

The Role of Green Technologies and Smart City Projects (Synergy for a Sustainable Future)

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Abstract— In the context of growing global challenges related to climate change, urbanization and the need for sustainable development, green technologies and smart city projects play a decisive role in the transformation of modern societies. Their potential to reduce environmental footprints, optimize resources and improve quality of life makes them an integral part of strategies for a sustainable future. The study focuses on the interaction between green technologies and smart city projects. It aims to analyze the synergies between them, highlighting their potential and contribution to sustainable development. The following objectives have to be settled for reaching the above-mentioned goal: 1. to research the main characteristics and types of green technologies; 2. to analyze the principles and best practices of smart city projects; 3. to identify the opportunities for synergies between the two concepts in the context of sustainability; 4. to assess the environmental, economic and social benefits of the integration of these approaches; 5. to formulate recommendations for enterprises and the public sector on the implementation of green technologies in smart city systems. In the course of the study shall be justified the thesis that the integration of green technologies in smart city projects not only contributes to sustainable development, but also creates innovative platforms for effective natural resource management, pollution reduction and quality of life enhancement in urban areas. The methodology includes a comprehensive literature review, structured interview, needs analysis, gap analysis and SWOT analysis. The expected results are: clarification of the relationship between green technologies and smart city projects; assessment of successful examples of synergies between these approaches; formulation of recommendations for business and public sector to support their implementation; identification of the main challenges and barriers related to the integration of the researched innovations.

Keywords— green technologies, smart city projects, sustainable development, urban environment

I. INTRODUCTION

Green technologies are innovations and solutions focused on environmental protection, sustainable use of resources and reduction of harmful impacts on nature. They integrate the technological, environmental and economic aspects of the activity because they aim to create a sustainable future. Green technologies seek, on the one hand to reduce the environmental footprint and on the other to create a competitive advantage for the entity by enhancing its reputation and value in society. They are essential for the successful implementation of smart city projects that aim to create sustainable, environmentally, friendly and efficient urban areas. Smart city projects use technologies such as the Internet of Things, artificial intelligence, big data to improve quality of life. They support sustainable initiatives through transport optimization, energy loss reduction, pollution monitoring and smart resource management. Sustainable initiatives provide the strategic framework and guide efforts to implement green technologies and develop smart cities. They are based on policies and targets for carbon reduction, circular economy and social responsibility [1].

Green technologies, smart cities and sustainable initiatives are the “engine” of sustainable transformation. They have a strong interrelationship and brought together in a single study will reveal their roles in the context of the guiding principle of the 21st century – for Sustainable Development and the expectations, goals, transformation and role of an entire generation, businesses, non-financial sector enterprises, public sector organizations, etc.

II. MATERIALS AND METHODS

A. Theoretical framework of the issue

To achieve the set objectives, the team conducted an empirical study and performed an in-depth analysis. This

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research focuses on smart urban development in three key Bulgarian cities—Sofia, Plovdiv, and Varna—placing special emphasis on the role of green technologies and their synergy as a driver of a sustainable future. The methodology includes the application of z-transformation, SWOT analysis, AHP (Analytic Hierarchy Process), and GAP analysis to ensure a precise assessment of various aspects of smart development [2].

The study was conducted between July and November 2024 and is based on data collected through structured interviews with representatives of five main stakeholder groups: the public sector, citizens, businesses, educational institutions, and non-governmental organizations. The primary objective of the analysis is to assess the relative performance of the studied cities based on key smart development indicators, identify their strengths and weaknesses, explore opportunities and threats, and propose perspectives for future growth. The selection of Sofia, Plovdiv, and Varna is based on several significant factors. According to the European Smart Cities 4.0 platform research from 2015, Plovdiv and Varna were among the cities analyzed for smart development, whereas the previously considered Bulgarian cities—Ruse and Pleven—were excluded from the ranking that same year. Additionally, since 2020, Sofia has been featured in the prestigious IMD Smart City Index, making its inclusion in this study particularly relevant. Moreover, both Sofia and Varna are part of the European Commission (the largest network of European cities network), further highlighting their role in the broader European smart city landscape. [3]-[8]

The methodological framework of this study builds upon both established theoretical models and previous analyses and rankings in the field of smart cities. The authors adopt the concept that a smart city is one that effectively balances the development of six main dimensions: smart economy, smart mobility (transport), smart environment, smart education, smart living, and smart governance.

