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## DEVELOPING AN APPROACH TO MEASURE SMARTNESS AND SUSTAINABILITY OF UKRAINIAN CITIES

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### Pozdniakova A. M. Developing an Approach to Measure Smartness and Sustainability of Ukrainian Cities

The article is aimed to review international and national frameworks which measure smartness and sustainability of cities in order to suggest an approach for measuring smartness and sustainability of Ukrainian cities. In research we have considered several definitions of Smart Sustainable cities (SSC) and components included by different scholars. Based on the selected international indexes we have created a comparison table of components grouped within 4 dimensions: Smart People, Smart Economy, Smart Environment, representing triple bottom line and Smart Governance along with ICTs as a supporting tool. For Ukrainian cities framework we have outlined two stages and several dimensions within each of the stages: a) creating conditions for concept building; b) actual measurement of the sustainability and smartness of cities. The further research should contribute to actual Smart city index establishment that will serve as a comparison and benchmark tool on the national level.

**Keywords:** Smart sustainable city, digitalization, ICTs, innovations, triple bottom line.

**Fig.:** 5. **Tbl.:** 2. **Bibl.:** 23.

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### Позднякова А. М. Розробка підходу до вимірювання «розумності» та сталості українських міст

Стаття ставить за мету розглянути міжнародні та національні моделі для оцінки «розумності» та сталості міст і розробити підхід до оцінки в цьому аспекті українських міст. Розглянуто ряд визначень для «розумних сталих міст» (РСМ) та їх компонентів, що пропонуються різними школами. Грунтуючись на методологіях обраних міжнародних індексів, створено таблицю для порівняння компонентів, що були перегруповані за чотирма складовими: Розумні люди, Розумна економіка, Розумна екологія, Розумне урядування та ІКТ як підтримуючий механізм. Для моделі в українських містах виділено дві стадії із кількома складовими: а) створення умов для розбудови концепції РСМ; б) безпосереднє вимірювання сталості та «розумності» міст. Подальше дослідження має сконцентруватися на розробці індексу Розумних Сталих Міст, який дозволить порівнювати міста та їх прогрес на національному рівні.

**Ключові слова:** «розумне» стале місто, діджиталізація, ІКТ, інновації, модель потрійного критерію.

**Рис.:** 5. **Табл.:** 2. **Бібл.:** 23.

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### Позднякова А. М. Разработка подхода для измерения разумности и устойчивости украинских городов

Целью статьи является рассмотрение существующих международных и национальных моделей для оценки «разумности» и устойчивости городов, а также разработка подхода к оценке в этом аспекте украинских городов. Рассмотрен ряд определенных «умных» устойчивых городов (УУГ) и их компоненты, которые предлагаются разными школами. Используя методологии выбранных международных индексов, создана таблица для сравнения компонентов, которые были сгруппированы по четырем направлениям: Умные люди, Умная экономика, Умная экология, Умное управление и ИКТ в качестве поддерживающего механизма. Для создания модели в украинских городах выделено две стадии с рядом составляющих: а) создание условий для развития концепции УУГ; б) непосредственное измерение устойчивости и «разумности» городов. Последующие исследования должны сконцентрироваться на разработке индекса Умных Устойчивых Городов, который позволит сравнивать города и их прогресс на национальном уровне.

**Ключевые слова:** «умный» устойчивый город, диджитализация, ИКТ, инновации, модель тройного критерия.

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The concept of Smart Sustainable Cities (SSC) has been actively spreading around the globe since the late 90s, making more and more cities think about their contribution to building a better future for the coming generations. Urbanization and fast growth of technology as well as a number of pressing urban challenges (pollution, congestion, ageing of population in some countries along with the high birth rates in others, etc.) contribute to the concept development.

According to McKinsey&Company, smart cities that use new technologies and data in their decision-making processes managed to reduce the crime incidents rate by 30–40%, decrease water consumption by 20–30%, and accelerate emergency response times by 20–35% [1].

It is worth mentioning that at present there is no commonly accepted definition for Smart Sustainable City or universal framework to measure the progress of the cities and their success. However, the concept is being actively discussed and developed in both the academic and private sector. Such institutions as IESE, European Commission, ITU, OECD, UN-Habitat and business sector actors, including Ericsson, Huawei, Microsoft, developed their own definitions and methodologies. While the international experience of such cities as London, Stockholm, Vienna demonstrates successful examples, Ukrainian cities can follow them reaping the benefits.

