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Evaluating Urban Sustainability in Uzbekistan: A Novel Formula for Empirical Analysis

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Abstract: Urban sustainability has become a critical issue in the past few decades due to rising urbanisation and mounting environmental problems. This article aims to develop a novel formula for assessing urban sustainability in Uzbekistan, a country with very little recent research in the field of sustainable development. The formula was created specifically for the setting of Uzbekistan to evaluate urban sustainability by taking into account a variety of socioeconomic and environmental aspects specific to the discussed region. The article provides a thorough review of the research on urban sustainability, with an emphasis on evaluation techniques and their use in the Uzbek context, which not only contributes to the development of the theoretical framework for the research but also identifies the knowledge gaps in the assessment of urban sustainability in Uzbekistan. Utilising this newly developed formula, an empirical analysis of urban sustainability in Uzbekistan urban settings was conducted, offering comprehensive insights and suggestions for urban planning and policymaking. The results of this research are expected to advance the discussion about urban sustainability on a global scale as well as act as a catalyst for additional research in the area.

Keywords: urban sustainability; sustainable urban development; evaluation; sustainability assessment; Uzbekistan

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1. Introduction

As the world continues to experience rapid urbanisation, population increase, and escalating environmental issues, urban sustainability is becoming an increasingly important concern [1,2]. In recent years, scholars have sought to define and measure urban sustainability to better comprehend its many facets and support efficient policymaking [3,4]. The Central Asian nation of Uzbekistan, which has a substantial urban population, is no exception to this pattern [5]. There has not been any recent research on the assessment of urban sustainability in Uzbekistan, despite the country's rising understanding of the significance of this issue [6].

This research aims to fill this knowledge gap by creating and applying a new method for assessing urban sustainability in Uzbekistan. The developed formula takes into account a variety of socioeconomic and environmental elements adapted to the specific national setting. Due to the absence of research on urban sustainability in Uzbekistan, this research attempts to advance the discussion about urban sustainability on a global scale and offer valuable insights and policy recommendations for the region.

The rationale for this research is rooted in several key factors that underscore the importance of urban sustainability evaluation in Uzbekistan. First, the country's urban areas are under increasing strain due to substantial socioeconomic, infrastructure, and environmental issues brought on by rapid urbanisation [1,5]. A thorough grasp of urban sustainability is necessary to support evidence-based decision-making and better policy results with this growing concern [2,7]. Additionally, since urban sustainability is a multifaceted idea encompassing social, economic, and environmental concerns, creating an

evaluation framework specific to Uzbekistan's urban contexts is crucial. Last but not least, this research can assist Uzbekistan in harmonising its urban planning and management practices with international sustainability goals, such as the Sustainable Development Goals (SDGs) and the New Urban Agenda (NUA), given the growing global emphasis on sustainable urban development [8,9]. Uzbekistan can promote a more sustainable urban future by utilising the study's findings, improving the well-being of its residents, and fostering sustainable growth in the area.

The structure of this article is as follows: A thorough assessment of the research on urban sustainability is presented in Section 2, emphasising evaluation techniques and their use in the Uzbek setting. Part 3 discusses the procedure for gathering data and choosing samples and how the unique formula for evaluating urban sustainability was developed. Urban sustainability in Uzbekistan is empirically analysed in Section 4, while Section 5 looks at the implications of the findings and potential directions for future research.

Urban sustainability assessment has received much attention lately, with much research concentrating on creating and assessing instruments for sustainable cities. Unfortunately, urban sustainability evaluation literature primarily focuses on industrialised nations, focusing little on underdeveloped areas such as Uzbekistan. Most currently used assessment instruments were created and tested in Europe and North America and might need to be revised in the setting of Uzbekistan. This creates a sizable gap in the literature, making it challenging to analyse urban sustainability in Uzbekistan due to a lack of region-specific assessment methodologies. In addition, assessment methodologies that consider regional specifics are necessary due to Uzbekistan's particular social, economic, and environmental setting. As a result, it is necessary to create evaluation instruments tailored to the Central Asian context, specifically Uzbekistan.

2. Literature Review

2.1. Concept of Urban Sustainability

Due to its complexity and the increasing importance of ever-growing urban surroundings, urban sustainability has become a crucial topic in recent years [10]. Despite its widespread use, urban sustainability remains a controversial concept, with various scholars offering different definitions and interpretations [3,11]. To ensure the long-term viability, resilience, and well-being of urban regions, urban sustainability is widely defined as the integration of social, economic, and environmental factors [12,13].