For the purposes of this research, 120 structured interviews were conducted in each of the three cities, with a total sample of 360 respondents. Instead of focusing solely on the absolute number of surveys, the analysis emphasizes the distribution of participants by percentage, providing a clearer perspective on the sample structure. The respondents were categorized as follows: 5.6% from the public sector (20 interviews), 19.4% citizens (70 interviews), 8.3% businesses (30 interviews), 4.2% educational institutions (15 interviews), and 4.2% non-governmental organizations (15 interviews). A combined approach was used to select participants. Specialists and experts from the public sector, businesses, educational institutions, and NGOs were chosen through purposive sampling to ensure a high level of expertise and credibility. Meanwhile, citizens were selected randomly to enhance representativeness and minimize selection bias. This approach is based on the principles of stratified sampling, which integrates expert opinions with broader public

perspectives. The selected methods ensure a balance between analytical depth and result objectivity. Structured interviews facilitated the collection of both quantitative and qualitative data, allowing for a comprehensive SWOT analysis supported by z-transformation, AHP, and GAP analysis. Respondents evaluated various aspects of smart city development using a five-point scale, where 1 represents "poor performance" and 5 indicates "excellent performance." Additionally, respondents had the opportunity to provide open-ended feedback, which was also analyzed and incorporated into the findings [9]. This study contributes to the expansion of scientific knowledge in the field of smart urban development and provides empirically grounded recommendations for the future sustainable growth of Bulgarian cities through the integration of innovation, technology, and strategic management.

III. RESULTS AND DISCUSSION

A. *The impact of green technologies*

Green technologies are related to practical problems, and needs analysis leads to real solutions. This allows us to adapt our approach to the specificities of non-financial enterprises and public sector organizations. The analysis makes the report more valuable and useful for stakeholders as it identifies real needs and opportunities for action. This analysis not only demonstrates the importance of the topic but also provides a strategic approach to the research.

We will conduct a needs analysis at the beginning of the overall study we are pursuing: ✓ *First*, to identify key needs and issues. Green technologies are diverse and widely applicable. The analysis will allow us to identify which specific needs and issues need to be addressed in the context of non-financial enterprises and public sector organizations. As a result, we will focus on the real challenges – energy efficiency, resource management, regulations, etc. ✓ *Second*, to provide a basis for strategic planning by answering two important questions – why and what will be achieved. The analysis will provide us with a clear picture of needs and gaps, which is necessary for formulating strategies and policies. This will make it easy to define concrete steps and recommendations for green technology deployment based on real needs. ✓ *Third*, support for informed decision making. Businesses and the public sector often have limited resources. The analysis will help to allocate resources efficiently to the areas with the greatest impact. This will reduce the risk of unnecessary investment and focus on the most efficient technologies. ✓ *Fourth*, assessing the potential for synergy. Green technologies and smart city projects are often treated separately. The analysis allows us to identify areas where they can work together in an inclusive and coordinated way. This will visualize how integrating different approaches can lead to better results. ✓ *Fifth*, preparing for access to finance and regulatory incentives. Many innovations in green technologies require external funding or must necessarily meet specific regulatory requirements. Analysis will reveal and demonstrate the need for investment, and thus facilitate attracting funding and/or

political support. In the process of our research we have: 1) assessed the environment and stakeholders. We have analyzed the needs of businesses and public sector organizations in relation to the challenges of sustainable development. 2) identified key areas for action. We have defined specific points where green technologies can be deployed with the greatest impact. 3) established a basis for specific recommendations [10]-[11]. The analysis will help inform practical proposals for businesses and public organizations. 4) supported the argument for the importance of green technologies. Through the analysis we have shown that these technologies are not just an innovation but a necessity for the sustainable development of society. For both non-financial sector enterprises and public sector organizations, green technologies are not just an option, but a necessity for achieving sustainable development.

