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## Food Production Surpluses and Domestic Energy Supply in Poland and the EU-27: A Comparative Analysis

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**Abstract:**

**Purpose:** To compare two complementary mechanisms shaping food system performance in Poland between 2010 and 2023: (i) the production–trade mechanism, reflected in food self-sufficiency ratios (SSR), and (ii) the domestic nutritional availability mechanism, captured by dietary energy supply (DES). The study evaluates whether rising production surpluses translate into improved domestic nutritional outcomes and how Poland’s trajectory compares with that of the EU-27.

**Design/Methodology/Approach:** The analysis uses harmonised FAOSTAT Food Balance Sheets (2010–2023) for Poland and the EU-27. SSR is calculated as the ratio of domestic production to total availability, while DES (kcal/capita/day) is examined for five key food groups: cereals, vegetables, fruits, meat and milk. Trend analysis, cross-group comparisons and Poland–EU differentials are used to identify reinforcing versus diverging mechanisms linking production and domestic availability. All indicators are constructed transparently, using consistent definitions and year-to-year comparability.

**Findings:** SSR in Poland shows a strong and continuous rise, surpassing 130% in 2023 and diverging from the EU-27. DES trends, however, follow a fragmented pattern: dairy and meat DES increase substantially, whereas DES from cereals, fruits and vegetables stagnates or declines. This reveals a structural decoupling between production surpluses and domestic nutritional availability in plant-based food groups, while animal-source foods show alignment between SSR and DES. The duality is consistent across food groups, robust across years, and clearly differentiates Poland’s profile from broader EU trends.

**Practical Implications:** Policies should prioritise strengthening domestic availability of nutrient-dense plant foods—particularly fruits, vegetables and cereals—while maintaining export competitiveness in surplus sectors. Effective interventions include improving supply-chain stability, investing in storage and distribution infrastructure, monitoring domestic versus export flows, and promoting dietary patterns aligned with public health objectives. Integrated, cross-sectoral approaches are required to ensure that high production strength translates into improved domestic nutritional outcomes.

**Originality/Value:** This study offers a clear, decision-relevant comparison of “how much is produced” versus “how much is nutritionally available,” providing a framework for diagnosing production–nutrition asymmetries in national food systems. It contributes one of the first systematic, long-term comparisons of SSR and DES dynamics for Poland in the context of the EU-27 and highlights structural mechanisms that shape both food security and dietary quality.

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## 1. Introduction

Food security has become a major policy concern in Europe as multiple shocks increase volatility in agricultural markets and supply chains. The global food system has entered a period of structural fragility driven by climate change, resource constraints, pandemics, and geopolitical tensions (FAO, 2023). In Europe, the COVID-19 pandemic, energy price shocks, inflation, and the effects of the Russian invasion of Ukraine have exposed vulnerabilities and intensified debates on self-sufficiency and strategic autonomy (European Commission, 2022; OECD, 2023).

Food security rests on four pillars—availability, access, utilisation, and stability (FAO, 2008; HLPE, 2020)—with availability remaining fundamental, especially where agriculture is economically significant (Swinnen & McDermott, 2023). The self-sufficiency ratio (SSR) is a common measure of domestic production capacity (FAO, 2022; Clapp, 2021), yet it reflects only the balance between production and net trade. It does not indicate how much energy actually reaches consumers.

For this reason, analyses increasingly use food supply data (kcal/capita/day) from FAOSTAT Food Balance Sheets (FAO, 2023). Research shows that high SSR may coexist with declining domestic food energy availability when export orientation or rising losses reduce the share of production retained domestically (IPES-Food, 2023; von Braun *et al.*, 2022).

Poland exemplifies this issue. Over the past fifteen years, it has become a major EU agri-food exporter, with SSR values above 100% for many groups and growing integration into global value chains (Eurostat, 2023). Yet little research links these trends with domestic energy availability using consistent FAOSTAT FBS data.

This study examines Poland’s self-sufficiency and caloric availability from 2010–2023 within the EU-27 context, combining SSR indicators with energy-based food supply metrics across key food groups. This integrated approach fills an empirical gap and informs debates on resilience, trade dependency, and strategic food autonomy.

