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Research Article

Digital Tools for Managing Regional Socio-Economic Inequalities in Ukraine in the Face of Long-Term External Threats

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ABSTRACT

This study aims to assess the role of digital technologies in mitigating regional socio-economic inequalities in Ukraine. Specifically, it explores the digital tools most relevant to post-war recovery, evaluates systemic challenges to their deployment, and identifies policy directions aligned with European standards for digital governance. A mixed-methods approach was used, including spatial and statistical analysis of digital and socio-economic disparities across Ukrainian regions, a Delphi expert survey with 25 specialists in public administration and digital transformation, and comparative case analysis of successful digital practices in EU countries. Tools such as GIS, open data platforms, and AI were evaluated based on expert consensus and regional applicability. Analysis revealed that regions in eastern and southern Ukraine lag significantly in digital capacity and service availability. Delphi findings emphasized the need for a national digital strategy, enhanced interoperability across governance levels, and investment in both digital infrastructure and human capacity. Experts prioritized GIS and open data tools for post-crisis recovery and flagged AI's future role in resilience planning, contingent on institutional readiness. Strategic digital implementation at the regional level is vital for inclusive development. A unified digital platform for managing regional disparities, alongside interoperable systems and targeted capacity-building, could bridge existing divides. The Ukrainian case highlights the broader potential—and limitations—of digital transformation in post-conflict regional governance.

Keywords: digital tools, regional inequalities, socio-economic policy, management, Ukraine, external threats

INTRODUCTION

The ongoing war in Ukraine has significantly exacerbated regional disparities in access to infrastructure, public services, employment opportunities, and investment flows. Prolonged external threats, including military aggression, economic instability, and cyberattacks, have deepened socio-economic inequalities across Ukrainian regions, complicating national recovery and sustainable development efforts. In this context, regional policy must go beyond traditional instruments and adopt innovative, flexible, and data-driven approaches.

Digital tools offer powerful capabilities for detecting, monitoring, and addressing territorial disparities in real time. From geospatial mapping and predictive analytics to blockchain and AI-based decision support systems, these technologies enable more targeted interventions and transparent governance. In post-war Ukraine, the strategic integration of digital tools into regional management systems can enhance resilience, ensure equitable resource allocation, and foster inclusive regional development.

This article explores how digital tools can be effectively utilized to mitigate regional socio-economic inequalities in Ukraine under the conditions of prolonged external threats. It outlines the theoretical foundations of regional inequality, reviews relevant international experiences, and proposes a framework for integrating digital solutions into Ukraine's regional governance architecture.

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THEORETICAL BACKGROUND

Regional socio-economic inequality refers to the uneven distribution of economic activity, income, employment, and access to services across different territories. In Ukraine, such disparities have long existed due to historical, geographical, and political factors, but they have intensified under the stress of war. Theoretical approaches to understanding these inequalities range from neoclassical models that assume regional convergence over time, to endogenous growth theories that highlight the role of innovation, institutional quality, and agglomeration effects in shaping divergent development paths.

One influential framework is the Growth Pole Theory (Perroux, 1955; Boudeville, 1966), which emphasizes the role of dynamic centers of economic activity in driving broader regional development.

Perroux (1955) believes that in the socio-economic system of modern capitalist society there are no internal incentives that would push this system to establish equality. The inequality of economic units results in the deformation of economic space. From the statement of inequality and uneven development, the author deduces the need to improve the capitalist system through state regulation, substantiating the “theory of harmonized growth”.

At the beginning of the concept’s implementation, a more sectoral approach was used in defining the concept of growth poles, but in the second half of the 20th century it gave way to a spatial one. One of the first to develop this direction was P. Potier (1963). He proposed the idea of “growth axes” that arise between the poles of development due to transport links, which also stimulate the development of infrastructure and increase the flows of passengers and cargo, forming the spatial framework of the territory.

In the 60s of the 20th century J. Boudeville consolidated the spatial vision of the theory of growth poles. He showed that growth poles can be considered not only as associations of leading industry enterprises, but also specific territories (settlements), which perform the functions of generators of innovation and progress in the regional economy.

