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**A CONCEPTUAL FRAMEWORK FOR ORGANIC LIVESTOCK DEVELOPMENT IN PASTURE
AND FOREST-BELT LANDSCAPES OF KAZAKHSTAN: AN INTEGRATED SPATIAL-
ECONOMIC APPROACH**

Abstract: Sustainable organic livestock development requires environmental safeguards to be considered together with production performance, economic feasibility, and farmers' readiness for transition. This methodological study proposes an integrated spatial-economic framework for evaluating organic livestock systems in pasture and forest-belt landscapes of Kazakhstan. The framework combines spatial-environmental, production, financial, and behavioural-institutional dimensions and introduces an environmental eligibility condition to prevent strong economic performance from compensating for critical ecological failure. Four hypothetical scenarios are used solely to demonstrate the calculation procedure: baseline conditions, pasture expansion, forest-belt conservation, and an integrated organic system. The scenario scores are illustrative inputs rather than measurements from farms, remote sensing, accounting records, or a new survey. Under the illustrative equal-weight example, the integrated indices are 0.50, 0.53, 0.57, and 0.73, respectively. These values demonstrate how the framework differentiates trade-offs among dimensions; they do not constitute empirical evidence that one scenario will produce these outcomes in Kazakhstan. The framework is intended to guide future farm-level data collection, GIS analysis, economic assessment, and behavioural surveys. Empirical validation should include region-specific carrying capacities, spatial data, cash-flow parameters, stakeholder-derived weights, and sensitivity analysis.

Keywords: organic livestock farming; pasture management; forest belts; conceptual framework; spatial-economic approach; environmental threshold; Kazakhstan.

Introduction

The sustainable development of organic livestock farming in landscapes shaped by natural woodlands and pastures presents a compelling challenge and opportunity for the integration of ecological stewardship with productive agricultural systems. An effective development pathway in this domain requires an integrated spatial-economic assessment that simultaneously accounts for (i) the ecological functions provided by semi-natural woody pastures, grazed woodlands, and associated native vegetation, (ii) the provisioning of nutritious forage and resilient production for organic livestock systems, and (iii) the economic viability and policy contexts that govern land-use decisions. Across the literature, these components are repeatedly shown to be interdependent and mutually reinforcing when addressed through explicit spatial and economic analysis that links landscape structure to livestock outcomes and farmer incentives [1–3].

A core premise of integrating natural woodlands with organic livestock production is that woody pastures and wood-pasture mosaics can deliver essential ecosystem services beyond mere forage. Agroforestry-and-livestock systems, including two-layered wood pastures and derived grassland-woodland configurations, are documented to provide biodiversity benefits, microclimatic regulation, soil protection, and potential fire risk reduction in fire-prone regions, while simultaneously supporting livestock production under low-input regimes [4]. Comparative analyses of landscape configurations repeatedly highlight the sensitivity of biodiversity and ecosystem service delivery to spatial patterning, patch size, edge effects, and connectivity, underscoring the need for spatially explicit planning in

wood-pasture systems [4, 5]. In Mediterranean and temperate landscapes alike, historical and ongoing land-use transitions involving grazing, woodland encroachment, and restoration efforts demonstrate that landscape configuration mediates both ecological outcomes and forage provisioning for organic systems [5–7].

The integrated role of woody components with forage production has been framed in terms of high nature and cultural value (HNCV) agroforestry, which characterizes systems that combine trees with livestock to deliver multiple services (biodiversity, carbon, watershed protection, heritage values) alongside agricultural outputs. The evidence base shows that HNCV agroforestry systems commonly enhance biodiversity and regulate ecosystem processes relative to conventional systems, and they can contribute to fire risk mitigation, carbon sequestration, and soil conservation, even though effects may be context-specific and require site-level evaluation [4]. Within this complexity, quantitative tools that couple landscape state and transition models with forage provisioning indicators provide a promising route to transparently assess how different woodland-pasture configurations perform under organic management goals [8, 9].

