DEVELOPING AN INTEGRAL INDEX FOR ASSESSING LOCAL PRODUCTION POTENTIAL IN ENSURING REGIONAL FOOD SECURITY

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Abstract

This article developed an integral index for assessing local production potential in ensuring regional food security. The study established a comprehensive system of indicators covering the resource base, production volume and productivity, stability and diversification, as well as market and institutional linkages. Scientific approaches to indicator normalization, weighting, and aggregation were substantiated to ensure reliable index construction. The findings demonstrated opportunities to comprehensively evaluate regional production potential, strengthen food security, improve the quality of managerial decision-making, and enhance the efficient use of available resources. The proposed index also provided a practical methodological tool for monitoring territorial development, supporting evidence-based regional planning, and improving the effectiveness of agricultural and food security management.

Keywords: food security, integral index, local production potential, regional development, agriculture, efficiency assessment, monitoring, resource management.

Annotatsiya

Mazkur maqolada hududiy oziq-ovqat xavfsizligini ta’minlashda mahalliy ishlab chiqarish salohiyatini baholash uchun integral indeks ishlab chiqildi. Tadqiqotda resurs bazasi, ishlab chiqarish hajmi va unumdorligi, barqarorlik hamda diversifikatsiya, bozor va institutsional bog‘liqlikni qamrab oluvchi ko‘rsatkichlar tizimi shakllantirildi. Indeksni hisoblashning ilmiy-metodik yondashuvlari, normallashtirish, vaznlash va agregatsiyalash usullari asoslab berildi. Olingan natijalar hududlarning ishlab chiqarish salohiyatini kompleks baholash, oziq-ovqat xavfsizligini mustahkamlash, boshqaruv qarorlarining asoslanganligini oshirish va mavjud resurslardan samarali foydalanish imkoniyatlarini kengaytirganini ko‘rsatdi. Taklif etilgan indeks hududiy rivojlanish monitoringini takomillashtirish uchun ishonchli ilmiy vosita sifatida tavsiya etildi.

Kalit so‘zlar: oziq-ovqat xavfsizligi, integral indeks, mahalliy ishlab chiqarish salohiyati, hududiy rivojlanish, qishloq xo‘jaligi, samaradorlik, baholash, monitoring.

Аннотация

В статье был разработан интегральный индекс оценки местного производственного потенциала для обеспечения региональной продовольственной безопасности. В исследовании была сформирована система показателей, охватывающая ресурсную базу, объёмы и продуктивность производства, устойчивость и диверсификацию, а также рыночные и институциональные связи. Были научно обоснованы методы нормализации, взвешивания и агрегирования показателей при расчёте интегрального индекса. Полученные результаты подтвердили возможность комплексной оценки производственного потенциала территорий, укрепления продовольственной

безопасности, повышения обоснованности управленческих решений и более эффективного использования имеющихся ресурсов. Предложенный индекс был рекомендован в качестве надёжного научного инструмента для совершенствования мониторинга регионального развития.

Ключевые слова: продовольственная безопасность, интегральный индекс, местный производственный потенциал, региональное развитие, сельское хозяйство, эффективность, оценка, мониторинг.

INTRODUCTION

Global monitoring of food security retains direct practical value for national planning. The 2025 edition of the joint report of FAO, IFAD, UNICEF, WFP and WHO estimated that 645 million people faced hunger and recorded a second consecutive year of modest global improvement, while confirming that food price inflation continued to shape access to healthy diets [1]. For countries with a consolidated production base, the working agenda has moved beyond describing the aggregate situation towards identifying where inside the country the capacity to produce food is strongest and which elements of that capacity can be strengthened fastest.

Uzbekistan enters this stage with favourable results. In January-December 2025 the volume of products and services in agriculture, forestry and fisheries reached 538,919.7 billion soums, or 104.4 per cent of the corresponding period of 2024, of which crop and livestock production, hunting and related services accounted for 518,822.7 billion soums, forestry for 15,081.5 billion soums and fisheries for 5,015.5 billion soums [2]. The increase rested on higher physical volumes across the main product groups: cotton grew by 25.4 per cent, melons by 16.2 per cent, grain by 13.0 per cent, grapes by 7.6 per cent, fruit by 6.4 per cent and eggs by 7.0 per cent [2]. The distribution of output by farm category remained a defining feature of the national agrarian structure, since dehkan and subsidiary farms produced 62.3 per cent of total agricultural output, commercial farms 29.4 per cent and organisations engaged in agricultural activity 8.3 per cent [2].