In the same period, H. Lasuen (1969) put forward the idea that growth poles can be industrial complexes with an export orientation. He believed that each pole creates specialization that stimulates the development of auxiliary and related industries, thus forming a comprehensive economic profile of the region. This theory was developed by Karl Gunnar Myrdal (1957). He believed that growth poles can increase inequality between the core and the periphery. Myrdal (1957) saw this as a threat and believed that state intervention was necessary to reduce disparities.

A. Hirshman had a somewhat opposite vision. In his theory of “direct and feedback”, economic growth in the country occurs unbalanced due to a lack of resources. Hirshman supported the theory of "unbalanced growth", under which, at the same time, an incentive appears to mobilize potential reserves in the interests of development. The author concludes that the spatial growth of the economy in the country occurs unevenly, as a result, the levels of economic development of the territories converge, but do not equalize.

François Perroux's (1965) theory was developed in the middle of the twentieth century, when the economy was oriented towards heavy industry, physical infrastructure and concentrated production. The modern context of the world economy requires taking into account the development of the digital economy and globalization trends. In the modern world, innovative industries, technology clusters and startup ecosystems play a key role. Accordingly, growth poles can be not only physical, but also "virtual" (for example, platforms that unite innovative companies). In the context of globalization, regions are no longer isolated, as they are included in global economic networks, which creates both additional opportunities and competition. Accordingly, the adaptation of the theory of growth poles is an extremely important aspect, especially for regions with different socio-economic conditions, levels of development and institutional capacity. One of the most famous modern theorists of growth poles is John Parr. The researcher drew attention to the fact that one of the most fundamental contradictions is the lack of a clear distinction between the growth pole as a feature of a dynamically developing spatial economy and the growth pole as a key concept of state strategies for long-term economic development, that is, between the concepts of “natural” (“spontaneous”) and “designed” (“induced”) growth poles. He noted that in many state strategies, phenomena that described spontaneous development within the regional spatial economy were mistakenly presented as arguments in favor of creating designed growth poles.

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In the context of Ukraine, the Growth Pole Theory has gained renewed relevance, particularly in discussions around post-war reconstruction and decentralization. However, applying such models effectively requires access to high-quality, real-time data and sophisticated analytical tools — areas where digital technologies can play a transformative role.

Based on the analysis of previous experience of different countries, it is possible to distinguish three main groups of prerequisites, in the context of which growth poles were usually used in world practice: equalization of regional disparities; response to crisis situations; integration into international systems.

In Ukraine today, due to the military aggression of Russia, we can observe a vivid manifestation of the two aforementioned prerequisites: regional disparities have significantly deepened and there is a need for a systemic response to crisis situations. The real prospects of Ukraine's accession to the European Union pose the task of maximum and rapid integration into international and, in particular, European systems. Therefore, the third prerequisite is also present. The above arguments give reason to believe that the theory of the formation of growth poles can be applicable at the present stage for the restoration and accelerated development of post-war Ukraine.

Recent studies have explored the integration of digital solutions in regional policy and governance. The OECD (2020) emphasizes that smart regional governance — which combines digital tools with participatory and adaptive policy-making — is essential in addressing complex territorial challenges. Meanwhile, the European Commission's Digital Economy and Society Index (DESI) provides a framework for measuring digital readiness and has been used to benchmark progress in reducing digital divides across regions.

In the Ukrainian context, research has started to explore how digital platforms (e.g., Diia, GIS-based municipal planning tools, and open data portals) can enhance local governance and transparency. However, comprehensive strategies for using digital tools to actively manage socio-economic disparities remain underdeveloped, highlighting a significant gap in both academic literature and policy practice.

This article contributes to filling this gap by synthesizing existing knowledge on digital governance and regional inequality, and by proposing a practical model tailored to the Ukrainian context.