An integrated spatial-economic assessment must explicitly connect land-use decisions to farm-level profitability and policy instruments. Do investments in revegetation, restoration, or retention of native woodland in pasture systems improve biodiversity and ecosystem services at reasonable costs? Evidence from regional analyses indicates that biodiversity benefits from investment policies can be modest if actions are narrowly targeted, yet cost-effectiveness improves when investments align with broader resource-management objectives (e.g., salinity control, erosion reduction) and are delivered in high-conservation-value areas or across mosaic landscapes that maximize co-benefits. These findings emphasize the importance of incentive design and spatial targeting in achieving landscape-scale biodiversity and ecosystem-service gains alongside organic livestock production goals [10].

The farm-scale natural capital perspective offers a practical framework for integrating ecological and economic information. Frameworks that quantify natural capital stocks and ecosystem services on farms and relate them to forage provisioning, habitat quality, carbon storage, and other services support transparent sustainability reporting and informed decision-making by producers, buyers, and policy-makers. Such farm-scale accounts demonstrate the feasibility of integrating ecological modeling, remote sensing, and production data to generate verifiable indicators of both environmental performance and forage capacity, which are essential for organic livestock operations seeking resilience and market positioning [8, 9].

The development of organic livestock farming within woodland–pasture mosaics benefits from governance that recognizes multifunctionality and resilience as core objectives. Policy instruments that reward land stewardship, biodiversity conservation, and sustainable forage provisioning can align economic incentives with ecological outcomes, enabling landholders to maintain traditional woodland–pasture practices while expanding organic production. Cross-scalar learning from regional to farm scales indicates that successful pathways combine spatial targeting of biodiversity actions with economic incentives that reflect opportunity costs and the broader benefits of landscape-level stewardship [1, 9, 10].

Building on these strands of literature, the present study proposes a methodological framework rather than reporting a completed national GIS or farm-level economic assessment. The methodological contribution is not a new arithmetic averaging formula. It lies in the proposed integration, for Kazakhstan-oriented future applications, of four evidence domains—spatial-environmental, production, financial, and behavioural-institutional performance—within one scenario architecture, together with a non-compensatory environmental eligibility condition. This condition prevents a critically low environmental score from being fully offset by stronger economic or production scores. The framework also specifies how future GIS layers, farm records, financial data, and farmer surveys can be linked and transparently tested through sensitivity analysis. [11]

Terminology is used consistently in this article. “Forest belts” refers specifically to protective tree and shrub belts within or adjacent to pasture landscapes; it does not denote natural forest or all wooded pasture. “Pasture and forest-belt landscapes” is therefore used as the study-framework term in the title, abstract, methods, and conclusions. Evidence from natural woodlands or silvopastoral systems is cited only as supporting literature and is not treated as an identical land-use category.

Materials and methods

This study is a conceptual and methodological synthesis informed by published work on spatially explicit land-use transitions [12] and empirical evidence on livestock farmers' risk preferences in Kazakhstan [13]. It does not present a completed GIS analysis, a new farm survey, or newly measured economic or ecological effects. The proposed unit of analysis for future empirical application is an individual farm and its associated pasture and forest-belt area within a defined spatial grid. Scenario horizons of 5, 10, and 20 years are proposed for subsequent empirical evaluation.

All numerical scenario scores reported below are synthetic demonstration values created to show the mechanics of the framework. They are not estimates derived from remote sensing, cadastral data, farm accounts, veterinary records, or respondent-level survey data. Accordingly, the worked example is labelled as illustrative throughout the Results, Discussion, tables, figure caption, and conclusions.

Efficiency is assessed across four interrelated dimensions: spatial and environmental, production, economic, and behavioural and institutional. The indicators are normalised so that an increase in a normalised value always represents an improvement in performance.

The spatial and environmental dimension includes the proportion of stable vegetation cover, pasture stocking rate relative to carrying capacity, proportion of preserved forest belts, connectivity of woody landscape elements, distance to water sources, and erosion risk. In a future empirical application, data should be obtained from remote sensing, geographic information systems, field surveys, and cadastral records. These indicators reflect the condition of natural capital and the spatial sustainability of land use.

The production dimension includes live-weight output, young-stock survival rate, seasonal weight-gain patterns, feed availability, and the proportion of pasture-based feed in the diet. In a future empirical application, farm records and veterinary data should be used as the main sources of information. These indicators describe the technological and production performance of the farming system.

