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05.01.00 – Axborot texnologiyalari, boshqaruv va kompyuter grafikasi
05.01.01 – Muhandislik geometriyasi va kompyuter grafikasi. Audio va video texnologiyalari
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05.02.00 – Mashinasozlik va mashinashunoslik
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Ma'lumot uchun, OAK Rayosatining 2024-yil 28-avgustdagi 360/5-son qarori bilan "Dissertatsiyalar asosiy ilmiy natijalarini chop etishga tavsiya etilgan milliy ilmiy nashrlar ro'yxati"ga texnika va iqtisodiyot fanlari bo'yicha "Muhandislik va iqtisodiyot" jurnali ro'yxatga kiritilgan.

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DIGITAL TECHNOLOGIES AND FOOD SECURITY IN DEVELOPED COUNTRIES

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Abstract. This article examines the role of digital technologies in strengthening food security in developed countries. Although high-income economies have advanced infrastructure, modern logistics, strong statistical systems and sophisticated social-protection programs, food insecurity remains present because access to food depends not only on aggregate supply but also on income, prices, nutrition, territorial inequality and institutional design. The study uses an IMRAD structure and combines theoretical analysis with selected empirical data from the United States, the European Union, Canada and OECD economies. It analyzes digital agriculture, online food-assistance systems, agri-food data spaces, precision farming, digital price monitoring, e-commerce and supply-chain traceability. The evidence shows that digital technologies can improve food availability, accessibility, utilization and stability by reducing information asymmetry, improving resource efficiency, enabling faster public assistance and strengthening early-warning capacity. However, digital transformation does not automatically eliminate food insecurity. The article concludes that digital food-security strategies in developed countries should combine innovation with social protection, competition policy, cybersecurity, data governance and nutrition-oriented public policy.

Keywords: digital technologies, food security, developed countries, precision agriculture, online food assistance, digital agriculture, food access, data governance, food systems

Annotatsiya. Ushbu maqola rivojlangan mamlakatlarda oziq-ovqat xavfsizligini mustahkamlashda raqamli texnologiyalarning rolini o‘rganadi. Yuqori daromadli iqtisodiyotlar rivojlangan infratuzilma, zamonaviy logistika, kuchli statistik tizimlar va keng raqamli ulanishga ega bo‘lsa-da, oziq-ovqat xavfsizligi muammosi to‘liq bartaraf etilgan emas. AQSH, Yevropa Ittifoqi, Kanada va OECD mamlakatlari tajribasi shuni ko‘rsatadiki, asosiy muammolar ko‘pincha umumiy oziq-ovqat taqchilligi emas, balki xarid qilish imkoniyati, daromadlar tengsizligi, mintaqaviy nomutanosiblik, raqamli chetlanish va tizimlarning barqarorligi bilan bog‘liq. Maqolada aniq dehqonchilik, sun’iy intellekt, katta ma’lumotlar, onlayn oziq-ovqat yordami, raqamli to‘lovlar, bozor monitoringi va ma’lumotlar boshqaruvi kabi vositalar tahlil qilinadi. Rasmiy statistik ma’lumotlar asosida raqamli texnologiyalar mahsuldorlik, shaffoflik va foydalanish imkoniyatlarini yaxshilashi mumkinligi, ammo ular kuchli institutlar, ijtimoiy himoya, arzon ulanish va inklyuziv siyosat bilan birga qo‘llanilgandagina oziq-ovqat xavfsizligiga sezilarli ta’sir ko‘rsatishi asoslanadi.

