating land, labor, capital, and water toward activities with stronger economic, social, and environmental performance.

Table 1. Criteria for assessing regional specialization under water scarcity

Assessment dimension	Main indicator	Regional policy interpretation
Economic efficiency	Value added and profitability	Priority for sectors generating higher regional income
Water efficiency	Economic return per unit of water	Expansion of activities with lower water intensity
Employment effect	Jobs and household income	Protection of socially important activities
Environmental impact	Salinity, depletion, ecosystem pressure	Modernization or gradual contraction of risky activities
Market potential	Demand, exports, processing opportunities	Support for competitive value chains

The assessment may be performed under a baseline scenario, a moderate water-scarcity scenario, a severe scarcity scenario, and a technological modernization scenario. The modernization scenario should examine the impact of drip irrigation, digital metering, canal rehabilitation, improved crop varieties, precision agriculture, and wastewater reuse. A broader structural-transformation scenario may combine these measures with crop diversification and the expansion of processing, logistics, tourism, and other less water-intensive sectors.

Results and Discussion: The proposed approach suggests that conventional specialization patterns may change significantly when water scarcity is included in the analysis. Some activities with large cultivated areas and high production volumes may demonstrate low economic efficiency because they consume substantial amounts of water and generate limited value added. In contrast, horticulture, seed production, greenhouse farming, medicinal plants, food processing, logistics, tourism, and selected industrial activities may provide higher economic returns with less water. The final choice depends on local climate, soil quality, labor skills, infrastructure, market access, and investment capacity.

Regional policy should gradually shift from maximizing output per hectare toward maximizing sustainable value added per unit of water. Land productivity remains important, but it should be assessed together with water productivity. Activities that perform well on both criteria may be expanded. Activities with high land productivity but low water efficiency require technological modernization. Activities with weak performance in both areas may need gradual contraction or replacement.

The development of value chains is another major direction. A region can increase the economic return from water by processing agricultural products rather than exporting them as raw materials. Storage, sorting, packaging, certification, branding, logistics, and food processing raise regional value added without requiring a proportional increase in agricultural water consumption. Interregional trade can also reduce pressure on local water resources, although food security, rural employment, and price stability must be considered.

The social effects of restructuring are equally important. A production structure that maximizes regional income may not benefit all groups equally. Small farmers may lack finance, technology, training, and market access. Therefore, optimization should be accompanied by

concessional credit, technical assistance, professional training, cooperative development, and targeted social protection.

Policy Implications: Regional development programs should incorporate water availability, economic water productivity, employment, environmental risk, and market potential into sectoral planning. Public support should prioritize projects that generate higher value added and employment with lower water consumption. Water-saving technologies should be promoted through affordable finance, leasing, tax incentives, technical assistance, and performance-based support.

Reliable water accounting is essential. Accurate information is required on abstraction, delivery, consumption, return flows, groundwater use, and losses. Digital meters, remote sensing, and geographic information systems can improve transparency and support more efficient allocation. Regional policy should also encourage processing, logistics, storage, tourism, digital services, and other relatively less water-intensive activities. Water allocation must be coordinated at the regional, national, and river-basin levels because decisions in one territory may affect downstream regions and ecosystems.

Conclusion: Limited water resources require a reconsideration of conventional regional specialization strategies. Production volume, cultivated area, and historical concentration are not sufficient indicators of sustainable economic advantage. Regional specialization should be assessed according to the value added, employment, export income, and social benefits generated from the available water, while also accounting for environmental risks, food security, and market demand.

Optimization does not require the complete abandonment of agriculture. It requires a transition toward more efficient irrigation, higher-value crops, diversified production, expanded processing, improved logistics, and less water-intensive economic activities. When properly incorporated into regional planning, water scarcity can become an incentive for technological modernization, structural diversification, efficient resource allocation, and long-term economic resilience.

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