## **2. Literature Review**

The concept of food security evolved from early debates on self-reliance in the 1970s to today's multidimensional definitions. The FAO framework defines food security as physical, social, and economic access to sufficient, safe, and nutritious food, structured around four pillars: availability, access, utilisation, and stability (FAO; HLPE).

Following the HLPE report Food security and nutrition: building a global narrative towards 2030, research increasingly adopts a food-systems perspective, highlighting links between production, supply chains, food environments, and consumer behaviour. Studies show stalled progress toward SDG 2 and the coexistence of various forms of malnutrition worldwide.

In Europe, food security is analysed through the lens of system resilience to pandemic, climatic, geopolitical, and price shocks. Recent literature describes a “polycrisis” in which climate change, COVID-19, energy price spikes, the war in Ukraine, and trade tensions interact (IPES-Food). Structural vulnerabilities—value-chain concentration, fossil-fuel dependence, indebtedness—amplify risks. Within this context, the availability pillar remains central, especially in countries with a strong agricultural base, such as Poland.

A core indicator of the supply-side dimension is the Self-Sufficiency Ratio (SSR), defined by FAO as:

$$\text{SSR} = \text{production} / (\text{production} + \text{imports} - \text{exports}) \times 100\%.$$

It is widely applied for commodities and food groups. In the literature,  $\text{SSR} > 100\%$  signals production surplus; around 100% indicates equilibrium;  $\text{SSR} < 100\%$  reflects import dependence. Clapp (2017) distinguishes self-sufficiency from self-reliance, noting that high SSR does not imply autarky but indicates the extent to which domestic needs can be met internally. Brankov *et al.* (2021) show that SSR can function as a vulnerability indicator: low SSR increases exposure to global volatility, whereas high SSR may strengthen regional buffering capacity.

However, SSR has limitations: it captures only quantitative flows, is sensitive to short-term yield and trade fluctuations, and may mask export-driven specialization. High SSR does not necessarily improve domestic food availability, which is why literature emphasises the need to interpret SSR alongside indicators of dietary energy, structure, and access.

FAOSTAT Food Balance Sheets (FBS) provide harmonised data on production, trade, stock changes, and allocation of agricultural products into food, feed, processing, losses, waste, and non-food uses. They form the basis for the Dietary Energy Supply (DES, kcal/capita/day), calculated after accounting for the entire pathway of a

commodity through the food system. FBS are widely used to analyse food availability, dietary patterns, import dependency, and the effects of agricultural and trade policies. Recent methodological work, such as Zhao *et al.* (2025), calls for stronger linkages between FBS and macro-economic or environmental datasets to improve traceability of energy, protein, and fat flows. FAO reports show that global DES has continued to rise, reaching about 2,980 kcal/capita/day in 2022, albeit with regional disparities.

European research increasingly integrates the four-pillar concept with resilience analysis. Poczta-Wajda and Poczta (2024) show that while EU food availability is generally high, Member States differ in stability, price dynamics, and exposure to disruptions.

For Poland, numerous studies emphasise its strong and export-oriented agri-food sector. FI-Compass (2019) and subsequent analyses highlight Poland's lasting net-exporter position, with food accounting for over 15% of total exports (Pawlak, 2024). Analyses of production and self-sufficiency—e.g., Klikocka *et al.* (2022)—confirm high SSR for cereals, milk, and meat, with deficits in vegetable oils or products from other climatic zones. Earlier work links Poland's food security to sustainable production within EU strategies.

A recurring theme is the tension between high self-sufficiency and export structure. Poland's growing surpluses in cereals, meat, and dairy reinforce its role as an EU “net supplier,” but raise questions about domestic food availability. Some studies note that high SSR may coincide with stagnant or declining domestic caloric availability due to export orientation, losses, or shifts toward lower-calorie production profiles.

### **3. Methodology**

The study draws exclusively on FAOSTAT Food Balance Sheets (FBS), which provide harmonised annual data on production, trade, stock changes, and the allocation of agricultural products to food, feed, processing, losses, waste, seed, and non-food uses. As full mass-balance accounts, FBS remain the primary source for cross-country assessments of food availability and self-sufficiency.

