African Journal of Biological Sciences

Journal homepage: http://www.afjbs.com

Research Paper   **Open Access**

Comparative Analysis of the Level of Sustainable Development of Republican Significance Cities in The Context of Kazakhstan

[1]G. K. Kenzhegulova*, [2] T. Abdykadyr, [3] A. S. Bekbossinova, and [3] Zh. Zh. Birzhanova

[1] University of International Business named after K.Sagadiyev, Almaty, Kazakhstan [2] University of Hong Kong, Hong Kong, China [3] University of International Business named after K.Sagadiyev, Almaty, Kazakhstan

[4] University of International Business named after K.Sagadiyev, Almaty, Kazakhstan

[1] gaukhar.kenzhegulov@gmail.com, [2] tabdykadyr@gmail.com, [3] assel.bekbossinova@narxoz.kz, [4] birzhanovazhanel6@gmail.com

Abstract — **Sustainable development of cities is a concept that strives to create a harmonious environment for life, ensuring economic progress and social justice. The purpose of the research was to analyze the level of sustainable development of cities of republican importance — Almaty, Astana and Shymkent — using Shannon's entropy approach. Research methodology included the process of normalization of data on economic, industrial, labor and social indicators for the three cities. Data normalization was performed by standardizing measurements to ensure comparability, considering both positive and negative values of indicators. The urbanization index for each city was derived by aggregating the normalized values of indicators, which allowed to obtain a comprehensive assessment of the level of urban development. This ensured the formation of a ranked picture of urbanization, in which each city is represented on a relative scale of urbanization from the lowest to the highest level. The findings of the study allowed highlighting key aspects that require attention to improve the sustainable development of cities. The main results of the study revealed differences in the level of sustainable development between Almaty, Astana and Shymkent cities. Almaty and Astana showed higher values of entropy, which reflects a more complex and diversified economic and social structure. Shymkent, despite its strategic position and role in the regional economy, demonstrates a lower level of urbanization, which may reflect both the presence of certain obstacles to development and the potential for further economic growth and urbanization.**
Index Terms— regional economy, Shannon entropy, smart city, sustainable development

I. INTRODUCTION

Sustainable development has deep roots, starting from ancient cultures where environmental responsibility was an integral part of religious and cultural beliefs. In the 1960s, the formation of the modern environmental movement began, significantly influencing public consciousness. Carson played a key role in shaping the concept of sustainable development, focusing on environmental aspects that subsequently laid the foundation for understanding the need to improve the quality of life through environmental practices [1], [2]. The concept of sustainable development, presented in the Brundtland

Commission report in 1987, had a significant impact on the understanding of sustainable urbanization. For the first time, a widely recognized definition of sustainable development was formulated, involving progress that meets the needs of the current generation without compromising the ability of future generations [3], [4]. These principles have become the basis for planning and developing cities in a way that they can support economic growth, social well-being, and environmental sustainability. In 2015, the UN Sustainable Development Goals were adopted, aimed at achieving more specific and measurable sustainability indicators on a global scale, establishing new standards and criteria for assessing progress in sustainable development. Urban areas, facing various development challenges, play a key role in implementing sustainable development goals [5], [6].

The goal of this research is to evaluate and improve the understanding of sustainable development within urban environments, specifically focusing on its economic dimensions. This study aims to analyze how investments in fixed assets, contributions from Gross Regional Product (GRP), and tax contributions to national funds drive sustainable urban development. These factors are critical as they directly influence the economic landscape of cities, promoting a thriving, sustainable environment that benefits current and future generations. By examining these elements, the research seeks to contribute to the broader discourse on sustainable urban planning and policy-making, ensuring that development initiatives are both economically viable and environmentally responsible.

II. BACKGROUND

Sustainable urban development is often interpreted differently, depending on the perspectives and priorities of different researchers and practitioners. Camagni [7] emphasizes that sustainable urban development is a continuous process of adaptation and learning rather than the achievement of a fixed set of outcomes. This dynamic approach allows cities to develop strategies that reflect their evolving economic, social and environmental contexts. Mensah [8] highlights that the vitality of urban ecosystems is under increasing pressure as a result of population growth and urbanization, highlighting the need for sustainable development to maintain a high quality of life. Moroke et al. [9] define sustainable urban development as a process aimed at creating a balance between different types of urban areas at different levels – regional, national and global.