According to IHS Technology, by 2025 there will be at least 88 smart cities worldwide [2]. They define smart cities as “cities that have deployed – or are currently piloting – the integration of information, communications, and technology (ICT) solutions across three or more different functional areas of a city (mobile and transport, energy and sustainability, physical infrastructure, governance, safety, and security) [2].

Digital Agenda of Ukraine-2020 identifies the concept of Smart City as a model of a city based on full-scale use of digital technologies to solve current issues of the city, ensure its sustainable development, and improve the quality of life of its citizens [3].

Presently, the definition of a smart sustainable city suggested by the ITU (International Telecommunication Union) is considered to be one of the most comprehensive. It states that “a smart sustainable city is an innovative city that uses ICTs and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social and environmental aspects.” Six factors are considered crucial for building and developing smart sustainable cities: smart living, smart people, smart environment and sustainability, smart governance, smart mobility, and smart economy [4].

Based on the research conducted, we have identified several components that are mixed in various combinations to receive Smart Sustainable City Framework (Fig. 1).

All of them can be roughly grouped in four dimensions: Smart People, Smart Economy, Smart Environment, representing so-called triple bottom line and Smart Governance (Fig. 2), with ICTs serving as a supporting tool.

Most studies specify quite similar instruments required to build smart cities: ICTs, open data, innovations, citizen engagement, partnership, and Internet of Things.

The article *aims* to review different international and national frameworks used to measure smartness and sustainability of cities in order to develop a model for Ukrainian cities taking into account our national peculiarities. To achieve the aim, we apply the methods of theoretical, logical and systematic analysis of literature (index methodologies, reviews, plans and strategies) along with the methods of comparative analysis and generalization. Fig. 3 illustrates our research plan.

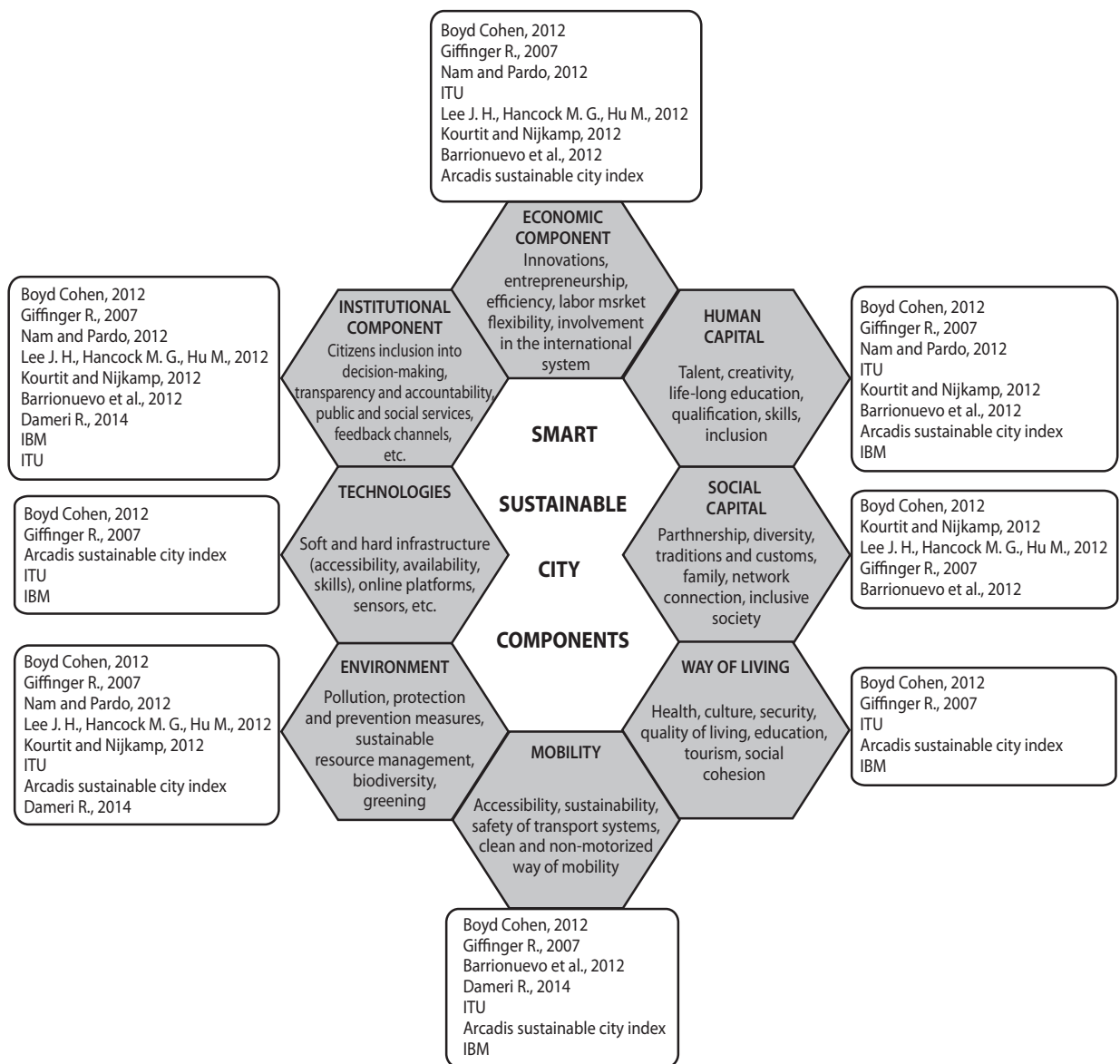
Indexes can bring benefits for all stakeholders: a) governments can track their goals and compare performance against other cities; b) citizens get involved into development processes; c) academic and business sectors receive a tool to come up with new ideas and solutions for pressing issues.

