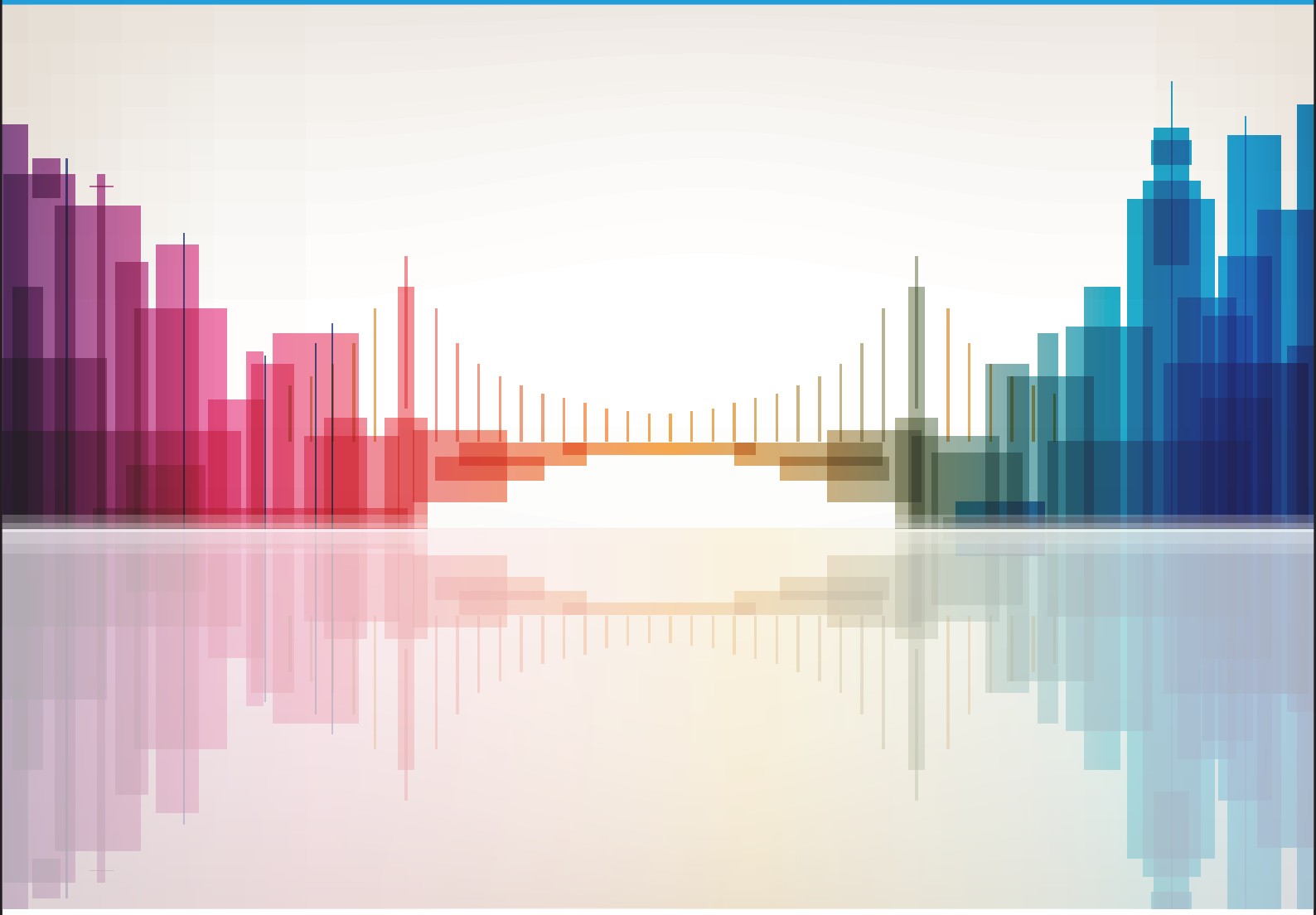
United 4 Smart Sustainable Cities

Factsheet

Mashhad, Iran (Islamic Republic of)

September 2021



Ministry of ICT
ITRC ICT Research Institute

سازمان فناوری اطلاعات و ارتباطات شهرداری مشهد

شهرداری مشهد

ITU



United 4 Smart Sustainable Cities

Factsheet

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Foreword

This publication has been developed within the framework of the United for Smart Sustainable Cities (U4SSC) initiative. It provides an overview of the reporting and implementation of key performance indicators (KPIs) for smart sustainable cities (SSC) in Mashhad, Islamic Republic of Iran. The U4SSC KPIs are based on Recommendation ITU-T Y.4903.

This set of KPIs for SSC was developed to establish the criteria to evaluate ICTs' contributions in making cities smarter and more sustainable, and to provide cities with the means for self-assessments.

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This publication is based on the project conducted in Mashhad, Islamic Republic of Iran in 2021.

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Contents

Foreword ii

Acknowledgements ii

Disclaimer ii

Abbreviations iv

Executive Summary 1

Background: The United 4 Smart Sustainable Cities (U4SSC) Initiative 2

Mashhad and the U4SSC KPI Project 5

- Mashhad Initiative 5
- City Profile: Mashhad, Iran (Islamic Republic of) 8
- Benchmarks and Scoring Methodology 9
- Mashhad and the KPIs: A Snapshot 12

Economy Dimension KPIs: Review of Data 13

Environment Dimension KPIs: Review of Data 25

Society and Culture Dimension KPIs: Review of Data 33

Mashhad: Key Findings and Conclusions Across the KPIs 41

Appendix 46

- Mashhad Initiative 46
- United for Smart Sustainable Cities (U4SSC) 55
- Smart Sustainable City Maturity Model 55
- U4SSC Implementation Programme (U4SSC-IP) 56

U4SSC in the International Context 57

- The United Nations Sustainable Development Goals (SDGs) 57
- New Urban Agenda 58

Abbreviations

CBD	Convention on Biological Diversity
CO_2	Carbon Dioxide
ECLEC	UN Economic Commission for Latin America and the Caribbean
EMF	Electric and Magnetic Fields
GDP	Gross Domestic Product
eCO2	Equivalent Carbon Dioxide
FAO	Food and Agriculture Organization
GHG(s)	Greenhouse Gas Emission(s)
GIS	Geographic information System
ICT(s)	Information and Communications Technology/Technologies
IEA	International Energy Agency
ITU	International Telecommunication Union
KPI(s)	Key Performance Indicator(s)
NO2	Nitrogen Dioxide
O3	Ozone
OECD	Organisation for Economic Co-operation and Development
PVC	Polyvinyl Chloride
PM	Particulate Matter (2.5 and 10)
R&D	Research and Development
SDG(s)	Sustainable Development Goal(s)
SME(s)	Small and Medium-Sized Enterprise(s)
SO2	Sulphur Dioxide
SSC	Smart Sustainable City/Cities
U4SSC	United for Smart Sustainable Cities
UIS	UNESCO Institute of Statistics
UN	United Nations
UNDP	United Nations Development Programme
UNECA	United Nations Economic Commission for Africa
UNECE	United Nations Economic Commission for Europe
UNEP	United Nation Environment Programme
UNEP-FI	United Nations Environment Programme Finance Initiative
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organization
UNOP	United Nations Office for Project Services
UNU-EGOV	United Nations University Operating Unit on Policy-Driven Electronic Governance
WHO	World Health Organization

Executive Summary

The United for Smart Sustainable Cities (U4SSC) has developed a set of international key performance indicators (KPIs) for Smart Sustainable Cities (SSC) to establish the criteria to evaluate information and communication technologies' contributions in making cities smarter and more sustainable, and to provide cities with the means for self-assessments to achieve the sustainable development goals (SDGs). In 2021, Mashhad, Islamic Republic of Iran agreed to implement and report on the U4SSC KPIs. This factsheet documents the Mashhad KPI project.

- The factsheet starts by introducing the U4SSC initiative within the context of digitalization and the importance of the standardization of data in fostering smart sustainable city transitions.
- This is followed by an overview of Mashhad's framework for implementing projects to become smarter and more sustainable ('The Mashhad Initiative') and a profile of the city.
- Next is the explanation and result of the U4SSC KPI benchmarking process.
- The subsequent sections review the data collected under the three U4SSC dimensions (Economy, Environment, and Society and Culture) providing a picture of Mashhad's efforts in each of these areas.
- The final section contains the key findings and conclusions based on an analysis the KPI data, the Mashhad Initiative and the KPI benchmarks.
- The factsheet also outlines the current projects within the Mashhad Initiative in the report appendix.

The knowledge gained through Mashhad's experience will continue to be an important part of ongoing efforts to make using the KPIs an even more effective method to measure progress and provide guidance to cities on their journey towards becoming smarter and more sustainable.

Mashhad's collection and reporting of data in accordance with the KPIs, and the verification process undertaken, are summarized in the following table.

	Total	Reported	Verified	% KPIs Verified
Economy				
Core KPIs	23	22	22	96 %
Advanced KPIs	22	18	18	82 %
Environment				
Core KPIs	12	11	11	92 %
Advanced KPIs	5	5	5	100 %
Society & Culture				
Core KPIs	19	16	16	84 %
Advanced KPIs	10	8	8	80 %
Overall				
Core KPIs	54	49	49	91 %
Advanced KPIs	37	31	31	84 %
Total	**91**	**80**	**80**	**88 %**

Background: The United 4 Smart Sustainable Cities (U4SSC) Initiative

The United for Smart Sustainable Cities (U4SSC) is a UN initiative created to foster the standardization, integration and interoperability of digital technologies within cities to make them smarter and more sustainable.

The initiative has developed a set of international **key performance indicators (KPIs) for Smart Sustainable Cities (SSC)**[1] to establish criteria to evaluate ICTs' contributions towards making cities smarter and more sustainable, and to provide cities with the means for self-assessment in the move towards smartness and sustainability.

The aim is to help cities worldwide use technology to serve the best interests of the people, and of the environment. For this reason, environmental aspects, as well as socio-economic factors, also play a key role in the U4SSC framework.

Helping cities become smarter and more sustainable: The U4SSC KPIs

The U4SSC KPIs offer a common format to report the progress of smart sustainable city strategies. These indicators also enable cities to measure their progress relative to the United Nations Sustainable Development Goals (SDGs).

ITU's objectives for the U4SSC KPIs for SSC project in cities are as follows:

- Assisting cities with implementing the KPIs in order to measure and evaluate a city's progress in becoming smarter and more sustainable as they move towards meeting the SDGs within the local context.
- Learning from cities' experiences, and sharing the rich and varied knowledge, insights and feedback with other cities around the world, in order to set them on the path towards enabling them to refine their own smart sustainable city strategies.
- Evaluating the strengths of this system of KPIs, and identifying any areas for improvement, and to obtain practical and actionable feedback towards supporting the international standardization work of ITU-T Study Group 20: Internet of Things, and Smart Cities and Communities.
- Providing cities with a consistent and standardized method of collecting data and measuring performance and progress.

The KPIs are categorized into three dimensions:



ECONOMY



SOCIETY AND CULTURE



ENVIRONMENT

A further seven sub-dimensions are:

 ICTs

 Productivity

 Infrastructure

 Environment

 Energy

 Education, Health and Culture

 Safety, Housing and Social Inclusion

The KPIs are further subdivided into **core** and **advanced** indicators.

Core indicators are those that all cities should be able to report. They provide a basic outline of the city's smartness and sustainability – higher levels of performance are generally achievable within these KPIs.

Advanced indicators provide a more in-depth view of a city and measure progress on more advanced initiatives.

Details on each indicator are available online in the 'Collection Methodology for Key Performance Indicators for Smart Sustainable Cities'.

Each indicator has been chosen through a process of review and input by international experts and UN agencies, programmes and secretariats to ensure that the data collected support the SDGs in a local context. City leaders will benefit from these KPIs in terms of strategic planning and the measurement of their cities' progress towards their individual smart sustainable city (SSC) goals. The indicators will enable cities to:

- measure their progress over time;
- use the data and insights gleaned as policy tools towards informed policy-setting and decision-making; and
- Enable analysis and sharing – in order allow for the dissemination of best practices and set the standards for progress in meeting the SDGs.



