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POTENTIAL AND KEY BARRIERS TO THE DEVELOPMENT OF ORGANIC ANIMAL HUSBANDRY IN KAZAKHSTAN: AN INTEGRATED SPATIAL AND ECONOMIC ASSESSMENT

Abstract: This study develops a reproducible spatial and economic framework for prioritising the transition of Kazakhstan livestock farms to organic production. Methods. A multi-criteria index combines four blocks: spatial and environmental suitability, production readiness, financial viability, and behavioural and institutional readiness. Indicators are normalised to a 0–1 scale, aggregated with equal block weights, and constrained by a minimum environmental score of 0.55. Four five-year scenarios are compared: baseline, pasture expansion, shelterbelt conservation, and an integrated organic system. National pasture statistics and legal and sectoral sources provide the contextual baseline; scenario parameters are model assumptions rather than observed farm outcomes. Results. The model produces index values of 0.50, 0.53, 0.57, and 0.73, respectively. Pasture expansion fails the environmental threshold despite higher production and financial scores. The integrated scenario remains first under alternative weights and input perturbations. Conclusion. Expansion of grazing area alone is insufficient. Priority should be given to farms and districts where controlled grazing, water access, shelterbelt protection, traceability, certified feed, veterinary services, processing, and market access can be implemented as one value chain. Farm-level geospatial, production, financial, and survey data are required before investment decisions.

Keywords: organic animal husbandry, pastures, protective shelterbelts, spatial assessment, economic efficiency, certification, Kazakhstan

Introduction

Agriculture remains an important part of Kazakhstan's economy, particularly in terms of food security, rural livelihoods, and livestock production. Since the transition from the Soviet agricultural system, the country has introduced market-oriented reforms while continuing to face a number of economic, environmental, and institutional challenges. Against this background, organic animal husbandry has attracted growing attention as an approach that may help combine livestock production with more sustainable use of natural resources and improved animal welfare [1–4].

Livestock farming is especially important for Kazakhstan because of the country's large pasture areas and long tradition of grazing-based animal production. At the same time, the sector faces several persistent challenges, including differences in farm structure, relatively low productivity in some production systems, and a strong dependence on natural pastures. These characteristics create both opportunities and limitations for organic livestock farming. Extensive grazing systems may provide a suitable basis for more sustainable production, but their further development requires better pasture management, efficient use of feed resources, and appropriate technologies. The use of crop residues and agricultural by-products as feed, together with manure recycling, may also help reduce production costs and improve resource efficiency [3–5].

The development of organic livestock farming also depends strongly on government policy and institutional support. In Kazakhstan, state programs have traditionally supported livestock production through subsidies, infrastructure development, and measures aimed at increasing agricultural output and competitiveness. Organic production, however, involves additional requirements. Farmers need access to certification, reliable traceability systems, veterinary and animal-health services, appropriate pasture management, processing facilities, and markets for organic products. It is therefore important to distinguish between livestock raised under traditional pasture-based conditions and livestock that meets formal organic production and certification requirements [2, 4].

Conditions for developing organic livestock farming also differ considerably between regions. Kazakhstan is a large country, and regions vary in their pasture resources, climate, farm structure, infrastructure, and access to markets. For example, livestock-producing areas such as Akmola and West Kazakhstan may face different production and market conditions. This suggests that the expansion of organic farming cannot rely on a single approach across the country. Regional

strategies should take local conditions into account and support farmers through extension services, technology transfer, cooperation, processing facilities, and improved market access [2–4].

Market development is another important factor. The future of organic livestock production will depend not only on farmers' ability to produce organic products but also on whether consumers are willing to purchase them and whether producers can access profitable domestic and international markets. Certification and traceability are particularly important because they provide consumers and buyers with confidence that products meet organic standards. At the same time, stable supply chains, processing capacity, consumer awareness, and cooperation between the public and private sectors are needed to support the development of this market [2, 3].

Despite the potential of Kazakhstan's livestock sector, there is still limited empirical evidence on how widely organic practices are actually adopted and what factors influence farmers' decisions to adopt them. More detailed information is needed on certified farms, pasture and feed management, animal health, productivity, production costs, and the economic performance of organic systems. It is also important to understand how farmers perceive organic production, including its potential benefits, costs, risks, and practical difficulties. Such information can help determine whether existing subsidies, certification systems, extension services, and market-support measures adequately address the needs of farmers interested in organic production.

