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A METHODOLOGICAL APPROACH TO THE COMPOSITE ASSESSMENT OF UKRAINE'S SOCIAL SECURITY UNDER WAR CONDITIONS

Full-scale war has altered the circumstances in which social security is provided in Ukraine. Its new determinants include physical protection, the continuity of essential services, the state's ability to resume its functions following attacks, and the proportion of territory under its control. Meanwhile, official statistics have become less reliable. The Ukrainian Social Security Index (USSI), which was developed here, combines a weighted, additive core of critical security, economic security, social stability, and agroclimatic conditions, as well as two multiplicative factors: institutional resilience and territorial control. It is applied to Ukraine for the period 2019–2026, with a provisional estimate for 2026. Wartime losses act as multipliers and the agroclimatic component is computed using remote sensing data. The mean index declines from 0.625 between 2019 and 2021 to 0.313 between 2022 and 2026, representing a 50.0 per cent decrease. This trend is consistent across all tested aggregation schemes, with a ± 0.05 shift in the expert-assigned inputs maintaining the decline within the range of 48.5–51.6 per cent. In a conditional variance decomposition for 2026, the resilience factor has a total-order sensitivity index of 87.0 per cent under the adopted uncertainty scheme, and it is also the quantity that is least supported by primary data. After controlling for a linear time trend, drought exposure was found to be negatively associated with cereal yield (partial $r = -0.861$; $p = 0.0003$; $n = 13$), which supports the content of the agroclimatic component. Although aggregation is fully reproducible, the scoring of the three components relies on expert judgement. Furthermore, the index as a whole has not been validated against an external criterion.

Keywords: social security, composite indicator, index construction, institutional resilience, territorial control, sensitivity analysis, wartime, Ukraine.

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МЕТОДИЧНИЙ ПІДХІД ДО ІНТЕГРАЛЬНОГО ОЦІНЮВАННЯ СОЦІАЛЬНОЇ БЕЗПЕКИ УКРАЇНИ В УМОВАХ ВІЙНИ

Повномасштабна війна змінила умови забезпечення соціальної безпеки в Україні: тепер до її визначальних факторів належать фізичний захист, безперебійність надання життєво важливих послуг, здатність держави відновлювати свої функції після ударів та частка території, яку вона контролює, тоді як офіційна статистика втратила свою повноту. Розроблений у цій роботі Індекс соціальної безпеки України (ІСБУ) поєднує зважене адитивне ядро, що охоплює критичну безпеку, економічну безпеку, соціальну стабільність та агрокліматичні умови, з двома мультиплікативними коефіцієнтами, що відображають інституційну стійкість та територіальний контроль, і застосовується до України на період 2019–2026 років із попередньою оцінкою на 2026 рік. Воєнні втрати діють як мультиплікатори, а агрокліматичний компонент розраховується на основі даних дистанційного зондування. Середнє значення індексу знижується з 0,625 у 2019–2021 роках до 0,313 у 2022–2026 роках, що становить зниження на 50,0 відсотків; напрямок цієї різниці зберігається за кожною з перевірених схем агрегації, а рівномірне зміщення значень, визначених експертами, на $\pm 0,05$ утримує зниження в межах 48,5–51,6 відсотків. У розкладі умовної дисперсії на 2026 рік коефіцієнт стійкості має індекс чутливості загального порядку 87,0 % за прийнятою схемою невизначеності і водночас є величиною, яка найменше підтверджується первинними даними. Частка території у класах посухи має негативний зв'язок з урожайністю зернових після врахування лінійного часового тренду (частковий коефіцієнт $r = -0,861$; $p = 0,0003$; $n = 13$), що підтверджує зміст агрокліматичного компонента. Агрегація є повністю відтворюваною, проте оцінювання трьох складників ґрунтується на експертному судженні, а індекс у цілому не валідовано за зовнішнім критерієм.

Ключові слова: соціальна безпека, композитний індикатор, побудова індексу, інституційна стійкість, територіальний контроль, аналіз чутливості, воєнний час, Україна.



