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Supplement

ITU-T Y Suppl. 77 (09/2023)

SERIES Y: Global information infrastructure, Internet protocol aspects, next-generation networks, Internet of Things and smart cities

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ITU-T Y.4051 – Digital transformation for people-centred smart cities and communities: An analysis of definitions

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Supplement 77 to ITU-T Y-series Recommendations

ITU-T Y.4051 – Digital transformation for people-centred smart cities and communities: An analysis of definitions

Summary

Supplement 77 to Recommendation ITU-T Y.4051 aims to comprehend the multi-dimensional definitions, based on open literature, of the term *digital transformation* for people-centred smart cities and communities (SC&C). It uses keywords and attributes from analytical methodology to propose a formal and comprehensive definition for the term *digital transformation*.

The process for developing a new definition will not only give a clear definition of the term but will also help in understanding the relevant works and tasks for achieving digital transformation in people-centred smart cities and communities.

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The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

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ITU-T Y.4051 – Digital transformation for people-centred smart cities and communities: An analysis of definitions

1 Introduction

Today, 55% of the world's population – 4.2 billion inhabitants – live in cities. This trend is expected to continue. By 2050, with the urban population more than doubling its current size, nearly 7 of 10 people in the world will live in cities[1]. At present, cities are facing increasing pressure to develop in an integrated and rapidly changing world. In order to successfully adapt to this situation, cities need to continuously adapt to the changing environment. Digital transformation enables human beings and autonomous devices to cooperate beyond their own context using information technology (IT) facilitated by big data, cloud computing, and mobile and social technologies. Such a transformation is an important shift from the previous modus operandi and results in potentially disruptive urban-wide transformation enabling municipalities to move from conventional operation to a digital-based approach. Transforming cities as a response to digital change is challenging and requires a structured approach, particularly as cities are comprised of different entities with different technological and social elements all of which can govern the success or failure of digital transformation. Furthermore, the increasing dynamics in both economy and technology imposes serious challenges for cities since there is a need to adapt to complex changing conditions while at the same time ensuring system integration.

Digital transformation is critical for every country. The World Economic Forum estimates that the combined global value of digital transformation to society and industry will exceed US$100 trillion by 2025. The Organization for Economic Cooperation and Development (OECD) also called on G20 member countries to formulate national digital strategies and make every effort to deal with the many challenges, such as outdated infrastructure and digital skills shortages. Moreover, since 2010, more and more governments have also gradually increased the investment of state-owned investment vehicles in technology companies, which was disclosed to have exceeded US$12 billion in 2016.

Digital transformation must adhere to the people-centred concept. Although countries are fully promoting the construction of digital transformation, due to a lack of focus, excessive digital demand has been generated. Meanwhile, due to a lack of corresponding financial and technical support in some countries, there is a serious imbalance between supply and demand. At the same time, as the digital transformation strategies of various countries usually focus on the development of new technologies rather than on improving the quality of life and enhancing national strengths, national digitalization processes have stagnated. Using technology and innovation to improve human quality of life and promote national economic growth should be the core goal of a national digital strategy and this is the reason why digital transformation must adhere to a people-centred approach.

2 Scope

This Supplement will take as a start point four components of digital transformation for people-centred cities and communities: data, people, digital technologies and their interrelationships. It will then analyse different terminologies, concepts, keywords and attributes around the 'people-centred' concept. Such an analysis of the definition of *digital transformation*, is helpful not only for understanding the tasks of digital transformation, but also for carrying out concrete work in the

[1] https://www.worldbank.org/en/topic/urbandevelopment/overview.

aspects of information and communication technology (ICT) infrastructure, key performance indicators (KPIs), stakeholders and strategies, for what ITU considers as smart sustainable cities.

3 Definitions

This Supplement does not define any new terms.

4 Abbreviations and acronyms

This Supplement uses the following abbreviations and acronyms:

AI	Artificial Intelligence
ANSI	American National Standards Institute
BIM	Building Information Modelling
BSI	British Standards Institution
EMF	Electro-Magnetic Field
FG-SSC	Focus Group on Smart Sustainable Cities
IEEE	Institute of Electrical and Electronics Engineers
IEC	International Electrotechnical Commission
ICT	Information and Communication Technology
ISO	International Organization for Standardization
IT	Information Technology
IoT	Internet of Things
IUN	International Union for Conservation of Nature
KPI	Key Performance Indicator
ML	Machine Learning
MRT	Mass Rapid Transit
NGO	Non-Governmental Organization
QoL	Quality of Life
RFID	Radio Frequency Identification Device
RPA	Robotic Process Automation
SC&C	Smart Cities and Communities
SDO	Standards Development Organization
SG	Study Group
SSC	Smart Sustainable City
UNEP	United Nations Environment Programme
WG	Working Group
WHO	World Health Organization
WWF	Worldwide Fund for Nature

5 Conventions

None.

6 Goals and motivation for a comprehensive definition

6.1 Goals

With rapidly increasing urban populations, cities are facing increasing pressures in terms of urban development and management. Digital transformation aims to improve the quality of citizens' life by adopting smart technologies for city management.

The primary goal of this Supplement to Recommendation ITU-T Y.4051, is to help understand the multi-dimensional definitions, based on open literature, of the concept of digital transformation for people-centred smart cities and communities, and to analyse the various terminologies and concepts so as to propose a formal and comprehensive definition for the term *digital transformation* focusing on people-centred smart cities and communities (SC&C).

6.2 Lack of standardized terminologies

Although there is an enormous amount of literature available on digital transformation, there are no standardized terminologies which would help in the understanding of digital transformation in people-centred smart cities and communities.

Digital transformation in the context of people-centred smart cities and communities is seldom mentioned, and there are no standardized and commonly accepted terminologies to fully describe a digital transformation in the context of people-centred smart cities.

6.3 Need for a comprehensive definition of digital transformation

The International Telecommunication Union (ITU) is currently working on standardization of the terms *digital transformation* and *digital twin*. The process for developing a new definition for digital transformation will not only give a clear definition of the term but will also help to outline the relevant works and tasks for digital transformation in people-centred smart cities.