For this reason, the development of organic animal husbandry should not be assessed only in terms of Kazakhstan's natural resources. Although the country has extensive pastures and favorable conditions for grazing livestock, the availability of these resources does not automatically lead to certified organic production. Farmers' decisions are also shaped by economic opportunities, access to finance and information, market conditions, perceived risks, and the institutional environment. Examining these factors together provides a more realistic understanding of the opportunities and barriers associated with the transition to organic livestock farming [2–4].

Kazakhstan has considerable potential for developing organic livestock production, particularly because of its extensive pasture resources and established livestock-farming traditions. However, realizing this potential requires more than the availability of land and animals. Farmers need clear certification procedures, reliable traceability, technical and advisory support, appropriate processing infrastructure, and access to stable markets. At the same time, more farm-level and region-specific evidence is needed to understand what encourages or prevents farmers from adopting organic practices. Such evidence can provide a stronger basis for policies and practical measures aimed at supporting the gradual development of organic animal husbandry in Kazakhstan [2–4].

The potential for organic animal husbandry in Kazakhstan depends on the interaction of pasture resources, feed availability, certification, traceability, veterinary services, processing infrastructure, and market access. This study does not attempt to estimate the current national volume of certified organic livestock production; instead, it evaluates the resource potential and institutional conditions that may support or constrain its development.

The research objective was to construct and test an integrated index for comparing alternative pathways of organic livestock development in Kazakhstan. The scientific novelty lies in combining spatial-environmental, production, financial, and behavioural-institutional criteria within one transparent decision framework and applying an environmental feasibility constraint before scenario ranking. Unlike descriptive sector reviews, the proposed approach explicitly separates resource potential from certified organic production and identifies the farm-level data required for subsequent validation.

Materials and Methods

Study design and unit of analysis

The model is designed for application at district level for screening and at farm level for investment appraisal. The national analysis provides the contextual baseline; the operational unit is a farm or a spatially coherent group of cooperating farms. The recommended spatial resolution is the cadastral parcel and seasonal grazing unit, aggregated to rural district and district. The analytical horizon is five years, covering the conversion period and early certified operation.

Data sources and spatial variables

The framework uses official land-balance and agricultural statistics of the Bureau of National Statistics of the Republic of Kazakhstan, sectoral information of the Ministry of Agriculture, cadastral land-use layers, water-point and road locations, veterinary and processing infrastructure, Sentinel-2 or Landsat vegetation indices, digital elevation and distance surfaces, and farm records. International contextual indicators should be cross-checked against FAOSTAT and FiBL/IFOAM datasets for the

same reporting year. Because published pasture totals may differ by year and definition, no national pasture figure is treated as a farm-level capacity estimate. In a regional application, each land indicator must be linked to a specific reporting year, table or database, and access date.

Indicator system and normalisation

The index contains four blocks. Each block is calculated as a weighted mean of three indicators. Equal block weights of 0.25 are used in the base model to avoid claiming unsupported priority for one domain. Within each block, the weights sum to one. Positive indicators are normalised as $(x - x_{\min})/(x_{\max} - x_{\min})$; negative indicators, such as distance or unit cost, are normalised as $(x_{\max} - x)/(x_{\max} - x_{\min})$. Values outside the reference range are truncated to 0 or 1. When empirical minima and maxima are unavailable, policy targets and the 10th and 90th percentiles of the farm sample should define the reference range.

The relevant data are presented in Table 1.

Table 1 – Structure of the integrated efficiency index

Block and weight	Indicator	Direction	Within-block weight	Primary evidence
Spatial and environmental 0.25	Pasture condition and NDVI stability	Positive	0.40	Remote sensing and field survey
	Grazing pressure relative to carrying capacity	Negative	0.35	Stock records and forage yield
	Shelterbelt condition and protected area	Positive	0.25	Orthophoto and inventory
Production 0.25	Water-point accessibility	Positive	0.35	GIS network distance
	Certified feed coverage	Positive	0.35	Feed records and certificates
	Veterinary and traceability readiness	Positive	0.30	Farm audit
Financial 0.25	Discounted net benefit	Positive	0.45	Farm cash flow
	Payback period	Negative	0.30	Investment model
	Exposure to price and support changes	Negative	0.25	Sensitivity analysis
Behavioural and institutional 0.25	Willingness to certify	Positive	0.35	Farm survey
	Cooperation and service access	Positive	0.35	Survey and registry
	Market and processor commitment	Positive	0.30	Contracts and interviews

For scenario s , block b and indicator j , the integrated efficiency index is $I_s = \sum_b W_b (\sum_j w_{bj} z_{sbj})$, where W_b is the block weight, w_{bj} is the within-block weight, and z is the normalised indicator. The environmental constraint is applied before ranking: the spatial and environmental block must be at least 0.55, and stocking pressure must not exceed estimated carrying capacity. A scenario that violates either condition is marked infeasible even if its aggregate index is high. The value of 0.55 is a provisional screening threshold rather than an empirically established national standard. It was selected to prevent weak environmental performance from being compensated for solely by stronger economic or production scores and must be calibrated against observed vegetation condition, erosion risk, forage yield, and carrying capacity.