Kalit so‘zlar: raqamli texnologiyalar, oziq-ovqat xavfsizligi, rivojlangan mamlakatlar, aniq dehqonchilik, onlayn oziq-ovqat yordami, raqamli qishloq xo‘jaligi, oziq-ovqatdan foydalanish imkoniyati, ma’lumotlar boshqaruvi

Аннотация. Данная статья рассматривает роль цифровых технологий в укреплении продовольственной безопасности в развитых странах. Несмотря на то что экономики с высоким уровнем дохода обладают развитой инфраструктурой, современной логистикой, сильными статистическими системами и широким цифровым доступом, проблема продовольственной безопасности в них не исчезла полностью. Опыт Соединённых Штатов, Европейского союза, Канады и стран ОЭСР показывает, что основные вызовы часто связаны не с общим дефицитом продовольствия, а с доступностью продуктов, неравенством доходов, региональными различиями, цифровым исключением и устойчивостью продовольственных систем. В статье анализируются такие инструменты, как точное земледелие, искусственный интеллект, большие данные, онлайн-системы продовольственной помощи, цифровые платежи, мониторинг рынков и управление данными. На основе официальных статистических данных обосновывается, что цифровые технологии могут повышать производительность, прозрачность и доступ к продовольствию, однако их влияние становится значимым только при сочетании с сильными институтами, социальной защитой, доступной цифровой инфраструктурой и инклюзивной политикой.

Ключевые слова: цифровые технологии, продовольственная безопасность, развитые страны, точное земледелие, онлайн-продовольственная помощь, цифровое сельское хозяйство, доступ к продовольствию, управление данными

INTRODUCTION

Food security is often associated with developing economies, but it is also a significant policy issue in developed countries. High-income economies usually possess productive agricultural sectors, modern transport systems, digital retail networks and strong public institutions. However, these advantages do not automatically

guarantee equal access to sufficient, safe and nutritious food for every household. Food insecurity can persist even where food is physically abundant, because people may lack purchasing power, reliable transport, local retail options or access to appropriate nutrition information.

The concept of food security includes four interrelated dimensions: availability, access, utilization and stability. Availability refers to the physical presence of food through production, stocks and imports. Access concerns the economic and physical ability of people to obtain food. Utilization refers to nutrition, safety and the capacity of people to benefit from consumed food. Stability means that these three dimensions can be maintained over time, including during price shocks, pandemics, climate events, cyber incidents or geopolitical disruptions.

Digital technologies influence all four pillars of food security. Precision agriculture can support availability by improving yields and resource efficiency. Online grocery systems and electronic benefit programs can support access by reducing physical and administrative barriers. Digital traceability and nutrition information can support utilization by improving food safety and consumer knowledge. Early-warning platforms, price dashboards and supply-chain monitoring can support stability by helping governments and businesses respond faster to crises.

Developed countries are useful cases because they reveal both the promise and limits of digital food systems. The United States has advanced precision agriculture and online food-assistance systems, yet household food insecurity remains significant. The European Union has sophisticated data governance and market-transparency tools, yet some households still cannot afford regular nutritious meals. Canada has strong institutions and high average income, yet recent evidence shows high levels of household food insecurity. These cases demonstrate that digital infrastructure is necessary but not sufficient for food security.

The research problem addressed in this article is how developed countries can use digital technologies to strengthen food security while reducing risks related to unequal access, market concentration and dependence on specific technologies. The objective is to analyze the economic and institutional role of digital technologies in food security in the United States, the European Union, Canada and broader OECD economies. The article argues that developed countries face a specific food-security paradox: high technological capacity coexists with unequal affordability and access.

LITERATURE REVIEW

Food-security literature emphasizes that hunger and inadequate diets cannot be explained only by aggregate food supply. Amartya Sen's entitlement approach showed that people may suffer hunger even when food exists in the economy, because access depends on income, rights, exchange relations and institutions. This insight is highly relevant to developed countries. Food may be available in supermarkets and online platforms, but households can still experience food insecurity when wages, benefits and local access do not keep pace with living costs.

Classical and neoclassical economic theories explain food markets through supply, demand, prices and competition. From this perspective, digital technologies improve efficiency by reducing search costs, improving matching between buyers and sellers, lowering transaction costs and expanding information. Price-comparison tools, digital marketplaces and logistics platforms can improve consumer choice and reduce inefficiencies. Yet food is a basic necessity, so market efficiency alone may not protect low-income households from food hardship.