The economic dimension includes net present value, production costs, organic price premiums, transition costs, and income variability. In a future empirical application, the required information should be obtained from accounting records, market prices, and contracts. These indicators are used to assess commercial viability and financial risk.

The behavioural and institutional dimension includes risk preferences, attitudes, resource capacity, institutional opportunities, social legitimacy, trust, and readiness for certification. In a future empirical application, these variables should be measured through surveys using Likert scales. They indicate the probability that farmers will adopt the proposed practices.

The relevant data are presented in Table 1.

Table 1 – Indicator system for the integrated assessment. Compiled by the author based on references [12, 13].

Dimension	Key indicators	Data source	Expected role
Spatial and environmental	Share of stable vegetation cover; pasture stocking rate/carrying capacity; proportion of preserved forest belts; connectivity of woody elements; distance to water sources; erosion risk	Remote sensing, GIS, field surveys, and cadastral records	Reflects the condition of natural capital and the spatial sustainability of land use
Production	Live-weight output; young-stock survival rate; seasonal weight-gain patterns; feed availability; proportion of pasture-based feed in the diet	Farm records and veterinary data	Indicates technological and production performance
Economic	Net present value; production costs; organic price premium; transition costs; income variability	Accounting records, market prices, and contracts	Assesses commercial viability and financial risk

Dimension	Key indicators	Data source	Expected role
Behavioural and institutional	Risk preference; attitude; capacity; opportunity; legitimacy; trust; readiness for certification	Likert-scale surveys	Determines the probability of actual adoption of organic practices

For a positively oriented indicator x , the normalised value is calculated using the following equation:

$$z_i = (x_i - x_{\min}) / (x_{\max} - x_{\min}).$$

For a negative indicator, such as erosion risk or the exceeding of pasture carrying capacity, reverse normalisation is applied:

$$z_i = (x_{\max} - x_i) / (x_{\max} - x_{\min}).$$

The partial indices E, P, F, and B represent environmental performance, production performance, financial performance, and behavioural and institutional readiness, respectively. Each partial index is calculated as a weighted sum of the relevant normalised indicators. The integrated efficiency index is determined as follows: In an empirical application, $x_{\min}$ and $x_{\max}$ must be defined separately for each indicator from a documented reference range, observed sample range, or justified policy/ecological benchmark. Indicator-level weights within each dimension must likewise be reported explicitly. The present worked example starts at the dimension-score level and therefore does not claim that the underlying indicator matrix has been empirically estimated.

$$I_{\text{eff}} = w_E E + w_P P + w_F F + w_B B, \sum w = 1.$$

For the worked example, each of the four dimensions is assigned an equal weight of 0.25 for transparency. This is an illustrative assumption, not an empirically validated weighting scheme. In empirical applications, weights should be elicited using the analytic hierarchy process, entropy weighting, or structured stakeholder consultation and tested through sensitivity analysis. Likewise, the environmental eligibility threshold used in the demonstration ($E_{\min} = 0.40$) is a screening assumption chosen only to illustrate a non-compensatory rule; it is not a regulatory or ecological threshold for Kazakhstan and must be replaced by a region-specific value supported by carrying-capacity and ecological data.

The pasture stocking coefficient is calculated as the ratio of the actual stocking rate to the environmentally sustainable carrying capacity:

L = actual stocking rate / environmentally sustainable carrying capacity.

The value of L must not exceed the established regional threshold.

The intertemporal efficiency of an investment decision is assessed using net present value:

$$NPV = \sum_t [(R_t - C_t - D_t + S_t) / (1 + r)^t] - I_0,$$

where R_t is revenue from product sales, C_t represents operating costs, D_t is the estimated environmental damage or restoration cost, S_t represents subsidies and payments for ecosystem services, r is the discount rate, and I_0 represents the initial investment and organic certification transition costs.

No investment amount, operating-cost series, organic price premium, certification cost, subsidy stream, environmental-damage estimate, discount rate, or 5-, 10-, and 20-year cash-flow series is estimated in the present article. Consequently, the financial scores in the worked example are synthetic inputs rather than results of an NPV calculation. A future empirical application must report these parameters and the resulting cash flows transparently.

Scenarios without an organic price premium and scenarios with different premium levels are calculated separately. This approach is necessary because a market premium should not conceal the degradation of the natural resource base.