1. Introduction.

Full-scale war has changed the circumstances in which social security is provided in Ukraine. Alongside income and employment, decisive factors now include physical protection of the population, continuity of essential services, the state's capacity to restore its functions after strikes and the territory over which these functions are exercised. At the same time, the availability and coverage of official statistics has declined: part of the household survey programme has been interrupted and a number of indicators are not observed in occupied territories.

Here, social security is understood in the sense established in Ukrainian research on the subject. It refers to the state and capacity of the socio-economic system, whereby the social interests of individuals, economic entities, regions and the state are safeguarded against internal and external threats based on social justice. In this state, the population is legally guaranteed access to essential social goods and services, and economic relations that govern the formation, distribution, and use of societal resources support the development of human potential and the ability to adapt to global shocks. In international usage, however, the term is narrower. The International Labour Organization (ILO) [7] defines social security as 'the protection that a society provides to individuals and households to ensure access to health care and to guarantee income security, particularly in cases of old age, unemployment, sickness, invalidity, work injury, maternity or loss of a breadwinner'. According to this definition, social security is a component of social protection. This category is broader, extending to physical protection, essential services, institutional capacity, and territorial control. Its focus is on the state and capacity of the national system. While it overlaps with human security [26], it focuses on the system rather than the security of the individual.

Existing frameworks provide the conceptual and indicator foundations for such an assessment. Most of these frameworks were designed for peacetime and are organised by areas of social policy. The approach reviewed in Section 2 addresses the wartime context and measures the social security of individuals. It includes wartime indicators in the indicator set, without separating institutional capacity for recovery or territorial limits on the provision of public services from the current state of the social sphere. The present paper addresses the gap created by the combination of these three elements within a single construction under a structural break in statistical observation.

The paper presents a composite indicator, the Ukrainian Social Security Index (USSI), and establishes the limits of evidence within which its results can be interpreted. The contribution is threefold. Firstly, wartime and territorial losses are incorporated into the calculation as multiplicative factors rather than negative additions. Secondly, the agroclimatic component is derived from remote sensing data, making it independent

of national statistical observations. Finally, the sensitivity analysis explicitly establishes the dependence of the findings on modelling choices. The analysis has three main objectives: to define the structure and rules for computing or scoring each input; to apply the index to Ukraine for the period 2019–2026; and to determine the extent to which the findings depend on modelling choices through sensitivity analysis and an external check of one component. The analysis's contribution is methodological: it describes the movements of a constructed measure under an adopted specification, rather than identifying causal effects.

The paper is organised as follows: Section 2 positions the construction against existing approaches. Section 3 presents the model, distinguishing between components that are computed and those that are assigned by experts. Section 4 describes its application to the period 2019–2026. Sections 5 and 6 present the sensitivity analysis and external validation of the agroclimatic component, respectively. Section 7 discusses what the results do and do not support, while Section 8 provides a conclusion.

2. Background and related approaches.

Research on social security in Ukraine approaches the subject from three angles: the protection of vital individual and societal interests [14; 27], the multi-level construction of the system providing it [28], and, in adjacent literature on national resilience, as a distinct object of state policy [24]. While these contributions establish the conceptual framework, they do not provide a method for calculating a composite assessment under martial law.

The closest methodological reference point is the framework of Bazhenova, Varnalii and Cheberiaiko [1]. This framework uses 29 indicators in five groups and applies them to the period from 2014 to 2020. It also incorporates measures of defence and forced displacement. Normalised indicators are averaged arithmetically within groups, and the group scores are then combined to calculate a geometric mean. This framework therefore already accommodates a wartime context and multiplicative aggregation at the upper level.

The USSI differs in how its components enter the index. It focuses on the state and capacity of the country's social security system rather than the social security of the individual. Its structure consists of four additive core components and two multipliers, and aggregation is a weighted sum of the core multiplied by resilience and territorial control factors. The comparison only concerns structure—no claim of superior accuracy on a common sample is tested here.