7 Observations from literature

The following observations are drawn from the literature on digital transformation. The definition of digital transformation is dependent on the point of view (for a list of definitions, and characteristics analysed, see Appendix I). This approach will provide a sense of why and what attributes are important. There are many subjective viewpoints of what a digital transformation for people-centred smart cities and communities is, and these can be separated into the following aspects:

- Attributes.
- Themes of people-centred smart cities.
- Digital technologies.

This Supplement is based on the integration of digital transformation in smart cities and communities, with an emphasis on putting people at the centre. It should be noted that this Supplement does not provide recommendations for best practices, but rather provides a description of what is commonly found in the available literature.

7.1 Attributes

The following attributes appear consistently across the literature in terms of describing *digital transformation*:

- **Business model** – A business model is a framework that describes how city business operates, creates and delivers value to its stakeholders, and generates revenue.
- **Data-driven** – Making informed decisions based on data analysis is essential in digital transformation. It involves collecting, analysing, and interpreting data from various sources to gain insights and improve decision-making processes.
- **Innovation and creativity** – Digital transformation encourages organizations to think differently and foster a culture of innovation. It involves seeking out new technologies, ideas, and approaches to improve business operations to improve efficiency and productivity.

7.2 Theme of people-centred smart cities

- **Sustainability** – Digital transformation in smart cities and communities should consider the long-term impact on the environment and society.
- **Citizen participation** – The emphasis is on actively involving citizens in decision-making processes, policy formation, and urban planning. People are encouraged to participate and contribute to shaping the city's development, fostering a sense of ownership and belonging.
- **Quality of life** – People-centred smart cities strive to improve the quality of life for their residents. They prioritize factors such as safety, health, and well-being by implementing smart and connected solutions.

7.3 Digital technologies

Digital technology is a critical enabler of digital transformation. It refers to the use of various digital tools, platforms, and technologies to overhaul existing business processes and operations to achieve improved efficiency, innovation, and citizens' experience.

Some key applied digital technologies include:

- **Cloud computing**: Organizations in an urban environment are transitioning from traditional on-premises infrastructure to cloud-based services for storage, computing power, and software delivery. Cloud computing allows for scalability, flexibility, cost-effectiveness, and remote access to data and applications.
- **Big data and analytics**: Digital transformation leverages big data and analytics to extract valuable insights and make data-driven decisions. Platforms in smart cities collect and analyse large volumes of structured and unstructured data to understand citizen behaviour, enhance operational efficiency, and identify business opportunities.
- **Internet of things (IoT)**: IoT encompasses connected devices and sensors that collect and transmit data for analysis. In digital transformation, IoT enables smart city platforms to automate processes, monitor equipment performance, predict maintenance needs, and enhance public services.
- **Artificial intelligence (AI) and machine learning (ML)**: AI and ML technologies are used to automate tasks, improve decision-making, and enhance people interactions. AI chatbots, virtual assistants, predictive analytics, and personalized recommendations are examples of how AI transforms business processes.
- **Robotic process automation (RPA)**: RPA automates repetitive and rule-based tasks, freeing up people to focus on more complex activities. It enables organizations to streamline operations, improve accuracy, and reduce costs.

8 Methodology of analysis

8.1 Sources of information

In order to provide a sense of comprehensiveness and inclusiveness any definition of digital transformation, from the perspective of people-centred smart cities and communities, needs to be analysed from the diverse and in-depth set of definitions from the large amount of data (the 80 definitions for digital transformation). This clause presents a study of definitions and related attributes in terms of descriptions, journal articles, and research reports on digital transformation for people-centred smart cities. In this Supplement, various articles were collected from the Internet and other databases covering the following major aspects:

– Academia and research communities
– Government initiatives
– Corporate/company profiles
– Trade associations
– Standards development organizations (SDOs).

A complete list of all the definitions can be found in Appendix I.

8.2 Systematic analysis approach

The systematic analysis approach provides a diverse set of definitions and a sense of comprehensiveness to the study. As part of the research, multiple words and combinations were used during the search from primary sources. Primary search words include but not limited to digital, transformation, intelligent, people-centred, smart, city (cities), definition, attributes, ICT, intelligent, characteristics, etc. A systematic analysis approach was followed throughout the study, the steps of this systematic analysis are shown in Figure 1 and described below.

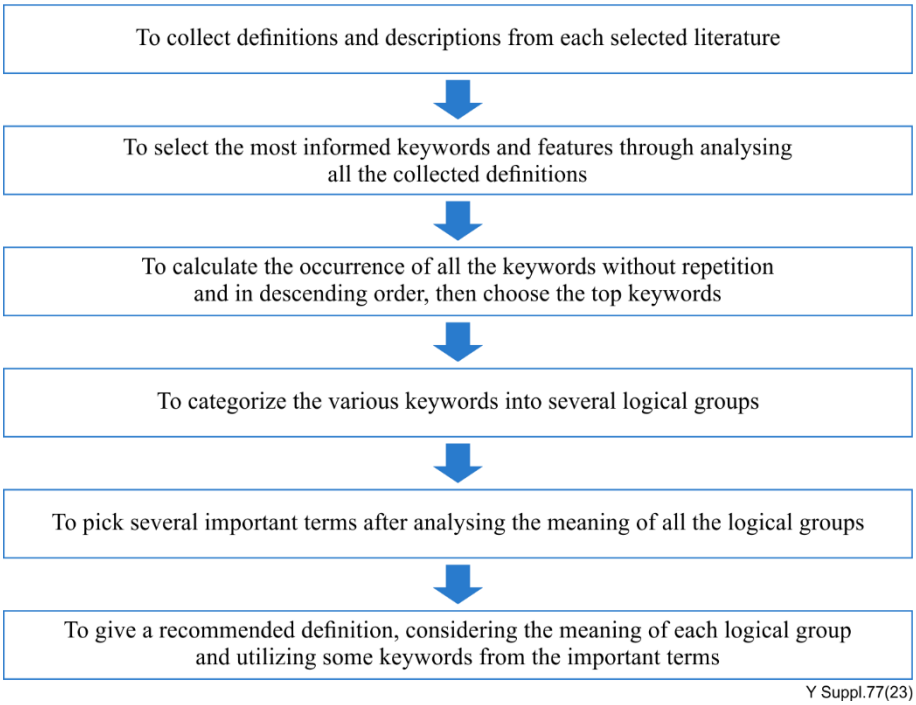

Figure 1 – Systematic analysis approach

Step 1: Collect definitions and descriptions from each selected literature, which are related to digital transformation and people-centred smart cities and communities.