International indexes are of interest because they involve cities from different countries making the methodology adaptive and re-usable within different national systems. Moreover, they encourage cities to compete at the international level. We have reviewed frameworks suggested by the academic (IESE, Boyd Cohen, European Smart Cities, Global Power City Index), business (Ericsson) and institutional sector (UN-Habitat) (Tbl. 1). The selection of the indexes was based on the methodology presented in Fig. 4.

The selected Indexes demonstrate similar results (the top cities include Singapore, Stockholm, London, Paris, New York), as well as cover similar dimensions in their analysis. Moreover, they have similar limitations. For example, the lack of data at the city level and the need to use average values, which can lead to certain distortions; comparison of data over several years is quite doubtful due to changes in the methodology that occur regularly; coverage is typically limited to large cities, ignoring small and medium-sized ones. The considered Indexes use different approaches for data normalization (min-max approach, DP2 technique, Z-Score, etc.) and different models for estimation of the index (using the same weight or different weights for the components). Table 1 presents the summarized information about the selected indexes.

Ukraine is presented by only one city – Kyiv, in only one ranking, Cities in Motion Index 2017, where it occupies the 113rd place, demonstrating the worst positions in social cohesion, environment and economy [10].

We have dug deeper into the methodology of the specified above indexes and compared the composite indicators used in their frameworks. Based on this we have