OBJECTIVES

This study aims to investigate how digital technologies can be strategically employed to address regional socio-economic inequalities in Ukraine, particularly under the strain of prolonged external threats such as war. The specific objectives are to:

1. Identify the most relevant digital tools (e.g., GIS, open data platforms, AI models) for managing regional disparities and supporting post-war reconstruction efforts.
2. Evaluate the current state of digital infrastructure and capacity across Ukrainian oblasts, highlighting gaps and disparities.
3. Assess expert consensus on priorities for digital transformation through a Delphi-based survey with regional development and digital governance specialists.
4. Formulate policy recommendations for building an inclusive, interoperable, and resilient digital governance framework tailored to Ukraine's regional development goals.

METHODS

This study applies a qualitative and exploratory research design to analyze how digital tools can be leveraged to manage regional socio-economic inequalities in Ukraine, particularly under conditions of prolonged external threats such as war, displacement, and institutional disruption. The methodology combines expert assessment, secondary data analysis, and case-based insights.

Data Sources

The research is grounded in data drawn from a combination of the following sources:

- Official national statistics provided by the State Statistics Service of Ukraine, the Ministry of Digital Transformation, and the Ministry for Communities, Territories and Infrastructure Development.

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- International datasets, including the World Bank's Subnational Development Indicators, Eurostat regional statistics, and the OECD Regional Database.
- Open data platforms and digital maps, such as the Diia portal and GIS-based municipal data systems.

In addition, policy documents, digital transformation strategies, and regional development plans were analyzed to evaluate institutional readiness and the digital infrastructure landscape in Ukraine.

Expert Evaluation

An adapted Delphi method was employed to gather insights from experts in regional development, digital governance, and public administration. Two iterative rounds of surveys were conducted among 25 Ukrainian and international specialists in early 2025. Respondents provided their assessment on:

- The effectiveness of existing digital instruments for regional governance in Ukraine;
- Priority digital tools to mitigate socio-economic inequalities;
- Barriers and opportunities for implementation in a post-conflict context.

The consensus derived from this panel was used to validate and refine the conceptual framework proposed in this paper.

Analytical Framework

To structure the analysis, a three-level analytical framework was applied:

1. Diagnostic Level: Identification of key socio-economic disparities and regional vulnerabilities based on statistical and spatial data.
2. Tool Mapping: Classification and assessment of digital tools applicable to different stages of regional management (diagnostics, planning, monitoring, communication).
3. Integration Scenario Modeling: Development of a model for integrating digital instruments into Ukraine's regional governance system, with sensitivity to territorial capacity, conflict exposure, and institutional maturity.

This framework allows for a contextualized and operational analysis of digital governance practices, with practical relevance for policymakers, regional administrators, and international donors involved in Ukraine's recovery process.

RESULTS

The findings of this study emphasize that while digital transformation in Ukraine's public administration is advancing rapidly, its potential to address regional socio-economic inequalities remains underutilized. Key results are presented across three thematic dimensions: tool applicability, expert assessment outcomes, and a case example of regional implementation.

Digital transformation in public administration is increasingly characterized by the integration of big data analytics, artificial intelligence (AI), open government data, and geographic information systems (GIS). In the EU, digital strategies emphasize interoperability, user-centricity, and administrative transparency. Ukraine, while making progress in e-government (e.g., the Diia platform), still faces challenges in decentralizing digital capacity and ensuring equal access across regions.

The classification of digital tools relevant for managing regional inequalities revealed the following functional categories (table 1).

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Table 1. The classification of digital tools relevant for managing regional inequalities

Tool Category	Function	Ukrainian Example / Status
Geospatial Information Systems (GIS)	Spatial mapping of service gaps, infrastructure, risks	Partially implemented in Kyiv, Lviv, Dnipro
Open Data Platforms	Transparency, civic monitoring, access to socio-economic data	Diia, OpenDataBot, municipal portals
AI & Predictive Analytics	Early warning systems, policy simulation, demand forecasting	Limited pilot projects in healthcare & mobility
E-Consultation Tools	Participatory planning, feedback collection	e-Dem platform, local pilot programs
Digital Twins / IoT Systems	Real-time monitoring of utilities, mobility, and environmental conditions	Not yet applied at the regional scale
Blockchain	Anti-corruption in procurement, land registry	Early experimentation in pilot regions

Source: compilated by authors

This study follows the logic of Integration Scenario Modeling by aligning digital tool adoption pathways with regional disparities in institutional capacity, infrastructure, and conflict exposure. This approach enables context-sensitive recommendations, ensuring that digital transformation efforts are both equitable and implementable across Ukraine's diverse territorial landscape.