Mashhad and the U4SSC KPI Project

To be able to respond to queries regarding the level of its digital development and sustainability, the City of Mashhad decided to join this ITU-led project, utilizing the needs, aims and solutions of the U4SSC. This ambitious project would help Mashhad to measure and compare its degree of digitalization and sustainability in accordance with established international standards.

Findings from the project are expected to form an SSC development trajectory to which administrators of other municipalities and regions similar in size and capacity to Mashhad will be able to adapt when developing their own smart sustainable strategies. The KPIs will also help demonstrate how Mashhad is progressing in its achievement of the SDGs. The continuation of the project could also assist Mashhad in conducting a periodic internal review of its current ICT-related efforts, thereby allowing the city to benchmark how its ICTs can best be used to monitor and improve its smart city processes and operations. This project can, therefore, play a key role in planning Mashhad's SSC future.

Mashhad Initiative

The Mashhad Initiative is the overarching framework that charts Mashhad's path to becoming smarter and more sustainable. The Initiative starts with a city action plan and is guided by an overall mission and vision, as follows:

Mashhad Smart City Mission:
Changing the management method of Mashhad city based on citizens' participation and providing integrated and adaptable technological solutions for all urban services in order to increase quality using efficient and comprehensive access to services in all operational areas of Mashhad.

Mashhad Smart City Vision:
A creative, innovative city that wants to become a leader in the region by using new technologies and increase civic participation and improve the quality of life of citizens by increasing accessibility, accountability and transparency.

The city action plan was developed based on studies of the level of smart maturity of the city's services in the implementation of different projects and in the introduction of technology.

The maturity study goals were to determine how Mashhad could re-imagine itself as:

- A competitive city with a dynamic economy
- A balanced and safe city

- A city of hope and life
- A smart and citizen-centred city
- A clean and environmentally friendly city
- A connected city

This maturity study allowed Mashhad to define holistic and integrated city implementation projects based on three main elements and their subsets:

Technological Factors

- Physical infrastructure
- Mobile technologies
- Smart technologies
- Digital networks

Human Factors

- Human infrastructure
- Social capital

Institutional Factors

- Government
- Policies and Laws

The comprehensive planning system in Mashhad is based on strategic thinking, and has been developed at three levels: long-term, medium-term and short-term plans.

The long-term plan of Mashhad Municipality is a 20-year plan with the main pillars of the mission statement, values, vision statement, long-term goals, vision indicators and strategies.

The mid-term operational plan of contains six main themes, 31 major goals, 41 strategies and six mission areas, and is being implemented in the 13 districts of Mashhad.

Mashhad defines projects within its smart city actions plan in six dimensions:

- Smart government
- Smart living
- Smart mobility
- Smart environment
- Smart people
- Smart economy

Priority is given to the projects based on the needs of the municipality. Mashhad has implemented initiatives in improving ICT infrastructure, developing electronic services, providing electronic services on social networks, providing electronic micro-payment tools, developing spatial data infrastructure, developing smart and new technologies, and developing an open government portal.

Some current goals of the projects are:

- Upgrading handling and transportation infrastructure
- Reducing energy consumption through smart grids
- Increasing public participation
- Achieving efficient and effective governance
- Sustainable environment
- Development of the tourism economy
- Creating equal economic opportunities
- Creating a resilient society
- Development of the communication infrastructure
- Improving quality and access to online services
- Improving privacy
- Supporting innovative businesses
- Ensuring equal access to services
- Interaction with the global economy
- Upgrading the safety level of the city
- Developing a city of knowledge and learners

City Profile: Mashhad, Iran (Islamic Republic of)

City Profile			
Inhabitants	3 062 242	City GDP	USD 38 999 992 440
Area	343 km^2	Household Income	USD 10 344
Households	931 341	Inflation Rate	28.00 %

Mashhad is located in the Kashafrud River catchment basin, at the end of the Mashhad sedimentary plain between the Hezar Masjid and Binalood mountains ranges. It lies at an elevation of 1 050 m above sea level and has a moderate and variable climate.

This city consists of three districts – Markazi, Ahmad Abad and Razavi – three cities and 11 rural districts. Mashhad is the Islamic Republic of Iran's second largest city and (after Tehran) its second most populous; because of its religious, industrial and economic situation, it is also the Islamic Republic of Iran's second most important city. Mashhad is known as the most important religious attraction in the Islamic Republic of Iran for visitors and pilgrims who visit the Imam Reza holy shrine (8th Shia Imam), the biggest holy shrine in the Islamic Republic of Iran.

As one of the most magnificent religious places in the Islamic Republic of Iran, Astan Qods Razavi is the symbol of Mashhad, a place where Islamic art and religion are linked to one another. Located along the Silk Road, it is the economic capital, and the intercontinental commercial centre in the Central Asia area.

Mashhad's economic activities revolve around services, industry and agriculture; however, it is heavily focused on a service-based economy, due to the presence of visitors and pilgrims who travel to the city. Each year, Mashhad hosts around 20 million tourists and pilgrims, and approximately 55 per cent of the Islamic Republic of Iran's hotels are in Mashhad. About 40 per cent of Mashhad's industry is based on food, metal and handicrafts. Most of Mashhad's people are of Iranian Aryan race, although many Kurds, Turks and Arabs also live there. Mashhad residents speak Persian with a Mashhadi accent and are the followers of Ja'afari Shia.[2]

Infrastructure-development initiatives have significantly expanded the road and railroad systems in Mashhad. The ring road circling the city – featuring modern highway roadbeds, dividers and shoulders – was one such project. The city is connected by rail with Tehran and other Iranian cities, such as Bāfq and Sarakhs. Mashhad also has a metro system, the first line of which opened in 2011. The city's airport is one of the country's largest, with domestic flights to many Iranian cities and international routes to Europe Asia, and the Middle East.[3]

Mashhad profiles itself as 'Mashhad; smart city, city of hope and life'.[4] Mashhad's smart sustainable development concept (The Mashhad Initiative) is based on the holistic approach, which includes technological, human and institutional factors, and is reflected in Mashhad's Smart City Action Plan. The Mashhad Smart City Action Plan defines the city's mission, vision and strategic goals, as well as projects in six smart city dimensions.

Benchmarks and Scoring Methodology

As part of the U4SSC KPI project, benchmarks were developed for most KPIs to develop a reporting framework to demonstrate to cities how their performance could be reported.

The benchmarks were set based on several factors:

- Meeting the aligned SDG(s) fully
- Performance compared to other international and transnational targets (e.g., OECD, European Commission)
- Performance against UN agency goals (e.g., International Telecommunication Union)
- Evaluation of city performance using UN and other international statistical data
- Performance measured vis-à-vis leading city performance globally.

Performance to benchmarks were then scored in four ranges for every KPI and data point reported:

- 0 – 33 % of target – 1 pt.
- 33 – 66 % of target – 2 pts
- 66 – 95 % of target – 3 pts
- 95 + % of target – 4 pts

Benchmarking Example: KPI: Fixed Broadband Subscriptions EC: ICT: ICT: 2C

Using ITU's ICT Development Index Indicators, a reference value of 60 per cent for fixed broadband subscriptions is used. For this indicator, 60 per cent was used as 100 per cent of target.

The ranges of benchmark performance for this indicator and how it is represented are described in the following table:

Benchmarking Range	Actual Benchmarks: Percentage of Households with Fixed Broadband	Performance to Benchmark Icons	Colour Scale on Benchmarking Snapshot
95 + % of target	More than 57.0 %		
66 – 95 % of target	39.6 – 57.0 %		
33 – 66 % of target	19.8 – 39.6 %		
Less than 33 % of target	Less than 19.8 %		

Benchmarking Example: Category – Education 4 KPIs

The scores for each reported KPI and data point were added to give a percentage score for categories, sub-dimensions, and dimensions, and reported, based on the above target scores. KPIs or data points that are not reported or have no benchmarks yet defined, were excluded.

If all four are reported, and the scores are 1 pt, 3 pts, 4 pts and 1 pt;

- Total score 9 pts out of 16 = 56.25 % is reported as 33–66 % of target.

If only three are reported and the scores are 3 pts, 4 pts and 2 pts;

- Total score 9 pts out of 12 = 75 % is reported as 66–95 % of target.

U4SSC Unique Method

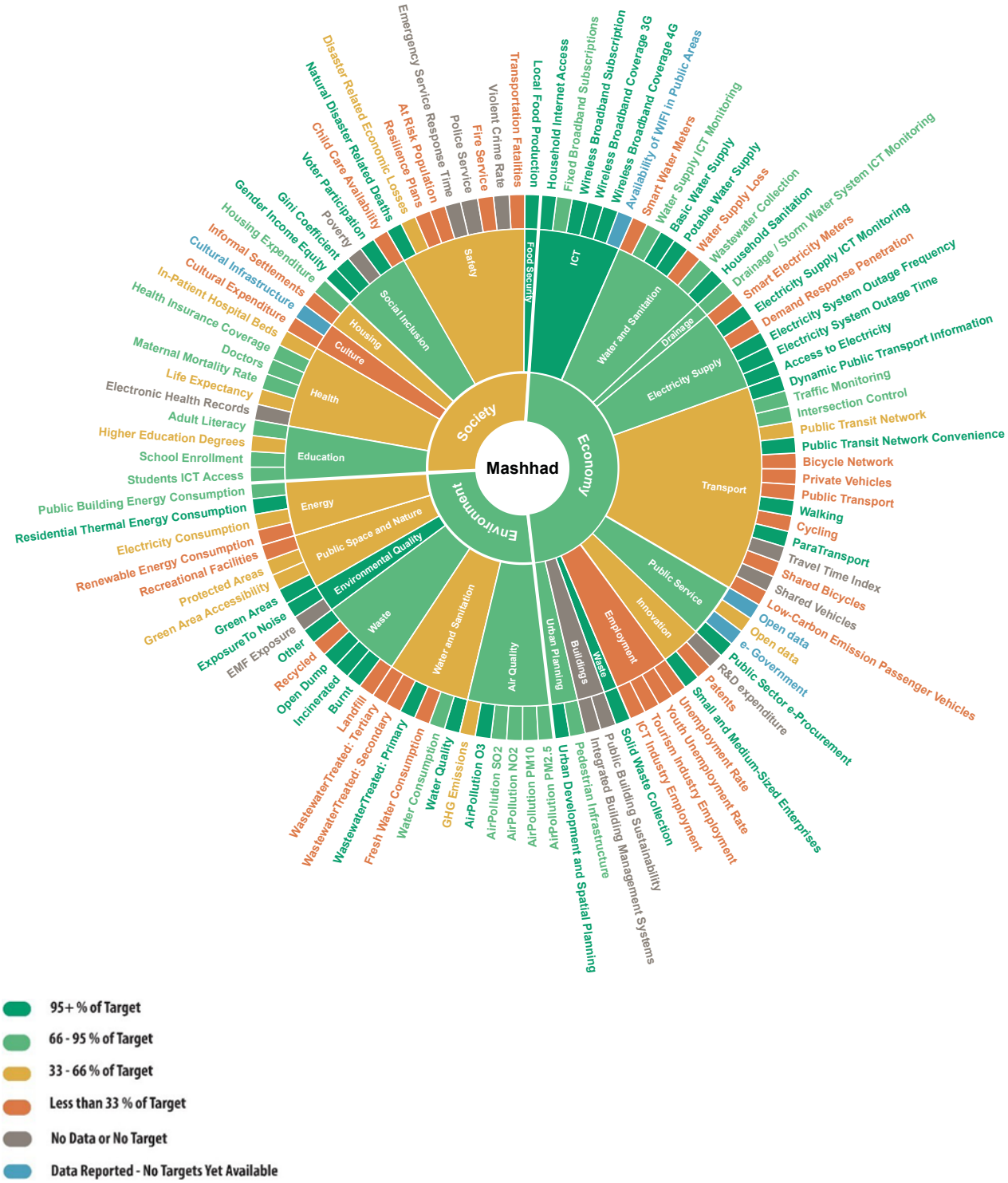
The originality of U4SSC's method lies in the fact that it regards ICTs and digital technologies not as ends in themselves, but rather as tools with which to make a meaningful contribution to achieving the SDGs in an increasingly digitalized landscape. Approximately one-third of the U4SSC KPIs concern digitalization (for example, Student ICT Access) and two-thirds primarily concern sustainable development and environmental impact (for example, Noise Exposure). As such, U4SSC forms a necessary bridge between digitalization and sustainable development.