**Fig. 1. Components of Smart Sustainable City Framework**

**Source:** developed by the author based on different studies.

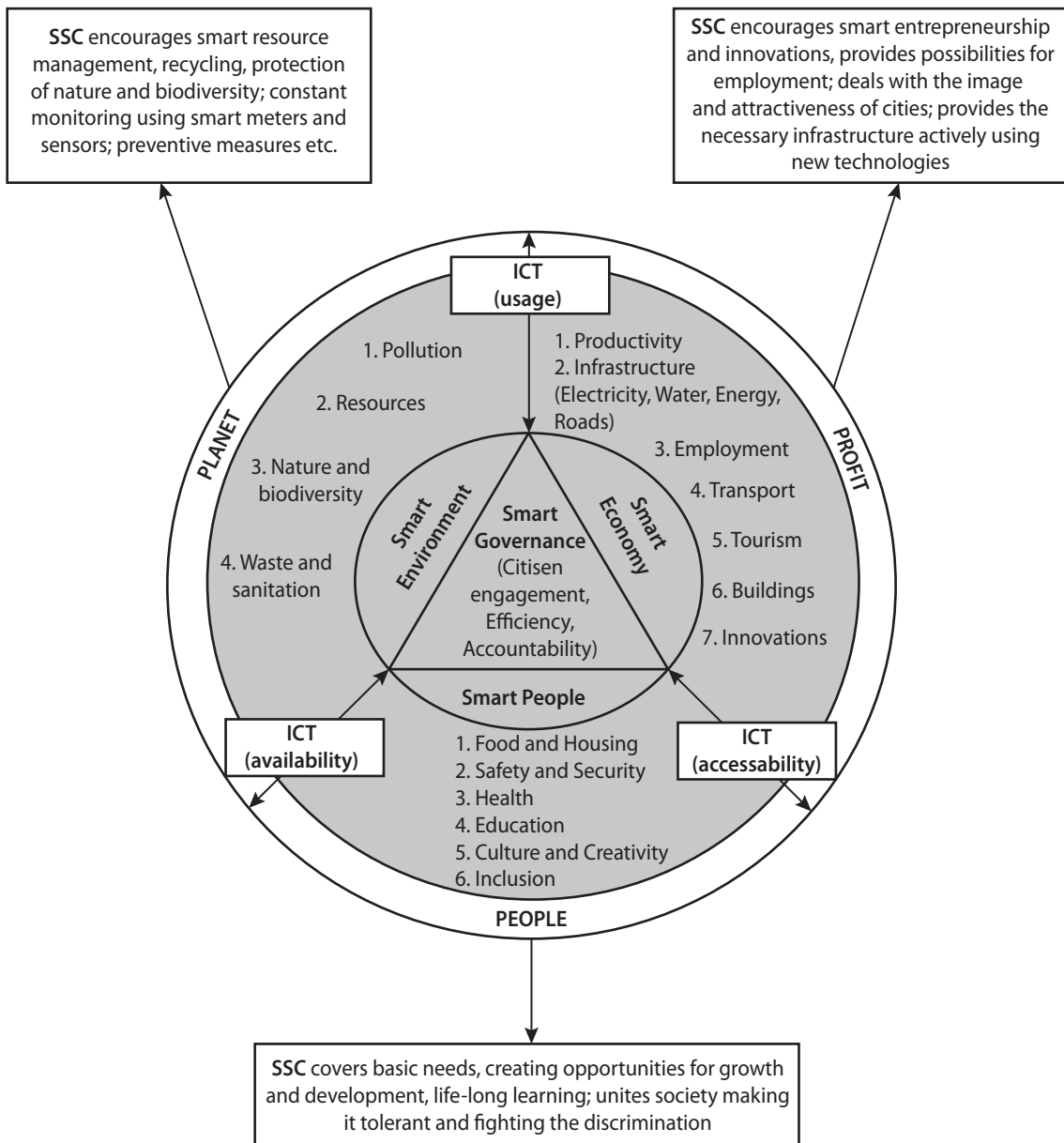
created a comparison table (*Tbl. 2*), re-organizing all the categories into the four components mentioned above: People, Planet, Profit, Governance and ICT.

ITU has summed up principles for key performance indicators (KPIs) to follow during the development:

- 1) **Comprehensiveness:** indicators should cover all the aspects of smart sustainable cities.
- 2) **Comparability:** the framework should include indicators that must be comparable over time and space.
- 3) **Availability:** the data, both current and historic, should be either available or easy to collect.
- 4) **Independence:** the overlap of KPIs should be avoided as much as possible.
- 5) **Simplicity:** the concept should be simple to understand and follow.
- 6) **Timeliness:** prompt reaction to changes in the world for corresponding adjustment of the methodology [14].

Some countries, seeing possible benefits from applying the indexes have started to develop their own nationwide frameworks, which can take a form of a relevant index (India Liveability Index, Portugal Smart City Index), a form of a system of indicators that outline government priorities (Australia), a form of a system to measure the progress of Smart City Concept development (Russia), etc. It's quite interesting that not only developed economies are engaged in this practice.

