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Convergence of Digital and Ecological Transition in the European Union and Romania: Theoretical Perspectives and Statistical Evidence

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Abstract

The significant turbulences that have occurred in recent years in the external environment, along with the continuous development of new technological innovations, have prompted the European Union to establish two major strategic directions for the future of the region: the digital transition and the green transition.At the urban level, these transitions hold considerable importance, as they contribute to infrastructure improvement, enhanced quality of life, and reduced environmental impact. The digital transition in urban environments is considered a key pillar in advancing sustainable development within both the European Union and Romania.Currently, cities have the capacity to generate a substantial share of GDP, despite facing persistent challenges related to sustainability, mobility, and social inclusion. The green transition brings numerous improvements to the economy, infrastructure, and urban lifestyle.This study aims to examine the level of both digital and green urban transitions across the European Union and Romania by employing a set of relevant statistical indicators. In addition to providing a solid framework for the formulation of public policies aimed at reducing inequalities across member states and establishing a sustainable urban ecosystem, this analysis will highlight the current state of digitalization and urban greening.

Keywords: Digital Transition, Ecological Transition, Ecosystems, Smart City European Union, Romania

Introduction

The multiple global crises that have occurred in recent years have underscored the urgent need to integrate digital and green technologies into urban activities. The urban environment plays a crucial role in driving economic, social, and environmental transformations. Currently, a significant proportion of the population resides in urban areas, which have the capacity to generate a substantial share of the Gross Domestic Product (GDP). The digital and green transitions are essential for enhancing the functioning of urban systems. The digital transition reflects not only how emerging technologies can be implemented in

urban environments to improve operational efficiency, but also how cities can better respond to global climate challenges.

The digital and ecological transitions possess the capacity to address essential adaptation needs of cities to new global realities. For this reason, the study of these two transitions is of paramount importance, as it reveals the extent to which they are currently being implemented in urban areas and highlights the aspects that must be further developed to enhance administrative efficiency. Through their implementation, cities can become innovation hubs, optimize resource consumption, and reduce pollution levels.

The topic addressed in this study is highly significant, as both the digital and green transitions have the transformative potential to reshape the functioning of cities within a country. These transitions can improve urban infrastructure, enhance energy efficiency, and play a key role in promoting social inclusion. Furthermore, this topic is crucial for understanding how existing policies at both the European and national levels are translated into action at the urban level. The study also outlines the commonalities and disparities that currently exist among European Union member states in terms of digital and green transition efforts.

This research offers substantial theoretical and practical contributions. Its utility and relevance lie in the potential to support local administrations in designing effective public policies and in accessing European funds aimed at reducing territorial disparities. The findings of this exploratory research provide evidence-based insights that can guide strategic decision-making for sustainable urban development.

The Shift to Digital in Relation to Urban Development

The urban environment has seen significant changes in recent years as a result of globalization and digitization. Rapid data gathering and processing, digital connectivity for people, and the growth of a collaborative economy in urban areas have all been made possible by the digital age(Peratalo et al., 2022).

Technological advancements and the benefits brought by emerging technologies to individuals, companies, and the urban environment as a whole have led to their increasing use in cities to enhance infrastructure, improve communication with citizens, and streamline operational activities. In this regard, emerging technologies have presented cities with both new challenges and opportunities.Urban administrative structures often employ these digital tools to address the challenges arising from urban growth and to capitalize on the opportunities that support their development (Ajoudanian & Aboutalebi, 2025).

The concept of digital transition is not new in the academic literature (Reis et al., 2023). It has been used over time by numerous scholars across various fields. It refers to the effects resulting from the implementation of emerging technologies and digital innovations, which give rise to new structures, practices, values, and beliefs that can enhance operations within organizations or specific sectors (Hinings et al., 2018).

The digital transition at the city level is highly significant, as it enables public administrations to adopt market-driven innovations to create new products and services for

citizens, improve mobility, and optimize transportation systems. In many cases, the digital development of cities is also driven by partnerships between local governments and startup ecosystems.Urban digital transition efforts often rely on innovations developed by these startups to support long-term urban growth. Emerging technologies can be implemented in a variety of urban sectors, including healthcare, commerce, e-services, communication, transport, and social services. The implementation of these digital technologies is aimed at transforming cities into so-called ''smart cities'' (Paunov, 2019).

Over the past ten years, the idea of the "smart city" has gained popularity. Global political organizations started to express increasing interest in the creation of smart cities as a way to solve urgent problems including poverty, sustainability, and national economic development as early as 2014(Lim et al., 2019). The use of disruptive technologies in urban environments serves not only to improve the services provided to citizens and to facilitate communication processes but also to enhance the competitiveness of cities. As a result, smart cities are better positioned to attract increased investment, create more job opportunities for residents, and draw skilled labor from other regions.