Step 2: Determine the most informed keywords and features through analysing all the collected definitions (listed in Appendix). All these keywords are meaningful nouns, adjectives and verbs that are extracted from those definitions.

Step 3: Calculate the occurrence of all the keywords without repetition and in descending order, then choose the top keywords.

Step 4: Categorize the various keywords into several logical groups based on the chosen keywords. After that, create a table separated by different color-coded logical groups. In each logical group, the keyword occurrence is listed in descending order (see Table 9-1).

Step 5: Pick several important terms after analysing the meaning of all the logical groups.

Step 6: Give a recommended definition, considering the meaning of each logical group and utilizing some keywords from the important terms. The results of this analysis, which identified the top keywords and characteristics of a digital transformation for people-centred smart cities and communities, are discussed in clause 9.

9 Results

All the definitions (listed in Appendix I) have been analysed in order to determine the most important keywords and features that have prompted a digital transformation for people-centred smart cities and communities. Words such as "digital" and "transformation" are implicit and referred to in nearly all the descriptions, and these words are not the separate keywords to capture.

A total of 50 keywords were found that appeared in more than one reference across these studied definitions. There were a total number of 473 instances of these 50 keywords. These are captured and presented below in Table 9-1 to reflect the relative number of times that these keywords were repeated across all 80 definitions. As an overview of the literature review, a graphical representation of the relative importance of keywords was developed. The bigger the font is, the more important the word is, see Figure 2.

Figure 2 – Graphical representation of top 50 keywords

9.1 Keyword analysis from definitions

Table 9-1 represents a comprehensive examination of various keywords and their frequencies within the documents analysed (as outlined in Appendix I).

NOTE – There are four colours, which represent the four categories, in Table 9-1 and Table 9-2. Each colour-coded block refers to one category which corresponds with that of Table 9-2.

Table 9-1 – List of keywords, occurrences, and relative percentages

No.	Keyword	Total occurrences	% occurrence
1	business models	15	5.07%
2	process	8	2.70%
3	change(s)	9	3.04%
4	innovation(s)	8	2.70%
5	data/data driven	8	2.70%
6	stakeholders	6	2.03%
7	shift	5	1.69%
8	analytics	4	1.35%
9	improve	4	1.35%
10	solutions	3	1.01%
11	strategy	3	1.01%
12	opportunities	3	1.01%
13	performance	3	1.01%
14	effectively/efficiency	8	2.70%
15	business improvements	3	1.01%
16	(digital) technologies	44	14.86%
17	digital/digital asset	12	4.05%
18	products	8	2.70%
19	ICT(s)	6	2.03%
20	devices	4	1.35%
21	IoTs	2	0.68%
22	big data	2	0.68%
23	AI	2	0.68%
24	services/public services	17	5.74%
25	mobile	5	1.69%
26	operations/operational	6	2.03%
27	way(s)	6	2.03%
28	processes /business process	5	1.69%
29	actors	3	1.01%
30	decision-making	3	1.01%
31	organization(s)	4	1.35%
32	economic	2	0.68%
33	governance	2	0.68%
34	values	9	3.04%
35	citizens	6	2.03%
36	costs	5	1.69%
37	people/human	6	2.03%

Table 9-1 – List of keywords, occurrences, and relative percentages

No.	Keyword	Total occurrences	% occurrence
38	sustainability	4	1.35%
39	automation	4	1.35%
40	sustainable	4	1.35%
41	customers/customer experience	5	1.69%
42	social/society	6	2.03%
43	people centred	3	1.01%
44	life	3	1.01%
45	cities/city's	7	2.36%
46	development	3	1.01%
47	smart city	2	0.68%
48	inclusive	2	0.68%
49	wellbeing	2	0.68%
50	productivity	2	0.68%
Total		296	100.00%

9.2 Keyword grouping

Table 9-2 demonstrates several logical groupings, which were utilized to categorize the various keywords. These groupings were appropriately colour-coded to facilitate comprehension and assess the relative significance of each keyword and category.

NOTE – The corresponding colour-coded groups are derived from the reading of the literature in clause 7. The relevant definitions of digital transformation are related to the attributes such as digital technologies, data-driven, and so on. In addition, people-centred smart cities and communities include providing people with sustainable environments and high-quality public services. Considering the definition needs to include both meanings, it is therefore divided into four logical groups.

Table 9-2 – Logical groupings

Category	% occurrence
Technology-enabled/data-driven solution	30%
Digital technologies/ICT/digital asset	27%
Public services	18%
Sustainable, inclusive, and liveable communities	25%
Total	100%

To reduce any subjective biases in defining the aforementioned keyword grouping, a thorough literature search was conducted to obtain the most appropriate descriptions for each keyword. This step is crucial to establish a standardized understanding of the meaning behind each of these keywords.

Technology-enabled/data-driven solution[2]

Technology enabled data driven advanced planning and decision support solutions combined with lean construction is a potent combination. The combination will be a valuable tool for all stakeholders in business planning and delivery.

Digital technologies/ICT/digital asset

There has been a significant emphasis on the necessity for organizations in the construction industry to embrace digital technologies such as building information modelling (BIM), Internet of things (IoT), and Industry 4.0.[3]

Public services[4]

The technical definition of a public service is a service provided by the government to the people in a specific jurisdiction. The primary aim of an upgrade of urban public services is to improve the quality of life of the urban population.[5]

Sustainable communities[6]

Specifically, the concept of "sustainable cities and communities" of the World Bank's *Urban, Disaster Risk Management, Resilience and Land Global Practice* (GPURL) includes four key dimensions:

– Sustainable communities are environmentally sustainable in terms of cleanliness and efficiency.

– Sustainable communities are resilient to social, economic, and natural shocks. They are well prepared for natural disasters, which are increasing in intensity and frequency due to climate change.

– Sustainable communities are inclusive communities. They bring all dimensions of society and all groups of people – including the marginalized and vulnerable – into their markets, their services, and their development.