In Portugal the methodology was developed back in 2012 by the innovation center INTELI and initially tested on 20 cities [15]. The methodology is composed of 5 dimensions of analysis – innovation, sustainability, social inclusion, governance and connectivity; 21 sub-dimensions and a set of 80 indicators. They define smart cities as innovative, sustainable, inclusive and connected cities that are focused on business development, employability and improving the quality of life. The Index is based on three



**Fig. 2. Smart Sustainable City Framework**

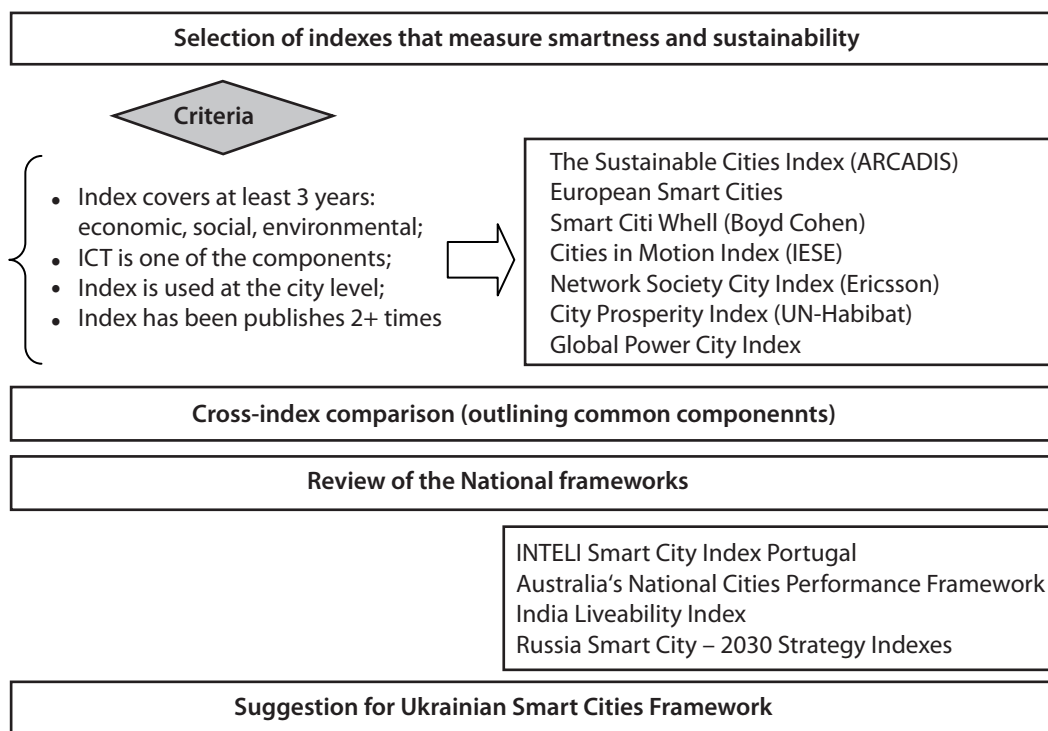
**Source:** developed by the author based on [5].

types of indicators (a) characterization indicators, which are aimed at diagnosing the municipality; (b) strategy indicators, which are used to analyze urban strategies in course and in design, using policy documents and action plans; (c) smart indicators, which are intended for assessing the use of innovative solutions relating to urban intelligence.

In Australia, the National Cities Performance Framework, along with the Smart City Plan, was launched in 2017 to track the progress and performance of the largest cities. The framework is based on two types of indicators: *contextual indicators* (help users to understand city's inherent social, economic and demographic characteristics) and *performance indicators* (used to track and measure the performance against policy priorities). Performance indicators are split in six groups: infrastructure and investment; jobs and skills; liveability and sustainability; innovation and digital opportunities; gover-

nance, planning and regulation; housing [16]. Moreover, all the information is presented in a user-friendly way on the national online dashboard. The Framework is used to analyze the efficiency of the agreements between cities and government that are needed to meet the targets of Smart city Plan. Every three years the model will be reviewed to ensure its relevance.

In 2017 the Ministry of Urban Development of India developed a set of "Liveability Standards in Cities" to generate a Liveability Index and rank cities. The model is based on core and supporting indicators. The source of the Liveability Standards are the 24 features contained in the Smart City Proposals (SCPs), which have been grouped into 15 categories [17]. These categories are part of the four pillars of so called comprehensive development of cities (Institutional, Social, Economic and Physical).