Nowadays, with more than half of the world's population living in cities, urbanisation is a worldwide phenomenon. Significant environmental and socioeconomic problems brought on by rapid urbanisation include increasing greenhouse gas emissions, air and water pollution, biodiversity loss, and social inequality. Urban sustainability evaluation is becoming more and more crucial to addressing these issues. To make sure that the demands of the present and future generations are addressed while limiting adverse effects on the environment, urban sustainability assessment examines the social, economic, and environmental aspects of urban growth. An evaluation of urban sustainability can assist policymakers in identifying areas that need improvement and prioritising initiatives to solve these problems. Many factors, including land use, infrastructure, energy use, waste management, air quality, and water quality, go into assessing urban sustainability.

Nevertheless, the concentration of population in urban areas can result in lower per capita resource usage, which may contribute to more sustainable resource consumption. Moreover, urban areas often serve as hubs of intellectual and professional energy, fostering innovation and collaborative efforts towards sustainable development. Therefore, while the article primarily addresses the challenges of urbanization, it is important to recognize and emphasize the potential benefits and opportunities it brings. The application of the methods discussed should take into account this balanced perspective, as well as the interconnectedness of the various aspects of urbanization.

2.2. Urban Sustainability Assessment and Carrying Capacity

Environmental carrying capacity is a crucial aspect to take into account when evaluating urban sustainability. Environmental carrying capacity is the extent to which an ecosystem can sustain a certain amount of human activity without suffering material harm [14]. Many indicators can be used to measure environmental carrying capacities, such as air and water quality, land usage, and biodiversity [15].

Because urbanisation can have detrimental effects on the environment, such as pollution, deforestation, and biodiversity loss, the health and well-being of urban dwellers and the ecosystems they depend on may be seriously harmed by these adverse effects. To ensure that urban areas are sustainable over the long term, evaluating the environmental carrying capacity is crucial. Environmental carrying capacity ensures that urban development is within the limits of the environment to support human activity. Policymakers can identify areas that require improvement and prioritise interventions to address these areas. In this article, we try to incorporate some elements from the environmental carrying capacity evaluation as it addresses the environmental pillar of sustainability.

2.3. Dimensions and Challenges of Urban Sustainability

Urban communities' wellness, equity, and inclusiveness are critical considerations in social sustainability [16]. Housing, health, education, social cohesion, and cultural preservation are among a few of the many facets it covers [17]. Contrarily, economic sustainability focuses on the long-term stability and growth of urban economies, taking into account elements such as employment, income distribution, and economic resilience [18]. To preserve ecosystems and improve human health, environmental sustainability focuses on conserving and managing natural resources and reducing waste and pollution [4,19].

To achieve balanced and comprehensive urban development, all three aspects of urban sustainability must be integrated [20,21]. Over time, the idea of urban sustainability has evolved, embracing new components such as governance, technology, and innovation [3,4]. In addition, the role of social norms and culture in determining urban sustainability is becoming more widely acknowledged, highlighting the necessity of region-specific methods and solutions [13,22].

Urban sustainability is a multifaceted concept that seeks to tackle the social, economic, and environmental issues that urban areas face in a comprehensive and integrated way. While there is no commonly accepted definition [11,12], urban sustainability is usually regarded as the goal of long-term resilience, well-being, and prosperity in urban environments, with respect for context-specific elements and the interconnectedness of many characteristics in social, economic, and environmental fields.

Understanding the state of urban regions today and using that knowledge to direct future policy and planning initiatives requires a critical appraisal of urban sustainability [2]. The performance of urban sustainability has been evaluated using a variety of indicators and tools in the literature [20]. Indicator-based frameworks, composite indices, and qualitative methodologies are the three primary categories into which these approaches can be generally grouped [23,24].

Key performance indicators (KPIs) are used in indicator-based frameworks to measure many aspects of urban sustainability [2]. These metrics might be qualitative, such as with inhabitants' satisfaction with public services, or quantitative, such as with CO2 emissions or green space per person [25,26]. The selection of indicators is essential because they must be relevant, quantifiable, and responsive to the unique circumstances of the investigated urban areas [27,28].