The analysis covers 2010–2023 and focuses on five major food groups, cereals, vegetables, fruits, meat, and milk, selected due to their contribution to dietary energy and consistent reporting in FAOSTAT. The units of analysis are Poland (case study) and the EU-27 (benchmark).

All data were downloaded as annual series from FAOSTAT and processed in Microsoft Excel, including cleaning, aggregation, and preparation of analytical datasets for graphical and statistical comparison.

To assess the ability of Poland to meet domestic food demand from domestic production, the study employs the Self-Sufficiency Ratio (SSR), defined by FAO as:

$$SSR = \frac{production}{production + imports - exports} \times 100\%$$

SSR captures the relationship between domestic production and domestic utilisation after adjusting for net trade. The study follows the standard interpretation: SSR > 100% indicates a net exporter; SSR = 100% reflects equilibrium; and SSR < 100% denotes import dependence.

The second indicator is Dietary Energy Supply (DES), expressed in kcal/capita/day. DES reflects the availability of food energy after all upstream flows in the food system are accounted for. DES is not a measure of intake but of supply available for human use.

FAOSTAT computes DES in four steps:

- (1) Domestic supply = Production + Imports – Exports ± Stock changes;
- (2) Deduction of non-food uses (feed, processing, losses, waste, seeds, non-food uses);
- (3) Conversion to kilocalories using standard coefficients (kcal/kg);
- (4) Normalisation per capita per day:  $DES_t = FoodEnergy_t / (Population_t \times 365)$ .

This study uses FAOSTAT's ready-made DES values for 2010–2023. For each food group, DES was extracted for Poland and EU-27 and plotted as time series.

The analysis has three stages:

1. trend assessment of SSR and DES;
2. cross-indicator comparison to detect divergence between production capacity and domestic energy availability;
3. food-group decomposition (cereals, vegetables, fruits, meat, milk).

All calculations were done manually in Excel based on raw FAOSTAT data. Analytical tables were copied as values before chart creation.

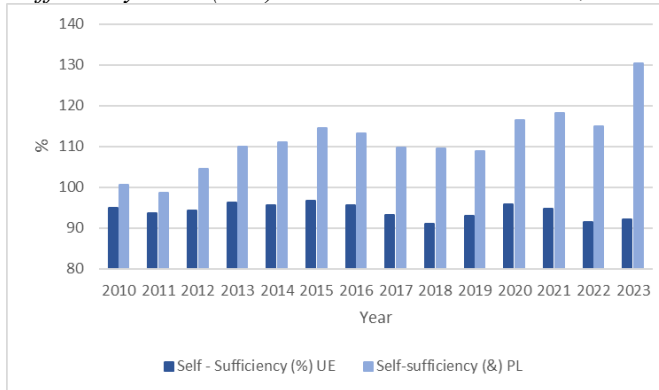
#### **4. Research Results and Discussion**

##### *Self-sufficiency dynamics (2010–2023):*

As shown in Figure 1, the self-sufficiency ratio (SSR) reveals a consistent divergence between Poland and the EU-27 across the entire study period. Poland's SSR rose from approximately 100% in 2010 to more than 130% in 2023, reflecting a strengthening export-oriented production structure and resilient agricultural output. In contrast, the EU-27 remained below 100%, fluctuating between 92% and 98%, indicating structural import dependence.

The post-2020 increase in Poland corresponds to favourable cereal harvests, growing external demand, and relatively stable domestic production conditions.

**Figure 1.** Self-sufficiency ratio (SSR) in Poland and the EU-27, 2010–2023.



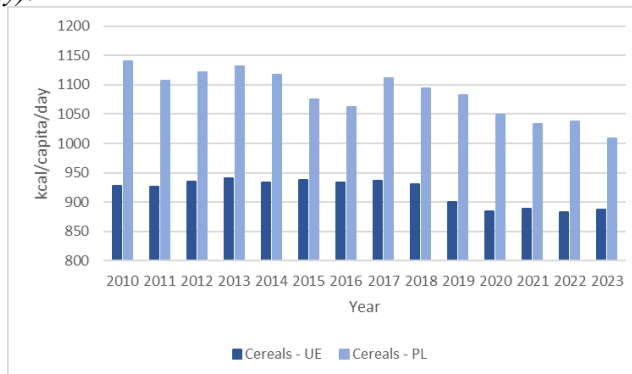
**Source:** FAOSTAT Food Balance Sheets, own calculations.