Keynesian and welfare-state approaches emphasize the role of government in stabilizing demand and protecting vulnerable groups. In developed countries, food-security policy is closely linked with social assistance, school meals, nutrition programs, unemployment benefits and income support. Digital technologies can improve these programs through faster payments, better eligibility management, fraud detection and online purchasing. However, these systems require safeguards so that eligible households are not excluded by data errors, digital barriers or complex verification procedures.

Institutional economics highlights the importance of rules, governance and trust. Digital food systems depend on reliable standards, competition policy, data governance, cybersecurity rules, consumer protection and interoperability. The European Union's approach to agricultural data spaces reflects an institutional model in which data sharing is organized around trust, public oversight and interoperability rather than being controlled only by private platforms.

Digital agriculture research focuses on farm-level technologies such as yield monitors, sensors, drones, satellite imagery, machine learning, soil mapping, variable-rate inputs and automated equipment. These tools can improve productivity and reduce waste. In the United States, precision agriculture adoption is especially high on large crop farms, but adoption varies by farm size, capital availability and technical capacity. This creates a distributional issue: digital agriculture may improve total output while increasing the advantage of

large-scale producers.

The literature on digital food assistance shows that electronic benefit transfer and online purchasing can reduce physical barriers to food access. The U.S. SNAP Online Purchasing Pilot is an important case because evidence indicates that its early rollout reduced food insufficiency among low-income households during the pandemic. This suggests that digital tools can improve access when they are integrated with social protection and designed around user needs.

RESEARCH METHODOLOGY

This study applies a qualitative analytical research design supported by selected empirical indicators. It is not an econometric study; rather, it uses official and institutional data to illustrate the relationship between digital technologies and food security in developed countries. This approach is appropriate because the topic involves both measurable outcomes and institutional mechanisms.

The analysis focuses on the United States, the European Union and Canada, with additional reference to OECD economies and global food-security indicators. These cases were selected because they provide strong examples of advanced digital infrastructure, reliable food-security data and different policy models. The United States is useful for analyzing precision agriculture and digital food assistance. The European Union is useful for examining data governance and digital public infrastructure. Canada is useful for showing that food insecurity can rise even in high-income economies with strong institutions.

The data sources include the United States Department of Agriculture Economic Research Service, Eurostat, Statistics Canada-related public health sources, the European Commission, the U.S. Government Accountability Office, the OECD, the World Bank and the SOFI 2025 report prepared by FAO, IFAD, UNICEF, WFP and WHO. These sources were selected because they are official, intergovernmental or institutionally credible.

The analytical method combines comparative analysis, institutional analysis and theoretical synthesis. Comparative analysis identifies differences among developed-country cases. Institutional analysis examines how public programs, data governance and market regulation influence digital food-security outcomes. Theoretical synthesis connects digital-economy concepts with the four pillars of food security: availability, access, utilization and stability.

A limitation of the study is that developed countries use different food-security measures. The United States measures household food insecurity through a national survey, the European Union indicator used here captures the inability to afford a proper meal every second day, and Canada uses household food-insecurity estimates from income- and health-related sources. These indicators are useful for comparative interpretation but should not be treated as a single ranking system.

Analysis and Results

The empirical evidence shows that developed countries combine high digital capacity with continuing food-security challenges. Digital infrastructure is widely available in high-income economies, but access to food remains uneven. This confirms the central argument of the article: food security is not a simple function of technological sophistication. It is shaped by the interaction of technology, prices, income, social protection, market structure and governance.

4.1. Food Insecurity Remains Present in Developed Economies

Food insecurity remains significant even in wealthy countries. In the United States, 13.7% of households experienced food insecurity in 2024, including 5.4% with very low food security. In the European Union, 8.5% of people could not afford a proper meal every second day, while the figure reached 19.4% among people at risk of poverty. Canada also reported high levels of household food insecurity, affecting 25.5% of people in the provinces and 37.4% in the territories. These findings show that the main issue in developed economies is often food access rather than food availability.