All things considered, it is important to stress that a number of elements, such as technological, social, and cultural aspects, influence the digital transformation of urban settings. The technological change of companies operating in cities must be taken into account while examining the digital transition in certain places. The digital shift is made possible in large part by innovations that are applied both at the organizational and urban levels. Innovation development and application are essential in urban environments because they enable cities to more easily adjust to social, political, and technical shifts in the outside world(Mariani & Bianchi, 2023).

Given the variety and complexity of the issues that smart cities face, it is critical to acknowledge that their development is complicated (Rodionov et al., 2024). Before developing technologies are introduced in a city,a series of assessments are typically conducted to identify current issues, evaluate the required software for operational efficiency, and determine the most effective strategies for supporting digital transition. The selection of appropriate software solutions is not arbitrary but rather follows a clearly defined plan aligned with the development strategy of the respective city (Aljowder et al., 2019).

Empirical evidence from previous smart city initiatives has shown that the implementation of emerging technologies has significantly contributed to the enhancement of their digital transformation strategies. These technologies have improved market access for e-services, strengthened local infrastructure, boosted digital competencies, and diversified the mechanisms for innovation financing (Komninos et al., 2020).

In light of the aforementioned considerations, it is evident that digital transition is now regarded as a key factor in accelerating sustainable urban development. The integration of emerging technologies into urban management processes contributes to the improvement of public services, the quality of life for citizens, and the efficient allocation of local resources. Furthermore, technological innovations have the potential to strengthen the relationship between public authorities and community members.

In conclusion, the shift to digitalization should not be seen as just a technical solution. Instead, it need to be viewed as a driving force behind urban social and economic innovation.

The Role of Urbanization in Ecological Transition

Among the primary factors boosting economic activity through increased output and consumption is urbanization (Sadorsky 2013). The speeding of the urbanization process represents the greatest human social development since the 20th century. As urbanization evolves, the extending of land use in the purpose of urban construction led to significant dislocation of ecological and construction land and became an important ecological security challenge for many states(Plinere et al. 2021).

The delicate ecological environment deteriorated with the change of land development and use patterns (Naveh, 1994), posing a considerable threat to the ecological security at the national and regional levels as well as to the sustainability of the socio-ecological systems.

Urban areas serve as centers of economic development. By 2050, it is expected that over 68% of the world's population would live in urban regions, up from 55% at the present time (United Nations, 2018). Asia and Africa are predicted to account for the majority of this expansion. Since about 2000, cities around the world, and developing states in particular, have been growing at an unsustainable rate, making the urban environment more fragile. Common environmental issues municipalities must address include air pollution, waste management, contaminated rivers and waterways, effects on local flora and fauna biodiversity, habitat fragmentation, and strain on urban and peri-urban resources. Climate change is an additional challenge.

Urban settlements are multidimensional approach systems which imply social, ecological and technical aspects (Frantzeskaki et al. 2021). Within urban areas arose a conflict between residential, transport and commercial infrastructure development with potentially harmful effects at the environmental level and the creation of green urban spaces that aim to reduce and adapt to climate changes in order to maintain high living standards for the citizens(Artmann et al. 2019).

Due to their role in greenhouse gas emissions and susceptibility to its effects, cities are at the center of the climate change controversy. In addition to urbanization, local habitats are under additional stress due to regional and global climate change. Therefore, it is essential to identify the connections between urbanization, the local environmental changes that are occurring now, and the increasing climate change (Revi et al. 2014). Sustainable development goals play two key roles in what regards the regional and industrial ecosystems, namely enhancing the economic output per unit of consumed natural resources and reducing the auxiliary negative effects on the environment (Figge et al., 2017).

From the viewpoint of urban metabolism, industrial production has an important part in resource consumption. Flows of industrial energy transform raw materials into products that can be utilized (Caiado et al., 2017). In this way, it can have a decisive impact on the regional economy by enhancing prosperity through jobs and infrastructure models. An innovative approach on industrial production is the industrial energy eco-efficiency that is

capable of increasing the production output with reduced energy consumption. This new approach can be either as a form of waste prevention and recycling or as a manner of treatment (Bai et al. 2018). However, industrialization has a major impact on the environment through waste and gas emissions (Han et al., 2018).