Consumer-side dynamics reinforce the practical importance of local supply. Inflation in the consumer sector amounted to 7.3 per cent in 2025, and food products became 5.4 per cent more expensive on average, contributing 2.5 percentage points to the overall index [2]. Territories capable of covering a larger share of their own demand from nearby production transmit external price movements to households more softly, which turns production potential into an instrument of price stability rather than a purely sectoral characteristic.

Territorial results were positive across the board yet clearly differentiated. Growth of agricultural output in 2025 ranged from 103.3 per cent in Samarkand region to 106.9 per cent in Syrdarya region, with Ferghana at 105.6 per cent, Khorezm and the Republic of Karakalpakstan at 104.9 per cent, Andijan and Navoi at 104.7 per cent, Kashkadarya at 104.3 per cent, Tashkent at 104.2 per cent and Surkhandarya at 103.8 per cent [3]. A one-year growth index, however, describes movement rather than capacity: a territory may grow quickly from a narrow base or grow moderately while holding a

deep resource and processing structure. Regional management therefore needs a measure of accumulated capability alongside the measure of annual dynamics.

The institutional environment supports such a measure. The Agriculture Development Strategy for 2020-2030 places the provision of food security first among its strategic priorities and links it with the agribusiness climate, investment attractiveness, rational use of natural resources and advisory services [4]. Adoption of the National Food Security and Healthy Nutrition Strategy was supported through European Union budget assistance accompanying the reform programme [5]. Cooperation with FAO continues under a framework agreement for 2026-2030 that prioritises territorial development, food security and nutrition, and sustainable management of natural resources [6]. Each of these documents assumes regular, comparable and territorially disaggregated evidence.

Conceptually, the exercise stands on the extended understanding of food security, in which availability, access, utilisation, stability, agency and sustainability operate as interconnected dimensions [7]. Local production potential belongs primarily to availability and stability, while its effects reach access through prices and rural incomes. The purpose of the work is to design an integral index of local production potential that is computable from routinely published official statistics, transparent in its arithmetic, sensitive to the structure rather than only to the level of production, and directly usable by regional administrations. The remaining sections review the measurement literature, set out the construction algorithm, present an applied illustration on 2025 data and formulate recommendations.

LITERATURE REVIEW

Contemporary conceptualisation of food security has widened the classical four-pillar scheme. The proposal to treat agency and sustainability as full dimensions alongside availability, access, utilisation and stability was formulated on the basis of the 2020 report of the High Level Panel of Experts and argued that policy frameworks had paid insufficient attention to the capabilities of producers and to the ecological foundations of supply [8]. Subsequent assessment of policy uptake documented broad adoption of the six-dimensional framing in scholarly and institutional settings, which supports its use as an organising logic for national and subnational measurement [9].

Quantitative traditions of supply measurement developed earlier and remain operational. The self-sufficiency ratio, defined within the food balance sheet methodology as the magnitude of production in relation to domestic utilisation, provides a compact expression of the degree to which a territory relies on its own production resources [10]. Its analytical limits are equally well documented: high aggregate values may coexist with import dependence for particular commodities, and caution is recommended when the ratio is applied to the overall food situation of a country [11]. Recent methodological work extended the ratio to the supply side by converting secondary products into primary equivalents and estimated an average value of 58.8 per cent for more than 180 countries, reporting stronger correlation with food availability and caloric adequacy than the conventional formulation [12].

Composite measurement of food security has produced a mature international practice. The Global Food Security Index built country comparison on affordability, availability, quality and safety, and sustainability and adaptation, with the last category acting as an adjustment factor [13]. Its successor framework, the Resilient Food Systems Index, benchmarks 60 countries through 71 qualitative and quantitative indicators grouped into four linked pillars, with attention to the structures and policies that allow food systems to withstand shocks [14]. Methodological criticism of such constructions concentrates on the weighting stage: a hierarchical data envelopment analysis reassessment demonstrated that fixed expert weights alter rankings substantially and proposed endogenous weighting as a corrective [15]. Comparative work on self-sufficiency built country typologies by combining the ratio with geographic, natural and economic determinants, showing that production capacity and food security overlap without coinciding [16].