Another reference point is the national methodological guidance approved by Order No. 1277 of the Ministry of Economic Development and Trade on October 29, 2013 [9], which defined the indicators, characteristic thresholds, normalisation, weights, and the algorithm for the composite assessment of economic security. Social security is one of the nine components of the overall

index. The USSI adopts normalisation against fixed characteristic values from that document; therefore, the principle is not an innovation of the present approach. The order ceased to have effect on August 11, 2025, under Order No. 199, in connection with the introduction of continuous economic resilience monitoring [10]. The USSI is not positioned as its official replacement.

The construction's international foundations are the human security framework of the United Nations Development Programme [26] and the OECD guidance on building composite indicators [13]. The requirement that any such index be tested under alternative assumptions is motivated by work on non-compensatory aggregation [12], the divergence between nominal weights and the effective importance of components [17], and sensitivity to normalisation thresholds [8]. Section 5 applies this requirement to the USSI.

3. The USSI model:

3.1 Structure and weights

The USSI combines four components of an additive core with two multipliers:

$$\text{USSI} = A \cdot \text{RF} \cdot \text{TF}, \quad A = 0.36\text{CS} + 0.27\text{ES} + 0.27\text{SS} + 0.10\text{EN}. \quad (1)$$

The critical security index (CS) measures the continuity of essential services, while the economic security index (ES) measures economic resources and macro-financial conditions. The social stability index (SS) measures social financing, income equality, planned humanitarian assistance, and institutional trust, while the agroclimatic component (EN) measures the territory's exposure to drought. All inputs lie within the unit interval, as do the core weights, so the index itself also lies within the unit interval.

The social security infrastructure is considered here to be the material and institutional basis for carrying out social functions, characterised by five measurable properties. Capacity corresponds to social budget expenditure (SI) and the economic base of provision (EI); accessibility to price affordability (LI), the distributive precondition of access (GI), access to safe conditions (PI) and the territorial factor (TF); reliability to uninterrupted supply (II) and the resilience of financing (FI); redundancy to planned humanitarian assistance (HI) together with external assistance in covering the fiscal deficit as a separate dimension of FI; and recoverability to recovery potential (RI), adaptability (AI) and institutional trust (CI). Two further subcomponents – the operational safety of essential services (MI) and defence capability (DI) – characterise the crisis regime and cut across all five properties. EN, however, constitutes the natural basis on which provision rests and is not treated as a sixth property.

The weights of 0.36, 0.27, 0.27 and 0.10 represent a normative choice. The greater weight given to CS reflects the priority placed on physical protection and essential services in times of war. The equal weights given to ES and SS reflect the equal importance of resources and social characteristics. The smaller weight given to EN

reflects the indirect effects captured by this component, which operate through yields, food prices and rural incomes. While these considerations establish the order of priorities, they do not determine the uniqueness of the coefficients. Equal weights are therefore tested among the alternatives in Section 5.

The two factors constrain the index from above since $\text{USSI} \leq \text{RF} \cdot \text{TF}$. If either factor has a value of zero, the index also has a value of zero. However, if either factor has a positive value, partial compensation between inputs remains possible. Therefore, the construction exhibits limited compensability rather than the full non-compensability sometimes attributed to multiplicative aggregation. Due to the overlap in content between CS, RF and TF, checks for double counting of wartime losses are required.

3.2 Computed components

The social stability index is obtained from two layers: the income equality indicator GI and a component X that combines social financing, planned humanitarian assistance, and institutional trust:

$$\text{SS} = 0.20\text{GI} + 0.80\text{X};$$

$$\text{X} = 0.375\text{SI} + 0.3125\text{HI} + 0.3125\text{CI}. \quad (2)$$

Here $\text{SI} = \min(1; \text{TOT} / 17.3)$, where TOT denotes consolidated budget expenditure on health care, education and social protection [11] as a percentage of GDP, and 17.3 per cent is a benchmark fixed by the author rather than a statutory norm. The ratio has a known weakness: when GDP falls it can rise without any expansion of services.