– Sustainable communities are competitive communities that can remain productive and generate jobs for members of the community.

9.3 Important terms to be included in a standardized definition

After comprehensively analysing the information provided and utilizing the main categories and important keywords, the conclusion is that the standardized definition for digital information for people-centred smart cities and communities could incorporate the 30 crucial terms listed in Table 9-3.

NOTE – These 30 terms mainly come from the high-frequency terms among the 50 keywords, such as digital technologies with the highest frequency at 14.86%, public services at 5.74% and business models at 5.07% with the second and third frequencies respectively. The rest comes from keywords selected from different colour blocks, in order to ensure the integrity of the definition.

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2 Technology enabled data driven decision support tools for capital projects | SpringerLink.

3 The 'how' of benefits management for digital technology: From engineering to asset management – ScienceDirect. Retrieved 14th July 2023 from The 'how' of benefits management for digital technology: From engineering to asset management – ScienceDirect.

4 The Importance of Public Service | The Link (columbiasouthern.edu).

5 Digital Public Services in Smart Cities – an Empirical Analysis of Lead User Preferences – ProQuest.

6 Sustainable Cities and Communities: Development news, research, data | World Bank.

Table 9-3 – Crucial terms

digital technologies public services business models values process solution social people	innovation stakeholders shift toward sustainability automation social impact development operations	citizens quality of life information ICT productivity data process	participation collaboration co-creation resilient sustainable economic wellbeing

10 Recommended definition

Digital transformation for people-centred smart cities and communities refers to the process of integrating digital technologies and revamped business models to drive innovation and sustainability solutions for citizens to improve economic opportunities, public services, social well-being, and quality of life.

10.1 Criteria for definition

After conducting a thorough examination of the keywords used in 80 definitions of digital transformation and people-centred cities and communities, it was determined that the most accurate criteria for defining such a city are as follows:

Key categories or groups

– Technology-enabled/data-driven solutions.
– Digital technologies/ICT/digital assets.
– Public services.
– Sustainable, inclusive and liveable communities.

10.2 Specification

The analysis referred to in this Supplement provides the groundwork for creating a specification for a "digital transformation for people-centred smart cities and communities".

Digital transformation for people-centred smart cities and communities is a process that leverages automation and ICT solutions to streamline and enhance the operation of cities and communities. It encompasses changes in processes and the adoption of new technologies to improve efficiency, effectiveness, and responsiveness to citizens' needs. This transformation is centred around people, with the primary focus being to empower citizens and enhance their overall well-being. It emphasizes the provision of digital services that enrich citizens' daily lives, promote inclusivity, and support social development. Key elements of digital transformation in people-centred smart cities and communities:

– Improve the quality of life of citizens.
– Enhance ability of citizens to access essential services, such as healthcare, education, transportation, and public safety.
– Engage citizens in the planning and design of urban spaces and services, as well as empowering them with access to information and digital tools.
– Improve city operational efficiency and enhance the overall experience of citizens.
– Enable citizens' active participation in community activities.

– Foster a sense of community ownership and social inclusion, promoting collaboration and co-creation among diverse stakeholders to build more resilient and sustainable smart cities and communities.

Appendix I

Definitions of digital transformation for people-centred smart cities and communities

NOTE – **Key concept/Keywords** are selected nouns, verbs and adjectives that have specific meanings from **Definitions/Features**

Ref. No.	Category	Definitions/Features	Key concept/Keywords	Source
1	Academic	The people-centred cities need to be socially just, environmental sustainable, politically participatory, economically productive, culturally vibrant and globally connected.	Environmental-sustainable, socially-just, politically-participatory, economical-productive, culturally-vibrant, globally-connected.	[b-Witoelar, E]
2	Academic	A city that combines best two worlds; on the one hand, a social city that is people-centred, values active citizenship and embraces community-driven innovation, and on the other, a smart city that welcomes the possibility of future internet and related technology-driven innovations, such as open data, Internet of things and Living Labs offer.	Social-city, values, citizenship, innovation, community-driven, technology-driven, IoTs, future-internet, open-data.	[b-Mulder]
3	Academic	Technology and technological solutions should be understood as a tool to develop solutions and services, and achieve sustainable living, and digital transformation should be understood and as a social process.	Technology, technological-solutions, tool, solutions, services, sustainable-living, social-process.	[b-Zavratnik]
4	Academic	Digital transformation allows humans to cooperate with autonomous systems, the structural challenges are high, especially in cities that are composed of different entities with different technological and social structures.	Autonomous-systems, structural-changes, entities, technological-structures, social-structures.	[b-Reis]

Ref. No.	Category	Definitions/Features	Key concept/Keywords	Source
5	Academic	The concepts of digital transformation and digital maturity highlighted the various types of digital maturity models created to help organizations assess, benchmark, and improve their digital maturity. NOTE – Digital maturity modes dimensions: Customer, Strategy, Technology, Operations, Organizations & Culture.	Digital-maturity-models, organizations, assess, benchmark, customers, strategy, technology, operations, culture.	[b-Lee]
6	Academic	The unprecedented development in information and communication (ICT) has caused the production of massive volumes of digital data. This phenomenon encouraged academics and practitioners to search for unconventional means to benefit from analysing this data in several domains. This reliance on ICT and leveraging digital data analysis is referred to as "digital transformation" The smart city (SC) is one of the recently adopted concepts that rely mainly on digital transformation to realize city smartness.	Digital-data, analysis, domains, smart-city, ICT, unconventional-means, digital-data – analysis, city-smartness.	[b-Osman]
7	Academic	Digital transformation is a multi-faced phenomenon that originate from the exploitation of a bundle of evolving digital technologies in a fast-paced landscape and the transformation of organizations attempting to exploit these technologies.	Multi-faced-phenomenon, digital-technologies, fast-paced-landscape, exploit, transformation, organizations, technologies.	[b-Zomer]