**Fig. 3. Research plan**

**Table 1**

**International Indexes for measuring smartness and sustainability of cities**

Name	Developer	Year/frequency	Number of cities	Object of measurement	Components
1	2	3	4	5	6
Arcadis Sustainable Cities Index	Arcadis and Centre for Economic and Business Research	2015 / every year	100	Urban sustainability that encompasses measures of the social, environmental and economic health of cities	Social, economic, environmental components
Cities in Motion Index	IESE	2013 / every year	181	Future sustainability of the world's largest cities as well as the quality of life of their inhabitants	Human capital, social cohesion, economy, international outreach, public management, governance, mobility, environment, urban planning, technologies
Networked Society City Index	Ericsson	2011 / every year	41	Describes the development status of cities worldwide in terms of their ICT maturity and triple bottom line effects derived from ICT	Triple-bottom line and ICT (availability, usage, accessibility)
City Prosperity Index (CPI)	UN-Habitat	2012, 2015	60	The way cities create and distribute socio-economic benefits or prosperity and the overall achievements of the city	Productivity, quality of life, infrastructure, equity and social inclusion, environmental sustainability, governance and legislation
European Smart Cities	Vienna University of Technology	2007, 2013, 2014, 2015	90	City functioning in six dimensions (smart economy, smart mobility, smart environment, smart people, smart living, smart governance)	Smart economy, smart mobility, smart environment, smart people, smart living, smart governance

1	2	3	4	5	6
Global Power City Index (GPCI)	The Institute for Urban Strategies at the Mori Memorial Foundation	2008 / every year	44	Cities magnetism, their ability to attract creative people and businesses from different countries of the world	Economy, R&D, cultural interaction, liveability, environment, accessibility
CITYKeys Performance Measurement Framework	Partnership of research institutes and 5 european cities	2017	-	Monitoring and comparing the implementation of Smart City Solutions, with the objective of speeding up the transition to low carbon, resource efficient cities	People, planet, prosperity, governance and propagation

Source: developed by the author based on [6-13].

Table 2

### Components comparison across indexes and rearrangement

Categories		Arcadis Sustainable Cities Index	European Smart Cities	Smart City Wheel	Cities in Motion Index	Network Society Index	City Prosperity index	Global Power City Index	CITYKeys Framework
1		2	3	4	5	6	7	8	9
SOCIAL	Education								
	Health								
	Unemployment								
	Inequality								
	"Work-life" balance								
	Quality of life								
	Security								
	Social, gender, ethnic diversity								
	Creativity								
	Participation in public life (elections, volunteering etc.)								
Culture									
ENVIRONMENT	Energy efficiency								
	Tendency to natural disasters								
	Air pollution								
	CO <sub>2</sub> emissions								
	Waste management								
	Drinking water and sanitary								
Greening									
ECONOMIC	International outreach (headquarters of international organizations, international connections, etc.)								
	Productivity								
	Ease of doing business								
	Transport (modes, traffic)								

	1	2	3	4	5	6	7	8	9
	Research and development								
	Labor market flexibility								
	Touristic attractiveness								
GOVERNMENT	Participation in decision-making								
	Quality of public and social services								
	Transparency								
	Online public services								
ICT	Open data								
	ICT (availability, accessibility, usage)								

Source: developed by the author based on [6–13].

Physical component has the highest weightage. Category Indexes include: Governance index, Identity and Culture Index, Education Index, Health Index, Safety and Security Index, Economic Index, Housing and Inclusiveness Index, Open Space Index, Mixed Use and Compactness index, Energy Index, Mobility Index, Water Index, Waste Water Index, Solid Waste Index, Pollution Index. The Liveability Index aims to improve different institutional, social, economic and physical aspects that affect quality of life of citizens. Besides, a platform has been established for citizens to monitor and compare the progress [17].

Russia is currently working on the national framework along with Moscow Smart City Strategy. The Strategy suggests using two indexes – Quality of Life Index (which is based on statistical data and survey results and covers human and social capital, safety and environment, urban economy and digital government) and Quality of Urban Environment Index (which shows to what extent urban environment meets the needs of citizens and covers housing, green and water areas, street infrastructure, public-private infrastructure, general public space) [18].