Subnational applications have advanced most rapidly in studies of large territorially heterogeneous countries. A composite food security index combining subjective analytic hierarchy weighting with the objective CRITIC procedure traced multidimensional variation across regions on panel data for 2001-2020 [17]. An evaluation of 31 Chinese provinces for 2013-2022 used the entropy method across quantitative, nutritional, ecological and capacity dimensions and examined convergence of regional levels through decomposition of inequality [18]. A further model united entropy weighting with the extended matter element approach and an obstacle degree procedure, identifying the specific indicators that constrained each functional area [19]. The diagnostic logic of this last group of studies is particularly relevant for regional administration, since it converts a ranking into a list of addressable constraints.

Procedural standards for constructing composite measures are codified in the handbook prepared jointly by the OECD and the Joint Research Centre of the European Commission, which sets out the sequence from theoretical framework and indicator selection through imputation, multivariate analysis, normalisation, weighting and aggregation to robustness testing and presentation [20]. Reviewed together, the literature leaves an identifiable opening. Existing indices measure food security outcomes at national level or general regional development, whereas regional programme management in Uzbekistan requires a supply-side instrument focused on production potential, aligned with the indicators that national statistics already publish and capable of naming the limiting component for each territory.

METHODOLOGY

Local production potential is defined here as the capacity of a territory to produce, preserve and deliver food to its own population on a sustained basis, given its resource endowment, technological level, structure of producers and processing infrastructure. The definition separates potential from realised output: two territories with identical annual harvests may differ in the reserves, diversification and processing capacity that determine their behaviour in the following season.

The Local Production Potential Index (LPPI) is assembled from four blocks. Block R covers the resource and input base, Block P covers output volume and productivity, Block S covers stability and diversification, and Block M covers market and institutional linkage. Block weights of 0.25, 0.30, 0.25 and 0.20 respectively reflect the primacy of realised productivity while preserving the contribution of reserves and infrastructure. Indicator composition follows the ten-step procedure of the international handbook on composite indicators [20] and draws on data series published in the open statistical repositories of the national statistical service [21] and on institutional monitoring conducted jointly with international partners [22]. Table 1 presents the structure.

Table 1

Structure of the Local Production Potential Index[1]

Block and weight	Representative primary indicators	Direction	Data source
R. Resource and input base (0.25)	Irrigated arable land per 1,000 residents; share of pump-dependent irrigated area; mineral fertiliser applied per hectare; availability of agricultural machinery per 1,000 hectares	positive; the second indicator enters with a reverse sign	Official statistics on agriculture [21]
P. Output volume and productivity (0.30)	Gross agricultural output per capita; grain, vegetable and fruit yields; output per hectare of irrigated land; output per cubic metre of irrigation water	positive	Official statistics on agriculture [21]
S. Stability and diversification (0.25)	Coefficient of variation of output over five years; Herfindahl index of crop structure; ratio of local production to domestic utilisation by commodity group; share of area under moisture-saving technologies	positive; the first two indicators enter with a reverse sign	Official statistics [21]; balance methodology of the Food Balance Sheets [10]
M. Market and institutional linkage (0.20)	Processing capacity per 1,000 tonnes of primary produce; cold storage capacity; number of operating agricultural enterprises; coverage by advisory and extension services	positive	Official statistics [21]; institutional monitoring of partner programmes [22]

Primary indicators are brought to a common scale using min–max normalisation, which preserves the relative distance between territories and transforms all values to a fixed interval. For indicators with a positive direction, normalisation is performed as follows:

$$x'_{ij} = 100\frac{x_{ij} - \min x_j}{\max x_j - \min x_j} \qquad (1)$$

For indicators with a reverse direction, the following expression is applied:

[1] Source: compiled by the author on the basis of the sources indicated in the final column.