Sustainable urban development is a multidimensional process, emphasizing not just the integration of social and environmental systems, but significantly focusing on the economic sustainability within urban environments. According to Tang H-T and Lee Y-M [10], the framework for economically sustainable urban development necessitates the creation of resilient economic structures that are capable of withstanding global economic fluctuations and shifts in market dynamics. This involves diversifying the urban economy through the promotion of various sectors including technology, services, and green industries, which are crucial for reducing dependency on any single industry [11], [12]. Based on the definitions of sustainable urban development provided by the authors, focusing on small and medium enterprises (SMEs), gross regional product (GRP), investment and tax contributions is key to the economic sustainability of cities.

Small and medium enterprises generate jobs and stimulate economic growth, contributing to the diversity of economic activities and increasing resilience to economic fluctuations [13]. Small and medium enterprises possess significant flexibility, allowing them to quickly adapt and implement innovative practices [14]. They make sustainable decisions such as recycling and waste reduction, as well as utilizing energy-efficient technologies, based more on internal convictions and management values than on external incentives [15]. Often focused on local markets, SMEs facilitate the circulation of capital within the city and strengthen economic self-sufficiency and resilience, which in turn enables them to have a significant impact on local economic development, stimulating innovation and entrepreneurship [16].

Thacker et al. [17] emphasize that current investments in infrastructure often focus on a narrow range of economic outcomes, frequently overlooking aspects of sustainable development. Consequently, a reorientation of investment flows towards sustainable development is necessary to secure long-term benefits and avoid adverse consequences such as environmental degradation, social inequality, and economic instability. According to Bonilla-Roth and Zapparoli [18], investments in fixed assets directly influence regional economic development by increasing Gross Regional Product (GRP). Well-developed

infrastructure enhances the economic environment, attracts additional investments, stimulates business activity, and creates new jobs, which in turn contributes to GRP growth.

Kouam and Asongu [19] noted four aspects. Firstly, a significant portion (about 40%) is directed towards financing essential infrastructure and public services. Secondly, tax policy influences business behavior and investment decisions at a level of 20%. Thirdly, tax incentives encouraging environmentally friendly practices account for another 20%, enhancing the ecological sustainability of cities. Additionally, progressive taxation, which facilitates income redistribution and reduces inequality, also constitutes 20%, contributing to social stability. There is a notable impact on the efficiency of fiscal systems, particularly in developing nations characterized by significant distortions in their tax systems often stem from inefficient tax administration, lack of clarity in tax codes, and a widespread informal economy [20]. Drobiazgiewicz [21] posits that taxes serve as a critical instrument for mitigating pollution, promoting the adoption of renewable energy sources, and fostering sustainable practices. Consequently, tax policy and systematic reforms within the taxation framework can substantially contribute not only to ecological sustainability but also enhance social and economic stability, thereby advancing the fulfillment of key Sustainable Development Goals. This makes tax contributions a central element in managing sustainable development, underscoring the need for a strategic approach to financial stability and city development, reflecting the complexity and multilevel nature of the tasks of sustainable development as described by researchers.

Economic sustainability of cities plays a vital role in reflecting the overall economic output of the region, which is crucial for planning and resource distribution, helping to assess the city's contribution to the national economy. Thus, tax payments, SMEs, investments and GRP are main factors for economic sustainability. Therefore, it is important to analyze economic sustainability of cities.

III. METHODOLOGY

The research methodology included analysis of the dynamics of the Sustainable Development Index for the cities of Republican meaning: Shymkent, Astana, and Almaty, over the period from 2010 to 2022. The analysis included following stages (Fig.1.):
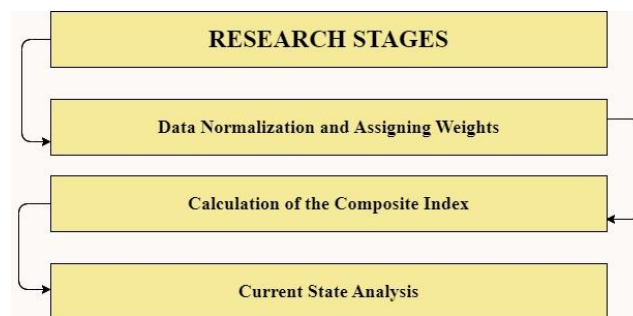

Fig. 1. Research analysis index. There are illustrated stages of analysis conducted to compare the sustainable development dynamics for three cities of republican meaning.