Ref. No.	Category	Definitions/Features	Key concept/Keywords	Source
8	Academic	The Smart City involves the implementation of digital strategies that are necessary people-centred and lead into high technology-based innovations to build more capabilities and opportunities.	Digital-strategies, high-technology-based, innovations, capabilities, opportunities.	[b-Orecchini]
9	Academic	The benefits of replacing conventional production-oriented service provision models with the people-oriented service paradigm is to create inclusive and efficient public services with better predictions of where public service investments can have the largest welfare impacts.	People-oriented-service, inclusive, efficient, public-services, welfare-impacts.	[b-Rönkkö]
10	Academic	Digital transformation is the process of shifting an organization from a legacy approach to new ways of working and thinking using digital, social, mobile and emerging technologies.	Process, shift, organization, new-ways, working, thinking, digital, social, mobile, technologies.	[b-Karagiannaki]
11	Academic	Focus was on understanding and analysing modern management approaches to make use of information systems for business process and product/service development in digital transformation enabled by software based systems and business models. Digital transformation is tightly related to digital business platforms and new business models.	Information-system, business-process, products, services, Software-based-systems, business-models, digital-business-platforms.	[b-Collin]

Ref. No.	Category	Definitions/Features	Key concept/Keywords	Source
12	Book	Several thinkers do not doubt that this is the only possible path to digital transformation: people-centred and sustainability-focused. DT is the generalized use, based in data, computation and analytics of digital technology in all fields of scientific, technologic and economic activities.	People-centred, sustainability, data, computation, analytics, digital-technology, fields, scientific-activities, economic-activities.	[b-Salavisa]
13	Book	Digital Transformation is the changes that digital technology causes or influences in all aspects of human life.	Changes, digital-technology, human life.	[b-Stolterman]
14	Book	We use the term digital transformation to describe these social, cultural, and economic changes resulting from digital innovations, and identify four socio-technological areas in which people are particularly affected by this transformation: work and income goods and services, money and finance, and state and governance. The digital transformation results in benefiting society at large by putting users at the centre of it.	Social, cultural, economic, changes, digital, innovations, work-goods, income-goods, services, finance, sate, governance, society, benefit, users.	[b-Brülisauer]
15	Book	Digital transformation can be explained as the shift in work, jobs, and products through the use of technology in a company or the operational context of that company. Customer-oriented rethinking of business by leveraging data and technology. "Digital Transformation" means an entirely new	Shift, products, technology, operational-context, data, business-models, value, services, operational-efficiencies, revenue-gains, productivity.	[b-Kern]

Ref. No.	Category	Definitions/Features	Key concept/Keywords	Source
		organizational existence based on new business models. The digital transformation could bring substantial benefits in the form of new valued-add services, operational efficiencies, revenue gains, productivity, and improved partner relations, there are some hurdles to overcome.		
16	Book	The role of digital transformation is important for cities to improve smart services. Accordingly, digital transformation has been targeted by municipalities as a goal towards achieving a sustainable future. But cities face considerable challenges with technological development in seeing through the complexity involved in transforming urban services.	Cities, improve, smart-services, municipalities, achieve, sustainable-future, transforming, urban-services.	[b-Grab]
17	Book	The process of digital transformation must be embraced as an interdisciplinary field from developers, computer scientists, data scientists, urban and regional planners, and policymakers.	Interdisciplinary, field, developers, computer-scientists, data-scientists, urban-planners, regional-planners, policymakers.	[b-Coelho]

Ref. No.	Category	Definitions/Features	Key concept/Keywords	Source
18	Book	A smart city uses digital technologies or information and communication technologies to enhance quality and performance of urban services, to reduce costs and resources consumption, and to engage more effectively and actively with its citizens.	Digital-technologies, ICT, quality, performance, urban, services, reduce, costs, resource, consumption, effectively, actively, citizens.	[b-Khamis]
19	Book	Instead, it appears crucial the virtualization process, that is, the transformation of a material city into a virtual city, able to create a new intangible urban dimension where people, relationships and services are virtually joined and shared to build a smarter community.	Virtualization, process, material-city, virtual-city, intangible, urban-dimension, people, relationships, services, virtually, joined, shared, smarter-community.	[b-Cocchia]
20	Book	Digital transformation refers to the use of new digital technologies that create and flexibly modify new business models and is not an end in itself.	Digital-technologies, create, flexibly, modify, business models.	[b-Kankara]
21	Book	In virtually all industries, companies are undertaking numerous initiatives to explore and exploit new technologies, impacting business processes and products, services, business models, and organizational structures. But digital transformation is not about the technology itself, rather it is "about how technology changes the conditions under which business is done, in ways that change the expectations of customers, partners, and employees".	Technologies, business-process, products, services, business-models, organizational-structures, expectations.	[b-Wenzel]

Ref. No.	Category	Definitions/Features	Key concept/Keywords	Source
22	Book	The digital transformation of society is a multi-faced phenomenon that provides people, social institutions, and organization, access to the use of Information technologies (IT) for success in various areas of everyday life (e.g., education, industry). The digital transformation has led to the rise of data-rich service systems, in which organizations engage in data collection and analytics activities.	Multi-faced, phenomenon, people, social-institutions, organization, access, use, IT, data-rich, service, life, data-collection, data-analytics.	[b-Hofmann]
23	Corporate	The most fundamental technology need for digital transformation is a digital platform of integrated data and process.	Technology, digital-platform, integrate-data, process.	[b-Westerman 2011]
24	Corporate	Maturing digital businesses are focused on integrating digital technology, such as social, mobile, analytics and cloud, in the service of transforming how their business work.	digital-technology, social, mobile, analytics, cloud, service, transform, business-work.	[b-Kane]
25	Corporate	The use of technology to radically improve performance or enterprises.	Technology, improve, radically, performance.	[b-Westerman 2014]
26	Corporate	The use of new digital technologies, such as social media, mobile, analytics or embedded devices, in order to enable major business improvements like enhancing customer experience, streamlining operations or creating new business models.	Digital-technology, social-media, mobile, analytics, devices, business-improvements, streamlining, operations, business-models.	[b-Fitzgerald]