Although industrial waste has generally delayed effects, it shows a major risk at the environmental level, which prompts novel ways of recovery and waste reduction. It is alarming that the quantity of industrial waste showed an impressive rise given to urban and industrial ecosystems in the past years (Guan et al., 2019). The stability of the ecosystem services is reflected by the ecological security. It can assure the sustainability of human aspects in what concerns life and productivity and also provide resilience to environmental changes (Hodson and Marvin, 2009). In order to achieve their design goals, eco-developments can make use of a variety of sustainable planning concepts, urban systems, and technical tools (Codispoti, 2021). Implementing low-carbon and energy-efficient technology, which minimize resident involvement, reduce emissions naturally, and don't necessitate changes to lifestyle or personal beliefs, is given priority by the recurrent design approach. It is much less certain that additional carbon reductions will be achieved by implementing bicycle lanes, urban gardens, and other on-site initiatives that may encourage or restrict environmentally friendly family practices (Wiliams et al. 2008).

Although the number of eco-developments has increased, they have primarily been implemented as singular demonstration projects because of a lack of market demand and policy drivers for more sustainable housing (Bayulken et al. 2015). The spatial scale of the developments has varied, ranging from eco-cities to small home projects. The neighbourhood scale is thought to be especially well-suited for integrating new technologies with urban planning (Newton, 2014), providing the opportunity to respond to and recreate the locality, taking advantage of economies of scale, and producing new knowledge (Fitzgerald & Lenhart, 2015).

In conclusion, growing metropolitan areas present a chance to incorporate cutting-edge technologies and high energy efficiency while also influencing environmental behavior and achieving additional carbon emission reductions. In addition to providing high-performing homes, new government policies must be more comprehensive and encourage the construction of innovative projects that enable sustainable urban living. Future housing initiatives and local plans may be more ambitious, incorporating performance standards that account for carbon-intensive household behaviors in addition to building performance. Setting measurable performance goals and mandating continuous performance evaluations appear to be crucial for encouraging developers to fulfill the design measures that were promised.

Statistical Analysis of key Digital Transition Indicators at the Level of European Union and Romania

The idea of digitalization has grown in significance in recent years on both an economic and societal level. In this regard, Romania and the European Union have made the digital transformation of urban areas a top priority.Cities are no longer perceived merely as centers of innovation and economic development, but as strategic spaces where the implementation

of new digital technologies is essential for improving infrastructure, governance, and social inclusion.

Given the significance of digitalization in urban environments, it is important to analyze the most relevant statistical indicators related to urban digital transition. These indicators help to illustrate the progress made by EU member states and to highlight the challenges some have encountered in the past few years. An initial crucial element analyzed within the framework of the digital shift in the European Union and Romania concerns the evolution of key indicators related to individuals' digital skills in 2023. One of the primary indicators in this regard refers to the rate of internet usage in both the EU and Romania. This indicator measures the proportion of individuals aged 16 to 74 who use the internet at least once a week. The highest usage rates were observed in the Netherlands (98.92%), followed by Denmark (97.47%) and Luxembourg (96.87%). In contrast, the lowest rates were recorded in Portugal (84.18%), Croatia (82.46%), and Bulgaria (79.83%). At the EU level, 90.27% of individuals used the internet at least once a week, compared to 88.05% in Romania(European Commission, 2024).

The percentage of people in the EU and Romania between the ages of 16 and 74 who have at least rudimentary digital abilities in 2023 was another significant indication that was examined.The data show that the Netherlands ranked first with 82.70% of individuals meeting this criterion, followed by Finland (81.99%) and Ireland (72.91%). The countries with the lowest shares of individuals with basic digital skills were Poland (44.3%), Bulgaria (35.52%), and Romania (27.73%), which ranked last. At the EU level, the average for this indicator was 55.56%.

Regarding the total number of ICT specialists in the European Union and Romania in 2023, the data reveal that Sweden ranked first, with ICT specialists representing 8.7% of total employment, followed by Luxembourg (8%) and Finland (7.6%). The lowest shares were recorded in Slovenia (3.8%), Romania (2.6%), and Greece (2.4%). Overall, this indicator reached an average of 4.87% of total employment across the European Union.