Table 1. Food-Security Indicators in Selected Developed Economies

Country / region	Indicator	Value	Period
United States	Food-secure households	86.3%	2024
United States	Food-insecure households	13.7%	2024
United States	Households with very low food security	5.4%	2024
European Union	Unable to afford meat, fish or vegetarian equivalent every second day	8.5%	2024
European Union	Same indicator in previous year	9.5%	2023
European Union	At-risk-of-poverty population unable to afford a proper meal	19.4%	2024

European Union	Not-at-risk-of-poverty population unable to afford a proper meal	6.4%	2024
Canada	People in ten provinces living in food-insecure households	25.5%	2024
Canada	People in territories living in food-insecure households	37.4%	2024

Source: USDA ERS Household Food Security in the United States in 2024; Eurostat proper-meal affordability release; Canada.ca commentary based on Statistics Canada / Canadian Income Survey estimates.

4.2. Digital Connectivity Creates the Infrastructure for Digital Food Systems

The second empirical result is that developed economies possess the digital foundation needed for advanced food-system tools. Eurostat reported that 93 percent of people aged 16 to 74 in the EU used the internet in 2024, up from 86 percent in 2019. It also reported that 94 percent of EU households had internet access in 2024, with the Netherlands and Luxembourg reaching 99 percent. These figures show that digital food services can potentially reach a very large share of the population.

High connectivity enables several food-security functions. Consumers can compare prices, order groceries online, access nutrition information and use benefit platforms. Farmers can receive weather data, market forecasts and technical advice. Retailers can manage inventory and reduce waste. Governments can monitor food prices, publish market data and deliver targeted assistance. However, high average connectivity does not eliminate digital exclusion; older adults, rural residents, low-income households, migrants and people with disabilities may still face difficulties using digital food services.

4.3. Precision Agriculture Strengthens Availability but Raises Distributional Questions

Precision agriculture has become an important part of developed-country food systems. Technologies such as GPS guidance, drones and yield-monitoring systems improve productivity and reduce waste. In the United States, 27% of farms used precision agriculture practices in 2023, while adoption rates were much higher among large-scale farms. However, smaller farms often face financial and technical barriers to adopting these technologies.

Digital social protection programs also improve food access. During the COVID-19 pandemic, the SNAP Online Purchasing program in the United States expanded rapidly and helped reduce food insufficiency among low-income households. By 2023, online SNAP and P-EBT transactions reached $2.3 billion. Nevertheless, delivery fees, digital exclusion and data-privacy concerns remain important challenges.

4.4. Data Governance, Resilience and Global Context

The European Union provides a useful governance model because it has emphasized digital public infrastructure, market transparency and trusted data sharing. The European Commission's Agri-food Data Portal provides data on agricultural markets, production, trade, prices and farm economics. The Common European Agricultural Data Space aims to support secure, trusted and interoperable data sharing across the agri-food sector. For food security, this matters because data are increasingly central to production planning, risk assessment, environmental monitoring and supply-chain coordination.

A strong governance model can help prevent excessive concentration of agricultural data within a limited number of platforms. If data are locked into proprietary systems, farmers and public agencies may lose bargaining power. Interoperability, data portability and clear ownership rules are therefore food-security issues, not only technical matters. Developed countries should combine private-sector platforms with public oversight, interoperability standards and transparent data-governance mechanisms when organizing food-system data.

Digital technologies can also improve resilience to shocks. Remote sensing can monitor crop conditions and drought risk. Artificial intelligence can support forecasting of demand, yields and prices. Supply-chain platforms can track inventory and transport flows. Traceability systems can identify contamination sources quickly, and digital benefits can deliver assistance during emergencies. Yet resilience also requires redundancy, because food systems dependent on online payments, automated warehouses and digital logistics can be vulnerable to cyberattacks or outages.

Table 2. Global Food-Security Context Relevant to Developed Countries

Indicator	Value	Period	Main source
People facing hunger globally	673 million	2024	SOFI 2025 / UNICEF key findings
Share of world population facing hunger	8.3%	2024	SOFI 2025 / UNICEF key findings
People experiencing moderate or severe food insecurity	2.3 billion	2024	SOFI 2025 / UNICEF key findings
People unable to afford a healthy diet	2.6 billion	2024	SOFI 2025 / UNICEF key findings

Source: SOFI 2025 / UNICEF key findings; World Bank Food Security Update, January-March 2026.