Help improve quality of life for your citizens or evaluate the urban functionality of your own city by piloting the U4SSC KPIs.

Contact us at u4ssc@itu.int to find out more!

Mashhad and the KPIs: A Snapshot

The following chart provides an overview of how the KPIs are being met. Starting from the centre, the benchmark performance is indicated for: Dimensions, Categories and KPIs.



Economy Dimension KPIs: Review of Data

The first U4SSC KPI dimension is Economy. This dimension covers the sub-dimensions of Information and Communication Technologies (ICTs), Productivity and Infrastructure.

In the ICTs sub-dimension, the KPIs include those related to a city's ICT infrastructure, water and sanitation, drainage, electricity supply, transport and public sector. These KPIs aim to assess the availability and use of the ICT infrastructure in cities that facilitate smart sustainable city services.

The Productivity sub-dimension includes KPIs related to innovation and employment. These KPIs aim to assess the use and impact of ICTs in the economic development of cities. They cover innovation, job creation, trade and productivity. These KPIs are also expected to play a pivotal role in assessing a city's adoption of the ICTs that support socio-economic growth.

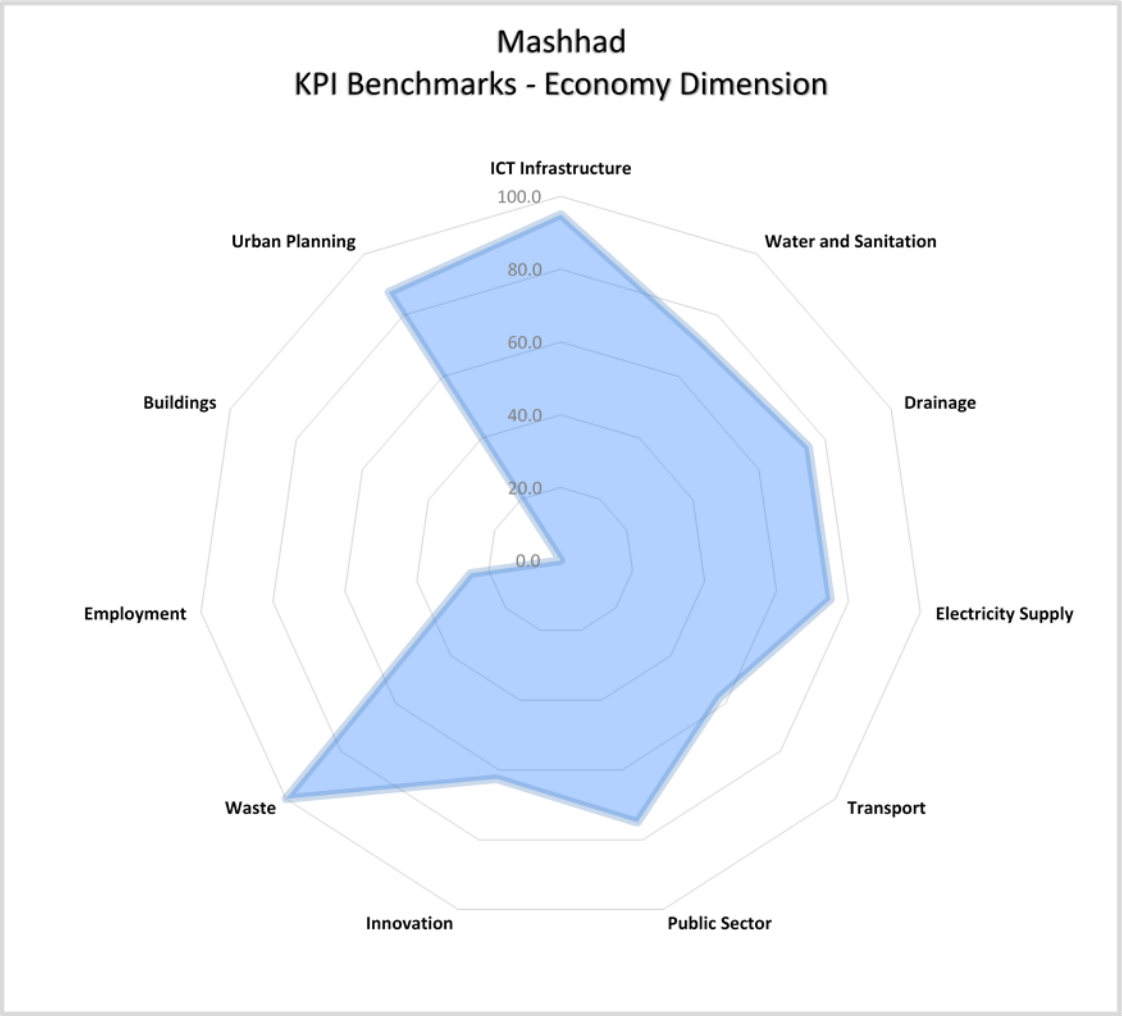
The infrastructure sub-dimension relates to water and sanitation, waste, electricity supply, transport, buildings and urban planning. These KPIs aim to assess the impact of ICTs on city infrastructure, development and sustainability.

The key theme assessed by the Economy KPIs is the level of implementation of ICTs. A smart sustainable city (SSC) requires fixed and mobile ICT infrastructures to allow for the deployment of applications that will:

- facilitate the development of smart and sustainable cities;
- promote civic engagement; and
- foster improvements in sustainability (gained though efficiencies in operations).

There are also KPIs within this dimension that are designed to help analyse the general economic well-being and innovation of a city, and measure the support from ICTs in the process.

The following diagram summarizes Mashhad's KPI performance, detailing the categories within the Economy dimension against the current U4SSC benchmarks.


Mashhad
KPI Benchmarks - Economy Dimension
ICT Infrastructure
100.0
80.0
60.0
40.0
20.0
0.0
Water and Sanitation
Drainage
Electricity Supply
Transport
Public Sector
Innovation
Waste
Employment
Buildings
Urban Planning

Category: Information and Communication Technology (ICT) Infrastructure

Category	KPI	Result	Performance to Benchmark	SDG
	Fixed Broadband Subscriptions	42.56 %		
	Wireless Broadband Subscriptions (per 100 000 inhabitants)	182 262		
	Household Internet Access	100.00 %		
	Wireless Broadband Coverage – 3G and 4G	100.00 %		
	Availability of Wi-Fi in Public Areas	3 Spots	No benchmark available	

In keeping with its objective of becoming a leading smart and sustainable city, Mashhad's ICT infrastructure scores well on the KPIs within this category. At the same time, as technology advances and as initiatives to make more digital services available to its citizens continue to be implemented, improvements to the ICT infrastructure of the city will still be needed in order to upgrade speed and the capacity to handle increasing levels of data.

Mashhad is currently adding more than 400 additional km of fibre-optic cable to its urban network to increase capacity and reliability as a current project.

As Mashhad's economy has a heavy focus on tourism, free public Wi-Fi spots will be expected by tourists and visitors. Therefore, plans to expand the public Wi-Fi network should be reviewed as there are currently very few public Wi-Fi spots.

Enhancing Performance Using ITU-T Recommendations:

Recommendation ITU-T Y.4901/L.1601: KPIs related to the use of ICT in smart sustainable cities will provide Mashhad with additional ICT KPIs related to smart, sustainable cities that can be implemented and measured.

Recommendation ITU-T Y.4902/L.1602: 'KPIs related to the sustainability impacts of ICT in smart sustainable cities' will provide Mashhad with additional KPIs that will measure the sustainability impact of the use of ICTs.

Recommendation ITU-T L.1400: Overview and general principles of methodologies for assessing the environmental impact of ICTs and/or Recommendation ITU-T L.1440: Methodology for environmental impact assessment of ICTs at city level, will allow Mashhad to measure the environmental impacts of the use of ICTs.

Category: Public Sector

Category	KPI	Result	Performance to Benchmark	SDG
	Open Data Sets: Published	298	No benchmark available	
	Open Data Sets: Availability	38.95 %		
	e-Government Services	150 Services	No benchmark available	
	Public Sector e-procurement	100.00 %		

There are a large number of public services (150) that are digitally enabled, and even more are in the works, or proposed. Mashhad has implemented electronic service delivery in the areas of:

- Urban planning and civil construction
- Transportation services
- Public and green spaces
- Cultural and social services

Procurement has gone 100 per cent digital, and a large number of open data sets are available; however, the percentage of total sets that could be published can be improved.

Mashhad has also developed an open government portal to allow citizens to monitor data streams, and thereby improve the accountability and transparency of government. This correlates well with Mashhad's Smart City vision of increasing accessibility, accountability, and transparency.

Published data include following items:

- Municipality budget
- Tenders and auctions
- Project status
- Contracts
- Vendors
- Municipality managers and organizations board members

Enhancing Performance Using ITU-T Recommendations:

Recommendation ITU-T Y.4461: 'Framework of open data in smart cities' provides Mashhad with the concept of open data in smart cities, analyses the benefits of open data in smart cities, identifies the key phases, key roles and activities of open data in smart cities, and describes the framework and general requirements of open data in smart cities.

Category: Innovation and Employment

Category	KPI	Result	Performance to Benchmark	SDG
	R&D expenditure (relative to GDP)	Not Reported		
	Patents (per 100 000 inhabitants)	0.59		
	Small and Medium-Sized Enterprises (SMEs)	98.05 %		
	Unemployment Rate	12.00 %		
	Youth Unemployment Rate	16.60 %		
	Tourism Sector Employment	0.29 %[1]		
	ICT Sector Employment	0.33 %[2]		

This category highlights a few areas which need to be further advanced on to enable Mashhad to succeed in their smart city endeavour. Addressing the current level of unemployment should be a priority for the city.

Since tourism is a major engine of the economy in Mashhad, an effort to collect the data for private sector tourism sector employment should also be viewed as a matter of importance.

Around Mashhad, there is a science park and a technology park and eleven incubators[5] to support innovative companies and start-ups by providing businesses based in the parks with benefits. The benefits to companies within the parks include tax exemption, annual performance exemption, exemption of duty payments and export duties, protection of commercial interests, and the easing of foreign exchange transactions.[6] An effort to collect the data on the size of the private sector ICT labour force should, therefore, also be a high priority.

A better understanding of the actual private market employment within the tourism and ICT sectors can provide city leaders with the data to measure the impact of smart, sustainable city policies and programmes that are targeted at these sectors, and benefit the city.

Category: Water and Sanitation, Drainage and Waste

Category	KPI	Result	Performance to Benchmark	SDG
	Smart Water Meters	2.62 %		
	Water Supply ICT Monitoring	92.20 %		
	Basic Water Supply	100.00 %		
	Potable Water Supply	100.00 %		
	Water Supply Loss	21.76 %		
	Wastewater Collection	79.67 %		
	Household Sanitation	100.00 %		
	Drainage/Storm Water System ICT Monitoring	84.21 %		
	Solid Waste Collection	100.00 %		

Wastewater and stormwater systems within Mashhad are monitored in-depth as is the delivery of potable water and collection of waste.