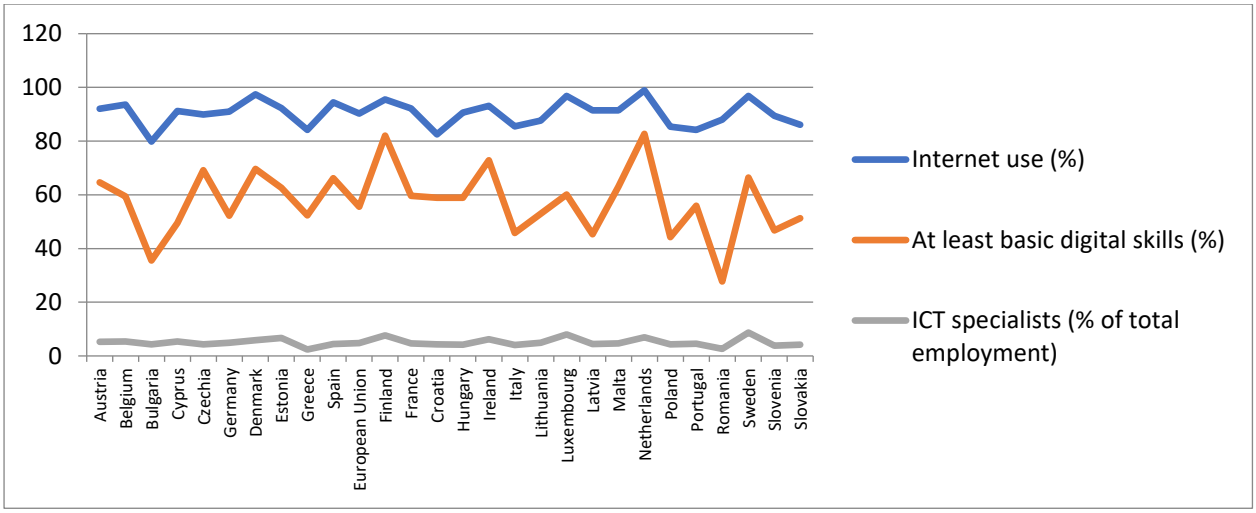

Figure 1. DESI Indicators – Digital Skills at the EU and Romania levels
Source: adaption of European Commission (2024)

The degree of digitization of public services in Romania and the European Union in 2023 is another important factor examined in this study, which is based on the degree of digitalization of human resources.

The first indicator considered in this regard is the proportion of individuals who used the internet in the past year to interact with public authorities through their official websites or mobile applications. An assessment of this indicator at the EU level revealed that the highest usage rates were recorded in Denmark (98.68% of internet users), Finland (97.61%), and Sweden (96.44%). In contrast, the lowest rates were found in Germany (62.15%), Bulgaria (35.39%), and Romania (24.64%). At the European Union level, this indicator reached a value of 75.01%.

Another analyzed indicator refers to the availability of digital public services for citizens, where each country was assigned a score ranging from 0 to 100. According to the 2023 data, Malta (score of 100), Estonia (score of 95.83), and Luxembourg (score of 94.78) had the highest scores.The European Union's average score was 79.44, with Croatia, Poland, and Romania having the lowest ratings (67.17, 63.73, and 52.18, respectively).

To further assess the digital transition in urban areas across the European Union and Romania, the analysis also included the scores obtained by each country regarding the digital public services available to businesses. This indicator refers to the extent and quality of services provided to those operating within the business environment. The highest possible score in 2023 was obtained by Finland, Ireland, and Malta (Score – 100 each). The EU average stood at 85.42. The lowest scores were registered in Hungary (Score – 74.86), Poland (Score – 72.88), and Croatia (Score – 66.18).

Another relevant indicator evaluated at both EU and national level concerns the score attributed to each country based on the availability of pre-filled forms for citizens in the online environment. The analysis shows that Malta achieved the highest score (Score – 93.97), reflecting the extensive availability of pre-filled online forms for individuals. It was followed by Lithuania (Score – 92.30) and Denmark (Score – 91.01). The EU average score for this

indicator was 70.82. The countries with the lowest scores, indicating limited access to such digital solutions, were the Czech Republic (Score – 45.09), Germany (Score – 40.81), and Romania (Score – 39.58).

Tabel 1

DESI Indicators on Public service digitalization

Countries	Proportion of people who interacted with governmental authorities online using official websites or mobile applications during the last 12 months (%)	Citizens' digital public services (Score range: 0 – 100)	Businesses'digital services (Score range: 0 – 100) (Score 0 -100)	Pre-filled forms availability (Score 0 - 100)
Austria	78.98	80.72	82.86	66.49
Belgium	85.85	82.33	91.59	75.08
Bulgaria	35.39	67.47	91.88	71.08
Cyprus	72.37	73.96	86.07	59.38
Czechia	76.68	76.33	83.75	45.09
Germany	62.15	75.83	78.58	40.81
Denmark	98.68	84.24	88.69	91.01
Estonia	94.72	95.83	98.75	88.06
Greece	79.66	75.92	86.20	79.01
Spain	83.03	84.18	91.00	80.73
European Union	**75.01**	**79.44**	**85.42**	**70.82**
Finland	97.61	90.61	100.00	87.59
France	90.81	72.09	79.31	62.78
Croatia	88.46	67.17	66.18	49.38
Hungary	82.39	73.36	74.86	71.11
Ireland	91.53	81.21	100.00	62.85
Italy	68.53	68.28	76.27	47.91
Lithuania	80.69	86.70	95.94	92.30
Luxembourg	89.43	94.78	96.67	69.63
Latvia	78.85	88.22	87.22	79.05
Malta	88	100.00	100.00	93.97
Netherlands	95.48	85.87	86.67	89.01
Poland	66.44	63.73	72.88	79.95
Portugal	80.61	81.54	81.94	79.89
Romania	**24.64**	**52.18**	**50.03**	**39.58**
Sweden	96.44	93.28	95.97	83.12
Slovenia	78.37	77.00	83.96	73.89
Slovakia	80.46	72.06	79.18	53.33