Composite indices provide a simplified and readily conveyed assessment of urban sustainability performance by combining many variables into a single value [29]. The Global City Indicators Facility (GCIF), the European Green City Index (EGCI), and the Sustainable Development Goal (SDG) Index are a few examples of composite indexes [30,31]. Even though composite indices provide a clear and succinct picture of urban sustainability, they may oversimplify complicated problems and conceal inconsistencies across dimensions or

sub-indicators [23]. Yet, advocates of composite indices assert that two of their significant advantages are how simple and straightforward they are [32]. Although composite indices may indeed oversimplify complicated topics and conceal inequalities between dimensions or sub-indicators, they can be helpful communication tools to involve the public and politicians in concerns of urban sustainability [33]. Composite indices enable city comparisons and aid in identifying best practices and areas for improvement by combining various indicators into a single value [34]. Moreover, the limitations of composite indices can be addressed through methodological refinements and the incorporation of supplementary analyses [35]. For instance, combining composite indices with more detailed indicator-based frameworks can provide a more nuanced and comprehensive assessment of urban sustainability, balancing the strengths and weaknesses of both approaches [36].

Furthermore, as they often require the integration of diverse data sources and expertise from various fields, creating and using composite indices can encourage interdisciplinary study and cooperation [37]. In this way, composite indices might work as catalysts for improving urban sustainability theory and practice [35]. Thus, in this research, we attempt to develop a composite index.

Qualitative approaches such as case studies, interviews, and focus groups provide insights into local perspectives, experiences, and context-specific aspects that may affect urban sustainability results, which can be used in conjunction with quantitative analyses [22,38]. These techniques are beneficial for capturing urban sustainability's social and cultural aspects, which could be challenging to measure using traditional metrics [13,39].

2.4. Sustainable Development in Uzbekistan

The difficulties and opportunities associated with urban sustainability take on a particular dimension due to the unique circumstances of Uzbekistan. Uzbekistan, a nation in Central Asia that is rapidly urbanising, presents a complex range of economic, social, and environmental problems that call for specialised policies and evaluation frameworks [40].

Sustainable development in Uzbekistan has gained significant attention in recent years as the nation attempts to balance its rapid economic growth with environmental protection and social development.

During the Soviet era, Uzbekistan experienced extensive industrialization and urbanization, which has contributed to many environmental and socioeconomic challenges. The overuse of water resources, soil degradation, and poor air quality remain pressing issues, exacerbated by the rapid growth of urban centres such as Tashkent, Samarkand, and Bukhara.

In recent years, the government of Uzbekistan has taken steps to promote sustainable development, including the adoption of the 2030 Agenda for Sustainable Development, which outlines 17 Sustainable Development Goals (SDGs). This agenda has guided the country's efforts in areas such as poverty alleviation, climate change mitigation, and responsible resource consumption.

Additionally, Uzbekistan has actively sought international cooperation to support its sustainable development initiatives [40]. The country has partnered with organizations such as the United Nations Development Programme (UNDP), the World Bank, and the Asian Development Bank (ADB) to implement projects that focus on sustainable urban planning, renewable energy, and environmental protection.

Urban sustainability in Uzbekistan is highly dependent on economic growth as the nation transitions from a resource-based to a more diversified and knowledge-based economy. Infrastructure, education, and innovation spending are crucial for fostering long-term economic growth and raising living standards in urban areas [41,42]. Yet, attaining balanced and fair development is still challenging due to persistent income and resource availability differences between various regions and socioeconomic groups [6].

Since rising urbanisation and industrialisation have increased pollution, resource consumption, and the deterioration of natural ecosystems, environmental issues are also a top priority in Uzbekistan [43]. Climate change makes these issues worse, making the nation particularly susceptible to water scarcity, temperature swings, and extreme weather

occurrences [44]. The complex interdependencies between urban systems, natural resources, and global environmental processes call for integrated and flexible policies to address these environmental concerns.

In Uzbekistan, many challenges fall under the social dimension of urban sustainability, including housing, public health, safety, and social cohesion [45]. Due to the demands that rapid urbanisation has placed on housing and social infrastructure, there are frequent informal settlements and poor living conditions [6]. It is essential to ensure that all urban residents have fair access to quality housing, public services, and social opportunities to promote social sustainability and improve residents' well-being [41].

Despite these insights, the literature on urban sustainability in Uzbekistan remains scarce and fragmented, with limited empirical evidence and few evaluation frameworks tailored to the country's specific context. This research gap highlights the importance of further research to create and implement context-sensitive evaluation methods, such as the suggested formula, to enhance the understanding and practice of urban sustainability in Uzbekistan.