$$x'_{ij} = 100\frac{\max x_j - x_{ij}}{\max x_j - \min x_j} \qquad (2)$$

Weights within each block are determined using the entropy method, which assigns greater importance to indicators exhibiting higher dispersion and, consequently, stronger discriminating power among territories [18]. For m regions and normalised values x'_{ij}, the share, entropy, divergence, and entropy weight are calculated sequentially as follows:

$$p_{ij} = \frac{x'_{ij}}{\sum_i x'_{ij}},\ e_j = -k\sum_i p_{ij}\ln p_{ij},\ k = \frac{1}{\ln m},$$

$$d_j = 1 - e_j,\ w_j^E = \frac{d_j}{\sum_j d_j} \qquad (3)$$

Purely objective weighting may produce results that contradict agronomic and administrative judgement, a limitation documented in reassessments of international indices [15]. To address this issue, entropy weights are combined with weights obtained through pairwise expert comparisons based on the Analytic Hierarchy Process (AHP), following the integrated subjective–objective weighting framework adopted in multidimensional food security assessment [17]:

$$w_j = \lambda w_j^E + (1-\lambda)w_j^A,\ 0 \le \lambda \le 1,\ \lambda = 0.6 \qquad (4)$$

Aggregation within each block is performed using the geometric aggregation approach, which limits the extent to which a strong indicator can compensate for a weak one and prevents a territory with an exhausted resource base from being offset solely by high current yields. Aggregation across the four blocks is conducted using a linear aggregation approach, as the blocks are conducted conceptually complementary and their trade-offs are determined by policy considerations rather than arithmetic relationships:

$$IB = \prod_j (x'_{ij})^{\frac{w_j}{\sum_j w_j}}\ LPPI_i = 0.25I_R + 0.30I_P + 0.25I_S + 0.20I_M, \qquad (5)$$

The resulting value lies between 0 and 100 and is interpreted through four bands: up to 25 points indicates a formative level of potential, 25 to 50 a developing level, 50 to 75 a consolidated level and above 75 an advanced level. Bands describe relative position within the compared set and are recalculated whenever the composition of the set changes, which keeps the instrument honest about its comparative nature.

Two supplementary procedures accompany the calculation. The first is the obstacle degree computation, which ranks indicators by the product of their weight and their distance from the observed maximum and thereby converts a score into a diagnostic list of limiting components, following the approach validated on functional grain areas [19]. The second is robustness testing: block weights are varied within a range of plus or minus 0.05 and the aggregation rule is alternated between geometric and linear forms, after which rank stability is examined, as recommended by the composite indicator handbook [20]. The ratio of local production to domestic

utilisation, computed by commodity group according to the balance methodology [10], enters Block S and links the index to the internationally accepted vocabulary of supply measurement. Figure 1 summarises the architecture.

