

# Automated method for assessing the degree of intellectualization in the "Smart City"

Venera Garyaeva<sup>1\*</sup>, El-Maved Ahmad<sup>1</sup>, and Andrei Garyaev<sup>1</sup>

<sup>1</sup> Moscow State University of Civil Engineering; 26, Yaroslavskoe Shosse, Moscow, 129337, Russia

**Abstract.** This paper presents a developed automated system for assessing the level of intellectualisation of urban spaces, which facilitates the measurement of a city's progress towards becoming a smart city. This method allows making informed decisions about investing resources and implementing changes. Moreover, the automated assessment function allows continuous monitoring and tracking of smart city progress, identifying any regressions or inefficiencies in the system. Keywords: smart city, level of intellectualization, process management, sustainable construction, construction productivity, urban area management.

## 1 Introduction

With urban areas expanding and becoming increasingly complex, city officials are seeking sustainable and effective solutions to manage these growing environments. One promising strategy is the integration of information and communication technologies (ICT), encompassing tools like the Internet, wireless networks, computers, mobile phones, and other related technologies [1,2,4]. Collaborations between city governments and major corporations such as IBM and Cisco aim to enhance urban life at various scales, improving transportation, environmental health, economic sustainability, social well-being, and governance [1,2,4].

The "Smart City" concept leverages Information and Communication Technology (ICT) to tackle urban issues, streamline city governance, and elevate the quality of life for inhabitants. By optimizing and integrating municipal resources into a cohesive information network, these cities prioritize convenience, efficient services, safety, and fulfilling daily needs for residents [1,2,4].

Achieving urban intelligence encompasses a range of interdisciplinary elements. These include the accessibility and quality of education, the presence of scientific and research institutions, innovative and prescriptive capabilities, cultural practices, and the capacity to provide support [3, 5, 6]. The scales of city intelligence include patient records, scientific publications, university records, high-tech production, culture, education, and highly educated individuals in the region [3, 5, 6].

Studies based on official statistics from national and international organizations, social networks, and online platforms measure community participation in intellectual discussions. Automated ratings reveal the complex social, economic, and cultural dynamics of city

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\* Corresponding author: [garyaevavv@mgsu.ru](mailto:garyaevavv@mgsu.ru)

intelligence. Increasing intelligence levels in different cities can have unique consequences due to their specific characteristics and issues [3,5,6].

While automated urban intelligence assessments offer valuable insights, they should complement qualitative research and expert opinions to provide a more comprehensive understanding of urban intelligence. Integrating diverse methodologies and data sources enriches the assessment process, enabling a nuanced perspective on urban development and governance.

## 1.1 Formulation of the problem

This research centers on the automated assessment of intellectualization in "smart cities," with Al Ain in the UAE serving as the case study [7,8,9,10-12]. The primary goal is to establish a framework for evaluating the intellectualization of a "smart city," using Al Ain as a representative example [7,8,9,10-12]. The study examines several elements, including the historical context, theoretical foundations, structural components, and influencing factors of "smart cities," along with current methods used to measure their level of intellectualization [7,8,9,10-12].

Urbanization has witnessed significant growth globally over recent decades, particularly in megacities. Intellectualization emerges as a crucial approach to urban management, with the concept of a "smart city" taking center stage. The study endeavors to streamline the assessment process of a "smart city's" intellectualization level and identify pertinent indicators for such assessment [7,8,9,10-12].

Objectives of scientific work:

1. Development of a methodology for assessing the level of intellectualization in smart cities.
2. Creation of an automated assessment tool.
3. Conducting experiments and testing the methodology on real data.
4. Evaluation of the effectiveness and practical applicability of the developed method.
5. Formulating recommendations to improve the intellectualization of smart cities.

## 1.2 Evaluation of existing approaches

Currently, a wide array of cities across the globe, such as Amsterdam, Dublin, Barcelona, Madrid, Chicago, Stockholm, Glasgow, Beijing, numerous Indian metropolises, and others, have adopted smart city projects. In Russia, similar initiatives are being pursued in cities like Moscow, St. Petersburg, Kazan, Yekaterinburg, Omsk, and several additional urban centers. In the UAE, Abu Dhabi and Dubai are the main cities where smart city projects are being carried out. Although there are several definitions of smart cities, experts and government agencies often emphasize the use of technologies that gather and process data to monitor, optimize, and manage cities. Table 1 presents various interpretations of the concept of a "smart city" from different authors' perspectives.