HI is the ratio of the target number of aid recipients in the United Nations humanitarian response plan covering the year, in the first version of the plan with such coverage, to the estimated need [15]; it therefore measures planned rather than realised coverage. Social capital is represented by $\text{CI} = (\text{B} + 100) / 200$, where B is the mean balance of trust in nine state institutions, in percentage points, from nationwide surveys by the Razumkov Centre [18–23] and, for 2022, by the Ilko Kucheriv Democratic Initiatives Foundation and Razumkov Centre Sociological Service [6]; the 2019 value is approximated by the February 2020 survey wave [18], which introduces a known timing error.

The income equality indicator is $\text{GI} = \min(1; \max(0; 1 - (\text{G} - 0.25) / 0.35))$, where G is the Gini coefficient of household income per adult equivalent and the bounds 0.25 and 0.60 are scale benchmarks fixed by the author. For the years 2019 to 2021, G is the official coefficient for total income from the Household Living Conditions survey of the State Statistics Service of Ukraine [25] – 0.249, 0.247 and 0.244, respectively – so that GI stands at its upper bound of unity in the pre-war years. For the years 2023 to 2025, it is taken from World Bank estimates based on the Monitoring Living Conditions in Ukraine survey [3]. Because G is unavailable for 2022, the weight of GI is excluded and the remaining weights renormalised, so that $\text{SS}_{2022} = \text{X}_{2022}$; for 2026 both X and

GI are carried over from 2025, which is an imputation rather than a new observation.

The computed component X for 2019–2026 equals 0.710, 0.677, 0.641, 0.761, 0.699, 0.634, 0.573 and 0.573, and GI equals 1.000, 1.000, 1.000, not available, 0.543, 0.457, 0.286 and 0.286. The underlying series for SI, HI and CI, with the source of each value indicated, are documented in the computational materials of the study (see the data and code availability statement).

The agroclimatic component is $EN = 1 - DA / 100$, where DA is the share of the country's area in the warning and alert classes of the Combined Drought Indicator, averaged over April–September and weighted by the cosine of cell latitude [5; 2]. The annual figure covers the 18 ten-day periods from April to September. For 2026, however, only the first 12 periods from April to July were available by the data cut-off date of July 21st, meaning that this season is not fully comparable with the others. The EN index measures drought exposure rather than food security per se: it does not capture mine contamination, access to land, logistics, or purchasing power.

The territorial factor is $TF = TC / TT$, where TC is the area of controlled territory and TT the area of Ukraine within its internationally recognised borders [4]. This is an approximate figure and does not represent the proportion of the population covered by social protection, as it does not take into account uneven settlement patterns.

3.3 Expert-assigned components and their traceability

CS, ES and RF are assigned directly on a scale from 0 to 1. For RF, the conceptually intended structure is $RF = 0.40AI + 0.30RI + 0.30DI$. However, no series for these subcomponents are computed separately in the implemented version; the formula merely explains the intended structure rather than providing a procedure for obtaining the series.

The model's expert input thus consists of 24 scores, covering CS, ES and RF over eight years. CS draws on evidence of the intensity of hostilities and interruptions to essential services, ES draws on the dynamics of

output, inflation and the fiscal deficit, and RF draws on the capability of the administration and the conditions for recovery. Each score is placed within a band, which is defined by the scale's anchor levels, for CS these are 0.75 and 0.50. This means that assignment to a band is based on observable signs, while the exact position within the band is subjective.

The declared resolution of the scale is 0.05; movements in the scored inputs that are smaller than this figure carry no independent interpretation. This figure is a stated resolution rather than a standard error. Three consistency checks were applied to the 24 scores. An annual check of the 21 transitions between consecutive years revealed that the change exceeded 0.05 in six cases, all of which were corroborated by documented evidence. A cumulative check, which compares each year's deviation from the pre-war anchor year of 2019 with the direction of the accumulated evidence whenever that deviation exceeds 0.05, and a band-transition check, which requires a change of at least 0.05 whenever the evidence moves a year into a different band on the scale, identified no violations of the scoring rules. While these checks establish internal consistency with the declared rules, they do not substitute for independent validation of the scores themselves.