In Ukraine, as in many other countries, there is neither commonly accepted definition for Smart City nor a methodology for measuring smartness and sustainability of cities. However, some of the studies measure one or several components of the concept. For example:

- ✦ *Transparent Cities Ranking*, which is prepared by the Transparency International for 100 Ukrainian cities. It evaluates transparency of the cities, amount of proactively provided information to citizens, quality of preventive measures against corruption, and openness of information for citizens [19].
- ✦ *Top 55 Ukrainian Cities to Live* (the ranking of comfortability of Ukrainian cities, which has been calculated by the Focus magazine since 2007). It covers six categories: economy, safety,

mobility, quality of service, environment taking into account public survey [20].

- ✦ *The Poll of International Republican Institute* that studies satisfaction of citizens with the quality of services and opportunities provided in cities [21].

Based on the conducted research and already available indexes, we would like to suggest a framework for Ukrainian cities (Fig. 4). Taking into account the Ukrainian context, the process can be split in two stages: a) creating conditions for building the concept; b) actual measurement of the sustainability and smartness of cities.

The first (preparation) stage can be broadly described as provision of technical and organizational support. It implies that people should have devices (PCs, smartphones, laptops, etc.) available and Internet access. Moreover, the state should provide citizens with the access to open data, because this allows creating smart applications and solutions to improve the quality of life. We will call this component “*Digitalization*”. The second component of the preparation stage deals with the organizational component, we will call it “*Conceptualization*”. It implies the availability of a smart city strategy, platform for communication and feedback, financial mechanism; establishment of a responsible body, etc.

The second stage measures actual people-friendliness, sustainability and smartness of cities as living environment. The core idea is a human-centric approach, which can be disclosed through the following scheme (Fig. 5).

#### ✦ Quality of life of citizens.

The city of the future ensures satisfaction of all basic human needs (housing, food, clothes, health, etc.). It provides opportunities to reveal human potential (education, business creation, job search) and opportunities for intellectual enrichment (cultural sphere, travel opportunities, etc.).

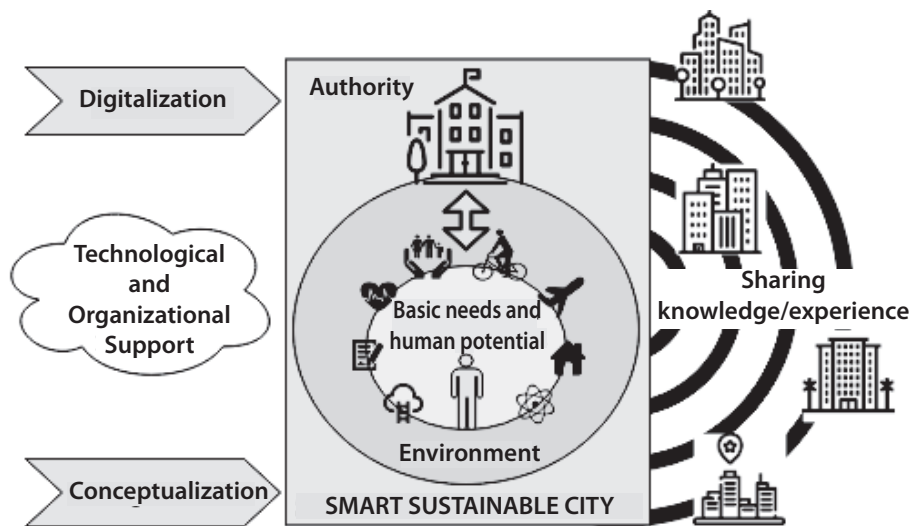


Fig.4. Smart Sustainable City Framework for Ukrainian cities

Source: developed by the author.