3. Materials and Methods

The first step in this research involved identifying the key factors affecting Uzbekistan's urban sustainability. A comprehensive literature review explored the existing knowledge on urban sustainability in the country and its specific challenges and opportunities. We conducted a systematic literature review using the PRISMA method, after which 28 papers were selected for the final analysis. The PRISMA method (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) is a widely recognized approach for conducting literature reviews, specifically in the field of social sciences. It provides a systematic and transparent framework that enables researchers to identify, appraise, and synthesise relevant studies, reducing the risk of bias and ensuring reliability of the review's findings. Based on this review, a list of potential factors was generated by tagging of the selected documents, encompassing economic, environmental, and social dimensions. Initially, 32 indicators were chosen for the analysis, followed by the exclusion of 3 indicators due to the non-availability of data.

To ensure the validity and relevance of the identified factors, a panel of experts in the field of urban sustainability was assembled, considering their diverse backgrounds, expertise, and experience in the Uzbek context. The selection criteria for the panel of experts were as follows:

1. Expertise in urban sustainability: The experts chosen had demonstrated knowledge and experience in the area of urban sustainability, including research, practice, and policymaking.
2. Experience in the Uzbek context: The experts were familiar with the unique challenges and opportunities related to urban sustainability within the Uzbekistan setting, which ensured the findings' relevance and applicability to the local context.
3. Minimum years of experience: The experts were required to have a minimum of five years of experience in the field of urban sustainability or a related area, demonstrating a depth of understanding and a track record of engagement in the field.
4. Previous involvement in relevant projects or research: The experts had previously participated in projects, research, or initiatives related to urban sustainability, showcasing their ability to contribute valuable insights to the study.
5. Recognized contributions to urban sustainability initiatives: The experts were selected based on their achievements or recognitions in the field, which could include awards, published research, or leadership roles in urban sustainability projects.

Initially, the invitation was sent out to 18 experts. However, 8 experts did not respond to the invitation. By applying these selection criteria, a diverse and knowledgeable panel of 10 experts was formed, comprising 2 government representatives, 2 representatives of international organisations (UN), 1 representative from KPMG's sustainability consulting department, 3 academics, 1 journalist specialising in ecological problems of the country, and an owner of a social-change-related business. The experts were asked to confirm the selection of the indicators. They were offered to include indicators they deemed necessary

or exclude the ones presented to them. The experts agreed to exclude one indicator: the percentage of children enrolled in primary education. This indication showed no variance throughout the years and was not believed to be relevant since extremely high enrolment in primary school was changing dramatically towards the end of the school years and the beginning of higher education.

Following agreement on the final list of indicators, they were divided into 4 groups and 1 subgroup according to their thematic connections and potential interdependencies. This categorisation sought to make it easier to analyse and explain the results later and to give the evaluation framework a more explicit structure.

The expert panel assessed the importance of each aspect in the context of urban sustainability in Uzbekistan using a Likert scale ranging from 1 (least important) to 10 (most important). This step was intended to compile the collective wisdom and insights of the experts and weigh the various elements under their perceived importance. Once the ranking was complete, the results underwent statistical analysis depicting descriptive statistics: including range (minimum and maximum values), mean, standard deviation, and variance. Then, using the results, we calculated the weights for each indicator. Applying this methodology corresponds to transforming actual averages into coefficients ranging from 0.8 to 1.2, where the worst performer obtains a score of 0.8 and the best performer a 1.2.

Once the weights were calculated, we ran the descriptive statistics on each indicator and performed a correlation analysis to ensure no high correlation between any two indicators was detected. Then we normalised the data for each indicator from 15 years using this formula:

$$x_{in}^{s} = \frac{x_{in} - x_{min}}{x_{max} - x_{min}}$$

where x_{in}^{s} is the normalised value of the stimulative variable; x_{min} is a minimum value of stimulative raw data value; x_{max} is a maximum value of stimulative raw data value; and n is the country, i—year.

Finally, based on the expert evaluations, a model incorporating all the selected indicators and their assigned weights was developed to assess urban sustainability in Uzbekistan. This formula was designed to provide a quantitative measure of urban sustainability performance, taking into account the unique challenges and opportunities faced by the country's cities.

Later, we repeated the steps mentioned above (descriptive statistics, correlation, data normalisation) with data from other countries to detect the minimum and maximum possible values in this methodology.