To normalize the data to ensure comparability Min-Max scaling method was used. After the data was normalized between 0 and 1. All indicators were assigned equal importance and equal weight 1. Therefore, the composite index for each year was calculated as the arithmetic mean of the normalized values for all five indicators according to the following Sustainability Index formula (1):

$$Sustainability\ Index\ (Year) = \frac{1}{n}\sum_{i=1}^{n} X_i$$

(1)

Where

n – the number of indicators, and

X_i – the normalized value of the i-th indicator..

IV. RESULTS

The Sustainability Index was calculated for all three cities from 2010 to 2022.

TABLE I
SUSTAINABLE DEVELOPMENT INDEX

Results	Shymkent	Astana	Almaty
Average Mean	0,064	0,755	0,787
Standard Deviation	0,084	0,064	0,075
Median	0,007	0,777	0,790
Max	0,209	0,816	0,925
Min	0,006	0,573	0,660
Range	0,203	0,243	0,264

Almaty city stands out with the highest average Sustainable Development Index among the cities considered - 0.787 (the median - 0.790). The standard deviation of 0.075 indicates some instability in the metrics, but it does not exceed that of other cities. The maximum sustainability index of 0.925 is the highest among all considered cities and may indicate a favorable year for economic and social sustainability.

The results for Astana city indicate a relatively high average Sustainable Development Index of 0.755, showing a stable economic and social status during the analyzed period. The observed standard deviation of the index is 0.064, which suggests moderate variability in annual performance. The median value, reaching 0.777, is close to the average. The maximum index value of sustainable development - 0.816, whereas the lowest sustainability performance was at 0.573.

Shymkent showed a significantly lower average Sustainable Development Index of just 0.064. A relatively high standard deviation of 0.084 reflects greater uncertainty and potential internal or external shocks affecting the city's metrics. The median approaching zero and the range up to 0.203 emphasize a wide variation in annual sustainability performance.

To sum up, Almaty and Astana have similar levels of sustainability, although Almaty's average is slightly higher. Both cities showed higher and more stable performance compared to Shymkent. Thus, the results showed that Shymkent indicated weak economic dynamics and social issues conditioned to more challenges during the analyzed period.
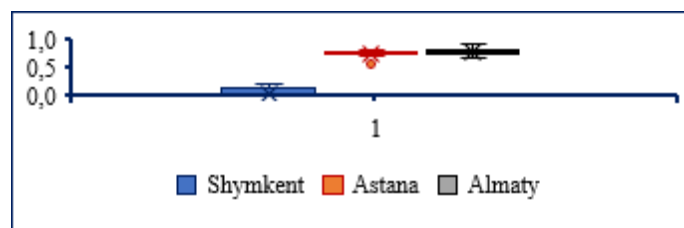

Fig. 3. Dynamics of the Sustainable Development Index for Almaty, Astana and Shymkent cities, based on the data 2009-2025

Shymkent exhibits a significantly lower median Sustainable Development Index compared to Astana and Almaty. The notable variability in the index in Shymkent indicates increased uncertainty in the sustainable development aspects of this city. The presence of outliers suggests potential individual years with extremely high or low values. Astana and Almaty displayed relatively high and stable sustainability, similar upper limit median. However, the range of fluctuations in the index in Astana is somewhat wider compared to Almaty, as slightly greater temporal variability in sustainable development in Astana.
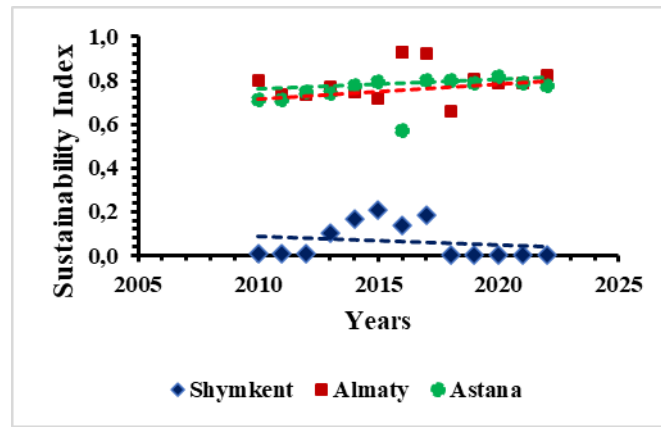
Fig. 3. Dynamics of the Sustainable Development Index for Almaty, Astana and Shymkent cities, based on the data 2009-2025

The data indicated a low level of sustainable development index for Shymkent, with a median value approaching zero and an observed increment over the considered period. The presented range of index changes demonstrated a high degree of volatility of this parameter.