However, the Islamic Republic of Iran as a country has been identified as having a high level of water stress,[7] so that the level of water loss within the distribution system is a concern and should be reviewed to see what steps can be taken to reduce this loss. Furthermore, the Mashhad plain possesses only 2 per cent of the total province groundwater although 65.97 per cent of the urban provincial population live there. Furthermore, 92.7 per cent of surface water comes from the Dousti dam, which is located 220 km from Mashhad, and only 30 per cent of domestic sewage is recycled.[8]

It is highly recommended that Mashhad develop programmes to prioritize the conservation of the city's water resources. This should involve policies and programmes to protect water resources, programmes to proactively detect leaks and make repairs within the water distribution system, programmes to encourage water conservation, and an ICT-based system for smarter water management.

Capturing all wastewater flows for treatment is the most effective way to ensure that pollution is minimized. The current methods pertaining to the treatment of wastewater can be made more effective if expansion to the wastewater collection system to capture all wastewater flows becomes another priority for Mashhad.

Enhancing Performance Using ITU-T Recommendations:

Y Suppl. 36: ITU-T Y.4550-Y.4699: 'Smart water management in cities' provides municipalities, decision-makers and interested stakeholders with an overview of the main technical aspects that need to be considered to effectively design and implement smart water management in cities.

L Suppl. 15: ITU-T L.1500 series – 'Requirements for water sensing and early warning systems' illustrates the different technologies for sensing water quality indicators, in addition to early warning systems. The Supplement also demonstrates the most commonly measured water parameters and associated sensing technologies.

Category: Electricity Supply

Category	KPI	Result	Performance to Benchmark	SDG
	Smart Electricity Meters	3.72 %		
	Electricity Supply ICT Monitoring	100.00 %		
	Demand Response Penetration	3.02 %		
	Electricity System Outage Frequency	0.80		
	Electricity System Outage Time	70.87 Minutes		
	Access to Electricity	100.00 %		

The implementation of many smart city initiatives requires a stable electrical service to power the data centres and sensors that form the infrastructure needed. The KPI data reported show that Mashhad's electrical service is universal and reliable.

The KPI data also show that the implementation of a smarter grid is possible. Smart meter installations are currently in their infancy, and increasing the coverage will provide a greater understanding of the electrical usage and demand patterns across the city, as well as better data pertaining to it. Furthermore, the implementation of demand-response capabilities (either through time-of-day pricing or demand shedding) can be the basis for an overall campaign to manage and reduce electrical demand and mitigate the need for additional generation capacity.

Enhancing Performance Using ITU-T Recommendations:

Recommendation ITU-T Y.4000-Y.4999: 'Internet of Things and Smart Cities and Communities' contains guidance on IoT applications and ubiquitous sensor networking, including, for example, Recommendation ITU-T Y.4409: 'Requirements and architecture of the home energy management system and home network services'.

Category: Buildings

Category	KPI	Result	Performance to Benchmark	SDG
	Public Building Sustainability	Not Reported		
	Integrated Building Management Systems in Public Buildings	Not Reported		

Mashhad was unable to report on these KPIs. It is, therefore, strongly recommended that Mashhad collect and report on these two KPIs as an initial step and, if needed, invest in building sustainability assessments and ICT-based integrated building management systems for its public buildings.

For the development of more sustainable public (and private) buildings, Mashhad should review the goals, standards, and policies implemented in leading cities around the world. Goals could follow the lead of a city like Singapore, which is striving towards a target of 'greening' 80 per cent of its buildings by 2030, or by implementing policies and standard on sustainable design like the Toronto Green Standard[9]which provides sustainable design requirements for new private and city-owned developments.

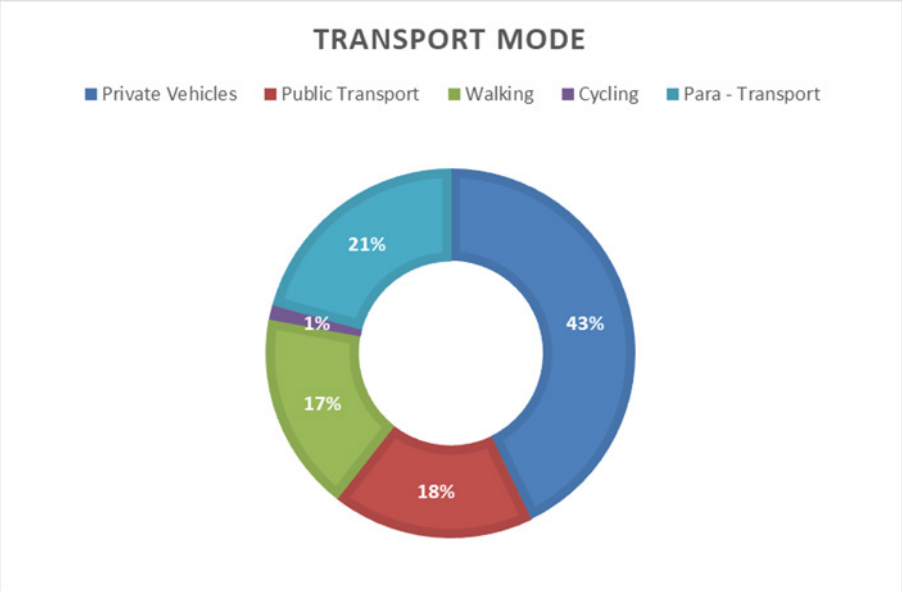
Enhancing Performance Using ITU-T Recommendations:

Mashhad should review the concepts presented in Recommendation ITU-T L.1370: 'Sustainable and intelligent building services'. This Recommendation sets the minimal requirements for the efficient and sustainable management of the building as a unit. It also defines the services enabled by the sustainable and intelligent building (SIB) concept, the way it contributes to the goals of sustainability, its features and possible functioning modes, its internal architecture, and requirements with the IoT node at its core.

It is also recommended that Mashhad implement Recommendation ITU-T L.1371: 'A methodology for assessing and scoring the sustainability performance of office buildings' as the basis for improving the sustainability of its public (and possibly) private buildings. This Recommendation provides a framework to critically assess and score ten key areas of environmental performance and management: Energy, Water, Air, Comfort, Health and Wellness, Purchasing, Custodial, Waste, Site, and Stakeholders. Use of this standard will allow Mashhad to develop baseline measures of building sustainability, a plan for improving building performance, and measure the effects of improvements on building performance.

Category: Transport

Category	KPI	Result	Performance to Benchmark	SDG
	Dynamic Public Transport Information	100.00 %		
	Traffic Monitoring	79.87 %		
	Intersection Control	90.55 %		
	Public Transport Network (per 100 000 inhabitants)	112.57 km		
	Public Transport Network Convenience	97.63 %		
	Bicycle Network (per 100 000 inhabitants)	4.40 km		
	Transportation Mode Share: Private Vehicles	42.83 %		
	Transportation Mode Share: Public Transport	17.72 %		
	Transportation Mode Share: Walking	17.38 %		
	Transportation Mode Share: Cycling	1.33 %		
	Transportation Mode Share: Para Transport	20.74 %		
	Travel Time Index	Not Reported		
	Shared Bicycles (per 100 000 inhabitants)	82.95		
	Shared Vehicles (per 100 000 inhabitants)	Not Reported		
	Low-Carbon-Emission Passenger Vehicles	0.00 %		



Traffic congestion continues to be an issue for Mashhad (and for most large cities). The excess traffic demand is related to an increasing number of new private vehicles, a lack of parking capacity, and explosive traffic demand in particular periods.[10] Traffic still tops the list of all urban issues, and is one of the most important concerns of citizens.[11]

A review of the performance in the transport categories shows that there are several areas of improvement in Mashhad. Mashhad's citizens have public transport options mainly comprising the metro/light rail system and the bus rapid transit system; however, private vehicles remain the preferred option. Private vehicle use is closely related to poorer air quality and higher GHG emissions given that, globally, private vehicles account for less than one-third of trips in cities worldwide but are responsible for 73 per cent[12] of urban air pollutants. Per capita, private cars generate three times more greenhouse gas emissions than public transport systems like buses.[13]

A 4th generation bicycle sharing network has been implemented and through a city-run website,[14] the public can check the availability of free public parking spots.

A better understanding of traffic flows and traffic congestion is helpful to prioritize areas for improvement. Measuring and understanding the Travel Time Index would be a useful start.

It is recommended that Mashhad further encourage greater use of local public transport over private vehicles and continues to prioritize modes of transport (e.g., walking and cycling) that do not contribute to the effects of climate change and do have associated health benefits.

Enhancing Performance Using ITU-T Recommendations:

Recommendation ITU-T Y.4456: 'Requirements and functional architecture for smart parking lots in smart cities' can also help guide measures to implement smarter parking to alleviate the issue of congestion and impeding of traffic flows, as automobiles search for parking spaces.

Category: Urban Planning

Category	KPI	Result	Performance to Benchmark	SDG
	Pedestrian Infrastructure	2.30 %		
	Urban Development and Spatial Planning: Compact	YES		
	Urban Development and Spatial Planning: Connected	YES		
	Urban Development and Spatial Planning: Integrated	YES		
	Urban Development and Spatial Planning: Inclusive	YES		
	Urban Development and Spatial Planning: Resilient	YES		

While Mashhad scores well on this KPI, creating additional pedestrian zones will help the city encourage its citizens and its tourists to walk and cycle more, and will provide additional places where people can engage socially, as well as creating a sense of community and reducing the environmental impact of the city. Pedestrian zones can also have a favourable impact on the tourism industry.

To be considered 'sustainable', urban plans should have the following five principles/elements listed with the KPIs, as demonstrated through evidence-based and innovative methodology (including data innovations like spatial analytics, GIS and Big Data).

While Mashhad reports that these policies are in place, urban sprawl related to unplanned or illegal construction has been, and continues to be, an issue. In recent decades, uncoordinated urban development has led to the city, and other urban spaces, becoming places that do not belong to the people. This sense of alienation and lack of belonging to such areas is increasing day by day, and irregular construction in the city has resulted in the loss of urban green spaces.[15]

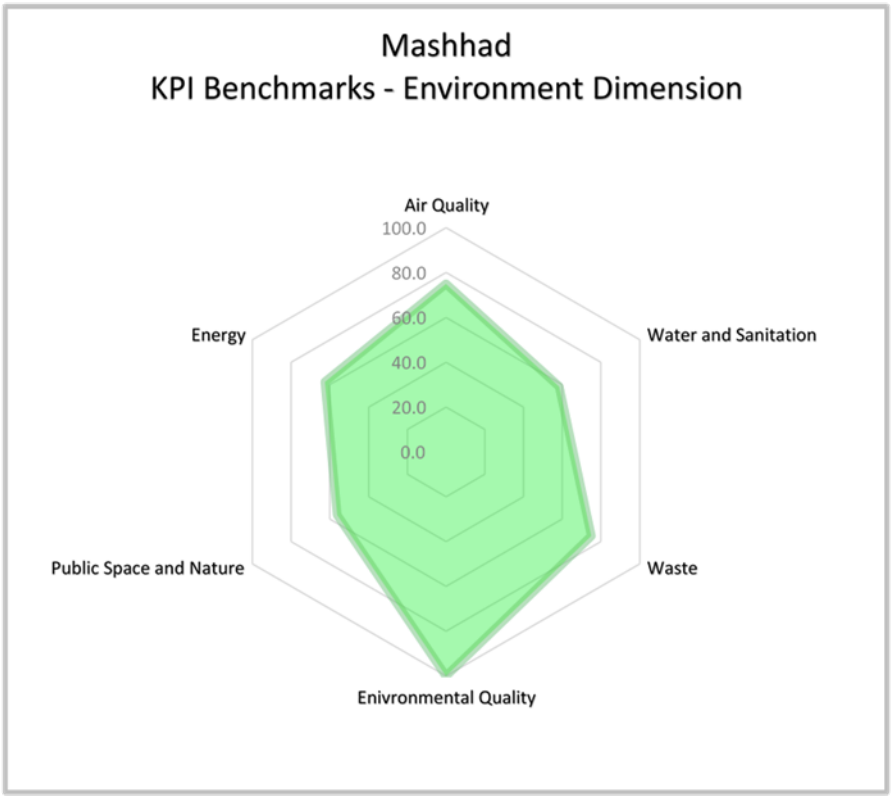
In response, Mashhad has implemented – as part of the Mashhad Initiative – systems for monitoring and preventing illegal construction by using unmanned aerial vehicles (UAV). With UAVs, Mashhad can detect new buildings or additions, additional walls, changes in grading and changes in tree cover.