Needs analysis – Enterprises of non-financial sector: 1) *Need for energy efficiency* (businesses operating in the non-financial sector (manufacturing, transport, logistics) often use significant energy resources; green technologies such as energy saving systems and renewable energy sources can reduce costs and carbon footprint); 2) *Resource optimization and waste reduction* (non-financial sector needs circular economy technologies that enable recycling and reuse of materials; sustainable management of water and raw material resources is essential); 3) *Compliance with regulatory requirements* (European directives such as CSRD and sustainability reporting requirements put pressure on enterprises to integrate green practices; green technologies facilitate meeting environmental standards); 4) *Improving corporate image and attracting customers* (consumers are becoming increasingly sensitive to sustainability. Investment in green technologies improves companies' reputation and strengthens competitiveness); 5) *Access to finance and subsidies* (many green projects are co-funded by EU or national programs. Businesses need a willingness to take advantage of such opportunities); 6) *Innovation and technological development* (non-financial sector is looking for ways to implement smart systems for resource consumption monitoring, waste management and logistics through green technologies).

Needs analysis – Organizations of public sector: 1) *Improving the quality of the urban environment* (cities and municipalities need technologies to reduce air, water and soil pollution; smart solutions such as green roofs, air quality monitoring systems and sustainable waste management are therefore essential); 2) *Resource management* (public sector needs energy efficiency technologies in public buildings, street lighting and transport; water resource management through smart water irrigation systems and loss reduction is important in the context of climate change); 3) *Integration of smart city projects* (creating "smart cities" including smart transport, energy grids and digital service management platforms; need for green technologies for electrification of public transport and deployment of electric vehicle charging stations); 4) *Environmental policies and regulations* (National and European regulations require the public sector to integrate sustainable practices into urban planning

and management; green technologies are a strategic tool for achieving carbon neutrality targets); 5) *Enhancing social sustainability* (public sector must respond to citizens' growing expectations for greener, healthier and environmentally friendly urban spaces; the need for solutions to improve mobility, access to green spaces and quality of life); 6) *Funding and international projects* (public sector has a need for technologies that allow access to European funds and programs for sustainable development).

While business seeks competitiveness and innovation, the public sector acts as a strategic planning and regulatory "driver". Their common interest creates synergies for a sustainable future.

B. Analysis of smart city projects

The theoretical study identified six key areas that form the basis of the research. Each of these areas encompasses different aspects of the development and functioning of modern cities, with an emphasis on the integration of innovative technologies, sustainable practices, and effective governance [12]-[14].

K1 (Smart Economy) – focuses on developing a competitive and sustainable economic environment through digital technologies, innovation, and entrepreneurship. It includes aspects such as business digitalization, startup development, production automation, and the use of artificial intelligence to optimize economic processes. The smart economy promotes investments in research and development, as well as the integration of sustainable business models. **K2** (Smart Mobility) – examines the efficiency of transportation systems and their environmental impact. It includes the development of eco-friendly transport solutions such as electric vehicles, intelligent transport systems (ITS), integrated public transport platforms, and sustainable urban planning. The primary focus is on enhancing citizens' mobility, reducing congestion, and optimizing logistics through data analysis and automation. **K3** (Smart Environment) – relates to environmental sustainability and the management of natural resources in urban areas. It includes the use of smart technologies for pollution monitoring, waste management, improving energy efficiency, and implementing renewable energy sources. The goal is to reduce the ecological footprint of urbanized areas and create a healthier, more sustainable urban environment. **K4** (Smart Governance) – refers to the application of modern technologies in public administration to improve efficiency, transparency, and accessibility of services for citizens. It includes the implementation of e-government solutions, big data analytics for informed decision-making, and the introduction of digital platforms for citizen engagement and interaction with institutions. **K5** (Smart Living) – this category examines aspects related to the quality of life in modern cities, including healthcare, culture, social services, and public safety. Smart living involves leveraging technology to enhance medical services (telemedicine, electronic health records), provide access to

cultural and social activities via digital platforms, and develop smart housing solutions. The ultimate goal is to create an urban environment that is comfortable, secure, and accessible to all citizens. **K6** (Smart Education) – focuses on the use of modern technologies to improve the learning process and access to knowledge. This includes the digitization of educational materials, the implementation of interactive learning platforms, the application of artificial intelligence for personalized education, and the development of distance learning solutions. Smart education fosters an innovative learning environment that adapts to the needs of students while promoting critical thinking and creative development.