The analysis of indicators for Astana and Almaty revealed significantly higher index values compared to Shymkent. Both cities exhibited sustainability close to the upper limits of the observed range of values. In the case of Astana, fluctuations in the index are noted, which may be associated with changes in economic policy or the social sphere. In the context of Almaty, a more stable state of the sustainability index is observed, which may correlate with consistent and effective urban policy.
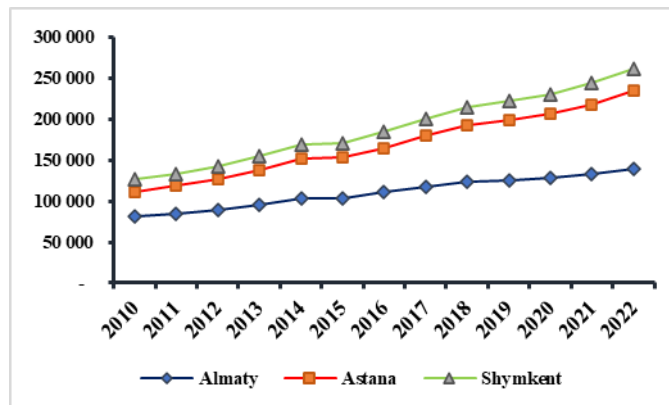

Fig. 4. The analysis of the growth in the number of Small and Medium Enterprises (SMEs) in three major cities—Almaty, Astana and Shymkent—over a twelve-year period from 2010 to 2022

Almaty, the largest city in terms of SME growth, saw its numbers rise from 81,269 in 2010 to 140,424 in 2022, indicative of robust economic development and an increasingly attractive business environment. In the capital city of Astana, the number of SMEs nearly tripled, starting at 30,492 in 2010 and expanding to 94,407 by 2022, likely benefiting from its status as the administrative center and from significant infrastructural developments. Shymkent, although growing at a slower pace compared to the other two cities, demonstrated consistent economic growth with SME numbers increasing from 14,604 to 27,004 over the same period. This growth trajectory in Shymkent underscores its emerging significance as a major urban and economic hub within Kazakhstan. Collectively, these trends not only highlight the dynamic nature of Kazakhstan's urban centers but also reflect broader regional efforts towards economic diversification and employment generation.
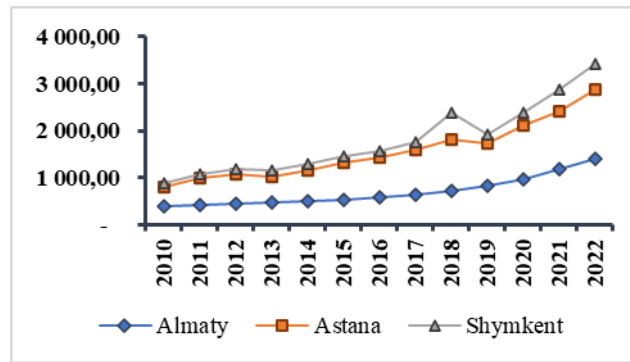
Fig. 5. Investments in fixed assets in the cities of Almaty, Astana, and Shymkent from 2010 to 2022.

In Astana, the capital, investments also significantly increased, particularly in recent years. This could be attributed to government programs aimed at infrastructure development and investment attraction, as well as active construction activities in preparation for international events and expositions.

Almaty exhibits a steady increase in investments from the initial figures in 2010, with a significant rise by 2022. This suggests the city's attractiveness for capital investment, likely due to its status as a major economic and financial hub.

Shymkent, despite having lower absolute investment figures compared to the other two cities, also shows a growth trend. The development of Shymkent as the third largest city in the country is accompanied by increased investments in industry and social sectors, supported by regional initiatives and national economic development projects.

All three cities are experiencing positive shifts in investment volumes in fixed assets, highlighting the strengthening economic positions of the cities and the improvement of the infrastructural environment.
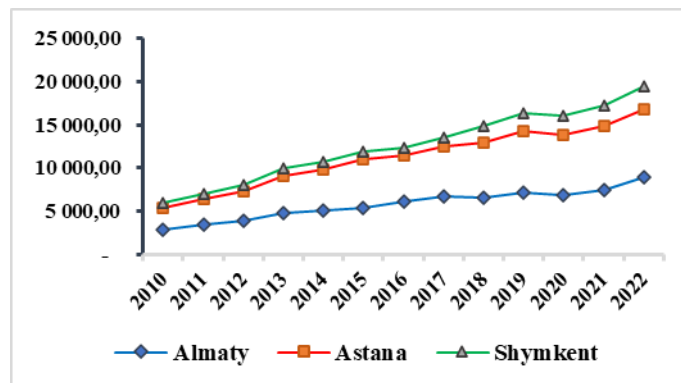

Fig. 6. Gross Regional Product (GRP) trends for Almaty, Astana, and Shymkent from 2010 to 2022.