Environment Dimension KPIs: Review of Data

The second U4SSC KPIs dimension is Environment. This dimension includes the sub-dimensions of Environment and Energy. The Environment sub-dimension covers a range of indicators classified according to categories, some of which can also be found in the first (Economy) dimension. The KPIs include those for air quality, water and sanitation, waste, environmental quality, and public space and nature. They aim to assess the use of ICTs in supporting urban environmental services and improving the overall environmental quality in cities.

The Energy sub-dimension includes all KPIs that report on energy. These KPIs aim to assess the use of renewable and sustainable sources of energy, as well as the city's energy-efficiency and energy- reduction measures. This dimension examines the level of ICT integration in supporting environmental sustainability and energy efficiency. These KPIs also provide a key baseline for future comparison, because achieving an efficient use of resources via ICTs will be fundamental to Mashhad's long-term environmental sustainability, and that of every other aspiring smart sustainable city.

The following diagram summarizes Mashhad's KPI performance detailing the categories within the Environment dimension against the current U4SSC benchmarks.



Category: Air Quality

Category	KPI	Result	Performance to Benchmark	SDG
	Particulate Matter (PM2.5)	25.70 µg/m^3		
	Particulate Matter (PM10)	41.20 µg/m^3		
	Nitrogen Dioxide (NO2)	73.90 µg/m^3		
	Sulphur Dioxide (SO2)	31.40 µg/m^3		
	Ozone (O3)	4.10 µg/m^3		
	GHG Emissions (eCO2 / capita)	7.49 tonnes		

Mashhad has implemented a website where citizens can see information on the air quality index in various parts of the city. While this is a good step towards increasing awareness of the problem, according to the World Health Organization (WHO) guidelines on the major components of air pollution,[16] Mashhad's current air pollution levels are at twice the level of the WHO recommended guidelines. Air quality not only affects citizens, it can also potentially affect the tourism industry as environmental concerns become more prevalent.[17]

The WHO air-quality guidelines estimate that reducing annual average fine particulate matter (PM2.5) concentrations from levels of 35 µg/m^3, which are common in many developing cities, to the WHO guideline level of 10 µg/m^3, could reduce air pollution-related deaths by around 15 per cent.[18]

Therefore, a concrete campaign to reduce the sources of air pollution, in particular those related to traffic congestion and the use of private vehicles, increasing air quality monitoring, and data collection and integration into the Mashhad Initiative, should be a priority for the city.

In terms of GHG emissions, the Islamic Republic of Iran has seen a 238 per cent increase in GHG emissions since 1990.[19] If it is assumed that Mashhad has followed the same path, then mitigation measures to reduce GHG emissions should be implemented.

Enhancing Performance Using ITU-T Recommendations:

Recommendations ITU-T Y.4207: Requirements and capability framework of smart environmental monitoring and ITU-T Y.4700/F.747.2: Y.4700: Deployment guidelines for ubiquitous sensor network applications and services for mitigating climate change can be used to manage the deployment of an expanded sensor network to monitor air quality.

Recommendations ITU-T such as L.1460: Connect 2020 greenhouse gases emissions – Guidelines and L.1470 Greenhouse gas emissions trajectories for the information and communication technology sector compatible with the UNFCCC Paris Agreement are available to provide further guidance in reducing the GHG emissions of the city.

Category: Public Space and Nature, and Environmental Quality

Category	KPI	Result	Performance to Benchmark	SDG
	Green Areas (per 100 000 inhabitants)	183.36 ha		
	Green Area Accessibility	47.29 %		
	Protected Natural Areas	9.00 %		
	Recreational Facilities (per 100 000 inhabitants)	15 579 m^2		
	EMF Exposure	Not Reported		
	Noise Exposure	5.50 %		

Quality of life in cities depends largely on the availability of attractive and accessible green spaces. It is generally agreed that urban green spaces are essential for the health and well-being of citizens.[20] While green spaces are prevalent, irregular construction in the city has resulted in loss of urban green spaces.[21] KPI data also show that accessibility to green spaces and the full protection of natural spaces are limited.

Noise exposure meets the benchmark but improvements to recreational spaces may be needed.

EMF exposure is not currently being measured.

Viewed through the lens of the tourism industry, it is evident that high-quality green spaces can support the success of the tourism industry by encouraging visits through the creation of attractive destination and enterprise imagery, and the provision of spaces in which activities, for example walking and wildlife watching, may be pursued.[22]

Therefore, a better living experience can be expected in a greener and less noisy city. While Mashhad performs well on these benchmarks, increasing green spaces and tree cover is an effective tool for climate change adaptation and should be encouraged.

Enhancing Performance Using ITU-T Recommendations:

Mashhad should refer to the ITU EMF Guide for more information and education resources on Electromagnetic Fields suitable for all communities, stakeholders and governments.[23]

Category: Water and Sanitation

Category	KPI	Result	Performance to Benchmark	SDG
	Drinking Water Quality	100.00 %		
	Water Consumption (per capita)	162.77 ℓ/day		
	Freshwater Consumption	100.00 %		
	Wastewater Treatment: Primary	95.55 %		
	Wastewater Treatment: Secondary	0.00 %		
	Wastewater Treatment: Tertiary	0.00 %		

The Islamic Republic of Iran is a country in which water resources are limited and under stress. As previously discussed, according to UN Water, the level of water stress in the Islamic Republic of Iran is currently in the high 75–100 per cent range and water use efficiency at the national level is less than USD 10 / m^3.[24]

While the quality of water is considered good, the optimization of water resources and the conservation of water should be primary concerns for Mashhad.

Although water consumption is at the lower end globally, with the Islamic Republic of Iran's more limited resources,[25] the KPI benchmark shows that improvements should be prioritized.[26]

The city should incentivize and prioritize water efficiency measures to preserve and protect the city's water sources and support its tourism industry. The re-use of greywater for other purposes may be a source of conservation to be explored.

Enhancing Performance Using ITU-T Recommendations:

ITU-T Y Suppl. 36: ITU-T Y.4550-Y.4699: 'Smart water management in cities' can be of help in this regard as the Supplement provides municipalities, decision-makers and interested stakeholders with an overview of the main technical aspects that need to be considered in order to design and implement smart water management in cities effectively.

This Supplement approaches smart water management systems from an overarching perspective. Therefore, it is expected that the smart water technologies described, as well as their integration into urban water management systems, can be relevant to inform the design of new systems (e.g., in the case of rapid urban growth and infrastructure extension), as well as to update existing systems.

Category: Waste

Category	KPI	Result	Performance to Benchmark	SDG
	Solid Waste: Landfill	78.87 %		
	Solid Waste: Burnt	0.00 %		
	Solid Waste: Incinerated	8.31 %		
	Solid Waste: Open Dump	0.00 %		
	Solid Waste: Recycled	11.19 %		
	Solid Waste: Other	0.00 %		

The KPI data demonstrate that most of Mashhad's solid waste is sent to landfill, which is not an optimal option. One of the problems with landfill disposal of waste is that many materials that end up as waste contain toxic substances. Over time, these toxins leach into our soil and groundwater and become environmental hazards for years. Electronic waste is a sound example of this. Waste such as televisions, computers and other electronic appliances contain a long list of hazardous substances, including mercury, arsenic, cadmium, PVC, solvents, acids and lead. Landfills can also be a source of leachate, a liquid formed when waste breaks down in the landfill and water filters through that waste. This liquid can be highly toxic and can pollute the land, groundwater and waterways. When organic material such as food scraps and green waste is put in landfill, it is generally compacted down and covered. This removes the oxygen and causes it to break down in an anaerobic process. Eventually, this releases methane, a greenhouse gas that is 25 times more potent than carbon dioxide in its effect on trapping heat.

Recognizing the need to address solid waste disposal by diverting waste from landfill, Mashhad has implemented a mobile application (SIMAP – Smart Recyclable Waste Collection) to improve its rate of waste recycling. The first phase of the project was implemented in one municipality region with over 65 000 citizens and after one year, the rate of recyclable waste collection doubled.

The second phase of the project has now been launched with private sector partnership and covers all city regions.

SIMAP was judged and was awarded the silver medal in the sustainable city category at the 4th WeGO Awards.[27]

Mashhad should continue to implement SIMAP and learn lessons from the implementation that can potentially be applied to other environmental issues where information and engagement are deemed to be important to engage inhabitants.

As with any smart city, as more and more ICTs are deployed and used by governments, companies and inhabitants, e-waste should be an area of focus to ensure long term sustainability of digital transformation initiatives.

Enhancing Performance Using ITU-T Recommendations:

ITU-T Series of Recommendations L.1000-L.1199: E-waste and circular economy provide standards and frameworks for the various aspects of e-waste management.

ITU-T L Suppl. 4: Guidelines for developing a sustainable e-waste management system provides a set of guidelines that can be referred to when designing or adjusting e-waste management systems.

Category: Energy

Category	KPI	Result	Performance to Benchmark	SDG
	Renewable Energy Consumption	0.32 %		
	Electricity Consumption (per capita)	2 378.01 kWh/yr		
	Residential Thermal Energy Consumption (per capita)	2.26 GJ/yr		
	Public Building Energy Consumption (per year)	26.48 ekWh/m^2		

The Islamic Republic of Iran as a country has seen a large increase in electricity consumption (415 % since 1990)[28] and the KPI data in this category show that renewable energy does not yet play a significant role in the energy mix. Electricity consumption, while on the higher side, is less that the Iranian national average of 3 300 kWh.[29]

Regardless of consumptions levels, reducing energy consumption is not only cost effective but also a measure needed to address global climate change. Opportunity also exists to make renewables a greater part of the energy mix to mitigate the effects of climate change.

Enhancing Performance Using ITU-T Recommendations:

When thinking about the ICT equipment used within the smart city eco system, Recommendation ITU-T L.1316: 'Energy efficiency framework' contains a framework of documents for collecting standards on energy efficiency metrics/key performance indicators (KPIs), measurement methodologies and energy management solutions for information and communication technology (ICT) equipment.

Society and Culture Dimension KPIs: Review of Data

The third U4SSC KPIs dimension is Society and Culture. This dimension covers the sub-dimensions of Education, Health and Culture, as well as Safety, Housing and Social Inclusion. As with the first two dimensions, each sub-dimension covers a range of indicators classified according to its categories.

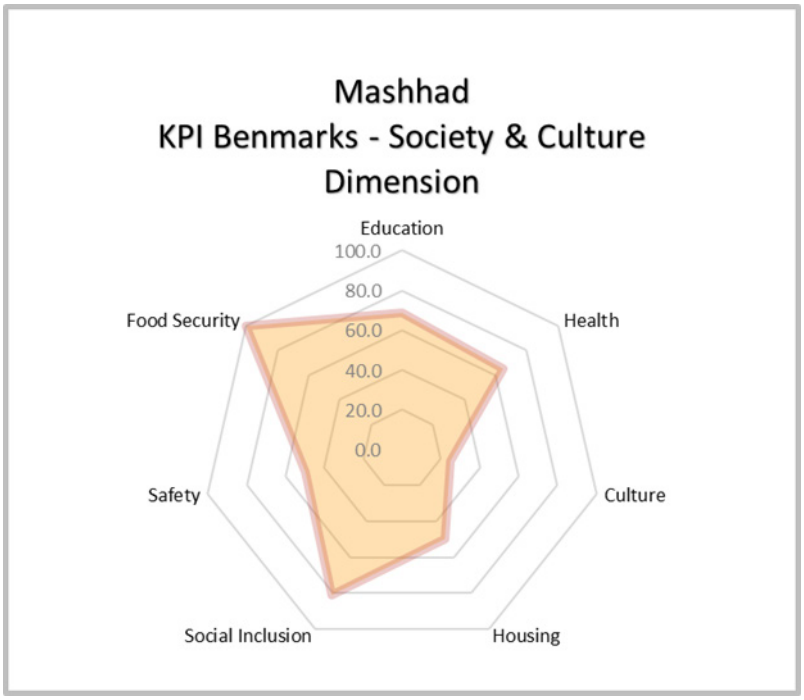
KPIs in Education, Health and Culture aim to assess the impact of the ICTs that improve citizens' quality of life. They focus on areas such as education, health and societal culture, among other aspects.