By examining the six key areas that form a comprehensive model for studying the intelligent development of cities and society, the authors aim to conduct an in-depth analysis of smart cities in Bulgaria. The specified criteria provide an analytical framework that encompasses economic and technological aspects, as well as social and environmental dimensions [15]. The interaction between these spheres is crucial for building modern, sustainable, and efficient urban environments that address the challenges of the contemporary world. As stated, the data was collected through a structured interview conducted among representatives of the public sector, citizens, businesses, educational institutions, and non-governmental organizations in the cities of Sofia, Plovdiv, and Varna. The weighting of the criteria was determined through expert assessments, reflecting their relative significance in the context of smart urban development. The evaluations were derived from the responses (Table 1) of the participants in the structured interviews, ensuring that the collected data accurately represents the perspectives and expertise of key stakeholders involved in the urban development process (Fig. 1).

Fig. 1 clearly illustrates the contrasts between the cities and highlights the specific strengths and weaknesses of each urban center. Sofia dominates in economic and mobility aspects, Plovdiv stands out with its education, while Varna offers a high quality of life but faces challenges in governance. This visualization provides a valuable basis for future strategies aimed at balanced and sustainable development of smart cities in Bulgaria.

TABLE 1 INPUT DATA

Criterion	Weights	Expert evaluations		
		Sofia	Plovdiv	Varna
K1	0,15	4,78	2,33	1,56
K2	0,20	3,67	1,25	3,85
K3	0,15	1,39	2,88	2,99
K4	0,10	3,27	2,56	1,45
K5	0,25	3,87	2,75	4,05
K6	0,25	3,36	4,75	2,11
K1	0,15	4,78	2,33	1,56

(Source: authors' own research)

In our study, z-transformation plays a key role in analyzing the ratings obtained from expert evaluations of various criteria for smart urban development. By standardizing the data, we can compare the ratings of the three cities—Sofia, Plovdiv, and Varna—regardless of the differences in the scales of the evaluations. This allows for a more objective analysis and assessment of the performance of each city against the defined criteria (Table 2). The Z-transformation also helps identify anomalies or extreme values, and by standardizing the data, our study provides a more accurate and reliable basis for conclusions about the development of the smart city in Bulgaria. This approach enables us to formulate recommendations for improving management and sustainable development in urban environments. Consequently, the evaluations for each criterion were normalized and analyzed using z-transformation [16].

An important role in our study is played by the Analytic Hierarchy Process (AHP), which provides a structured and systematic framework for decision-making. Through AHP, we can establish priorities among the different aspects of smart urban development, which is essential for the formulation of sustainable and effective strategies, guiding us towards improving the different indicators.

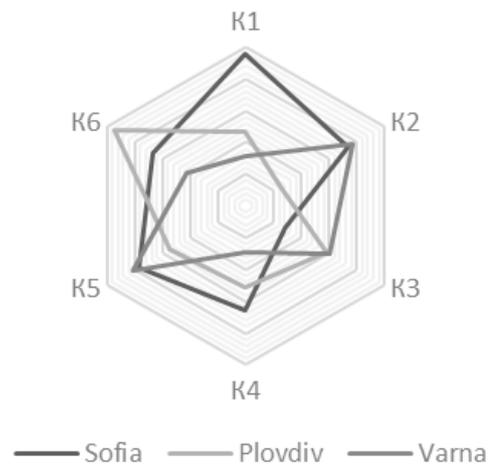


Fig. 1. Logic scheme and survey tools. (Source: authors' own research).

TABLE 2 Z-SCORES FOR THE STUDY CITIES

Criterion	Sofia	Plovdiv	Varna
K1	1,38	-0,41	-0,97
K2	0,63	-1,40	0,78
K3	-1,41	0,63	0,78
K4	1,12	0,17	-1,31
K5	0,53	-1,40	0,84
K6	-0,05	1,24	-1,20

(Source: authors' own research)

In the study, we use the AHP method to quantitatively evaluate cities according to set criteria and determine the relative importance of factors. This approach provides objectivity in the analysis of urban characteristics and identifies not only strengths and weaknesses, which helps in targeted improvements, but also indicates specific areas where targeted actions are needed. AHP is a valuable tool for informed management decisions and strategic planning.