**Table 1.** Presents various interpretations of the concept of a "Smart city".

Interpretation	Description
<b>Technocratic</b>	According to technocratic views, a smart city is characterized by the extensive implementation of advanced technologies such as Internet of Things (IoT), sensors, data analytics, and artificial intelligence (AI). These technologies are employed to optimize the management of urban infrastructure and resources, enhance efficiency, and improve overall urban living conditions. The focus is primarily on technological solutions to urban challenges.
<b>Social</b>	From a social perspective, a smart city prioritizes the well-being and satisfaction of its citizens. It aims to improve the quality of life by ensuring accessibility to essential services such as education, healthcare, transportation, and public

	amenities. This interpretation emphasizes inclusivity, equity, and social cohesion, striving to create a city where all residents can thrive and participate actively in urban life.
<b>Ecological</b>	The ecological interpretation of a smart city emphasizes sustainability and environmental stewardship. In this view, a smart city employs technologies and practices that minimize its ecological footprint and promote eco-friendly initiatives. This includes the adoption of renewable energy sources, energy-efficient infrastructure, green building standards, waste management strategies, and the preservation of natural habitats. The goal is to create a city that balances urban development with environmental conservation, ensuring a harmonious relationship between urbanization and nature.
<b>Economic</b>	Economically, a smart city is seen as a driver of innovation, economic growth, and competitiveness. It fosters a dynamic ecosystem that supports entrepreneurship, attracts investment, and stimulates job creation. Key features of an economically smart city include a thriving startup culture, a robust digital infrastructure, incentives for research and development, and partnerships between the public and private sectors. By leveraging technology and innovation, the city aims to enhance productivity, attract talent, and sustain long-term economic prosperity.
<b>Territorial</b>	From a territorial perspective, a smart city focuses on optimizing spatial planning, land use, and urban design. It utilizes technologies such as Geographic Information Systems (GIS), urban modeling, and spatial analysis to manage land resources efficiently, plan for sustainable growth, and create livable urban environments. This interpretation emphasizes the importance of urban form, connectivity, accessibility, and the quality of the built environment in shaping the spatial structure of the city.
<b>Political</b>	Politically, a smart city is viewed as a platform for effective governance, citizen engagement, and participatory decision-making. It leverages technology to enhance transparency, accountability, and responsiveness in government operations. Through digital platforms, open data initiatives, and e-participation tools, the city facilitates collaboration between government agencies, stakeholders, and citizens. This interpretation emphasizes the role of data-driven policymaking, democratic governance, and civic empowerment in shaping the future of urban governance.

As scientists from the Center for Regional Studies at the Vienna University of Technology noted in 2010, common definitions of smart cities emphasize six main areas of focus for smart city development. These areas outlined by scientists include smart environment, smart lifestyle, smart people, smart economy, smart mobility, and smart management, as shown in Table 2.

**Table 2.** Structural elements of the "smart city"

Direction	Description	Example
<b>Infrastructure</b>	Development of smart grids, water supply, and transportation systems to optimize resources and enhance mobility.	The smart traffic light management system in Singapore.
<b>Transportation</b>	Implementation of autonomous transportation and smart traffic management systems to improve efficiency and comfort.	Autonomous buses in Helsinki.
<b>Ecology</b>	Creation of sustainable cities using renewable energy sources and the development of green spaces.	The "Eco-district" project in Copenhagen.
<b>Data Management</b>	Collection and analysis of data to improve quality of life, monitor the environment, and ensure citizen safety.	The air quality monitoring system in Beijing.
<b>Digital Services</b>	Provision of urban services through digital platforms, such as e-government and smart healthcare.	The e-government portal in Estonia.
<b>Social Interaction</b>	Creating conditions for active citizen participation in city life through civic engagement platforms and smart public spaces.	The "Decide Madrid" platform in Madrid.

The idea of a "Smart City" integrates a variety of advanced technologies and systems. The primary administrative and economic benefits of implementing Smart City technology include:

1. The introduction of smart city technologies makes it possible to collect and provide information about various aspects of city life, which contributes to transparency in city management.
2. Information accessibility allows citizens to access city services, such as public transport or healthcare services, more conveniently and efficiently.
3. Through access to information about the state of infrastructure, services and resources, smart cities make the urban environment more inclusive and comfortable for all segments of the population.
4. Information accessibility helps to increase the education and awareness of citizens about various aspects of city life, which can lead to more responsible behavior and an improvement in the quality of life in the city. [1, 2].