Scenario definitions

The relevant data are presented in Table 2.

Table 2 – Five-year scenario assumptions

Parameter	S0 Baseline	S1 Pasture expansion	S2 Shelterbelt conservation	S3 Integrated organic
Grazed area	Current	+20% accessible area	Current	+10% after suitability screening
Stocking pressure	Current	+15% livestock units	Current or -5%	At or below carrying capacity
Pasture rotation	Limited	25% of grazing units	50%	80%
Functional shelterbelts	Current condition	No targeted action	+20% restored length	+25% restored and protected
Water points meeting access target	Current	+15%	+10%	+30%
Traceability and organic certification	Current	Current	Pilot coverage	Full pilot-chain coverage
Processing and market linkage	Fragmented	Fragmented	Partial	Contracted certified chain

The assumptions are transparent stress-test inputs, not measured changes. A regional application must replace them with observed farm values and documented project costs. The expansion scenario is deliberately tested as a partial intervention; it adds accessible grazing area without simultaneously resolving certification, shelterbelt condition, traceability, and processing constraints. The percentage changes in Table 2 are bounded scenario assumptions used to test model behaviour; they are not observed national trends and must be replaced by documented farm or district values in empirical applications.

Economic model

The financial block uses discounted incremental cash flow. Net present value equals the discounted sum of additional organic-price revenue, avoided losses, support payments, and additional operating benefits minus certification, conversion, water, fencing, shelterbelt, traceability, transport, and processing costs. Payback is the first year in which cumulative discounted cash flow becomes non-negative. The break-even organic premium is calculated as the annualised net transition cost divided by certified sale volume and the conventional unit price.

Because verified farm-level cost, certification expenditure, and organic livestock price-premium data were not available for the present modelling exercise, the financial ranges are exploratory stress-test assumptions rather than observed Kazakhstan averages. They are used only to examine model behaviour. Future applications should replace them with audited farm accounts, certification quotations, processor contracts, and observed market prices.

Farm survey and validation protocol

A subsequent empirical validation stage is proposed for the behavioural and institutional block. It should use a stratified sample of at least 120 livestock farms, with approximately 30 farms in each of the western, northern, central-eastern, and southern/south-eastern macroregions. This survey has not yet been conducted and is not part of the present dataset. Strata should include herd size, legal form, remoteness, and production type. The questionnaire should cover certification knowledge, willingness to convert, acceptable cost and conversion period, traceability practices, cooperation, service access, expected price premium, perceived risks, and intended market. Certification bodies, veterinary services, processors, and buyers should be interviewed separately. The final sample size must be recalculated from the actual farm population and desired confidence interval.

Sensitivity and uncertainty analysis

Robustness was tested by varying each block weight by $\pm 20\%$ and renormalising all weights to sum to one. Scenario component scores were additionally perturbed within ± 0.03 to represent uncertainty in normalisation and expert assumptions. The analysis evaluates whether the ordering of feasible scenarios changes under plausible parameter variation; it does not substitute for statistical uncertainty based on observed farm data. Future empirical applications should report the software

environment, number of simulation iterations, random seed where applicable, and the complete parameter matrix.