The graph showcases an upward trend for all three cities, highlighting significant economic growth over the twelve-year period. Almaty, with the blue line, consistently leads in GRP, reflecting its status as a major commercial and financial hub in Kazakhstan. Astana, following closely, shows a marked increase, particularly after 2013, which may correlate with its role as the capital and the influx of public and private investments aimed at bolstering administrative and infrastructural capabilities. Shymkent, while starting with the lowest GRP, displays steady growth, underscoring its developing industrial base and strategic importance in the region. This growth pattern across the three cities not only illustrates their individual economic strengths but also signals the broader economic vitality and potential for future investments within Kazakhstan.

The comparison of the cities revealed disparities in sustainability levels, with two of the three cities showing significantly higher indicators. The sustainability index for Shymkent, although showing a positive trend, remains at a low level, highlighting the need for targeted strategic actions to accelerate the city's sustainability development. It is worth noting that individual outliers on the graph for Shymkent may

indicate the presence of extreme events, which should be considered in planning for sustainable development.

CONCLUSION

The research results emphasize the differences in the sustainability levels of the cities, highlighting potential need for adaptation and the development of management and policy decisions specific to each city. The analysis conducted offers significant value for planning long-term sustainable urbanization in the context of regional development. The study focuses on analyzing the level of sustainable development of the three largest cities in Kazakhstan: Almaty, Astana, and Shymkent, over the period from 2010 to 2022. The results allow for several important conclusions regarding the level of sustainable development, the dynamics of small and medium enterprises (SMEs), investment activity, and the overall regional product (GRP).

Firstly, the data showed that among the cities considered, Almaty stands out with its high level of sustainable development, confirmed by an average sustainability index close to 0.787. This city also demonstrateв stable economic and social status throughout the analyzed period.

The city of Astana, in turn, has a comparatively high average sustainability index of about 0.755 and features a stable economic and social position, with an average median value close to 0.777, indicating its stability.

However, the city of Shymkent shows a significantly lower level of the sustainability index, only 0.064. This indicates weak economic dynamics and social issues it faced during the analyzed period.

The analysis of the dynamics of the number of SMEs is also an important aspect of the study. There is a significant growth in the number of SMEs in all three cities. Almaty and Astana show a higher growth rate compared to Shymkent, reflecting their significant economic development and attractiveness for business. Investment activity is also crucial for the economic development of the cities. All three cities have seen an increase in the volumes of investments in fixed assets, indicating their strengthening economic position.

Finally, the analysis of the overall regional product demonstrates steady growth of all three cities during the analyzed period. This factor confirms the economic dynamics and potential for further investments.

REFERENCES

[1]   Hariram, N. P., Mekha, K. B., Suganthan, V., and Sudhakar, K. "Sustainalism: An integrated socio-economic-environmental model to address sustainable development and sustainability," *Sustainability*, vol. 15, no. 13, 10682, 2023. [Online]. Available: https://doi.org/10.3390/su151310682

[2]   Carson, R. *Silent spring, fortieth anniversary edition*, Boston, MA: Houghton Mifflin, 2002.

[3]   Kroll, G. "Public Understanding of Science," vol. 10, no. 4, pp. 403–420, 2001. [Online]. Available: https://doi.org/10.1088/0963-6625/10/4/304

[4]   Tomislav, K. "The concept of sustainable development: From its beginning to the contemporary issues," *Zagreb International Review of Economics & Business*, vol. 21, no. 1, pp. 67-94, 2018. [Online]. Available: https://doi.org/10.2478/zireb-2018-0005

[5]   Ruggerio, C. A. "Sustainability and sustainable development: A review of principles and definitions," *Science of the Total Environment*, vol. 786, 147481, 2021. [Online]. Available: https://doi.org/10.1016/j.scitotenv.2021.147481

[6]   Borowy, I. "The social dimension of sustainable development at the UN: From Brundtland to the SDGs," in *The Struggle for Social Sustainability*, pp. 89-108, Policy Press, 2021. [Online]. Available: https://doi.org/10.51952/9781447356127.ch005