*Dietary energy supply from cereals:*

Figure 2 illustrates that Poland demonstrates a downward trend in dietary energy supply (DES) from cereals, decreasing from roughly 930 kcal/capita/day in 2010 to around 890–900 kcal/capita/day after 2020. This decline suggests a rising share of cereal production diverted into export flows, feed, and industrial processing.

Conversely, the EU-27 maintains higher and more stable cereal DES levels (1080–1150 kcal/capita/day), indicating more consistent allocation of cereals to domestic food supply. The structural gap between Poland and the EU (≈150–250 kcal) underscores notable differences in cereal utilisation patterns.

**Figure 2.** Dietary energy supply from cereals in Poland and the EU-27, 2010–2023 (kcal/capita/day).



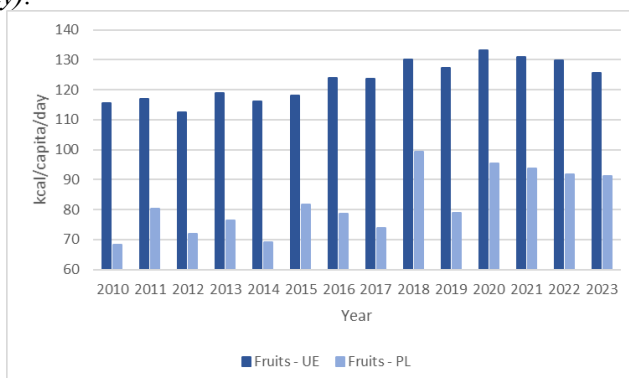
**Source:** FAOSTAT Food Balance Sheets, own calculations.

*Dietary energy supply from fruits:*

Figure 3 demonstrates that fruit-derived dietary energy supply (DES) shows the most persistent divergence between Poland and the EU-27. While the EU maintains levels between 110–135 kcal/capita/day, Poland fluctuates between 70 and 100

kcal/capita/day. The divergence widened after 2017, associated with climatic disruptions, expanding export orientation within the fruit-processing sector, and long-term shifts in domestic consumption patterns.

**Figure 3.** *Dietary energy supply from fruits in Poland and the EU-27, 2010–2023 (kcal/capita/day).*

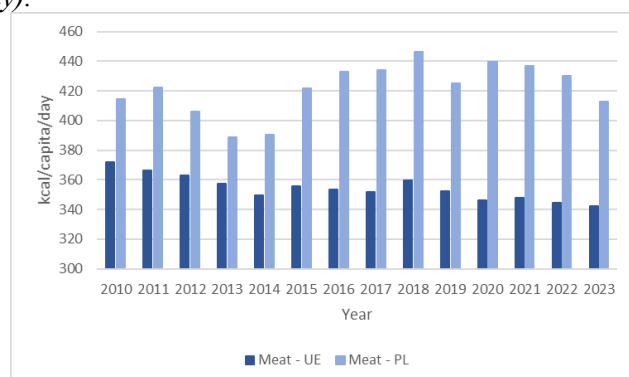


**Source:** FAOSTAT Food Balance Sheets, own calculations.

#### *Dietary energy supply from meat:*

As presented in Figure 4, the EU-27 exhibits a mild decline in meat-derived dietary energy supply (DES), decreasing from approximately 370 to 345 kcal/capita/day, in line with broader dietary transitions toward reduced meat consumption. In contrast, Poland displays a clear upward trend, rising from about 415 to 440–450 kcal/capita/day. This trajectory reflects the robustness of Poland's meat production sector, strong domestic demand, and the expansion of poultry and pork industries.