Global perspectives on the evolution of information systems across various human activities are encapsulated in the methodologies of leading management consulting firms like IBM, McKinsey, and Microsoft. This collective expertise indicates that any initiative aimed at developing a smart city, transforming a traditional urban area into a smart one, or further enhancing an existing smart city must be accompanied by comprehensive documentation:

- Smart City Characteristics.
- Smart City Architecture.
- Assessment of Smart City Initiative Maturity.
- Evaluation of Smart City Initiative Readiness.
- Smart City Development Roadmap [1, 2].

A collaborative effort by international scholars spanning Canada, Mexico, and the United States has identified eight pivotal categories of interdisciplinary factors crucial for guiding smart city endeavors. These categories encompass:

- Political landscape.
- Economic considerations.
- Management and organizational structures.
- Information and communication technology (ICT).
- Engagement with communities and citizens.
- Physical infrastructure.
- Governance frameworks.
- Environmental aspects [3].

These categories serve as the foundational framework for smart city models, empowering city administrations to formulate and execute smart city initiatives effectively.

## **2 Materials and Methods**

### **2.1 Development of an algorithm for assessing the level of intelligence of a smart city**

The system's algorithm operates within the Microsoft Excel platform, facilitating the assessment of a city's intellectualization level using a methodology grounded in indicators proposed by the International Telecommunication Union (ITU).

Nine key indicators have been selected to measure the level of intelligence of a city, including (table 3).

**Table 3.** Nine key indicators have been selected to measure the level of intelligence of a city

Indicator	Description
Internet access in households	Percentage of households with access to the internet.
Dynamic public transport information	Availability of real-time information regarding public transport schedules and routes.
Smart electricity meters	Adoption of electricity meters with smart capabilities for monitoring and management.
Smart water meters	Utilization of water meters equipped with smart technology for efficient water management.
Subscription to wireless broadband	Number of subscriptions to wireless broadband services per capita.
Subscriptions to fixed broadband	Number of subscriptions to fixed broadband services per capita.
Urban traffic monitoring	Implementation of systems for monitoring and managing urban traffic flow.
Wireless broadband coverage	Extent of coverage provided by wireless broadband networks within the city.
Access to ICT for students	Availability of Information and Communication Technology (ICT) resources for students across education levels.

Source information was obtained from various sources, including the official website of Al Ain Municipality, the UAE Statistics website, the websites of professional organizations involved in collecting information technology data, and other open-source sources.

Compare the smartness of Al Ain City with that of Singapore City as a reference. Based on the results calculated by the system, the main focus is on the indicators that need improvement.

Based on these data, suggestions are put forward to improve the level of urban intelligence.

## 2.2 . Validation of the developed automated system using the example of El Ain, UAE

After conducting a source study, the following raw data was obtained. For the city of El Ain UAE (Table 4).

**Table 4.** Source data for Ain City, UAE

Source data for Ain City, UAE	
City name:	El Ain
City area covered by mobile services (km2):	10000
City population:	766936
Number of fixed broadband subscribers:	55000
Number of households with internet access:	60000
Number of wireless broadband subscriptions:	251631
Total number of households:	70000
Total area of the city (km2):	13100
Number of smart water meters installed:	50000
Total number of water meters installed:	200000
Total number of smart electricity meters installed:	225000
Length of main streets monitored by ICT (km):	60
Number of learners with access to ICT facilities in the classroom:	76000
Number of stops and stations with dynamic information available:	200
Total length of major streets (km):	138
Total number of installed electricity meters:	250000
Total number of learners enrolled in schools:	144000
Total number of stops and stations:	1500

Based on the data obtained, indicators are calculated (Table 5).

**Table 5.** Indicators

KPI Indicator	El Ain	Singapore
Domestic Internet Access	86.0%	90.0%
Fixed Broadband subscriptions	79.0%	93.0%
Wireless Broadband subscriptions	33.0%	55.0%
Wireless Broadband coverage	76.0%	99.0%
Smart Water meters	25.0%	21.5%
Smart Electricity meters	90.0%	20.3%
Public Transport Dynamic Information	13.0%	90.0%
Traffic Monitoring	43.0%	85.0%
Student Access to ICT	53.0%	98.0%

After analysing the indicators obtained, an overall assessment of the level of intelligence for both cities was calculated, which was 55% for the city of El Ain and 72% for the city of Singapore.