[7]   Yu, S., Sial, M. S., Tran, D. K., Badulescu, A., Thu, P. A., and Sehleanu, M. "Adoption and implementation of sustainable development goals (SDGs) in China—Agenda 2030,"

Sustainability, vol. 12, no. 15, 6288, 2020. [Online]. Available: https://doi.org/10.3390/su12156288

[8]   Camagni, R. "Sustainable urban development: definition and reasons for a research programme," *International Journal of Environment and Pollution*, vol. 10, no. 1, pp. 6-27, 1998. [Online]. Available: https://doi.org/10.1504/IJEP.1998.002228

[9]   Mensah, J. "Sustainable development: Meaning, history, principles, pillars, and implications for human action: Literature review," *Cogent Social Sciences*, vol. 5, no. 1, 1653531, 2019. [Online]. Available: https://doi.org/10.1080/23311886.2019.1653531

[10]   Moroke, T., Schoeman, C., and Schoeman, I. "Developing a neighbourhood sustainability assessment model: An approach to sustainable urban development," Sustainable Cities and Society, vol. 48, 101433, 2019. [Online]. Available: https://doi.org/10.1016/j.scs.2019.101433

[11]   Tang, H.-T., and Lee, Y.-M. "The Making of Sustainable Urban Development: A Synthesis Framework," Sustainability, vol. 8, no. 5, 492, 2016. [Online]. Available: https://doi.org/10.3390/su8050492

[12]   Li, Q., Liu, S., Yang, M., and Xu, F. "The effects of China's sustainable development policy for resource-based cities on local industrial transformation," Resources Policy, vol. 71, 101940, 2021. [Online]. Available: https://doi.org/10.1016/j.resourpol.2020.101940

[13]   Rodrigues, M., and Franco, M. "Measuring the urban sustainable development in cities through a Composite Index: The case of Portugal," Sustainable Development, vol. 28, no. 4, pp. 507-520, 2020. [Online]. Available: https://doi.org/10.1002/sd.2005

[14]   Gherghina, Ș. C., Botezatu, M. A., Hosszu, A., and Simionescu, L. N. "Small and medium-sized enterprises (SMEs): The engine of economic growth through investments and innovation," Sustainability, vol. 12, no. 1, 347, 2020. [Online]. Available: https://doi.org/10.3390/su12010347

[15]   Loucks, E. S., Martens, M. L., and Cho, C. H. "Engaging small- and medium-sized businesses in sustainability," Sustainability Accounting, Management and Policy Journal, vol. 1, no. 2, pp. 178-200, 2010. [Online]. Available: https://doi.org/10.1108/20408021011089239

[16]   Lamoureux, S. M., Movassaghi, H., and Kasiri, N. "The Role of Government Support in SMEs' Adoption of Sustainability," IEEE Engineering Management Review, vol. 47, no. 1, pp. 110–114, 2019. [Online]. Available: https://doi.org/10.1109/EMR.2019.2898635

[17]   Westman, L., Moores, E., and Burch, S. L. "Bridging the governance divide: The role of SMEs in urban sustainability interventions," Cities, vol. 108, 102944, 2021. [Online]. Available: https://doi.org/10.1016/j.cities.2020.102944

[18]   Thacker, S., Adshead, D., Fay, M., Hallegatte, S., Harvey, M., Meller, H., ... Hall, J. W. "Infrastructure for sustainable development," Nature Sustainability, vol. 2, no. 4, pp. 324–331, 2019. [Online]. Available: https://doi.org/10.1038/s41893-019-0256-8

[19]   Kouam, J. C., and Asongu, S. A. "Effects of taxation on social innovation and implications for achieving sustainable development goals in developing countries: A literature review," International Journal of Innovation Studies, vol. 6, no. 4, pp. 259-275, 2022. [Online]. Available: https://doi.org/10.1016/j.ijis.2022.08.002

[20]   Khan, H. H., Malik, M. N., Zafar, R., Goni, F. A., Chofreh, A. G., Klemeš, J. J., and Alotaibi, Y. "Challenges for sustainable smart city development: A conceptual framework," Sustainable Development, vol. 28, no. 5, pp. 1507-1518, 2020. [Online]. Available: https://doi.org/10.1002/sd.2090

[21]   Drobiazgiewicz, J. "The importance of a participatory budget in sustainable city management," Zeszyty Naukowe Akademii Morskiej w Szczecinie, 2019. [Online]. Available: https://doi.org/10.17402/362