**Figure 4.** *Dietary energy supply from meat in Poland and the EU-27, 2010–2023 (kcal/capita/day).*



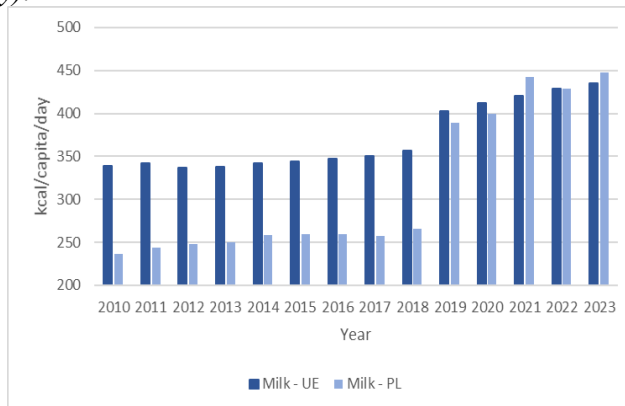
**Source:** FAOSTAT Food Balance Sheets, own calculations.

#### *Dietary energy supply from milk:*

Figure 5 indicates that milk-derived dietary energy supply (DES) demonstrates the most dynamic growth among all food groups in Poland, increasing from

approximately 230–250 kcal/capita/day in 2010 to more than 440 kcal/capita/day in 2023. This pattern reflects the rapid expansion of the dairy sector, rising productivity, and growing domestic availability of dairy products. In contrast, the EU-27 displays considerably greater stability (340–420 kcal/capita/day), with Poland surpassing the EU average after 2019.

**Figure 5.** Dietary energy supply from milk in Poland and the EU-27, 2010–2023 (kcal/capita/day).

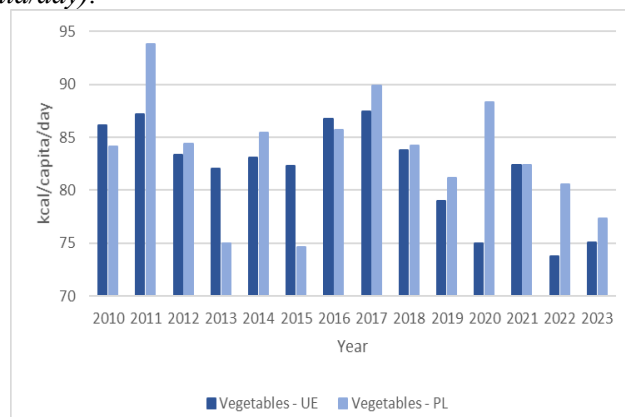


**Source:** FAOSTAT Food Balance Sheets, own calculations.

#### *Dietary energy supply from vegetables:*

As depicted in Figure 6, vegetable-derived dietary energy supply (DES) in Poland exhibits the greatest variability among all analysed food categories, ranging from 74 to 94 kcal/capita/day. This volatility is driven primarily by weather-related supply shocks and fluctuating export and processing demand. In contrast, the EU-27 displays a more stable pattern (80–88 kcal/capita/day), with a slight decline after 2018.

**Figure 6.** Dietary energy supply from vegetables in Poland and the EU-27, 2010–2023 (kcal/capita/day).



**Source:** FAOSTAT Food Balance Sheets, own calculations.

The results show a clear divergence between Poland's rising self-sufficiency and stagnating or mixed trends in dietary energy availability, indicating a partial decoupling between production performance and domestic nutritional supply. This aligns with evidence that food self-sufficiency and food security are related but distinct concepts, and that strong production does not necessarily ensure healthy diets for the population (Clapp, 2017; Fanzo and Davis, 2021). As the FAO framework emphasises, food security depends not only on availability but also on access, utilisation, and stability, making it possible for national surpluses to coexist with nutritional vulnerabilities (FAO *et al.*, 2023).

Poland's SSR, exceeding 130% in recent years, confirms its role as a structurally surplus producer and net exporter. Similar patterns occur in other high-productivity agricultural economies, where surpluses support regional stability but increase exposure to global volatility (Clapp, 2017; Poczta-Wajda and Poczta, 2024). For cereals, rising SSR combined with slightly declining DES fits the literature on export-oriented sectors, where more output is channelled into feed, industrial uses, or foreign markets rather than domestic food consumption (FAO *et al.*, 2023; Valin *et al.*, 2014).