Results

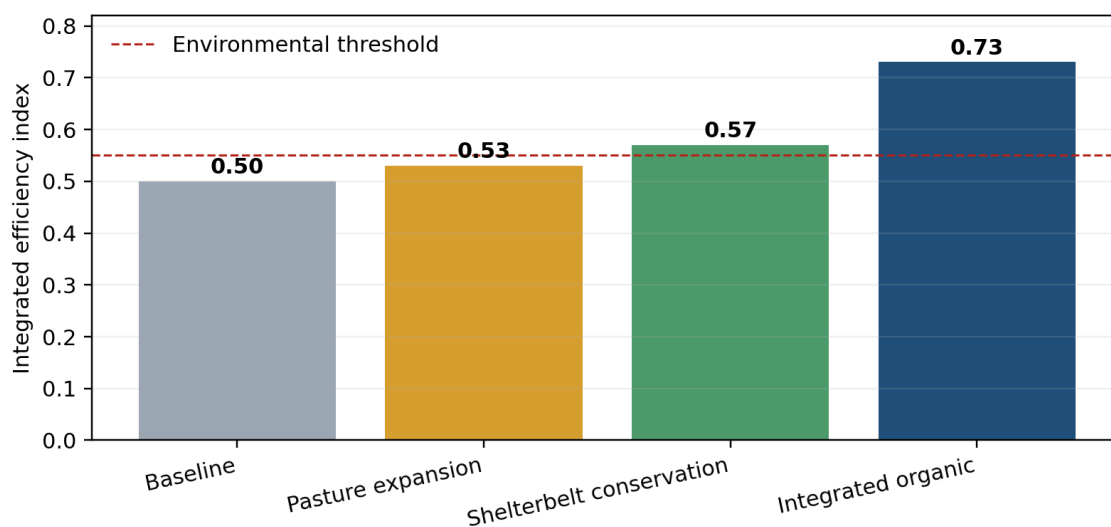
Scenario performance

The relevant data are presented in Table 3.

Table 3 – Modelled block scores and feasibility

Scenario	Environmental	Production	Financial	Institutional	Integrated index	Feasible
S0 Baseline	0.52	0.55	0.45	0.48	0.50	No: E < 0.55
S1 Pasture expansion	0.43	0.64	0.57	0.48	0.53	No: E < 0.55
S2 Shelterbelt conservation	0.68	0.54	0.50	0.56	0.57	Yes
S3 Integrated organic	0.78	0.75	0.69	0.70	0.73	Yes

The baseline score is 0.50 and does not meet the environmental threshold. Pasture expansion improves production and financial scores, raising the aggregate index to 0.53, but its environmental score falls to 0.43 because additional area and livestock pressure are not paired with rotation, shelterbelt restoration, and ecological screening. It is therefore rejected before ranking. Shelterbelt conservation reaches 0.57 and is feasible, but gains remain limited by certification and market-chain gaps. The integrated organic scenario obtains 0.73 and exceeds the threshold in every block.



The results are illustrated in Figure 1.

Figure 1 – Integrated index under four scenarios. The dashed line shows the minimum environmental block score; it is not an aggregate-index cut-off.

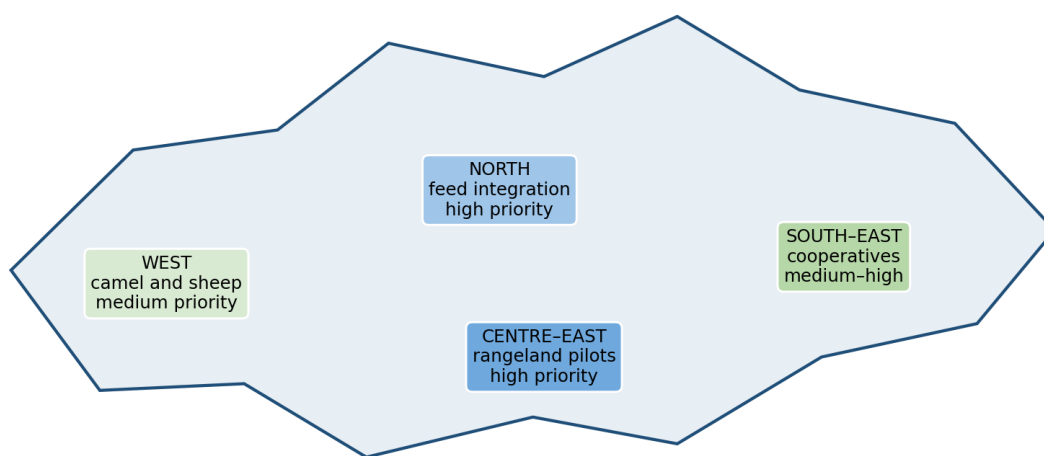
Sensitivity analysis

Weight variation changes the baseline index within 0.49–0.51, pasture expansion within 0.51–0.55, shelterbelt conservation within 0.55–0.59, and the integrated scenario within 0.71–0.75. Under the tested weight and component-score perturbations, the integrated scenario retains the highest index among feasible scenarios. The small difference between the pasture-expansion and shelterbelt scenarios is not treated as decisive on the index alone; feasibility is determined by the environmental threshold.