4. Results

Based on the most relevant papers on drivers of sustainability [25,29,46,47] and analysis of data availability, we selected 29 indicators to be included in the formula. These indicators were then grouped into four categories: environment, economy, awareness, and society, with a subgroup "gender equality and female empowerment". Gender equality and female empowerment were highlighted as a separate subgroup due to the deterioration in this field caused by barbaric social norms, discriminatory laws and regulations, and a very strong patriarchal structure of the society. The classification of the selected factors is presented in Figure 1. "Awareness" is not commonly used in sustainability assessment; however, it is believed to be an important factor in promoting sustainability as it acts as a first step in the creation of a sustainability culture. Burksiene et al. emphasise the importance of integrating sustainability into both individual and societal beliefs, values, and behaviours and suggest that culture can be a key element in fostering an understanding of sustainability and that incorporating cultural policy into social systems can shift values towards sustainable behaviour [48].

We decided to use uneven weights for each factor in accordance with studies on the methods for developing composite indices [49–51] based on the information gathered from experts in the following step of this research. The authors contacted ten experts in the area of sustainable development in Uzbekistan to evaluate the importance of each indicator. Some

experts come from academia, while others have practical experience in the field of sustainable development in Uzbekistan. Such selection was motivated by the need to gather various perspectives that result from the divergent experiences of practitioners and scientists.

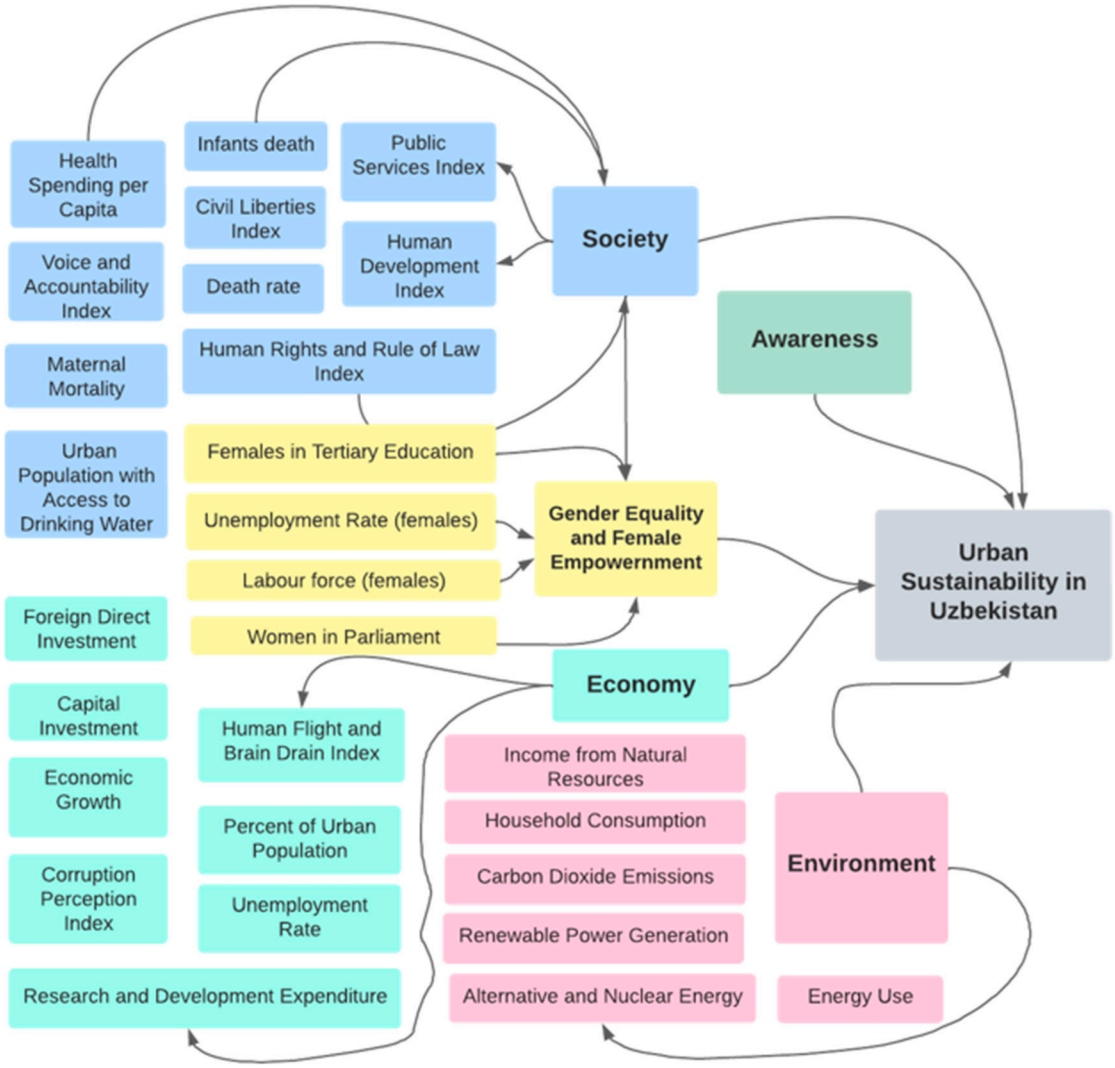

Figure 1. Indicators selected for inclusion in the formula and their classification (developed by authors).