In our study, we will use the weights previously established for each criterion to build a matrix (Table 3). This will allow us to analyze and compare the criteria related to smart urban development for more informed and effective decision-making. Furthermore, AHP allows for the integration of different perspectives and opinions in the decision-making process. By building a hierarchy and evaluating alternatives, we can ensure that the decisions made are well-founded and reflect the realities of the urban environment. The Analytic Hierarchy Process is a tool in our research that increases the reliability and validity of the results and allows us to develop more targeted and effective policies for the development of smart cities. [17]-[18]

The analysis of the normalized matrix and the priority weights, which are obtained as the average value of the rows in the normalized matrix, reveal the distribution of the relative importance of the criteria for smart urban development. The most important are the criteria K5 and K6, with priority weights of 0.227, which indicates that they play a leading role in the decision-making process. Criterion K2 also has a significant weight with a priority weight of 0.182, while K3 and K1 are of medium importance, with 0.147 and 0.134, respectively.

The lowest influence is K4 with a priority weight of 0.091, which means that its role is weaker compared to the others. These values indicate decision-making priorities and can be used to plan strategies and allocate resources.

The priority of the criteria thus determined allows us to make a more in-depth analysis of smart urban development, considering their relative importance.

TABLE 3 MATRIX FOR PAIRED COMPARISONS

Cr ite rio n	K1	K2	K3	K4	K5	K6
K1	1	0,75	1	1,50	0,60	0,60
K2	1,33	1	1,33	2	0,80	0,80
K3	1	0,75	1,5	1,5	0,60	0,60
K4	0,67	0,5	0,67	1	0,40	0,40
K5	1,67	1,25	1,64	2,5	1	1
K6	1,67	1,25	1,67	2,5	1	1
To tal	7,34	5,5	7,34	11	4,4	4,4
Normalized matrix						

Cr ite rio n	K1	K2	K3	K4	K5	K6
K1	0,136	0,136	0,204	0,055	0,136	0,136
K2	0,181	0,182	0,181	0,182	0,182	0,182
K3	0,136	0,136	0,204	0,136	0,136	0,136
K4	0,091	0,091	0,091	0,091	0,091	0,091
K5	0,227	0,227	0,227	0,227	0,227	0,227
K6	0,227	0,227	0,227	0,227	0,227	0,227

(Source: authors' own research)

Based on the determined priorities of the criteria, we calculated the SWOT index (2) - a weighted sum of z-scores with AHP weights (Table 4). It allows for a comprehensive assessment of the performance of the cities [2].

$$SWOT\ index = \sum_{n=1}^6 \omega_n Z_n \quad (2)$$

where:

ω_n are the AHP weights

Z are the Z-transformed values from the already calculated Z-scores

Table 4 presents the calculated values of the SWOT index for the three analyzed cities. Sofia shows the highest value (0.37), which suggests a better performance compared to the other cities in the context of the studied criteria. At the same time, Plovdiv and Varna have negative values (-0.20 and -0.18 respectively), which points to relatively weaker results.

TABLE 4 SWOT INDEX VALUES FOR THE ANALYZED CITIES

City	Sofia	Plovdiv	Varna
SWOT index	0,37	-0,20	-0,18

(Source: authors' own research)

For a more in-depth analysis, we proceed to the calculation of priorities based on the weights, z-scores and the results of the paired comparisons (Table 5). These priorities will allow us to understand more precisely which aspects have the greatest impact on the development of smart cities and how they differ between individual urban environments.

Table 5 presents the priorities of each city based on the SWOT analysis and the relevant criteria. Sofia has a strong economic strength (K1/S) as a main advantage, but faces serious challenges related to socio-economic inequality (K4/W) and transport problems (K2/W). Plovdiv stands out for its high quality of education (K6/S), but experiences

difficulties in terms of transport infrastructure (K2/W) and economic diversification (K1/W). Varna relies on a high quality of life (K5/S) and the potential for development of urban infrastructure (K2/O), but faces serious threats such as a lack of qualified labor (K6/T) and inefficient resource management (K4/W).

These results clearly outline the priority areas where targeted action and strategic efforts are needed to achieve sustainable and balanced development in each of the cities under review.

Table 6 presents a comprehensive analysis of the main factors influencing the development of Sofia, Plovdiv and Varna. Each of these cities has its own specific strengths and weaknesses, as well as unique opportunities and challenges that determine their potential for future development. The analysis helps to highlight even more clearly and categorically the key aspects on which efforts should be focused.

Sofia is distinguished by its developed economy and strong business environment (K1/S), as well as a well-developed transport infrastructure (K2/S), which supports its economic growth. However, the city faces significant challenges related to congestion (K2/W), leading to mobility inefficiencies, and high levels of air pollution (K3/W), impacting public health. Socio-economic inequality (K4/W) is another concern, with disparities in income and access to services.