Source: Adapted from European Commission, 2024

In addition to the previously mentioned indicators, the level of user support provided by digital public services was also examined. According to the 2023 data, the highest scores were recorded in Luxembourg (Score – 100), Malta (Score – 100), and the Netherlands (Score – 99.21). At the EU level, the average score for this indicator was 86.44. The lowest rankings in terms of user support were registered in the Czech Republic (Score – 75.4), Poland (Score – 74.07), and Romania (Score – 71.16).

Another significant indicator analyzed within the digital transition framework relates to mobile device compatibility of public services offered to citizens. In 2023, Finland (Score – 100), Sweden (Score – 100), and the Netherlands (Score – 99.68) achieved the highest scores. The EU average score stood at 95.34. Countries with the lowest levels of mobile compatibility include Cyprus (Score – 89.39), Hungary (Score – 87.19), and Romania (Score – 75.96).

Access to electronic health records represents another key indicator of digitalization in public services available to the population. The highest scores in this category were observed in Belgium (Score – 100), Denmark (Score – 97.92), and Estonia (Score – 97.5). The EU average score for access to electronic health records was 79.12. Countries with the lowest scores in this regard were Slovakia (Score – 66.34), Romania (Score – 58.58), the Czech Republic (Score – 51.06), and Ireland (Score – 11.37).

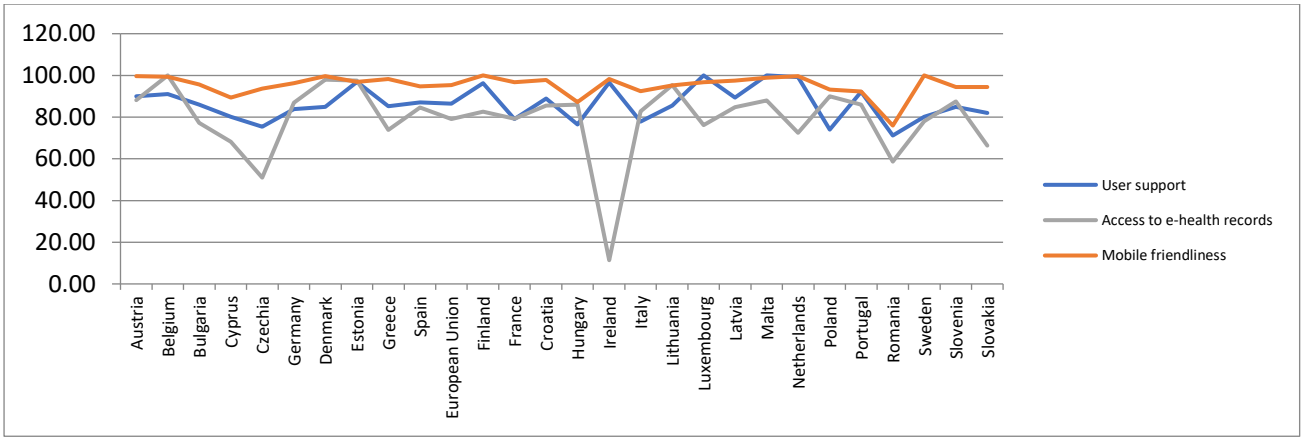

Figure 2. DESI Indicators – Digitalization of public services at the European Union level
Source: Adapted from European Commission, 2024

Digital transition as a driver of smart city development in the European Union and Romania

The urban population has experienced significant growth in recent years, which has naturally led to the expansion and development of cities. Emerging technologies have provided diverse methods to manage these demographic changes by leveraging data and digital tools. In recent years, European expenditure on smart city development has exceeded USD 19 billion. In 2020, experts in the field identified Barcelona, London, and Amsterdam as the leading cities pioneering the use of immersive new technologies for smart city development. Over time, with increasing financial investments directed toward urban areas, additional cities have emerged in this ranking and have achieved substantial growth based on digital technologies.

The European smart city Internet of Things (IoT) market was valued at USD 32.5 billion in 2020 and is projected to reach USD 90.2 billion by 2027. When analyzing the number of active IoT connections in smart cities across the EU, a steady increase is also anticipated. While there were approximately 1.01 million active connections in 2016, forecasts suggest this number will exceed 53.63 million by 2024 (Fiberroad, 2022).