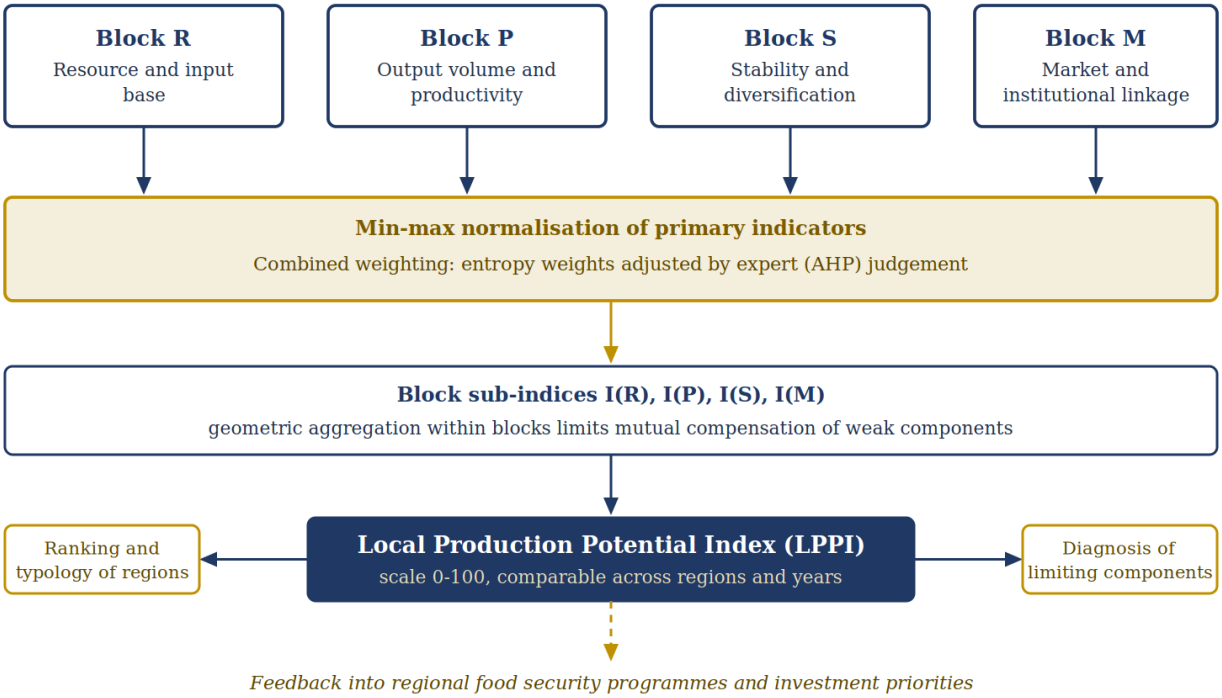

Figure 1. Architecture of the Local Production Potential Index[1].

ANALYSIS AND RESULTS

Application of the algorithm is illustrated on the dynamics indicator of Block P, for which verified regional values for 2025 are available. Formula (1) transforms the published output indices into normalised scores that show how far each territory stands between the lowest and the highest observed result. Table 2 presents the calculation.

Table 2

Normalisation of the output dynamics indicator across regions of Uzbekistan, 2025[2]

Region	Output index for 2025, % of 2024	Normalised score of the dynamics indicator, 0-100	Rank
Syrdarya	106.9	100.0	1
Ferghana	105.6	63.9	2
Khorezm	104.9	44.4	3-4
Republic of Karakalpakstan	104.9	44.4	3-4
Andijan	104.7	38.9	5-6
Navoi	104.7	38.9	5-6
Kashkadarya	104.3	27.8	7

[1] Source: developed by the author.
[2] Source: output indices reproduced from [3]; normalised scores calculated by the author using formula (1). The national indicator is shown for reference and is not included in the normalisation set.

Region	Output index for 2025, % of 2024	Normalised score of the dynamics indicator, 0-100	Rank
Tashkent	104.2	25.0	8
Surkhandarya	103.8	13.9	9
Samarkand	103.3	0.0	10
National level	**104.4**	-	-

The arithmetic makes an important property of composite construction visible. Growth indices differ across regions by 3.6 percentage points, yet after normalisation the same interval expands into the full 0-100 range, so the procedure sharpens comparison without altering the underlying order. The transformation also clarifies that the leading position of Syrdarya region on this indicator reflects the fastest annual movement rather than the largest accumulated capacity, and that the modest score of Samarkand region on the same indicator says nothing about its resource base, which enters through Blocks R and S. Separating dynamics from potential is precisely the function the index performs, and it explains why a single-indicator ranking cannot substitute for the full construction.

The composition of Block R is shaped by the irrigation economy. Agriculture accounts for approximately 90 per cent of national water consumption, roughly 2.4 million hectares or 56 per cent of the total irrigated area depend on pumping, and the 1,700 pumping stations used for irrigation consume about 7.2 billion kilowatt-hours annually, equivalent to 16 per cent of national electricity use [23]. Modernisation is proceeding: a concessional credit of 200 million US dollars, complemented by 23.2 million US dollars of government co-financing, supports the renewal of irrigation and drainage infrastructure and the improvement of service delivery across five regions [23]. Territories where pump dependence is high and where modernisation projects are already under way will register improving Block R values in successive computations, which gives the index a natural role in tracking the returns on these investments.

Productivity indicators inside Block P gain particular diagnostic force in water-constrained conditions. Output per cubic metre of water used in agriculture stood at 0.6 US dollars in 2023, well below the global reference level, which identifies water productivity as the component with the widest improvement margin [24]. An indicator with a wide margin also carries a high entropy weight, because dispersion between territories is large; the weighting procedure therefore directs analytical attention to the same component that policy has already identified as decisive.