Opportunities for improving urban transport (K2/O) and developing sustainable technologies (K3/O) can help address these issues, though economic instability remains a potential threat (K1/T).

Taking advantage of the opportunities for sustainable development and modernization of the urban environment will be key to the future of the capital as a smart and functioning city. Plovdiv relies on its cultural and historical tourism (K3/S) and high-quality education (K6/S) as its main advantages. However, the city suffers from low economic diversification (K1/W), transport problems (K2/W) and environmental challenges (K3/W). Development opportunities include promoting innovative sectors such as IT and startups (K1/O) as well as improvements in transport infrastructure (K2/O). However, the loss of young people due to lack of economic prospects (K1/T) is a serious risk that could limit the city's long-term growth. Varna, with its status as an attractive tourist destination (K3/S) and high quality of life (K5/S), has significant development potential. The city has natural and cultural assets that attract visitors and create a favorable living environment. However, the lack of economic diversification (K1/W), poor management of urban resources (K4/W) and the shortage of skilled labor (K6/W) pose significant obstacles. Development opportunities for urban infrastructure (K2/O) can help improve conditions, but the risk of environmental problems (K3/T) and the shortage of staff (K6/T) remain key challenges for Varna.

TABLE 5 PRIORITIES CALCULATED BASED ON WEIGHTS, Z-SCORES, AND PAIRED COMPARISONS

City	Priority					
	1	2	3	4	5	6
Sofia	K1/S (0,35)	K4/W (0,25)	K3/O (0,20)	K2/O (0,15)	K3/W (-0,10)	K2/W (-0,10)
Plovdiv	K6/S (0,31)	K3/T (0,09)	K4/W (0,02)	K1/W (-0,06)	K2/W (-0,28)	K5/T (-0,35)
Varna	K5/S (0,21)	K2/O (0,16)	K3/T (0,12)	K1/W (-0,15)	K4/W (-0,13)	K6/T (-0,30)

(Source: authors' own research)

TABLE 6 SWOT ANALYSIS OF CITIES BASED ON KEY CRITERIA

SWOT Category	Sofia	Plovdiv	Varna
Strengths (S)	K1: Developed economy and high concentration of businesses K2: Well-developed transport infrastructure (metro, buses, trams)	K3: Developed cultural and historical tourism K6: High-quality education.	K3: Attractive tourist destination (seaside resorts, beaches) K5: High quality of life (clean air, green spaces)
Weaknesses (W)	K2: Traffic congestion issues K3: High levels of air pollution K4: Socio-economic inequality	K1: Low economic diversification K2: Lack of an efficient transport network K3: Environmental issues K4: Migration of young people	K1: Lack of economic diversification K3: Risk of environmental problems. K4: Inefficient urban resource management K6: Lack of a qualified workforce
Opportunities (O)	K2: Improvement of public transport and infrastructure K3: Development of green technologies and sustainable energy	K1: Development of innovative sectors (IT, startups) K2: Improvement of transport infrastructure	K2: Improvement of urban infrastructure
Threats (T)	K1: Risk of economic instability	K1: Loss of young people due to a lack of economic opportunities	K3: Risk of environmental problems. K6: Lack of a qualified workforce

(Source: authors' own research)

In summary, the SWOT analysis shows that each of the three cities has unique strengths and challenges that require specific development strategies [19]. Sofia needs to address transport and environmental issues, Plovdiv needs to promote economic diversity and retain young people, and Varna needs to improve resource management and ensure

the attraction of qualified personnel. These conclusions serve as a basis for further strategic planning and prioritization of actions in the context of smart urban development.

C. Identifying sustainable initiatives

The SWOT analysis highlights the main strengths, weaknesses, opportunities and threats for each city, providing a structured understanding of their urban development landscape [20]-[22]. However, to gain a deeper insight into performance gaps and areas requiring improvement, we turn to gap analysis. [9]

Table 7 compares the performance of Sofia, Plovdiv, and Varna against target values for key criteria, using GAP values to highlight deviations and areas needing improvement. Sofia shows the smallest gaps in economic development (K1) and urban infrastructure (K2) but struggles with social equality (K4) and education (K6). Plovdiv performs well in economic growth (K1) and urban transport (K2) but faces challenges in education (K6) and environmental sustainability (K3). Varna has significant gaps in economic and transport infrastructure (K1, K2) but excels in social development (K4) and education (K6).