According to a report by the Eden Strategy Institute, the top ten smart cities in Europe include Helsinki, which ranks second in Europe and fifth globally, recognized for its significant digitalization investments and highly skilled professionals. Barcelona ranks third in Europe,

noted for substantial investments in IT infrastructure and IoT technology adoption. Vienna ranks fourth and has previously led in vision and performance, launching one of Europe's most significant urban development schemes in 2013. Amsterdam is distinguished by its investments in IT infrastructure and successful public-private partnerships, hosting annual gatherings of companies, authorities, universities, and citizens aimed at identifying effective digital solutions to advance the city. Other notable European cities investing heavily in smart city development include Stockholm, Copenhagen, Berlin, and Dublin (Fiberroad, 2022).

The European smart city market is expected to experience accelerated growth in the coming years. By the end of 2025, revenues are projected to reach USD 16.43 billion, illustrating the market's high potential. Furthermore, studies indicate a stable annual growth rate of 10.57% between 2025 and 2029, with the market volume expected to reach USD 24.56 billion by 2029. These projections underscore the anticipated substantial investments by European cities in emerging digital technologies to enhance urban efficiency (Statista (a), 2025).

From a city-level perspective, Paris is identified as having the greatest potential to become a leading smart city, achieving a score of 76.4. It is followed by London and Amsterdam, with scores of 73.1 and 72.8, respectively. Paris and London outperform Amsterdam in terms of connectivity and infrastructure readiness, whereas Amsterdam excels in the technology labor market segment (Statista (a), 2024). A September 2024 study further highlighted Paris as having one of the best smart city infrastructures, with a score of 91.8, followed by Madrid with a score of 71.7 (Statista (a), 2024).

Digital transition in Romania's urban environment – A foundation for smart city development

Analyzing the proportion of households with access to home internet in Romania reveals that 85.7% of households had internet access in 2023, representing an increase of 3.6% compared to the previous year. Furthermore, as illustrated in the figure below, there is a notably high penetration rate within urban areas. In 2022, the percentage of internet-connected households in urban environments was 88.6%, which slightly increased to 89.8% in 2023 (Institute of National Statistics, 2023).

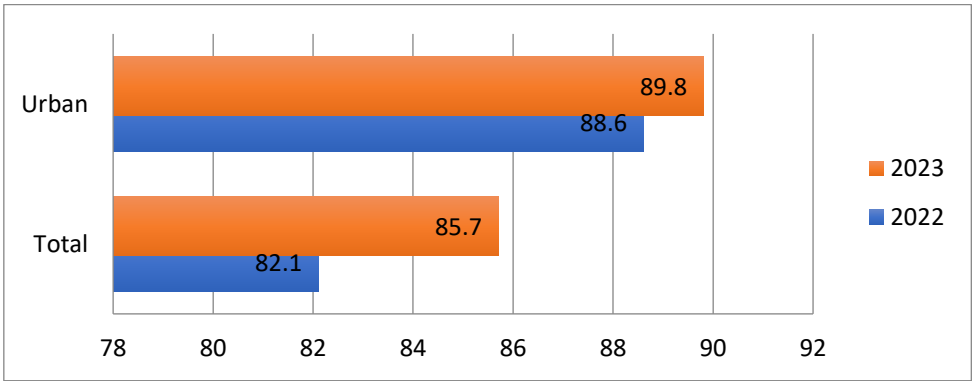

Figure 3. Percentage of Romanian urban households with Internet access (2022–2023)
Source: adaption of Institute of National Statistics (2023)

Smart cities in Romania – Challenges and perspectives of urban digital transition

In Romania, the term ''smart city'' has gained increasing prominence in recent years. A growing number of cities across the country have begun investing significant resources in

the implementation of emerging technologies, as well as in infrastructures aimed at improving urban operations. Moreover, Romania hosts a considerable number of cities distinguished by the volume of smart city projects undertaken and investments made toward building intelligent urban environments.

From a statistical perspective, by 2025 the Romanian smart city market is expected to be worth USD 179.82 million. A projected rate of compound annual growth (CAGR)of 12.56% is expected during the 2025–2029 period, which will lead to a market size of approximately USD 288.65 million by 2029. Currently, substantial investments are being made in both urban infrastructure and public service enhancements across Romania (Statista (b), 2025).

At the national level, partnerships between large corporations and mid- to large-sized cities have been key drivers of smart city development. Notable Romanian cities that have featured prominently on the international smart city map include Cluj Napoca, Târgu-Mureș, Alba Iulia, Brașov, and Oradea. The continuous investments in smart city initiatives have been reflected in the growing number and scope of projects implemented throughout the country. These projects have targeted diverse urban challenges: Cluj Napoca has emphasized digitalization of public services, sustainable urban mobility, and green infrastructure development; meanwhile, Iași and Brașov have focused on leveraging emerging technologies for efficient waste management.