Ref. No.	Category	Definitions/Features	Key concept/Keywords	Source
27	Corporate	As such, the Digital Transformation goes beyond merely digitizing resources and results in value and revenues being created from digital assets.	Digitizing-resources, value, revenues, digital-assets.	[b-McDonald]
28	Corporate	The realignment of, or new investment in, technology and business models to more effectively engage digital customers at every touch point in the customer experience lifecycle.	technology, business-models, effectively, digital, lifecycle.	[b-Solis]
29	Corporate	Digital Transformation is now commonly interpreted as such usage of Information and Communication Technology, when not trivial automation is performed, but fundamentally new capabilities are created in business, public government, and in people's and society life.	Usage, ICT, automation, business-created, public-government, society-life.	[b-Martin]
30	Corporate	Digital transformation is not a software upgrade or a supply chain improvement project. It's a planned digital shock to what may be a reasonably functioning system.	planned, digital-shock, functioning-system.	[b-Andriole]
31	International organization	The digital transformation - the adoption of online business models and general shift of economic and social activity online - is changing the way that business operate, the way economic function and the way that societies interact. The digital transformation provides for participatory democracy to counter	Business-models, shift, economic-activity, social-activity, online, business-operate, societies, data-driven, economy, sustainable, future.	[b-Ciuriak]

Ref. No.	Category	Definitions/Features	Key concept/Keywords	Source
		the power concentration of the data-driven economy and enable countries to navigate the course to a sustainable future.		
32	International organization	People-centred health service is an approach to care that consciously adopts the perspectives of individuals families and communities, and sees them as participants as well as beneficiaries of trusted health systems that respond to their needs and preferences in humane and holistic ways. By adopting people-centred and integrated health services, health systems will provide services that are better of quality, are financially sustainable and more responsive to individuals and communities.	Service, Individual families, communities, needs, preferences, people-centred, better-of-quality, financially-sustainable, responsive.	[b-WHO]
33	International organisation	PCSC is a multistakeholder approach to urban and digital transformation that works for the benefits of all, driving sustainability, inclusivity, prosperity, and human digital rights.	Multistakeholder, approach, Sustainability, inclusivity, prosperity, human, digital-rights	[b-UN-Habitat]
34	ITU	Digital transformation offers cities the tools they need to address the challenges and opportunities that define this century from climate change to social and economic inequality. But urban digital transformation must also be sustainable, resilient, and inclusive. Digital transformation is becoming a focus of strategic thinking and planning for	Tools, challenges, opportunities, sustainable, resilient, inclusive, strategic-thinking, planning, governments, cities, industries, digital-services, digital-applications, inhabitants, way-of-life, work, play, improvements, quality-of-life, wellbeing, Sustainable-Development-Goals, digital-technologies, ICTs, innovation,	[b-ITU Pub]

Ref. No.	Category	Definitions/Features	Key concept/Keywords	Source
		governments, cities, and industries. It is about putting the emphasis on how digital services and applications will change "transform" inhabitants' experiences and the way they live, work and play in cities, and how this will lead to improvements in quality of life and wellbeing, and lead to the attainment of the United Nations Sustainable Development Goals (SDG). Smart cities and communities rely on digital technologies and information and communication technologies (ICTs) to offer innovative and integrated services and solutions to their residents.	integrated-services, solutions, residents.	
35	ITU	Digital technologies and information communication technologies continue to transform the urban ecosystem, providing new sustainability opportunities across all sectors.	Digital-technologies, ICTs, transform, urban-ecosystem, sustainability, opportunities, sectors.	[b-ITU-T L-Sup.56]
36	ITU	The process of digital transformation is inclusive for all people regardless of their age, gender, ability, or location, three fundamental "A" pillars should be considered: Access to ensure connectivity; Affordability of the Internet and the devices; and Accessibility, which is enabled through Adoption of policies, development of accessible ICTs – devices, products, and services – as well as the appropriation of	People, Access, connectivity, affordability, Internet, devices, polices, adoption, development, ICTs, devices, products, services, technology, digital-economy.	[b-ITU EHT]

Ref. No.	Category	Definitions/Features	Key concept/Keywords	Source
		technology, to ensure that all population groups having access to ICTs can have meaningful participation within the digital economy.		
37	ITU	The digital transformation is vitally useful for sectors to optimize resources configuration, improve operational efficiency and innovation capability, and hence realize sectors 'sustainable development. Effective and efficient achievement of sector's digital transformation should be in alignment with the following core concepts: Innovation driving. Seamless data sharing. Coordinated development. Value creation.	Optimize, resources configuration, operational, efficiency, innovation, sustainable, capability, development, Innovation, seamless-data sharing, coordinated-development, value-creation.	[b-ITU-T Y.4906]
38	ISO	Cities wishing to deliver their vision and strategic objectives in a smart way also seek to articulate within the vision how this will "feel" different from their city as it is now, and to bring this to life through use of digital modelling, data visualization, social media, and/or other technologies.	Smart-way, city, life, digital-model, data-visualization, social-media, technologies.	[b-ISO 37106]
39	Report	In case of Birmingham smart city, the city government has planned for digital infrastructure via development of digital blueprint, regulating infrastructure and open data initiatives.	Smart-city, government, digital-infrastructure, digital, blueprint, open-data initiatives.	[b-Slater]
40	Journal	Addressing the impacts of necessary changes	Resources-efficient, city, resilient, urban-	[b-Krellenberg]

Ref. No.	Category	Definitions/Features	Key concept/Keywords	Source
		towards the Resources Efficient City or the Resilient City on the living conditions of urban residents, and communicating and promoting them explicitly, can increase awareness and acceptance, and also facilitate the finial implementation of resilience and resources efficiency. Putting people-centred approaches in the focus of UST is neither merely about the development of new technologies nor about the implementation of a political will but about the deep conviction that, through urban transformations towards sustainability, it is possible to improve living conditions, also for future generations.	residents, people-centred, technologies, political-will, sustainability, living-conditions, future-generations.	
41	Journal	In their own microcosm, cities pursue their own digital transformation by means of smart city strategies, essentially local development strategies with digital at their core. In 2020, the Commission revelled its vision for digital transformation by presenting a model for a digital society based on principles and values where technology would play a role in enforcing and not in challenging them.	Smart-city, strategies, digital, society, development strategy, model, technology, values, principles, digital-society.	[b-Mărcuț]
42	Journal	Digital transformation usually means the ability of firms, companies, broadcasters and other stakeholders to take full advantages of digital	Digital-technology, innovation, reinvention, complexity, reducing, costs, enabling predictions, repair, modification, public-	[b-Komarcevic]