In a future empirical application, farmers' readiness may be estimated using an ordered probit or ordered logit model based on variables used in the published Kazakhstan study by Wang et al. [13]. No new behavioural model is estimated in the present methodological paper. The purpose of this component is to specify how respondent-level readiness scores could subsequently be incorporated into the integrated framework.

$$H_i^* = \alpha + \beta RISK_i + \gamma_1 ATT_i + \gamma_2 CAP_i + \gamma_3 OPP_i + \gamma_4 LEG_i + \delta X_i + \mu_r + \varepsilon_i,$$

where H^* denotes latent readiness to adopt the proposed system, RISK represents risk preference, ATT denotes attitude, CAP represents resource capacity, OPP denotes institutional opportunity, LEG represents social legitimacy, X includes farm characteristics, μ_r represents regional effects, and ε_i is the error term.

For the analysis of the integrated forest–pasture system, resource capacity includes access to pastures, water sources, fencing, mobile infrastructure, and geographic information system services. Attitude includes farmers' perceptions of animal welfare and the importance of forest-belt conservation. Institutional opportunity reflects access to certification services and contracts with buyers.

The proposed spatial component is a workflow for future empirical implementation rather than a completed GIS analysis. It comprises: defining the study boundary and coordinate reference system; selecting a grid resolution appropriate to the available data; assembling dated land-cover, pasture, water-point, road, cadastral, and forest-belt layers; estimating region-specific carrying capacity; calculating accessibility and fragmentation indicators; and linking these spatial outputs to farm-level production, financial, and behavioural data. Data source, acquisition date, spatial resolution, projection, grid-cell size, and preprocessing steps must be reported when the framework is applied to a specific study area.

For that future implementation, natural pastures, managed grazing land, and protective tree/shrub belts should be represented as separate spatial classes so that changes in woody landscape elements are not concealed within aggregated land-use categories. In this article, no administrative boundary, coordinate set, satellite scene, or spatial allocation result is claimed.

Four scenarios are considered in the assessment.

The baseline scenario, S0, represents the existing land-use structure, current stocking rates, and prevailing institutional conditions. It is used to assess the development trajectory without additional measures.

The pasture expansion scenario, S1, assumes an increase in pasture area without mandatory protection of forest belts. It is used to examine the risk of shifting grazing pressure and losing natural landscape elements.

The forest-belt conservation scenario, S2, involves prohibiting or restricting the conversion of woody landscape elements and regulating access to shelter and water. It is used to assess environmental effects under unchanged production practices.

The integrated organic system scenario, S3, combines rotational grazing, forest-belt conservation, and environmental thresholds with certification, training, contracts, and insurance. It is used to assess the combined environmental, economic, production, and behavioural effects of the proposed system.

The relevant data are presented in Table 2.

Table 2 – Proposed scenario matrix. Compiled by the author based on references [12, 13].

Scenario	Land use	Management	Expected focus of assessment
S0: Baseline	Existing land-use structure	Current stocking rates and institutional conditions	Development trajectory without additional measures
S1: Pasture expansion	Increase in pasture area	No mandatory protection of forest belts	Risk of shifting grazing pressure and losing natural landscape elements
S2: Forest-belt conservation	Prohibition or restriction of the conversion of woody landscape elements	Regulated access to shelter and water	Environmental effects under unchanged production practices
S3: Integrated organic system	Rotational grazing, forest-belt conservation, and environmental thresholds	Certification, training, contracts, and insurance	Combined environmental, economic, and behavioural effects

Results

The following worked example demonstrates the calculation logic using synthetic dimension scores. It is not a measurement of Kazakhstan's pasture utilisation and does not estimate the area currently available for organic livestock expansion. In an empirical application, national and regional pasture statistics should be cited with their year and official definition and then combined with water access, infrastructure, forage productivity, veterinary coverage, degradation status, and carrying-capacity data.

In the illustrative dataset, the pasture-expansion scenario has higher production and financial scores than the baseline but an environmental score of 0.34. Under the demonstration rule $E_{\min}=0.40$, this synthetic case fails the environmental eligibility condition. This outcome illustrates the logic of the rule and should not be interpreted as an empirical finding about pasture expansion in Kazakhstan.