In 2018, Romania reported a total of 200 smart city projects across 38 cities. By the end of 2022, this number had surged to 1,001 projects spanning 144 cities of various sizes. This significant growth illustrates a strong national commitment to digital transformation and the optimization of urban activities. Among the cities investing most actively in digitalization are Cluj Napoca and Iași. In contrast, cities in the southern and southeastern regions, such as Constanța, Ploiești, and Galați, have exhibited comparatively lower levels of investment in digital initiatives (Drăgan et al., 2024).

Of the 1,001 smart city projects implemented nationwide in 2022, these aligned with the key pillars of smart cities: smart economy, smart mobility, smart environment, smart people, smart living, and smart governance. Notably, the majority of projects were directed toward enhancing smart mobility and smart governance (Vegacomp, 2022).

Table 2
Objectives targeted in the projects

Targeted Objective	**Number of Projects**
Smart Economy	130
Smart Mobility	322
Smart Environment	59
Smart People	35
Smart Living	217
Smart Governance	238

Source: Adapted from Vegacomp, 2022

Statistical Analysis of Key Ecological Transition Indicators at the EU and Romania Level

The TPI constitutes a simple and transparent tool, sufficiently robust on the conceptual and statistical level to be the compass we urgently need. It also invites European citizens to help define Europe's transformation and by doing so, contributing to increasing our collective well-being in Europe.

Environmental transition has a different dynamic than the three other transitions, showing that most countries have not yet bent their curve towards green transition. Across the 72 countries, around 1.4 billion people live in countries where the governance level has decreased between 2011 and 2020.

The EU is a strong transition performer with progress rates (4.9%) higher than the world average (4.3%), and every European nation, aside from Hungary, has shown an improvement in performance since 2011, particularly Croatia, with an exceptional increase (13.5%), as well as Greece and Estonia (progress above 10%)

As shown in the figure, the European Union average score is 68.96 which illustrates a strong ecological transition that is above the global average of 51.54. The outputs highlight the crucial role investment in research and innovation has to support the path to recovery towards prosperous sustainability.

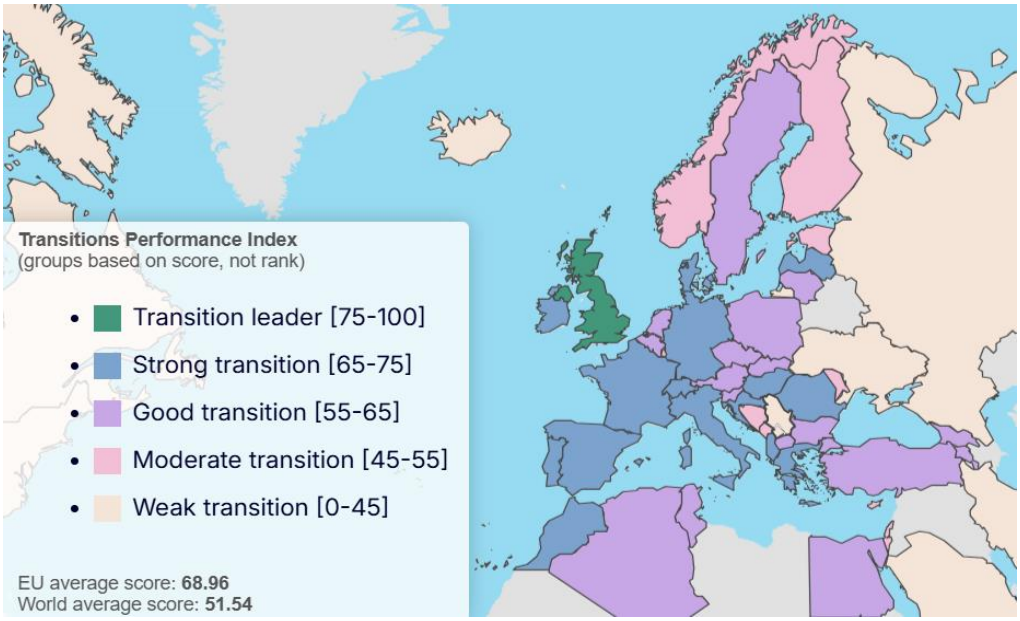

Figure 4. Ecological transition performance index (TPI) within Europe (2011-2021)
Source: European Commission (2021)

Figure 5 shows the Transition Performance Index (TPI) of Romania for the analyzed year 2021. Romania has an overall strong transition score between 65-75 which is a good score comparing to the global level. Its environmental score is 65.3 which is also strong. When it comes to the high income countries score that is 56.2 (moderate), Romania shows a strong transition with 65.3 for the environmental aspect. Comparing to the Europe and Central Asia score for the same aspect, Romania has a good ranking with a difference of 5.9 points (65.3).