Ref. No.	Category	Definitions/Features	Key concept/Keywords	Source
		technology in their domain. It is based on innovation, so the success of digitizing comes from unconventional innovation, or so-call reinvention, and it is therefore unconventional, changing space, time and level of complexity, reducing costs and enabling predictions. In addition, digitization allows the repair and modification of existing business models and public services. NOTE – Five key digital technologies: cloud computing, mobile, big data, social networks, and the internet of things.	services, business-models, cloud-computing, mobile, big-data, social-networks, IoTs.	
43	Journal	Digital transformation strategy is a blueprint that support companies in governing the transformations that arise owing to the integration of digital technologies, as well as in their operations after a transformation.	Strategy, blueprint, digital-technologies, operations, integration.	[b-Matt]
44	Journal	Digital transformation is the profound and accelerating transformation of business activities, processes, competencies, and models to fully leverage the changes and opportunities brought by digital technologies and their impact across society in a strategic and prioritized way.	Business-activities, processes, competencies, models, digital-technologies, society, strategic way, prioritized way.	[b-Demirkan]
45	Journal	Digital transformation is concerned with the changes digital technologies can bring about in a company's business model, which	Digital-technologies, business-model, change, products, organizational-structures, automation, process, Internet-based-	[b-Hess]

Ref. No.	Category	Definitions/Features	Key concept/Keywords	Source
		result in changed products or organizational structures or in the automation of processes. These changes can be observed in the rising demand for Internet-based media, which has led to changes of entire business models (for example in the music industry).	media.	
46	Journal	Digital transformation entails the connection of actors over the value chain and the deployment of systems for gathering, exchange, processing and analysis of city data to support decision making.	Connection, actors, value-chain, systems, gathering, exchange, processing, city-data, decision-making.	[b-Antonova]
47	Journal	Digital transformation involves the application of digital technologies to improve city performance and scale operations, services, and organisational structures.	Application, digital-technologies, city-performance, scale-operations, services, organizational-structures.	[b-Goerzig]
48	Journal	Digital transformation in cities is strongly focused on implementing novel digital technologies to better control, monitor and measure urban operations, for example using real-time data for decision making and predicting future services.	Cities, digital-technologies, control, monitor, measure, urban-operations, decision-making, predict, real-time-data, future-services.	[b-Heilig]
49	Journal	Digital transformation can create an integrated system of actors, stakeholders, and assets where citizens can exchange and communicate data within systems to facilitate decision-making process.	System, actors, stakeholders, assets, communicate, data, facilitate decision-making.	[b-Bertola]
50	Journal	To achieve digital transformation, digital agility is needed to recombine digital assets	Digital-agility, recombine, digital-assets, organizational-resources, change, way,	[b-Verhoef]

Ref. No.	Category	Definitions/Features	Key concept/Keywords	Source
		with other organizational resources in order to change the way of doing business.	business.	
51	Journal	Digital transformation in smart cities comprises of four main components which are data, people, digital technologies and their interrelationship.	Data, people, digital-technologies, interrelationship.	[b-Ashwell]
52	Journal	The goal of digital transformation is to make information, product offerings, and business procedures available in digital form via IT based applications. Under the notions digital transformation was suggested to identify key aspects of such changes and provide support for city's business transformation. Digital transformation comprises a combination of business models and innovation.	Information, product-offerings, business-procedures, digital, IT-based-applications, change, support, city's business-transformation, business-models, innovation.	[b-Jnr]
53	Journal	Digital transformation impacts the whole city (both citizens and stakeholders), and the ways city operations are operated and goes beyond digitalisation by changing simple urban process and tasks.	Citizens, stakeholders, city-operations, digitalization, urban-process, urban-tasks.	[b-Caponio]
54	Journal	Digital transformation is an emerging trend in developing the way how the work is being done, and it is present in the private and public sector, in all industries and fields of work. Smart cities, as one of the concepts related to digital transformation, is usually seen as a matter of local governments, as it is their responsibilities offered by the concept	Emerging-trend, private sector, public sector, industries, fields-of-work, create, values, stakeholders, living-city, ecosystems, way, work.	[b-Tomičić-Pupek]

Ref. No.	Category	Definitions/Features	Key concept/Keywords	Source
		of smart cities, creating new values to all stakeholders interacting in the living city ecosystems, thus serving as examples of good practice, while others are still developing and growing on their intentions to become smart.		
55	Journal	The future work involves improving performance and well-being, digital technology is used to reduce costs and resources consumption and engage more effectively with its citizens.	Improve, performance, well-being, digital-technology, reduce, costs, resources-consumption, effectively, citizens.	[b-Wei]
56	Journal	Technological infrastructures provide hardware support for digital transformation. IT human resources are those employees with the knowledge and skills and IT specialists. Digital technology itself is crucial to the digital transformation process.	Technology-infrastructures, hardware, IT-human resources, knowledge, skills, IT-specialists, digital-technology, process.	[b-Xiao]
57	Journal	Digital transformation, a term adopted from the private sector, is mostly associated with the need to use new technologies to stay competitive in the Internet age, where services and products are delivered both online and offline.	Technologies, competitive, Internet-age, services, products, delivered, online, offline.	[b-Mergel]
58	Journal	Others define digital transformation as a way to rebuild business models following the needs of customers by using new technologies.	Way, rebuild, business-models, needs, customers, technologies.	[b-Berman]
59	Journal	The establishment of various sensors and data centres give the data storage capability, processing and visualization ability to city administrations to	Sensors, data-centres, data-storage-capability, city-administrations, processing-ability, visualization-ability, digital-solutions.	[b-Kumar]