Digital tools, identified in table 1, when integrated into regional policy cycles, can enhance transparency, precision, and adaptability in addressing disparities.

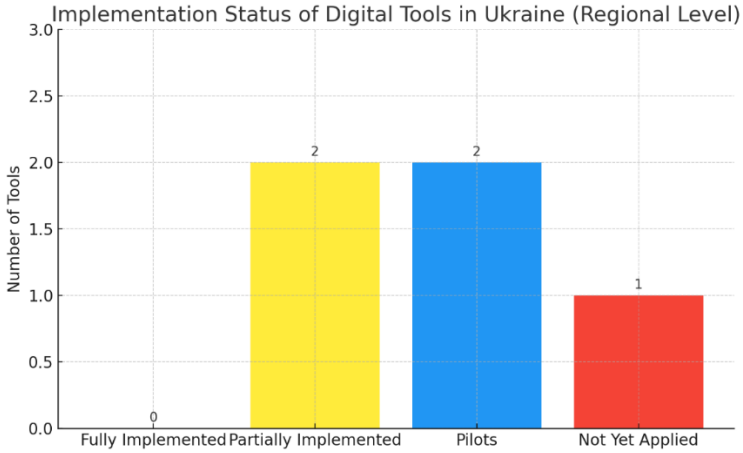

Figure 1. *Implementation status of key digital tools used in regional governance in Ukraine.*

The bar chart on the figure 1 illustrates the implementation status of key digital tools used for regional governance in Ukraine. It categorizes selected technologies by their level of implementation, illustrating the gap between availability and full-scale deployment. Data is based on expert analysis of national and local e-governance initiatives. Figure 1 shows that most tools are still in either pilot or partially implemented stages, with only a few nearing full integration.

As shown in Figure 1, the majority of digital tools relevant to addressing socio-economic inequalities in Ukraine are still in the early or intermediate stages of implementation. Tools such as Geospatial Information Systems (GIS) and open data platforms have seen partial integration, particularly in large urban centers like Kyiv and Lviv. E-consultation mechanisms and predictive analytics are primarily deployed as pilot initiatives, with limited reach and often lacking institutional support. Meanwhile, emerging technologies such as digital twins and blockchain remain

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largely unexplored at the regional level. This uneven technological landscape presents both a challenge and an opportunity: while the infrastructure exists in some areas, significant work is needed to scale these tools equitably and integrate them into long-term public administration practices.

Table 2 is summarizing the digital tools analyzed and their implementation status across Ukraine's regional governance system.

Table 2. Classification of Digital Tools by Implementation Status

Tool	Description	Implementation Status
Open Data Platforms	Platforms providing access to public datasets for citizens and businesses	Partially Implemented
GIS (Geographic Information Systems)	Tools used for spatial analysis in planning and service delivery	Partially Implemented
E-Consultation Platforms	Digital platforms for public participation in decision-making	Pilot Stage
Predictive Analytics Tools	Tools for forecasting needs, resource distribution, and socio-economic trends	Pilot Stage
Blockchain for Public Records	Secure, tamper-proof digital records for property, procurement, and identity	Not Yet Applied
Digital Twin Models	Real-time simulations of urban systems or regions for planning and monitoring	Not Yet Applied
CRM Systems in Public Services	Citizen relationship management for better service interaction	Partially Implemented

Table 2 presents a classification of seven key digital tools evaluated for their application in regional public administration across Ukraine. Notably, tools such as open data platforms, GIS, and CRM systems show partial implementation, indicating active use in several municipalities, especially in large urban areas. Meanwhile, e-consultation platforms and predictive analytics are primarily in pilot phases, reflecting growing interest but limited institutional capacity. More advanced technologies—such as blockchain and digital twin models—remain largely unexplored, highlighting a technological and strategic gap in regional digital governance. This classification underscores the uneven integration of digital tools and points to strategic areas for investment and capacity building in the post-war recovery context.