In the same synthetic example, the forest-belt conservation scenario has an integrated index of 0.57, while the integrated organic-system scenario has an index of 0.73. These differences are generated by the assumed input scores and are presented only to demonstrate how coordinated environmental, production, financial, and institutional measures can be compared within the framework.

The synthetic scores were deliberately assigned on a 0-1 scale to create contrasting profiles for demonstration: S0 represents mid-range values; S1 combines a deliberately low environmental score with higher production and financial scores; S2 combines a higher environmental score with moderate production and financial scores; and S3 is assigned relatively high values across all four dimensions. These numbers are pedagogical inputs, not expert elicitation, forecasts, calibrated parameters, or transformed observations. Because no indicator-level empirical dataset exists in this methodological paper, no claim is made that the synthetic dimension scores can be reproduced from underlying farm observations.

The relevant data are presented in Table 3.

Table 3 – Synthetic dimension scores used to demonstrate the integrated-index calculation (illustrative values; not empirical estimates)

Scenario	Environmental index	Production index	Financial index	Behavioural readiness	Integrated efficiency index	Assessment
S0: Baseline	0.48	0.55	0.50	0.46	0.50	Illustrative baseline
S1: Pasture expansion	0.34	0.68	0.60	0.49	0.53	Illustrative case: fails assumed E threshold
S2: Forest-belt conservation	0.70	0.56	0.48	0.52	0.57	Illustrative conservation case
S3: Integrated organic system	0.78	0.72	0.67	0.74	0.73	Illustrative integrated case

The integrated efficiency index was calculated by assigning an equal weight of 0.25 to each assessment dimension:

$$I_{\text{eff}} = 0.25E + 0.25P + 0.25F + 0.25B.$$

For the integrated organic livestock scenario, the calculation was:

$$I_{\text{eff}} = (0.78 + 0.72 + 0.67 + 0.74) / 4 = 0.73.$$

Within the synthetic equal-weight example, the S3 index is 46% higher than the baseline index (0.73 versus 0.50). This arithmetic comparison demonstrates the aggregation procedure only; it does not estimate a 46% real-world efficiency gain. Empirical conclusions require observed or independently estimated indicator values.

The values in Table 3 are therefore a reproducible calculation example at the dimension-score level. They must not be used for policy or farm selection until the underlying indicators, normalisation bounds, within-dimension weights, spatial inputs, and financial parameters have been populated with empirical data.

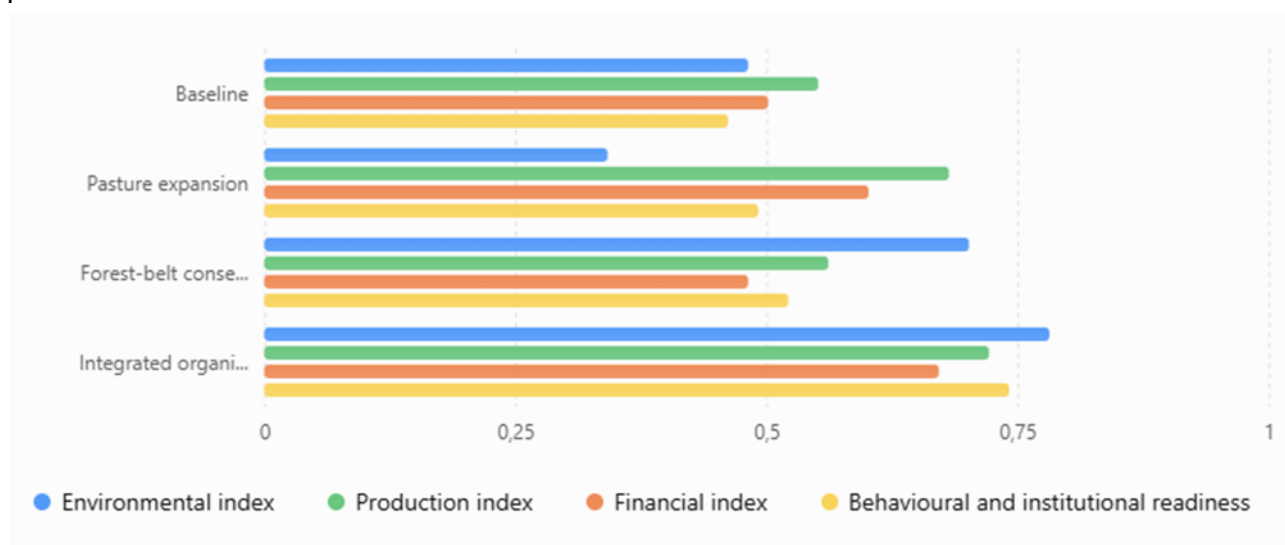
Sensitivity of the illustrative example was checked by varying the weight of each dimension from 0.10 to 0.40 while distributing the remaining weight equally among the other three dimensions. This exercise is a robustness check of the synthetic example only. The ordering of the illustrative integrated indices remained unchanged because S3 was assigned comparatively high values in every dimension. The assumed environmental threshold was also varied from 0.35 to 0.50: S1 remained below the threshold throughout this range, whereas S0 would pass at thresholds up to