Safety, Housing and Social Inclusion contains a KPI related to food security, in addition to those related to Safety, Housing and Settlements and Social Encompassment.

These KPIs aim to assess the impact of the use of ICTs to promote urban equity and citizen participation, and to enhance social inclusiveness. They focus on the themes of openness, public participation and transparency in governance. The KPIs that measure citizens' quality of life and the extent of ICT implementation in the education, health and safety sectors are also included here.

There is an emphasis on developing the foundation that allows for the creation of electronic platforms for public and private sector use. Such platforms lay the groundwork for more transparent and efficient governance and maintain the inclusiveness of the city inhabitants as stakeholders pivotal to the city's decision-making processes. They ensure that the health, education and safety services are deployed with the least amount of disruption, waiting times and manual intervention possible.

The following diagram summarizes Mashhad's KPI performance detailing the categories within the Society and Culture dimension against the current U4SSC benchmarks.



Category: Education

Category	KPI	Result	Performance to Benchmark	SDG
	Student ICT Access	79.58 %		
	School Enrolment	92.71 %		
	Higher Education Degrees (per 100 000 inhabitants)	13 270		
	Adult Literacy	93.34 %		

The ultimate goal of all smart city efforts and aspirations is to increase quality of life and ensure (economic) prosperity for all. The residents of a city or community play a crucial role in creating and implementing the right processes and solutions. Technology and data are key enablers, but without the smartness of people proper engagement will not be achieved.[30] Therefore, one of the key functions to enable a smart, sustainable city is for the population to have the requisite skills and training to develop and enable smart city applications and to be able to interact competently with the resulting programmes; and Mashhad understands this with its slogan 'Smart City, Smart Citizen'[31].

Keeping this focus on smart citizens in view, these KPIs show that Mashhad has the capacity to further develop these smart citizens, by increasing school enrolment at all levels, and increasing ICT access in schools.

Category: Health

Category	KPI	Result	Performance to Benchmark	SDG
	Electronic Health Records	Not Reported		
	Life Expectancy	76.00 Years		
	Maternal Mortality Rate (per 100 000 live births)	27.58		
	Physicians (per 100 000 inhabitants)	377.86		
	In-Patient Hospital Beds (per 100 000 inhabitants)	213.90		
	Health Insurance / Public Health Coverage	69.86 %		

This set of KPIs signifies mostly average health-related outcomes for Mashhad's citizens, with defined opportunities for improvement. However, the city has reported a higher value for maternal mortality rate than the national average of 16 deaths per 100 000 live births.[32] There may be lessons to be learned at the national level, given that the Islamic Republic of Iran has seen a 70 per cent reduction in maternal mortality rates since 2000.[33]

The COVID pandemic has shown the benefits of e-health systems in providing care without the need for personal contact. Mashhad should determine the implementation of e-health systems within the city, and possibly use the lessons learned in other smart city initiatives to achieve further progress in this area.

Enhancing Performance Using ITU-T Recommendations:

Mashhad should consider the benefits of and guidance in Recommendation ITU-T Y.4408/Y.2075: 'Capability framework for e-health monitoring services', and Recommendation ITU-T Y.4110/Y.2065: 'Service and capability requirements for e-health monitoring services' to implement and optimize e-health service provision to assist in the development of e-health systems and programmes that are currently lacking.

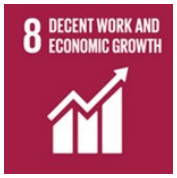
Category: Culture

Category	KPI	Result	Performance to Benchmark	SDG
	Cultural Expenditure	0.09 %		
	Cultural Infrastructure (per 100 000 inhabitants)	58.62	No benchmark available	

Mashhad, as the centre of religious pilgrimage in the Islamic Republic of Iran, is blessed with a significant cultural infrastructure, the most significant being the Imam Reza shrine. Mashhad is also home to one of the oldest libraries in the region, the Central Library of Astan Quds Razav.

As Mashhad city is the main tourist destination in the Islamic Republic of Iran, it is recommended that the city planners continue to invest in the maintenance and upkeep of the city's cultural and religious heritage, in particular the Imam Reza Holy Complex, which has been submitted for listing as a world heritage site.

Category: Housing and Social Inclusion

Category	KPI	Result	Performance to Benchmark	SDG
	Informal Settlements	30.04 %		
	Housing Expenditure	24.41 %		
	Gender Income Equity (Ratio of Female : Male)	1.00		
	Gini Coefficient	0.35		
	Poverty Rate	Not Reported		
	Voter Participation	76.00 %		
	Childcare Availability	0.12 %		

There are significant results from this category, the first being that equality is, from an income perspective, very good. The other significant result is that a considerable proportion of the population lives in informal settlements, with much of the buildings in these informal settlements constructed using unstable structures and materials.[34]

Housing may be the most important element of the city that relates directly to the sustainable development of the city. Consequently, sustainable housing to enhance and improve the quality of life of present and future generations needs to be addressed. Housing should be considered

from various perspectives, including architecture, building construction, residential buildings, land and building costs, housing loans, the housing market, housing regulations, house prices, and desirable housing.

The poverty rate was not reported. (It is highly recommended that this be undertaken.) One of the indirect indicators for measuring poverty can be the prevalence of informal settlements. From such an indicator, it could be assumed that this is also related to the poverty rate, given that according to research conducted, every year the lower income group has limited access to housing. Apart from individuals' social class and economic conditions, housing is always one of the most important needs and priorities of the household.

Informal settlements could, potentially, be addressed by drafting urban planning, architecture and housing construction in accordance with international standards. They could be addressed further by enhancing their flexibility and encouraging activities that benefit low-income groups, as well as by changing the views and plans of urban development projects accordingly.[35]

Category: Safety and Food Security

Category	KPI	Result	Performance to Benchmark	SDG
	Natural Disaster-Related Deaths (per 100 000 inhabitants)	0.00		
	Disaster-Related Economic Losses (relative to City GDP)	1.01 %		11 SUSTAINABLE CITIES AND COMMUNITIES
	Resilience Plans	No		
	Population Living in Disaster-Prone Areas	12.23 %		
	Emergency Service Response Time	Not Reported		
	Police Service (per 100 000 inhabitants)	Not Reported		3 GOOD HEALTH AND WELL-BEING
	Fire Service (per 100 000 inhabitants)	35.63 FTE		
	Violent Crime Rate (per 100 000 inhabitants)	Not Reported		16 PEACE, JUSTICE AND STRONG INSTITUTIONS
	Traffic Fatalities (per 100 000 inhabitants)	6.27		3 GOOD HEALTH AND WELL-BEING
	Local Food Production	70.00 %		2 ZERO HUNGER

The KPI data indicate that although a substantial portion of Mashhad's population is vulnerable to national disasters, the city has managed to minimize the loss of life. Local food production lies in the top range of cities that have been assessed. Traffic fatalities and the economic costs of disasters remain an area of progress to be reviewed, particularly for a city focused on tourism.

The opportunity to further collect and report KPIs in this category should be explored to provide a more detailed view of this category.

Enhancing Disaster Response: As Mashhad builds up its smart city initiatives and digital network, the city should review the approach in Recommendation ITU-T L.392 Disaster management for improving network resilience and recovery with movable and deployable information and communication technology (ICT) resource units for guidance on improving network resilience against disasters and assisting in network recovery after disasters.

As the effects of climate change are making the possibility of severe weather more likely, Mashhad is encouraged to take steps to protect its ICT infrastructure. Recommendation ITU-T L.390: Disaster management for outside plant facilities gives an overview of the technical considerations for protecting outside plant facilities from natural disasters, and Recommendation ITU-T L.391: Monitoring systems for outside plant facilities deals with monitoring systems to mitigate damage, and to secure outside plant facilities against disasters.

Mashhad: Key Findings and Conclusions Across the KPIs

KPIs Reporting and Engagement

This has been the first year of Mashhad's collaboration with ITU on this project that is designed, in part, to assist Mashhad and other cities in evaluating their progress to becoming smarter and more sustainable, and to meet the SDGs.

Within the framework of the U4SSC KPIs, ITU undertook a two-part approach to the indicators by preparing a basic set of core indicators that can be reported easily by most cities, along with a list of advanced indicators. The advanced indicators can be reported by cities that have attained good scores on the basic indicators. Mashhad successfully reported on 91 per cent of all core U4SSC indicators, and also on 84 per cent of all advanced indicators.

Mashhad was unable to report on the KPIs listed below. To obtain a full picture of the city's performance, Mashhad should carry out a review and determine how to collect data for these indicators:

- Travel Time Index
- Shared Vehicles
- R&D expenditure
- Public Building Sustainability
- Integrated Building Management Systems
- EMF Exposure
- Electronic Health Records
- Poverty
- Emergency Service Response Time
- Police Service

It is recommended that to evaluate Mashhad's progress towards becoming smarter and more sustainable, the data collection for the KPIs continue on a regular basis. Collecting data at regular intervals will enable the effectiveness of the programmes to be evaluated by measuring year-over-year trend analysis, and by progress benchmarking.

Mashhad should work closely with other Iranian cities – and similar cities around the world – on its SSC efforts, in order to leverage any best practices and shared experiences in developing and instituting smart sustainable policies and initiatives in the region. In addition, collaborative research programmes with local universities are encouraged. University students at all levels of study are an untapped resource that can be harnessed to provide the students with local research resources and real-life experience. Regular knowledge-sharing and discussions with ITU members and other international cities are also encouraged and can be facilitated through the U4SSC programme.

SDG View

The KPIs were developed to provide an overview of progress in the SDGs, particularly at the local level. While most of the KPIs relate to SDG 11, Sustainable Cities and Communities, data collected will also provide information on progress for most of the other SDGs. What follows is an overview of progress to the SDGs at the local level.

	The data needed for the SDG was not collected. However, the data on informal settlements indirectly show that significant progress may be needed in order to meet the goal of this SDG.
	Based on the data reported for local food production, progress in this SDG goal would be on track.
	Based on the data reported for traffic fatalities and the health KPIs, progress is lagging and will need attention with respect to this SDG goal.
	Based on the data reported, there is a lack of childcare, and education enrolment also is below optimum. Progress on this SDG is not on track.
	Based on the data reported, water is clean and available, but being in an area of high-water stress, losses in the system are a concern. The usage of water resources can be seen as not sustainable in the future. Progress on SDG is not on track.
	Based on the data reported, the electrical distribution infrastructure is excellent. Consumption needs to be reduced and renewable energy implemented to meet the goal of this SDG. Progress to the goal of this SDG is not on track
	Based on the data reported, income equality is very good, but unemployment is high and needs to be addressed to meet goal of this SDG. Progress to the goal of this SDG is not on track.
	Based on the data reported for ICT infrastructure and innovation, progress to the goal of this SDG is tracking positive.
	Based on the data reported for the GINI coefficient, progress to the goal of this SDG is tracking positive.
	Based on the data reported. significant improvements are needed to meet the goals of this SDG. Levels of air pollutants are above WHO guidelines. Expenditure on culture (in particular for a city based on cultural and religious tourism) is sub-optimal. Overall energy consumption is high. While green areas are available, there is a concern with how effective the city's planning and policy processes are to counteract urban sprawl, informal settlements and loss of green space. Traffic, and the resulting air pollution need to be addressed. Progress to the goal of this SDG is not on track.
	Based on the data reported, the waste infrastructure is in place and programmes to increase recycling are making an impact. Progress to the goal of this SDG is tracking positive.
	Based on the data reported, GHG emissions are not near enough to the required levels. Progress to the goal of this SDG is not on track.
	Based on the data reported for voter turnout and open data, there is progress to the goal of this SDG.