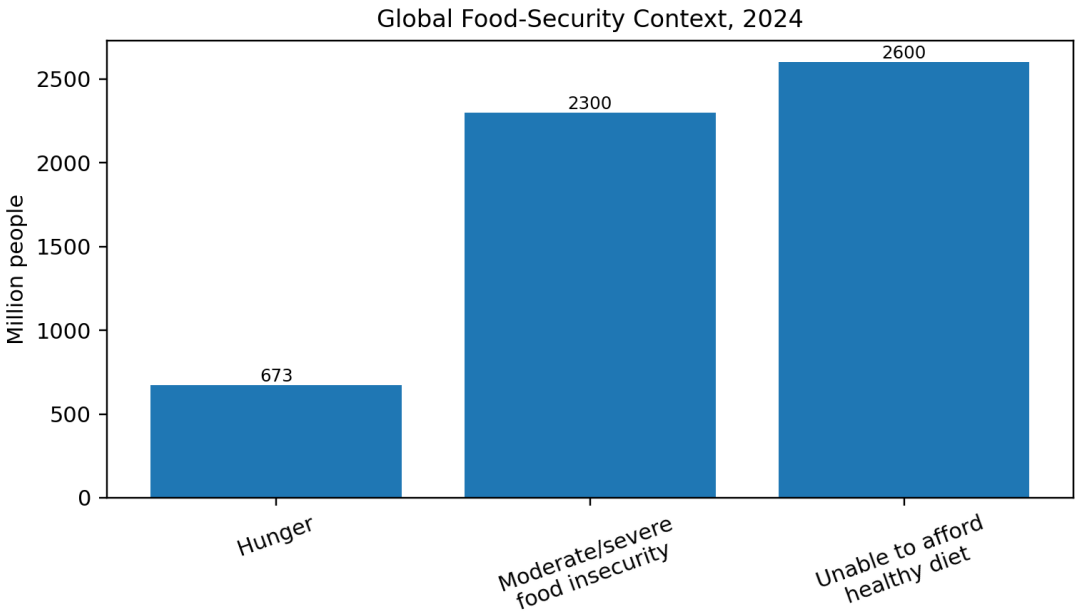

Figure 1. Global food-security, 2024.

Digital governance and data sharing are increasingly important for food security. The European Union promotes market transparency and interoperable agricultural data systems through initiatives such as the Agri-food Data Portal. Digital technologies also strengthen resilience by supporting forecasting, supply-chain monitoring and emergency assistance delivery.

At the global level, food insecurity remains a serious and persistent issue. In 2024, around 673 million people faced hunger worldwide, while 2.3 billion experienced moderate or severe food insecurity. These trends show that developed countries remain closely connected to global food markets and may be affected by international price shocks and supply disruptions.

The evidence indicates that developed countries face a paradox. They have advanced digital infrastructure, sophisticated food supply chains and highly developed agricultural technologies, yet food insecurity continues to affect some socially and economically vulnerable households. This paradox can be explained by the difference between food-system capacity and household food access. Digital technologies can improve capacity, but access depends on income, prices, social protection and local retail conditions.

The United States illustrates this paradox clearly. Precision agriculture can improve productivity on large farms, and online SNAP purchasing can reduce food-access barriers for low-income households. However, the presence of both technologies does not mean that all households are food secure. The policy challenge is to connect digital innovation with social outcomes. Technology should be evaluated by whether it reduces hunger and improves nutrition, not only by whether it increases efficiency.

The European Union illustrates the importance of governance. Its emphasis on data portals and agricultural data spaces shows that digital food systems require rules, trust and interoperability. This approach matters because data are becoming a strategic resource in agriculture and food retail. If data governance is weak, digitalization may increase private control over food-system information and reduce public accountability.

Canada illustrates the importance of affordability and household income. Even a high-income, highly connected economy can experience high household food insecurity when living costs rise. Digital grocery platforms or information tools alone are not sufficient to address income-related food-access problems. They can support access at the margin, but social and economic policy remain essential.