Consequently, 63 per cent of the nominal core weight is allocated to the directly scored CS and ES, while 37 per cent is allocated to the computed SS and EN. RF is introduced as an additional judgement-based multiplier. When classified by the availability of primary evidence within the full conceptual structure, the shares are 37.0 per cent, 29.7 per cent and 33.3 per cent across subcomponents with complete, fragmentary and absent series, respectively. However, it is the 63/37 split that describes the computation as it is actually implemented.

4. Results

The mean USSI is 0.625 for 2019–2021 and 0.313 for 2022–2026, which is a relative decline of 50.0 per cent. The control calculation, which excludes the provisional year of 2026, gives a figure of 49.9 per cent. Therefore, including that year leaves the gap between the two periods essentially unchanged. This figure represents a

Table 1

Components and aggregation results of the USSI, 2019–2026

Indicator	2019	2020	2021	2022	2023	2024	2025	2026*
CS	0.810	0.790	0.770	0.420	0.450	0.460	0.450	0.450
ES	0.760	0.620	0.700	0.510	0.620	0.630	0.650	0.670
SS	0.768	0.742	0.713	0.761	0.668	0.599	0.516	0.516
EN	0.690	0.421	0.897	0.631	0.812	0.531	0.353	0.681
RF	0.920	0.900	0.910	0.720	0.680	0.690	0.690	0.700
TF	0.930	0.930	0.930	0.820	0.820	0.810	0.810	0.810
Core A	0.773	0.694	0.748	0.557	0.591	0.551	0.512	0.550
USSI	0.662	0.581	0.633	0.329	0.330	0.308	0.286	0.312

Source: computed using equation (1) from the author's input values. * 2026 is a provisional estimate: the drought season covers April–July only (data as of July 21, 2026) and the social stability component is carried over from 2025. Values are reported to three decimal places; this does not imply measurement precision of the same order

shift in the index on a constructed scale and does not indicate a halving of social welfare.

The index fell by 48.0 per cent in 2022 compared to 2021. The additive core shrank from 0.74841 to 0.55747 (a 25.5 per cent decrease), while RF fell from 0.91 to 0.72 and TF from 0.93 to 0.82. Therefore, all three parts of the construction contribute to the collapse, and their separate effects should not be added together mechanically due to the multiplicative interaction between them.

Between 2023 and 2025, the index declined by a further 13.1 per cent. For 2022–2026, the weighted change in SS is -0.06615 , while that in ES is $+0.04320$. Therefore, the absolute value of the former exceeds the latter by approximately 1.5. Under this specification, the improvement in the economic component does not offset the deterioration in the social component. This relationship describes the composition of the index and does not identify a causal effect of macroeconomic policy.

The provisional USSI value for 2026 is 0.312. EN accounts for around 85.9 per cent of the increase in the additive core between 2025 and 2026. However, as the growing seasons differ in length and SS is carried over, this does not indicate a recovery in social security. A comparable seasonal window would be required in every year for this to be the case.

5. Sensitivity analysis

5.1 Aggregation schemes and perturbation of the expert inputs

Alternative aggregation schemes were applied to the main series, with the inputs remaining unchanged. The percentage decline of the mean for the period 2022–2026 relative to the period 2019–2021 was used as the measure of comparison. The baseline construction $A \cdot RF \cdot TF$ gives 50.0 per cent; $A \cdot RF$ gives 42.8 per cent; $A \cdot TF$ gives 34.5 per cent; the core alone gives 25.2 per cent; $A \cdot \sqrt{RF \cdot TF}$ gives 38.8 per cent; and equal weights on the four core components, with the multipliers retained, give 47.4 per cent. The direction of the difference between periods is preserved under every tested construction, while its magnitude depends on the aggregation rule. The equal-weight result shows that the substantive finding survives one alternative weighting scheme, but does not prove that the baseline weights are optimal.

Using min–max normalisation instead of fixed scales over the observed range of each series causes the minimum values of the multipliers to be driven to zero, as well as the product, which reduces the ability to discriminate between states. This conclusion relates specifically to the application of min–max normalisation to multiplicative factors in this context, and does not constitute a general objection to the method.