TABLE 7 GAP VALUES

Criterion	Target value	Sofia	Plovdiv	Varna
K1	5,0	0,22	2,67	3,44
K2	4,5	0,83	3,25	0,65
K3	4,0	2,61	1,12	1,01
K4	4,5	1,23	1,94	3,05
K5	4,5	0,63	1,75	0,45
K6	5,0	1,64	0,25	2,89

(Source: authors' own research)

The data presented in Table 8 show the need for individual strategies. Sofia should focus on improving social inclusion and education, Plovdiv should strengthen the environmental and educational sectors, and Varna needs targeted investments in economic diversification and transport infrastructure. This will help to overcome imbalances and achieve sustainable growth.

D. Synergy between all three elements

The analysis of the three cities reveals that sustainable initiatives, smart projects and green technologies are key to overcoming the challenges. Each city demonstrates specific strengths and weaknesses. In Sofia, the well-developed economy and transport infrastructure (K1/S and K2/S) create a solid foundation for the implementation of smart city solutions, such as digital traffic management and

optimization of public transport. However, serious problems with air pollution (K3/W) and socio-economic inequality (K4/W) require increased implementation of green technologies and sustainable policies aimed at energy efficiency and reducing carbon emissions. Plovdiv has strong positions in education (K6/S), but suffers from an underdeveloped transport network (K2/W) and limited economic opportunities for young people (K1/W). Investments in smart urban mobility and digitalization of services can help overcome these barriers. At the same time, the opportunity to improve infrastructure (K2/O) can be supported by introducing sustainable transport solutions, such as environmentally friendly vehicles and modernizing public transport. Varna, as a tourist destination, has a high quality of life (K5/S) and potential for developing a sustainable urban environment. However, environmental risks (K3/T) and insufficiently efficient management of urban resources (K4/W) pose threats to long-term development. The implementation of green technologies for waste management, water resources and energy efficiency can significantly improve the sustainability of the city.

The data from the GAP analysis (Table 7, Table 8) further highlight where the largest imbalances in urban development are located and which aspects require targeted action.

TABLE 8 GAP-SUPPLEMENTED SWOT ANALYSIS

SWOT Category	Sofia	Plovdiv	Varna
Strengths	Strong K1 GAP: 0,22	Higher K6 GAP: 0,25	Good K5 GAP: 0,45
Weaknesses	Bad K3 GAP: 2,61	Bad K2 GAP: 3,25	Bad K4 GAP: 3,05
Opportunities	Green policies	Investments in transport	Digital control
Threats	Bureaucratic barriers	Lack of fundin	Slow reforms

(Source: authors' own research)

In Sofia, the largest deviation is in air pollution (K3, GAP: 2.61), which requires immediate measures through green technologies. In Plovdiv, transport infrastructure remains a priority (K2, GAP: 3.25), while Varna needs to focus efforts on socio-economic inequalities (K4, GAP: 3.05).

Combining sustainability, smart technologies and green solutions offers an effective approach to solving the challenges: Sofia to focus on clean technologies and transport, Plovdiv - on digital solutions, and Varna - on eco-management, which will increase the quality of life and ensure sustainable growth.

IV. CONCLUSIONS

Sofia is distinguished by a developed economy and transport infrastructure, but faces serious problems such as congestion (K2/W), air pollution (K3/W) and socio-economic inequality (K4/W). It would be good to focus on

investing in sustainable transport and environmental technologies (K2/O, K3/O), as well as improving social policies to reduce inequalities. Plovdiv has an advantage in cultural tourism and education (K6/S), but suffers from a lack of transport efficiency (K2/W) and low economic diversification (K1/W). It is desirable to develop innovative economic sectors (K1/O) and modernize the transport network (K2/O) to attract investment and retain young people. Varna benefits from its tourism potential and good quality of life (K5/S), but experiences problems with urban resource management (K4/W) and the lack of qualified labor (K6/W). It is recommended to focus on improving the city's digital governance (K2/O) and promoting educational initiatives for staff qualification (K6/O). Overall, integrated strategies for transport, eco-innovation and economic development will help the three cities address the challenges and achieve sustainable growth.

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