The persistent gap in fruit- and vegetable-derived DES between Poland and the EU-27 is particularly important from a public health perspective. WHO recommends at least 400 g/day, yet intake remains low across Europe and especially in parts of Central and Eastern Europe (Afshin *et al.*, 2019; Stea *et al.*, 2020). Evidence from Eastern Europe and Central Asia confirms widespread underconsumption, especially among lower-income groups (Rippin *et al.*, 2023). Poland's lower and more volatile DES in these categories suggests supply-side instability and ongoing demand-side constraints.

By contrast, dairy-derived DES is rising steadily. Studies highlight modernisation, consolidation, and high productivity in Poland's dairy sector, alongside strong export capacity and high self-sufficiency (Zuba-Ciszewska, 2019; Zuba-Ciszewska, 2018). Here, increases in SSR appear to translate more directly into domestic availability. Meat shows a similar, though weaker, pattern: Poland's DES diverges upward from the EU-27 trend, consistent with evidence that meat consumption is increasingly differentiated across regions, with declines in Western Europe and stable or rising consumption in competitive livestock economies (Godfray *et al.*, 2018; Parlasca and Qaim, 2022).

Overall, the diverging trends between SSR and DES across commodities support the argument that food systems may display macro-level security alongside micro-level nutritional risks (Béné, 2020; FAO *et al.*, 2023). Declining or stagnant DES for cereals, fruits, and vegetables—combined with growth in animal-source foods—may result in diets that are energy-adequate but misaligned with health and sustainability recommendations (Afshin *et al.*, 2019; Willett *et al.*, 2019). This situates Poland within broader debates on “healthy and sustainable diets” and the need to rebalance

food systems toward a higher share of plant-based foods (Willett *et al.*, 2019; Fanzo and Davis, 2021).

Compared with the EU-27, Poland contributes to EU-level resilience through agricultural surpluses, especially cereals and dairy, while lagging in food groups central to diet quality, notably fruits and vegetables. Research shows that although the EU remains broadly food-secure at the macro level, nutritional outcomes depend increasingly on income, geography, and policy frameworks such as the CAP and social protection schemes (Poczta-Wajda and Poczta, 2024; Béné, 2020). Poland therefore faces a dual challenge: sustaining competitiveness and export capacity while promoting domestic dietary patterns that support healthier and more diversified food consumption.

## **5. Conclusions, Proposals, Recommendations**

This study provides an empirical and comparative examination of two complementary mechanisms underlying Poland's food system performance: the production–trade mechanism, reflected in self-sufficiency ratios, and the domestic nutritional availability mechanism, captured by dietary energy supply (DES).

Using harmonised FAOSTAT data, we demonstrate that the relationship between agricultural output, trade orientation, and domestic food energy availability is fundamentally asymmetrical. High production strength does not automatically translate into improved national dietary supply.

Poland's self-sufficiency exhibits a strong and consistent upward trajectory, exceeding 130% in 2023 and increasingly diverging from the EU-27 average. This trend highlights the structural export orientation of the Polish food system, particularly in cereals, dairy, and meat.

In contrast, domestic dietary energy supply follows a more fragmented pattern: DES from dairy and meat has grown substantially, whereas DES from cereals, fruits, and vegetables has stagnated or declined. This duality reflects broader evidence that modern food systems may simultaneously generate production surpluses and experience nutritional vulnerabilities.

The findings further indicate that the two mechanisms—production surpluses and domestic availability—operate with different intensities across food groups. In the dairy and meat sectors, self-sufficiency and DES align closely, demonstrating a reinforcing mechanism where production growth contributes to domestic nutritional supply.

For cereals, vegetables, and fruits, however, the relationship is decoupled, revealing a divergent mechanism whereby output expansion does not translate into increased domestic availability. Together, these patterns underscore that “how much is produced

or exported” and “how much remains available for domestic consumption” represent coexisting yet analytically distinct dimensions of food security, shaped by trade patterns, dietary preferences, supply-chain organisation, and climate sensitivity.