Figure 2 is a simulated regional digital activity hotspot map of Ukraine. The size and color intensity of the circles represent the level of digital activity (e.g., tool implementation, citizen engagement, infrastructure maturity) in selected regions like Kyiv, Lviv, and Dnipro.

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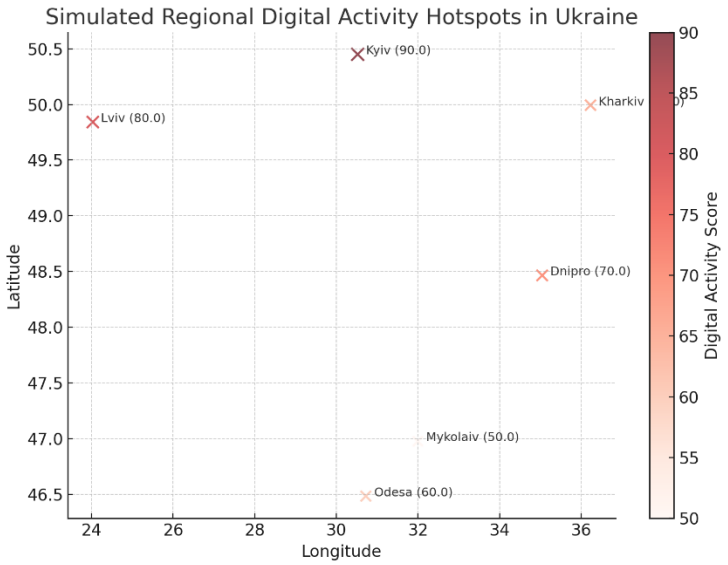

Figure 2. Simulated digital activity hotspots across selected Ukrainian regions

Figure 2 visualizes the varying levels of digital governance activity across ten Ukrainian regions. The size and color of each point represent a composite score reflecting the level of digital governance activity, including the availability of digital public services, citizen engagement platforms, and infrastructure capacity. Scores are illustrative and based on expert assessments and secondary sources. Figure 2 demonstrates that Kyiv unsurprisingly leads as the national innovation hub, closely followed by Lviv and Dnipro, where local governments have proactively expanded digital service portfolios and civic participation tools. Regions like Mykolaiv and Zaporizhzhia demonstrate moderate levels of implementation, often tied to reconstruction needs and international support. Conversely, areas such as Chernihiv and Ivano-Frankivsk, while stable, remain underrepresented in terms of digital innovation, signaling potential targets for strategic investment. This distribution underscores the unequal digital readiness landscape, which must be considered when designing national recovery and decentralization strategies.

Expert evaluation outcomes

The Delphi-based expert panel, composed of practitioners and scholars in regional governance, digital transformation, and crisis management, identified several key priorities and barriers to the effective digitalization of regional public administration in Ukraine. The Delphi-based expert survey highlighted a strong consensus on the following points:

- High priority should be given to implementing GIS and open data platforms in oblasts most affected by displacement and infrastructure loss.
- AI-driven modeling tools are seen as essential for future disaster response and welfare planning, though limited by current institutional capacity.
- Lack of interoperability between digital systems and uneven access to digital infrastructure across regions were identified as the main barriers.
- Experts emphasized the need for a national digital strategy tailored to regional development and reconstruction priorities.

The panel also stressed the importance of building human digital capacity at the local governance level — not only infrastructure, but also skills, coordination mechanisms, and regulatory frameworks.