0.48 and fail above that value. This demonstrates why empirical applications must justify both weights and environmental cut-offs rather than treating them as universal constants. The relevant data are presented in Table 4.

Table 4 – Sensitivity analysis of the synthetic worked example

Scenario	Equal-weight index	Index range when one dimension weight varies 0.10–0.40	Environmental score (E)	Threshold status for $E_{min} = 0.35–0.50$
S0: Baseline	0.50	0.487–0.508	0.48	Passes at $E_{min} \leq 0.48$; fails above 0.48
S1: Pasture expansion	0.53	0.490–0.565	0.34	Fails throughout 0.35–0.50
S2: Forest-belt conservation	0.57	0.538–0.592	0.70	Passes throughout 0.35–0.50
S3: Integrated organic system	0.73	0.716–0.739	0.78	Passes throughout 0.35–0.50

Note: For each scenario, one of the four dimension weights was set in turn to 0.10, 0.20, 0.30, or 0.40, while the remaining weight was divided equally among the other three dimensions. The reported range is the minimum–maximum index across these 16 illustrative weighting combinations. This sensitivity analysis tests only the arithmetic robustness of the synthetic example and does not validate the scenario scores.



The results are illustrated in Figure 1.

Figure 1 – Synthetic environmental, production, financial, and behavioural-institutional scores used in the worked example. Values are illustrative inputs for demonstrating the assessment framework and are not empirical estimates.

Figure 1 visualises the synthetic scores used in the worked example. S3 has the largest assumed scores across the four dimensions, whereas S1 has an assumed environmental score of 0.34. Because these values were assigned for demonstration rather than estimated from observations, the figure illustrates model behaviour and trade-offs, not measured scenario performance.

Discussion

This study should be interpreted as a methodological proposal. The literature indicates that pasture area alone is insufficient to characterise sustainable grazing because accessibility, water, forage condition, infrastructure, mobility, veterinary services, and institutional conditions also matter

[14, 15, 16]. The framework is designed to bring these factors into a common assessment, but the present article does not quantify them for a representative sample of Kazakhstan's farms.

The synthetic scenarios illustrate a potential trade-off: a scenario can receive favourable production and financial scores while failing an environmental screening rule. In the worked example S1 has $E=0.34$ and therefore fails the assumed $E_{\min}=0.40$. This is not evidence that actual pasture expansion necessarily causes ecological decline; rather, it demonstrates how the framework can prevent economic gains from automatically compensating for a critically low environmental score. Empirical testing should evaluate vegetation loss, erosion, fragmentation, and grazing concentration around water points using observed spatial and field data [17, 18].

The higher environmental score assigned to the forest-belt conservation scenario is also hypothetical. Its purpose is to represent mechanisms described in the literature, including vegetation connectivity, shelter, wind protection, soil protection, and landscape resilience. Whether these benefits occur, and at what magnitude, must be measured for the selected Kazakhstan study area. Conservation measures should therefore be evaluated jointly with water access, grazing rotation, livestock routes, and economic incentives rather than assumed to generate a predetermined index gain [19].