Ref. No.	Category	Definitions/Features	Key concept/Keywords	Source
		develop new digital solutions.		
60	Journal	Digital transformation is the process of combining digital technologies with sound business models to generate great value for enterprises.	Process, digital-technologies, business-models, generate, value, enterprises.	[b-Lee C. H.]
61	Journal	Smart city initiatives and data-driven technologies have gained substantial attention in cities in the Global North and Global South through recent ICT apps, devices, and platforms, including AI, digital twin, big data, blockchain, and augmented reality, among others.	Data-driven, technologies, ICT, apps, devices, AI, digital twin, big data, blockchain, augmented reality.	[b-Calzada 2021]
62	Journal	PCSC's foundational statements assume that digital technologies have a transformative potential and can contribute greatly to sustainable urban development if the concept of smart cities can be divested of its technocratic attributes.	Digital-technologies，transformative, potential, sustainable, urban, development, technocratic-attributes.	[b-Calzada 2018]
63	Government	Digital transformation is conductive for many cities on their way of becoming "smarter", providing them with the opportunity to improve digital process, pursue climate-friendly goals, or raise the standards of living of their citizens.	Way, smarter, Digital-process, climate-friendly, standards-of-living, citizens.	[b-Gryshchenko]
64	Government	Digital transformation in the public sector means new ways of working with stakeholders, building new frameworks of service delivery and creating new forms of relationships.	Ways, stakeholders, build, frameworks, service, delivery, forms, relationship.	[b-European Commission]
65	Non-profit	As well as creating new economic opportunities	Economic-opportunities, people,	[b-Langendorf]

Ref. No.	Category	Definitions/Features	Key concept/Keywords	Source
		for young people, digital transformation in the Arab world could have a positive political impact- by enhancing the free flow of information and creating the kind of secure direct communication channels that facilitate civic mobilization. For the EU, digital transformation opens new avenues to promote economic development, stabilization, and the empowerment of young people in the Arab world.	political-impact, information, communication-channels, civic, economic-development, stabilization.	
66	Conference	Digital transformation involves leveraging digital technologies to enable major business improvements, such as enhancing customer experience or creating new business models.	Digital-technologies, business-improvements, customer-experience, business-models.	[b-Piccinni]
67	Conference	Use of digital technologies to radically improve the company's performance.	Digital-technologies, improve, performance.	[b-Bekkhus]
68	Conference	Digital transformation encompasses both process digitization with a focus on efficiency, and digital innovation with a focus on enhancing existing physical products with digital capabilities.	Process, efficiency, digital-innovation, enhancing, products, digital-capabilities.	[b-Berghaus]
69	Conference	Digital transformation encompasses the digitization of sales and communication channels, which provide novel ways to interact and engage with customers, and the digitization of a firm's offerings (products and services), which replace or augment physical offerings. Digital transformation also	Sales-of- digitization, communication-channels, novel, ways, tactical, strategic, business-move, data-driven, insights, digital, products, services, replace, augment, physical-offerings, business-models, capture, value.	[b-Haffke]

Ref. No.	Category	Definitions/Features	Key concept/Keywords	Source
		describes the triggering of tactical or strategic business moves by data-driven insights and the launch of digital business models that allow new ways to capture value.		
70	Conference	Changes and transformations that are driven and built on a foundation of digital technologies. Within an enterprise, digital transformation is defined as an organizational shift to big data, analytics, cloud, mobile and social media platform. Whereas organizations are constantly transforming and evolving in response to changing business landscape, digital transformation are the changes built on the foundation of digital technologies, ushering unique changes in business operations, business processes and value creation.	Changes, transformations, digital-technologies, shift, big-data, analytics, cloud, mobile, social-media-platform, business-landscape, digital-technologies, changes, business-operations, processes, value.	[b-Nwankpa]
71	Conference	The changes digital technologies can bring about in a company's business model, which result in changed products or organisational structures or automation of processes.	Changes, digital-technologies, business-model, products, organizational-structures, automation, processes.	[b-Clohessy]
72	Conference	The use of new digital technologies, in order to enable major business improvements in operations and markets such as enhancing customer experience, streamlining operations or creating new business models.	Digital-technologies, business-improvements, customer-experience, operations, streamlining-operations, business-models.	[b-Paavola]
73	Conference	Transformation is an	Urban-wide-	[b-Babar]

Ref. No.	Category	Definitions/Features	Key concept/Keywords	Source
		important shift from the previous modus operandi and results in potentially disruptive urban-wide transformation enabling municipalities to move from conventional operation to digital based approach.	transformation, shift, digital-approach, modus-operandi, operation.	
74	Conference	Digital transformation involves applying digital technologies to several areas of enterprise, which lead to important changes in enterprises' activities and the way values are created for stakeholders.	Digital-technologies, values, stakeholders, enterprise, changes, enterprises' activities.	[b-Gampfer]
75	Conference	Digital transformation involves applying digital technologies to several areas of an enterprise, which lead to important changes in enterprises 'activities and the way values are created for stakeholders. Digital transformation aims to re-align processes, technology, and business models to create value for customers as well as enterprises.	Apply, digital-technologies, enterprise, changes, activities, created value, stakeholders, re-align, process, technology, business models, customers.	[b-Vobugari]
76	Conference	Digital transformation can bring about increased productivity and revenue, decreasing costs, improving client service.	Increased, productivity, revenue, decrease, costs, improve, client-service.	[b-Aliee]
77	Conference	Digital transformation in urban environment refers to the adoption of technologies, and its abilities to digitise city's assets.	Urban-environment, technologies, digitize city's assets.	[b-Kempegowda]
78	Conference	Cities adopt digital transformation in an effort to decrease costs and become more responsive to citizens demands.	Decrease, costs, responsive, citizens, demands.	[b-Roedder]
79	Conference	The endeavour is to	Pollution-free,	[b-Rai]

Ref. No.	Category	Definitions/Features	Key concept/Keywords	Source
		plan/rebuild pollution free, eco-friendly living spaces with the efficient means of Transportation, Communication, Governance, Health Services and other civic requirements. The quest to build smart cities from the standpoint of enhanced economic activity and operational efficiency with the use of High-end integrated technologies for automation, Artificial intelligence, and Internet of Things the importance of "Culture" as bedrock of "Smartness "has been subdued.	ecofriendly, living spaces, efficient, means, transportation, communication, governance, health services, civic-requirements, enhanced, economic, activity, operational, efficiency, High-end integrated-technologies, automation, AI, IOT.	
80	Conference	Dealing with people's contribution to a smart city, it is worth noting the essential contribution of digital platforms in enabling multiple actors 'interactions pointing to design and offering innovative solutions and services to citizens.	Digital-platforms, actors, interactions, design, offer, innovative, solutions, services, citizens.	[b-Bernardo]

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