When adjusting weights to the indicators based on the experts' evaluation, the individual indicators in each area were normalised on a 1-to-7 scale and aggregated by averaging the normalised scores so that all indicators' scores were calculated for each year [52]. In the second step, these scores were normalised again on a 0.8-to-1.2 scale. Applying this methodology corresponds to transforming actual averages into coefficients ranging from 0.8 to 1.2, where the worst performer obtains a score of 0.8 and the best performer a 1.2 [50]. Thus, we developed the following formula with adjusted weights:

$$US = f\,(0.944\,HFBDIt,\ 0.98\,PSIt,\ 1.06\,HRRLIt,\ 1\,HDIt,\ 1.08\,WPt,\ 1.04\,RWMTEt,$$

$$1.03\,PUPt,\ 1.01\,HSpCt,\ 0.9\,DRt,\ 1\,UPDWt,\ 0.97\,MMt,\ 1.04\,IDt,\ 0.95\,AEt,\ 1\,RDIt,$$

$$1.04\,CPIt,\ 0.98\,CLRIt,\ 0.96\,EpCt,\ 0.99\,CDpCt,\ 0.98\,INRt,\ 0.99\,RPGt,\ 1.02\,EGt,$$

$$1.03\,CIIt,\ 1.03\,HCt,\ 0.99\,Ut,\ 1\,UFt,\ 0.96\,LFFt,\ 0.96\,FDIt,\ 0.98\,VAIt,\ 1.05\,At)$$

where:
US—Urban sustainability;
HFBD—Human flight and brain drain index, 0 (low)–10 (high);
PSI—Public services index, 0 (high)–10 (low);
HRRLI—Human rights and the rule of law index, 0 (high)–10 (low);
HDI—Human Development Index (0–1);
WP—Women in parliament, percent;
RFM—Ratio of female to male students in tertiary level education;
PUP—Percent urban population;
HSpC—Health spending per capita;
DR—Death rate per 1000 people;
MM—Maternal mortality per 100,000 live births;
UR—Unemployment rate, percent;
ID—Infant deaths per 1000 live births;
UPADW—Percent urban population with access to drinking water;
ANE—Alternative and nuclear energy, percent of total energy use;
RDE—Research and development expenditure, percent of GDP;
CPI—Corruption Perceptions Index, 100 = no corruption;
CLI—Civil liberties index, 7 (weak)–1 (strong);
EUpC—Energy use per capita;
CDE—Carbon dioxide emissions per capita;
INR—Income from natural resources, percent of GDP;
RPG—Renewable power generation, billion-kilowatt hours;
EG—Economic growth: the rate of change of real GDP;
CI—Capital investment as a percent of GDP;
HC—Household consumption as a percent of GDP;
ERF—Unemployment rate for females;
LFF—Labour force, per cent female;
FDI—Foreign direct investment, percent of GDP;
VAI—Voice and accountability index (−2.5 weak; 2.5 strong);
A—Awareness;
t = at year t.

The data for each indicator were then normalised to be included in the calculation. A correlation analysis was performed to ascertain the statistical significance of each of the indicators mentioned above before data normalisation. No two independent variables were found to be highly linked, so no multicollinearity conundrum was encountered.

We have proposed a formula for evaluating urban sustainability in Uzbekistan. However, for the final results of such evaluations to make sense, we need to provide the maximum and the minimum possible values that would reference the actual level of urban sustainability. While some indicators already provide possible maximum and minimum values, such as Human Development Index or Corruption Perception Index, others, such as "research and development expenditure", 'economic growth', etc., do not. So, to provide such values, we needed to conduct a comparative analysis.

To obtain minimum values, we took data from Afghanistan. It is one of the countries Uzbekistan borders, and it is arguably the least developed in that region. The following reasons can additionally explain the choice of this country:

Historically, Afghanistan and Uzbekistan have a lot in common. These two states share a border and have some cultural ties [53]. Afghanistan is home to over 3.5 million ethnic Uzbeks, the second-largest Uzbek population [54]. These many Uzbeks in Afghanistan have some power to form cultural and social norms similar to the ones in Uzbekistan. While Uzbekistan was a part of the USSR, for many years, Afghanistan experienced the rise of communism and was ruled by the Communist Party, which was supported by the USSR [53]. This fact brings similarities in political background. Additionally, these two countries are very similar regarding nature reserves [55].