S3 has the highest integrated score in the worked example because the demonstration dataset intentionally assigns it relatively high values across all four dimensions. The value 0.73 is therefore a property of the synthetic input matrix, not an empirical estimate of the effectiveness of an integrated organic system. The methodological implication is narrower: a multidimensional framework can make explicit whether a proposed system balances environmental, production, financial, and behavioural-institutional criteria instead of optimising a single criterion [20].

The behavioural-institutional dimension is retained because adoption cannot be inferred from biophysical suitability alone. Published evidence from Kazakhstan indicates that risk preferences and related behavioural factors are relevant to organic-livestock transition [13]. In a future application, certification costs, market access, technical support, contracts, cooperation, and resource capacity should be measured directly rather than represented by assumed scores.

Once validated with empirical data, the framework could support the classification of pilot farms according to environmental condition and transition readiness. Such classification should be treated as a decision-support output, not as an automatic certification or investment decision. Farms with low environmental scores would first require diagnosis of the limiting indicators, while farms with low readiness scores would require investigation of financial, informational, or institutional barriers.

The principal limitation is that the scenario scores are illustrative rather than observed. No representative farm sample, completed GIS layer stack, cash-flow dataset, or new behavioural survey is analysed here. The equal weights and $E_{\min}=0.40$ threshold are demonstration assumptions. Future validation should report indicator-specific $x_{\min}/x_{\max}$ values, within-dimension weights, alternative aggregation rules, region-specific carrying capacities, discount rates and cash flows, spatial resolution and projection, and uncertainty/sensitivity analyses. Transfer of evidence from Europe, the Mediterranean, the United States, Australia, Africa, and Mexico to Kazakhstan should also be tested rather than assumed because biophysical and institutional conditions differ.

Kazakhstan-specific validation is therefore a substantive requirement rather than a minor data update. The empirical version should use current official national and regional sources for pasture categories and use, protective forest belts, water infrastructure, degradation status, livestock routes, veterinary accessibility, and carrying capacity. Such sources were not supplied for the present methodological manuscript, so unsupported national pasture-area figures have been removed rather than replaced with unverified statistics.

Overall, the worked example shows how the proposed framework can compare coordinated and single-focus strategies without allowing an assumed environmental failure to be hidden by stronger scores elsewhere. It does not establish which strategy is empirically preferable for Kazakhstan. That question requires application of the framework to specified territories and farms using transparent spatial, ecological, production, financial, and survey data.

Conclusion

This study proposes an integrated spatial-economic framework for future assessment of organic livestock development in Kazakhstan's pasture and forest-belt landscapes. The framework combines spatial-environmental, production, financial, and behavioural-institutional dimensions and adds an environmental eligibility rule to limit full compensation between ecological and economic performance.

The article does not estimate national pasture availability or report a completed GIS/economic assessment. Instead, it specifies the data architecture required for empirical application, including land-cover and forest-belt layers, water and infrastructure access, carrying capacity, farm production records, cash-flow variables, and farmer-readiness data.

The four scenario scores (0.50, 0.53, 0.57, and 0.73) are synthetic worked-example values. They demonstrate index calculation, environmental screening, and trade-off interpretation but should not be read as measured scenario effects. Their purpose is methodological transparency.

The framework is designed to test combinations of rotational grazing, stocking control, forest-belt conservation, water access, certification, training, market arrangements, and risk-management measures once empirical inputs are available. The relative contribution of these measures remains an empirical question.

Future studies should validate the framework in clearly defined Kazakhstan study areas, justify normalisation ranges and thresholds, estimate economic cash flows over stated horizons, derive weights from data or stakeholders, and conduct sensitivity and uncertainty analysis. Only after such validation should the framework be used to support farm or territorial prioritisation.