Spatial interpretation

Screening should identify clusters rather than isolated parcels. Northern districts may offer stronger links between certified crop and livestock farms. Central and eastern districts may suit

rangeland pilots where water and transport gaps can be closed. Southern and south-eastern districts require attention to fragmented farm structure and cooperative traceability. Western districts may support sheep and camel value chains, but aridity and distance raise water and logistics costs. These are hypotheses for screening, not administrative rankings.



The results are illustrated in Figure 2.

Figure 2 – Schematic macroregional screening framework. Boundaries and priority labels are conceptual and must be replaced by district-level GIS results before policy use.

Discussion

Kazakhstan has considerable potential for organic livestock production, largely because of its extensive pasture resources and long-established grazing systems. However, having large areas of pasture does not automatically mean that they can be used for certified organic production. Successful development also depends on pasture condition, water and feed availability, appropriate stocking rates, veterinary services, certification and traceability, as well as access to processing facilities and markets [6, 7].

These conditions differ considerably across Kazakhstan. Climate, vegetation, water availability, infrastructure, and livestock management practices vary between regions, which means that the same approach may not work equally well everywhere. The condition and productivity of pastures are particularly important because the number of hectares available says little about how many animals the land can support without degradation. This is especially relevant for livestock-producing regions such as Akmola and West Kazakhstan, where local environmental and production conditions need to be considered when assessing opportunities for organic farming [8, 9].

For these reasons, a gradual transition to organic production may be more practical than attempting large-scale conversion at once. Farmers need to meet requirements that extend beyond pasture management. Certified organic production also involves feed quality, recordkeeping, animal-health management, transportation, slaughter, processing, labeling, and traceability. This makes cooperation between farmers, certification bodies, veterinary and extension services, processors, and buyers particularly important. Cooperatives may help farmers share some of the costs associated with certification, processing, and marketing, although effective management and transparent traceability remain necessary [5, 8].

Environmental conditions should be considered together with economic benefits when decisions about organic livestock development are made. A production system may appear financially attractive but still place excessive pressure on pasture resources. Environmental thresholds, including the proposed value of 0.55, may therefore provide an additional tool for identifying situations in which ecological risks become unacceptable. Such assessments should ideally be supported by field data on vegetation condition, erosion, forage availability, and carrying capacity. Shelterbelts and other protective measures may also be useful in areas affected by wind erosion, uneven snow distribution, or heat stress. Their benefits, however, need to be weighed against water requirements, establishment costs, maintenance, and local environmental conditions [6–8].

Another important issue is the distinction between pasture-based and certified organic livestock production. Animals raised mainly on natural pastures are not necessarily produced according to organic standards. Certification requires documented compliance throughout the production chain, from feed and animal management to transportation, processing, labeling, and final product traceability. This distinction is particularly important when estimating Kazakhstan's potential for organic livestock production, as pasture resources alone may otherwise lead to an overestimation of the sector's actual readiness for organic certification.

Market conditions are equally important. Farmers are more likely to consider organic production when certification provides access to reliable markets and sufficient economic returns. This requires consumer confidence, transparent standards, stable supply chains, processing facilities, and buyers willing to pay for certified products. Cooperation between farmers, processors, certification organizations, businesses, and public institutions may therefore be just as important as improvements made at the farm level [8].

At the same time, there is still limited empirical information on the actual development of organic livestock farming in Kazakhstan. More region-specific data are needed on the number of certified farms, pasture management, productivity, animal welfare, production costs, and economic performance. Some of the available studies also address broader agricultural transitions rather than certified organic livestock production specifically in Kazakhstan. For this reason, estimates of production and market potential should be interpreted carefully until more farm-level evidence becomes available [6–10].

Taken together, the available evidence suggests that the development of organic livestock farming in Kazakhstan is likely to depend on gradual changes adapted to local conditions rather than a single nationwide model. Better pasture and feed management, veterinary support, certification and traceability, processing facilities, and stronger links between farmers and markets are all important. These measures should be accompanied by regular assessment of pasture condition and carrying capacity so that production growth does not come at the expense of rangeland sustainability. Farmer cooperation, extension services, technology transfer, and appropriate policy support could further help translate Kazakhstan's considerable natural potential into a viable certified organic livestock sector [8–10].

Conclusion

Within the proposed model, the integrated organic scenario produced the strongest balance across environmental, production, financial, and institutional criteria, whereas pasture expansion alone failed the environmental feasibility condition. These results are scenario-based and should be interpreted as evidence about the internal logic of the decision framework rather than as measured national outcomes.