The expert inputs were perturbed for nine specifications: the baseline and six with an individual shift of CS, ES or RF by ± 0.05 , as well as two with a simultaneous shift of all three. The decline in the mean

remained within the range of 48.5–51.6 per cent, and the rank correlation with the baseline series remained within the range of 0.976–1.000. As a uniform shift only tests for systematic bias, independent errors were examined separately. Perturbing each of the 24 scores independently by a uniformly distributed value within ± 0.05 over 50,000 realisations yielded a mean decline of 49.9 per cent, with a standard deviation of 1.5 percentage points. The ordering of every pre-war year exceeding every war year was preserved in all realisations. The ranges reported here are not confidence intervals.

5.2 Conditional global sensitivity analysis

Five independent input groups were specified for 2026: the weight vector W, CS, ES, RF and TF. The independence of these quantities is a property of the sampling design rather than an empirical claim; the four weights are combined into a single group precisely because they are correlated through the sum constraint. SS is held at 0.516 and EN at 0.681471. This removes them from the uncertainty budget, but does not imply that they have been measured without error. The weights follow a Dirichlet distribution with parameter vector 200μ , where $\mu = (0.36; 0.27; 0.27; 0.10)$; CS and ES follow triangular distributions with minimum, mode and maximum (0.40; 0.45; 0.50) and (0.62; 0.67; 0.72) respectively; RF follows (0.58; 0.70; 0.78) and TF (0.79; 0.81; 0.83). These ranges are based on modelling assumptions rather than on error distributions estimated from a sample.

First-order indices (S) were estimated using the Saltelli scheme and total-order indices (S^T) using the Jansen estimator, with 500,000 input vectors in each base sample and a random seed of 20260905; the Shapley effects were obtained by complete enumeration of the 120 permutations of the five groups, with the conditional variances estimated by nested Monte Carlo sampling (5,000 outer and 300 inner draws). While the enumeration is exact, the effects themselves remain numerical estimates.

Table 2

**Grouped sensitivity of the USSI
under the adopted assumptions for 2026**

Group	S / S^T , %	Shapley effect, %
Weight vector W	3.7 / 3.9	3.7
CS	4.6 / 4.4	5.1
ES	2.3 / 2.5	2.0
RF	83.7 / 87.0	86.1
TF	3.4 / 2.5	3.2

Source: author's calculation under the modelling scheme described in the text (seed 20260905). S denotes the first-order index and S^T the total-order index; SS and EN are held fixed. Full ranges across three independent runs: 0.01–0.17 percentage points for S^T , 0.56–1.62 for the Shapley effects and 0.52–5.76 for S (see text)

Under independence of the groups, theory requires $S^T \geq S$, and the Shapley effect of each group lies between its first-order and its total-order index [16].

In Table 2 both relations hold for RF ($83.7 \leq 86.1 \leq 87.0$) and for W, but not for CS, ES and TF, whose three estimates differ from one another by up to 0.9 percentage points. Convergence checks across three independent runs, using the seeds 20260905, 20260906 and 20260907, show that the full range of estimates is 0.01–0.17 percentage points for the total-order indices, 0.56–1.62 percentage points for the Shapley effects, and 0.52–5.76 percentage points for the first-order indices. The largest range in each column belongs to RF. Therefore, the departures from the theoretical ordering for the three minor groups are within the estimation error of the first-order and Shapley estimates, and do not indicate interaction. At the same time, the shares of these groups are only resolved to about one percentage point, and their ordering is not established. The sums of the first-order and total-order indices (97.7 and 100.3 per cent, respectively) differ by an amount of the same order as the error margin, meaning that interaction effects between the groups cannot be distinguished from zero. Therefore, the interpretation below rests on the total-order indices, which are reproduced almost exactly. Meanwhile, the first-order and Shapley columns are read as indicative.