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ҚАЗАҚСТАННЫҢ ЖАЙЫЛЫМДЫҚ ЖӘНЕ ҚОРҒАНЫШ ОРМАН ЖОЛАҚТАРЫ ЛАНДШАФТАРЫНДА ОРГАНИКАЛЫҚ МАЛ ШАРУАШЫЛЫҒЫН ДАМУДЫҢ ТҰЖЫРЫМДАМАЛЫҚ НЕГІЗІ: ИНТЕГРАЦИЯЛАНҒАН КЕҢІСТІКТІК-ЭКОНОМИКАЛЫҚ ТӘСІЛ

Органикалық мал шаруашылығын тұрақты дамыту экологиялық қауіпсіздікті, өндірістік нәтижелілікті, экономикалық орындылықты және фермерлердің көшуге дайындығын бірге бағалауды талап етеді. Бұл әдістемелік жұмыста Қазақстанның жайылымдық және қорғаныш орман жолақтары бар ландшафттарында органикалық мал шаруашылығын бағалауға арналған интеграцияланған кеңістіктік-экономикалық негіз ұсынылады. Тәсіл кеңістіктік-экологиялық, өндірістік, қаржылық және мінез-құлықтық-институционалдық өлшемдерді біріктіреді және экологиялық сәтсіздіктің жоғары қаржылық көрсеткіштермен толық өтелуіне жол бермейтін экологиялық жарамдылық шартын енгізеді. Төрт гипотетикалық сценарий есептеу тәртібін көрсету үшін ғана пайдаланылды. Иллюстрациялық есепте төрт өлшемге бірдей салмақ беріліп, экологиялық жарамдылық шегі өтемдік емес сүзгі ретінде қарастырылды. Әдістемені нақты қолдану кезінде көрсеткіштер шаруашылық және ветеринариялық есептер, нарықтық бағалар, кадастрлық деректер, қашықтан зондтау материалдары және фермерлер сауалнамасы негізінде қалыптастырылуы тиіс. Салмақтар мен шекті мәндер нақты өңірдің жайылым сыйымдылығы мен экологиялық жағдайына сәйкес негізделіп,

нәтижелер сезімталдық талдауымен тексерілуі қажет. 0,50; 0,53; 0,57 және 0,73 индекстері нақты шаруашылықтардан алынған эмпирикалық нәтижелер емес, иллюстрациялық мәндер. Ұсынылған негіз болашақта шаруашылық деңгейіндегі деректермен, GIS талдауымен, экономикалық есептермен және фермерлер сауалнамасымен тексерілуі тиіс.

Түйінді сөздер: органикалық мал шаруашылығы; жайылымдарды басқару; қорғаныш орман жолақтары; тұжырымдамалық негіз; кеңістіктік-экономикалық тәсіл; экологиялық шек; Қазақстан.

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КОНЦЕПТУАЛЬНАЯ ОСНОВА РАЗВИТИЯ ОРГАНИЧЕСКОГО ЖИВОТНОВОДСТВА В ПАСТИЩНЫХ ЛАНДШАФТАХ И ЗАЩИТНЫХ ЛЕСОПОЛОСАХ КАЗАХСТАНА: ИНТЕГРИРОВАННЫЙ ПРОСТРАНСТВЕННО-ЭКОНОМИЧЕСКИЙ ПОДХОД

Устойчивое развитие органического животноводства требует совместной оценки экологических ограничений, производственных результатов, экономической осуществимости и готовности фермеров к переходу. В данной методологической работе предлагается интегрированная пространственно-экономическая основа для будущей оценки органического животноводства в пастбищных ландшафтах и защитных лесополосах Казахстана. Подход объединяет пространственно-экологическое, производственное, финансовое и поведенческо-институциональное измерения и вводит условие экологической приемлемости, не позволяющее полностью компенсировать критическую экологическую неэффективность высокими экономическими показателями. Четыре гипотетических сценария используются исключительно для демонстрации расчета. В демонстрационном примере четырём измерениям присвоены равные веса, а экологический порог используется как некомпенсируемый фильтр. При практическом применении показатели должны формироваться по данным хозяйственного и ветеринарного учета, рыночным ценам, кадастровым сведениям, материалам дистанционного зондирования и опросам фермеров. Веса и пороговые значения необходимо обосновывать для конкретного региона, а устойчивость результатов проверять анализом чувствительности. Индексы 0,50; 0,53; 0,57 и 0,73 являются иллюстрационными, а не эмпирическими оценками. Предлагаемая основа требует последующей проверки на данных хозяйств, GIS-материалах, экономических расчетах и опросах фермеров.

Ключевые слова: органическое животноводство; управление пастбищами; защитные лесополосы; концептуальная основа; пространственно-экономический подход; экологический порог; Казахстан.

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