The robustness of these conclusions is supported by the consistency of trends across multiple product groups and across two levels of comparison—between Poland and the EU-27. The dual nature of Poland’s food system, characterised by high agricultural productivity alongside selective nutritional gaps, highlights the need for policy approaches that extend beyond the traditional production-oriented paradigm.

In light of these findings, strengthening the links between national agricultural production and domestic nutritional outcomes is essential. While high levels of food self-sufficiency are critical for macro-level food security, they do not guarantee optimal dietary availability, particularly in relation to fruits, vegetables, and cereals. Public policy should therefore prioritise enhancing the stability, affordability, and accessibility of these nutrient-dense food groups throughout the year, while preserving export competitiveness in surplus-producing sectors.

Integrated measures—including targeted support for domestic supply chains, improved storage and distribution infrastructure, the promotion of healthy dietary patterns, and systematic monitoring of food flows between domestic and export markets—are necessary to ensure that the food system remains simultaneously productive, resilient, and nutrition-oriented. Ultimately, only a coordinated, cross-sectoral strategy that aligns economic, health, and sustainability objectives can secure a long-term balance between Poland’s production potential and the dietary well-being of its population.

## **References:**

- Afshin, A., Sur, P.J., Fay, K.A., et al. 2019. Health effects of dietary risks in 195 countries, 1990–2017. *The Lancet*, 393(10184), 1958–1972.
- Béné, C. 2020. Resilience of local food systems and links to food security: A review of concepts. *Food Security*, 12, 805–822.
- Brankov, T., Matkovski, B., Đurić, M. 2021. Food self-sufficiency of the SEE countries: Is the region prepared for a future crisis? *Sustainability*, 13(16), 8747.
- Clapp, J. 2017. Food self-sufficiency: Making sense of it, and when it makes sense. *Food Policy*, 66, 88–96.
- FAO. 2008. *An Introduction to the Basic Concepts of Food Security*. FAO.
- FAO, IFAD, UNICEF, WFP & WHO. 2023. *The State of Food Security and Nutrition in the World 2023*. FAO.
- Fanzo, J., Davis, C. 2021. *Global Food Systems, Diets, and Nutrition: Linking Science, Economics, and Policy*. Springer.
- Godfray, H.C.J., Aveyard, P., Garnett, T., et al. 2018. Meat consumption, health, and the environment. *Science*, 361(6399), eaam5324.
- HLPE. 2020. *Food security and nutrition: Building a global narrative towards 2030*. High Level Panel of Experts on Food Security and Nutrition.

- Klikocka, H. 2022. Assessment of Poland's food security in the context of agricultural production in 2010-2020. *Agronomy Science*.
- Poczta-Wajda, A., Poczta, W. 2024. Stability of food security in EU Member States during recent crises. *Ekonomista*, 4, 395-419.
- Parlasca, M.C., Qaim, M. 2022. Meat consumption and sustainability. *Annual Review of Resource Economics*, 14, 197-222.
- Rippin, H.L., Obreja, G., et al. 2023. Suboptimal intake of fruits and vegetables in selected countries of the WHO European Region. *Preventing Chronic Disease*, 20, E60.
- Stea, T.H., Nordheim, O., et al. 2020. Fruit and vegetable consumption in Europe by gender, educational attainment and regional affiliation. *PLOS ONE*, 15(5), e0232521.
- Valin, H., Sands, R.D., van der Mensbrugghe, D., et al. 2014. The future of food demand: Understanding differences in global economic models. *Agricultural Economics*, 45(1), 51-67.
- Willett, W., Rockström, J., Loken, B., et al. 2019. Food in the Anthropocene: The EAT–Lancet Commission on healthy diets from sustainable food systems. *The Lancet*, 393(10170), 447-492.
- Zhao, X., Chen, B., et al. 2025. Traceable and scalable food balance sheets from agricultural commodity supply and utilization accounts (2010-2022). *Scientific Data*, 12(1).
- Zuba-Ciszewska, M. 2018. Transformations in the Polish dairy sector. *Economic and Regional Studies / SERiA*.
- Zuba-Ciszewska, M. 2019. Structural changes in milk production and self-sufficiency in Poland. *Roczniki Naukowe SERiA*.