In the adopted setting, the resilience factor has the highest total-order Sobol index (87.0 per cent, or 86.9 per cent on average across three runs) and the highest Shapley effect (86.1 per cent). Varying the weight distribution concentration across 50, 100, and 200 leaves the total-order index in the range of 78.1–86.9 per cent. Therefore, the dominance of RF is not an artefact of the concentration parameter. This result relates to model variance within the specified ranges and fixed values of SS and EN. It does not prove that institutional capacity determines the corresponding social security share.

6. External validation of the agroclimatic component

The agroclimatic channel was tested against a non-input model outcome variable: cereal yield in Ukraine for 2012–2024, taken from the World Bank AG.YLD.CREL.KG indicator [29]. In the validation script, the variable is drought exposure DA rather than normalised EN. Therefore, the negative coefficients reported below describe the relationship between DA and yield. For EN, the sign is reversed, but the absolute values remain unchanged.

The linear time trend of yield over 2012–2024 is +134.2 kg per hectare per year ($R^2 = 0.6527$; $p = 0.0008$) and is used as an approximation of long-run technological change, although a regression on time alone does not separate technology from other long-run factors. The correlation of the raw series is -0.4183 , which is not statistically significant ($p = 0.1549$). To isolate the short-term relationship, the two variables were detrended separately within each window.

For the period from 2012 to 2024, the partial correlation between drought exposure and yield, controlling for time, is -0.8606 ($p = 0.0003$; $n = 13$), with a Spearman coefficient of -0.9286 . For the pre-

invasion period from 2012 to 2021, the corresponding values are -0.9042 ($p = 0.0008$; $n = 10$) and -0.9152 . The significance is derived from a joint regression of yield on time and drought exposure, which accounts for the degree of freedom spent on estimating the trend. This approach avoids the overstatement produced by a two-step procedure on a detrended series. In the aforementioned regression model, the coefficient pertaining to drought exposure is determined to be -25.20 kg per hectare per percentage point (standard error 4.72; $t = -5.344$; 10 degrees of freedom). The coefficient of determination is thus calculated to be 0.910.

The squared partial correlations of 74.1 and 81.8 per cent are the proportion of yield variability explained by drought exposure once the trend has been removed. The trend alone explains 65.3 per cent of the original variation. These do not demonstrate a causal effect. In 11 out of 13 years, above-median drought exposure coincided with a negative yield deviation from the trend, while below-median exposure coincided with a non-negative deviation. The exceptions were in 2015 and 2018. The separate pre-invasion period reduces the issue of varying territorial coverage, as the drought measure covers the entire country, whereas wartime yield statistics are subject to observation limitations. Taken together, the results provide substantial support for the agroclimatic channel.

7. Discussion and limitations

Three features distinguish the construction from the approaches reviewed in Section 2, and each carries a specific cost. Treating wartime and territorial losses as multipliers instead of negative addends formalises the assumption that they simultaneously reduce the effectiveness of all other provision; the cost is that the resulting index is bounded above by $RF \cdot TF$ and that the separate contributions of the parts cannot be added. Treating territorial control as a factor in its own right rather than as one indicator among many makes a constraint that peacetime frameworks leave implicit explicit. However, an areal ratio is a coarse proxy for the territorial reach of public services. Computing the agroclimatic component from remote sensing data provides continuous territorial coverage, including temporarily occupied areas, and renders one component independent of national statistical observation. However, it only measures drought exposure and not agrarian risk in general.

The empirical findings should be interpreted within the appropriate context. While the between-period decline of 50.0 per cent is robust in direction and stable in magnitude across aggregation schemes and expert input perturbations, its precise value depends on the baseline specification. The divergence between the social and economic components – a weighted decline in SS exceeding the weighted gain in ES by approximately 1.5 times – describes the composition of the index, not a causal mechanism. The 2026 value is provisional due to the incomplete drought season and the social stability component that has been carried over.

The global sensitivity analysis yields the result with the clearest practical implications. The resilience factor has a total-order sensitivity index of 87.0 per cent – the proportion of the model's variance that can be attributed to it, including interactions, under the adopted uncertainty scheme – yet none of its three conceptual subcomponents has an independent statistical series. The most influential quantity in the model is simultaneously the least supported by primary data. Although documenting the grounds for scoring improves traceability, it does not substitute for such a series. Constructing one, together with institutionalising the scoring procedure, is therefore the main priority for further research.