When it comes to the European Union score which is 65.0 (strong) at the environmental level Romania presents an advantage of 0.3.

2020	TPI	TRANSITIONS			
		ECONOMIC	SOCIAL	ENVIRONMENTAL	GOVERNANCE
Romania ranks	**32**	**44**	**44**	**19**	**34**
Romania score	61.2	42.2	66.0	65.3	66.6
World score	51.5	45.4	59.4	53.4	47.6
High income countries score	65.6	60.6	76.6	56.2	74.1
Europe & Central Asia score	63.7	53.4	74.5	59.4	69.2
European Union score	69.0	61.1	77.5	65.0	74.0

■ Transition leader [75-100] ■ Strong transition [65-75[■ Good transition [55-65[■ Moderate transition [45-55[■ Weak transition [0-45[

Figure 5. Romanian transition performance index (TPI), 2021
Source: European Commission Country Report (2021)

Figure 6 shows the environmental transition of Romania for the year 2021. Its general ecological transition score is 65.3 which illustrates a strong transition. When it comes to the emissions reduction, Romania has a score of 75.4 making it a transition leader according to the studied index. For the aspect of biodiversity, Romania has a 73.9 score which is also a strong transition score. For the terrestrial key biodiversity areas it has a score of 76.0 which is also a transition leader score. For the freshwater key biodiversity areas the score is lower of 60.8 which shows only a good transition according to the index. When it comes to the pesticide use, Romania has the greatest score of all the analyzed aspects in the figure, of 95.9. For the material use the score is low, showing only 37.5 and the lowest being the resource productivity with a score of 17.5. For the material footprint Romania's score is 57.6 marking a good transition. For the energy productivity aspect, Romania registred a score of 74.5 which shows a strong transition.

3.	**Environmental transition**		**19**	**65.3**
3.1	EMISSIONS REDUCTION: Gross greenhouse gas emissions (tonnes per capita)	5.9	22	**75.4**
3.2	BIODIVERSITY	73.9	23	**73.9**
3.2.1	Terrestrial key biodiversity areas (KBAs) protected (%)	76.0	20	**76.0**
3.2.2	Freshwater key biodiversity areas (KBAs) protected (%)	60.8	30	**60.8**
3.2.3	Pesticide use per area of cropland (kg/ha)	0.6	7	**95.9**
3.3	MATERIAL USE	37.5	50	**37.5**
3.3.1	Resource productivity (PPP$ per kg)	1.0	63	**17.5**
3.3.2	Material footprint (tonnes per capita)	17.0	31	**57.6**
3.4	ENERGY PRODUCTIVITY: Energy productivity (PPP$ per koe)	14.9	14	**74.5**

■ Transition leader [75-100] ■ Strong transition [65-75[■ Good transition [55-65[■ Moderate transition [45-55[■ Weak transition [0-45[
Progress or decline in scores (2011-2020): ↓ below -10%, ↘ below 0%, – between 0% and 6.5%, ↗ above 6.5%, ↑ above 13%.
Note: Progress lines use automatic scaling and are based on values for indicators and scores for pillar/sub-pillar/index.
Source: European Commission, Transitions Performance Index 2021.

Figure 6. Environmental transition of Romania
Source: European Commission Country Report (2021)

Conclusions

The digital and ecological transitions play a crucial role in urban environments, contributing both to the enhancement of urban activities and to the creation of a supportive framework that enables cities to better address external climatic challenges.

Cities may now take advantage of new digital technologies like big data, cloud computing, artificial intelligence, and the Internet of Things (IoT) thanks to the digital shift, to

transform into smart ecosystems. The effective use of these technologies leads to the optimization of public services, improved mobility, and more efficient resource utilization. Conversely, the ecological transition aims to reduce the carbon footprint, conserve natural resources, and promote the development of sustainable cities.

Regular analysis of both digital and ecological transitions at the urban level facilitates understanding of how emerging technologies and sustainability can be simultaneously integrated into local policies and urban infrastructure. Furthermore, such analysis enables the identification of key objectives and the formulation of strategies necessary to achieve the initially set targets.

The digital and ecological transitions are the two strategic directions that the European Union has highlighted, and this study takes an integrated approach to them. Examining their development in recent years inside Romania and the European Union received special attention. This topic's importance stems from the fact that these two transitions were examined in comparison rather than separately. The analysis's conclusions are extremely valuable since they show how equipped Romania and the European Union are to achieve the dual transition goals. Given the crises that have impacted activities at both the EU and national levels in recent years, climatic challenges and the rapid development of emerging technologies, this study provides relevant insights essential for the development of sustainable urban models in the near future.

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