Mashhad Initiative

- The Mashhad initiative has had successes in the implementation of technology projects. These projects are summarized in the Appendix. The Mashhad Initiative as reviewed is focused mainly on technology implementation and projects. As an improvement to the Initiative, Mashhad should provide a clear horizon and systematic plans through taking into account the variety of different aspects involved in any smart city programme.[36]
- Comparison with the good practices of smart cities elsewhere (e.g., Amsterdam, Moscow or Barcelona), where there is a clear linkage from strategy, goals and targets to projects, and thereafter monitoring and measurement is recommended so that the Initiative can be refined.
- As a further improvement to the initiative, Mashhad should also link sustainability goals and targets to the outcomes of technology projects, and to the overall strategic plan of the Initiative.
- In addition, the Initiative should link to the pressing problems of the city (traffic, water, urban sprawl, air pollution) and to the major economic activity of tourism. This linkage can be mapped to KPIs, SDGs and projects to provide a better understanding of the linkages, and which KPIs are the most relevant to measure and monitor success. This could be built out based on the example below.

Issue	Impact on Economy	Impact on Environment / Sustainability	Impact on Quality of Life	Initiative Projects
Traffic congestion	Tourist dissatisfaction	Poor air quality	Greater commute times	Smart signage
		Increased noise pollution		Improvements in ITS
				Improvements in public transport

- In developing solutions for these city issues Mashhad can take guidance from the U4SSC publication City Science Application Framework,[37] which provides a four-step methodology for cities to solve their pressing urban challenges. By using empirical evidence as the basis for evaluation, the city science application framework offers a reliable and consistent way for Mashhad to assess, prioritize and boost city applications.
- Guidance on improvements to the Mashhad Initiative are also available through a variety of ITU-Recommendations including, in particular the Y.4000-Y.5000 supplements: Supplements to the Y-series Recommendations related to IoT and SC&C which includes, among others Y Suppl. 32: ITU-T Y.4000 series – Smart sustainable cities – A guide for city leaders and Y Suppl. 33: ITU-T Y.4000 series – Smart sustainable cities – Master plan.
- The Mashhad Initiative started with a study of the level of smart maturity of the city's services. Mashhad should now move to integrate a regular review of maturity through the KPIs to measure ongoing progress. Mashhad (and other cities) are encouraged to use Recommendation ITU-T Y.4904: Smart sustainable cities maturity model as a framework to determine their interim target

values for KPIs by taking into consideration their priorities, constraints, resources and optimal KPI performance levels. The SSC-MM is another tool that can be used to communicate progress to stakeholders, to help further refine the Mashhad Initiative and smart sustainable city strategy. Details are available in the appendix.

KPIs

- Mashhad should review each category in the data review section for guidance on ITU-T Recommendations that are directly related to the needs of the city.
- Mashhad should focus on KPI results in the 0–33 per cent of target range and that are also reflected in the city's priorities. The KPIs related to traffic, air quality, informal settlements and water availability should be put under scrutiny.
- The basic utility infrastructure of the Mashhad (ICT, water, electricity, waste collection) meets the needs of the city.
- The services delivered online by the city, the development of a city portal to provide inhabitants with a vast array of information, is a strong outcome of the Mashhad Initiative.
- The open government portal is a good demonstration of the strength of the city in providing transparency in local government financial status and performance.
- The electronic micropayment systems implemented are excellent tools not to only gather information on public transit usage but also to increase its use.
- Tourism is the major industry and employer in the city. As such, Mashhad should determine the private sector employment within the tourism sector. It is also important for the needs of this economic sector to be reflected in the Mashhad Initiative and to ensure that the needs of tourism and tourists are an ongoing and integral part of the smart city strategy and plans.
- With Mashhad being in an area of high-water stress, water management and conservation should be an increasing priority for the city administration, and smart water planning should implemented within the smart city strategy.
- Smart electrical meter installations are currently at a nascent stage within the city. Smart electrical meters are key for better understanding and collection of data related to the electricity usage and demand patterns across the city. To implement smarter grids within the city (to manage the demand and reduce consumption) will require increasing the coverage of electrical smart meters as an initial step.
- Traffic congestion and the resulting poor air quality are issues that require a high priority of action. The map.mashhad.ir website provides citizens with up-to-date information on traffic and air quality. There needs to be a strong connection from the data collected to programmes that can then positively counteract the negative environmental considerations. Traffic reduction strategies such as congestion charging for specific areas or specific times should be considered, in addition to upgrades to the current intelligent transportation systems.

- Mashhad should evaluate the success of the SIMAP waste recycling programmes to learn why it was successful and implement the lessons learned to address other environmental issues.
- Mashhad is the main tourist destination in the Islamic Republic of Iran. It is highly recommended to continue and increase investment in the maintenance and upkeep of the city's cultural and religious heritage.
- The COVID pandemic has shown the benefits of e-health systems in providing care without the need for personal contact. Mashhad should determine the implementation of e-health systems within the city and possibly use the lessons learned in other smart city initiatives to further progress in this area and consider the benefits and guidance within Recommendation ITU-T Y.4408: 'Capability framework for e-health monitoring services' and Recommendation ITU-T Y.4110: 'Service and capability requirements for e-health monitoring services'.

More information on the SDGs, the U4SSC initiative, can be found in the Appendix.

At this time, ITU would like to invite cities around the world to implement the U4SSC KPIs for SSC. Using the U4SSC KPI definitions and data-collection methodologies, all cities will be in a better position to establish clear data-collection methodologies, collect data consistently in a structured way, develop goals and targets for each KPI and collect data regularly to track their progress towards smart sustainable goals.

Appendix

Mashhad Initiative

Improving ICT infrastructure

Based on the ITU smart sustainable city definition used in the Mashhad smart city action plan, the ICT organization of Mashhad has two important and major duties:

- To strengthen the city's ICT backbone
- To provide the inhabitants with reliable services
- To strengthen the city's ICT backbone, Mashhad has implemented a city data centre and related disaster recovery sites, which can store and maintain more than 1 000 physical servers for urban IT services and management. The disaster recovery sites ensure that Mashhad can continue operations until it becomes safe to resume work at the usual location or at a new permanent location.
- To improve service reliability and capacity, Mashhad has installed more than 400 km of urban optical fiber to facilitate reliable communication.

Developing Electronic Services

More than 150 electronic services have been developed in five main urban service sections:

- Urban planning and civil construction
- Transportation services
- Public and green spaces services
- Cultural and social services
- Contact centre

Of these services, 57 electronic services can be accessed by citizens through the municipal One-Point portal – sm.mashhad.ir.

The web portal is a centralized service platform where citizens can submit and follow requests in the following areas as examples:

- Payment of city taxes
- Parking subscriptions
- Shared bike registrations
- Membership in neighborhood social councils
- Tree planting and removal requests
- Payment of construction and car tolls
- Cargo permits
- Renting of public sports halls
- Charging the city NFC card
- Registration of NFC cards for the disabled

Furthermore, these services are also available through an integrated mobile super app (ShahreMan application).

Urban Electronic Micro Payment

Mashhad has developed a city initiative to provide electronic micropayment tools, including special services for people with disabilities. The goals it to replace cash and traditional payment for public transportation and other urban micro payments transaction. There are two major methods for electronic payment: the MAN Card and the E-Wallet.

MAN Card

The MAN Card was established in 2008 to replace cash and ticket payments in the public transportation system specialty buses. Since then, over 6 million cards have been issued for citizens and tourists and more than 300 million transactions are conducted annually through the MAN card.

MAN, cards are also integrated with NFC enabled SIM cards, so that public transportation payments can be done directly through NFC enabled mobile phones.

Figure 1: MAN Card illustration



Citizens can charge their MAN Cards through a mobile application, charging stations, smart kiosks and through a web portal. https://mancard.mashhad.ir/index.php

MAN Cards are also personalized especially for people with disabilities with extra features and discounted fares for public transportation.

E-Wallet

The second electronic payment system that Mashhad has developed is an urban exclusive e-wallet which enables payments through smartphones by scanning QR codes.

The E-Wallet can be used for the payment of various modes of public transportation (bus and subway), taxies and shared bicycles; it can also be used in chain stores, urban expos and many other places.

Figure 2: E-wallet illustration



Spatial Data infrastructure

Mashhad has implemented several projects related to using and maintaining the spatial data of the city. Spatial data can be key for knowing where assets within the city are located, and can also be used to record various maintenance and repair activities. Base map services are provided for all urban applications.

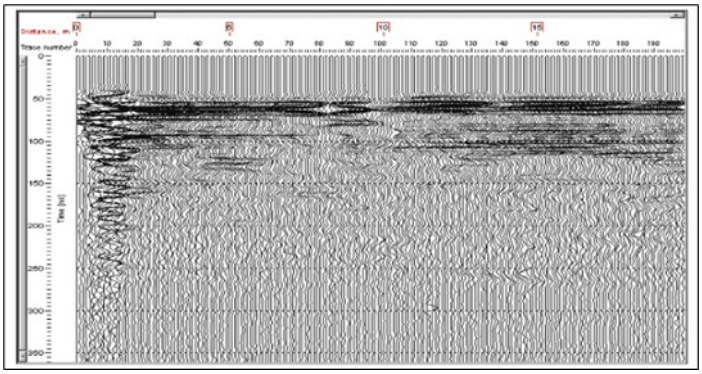
Up-to-date data are provided by using new methods of data collection:

- Ground-penetrating radar (GPR)
- Real-time kinematic positioning (RTK)
- Unmanned autonomous vehicles (UAV)

Ground-penetrating radar

Ground-penetrating radar (GPR) is a geophysical method that uses radar pulses to image the subsurface. It is a non-intrusive method of surveying the subsurface to investigate underground utilities such as concrete, asphalt, metals, pipes, cables or masonry. This non-destructive method uses electromagnetic radiation in the microwave band (UHF/VHF frequencies) of the radio spectrum, and detects the reflected signals from subsurface structures. GPR can have applications in a variety of media, including rock, soil, ice, fresh water, pavements and structures. In the right conditions, practitioners can use GPR to detect subsurface objects, changes in material properties and voids and cracks.

Figure 3: Example of GPR scan



Real-time kinematic positioning (RTK) – (https://rtk.mashhad.ir)

Real-time kinematic positioning (RTK) is the application of surveying to correct for common errors in current satellite navigation (GNSS) systems. It uses measurements of the phase of the signal's carrier wave in addition to the information content of the signal and relies on a single reference station or interpolated virtual station to provide real-time corrections, thereby providing up to centimetre-level accuracy.

Mashhad's steps in the installation and implementation of the RTK network included:

- Testing the accuracy of different brands in difficult conditions in the city
- Location of stations based on relevant principles
- Installation of fixed stations
- Software installation and server deployment
- Network stability testing
- Deployment

Smart and New Technologies

Smart signage

Figure 4: Smart signage in Mashhad



Smart signage is an information network that is located on main streets and intersections of the city, in public parks, near public parking locations and other areas where needed. The signage provides a variety of real-time information for citizens such as air quality index, public parking free spaces, shared bike usage rates, prayer times and other pertinent information for citizens.

Smart recyclable waste collection – SIMAP (Smart Recyclable Waste Collection)

Mashhad had an issue that needed to be addressed. The recyclable waste separation at source rate in the city of Mashhad was about only about 11 per cent.

To improve this recycling rate, Mashhad developed SIMAP, a mobile application to provide information on waste recycling streams to encourage people to improve their participation in waste separation and recycling.