Reproducibility can be divided into two questions that are best kept separate. The final aggregation is fully reproducible: the published inputs and formulas, together with the set of computational scripts listed in the data and code availability statement, can be used to regenerate the series, sensitivity checks and external validation. A cross-check of this set revealed no discrepancies. However, what is not reproducible by a third party is the primary scoring of CS, ES and RF. This would require operational rules capable of yielding the same score in different hands.

Several further limitations apply. The comparability of SS is limited by the absence of GI in 2022, the carry-over of data in 2026, and the differences between the sources of the inequality estimates before and after the full-scale invasion. EN does not cover all risks to agricultural production, and the area-based TF does not measure individual access to assistance. The overlap of wartime characteristics across CS, RF and TF may amplify the response of the index, and independent external validation would be required to ascertain whether this is justified.

The final index has not been validated against an external criterion; only the agroclimatic component has been verified using an independent variable. While the external check supports the content of this component, the sensitivity analyses demonstrate that the results are stable under alternative assumptions. This is a property of robustness, not evidence that the index measures the intended construct. The validity of the index as a whole remains unestablished. In practice, it is best to report the USSI as a set of component scores alongside the overall index, including the core, multipliers, status of underlying data, and results of checks, rather than as a single figure supporting categorical statements about particular years.

8. Conclusions

The paper presents a composite approach to assessing national social security under war conditions, which has been implemented in the USSI model. This approach combines a functional interpretation of social security infrastructure with a weighted, additive core of current characteristics. It also incorporates separate, multiplicative factors for institutional resilience and territorial control, as well as an agroclimatic component

derived from remote sensing data. Fixed normalisation benchmarks provide a consistent scale across changes in data coverage.

Applied to the period from 2019 to 2026, the index falls from an average of 0.625 between 2019 and 2021 to 0.313 between 2022 and 2026, representing a decline of 50.0 per cent. The collapse in 2022 reflects a contraction in the additive core, as well as lower values for both multipliers. The weighted decline in social stability exceeds the gain in the economic component by approximately 1.5 times. Excluding the provisional year 2026 results in a decline of 49.9 per cent. The direction of the difference between periods is preserved under every aggregation scheme tested, and shifting the expert-assigned inputs by a uniform ± 0.05 keeps the decline within 48.5–51.6 per cent.

Under the specified distributions for 2026, the resilience factor has first-, total- and Shapley order indices of 83.7 per cent, 87.0 per cent and 86.1 per cent of the model variance respectively. The total-order index was reproduced to within 0.17 percentage points across three independent runs. As this factor has the least primary-data support, the priority tasks for further development are to build an independent series for it and to institutionalise the scoring procedure. Controlling for a linear time trend, external validation of the agroclimatic channel reproduced a negative association between drought exposure and cereal yield, with r values of -0.861 and -0.904 for the periods 2012–2024 and 2012–2021 respectively, and a positive sign for the normalised component.

The model provides a reproducible aggregation of the given inputs, while retaining dependence on expert scoring of three of them. Further development requires transitioning to computed subcomponents, independently calibrating the scales, checking for the double counting of wartime threats and externally validating the index as a whole. Within these limits, the USSI adds a structured instrument to the toolkit for assessing social security under wartime conditions.

Data and code availability

The input series of the model, the documented grounds for the 24 expert scores, and the scripts that reproduce the aggregation, the sensitivity analyses (including the convergence log of the three runs reported in Section 5.2) and the external validation are available from the author on request.

Statement on the use of artificial intelligence

In preparing this article the author used tools based on large language models for cross-checking numerical statements against the computational materials of the study, and for checking bibliographic descriptions, which were then verified against the primary sources. The formulation of the research task, the construction of the model, the calculations, the interpretation of the results and the wording of the conclusions were carried out by the author, who has reviewed and verified the entire text and bears full responsibility for its content.

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