### 2.3 Recommendations for the application of the automated assessment of the level of intellectualisation of the city

Based on the difference found in the indicator values, the following recommendations can be made to increase the smart city indicators for the city of El Ain:

1. indicator (Domestic Internet access in the city), it is necessary to increase the number of Internet connections
- 2) Indicator (Fixed Broadband Subscriptions) need to develop a wider range of Internet access tariffs
3. Indicator (Wireless Broadband Subscriptions) Need to upgrade existing Internet infrastructure to improve speed of Internet access.
4. indicator (Wireless Broadband Coverage) increase the number of cellular base stations supporting high speed access protocols.
- 5.Indicator (Dynamic Public Transport Information) It is necessary to allocate a unit dedicated to the implementation of dynamic public transport information in the city infrastructure of El Ain.
- 6.Indicator (Urban Traffic Monitoring) The existing traffic monitoring equipment should be upgraded.
- 7.Indicator (Student access to ICT) Municipal funds are needed to procure e-learning tools for individual learning by educational institutions.

## 3 Results and Discussion

The automated system for assessing the intelligence of smart cities is based on the methodology recommended by the International Telecommunication Union (ITU). The scientific novelty of the study lies in the improvement of the ITU method, which allows the automated assessment of smart cities to be applied to a wider range of assessment parameters. In addition, this system can determine development directions for improvement and formulate development recommendations in order to increase the intellectualization of urban formations.

The introduction of an automated intelligence assessment system in smart cities provides a number of advantages:

- Objective assessment of the level of intellectualization of urban infrastructure based on the collected data.
- Effective monitoring of various aspects of the functioning of a smart city, which ensures a prompt response to problem areas.
- Optimizing the use of city resources such as energy and traffic flows to reduce costs and increase efficiency.
- Fostering innovation in information technology and data analytics to support the development of smart cities and economic growth.

The developed automated system for assessing the level of intellectualization of a city can be deployed on any personal computer with Microsoft Office Excel support.

The system has a number of advantages:

- Accessibility for a wide range of users.
- Low costs without the need to purchase specialized software.
- Easy to use thanks to an intuitive interface.
- Flexibility of customization to suit the needs of a specific city.
- Easy integration with other systems and the ability to export data.

Further development of the system is planned in addition to the development of applications for personal computers (Windows, Mac OS, Linux), the creation of a mobile application for platforms (Android, iOS) and cloud services. The scope of the system will also be expanded to include areas such as ecology, society and culture.

After testing the system in real conditions, it is planned to create a commercial platform based on it.

## 4 Conclusions

Research indicates that transforming cities into smarter urban centers is a multifaceted and interdisciplinary endeavor that involves evaluating numerous influencing factors.

It's crucial to recognize that enhancing urban intelligence is a long-term initiative, necessitating the collaboration and backing of government entities, businesses, community leaders, and the general public. Moreover, when devising and executing strategies to boost smartness, it is essential to consider the unique characteristics and requirements of each city and its inhabitants.

Furthermore, it is vital to continually measure the intelligence level through suitable metrics and data sources to monitor the progress and effectiveness of the implemented strategies and make necessary adjustments.

Further prospects of the research in the field of automated assessment of intelligence levels in smart cities can be directed towards several key aspects.

Firstly, expanding the assessment methodology may involve incorporating new technologies, changes in urban infrastructure, and advancements in data analytics to create a more comprehensive and accurate picture of intelligence levels in urban environments.

Secondly, enhancing the assessment tool for automation may involve the application of more sophisticated machine learning methods or optimization algorithms to improve its accuracy and efficiency.

Thirdly, applying the developed methodology and tool in various urban settings and contexts can help determine their universality and adaptability to different conditions.

Furthermore, integrating the assessment method with other management and monitoring systems in smart cities can enhance their functionality and effectiveness. Exploring the impact of intelligence levels on various aspects of urban life, such as the economy, social relationships, and the environment, also represents an important direction for further research. Thus, further investigations in this field may encompass a wide range of topics and include both technical and social aspects of smart cities.

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