Once the necessary data were obtained, we calculated the value that resulted in 3, which would be our minimum reference point. Similarly, we calculated the maximum value, which resulted in 1. As the reference for maximum values, we took data on Finland because it was voted the most successful in reaching sustainability goals [56] and the second most sustainably competitive country [57]. Then, when the minimum and maximum possible values were calculated, we could proceed with the evaluation of urban sustainability in Uzbekistan. Statistical analysis of these calculations is presented in Table 1.

Table 1. Statistical results of the evaluation of urban sustainability in Uzbekistan.

Indicator	Value	Weights	Value × Weight	Normalised
Human flight and brain drain index	5.2	0.944	4.91	0.0048202
Public services index	4.6	0.98	4.34	0.00439364
Human rights and the rule of law index	7.6	1.06667	7.17	0.00652647
Human development index	0.72	1	0.68	0.00163517
Women in parliament	33	1.08571	31.15	0.02458445
Ratio of female to male students in tertiary-level education	0.83	1.04	0.78	0.00171338
Percent urban population	50.44	1.03	47.62	0.03698332
Health spending per capita	101.2	1.01	95.53	0.07307085
Death rate, per 1000 people	5.4	0.9	5.10	0.00496239
Maternal mortality per 100,000 live births	28	0.97333	26.43	0.02102973
Infant deaths per 1000 live births	19.6	1.04	18.50	0.0150578
Percent urban population with access to drinking water	86.1	1.03	81.28	0.06233559
Alternative and nuclear energy, percent of total energy use	1.6	1	1.51	0.0022608
Research and development expenditure, percent of GDP	0.12	1	0.11	0.00120861
Corruption perceptions index	28	1.04	26.43	0.02102973
Civil liberties index	6	0.98	5.66	0.00538896
Energy use per capita	1405	0.96	1326.32	1
Carbon dioxide emissions per capita	2.7	0.98667	2.55	0.00304284
Income from natural resources, percent of GDP	13.5	0.98	12.74	0.01072104
Renewable power generation, billion-kilowatt hours	6.4	0.99	6.04	0.00567334
Economic growth: the rate of change of real GDP	7.4	1.02	6.99	0.00638428
Capital investment as a percent of GDP	32.4	1.02667	30.59	0.02415789
Household consumption as a percent of GDP	62.4	1.03	58.91	0.04548621
Unemployment rate	13.3	0.98667	12.56	0.01057885
Unemployment rate for females	39.44	1	37.23	0.02916293
Labour force, percent female	2.9	0.96	2.74	0.00318503
Foreign direct investment, percent of GDP	−1.58	0.96	−1.49	0
Voice and accountability index	27.2	0.984	25.68	0.02046098
Sustainability awareness	7.16	1.048	6.76	0.00621365

Source: (developed by authors).

The normalised values in Table 1 are added up to give us 1.45206814, which can be rounded up to 1.5. Uzbekistan is in the middle of the sustainability spectrum, which ranges from 1 to 3, with 1 being the highest level of sustainability and 3 the lowest. It indicates that even while Uzbekistan has made significant strides toward attaining sustainable urban development, plenty can still be done to raise the country's ranking.

5. Discussion

Our assessment of Uzbekistan's urban sustainability provides crucial insights into the country's current sustainability situation. The extensive methodology created for this study considers several variables that impact urban sustainability and enables a deeper comprehension of the opportunities and problems Uzbekistan is now facing.

The findings suggest that Uzbekistan falls somewhere in the middle of the urban sustainability scale. This result is consistent with how the nation performed in recognised indices, such as the Global Sustainability Competitiveness Index [57] and the Sustainable Development Report Calculations [56], which also emphasise the need for additional advancements in several sustainability-related areas.

It is important to keep in mind the larger context of urban sustainability when evaluating these findings, particularly in connection to the four major categories—environment, economy, awareness, and society—as well as the subgroup of gender equality and female empowerment. By focusing on these critical areas, policymakers, urban planners, and other stakeholders can develop targeted interventions and strategies to support more sustainable urban development in Uzbekistan.