Future district- and farm-level studies should test the framework using parcel-level GIS data, official certification records, audited farm accounts, verified feed sources, veterinary and traceability records, processor capacity, market contracts, and a stratified farm survey. This validation is necessary before the index is used for subsidy allocation, investment ranking, or estimates of the national organic livestock sector.

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ҚАЗАҚСТАНДА ОРГАНИКАЛЫҚ МАЛ ШАРУАШЫЛЫҒЫН ДАМУ ӨЛЕУЕТІ МЕН НЕГІЗГІ КЕДЕРГІЛЕРІ: КЕҢІСТІКТІК-ЭКОНОМИКАЛЫҚ БАҒАЛАУ

Қазақстандағы мал шаруашылығы кәсіпорындарының органикалық өндіріске көшу басымдықтарын анықтауға арналған кеңістіктік-экономикалық бағалау әдістемесін әзірлеу. Әдістері. Интегралдық индекс кеңістіктік-экологиялық, өндірістік, қаржылық және мінез-құлықтық-институционалдық блоктарды біріктіреді. Көрсеткіштер 0–1 аралығында қалыптандырылып, блоктарға 0,25-тен тең салмақ берілді. Экологиялық блок үшін 0,55 ең төменгі шек белгіленді. Бес жылдық төрт сценарий салыстырылды: бастапқы жағдай, жайылымды кеңейту, қорғаныш орман жолақтарын сақтау және интеграцияланған органикалық жүйе. Нәтижелері. Сценарийлер бойынша индекс тиісінше 0,50; 0,53; 0,57 және 0,73 болды. Жайылымды кеңейту сценарийі өндірістік көрсеткіштерді жақсартқанымен, экологиялық шектен өтпеді. Интеграцияланған сценарий салмақтар мен бастапқы мәндер өзгерген жағдайда да бірінші орынды сақтады. Қорытынды. Жайылым аумағын ұлғайту жеткіліксіз. Басымдық реттелетін жаюды, суаттарды, орман жолақтарын қорғауды, малды қадағалауды, сертификатталған жемшөпті, ветеринариялық қызметті, өңдеуді және өткізуді бір тізбекке біріктіре алатын шаруашылықтар мен аудандарға берілуі тиіс. Нәтижелер модельдік сипатта және шаруашылық деңгейіндегі деректермен тексеруді қажет етеді. Нақты деректермен толықтырылған жағдайда әдістеме аудандарды салыстыруға және органикалық көшу шараларының басым ретін негіздеуге мүмкіндік береді.

Түйінді сөздер: органикалық мал шаруашылығы, жайылым, қорғаныш орман жолақтары, кеңістіктік бағалау, экономикалық тиімділік, сертификаттау, Қазақстан

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ПОТЕНЦИАЛ И ОСНОВНЫЕ БАРЬЕРЫ РАЗВИТИЯ ОРГАНИЧЕСКОГО ЖИВОТНОВОДСТВА В КАЗАХСТАНЕ: ПРОСТРАНСТВЕННО-ЭКОНОМИЧЕСКАЯ ОЦЕНКА

Разработать воспроизводимую методику пространственно-экономической оценки приоритетов перехода животноводческих хозяйств Казахстана к органическому производству. Методы. Интегральный индекс объединяет пространственно-экологический, производственный, финансовый и поведенческо-институциональный блоки. Показатели нормированы в диапазоне 0–1, каждому блоку присвоен равный вес 0,25, а для экологического блока установлен минимальный порог 0,55. Сопоставлены четыре пятилетних сценария: исходные условия, расширение пастбищ, сохранение защитных лесополос и интегрированная органическая система. Результаты. Значения индекса

составили соответственно 0,50; 0,53; 0,57 и 0,73. Сценарий расширения пастбищ не прошёл экологический порог, несмотря на улучшение производственных и финансовых показателей. Интегрированный сценарий сохранил первое место при изменении весов и исходных оценок. Выводы. Простого увеличения площади выпаса недостаточно. Приоритет следует отдавать хозяйствам и районам, где регулируемый выпас, водообеспечение, защита лесополос, прослеживаемость, сертифицированные корма, ветеринарное обслуживание, переработка и сбыт могут быть объединены в единую цепочку. Результаты имеют модельный характер и требуют проверки на пространственных, производственных, финансовых и анкетных данных хозяйств. После заполнения фактическими данными методика может использоваться для сопоставления районов и обоснования приоритетов перехода.

Ключевые слова: органическое животноводство, пастбища, защитные лесополосы, пространственная оценка, экономическая эффективность, сертификация, Казахстан

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