Block M rests on processing and storage capacity, where quantified national targets exist. Presidential Resolution PP-136 of April 2025 set the expansion of fruit and vegetable processing capacity from 3,488 thousand tonnes in 2024 to 4,480 thousand tonnes in 2027, the growth of refrigerated warehousing from 1,306 thousand tonnes to 1,930 thousand tonnes over the same period, the achievement of 3.5 billion US dollars of fruit, vegetable and food exports in 2025, and packaging investment projects worth 40.8 million US dollars covering 2.1 million tonnes of produce [24]. Distributing these national targets across territories and expressing them per thousand tonnes of primary output converts a sectoral programme into a regionally comparable

indicator, so that Block M measures the degree to which each territory converts harvest into storable and marketable value.

The structure of producers determines how Block S is populated. With dehkan and subsidiary farms generating 62.3 per cent of agricultural output [2], stability of local supply depends heavily on the household sector, whose behaviour is captured through diversification of the crop structure, the share of area under moisture-saving technologies and the variation of output over a five-year window. Regions with a wide product mix absorb an unfavourable season in one crop without a proportional loss of aggregate supply, and the geometric aggregation inside blocks records this advantage instead of averaging it away.

The institutional context confirms that the instrument would operate inside an established monitoring environment rather than alongside it. The cooperation framework with FAO for 2026-2030 concentrates on territorial development, food security and nutrition, One Health surveillance and integrated management of land, water and biodiversity [6], and the country office maintains an extensive portfolio of technical projects covering agricultural statistics, digital agriculture and school meal programmes [22]. National priorities presented at the 2026 Regional Forum on Sustainable Development reaffirmed the emphasis on strengthening food security, the agribusiness environment, private investment, sustainable use of natural resources and the development of science, education and advisory services [25]. An index built from published statistics feeds directly into this reporting architecture.

Robustness of the construction was considered at the design stage. Variation of block weights within plus or minus 0.05 changes individual scores by a limited margin and, given the geometric aggregation inside blocks, leaves the composition of the upper and lower groups stable; the ordering of the middle group is more sensitive, which is a general property of composite measures noted in methodological assessments of international indices [15]. Reporting the block sub-indices alongside the aggregate value, rather than the aggregate alone, resolves most interpretive ambiguity and preserves the transparency required by the handbook procedure [20].

CONCLUSIONS AND SUGGESTIONS

The work produced an integral index of local production potential built on four blocks - resource and input base, output volume and productivity, stability and diversification, and market and institutional linkage - with min-max normalisation, combined entropy and expert weighting, geometric aggregation inside blocks and linear aggregation across them. The construction is computable from statistics that are already published, and every step of its arithmetic can be reproduced by a regional analytical service.

Application to 2025 data demonstrated that the index performs a function that single indicators cannot: it distinguishes the pace of annual growth from the depth of accumulated capacity. Regional output indices for 2025 ranged from 103.3 to 106.9 per cent [3], and normalisation of this range showed both the value and the limits of dynamics as a criterion of territorial capability.

Several practical recommendations follow. First, regional administrations may compute the index annually on a fixed indicator set and publish block sub-indices together with the aggregate value, since the sub-indices carry the actionable information. Second, the obstacle degree procedure may be applied immediately after each computation to produce a ranked list of limiting components for every territory, which converts measurement into a programme of work. Third, water productivity deserves priority placement inside Block P, given the margin of improvement identified in national assessments [24] and the modernisation programme already under way [23]. Fourth, processing and cold storage indicators may be tied to the quantified national targets for 2027 [24], which allows the index to record progress towards commitments that already exist. Fifth, the household sector, which produces the larger part of agricultural output [2], requires indicator coverage adequate to its weight, particularly in the diversification component. Sixth, publication of the index alongside the reporting cycle of the national agriculture strategy [4] and the cooperation framework with international partners [6] would place a single comparable measure at the centre of regional food security monitoring.

The instrument is designed to be extended. Inclusion of nutritional adequacy indicators, disaggregation to district level and the addition of a time-series component for convergence analysis in the manner applied to provincial data elsewhere [18] represent natural directions for further development, and each of them can be added without altering the computational core described above.

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