The logical step here would be to compare the findings from our research with other ones. However, a simple search on Scopus, Web of Science, or even Google results in almost no relatable content. The only article that is somewhat close to the scope of this paper is the one by Irnazarov and Kayumova [56], in which authors attempted to assess the potential for the introduction of smart city projects in six major cities of Central Asia (Almaty, Astana, Ashgabat, Bishkek, Dushanbe, and Tashkent). While the authors evaluated some sustainability factors, no overall urban sustainability assessment was performed. Apart from the article, as mentioned earlier, no relevant literature on the evaluation of urban sustainability, not only in Uzbekistan, but also in the whole of the Central Asian region, was found by the authors, which highlights the research gap in this area.

The results of this study have various ramifications for the future course of research. Our evaluation strategy, for instance, may be used to assess urban sustainability in neighbouring states, such as Tajikistan, Turkmenistan, Kazakhstan, and Kyrgyzstan, since they share similar political, cultural, and environmental backgrounds. This might contribute to improving the precision and applicability of urban sustainability assessments in the Central Asian region. Thus, future research might concentrate on comparing the findings of this study with those of other nations in the region. Such comparative assessments could assist in locating shared difficulties and ideal procedures that could guide regional policymaking and urban planning initiatives.

In the development of the method for analysing urban sustainability factors in Uzbekistan, the Uzbek context and its unique challenges were primarily taken into consideration. While this approach ensures relevance and effectiveness in addressing local concerns, it is also essential to acknowledge its potential for wider applicability and adaptability to other settings.

Although the method employed in this study was developed specifically for Uzbekistan, with the Uzbekistan context in mind, it is versatile and can be tailored to suit various urban contexts around the globe. When adapting the method for use in other countries or regions, it is crucial to consider the specific local challenges and priorities, as well as cultural, economic, and political differences. These adaptations can be made through the incorporation of locally relevant factors and the engagement of stakeholders with a deep understanding of the area's unique circumstances.

One significant advantage of employing this method in other regions is the possibility of comparison. By utilising the same method across different urban settings, a meaningful

comparison of urban sustainability factors, challenges, and solutions can be conducted. This comparative analysis can lead to the identification of patterns and trends in urban sustainability issues, facilitating the exchange of best practices and lessons learned among cities and countries.

Furthermore, the cross-regional application of this method can contribute to the development of a global understanding of urban sustainability, promoting collaboration and knowledge-sharing on an international scale. By adopting and adapting this method in various urban contexts, policymakers, practitioners, and academics can gain valuable insights into the diverse approaches to urban sustainability, ultimately fostering the implementation of more effective strategies to address the pressing global challenge of sustainable urban development.

6. Conclusions

The environmental, economic, sociological, and awareness components of sustainable development, as well as the subgroup of gender equality and female empowerment, are all taken into account using the comprehensive formula we established and are used in this study to assess urban sustainability in Uzbekistan. Our findings suggest that Uzbekistan is in the middle of the sustainability spectrum, showing growth in certain areas but also emphasising the need for additional development in others.

Policymakers, urban planners, and other stakeholders in Uzbekistan can benefit from the findings of this study by getting a more nuanced understanding of the state of urban sustainability today and the issues that must be resolved if the nation is to promote more sustainable development. The thorough method created in this study can be an effective tool for assessing urban sustainability in various nations and circumstances, adding to the expanding body of knowledge in this area.

Several areas still need more research, even though this study significantly contributes to our understanding of urban sustainability in Uzbekistan. Future studies can, for instance, concentrate on the possible influence of institutional, political, and technological elements on sustainable urban growth in Uzbekistan. It is recommended to use this methodology on separate regions in the country to indicate region-specific problems that need to be addressed first. At present, however, no data is available for such analysis. It would also be beneficial to test this methodology in other countries in the region to examine its applicability to other nations with similar backgrounds.

This study's conclusions have significant policy ramifications. Given the severe socioeconomic and environmental problems brought on by growing urbanisation, Uzbekistan should emphasise efforts to make its urban areas more sustainable. A few possible policy ideas are enhancing infrastructure development, encouraging sustainable transportation networks, and promoting eco-friendly urban design techniques. Additionally, promoting gender equality and female empowerment is believed to accelerate the pathway towards a higher sustainability level and due to improvements in social and economic spheres.

This research advances knowledge of urban sustainability in Uzbekistan and lays the groundwork for future studies and the formulation of relevant policies. Uzbekistan can work to create more sustainable urban environments that benefit all citizens and contribute to a more just, inclusive, and environmentally friendly future by addressing the major issues highlighted in this research, such as gender equality, environmental protection, and economic development.

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