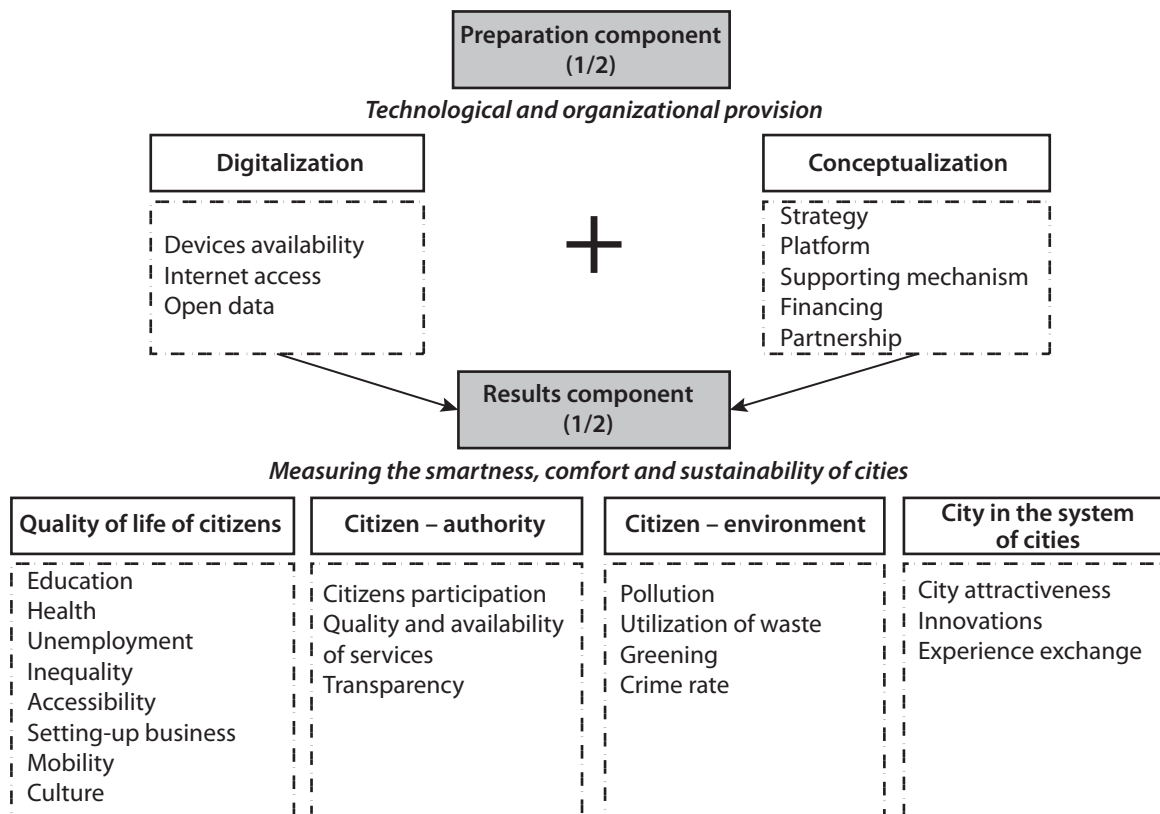


Fig. 5. Smart Sustainable Cities Framework: building blocks

✦ **“Citizen – authority” axis.**

It considers the quality of relations between citizens and authorized bodies (transparency, availability of services, accountability, etc.), as well as the civil activity of the inhabitants.

✦ **“Citizen – environment” axis.**

This dimension covers safe existence of citizens and their impact on the environment.

✦ **“City in a system of cities” axis.**

It measures attractiveness of a city for people who do not reside in it (attractiveness for tourists or business),

including exchange of knowledge and experience with other cities.

**CONCLUSIONS**

Ukrainian cities are just beginning to use benefits of the processes of digitalization and smartization, which actively evolve around the globe. In 2016 Ukraine joined the International Open Data Charter, which focuses on the public disclosure of information on activities of the state, municipalities, and other institutions. In 2017 the first national competition of IT innovative projects was



conducted (OpenDataChallenge). However, according to Global Data Index, only 20% of data is open in Ukraine [22]. Only 58% of Ukraine's population use the Internet, most of them living in the urban area [23].

The article aims to present different measurement frameworks, prepared by both the private and public sector, that are used on the international arena and within individual countries.

Ukrainian cities are yet to find their models and tools for successful development. However, the presented Framework may contribute to the development of the concept of Smart Sustainable Cities, allowing to see the state of different components in various cities. We have followed best practices picked from the studied methodologies which not only focus on the digital component itself but put a human being in the very center of the concept. In our opinion, as for now, the Framework should include the preparation stages and the stage of assessing actual results. In future, when Internet access, device availability, and open data will become ordinary things for all cities, the preparation stage can be omitted. Till the date, hardly any city in Ukraine has succeeded in terms of Conceptualization, since only Kyiv city has Smart City Strategy and a platform for communication and feedback. The Framework takes into account data limitations and also assumes that some data will be available only at the regional level. The next step is to develop a composite smart city index to measure the progress within our country. ■

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