Digital technologies contribute to food security through three main channels. First, they improve production efficiency by allowing farmers to use inputs more accurately, monitor crop conditions and respond to environmental change. Second, they improve market coordination by connecting producers, processors, retailers, consumers and public agencies through digital platforms and data systems. Third, they improve access by supporting online grocery services, electronic benefit systems and faster delivery of social assistance.

However, the same technologies can create new forms of exclusion. Precision agriculture can be expensive and may be adopted more rapidly by larger farms than by smaller ones. Digital food retail may improve convenience for households with stable internet access, digital payments and delivery options, but

it may be less useful for elderly consumers, people with disabilities or low-income households facing delivery fees. Digital benefit systems can accelerate assistance, but they require careful design so that users are not excluded by a lack of digital skills or limited broadband access.

Another important issue is market concentration. Developed food systems are increasingly shaped by large retailers, logistics providers, technology firms and platform companies. Digital systems can make these actors more efficient, but they can also increase their market power. Competition policy should therefore be integrated into digital food-security policy. Open standards, data portability and fair platform rules can help prevent exclusion.

Nutrition must also remain central. Digital tools can make food purchasing easier, but they may also encourage ultra-processed food consumption through targeted advertising, convenience algorithms or promotional design. Food-security policy should evaluate success not only by calorie availability, but also by nutritional quality and access to healthy diets. Digital platforms can support healthier choices through labeling, incentives and public-health information, but these tools require careful regulation and evaluation.

Cybersecurity is an emerging food-security concern. As food systems rely more on connected machinery, digital payments, automated warehouses and traceability systems, cyber disruptions may negatively affect food availability and access if appropriate safeguards are not in place. Food supply chains should be included in national critical-infrastructure planning, with public-private coordination because many digital systems are privately owned but have public welfare implications.

Theoretically, the findings suggest that food security in developed countries should be understood as a socio-technical system. The technical side includes precision agriculture, digital retail, electronic benefits, logistics platforms, artificial intelligence and data infrastructure. The social side includes income, trust, nutrition knowledge, institutional accountability, competition and regional access. Sustainable food security requires interaction between both sides.

5.1. Limitations and Future Research

This study has several limitations. First, it relies mainly on secondary data from official statistical agencies, international organizations and policy reports. These sources are reliable for comparative analysis, but they do not provide household-level causal evidence on how specific digital technologies change food-security outcomes over time. Precision agriculture indicators show adoption patterns, while food-security indicators show household access problems. The connection between the two must therefore be interpreted analytically rather than as direct statistical causality.

Second, the selected developed-country cases are not identical. The United States, the European Union and Canada differ in welfare systems, agricultural structures, digital-market regulation and survey methodology. The indicators are useful for comparative interpretation, but they should not be treated as perfectly equivalent measures. The value of the comparison lies in showing that food insecurity persists across different high-income institutional models.

Future studies should examine the distributional impact of digital food systems more deeply. Important questions include whether digital retail reduces or increases food-access inequality, whether precision agriculture improves environmental and nutritional outcomes, and how data governance affects the bargaining power of farmers, retailers and consumers. A comparative framework including both developed and developing countries would help distinguish universal mechanisms from country-specific institutional effects.

CONCLUSION AND SUGGESTIONS

This article has shown that digital technologies can strengthen food security in developed countries, but they do not automatically solve food insecurity. Developed economies have high digital capacity, advanced agricultural technologies and strong institutions, yet household food insecurity remains significant in the United States, the European Union and Canada. The core problem is that food security depends not only on production and technology but also on affordability, access, nutrition and institutional design.

Digital tools contribute most clearly when they reduce information gaps, improve payment and benefit systems, support precision agriculture, strengthen market transparency, improve traceability and enable faster crisis response. However, their benefits depend on inclusive access, data governance, competition policy, cybersecurity and social protection. The experience of developed countries therefore offers an important lesson: advanced technology can improve food systems, but food security requires deliberate policy choices that combine innovation with equity, resilience and public accountability.

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