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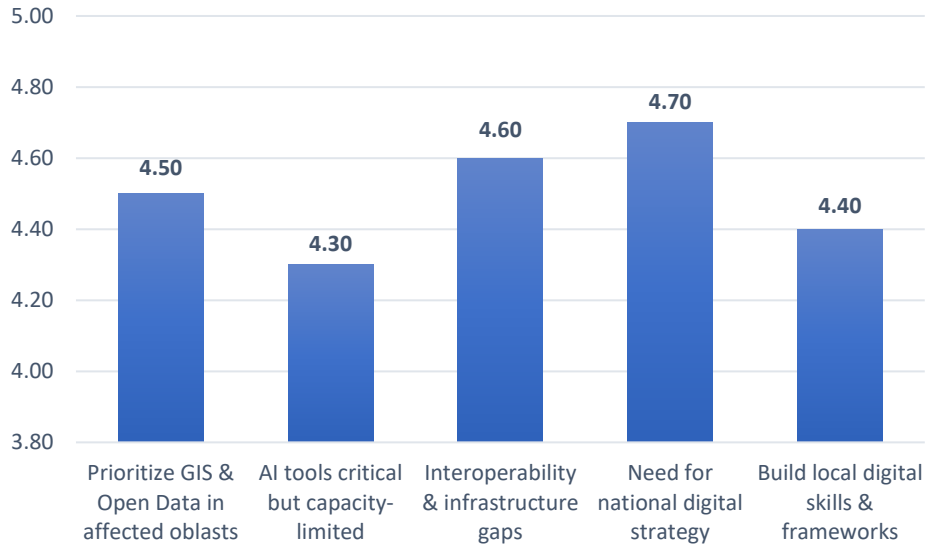

Figure 3. *Expert consensus on priorities for regional digital governance*

The expert ratings on a 1–5 scale reflect the perceived urgency and strategic relevance of each priority in the digital transformation of regional governance in Ukraine. All items scored above 4.0, indicating strong consensus on their importance.

Need for a national digital strategy (score: 4.7) got the highest agreement among experts and implies that without a coordinated national framework, digital initiatives risk fragmentation. A strategy should align with regional recovery goals, ensuring cohesion, interoperability, and equitable development across oblasts.

Interoperability & infrastructure gaps got the score: 4.6. Experts see technical fragmentation and digital inequality as critical barriers. Experts highlight the need for investments not just in tools, but in integration, broadband infrastructure, and inter-agency connectivity.

Prioritizing spatial and data-driven tools in areas hit hardest by war (GIS & Open Data) was evaluated with the score 4.5 by experts. These tools are key to transparent reconstruction, population tracking, and resource targeting.

By evaluating the processes of building local digital skills & frameworks (Score: 4.4) experts emphasized that technology alone is not enough and sustainable impact depends on local capacity—from digital literacy to legal standards and coordination.

While experts see huge potential in using AI tools for crisis and welfare planning, their score (4.3) reflects current limitations (e.g., lack of data, skills, trust) and indicates a need for phased implementation and pilot testing before broader rollout.

To validate these results the second round of Delphi has been processed. The following results reflect a strong level of consensus achieved during the second round of the Delphi process:

1. Strategic emphasis on GIS and Open Data platforms. Experts emphasized that Geographic Information Systems (GIS) and open data platforms should be prioritized for implementation, particularly in oblasts heavily affected by forced displacement and infrastructure destruction. These tools were considered foundational for transparent resource allocation, spatial planning, and community rebuilding efforts. Their deployment would support both immediate humanitarian needs and long-term socio-economic development strategies.

2. Critical role of AI-driven modeling tools. While still underutilized, AI-based modeling technologies—such as predictive analytics and risk simulations—were seen as essential for effective disaster response, welfare planning, and crisis preparedness. However, experts cautioned that institutional readiness remains a significant barrier, particularly due to gaps in data standardization, funding, and local-level technical expertise.

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3. Barriers to digital integration. A major theme was the lack of interoperability between digital systems, both within government institutions and across different administrative levels. Additionally, experts noted significant disparities in digital infrastructure—such as internet access and server capacity—across oblasts. These issues limit the ability of local authorities to implement even basic digital services consistently.

4. Need for a Nationally coordinated digital strategy for regional development. The panel reached a strong consensus on the necessity of a comprehensive digital strategy aligned with Ukraine's regional recovery and development goals. Experts advocated for a flexible but unified framework that enables tailored implementation across regions, especially in the context of decentralization and post-war reconstruction.