The goal of this public-private partnership is to:

- Reduce waste and increase recycling
- Conserve natural resources
- Prevents pollution
- Save energy

Figure 5: Mashhad WeGo certificate



The first pilot phase of project was implemented in one region with over 65 000 citizens, and after one year of running the project, the recyclable waste collection rate had increased by 100 per cent in that region.

The second phase was implemented with private partnership and covered all city regions.

To achieve success in this kind of project implementation of this application is not enough – this infrastructure must be available and accessible to, and acceptable by, almost all citizens.

SIMAP was entered in Sustainable City category for the 4th WeGO awards competition in 2020 and was awarded the silver medal in that category.[38]

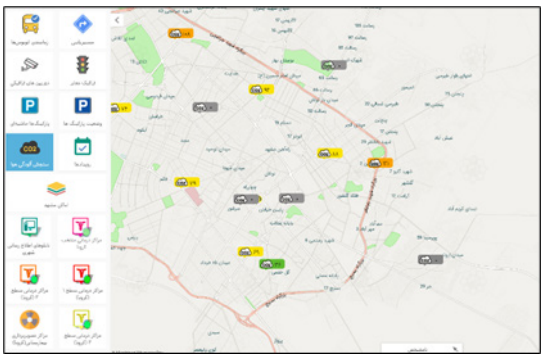
IOT-based projects

Various projects have been implemented using the power of IoT devices and sensors deployed throughout the city.

These projects include:

- Air quality index and air pollution monitoring
- Wearable devices like the Smart Health system and indoor tracker
- Traffic, vehicle and parking space monitoring
- Water resource and drainage management

Figure 6: CO_2 monitoring on 'ap.mashhad.ir'



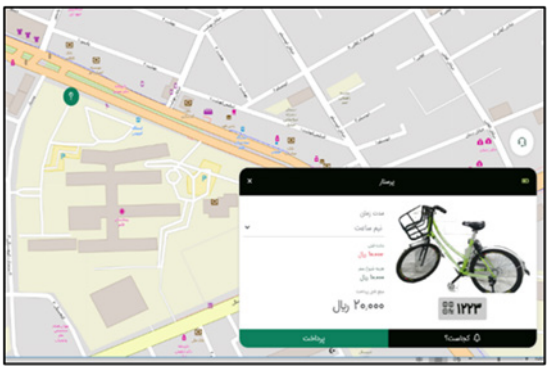
Using the 'ap.mashhad.ir' website allows citizens to obtain various kinds of urban information; for instance, the air quality index in different parts of the city, traffic conditions, bus routings, bus locations, bus arrival times, public parking free spaces, COVID-19 medical centres and various places in the city that are updated by crowd sourcing method, and much more urban information.

Shared bicycles

Mashhad has implemented a 4th generation shared-bicycles programme.

4th generation programmes are defined by real-time availability and GPS tracking bicycles. This allows citizens to locate a bicycle on a map through GPS trackers on the bicycle, make a reservation, use the bicycle and then lock it down.

Figure 7: Bicycle sharing website



Urban Observatory

In 2018, the Urban Innovation Centre in Mashhad was put into operation to establish a link between urban management and emerging technologies.

The conceptual model of the Mashhad Urban Observatory was that it first forms an urban data warehouse by collecting data and information from local organizations. In the next step, according to the key issues of Mashhad city, as well as the approaches of the urban observatory, scenario making, analysis and indexing are applied to these statistics and information and the products are presented in understandable and transparent formats for different stakeholders. It should be noted that the display window for each of the stakeholders is different according to their particular goals and responsibilities, and the display content is filtered for each of them.

The goals of the observatory are:

- Preparing and providing data, data bank data infrastructure, data visualization, indicators and criteria
- Creating a network of knowledge sharing and participation among different parts of government, universities and researchers (establishing a knowledge management cycle)
- Coordinating between stakeholders, and creating partnerships between public and private organizations
- Creating a decision-making system for urban planning
- Developing decision-making and simulation models
- Ensuring the comprehensive, sustainable and balanced growth of urban areas
- Expanding communication with the global network of partners and stakeholders

Open Government Data

Mashhad continues to develop and make available open data sets through its Open Government Portal. This portal allows citizens to monitor data streams, thereby improving the accountability and transparency of government. Under the principle of good and smart governance, the portal is also intended to make citizens aware of important issues, and be part of the decision-making process to address policy alternatives.

Published data include following items:

- Municipal budget
- Tenders and auctions
- Project status
- Contracts
- Vendors
- City managers and organizations board members

Figure 8: Mashhad Open Government Portal



Electronic Services on Social Networks

The final pillar of the Mashhad initiative consists of providing electronic services through locally based and global commercial social networks.

These networks are used to:

- Follow up citizen requests
- Conduct micropayments and payments of city tolls
- Give information to citizens

Figure 9: Local social network interface to electronic services



United for Smart Sustainable Cities (U4SSC)

United for Smart Sustainable Cities (U4SSC) is a UN initiative coordinated by ITU, UNECE and UN- Habitat, and supported by CBD, ECLAC, FAO, UNDP, UNECA, UNOPS, UNESCO, UNEP, UNEP-FI, UNFCCC, UNIDO, UNU-EGOV, UN-Women and WMO to achieve Sustainable Development Goal 11: 'Make cities and human settlements inclusive, safe, resilient and sustainable'.

U4SSC advocates public policy to encourage the use of digital technologies toward facilitating and easing the transition to smart sustainable cities (SSC) by catapulting key successful smart city measures into the spotlight for consideration.

It is currently working on five thematic groups:

- City Platforms
- Economic recovery in cities and urban resilience building in the time of COVID-19
- Innovative Financing Instruments for Smart Sustainable Cities
- Guiding principles for artificial intelligence in cities
- Procurement Guidelines for Smart Sustainable Cities

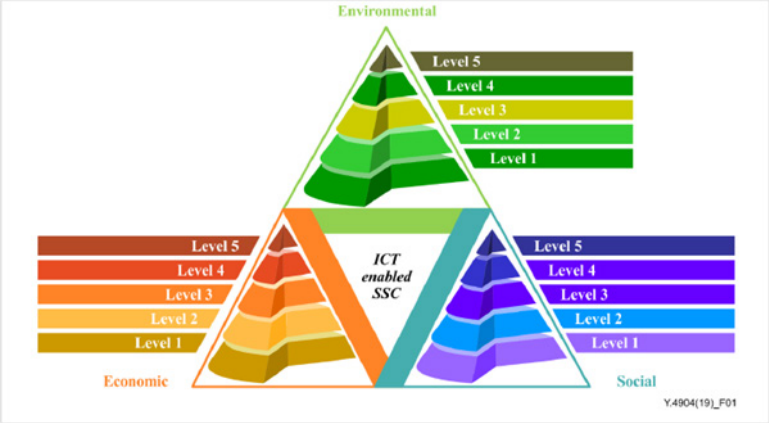
To find out more on the U4SSC initiative, visit: itu.int/go/u4ssc.

Smart Sustainable City Maturity Model

The Smart Sustainable City Maturity Model (SSC-MM) defines five levels of maturity in the process of becoming a smart and sustainable city with each level achieved being a higher level of maturity. The requirement to reach the intended maturity level is to achieve the target KPI values set for each maturity level.

As an example, for KPI Household Internet Access, a level 1 maturity level could be to collect the initial benchmark data.

Figure 10: Smart sustainable city maturity model (SSC-MM)



The other four levels could then be set as performance levels such as level 2 achieved at 30 per cent access, level 3 at 50 per cent access, level 4 at 70 per cent access and level 5 at 90 per cent access.

This can then be overlaid with maturity level performance for the other dimensions to provide insight into the issues that need to be addressed within each city in order to become smarter and more sustainable.

Available at: Recommendation ITU-T Y.4904: Smart sustainable cities maturity model

U4SSC Implementation Programme (U4SSC-IP)

The U4SSC Implementation Programme (U4SSC-IP) supports the implementation of projects, and builds partnerships for smarter and more sustainable cities worldwide.

To find out more on the U4SSC Implementation Programme, visit: https://www.itu.int/en/ITU-T/ssc/united/Pages/U4SSC-IP.aspx.

U4SSC in the International Context

The United Nations Sustainable Development Goals (SDGs)

> *'A smart sustainable city is an innovative city that uses information and communication technologies (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, environmental as well as cultural aspects.'*
>
> *(ITU and UNECE, 2015)*

The Sustainable Development Goals (SDGs) are a collection of 17 global goals set by the United Nations (UN) in 2015 as an urgent call for action by all countries – developed and developing – in a global partnership.[39] They recognize that ending poverty and other deprivations must go together with strategies that improve health and education, reduce inequality, and spur economic growth – all while tackling climate change and working to preserve our oceans and forests.

The goals are broad and somewhat interdependent, yet each has a separate list of targets to achieve. The SDGs cover social and economic development issues that include poverty, hunger, health, education, climate change, gender equality, water, sanitation, energy, economic growth, innovation, sustainability, responsible consumption, environment, social justice and partnerships. There are 169 targets for the 17 goals; achievement of all targets signals the accomplishment of all 17 goals. Twenty of the targets are quantitative in nature, while the majority are more qualitative.

The SDGs were presented as part of the 'Transforming our World: 2030 Agenda for Sustainable Development'. The 2030 Agenda was developed to succeed the Millennium Development Goals (MDGs), which ended in 2015. Unlike the MDGs, the SDGs framework does not distinguish between 'developed' and 'developing' nations; instead, the goals are meant to apply to all countries.

Localization, i.e., implementation of the SDGs, started worldwide in 2016. To further the progress of this localization, the SDGs are being promoted globally through several initiatives and advocacy platforms that are coordinated and supported by various UN programmes and agencies, including U4SSC in cities.

Meeting the SDGs is important for any city – particularly aspiring smart sustainable cities – because the SDGs framework is designed to help cities recognize priorities and establish long-term goals. The SDGs are designed to reveal the interdependent dynamics within various facets of sustainable development such as economic, social, and environmental conditions. The goals are meant to show, for example, how continued reliance on fossil fuels affects not only climate change and air quality but also public health, which then negatively impacts poverty rates and economic opportunities. By working within the SDGs framework, policymakers can get to the root of their cities' issues.[40]

Also, the analytical framework of the SDGs lends itself to the use of clear baselines to improve internal planning and implementation. Other benefits include gap analysis, infusing priorities into a budget process, cutting programming redundancies and saving resources, and tracking outcomes. Cities can also engage across the global network of other governments and institutions that are pursuing the same goals. The SDGs framework is also effective at different scales, offering the opportunity to align and harmonize policies and common goals vertically (up and down government jurisdictions), as well as horizontally (across city agencies). Therefore, if integrated and managed well, the SDGs can help strengthen local communities through values such as transparency, inclusion, and engagement.

New Urban Agenda

The New Urban Agenda[41] represents a shared vision for a better and more sustainable future. It was adopted at the UN Conference on Housing and Sustainable Urban Development (Habitat III) in Quito, Ecuador, on 20 October 2016. Habitat III had the convening power to bring together all actors to identify solutions for the complex challenge of urbanization, including Member States, multilateral organizations, local governments, the private sector and civil society. It helped to systematize the alignment between cities and towns and national planning objectives in their role as drivers of national economic and social development.

Urbanization is an unprecedented challenge, indeed. By the middle of the 21st century, four of every five people might be living in towns and cities. Urbanization and development are inextricably linked, and it will always be necessary to find a way to ensure the sustainability of growth.

The New Urban Agenda is premised on the basis that if well-planned and well-managed, urbanization can be a powerful tool for sustainable development and poverty reduction, for developing and developed countries alike. Governments can respond to this key development opportunity by promoting a new model of urban development that is able to integrate all facets of sustainable development to promote equity, welfare and shared prosperity. The model would focus on all levels of human settlements, including small rural communities, villages, market towns, intermediate cities and metropolises for social and economic growth.

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