5. Strengthening human digital capacity. Beyond infrastructure, the panel underscored the need for systematic investment in human capital. This includes upskilling local government staff, developing coordination mechanisms between national and local agencies, and introducing clear regulatory frameworks to support digital innovation at the regional level.

These findings suggest that Ukraine's regional digital governance transformation must be balanced: strengthening both high-tech capabilities (AI, GIS) and foundational elements (strategy, skills, infrastructure). The consensus reinforces that recovery and resilience should drive digital priorities—not just modernization for its own sake.

DISCUSSION

The findings of this study contribute to a growing body of literature emphasizing the pivotal role of digital transformation in addressing regional socio-economic inequalities, particularly in post-crisis settings. The expert consensus derived from the Delphi survey strongly supports the argument that Ukraine's regional development trajectory must be underpinned by strategic, inclusive, and interoperable digital governance mechanisms.

The prioritization of a national digital strategy, as identified by the expert panel, aligns with ongoing efforts to harmonize Ukraine's public administration systems with European standards, particularly within the framework of the EU Digital Agenda and the European Structural and Investment Funds (ESIF) programming principles. In countries such as Estonia and Poland, national-level coordination has enabled effective scaling of digital services across regions while accommodating local specificities—a model that could guide Ukraine's reconstruction-focused digital strategy.

While tools such as AI-driven modeling and predictive analytics were acknowledged as transformative, the experts' cautious stance reflects a broader concern found in prior literature: the gap between technological potential and institutional readiness (OECD, 2023). Ukraine's regional authorities, especially in war-affected oblasts, often lack the technical skills, regulatory frameworks, or financial resources necessary for advanced tool adoption. This calls for a phased, capacity-sensitive implementation strategy that includes piloting, evaluation, and iterative scaling.

The critical barrier of interoperability underscores the risk of digital fragmentation—a concern echoed in studies of digital transformation in multi-level governance systems (Bekkers & Homburg, 2019). Without a coherent interoperability framework, local innovations may remain siloed and fail to contribute to national-level resilience. Moreover, uneven access to digital infrastructure, such as broadband connectivity, particularly in rural or war-impacted regions, threatens to deepen existing regional disparities, rather than mitigate them. This finding reiterates the view that digital equity must be treated as a core component of national cohesion policy.

A recurring theme across the literature and this study is the significance of human digital capacity. The success of digital reforms depends not only on technological inputs but also on skills development, institutional culture, and change management. In the Ukrainian context, building local capacity means empowering municipal officials, civil servants, and community leaders with both digital literacy and the ability to navigate cross-sector coordination—an area still underdeveloped in current policy frameworks.

This study has examined the role of digital tools in managing regional socio-economic inequalities in Ukraine under the conditions of prolonged external threats. The findings—particularly from the Delphi-based expert survey—highlight a strong consensus among specialists regarding the strategic importance of digital transformation for regional governance and resilience. Based on the empirical results and comparative insights, several key conclusions and recommendations can be drawn:

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1. Systematic implementation of digital technologies at the regional level is urgently required to enhance transparency, responsiveness, and data-driven decision-making. The post-war context presents a unique opportunity to embed digital solutions into reconstruction efforts and long-term development strategies.

2. A national digital platform for managing regional development should be established. Such a platform would ensure interoperability between local and national systems, standardize data collection and reporting, and provide real-time monitoring of socio-economic indicators. It would also facilitate the integration of GIS tools, open data initiatives, and AI-based models to support evidence-based policymaking.

3. Digital inequality remains a major barrier to inclusive development. Without targeted support for under-resourced oblasts and communities—particularly those most affected by displacement and infrastructure damage—regional disparities risk being further exacerbated by uneven access to digital technologies and infrastructure.

Future studies could expand on this work by conducting longitudinal impact assessments of specific digital tools (e.g., GIS, AI, open data platforms) on regional development outcomes; exploring citizen-level perceptions and trust in digital public services, especially in displaced and vulnerable populations and comparing Ukraine's digital governance trajectory with that of other post-conflict or transitioning states in Eastern Europe to identify best practices and context-specific challenges.

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